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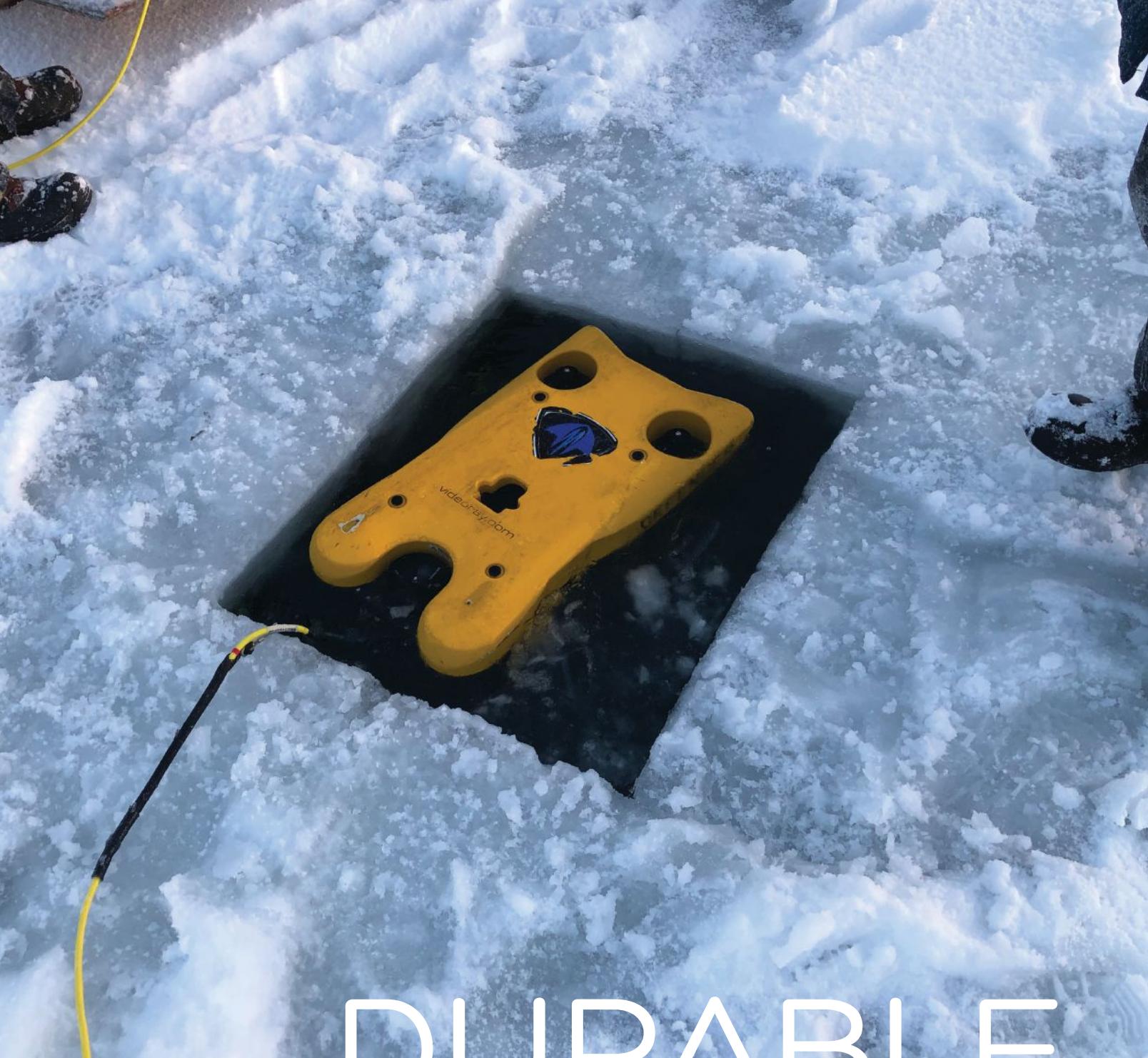


## ESSENTIAL INTELLIGENCE

Quiescent Imaging For Deep-Sea  
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The Discovery Of The Capitana  
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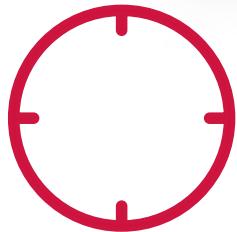
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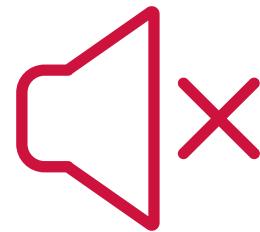
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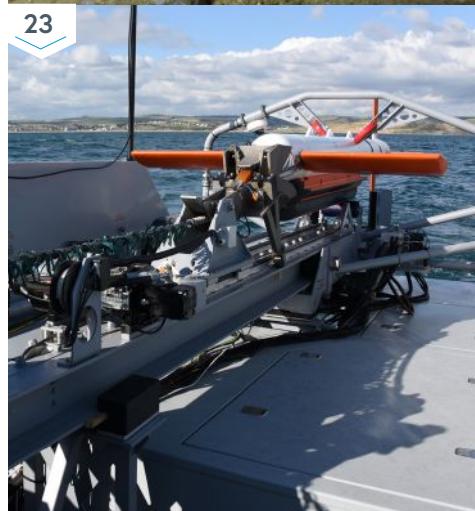
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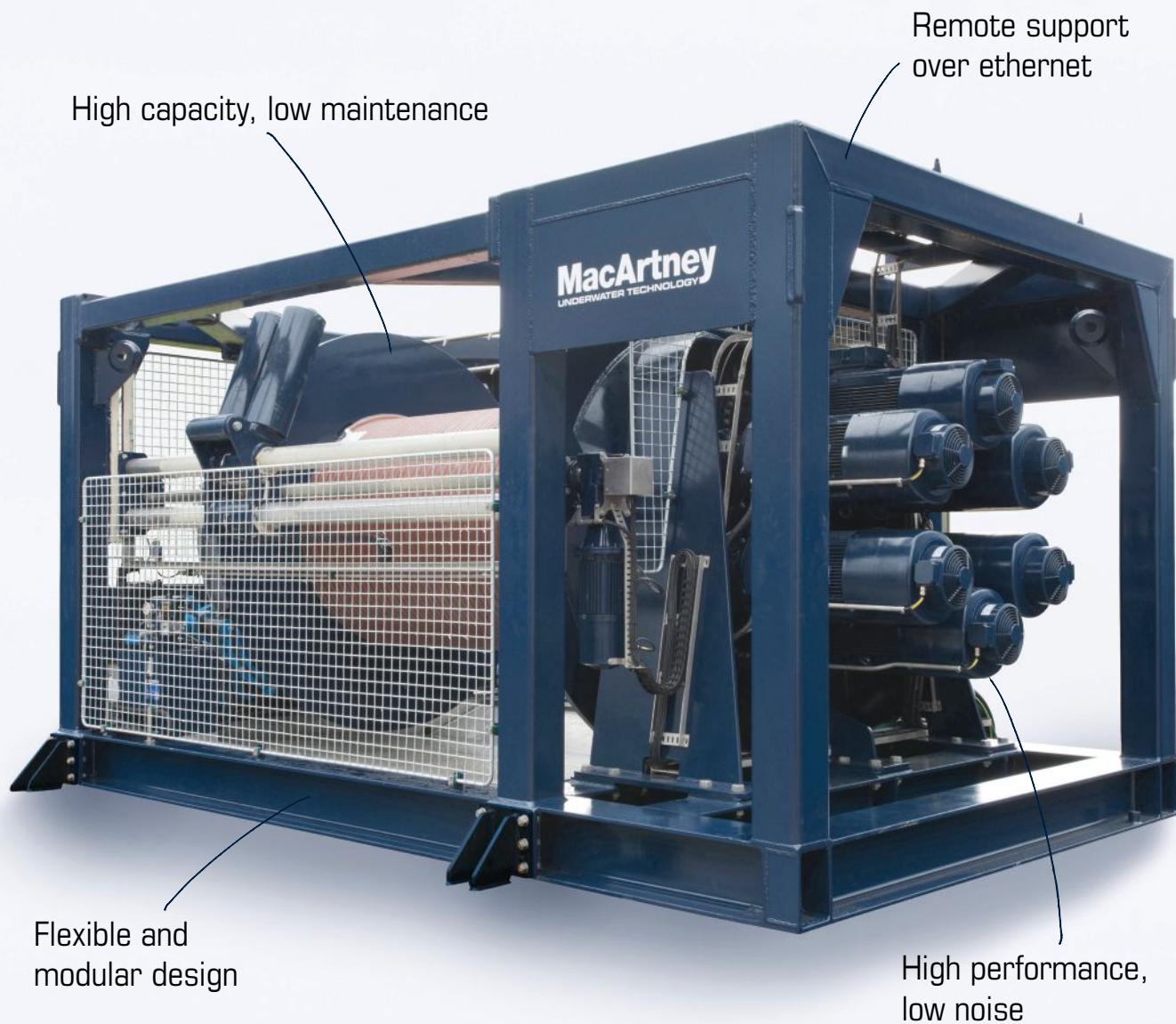
### ON THE COVER:

EVE is one of a new generation of 5-meter AutoNaut USVs. Read more about her on page 34.



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LISA CHILIK  
Tel: 574-261-4215  
Lchilik@tscpublishing.com

MIMI KING  
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## EVOLVING, ADVANCING, AND ADAPTING: THE FUTURE OF THE UNMANNED SUBMERSIBLE VEHICLE MARKET

**TODD NEWELL,**  
VP Technology, Oceaneering

The unmanned submersible vehicle market has emerged from a period of contraction – fewer days on hire, ultra-competitive pricing strategies, and an overall downturn – and found itself right-sized and primed for the next industry challenges. The market has accomplished this feat by focusing its energy on providing the trusted services customers need while simultaneously investing in advanced submersible vehicle technologies.

The step-change in technology, even in recent years, has been significant. While the traditional work class ROV is and will remain the industry workhorse, newer, innovative submersible vehicle technologies should find a niche in a challenging market. Customers are increasingly focused on submersible vehicles and subsea robots that enable them to optimize CAPEX and OPEX spending without compromising the functionality they need to complete operations.

These factors have driven service providers to push the boundaries of technology advancement and effectively change the paradigm in sub-sea robotics. The industry is experiencing palpable excitement as autonomy, true sub-sea residency, advanced battery technology, and real-time data transfer move from aspirational to attainable. Advancements in communica-

tion coverage, the ability to work in water depths up to 6000m, subsea robots that operate tether-free, and the ability for the robots to operate for long durations without requiring maintenance are supporting companies as they challenge the norm and help the market evolve. Hydrodynamic, energy-efficient subsea robots equipped with the latest in control systems, sensors, and capable tooling introduce new possibilities for the completion of light intervention tasks.

How soon will these advancements be embraced by operators? Questions of system reliability and a desire for field-proven solutions are understandably commonplace. Being the first to adopt a new technology can be a significant leap of faith, but can also reap great rewards. When considering inspection, maintenance and repair (IMR) campaigns, for example, where around 40% of submersible vehicles are deployed, resident robotic systems can eliminate the need for a support vessel. Removing the vessel from the equation results in lower costs, reduced risk, and a decreased carbon footprint. The potential to change the landscape of the industry is enormous.

The market is primed for growth, even in a slightly depressed environment where pricing remains a challenge. Innovation and willingness

to push the boundaries by building on proven technologies will continue to fuel the race to ensure customers are equipped with the submersible vehicle technology that will ensure operations remain cost-effective, safe, and suitable for a low carbon future.

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Alvin is part of the Woods Hole  
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# QUIESCENT IMAGING FOR DEEP-SEA SCIENCE: ADVANCES IN TECHNOLOGY AND PRODUCTIVITY

By Daniel J. Fornari – Woods Hole Oceanographic Institution

Aaron Steiner – DeepSea Power & Light (DSPL)

Stacey Church – DeepSea Power & Light (DSPL)

Eli Perrone – EP Oceanographic, LLC & Ocean Imaging Systems

Special thanks to the Woods Hole Oceanographic Institution and the DSPL team for their contributions to this article, as well as to the National Science Foundation's Division of Ocean Sciences for their support.

Since its emergence in the 19<sup>th</sup> century, underwater imaging has been responsible for many of the discoveries and advancements in the oceanographic sciences. With over 80% of the ocean undiscovered according to the National Oceanic and Atmospheric Administration (NOAA),<sup>1</sup> the need for high quality underwater imaging remains true today. Mapping the seafloor, studying the geochemical processes taking place in the ocean, observing marine life, and the myriad of other research initiatives related to understanding the world's oceans all benefit from high-resolution, data-rich images. Photographic and direct observations of the ocean floor are intimately tied to understanding the dynamic and interactive physical, chemical and biological processes occurring there.

## HISTORY AND TECHNOLOGICAL DEVELOPMENTS

Subsea imaging can be traced to the earliest days of underwater photography when French inventor Ernest Bazin took photographs from a diving bell in the 1860s. Nearly a century later, Harold Edgerton, an engineering professor at MIT, developed the deep-sea strobe light, providing the "sunlight" required to take photographs of the deep ocean and seafloor for the first time. That development, coupled with the engineering efforts at the Lamont Geological Observatory of Columbia University and the Woods Hole Oceanographic Institution (WHOI), led to the first generation of modern deep-sea cameras<sup>2</sup>. These systems were simple by



» Maurice 'Doc' Ewing (top left) and Allyn Vine (top right) on the original RV Atlantis holding one of the first deep-sea 35 mm cameras developed in the late 1950s. (Bottom) David Owen deploying a deep-sea camera from the RV Vema in the late 1950s.<sup>3</sup>

today's standards, but they provided key photographic evidence of animals and seafloor features over small areas in the deep ocean.

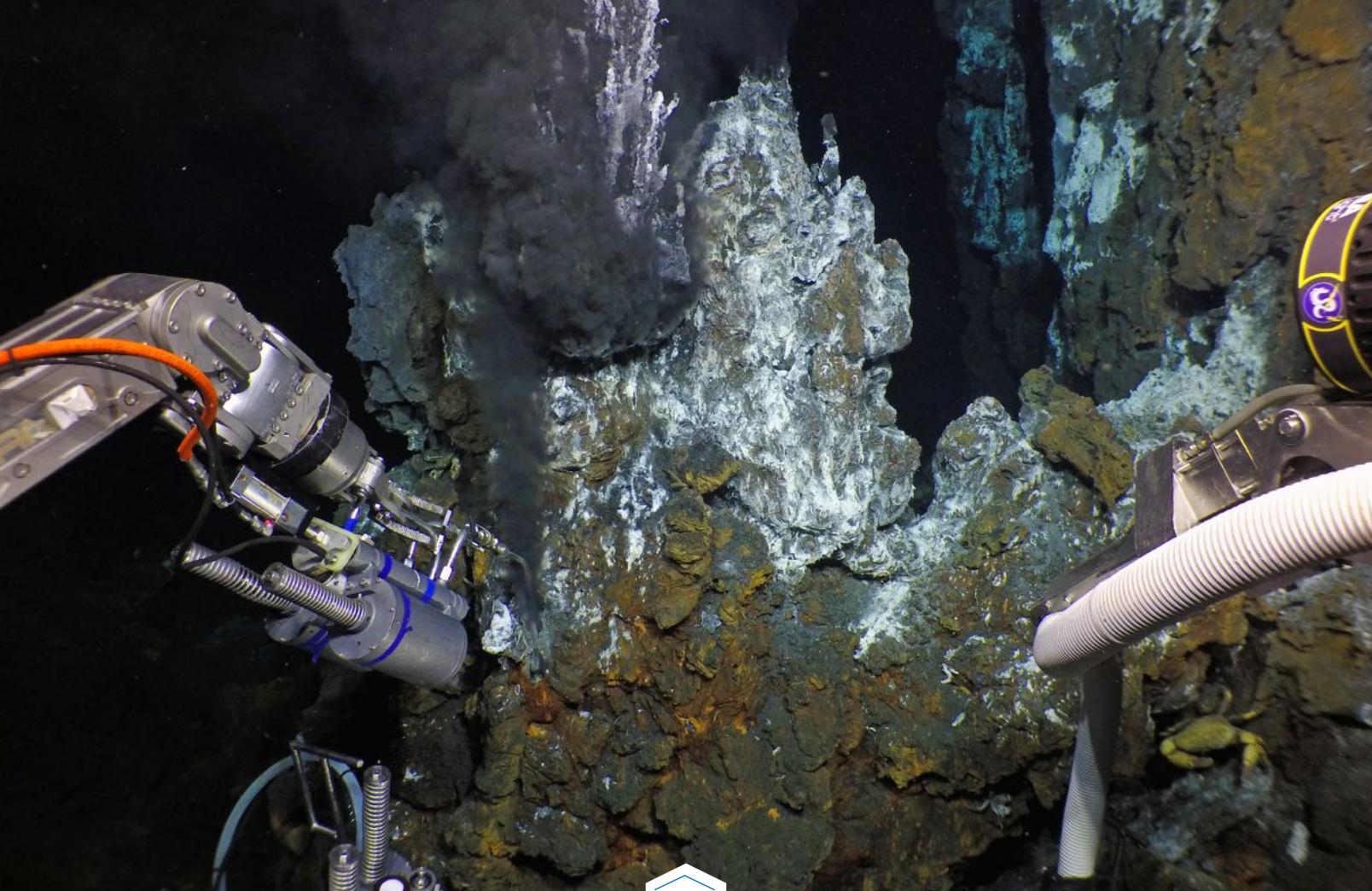
Subsea imaging capability leapt forward with the advent of digital imaging. Today, the ability to digitally image a large area

and merge the constituent images together in a photomosaic provides a powerful tool for mapping and understanding the geological relationships between features of various dimensions – from centimeter scale to tens or hundreds of meters in size. Biological features on the seafloor, and the distribution of biota in different environments, also lend themselves to precision study using digital images and mosaics. Revisiting various deep-sea study areas is now common, and has been an important research theme within the US Ridge2000 Program.<sup>4</sup>

## SUBSEA IMAGING AT WOODS HOLE OCEANOGRAPHIC INSTITUTION

High-resolution subsea imaging is at the core of the research performed at the Multidisciplinary Instrumentation in Support of Oceanography (MISO) Facility at the Woods Hole Oceanographic Institution (WHOI). MISO was developed with National Science Foundation – Ocean Sciences (OCE) Division funding to support US investigators requiring deep-sea digital imaging and sampling capabilities for seafloor experiments and surveys. MISO imaging systems have been used for a diverse suite of geological, biological, and biogeochemical investigations ranging from deep-sea coral studies; benthic biology traverses; hydrothermal vent research; and mid-ocean ridge and seamount volcanism, among others.

The WHOI-MISO Towed Digital Camera System (TowCam)<sup>5</sup> and related deep-sea imaging resources provide 6,000 m depth-



» Image captured by a MISO-OIS GoPro 12MP camera of the HOV Alvin sampling ~360°C hydrothermal fluids from the Bio9 vent at the East Pacific Rise axis at 2,510 m depth. Rapid, 5 sec. interval, quiescent imaging documented seafloor features, context and operations without requiring any resources from either the pilot or the two observers. The science objectives required intense manipulative tasks to sample biota, fluids and microbiology from the vent chimneys as well as to coordinate imaging with the DSPL 4K Apex camera mounted on the starboard manipulator forearm. Images such as this one have been acquired routinely on Alvin over the past ~3 years to assist in image acquisition for both science and operations, and to improve the quality of imaging capabilities.<sup>5</sup>

rated equipment for oceanographic research in a range of seafloor environments, from mid-ocean ridges to continental shelves. Since completion of their construction in mid-2002, the WHOI TowCam systems and the imaging capabilities within MISO have been used successfully on more than 60 research cruises. The current MISO camera and TowCam systems have recorded more than 1 million deep-sea photographs since being placed in service. MISO deep-sea camera capabilities have also played an important role over the years in advancing imaging systems on WHOI's research submersible *Alvin* and ROV *Jason*, which are part of the National Deep Submergence Facility (NDSF) operated by WHOI for the US University-National Oceanographic Laboratory System (UNOLS).<sup>7</sup>

### A Brief History of Imaging with TowCam

The original camera used for the MISO TowCam was developed by DeepSea Power & Light (DSPL) in the early 2000s using an original water corrected dome design by Mark Olsson at DSPL and a digital camera module based on the Nikon 995 series. The DSPL Digi SeaCam camera, rated for operations to 6000 m, was used for nearly a decade. The current camera used for TowCam imaging was developed by the late W. "Bill" McElroy of Ocean Imaging Systems (OIS). Since its original 12MP capability, it has been upgraded to 24MP using a Nikon D3300 35 mm DSLR and 20 mm Nikkor lens coupled with water-corrected dome optics, providing resolution from ~1 m to infinity. The MISO Facility currently operates five, 6,000 m rated OIS 24MP digital still cameras.

### QUIESCENT IMAGING

In recent years, quiescent, fixed-focus imaging has emerged as an important complement to other user-controlled imaging systems. With quiescent imaging, the camera is set up to record video and/or capture stills at regular time intervals, requiring no further user input. Within WHOI-MISO, there is an identified need for high-resolution, high-capacity quiescent cameras for automated image acquisition on deep submergence vehicles. In collaboration with Ocean Imaging Systems (OIS), WHOI integrated a 5.4 mm non-distortion lens into a GoPro Hero4 camera with internal power. Used with DSPL Digi SeaCam and Super SeaCam housings and water-corrected dome optics, this design is the basis for a family of self-contained quiescent cameras to meet WHOI's research requirements.



» Photomosaic of a volcanic, constructional fault scarp at 2,350 m depth at Loki Castle hydrothermal vent field acquired in quiescent mode. Images were taken using the MISO-OIS 12MP deep-sea digital still camera mounted on the Ægir6000 ROV.<sup>8</sup>

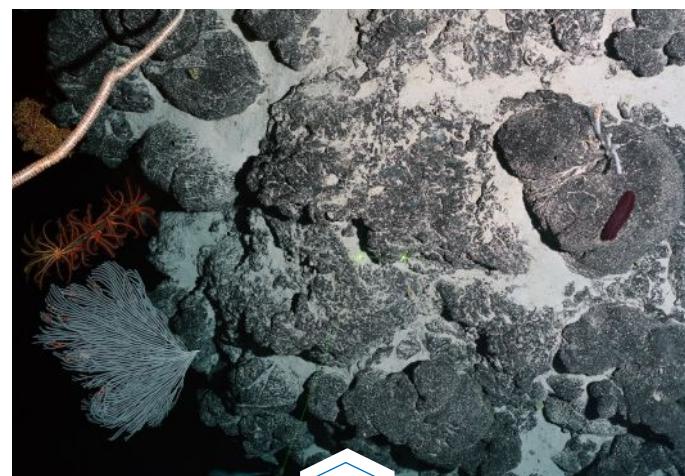
The time and attention of the human occupants in a submersible is a critical resource when conducting subsea operations. Tools that can operate with little or no input significantly leverage the mission time, especially when they can be put to uses that improve the quality and context of data acquired through other operations. This is how the MISO-OIS GoPro camera is routinely put to use on HOV *Alvin*. Mounted above the pilot's window, this camera sees and captures wide angle, full 12MP still images at intervals customized to the mission profile and provides a complete record of the dive operations, capturing images of geological and biological samples in the environment they were collected from. The camera also records how these samples were collected, so any follow-up on methods or approach can be addressed directly. Since the camera is separate from *Alvin*'s onboard systems there is nothing for the occupants to attend to. This frees them to completely focus on the intense job of piloting the submersible while conducting sampling, imaging, and other manipulator tasks.

Post-processed imaging data collected in 2018 with the MISO OIS GoPro camera system in collaboration with the University of Bergen on the Ægir6000 ROV shows the potential of this technology for documenting subsea features. In the image above, a series of 263 images were combined to produce a mosaic of a scarp feature about 100 meters long at the Loki Castle hydrothermal vent field in the Norwegian Arctic. A low-speed auto-position transverse operation was used during the data collection, allowing both the ROV positioning and imaging to take place semi-autonomously.

Another initiative that took advantage of quiescent imaging capabilities was the OASIS Expedition AT37-05 cruise on the R/V *Atlantis*. During this expedition, researchers gathered high-resolution mapping and imaging along the 8° 20'N Seamount Chain to better understand magma distribution and melting processes in the mantle on the flanks of a fast-spreading mid-ocean ridge. The 24MP OIS camera mounted on HOV *Alvin* provided high-resolution

imaging at 10-second intervals; this was an important mapping component that allowed investigators to quantitatively determine bottom type and faunal distribution along transects up the flanks of individual seamounts at various distances (up to ~200 km) from the East Pacific Rise axis.

More recently, in 2019, The Five Deeps Expedition deployed three landers to accompany the 11,000 m rated submersible, *Limiting Factor*, on a record-breaking series of dives to the deepest parts of the world's oceans. The landers primarily serve as sample return boxes and acoustic waypoints to aid *Limiting Factor* in navigating the water column and seafloor. Additionally, they have been outfitted with water sampling and coring equipment and a quiescent imaging system using the IP Multi SeaCam and LED-



» Sediment-covered pillow lavas on a volcanic seamount west of the East Pacific Rise axis along the 8° 20'N Seamount Chain taken on the OASIS Expedition. The pillows are heavily encrusted with Mn-coating and host abundant deep-sea fauna such as corals, sea fans, gorgonians, crinoids, holothurians, and sponges. The distance across the bottom of the image is ~4 m.<sup>9</sup>

SeaLites from DSPL. With the onboard recording capability of the IP Multi SeaCam, the Five Deeps team has been able to extend the range of science activities, providing additional seafloor context on biodiversity, geology, and hydrologic conditions without burdening primary submersible operations. Discoveries of potential new species were announced just weeks after being observed.

Subsea imaging has been intimately tied to our understanding of the world's oceans since its beginnings. Today, along with the use of sophisticated vehicles and acoustic and chemical sensors, scientists use underwater imaging systems to expand our knowledge of the dynamic processes happening far below the water's surface. Quiescent imaging systems, like those developed at WHOI and that take advantage of DSPL optical design and housing technology, free up time for scientists to observe and perform experiments while high-resolution images are captured. As more complex tasks are performed at extreme depths, quiescent imaging represents an important future component of hadal research.

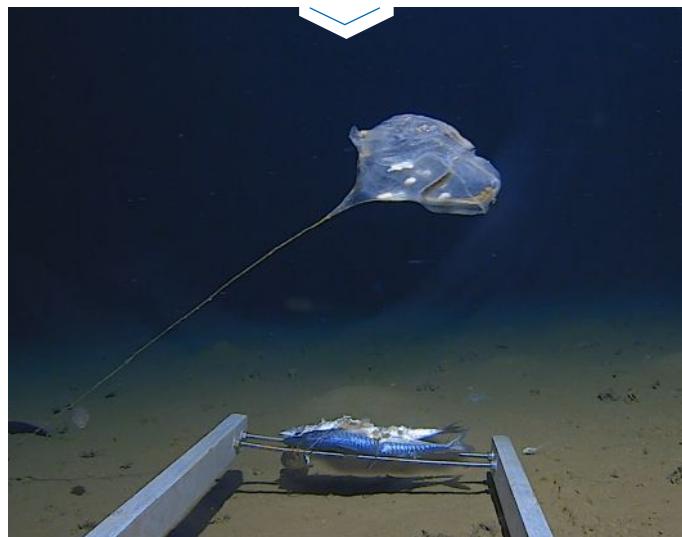
It remains to be seen what further technological advancements will be made in subsea imaging, but one thing is certain: it will continue to play a key role in revealing the wonders of the abyss.

To watch 4k video clips that were acquired with both quiescent MISO GoPro and DSPL 4k systems on HOV Alvin, go to this link or scan the QR code.

[media.dspl.com/quiescent-imaging-1](http://media.dspl.com/quiescent-imaging-1)



» A Primnoid sea fan hosting a collection of purple anemones and yellow-brown branching hydroids and sponges. Image was taken with a MISO-OIS GoPro camera from the HOV Nadir operating from the MV Alucia in the Galápagos between Santa Cruz and Santiago Islands in 2015. This expedition was a collaboration between WHOI and Boise State University to perform geological and geochemical studies of the Galápagos Platform. The MISO-OIS camera augmented the research activities by capturing 10-second interval images throughout the HOV operations, documenting sampling sites and giving investigators a detailed baseline on the faunal diversity of this section of the Galápagos Marine Protected Area.<sup>11</sup>



» A potential new species of stalked sea-squirt observed by one of the IP Multi SeaCam quiescent HD imaging cameras on the science landers built for the Five Deeps Expedition. This specimen was observed below 6,500 m in the Java Trench during the successful attempt to dive the deepest point in the Indian Ocean. Dr. Alan Jamieson, chief scientist for the expedition, said "amongst many other rare and unique observations, the stalked Ascidean was a really significant moment. It is not often we see something that is so extraordinary that it leaves us speechless. At this point we are not entirely sure what species it was, but we will find out in due course."<sup>10</sup>

<sup>1</sup> "How much of the ocean have we explored?" National Ocean Service. National Oceanic and Atmospheric Administration. Accessed July 22 2019.

<sup>2</sup> Ewing *et al.*, 1946; Hersey (ed.), 1967  
Hersey, J. B. (ed.) 1967. *Deep-Sea Photography*, Baltimore: The Johns Hopkins University Press.

Ewing, M. A., Vine, A. C. and Worzel, J. L. (1946). Photography of the Ocean Bottom. *Journal of the Optical Society of America*, 36, 307.

<sup>3</sup> Photo credit: Woods Hole Oceanographic Institution Photo Archives.  
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<sup>4</sup> E.g., Fornari *et al.*, 2012.  
Fornari, D.J., S. Beaulieu, J. Holden, L. Mullineaux, M. Tolstoy, (2012) Introduction to Special Issue - From RIDGE to Ridge2000", *Journal of The Oceanography Society*, p. 12, vol. 25-1, <http://dx.doi.org/10.5670/oceanog.2012.01>

<sup>5</sup> Photo Credit: Courtesy of D. Fornari, WHOI/NSF/HOV Alvin 2018, ©Woods Hole Oceanographic Institution.

<sup>6</sup> Fornari, 2003.  
Fornari, D.J., (2003) A New Deep-sea Towed Digital Camera and Multi-rock Coring System, *Eos, Trans. Am. Geophys. Union*, 84, 69 & 73.

<sup>7</sup> [www.unols.org/](http://www.unols.org/).

<sup>8</sup> Photo Credit: T. Barreyre and R. Pedersen - K.G. Jebsen Centre for Deep Sea Research, Department of Earth Science, University of Bergen. ©K.G. Jebsen Centre for Deep Sea Research, Department of Earth Science, University of Bergen.

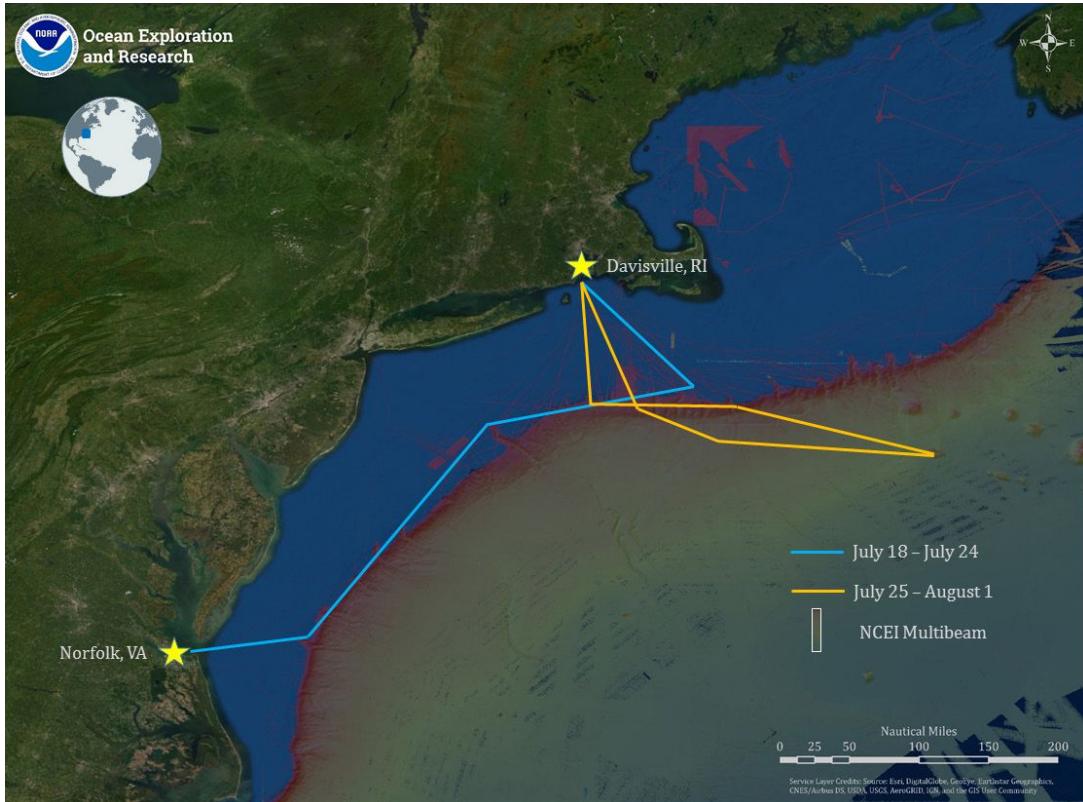
<sup>9</sup> Photo Credit: Courtesy of P. Gregg, Univ. of Illinois, D. Fornari, WHOI, and M. Perfit, Univ. of Florida, AT37-05 cruise on R/V Atlantis, NSF/WHOI-NSDF/WHOI-MISO, R/V Atlantis Officers and Crew, HOV Alvin Operations Group. ©Woods Hole Oceanographic Institution.

<sup>10</sup> Photo Credit: Five Deeps Expedition, ©Atlantic Productions Limited.

<sup>11</sup> Photo Credit: WHOI-MISO, Dalio Foundation – Dalio Explore Fund, MV Alucia officers and crew, HOV Nadir pilots, Galápagos National Park, Charles Darwin Research Foundation, INOCAR – Oceanographic Institute of the Ecuadorian Navy, © Woods Hole Oceanographic Institution.

# NOAA SHIP *OKEANOS EXPLORER*

## DEMONSTRATES MAPPING AND ROV TECH



» Map showing the approximate route of NOAA Ship Okeanos Explorer during the two legs of the 2019 Technology Demonstration and current, publicly available multibeam bathymetry data. Image courtesy of the NOAA Office of Ocean Exploration and Research, 2019 Technology Demonstration.

From July 18 to August 1, 2019, NOAA and partners conducted a telepresence-enabled expedition on NOAA Ship *Okeanos Explorer* to demonstrate, test, and evaluate five emerging and existing technologies for possible integration into NOAA operations. New technologies and novel integrations such as those tested during this mission will aid and accelerate the fulfillment of the NOAA Office of Ocean Exploration and Research (OER) objective to map and characterize the U.S. Exclusive Economic Zone by 2030. 2019 Technology Demonstration operations also included mapping and remotely operated vehicle (ROV) dives. The expedition, which took

place off the U.S. East Coast, from Virginia to Rhode Island, was broken into two legs.

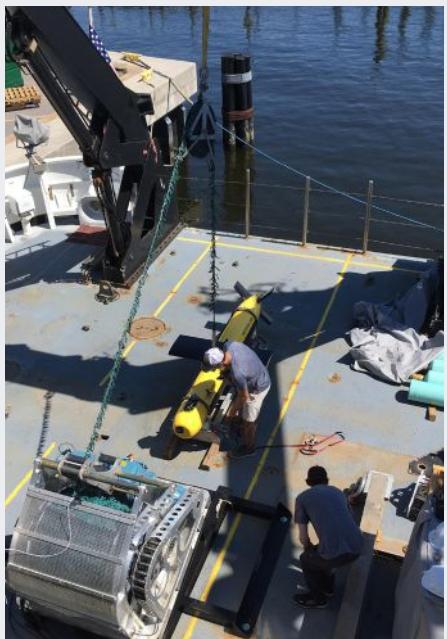
### LEG 1: JULY 18 - JULY 24

Leg 1 operations included the deployment of a REMUS 600 Autonomous Underwater Vehicle (AUV) in partnership with the NOAA Office of Coast Survey (OCS) and a towed Kraken Robotics KATFISH™ with Synthetic Aperture Sonar in partnership with Kraken Robotics and ThayerMahan, Inc. Targets for testing these systems focused on the U.S. northeast continental shelf and included areas with limited bathymetric coverage, Underwater Cultural Heritage sites (UCH), and sites identified in the 2013 NOAA

report, "Risk Assessment for Potentially Polluting Wrecks in U.S. Waters." These systems were deployed in concert with the *Okeanos Explorer*'s suite of deepwater mapping systems.

### LEG 2: JULY 25 - AUGUST 1

During Leg 2, the team tested the integration of three technologies with OER's ROV *Deep Discoverer*. These technologies include a 360-degree camera being developed at the Massachusetts Institute of Technology, a One-Way Travel-Time Inverted Ultra-Short Baseline navigation system from the Woods Hole Oceanographic Institution, and a Kraken



» Operations personnel from ThayerMahan, Inc. and Kraken Robotics integrating the KATFISH™ on the back deck of the Okeanos Explorer. Image courtesy of the NOAA Office of Ocean Exploration and Research, 2019 Technology Demonstration.

Robotics SeaVision® laser scanner. ROV dives targeted deepwater coral and sponge communities and a UCH target that is potentially the USS Baldwin, a U.S. Navy destroyer active during World War II that was intentionally scuttled on June 6, 1961. ROV dives took place off the coasts of New York, Rhode Island, and Massachusetts.

#### OBJECTIVES

The primary objectives of this demonstration were to test, integrate, and evaluate emerging and existing technologies for potential use in meeting the data requirements of OER, its partners, and the larger oceanographic research community. The secondary objective of this



» NOAA Ship Okeanos Explorer in port in Norfolk, Virginia, following the completion of the Windows to the Deep 2019 expedition. Image courtesy of the NOAA Office of Ocean Exploration and Research, Windows to the Deep 2019.

demonstration was to provide authoritative and actionable data to regional stakeholders. Finally, this demonstration contributed to NOAA's Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE) campaign. ASPIRE is a collaborative, multinational field campaign that provides publicly accessible baseline data to increase our understanding of the North Atlantic Ocean and data critical to emerging blue economy priorities, characterization, and management.

#### ONBOARD TEAM

The team onboard the Okeanos Explorer included personnel from ThayerMahan, Inc., Kraken Robotics, the Massachusetts Institute of Technology, Woods Hole Oceanographic Institution, the NOAA Office of Coast Survey, the University of New Hampshire/Center for Coastal and Ocean Mapping, the University of Rhode Island, the NOAA Office of Marine and Aviation Operations Unmanned Aircraft Systems group, and NOAA's National Centers for Environmental Information. Engineers from the Global Foundation for Ocean Exploration will facilitate data management, ROV integration and operations, and ship-to-shore communications. The expedition will be led onboard by the NOAA Office of Ocean Exploration and Research.

#### TECHNOLOGIES DEMONSTRATED

The five instruments described below were tested on the Okeanos Explorer during the 2019 Technology Demonstration. These were selected given their potential to contribute to OER's mapping and characterization goals while building a greater overall scientific understanding of our deep ocean.

#### KRAKEN ACTIVE TOWFISH (KATFISH™) WITH SYNTHETIC APERTURE SONAR

In 2018, OER and Kraken Underwater Systems began a partnership to jointly advance ocean exploration imaging technology. In the spirit of this collaboration, the 2019 Technology Demonstration served as an opportunity to test the Kraken towed KATFISH™ with Synthetic Aperture Sonar (SAS) on the Okeanos Explorer. KATFISH™ operates at shallower depths (less than 300 meters/984 feet) than current instruments on the Okeanos Explorer, giving it the potential to fill a gap in depth

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 ThayerMahan

 NOAA  
Ocean Exploration  
and Research

 KRAKEN

» Synthetic aperture sonar data collected over a shipwreck site offshore of Virginia/North Carolina using the towed KATFISH™ equipped with a 180-centimeter AquaPix® MINSAS synthetic aperture sonar sensor. Image courtesy of ThayerMahan, Inc., Kraken Robotics, and the NOAA Office of Ocean Exploration and Research.

data identified by OER and partners. The KATFISH™ system is comprised of an actively controlled smart towfish, SAS imaging, bathymetry and gap-filler sonars, launch and recovery system, operator console, and visualization software. The system collects 3D bathymetry and ultra-high-resolution seabed imagery, providing detailed images of the seafloor and objects on it with 30 times more detail than a conventional side scan sonar.

#### KRAKEN SEAVISION® SYSTEM

One objective of the NOAA-Kraken partnership was to test the SeaVision® laser line scanning system at deep-ocean depths. The SeaVision® laser scanner uses a line of laser light to generate high-resolution, 3D representations of objects on the seafloor, including biological and archaeological targets. Unlike traditional black and white scans, SeaVision® brings subsea laser imaging into vivid, full color. Practical applications include precise measurements of benthic organisms in order to accurately estimate the age and growth rates of these organisms and highly accurate measurements of percentage of benthic cover, one of the most frequently reported metrics in marine ecological studies.

Karl Kenny, Kraken's President and CEO said, "We were delighted to participate in the 2019 Technology Demonstrator with NOAA and ThayerMahan to showcase our KATFISH and SeaVision® products. While

its roots are in military applications, such as minehunting, our KATFISH system is generating significant commercial sector interest, particularly for ultra-high definition seabed mapping and imaging. SeaVision® is the world's first ultra-high resolution RGB underwater laser imaging system that delivers full color 3D point cloud images of subsea infrastructure with millimeter accuracy in real-time. SeaVision® enables the existing conditions of underwater assets to be captured as millions of data points, which can then be imported into 3D modeling software for creating realistic, to-scale images of the subsea asset. The level of detail provides more useful information for easy visualization and advanced analysis."

#### REMUS 600 AUTONOMOUS UNDERWATER VEHICLE

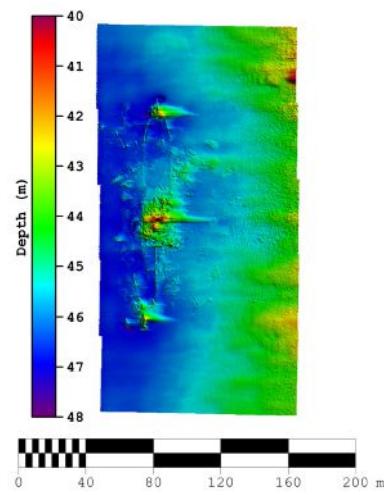
Autonomous underwater vehicles (AUVs) will become increasingly integral to achieving OER mapping and characterization goals, acting as a force multiplier during mapping and ROV operations, particularly given the ability for multiple units to work in concert. OER will work with OCS to test operations on the OCS-owned REMUS 600 AUV, which is equipped with an EM 3002 multibeam sonar system that allows for high-resolution mapping. The testing of this commercial AUV will allow OER and partners to better understand the launch and recovery process, the acquisition and processing

of AUV data, staffing and storage needs, as well as how AUV operations might fit into current Okeanos Explorer mapping and ROV exploration.

#### MIT'S 360-DEGREE CAMERA

The Massachusetts Institute of Technology has developed a 360-degree camera that was mounted on ROV Deep Discoverer and collected footage during Leg 2 2019 Technology Demonstration dives. The camera is named Maka'oi, which means 'sharp-eyed' in the Hawaiian language.

The system is comprised of six compact 4K studio cameras housed within a spherical aluminum/titanium unit. The housing is currently rated to a depth of 4,000 meters (13,123 feet), but is designed to tolerate up to 4,500 meters (14,764 feet) with a wide safety margin. The camera operator was able to view footage in real time and adjust each camera individually or in groups. The proximate goal was the creation of studio-caliber 360-degree video from the deep for virtual reality, augmented reality, documentary, and planetarium release. More experimentally, the ultimate goal was on-ship stitching of the video, giving the operator a real-time, live, 360-degree view from the ROV.



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and Research    KRAKEN

» Bathymetric image of the shipwreck, developed from data collected using the KATFISH™ system on the Okeanos Explorer on July 18, 2019. Scale is water depth in meters. Image courtesy of ThayerMahan, Inc., Kraken Robotics, and the NOAA Office of Ocean Exploration and Research.

## ONE-WAY TRAVEL-TIME INVERTED ULTRA-SHORT BASELINE NAVIGATION SYSTEM

This navigation system is in development at the Woods Hole Oceanographic Institution to support multi-AUV navigation capability. This work leverages a National Science Foundation grant and builds upon a project supported through OER's Federally



» The REMUS 600 AUV staged on the Okeanos Explorer's CTD deck while the ship was docked at NOAA Marine Operations Center - Atlantic in Norfolk. Image courtesy of the NOAA Office of Ocean Exploration and Research, 2019 Technology Demonstration.

Funded Opportunity. The aim is to develop a low-power acoustic navigation system for application with an array of autonomous vehicles. The system provides a single acoustic source that can be used for the navigation of multiple subsea vehicles, with no time or frequency sharing required. Three separate dives at a variety of depths will be conducted to test this technology, which will be mounted on ROV Deep Discoverer.

## WHY IT MATTERS

The 2019 Technology Demonstration enables OER and partners to develop additional methods of exploration, refine and improve existing operations, and evaluate how new data types can improve baseline observations and seafloor characterization. By leading national efforts to explore our ocean, and by making ocean exploration more accessible, OER is filling gaps in the basic understanding of U.S. deep waters and seafloor and providing critical deep-ocean data needed to sustain and accelerate the economy, health, and security of our nation. Using the latest tools and technologies, such as those demonstrated on this expedition, OER explores previously unknown areas of our deep ocean to make valuable scientific, economic, and cultural discoveries.

The logo for Shark Marine Technologies Inc. features a stylized yellow shark head facing left, with the word "SHARK" written in a bold, yellow, outlined font above it. Below the shark head, the company name "SHARK MARINE TECHNOLOGIES INC." is written in a smaller, yellow, sans-serif font.

# BARRACUDA

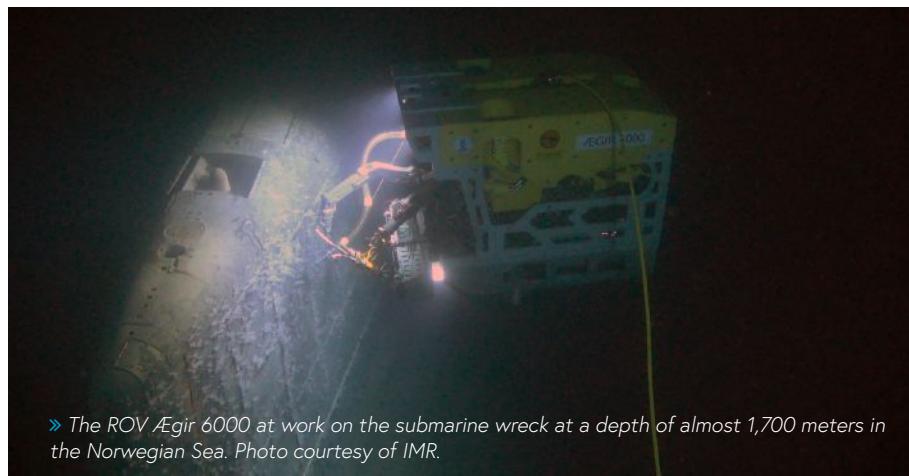
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  - Station Keeping.
  - Auto Depth / Altitude.
- Integrated Total Navigation System (TNS) Including GPS, DNS,(LBL also available).
- Able to run off of a wide range of power supplies.
- Easy to Deploy, High Thrust.

A photograph of the BARRACUDA ROV, a compact, yellow and black underwater vehicle. It has a central yellow hull with black structural elements and a black thruster at the rear. A large black manipulator arm extends from the side. The word "BARRACUDA" is printed in yellow on the side of the hull. The background shows blue ocean water.

Shark Marine Technologies Inc. [www.sharkmarine.com](http://www.sharkmarine.com) sales@sharkmarine.com Ph: (905) 687 6672



## ROV MEASURES RADIOACTIVE LEAK FROM WRECK OF SOVIET SUB

Researchers from Norway's Institute of Marine Research have documented a leak from the wreck of the Soviet nuclear submarine, using an ROV. Several samples taken in and around a ventilation duct on the wreck of the submarine contained far higher levels of radioactive cesium than you would normally find in the Norwegian Sea. The highest level measured in a sample was 800,000 times higher than normal. However, other samples from the same duct did not contain elevated values.

"We took water samples from inside this particular duct because the Russians had documented leaks here both in the 1990s and more recently in 2007. So we weren't surprised to find high levels here," said Hilde Elise Heldal, the expedition's leader.

The levels the researchers found in the sample were around 100 Bq per liter, as opposed to around 0.001 Bq per liter elsewhere in the Norwegian Sea.

### Above Normal, But Not Alarmingly High

Although that sounds like a lot, Heldal emphasizes that the levels aren't dangerously high. She puts them into perspective by citing the permitted limit for radioactive cesium in food products:

"After the Chernobyl accident in 1986, Norwegian authorities set this limit to 600 Bq/kg", says Heldal. "The levels we

detected were clearly above what is normal in the oceans, but they weren't alarmingly high," explains the expedition leader.

"Over the past few days we have also taken samples a few meters above the duct. We didn't find any measurable levels of radioactive cesium there, unlike in the duct itself", says Justin Gwynn, a researcher at the Norwegian Radiation and Nuclear Safety Authority (DSA).

### Interesting "Cloud" May Show Site Of Leak

Just before taking the first sample that gave a high reading, researchers noticed a kind of "cloud" rising up from the duct. A "cloud" was also seen rising from a grille nearby, where the researchers again measured high levels. The big question is whether this "cloud" may be related to the radioactivity the researchers observed inside the duct.

"It looks very dramatic on video, and it's definitely interesting, but we don't really know what we're seeing and why this phenomenon occurs. It's something we want to find out more about," says Justin Gwynn of the DSA.

### Located Submarine At The First Attempt

The research vessel G.O. Sars reached the area where the wreck was thought to be on the evening of 7 July 2019 and

the researchers were quite excited to see how quickly the ROV Ægir 6000 found Komsomolets. In fact, the ROV managed to locate the wreck on its first dive. Through the ROV's cameras, scientists were able to observe the state of the wreck with their own eyes, in real time. The ROV Ægir 6000 was designed by Kystdesign AS.

### A Thorough Investigation

The Institute of Marine Research (IMR) and DSA have performed joint annual surveys of the wreck since the 1990s. Each year they have taken seawater and sediment samples, but without being able to "see" the wreck. Their most recent pictures of it had been taken by a Russian expedition twelve years ago. This year's survey is the most thorough investigation of Komsomolets ever performed by Norwegian scientists.

"We have been wanting to do a survey with an ROV for a number of years. Ægir 6000 allows us to see exactly where we are taking samples around the wreck, and equally importantly we've been able to use its cameras to zoom in and study the whole nuclear submarine section by section," says Heldal.

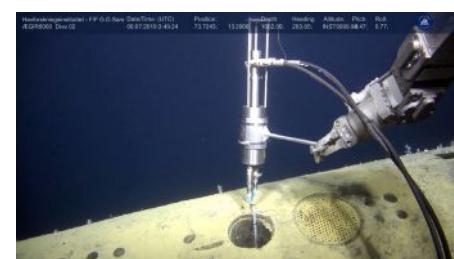
### Samples Of Seawater, Sediment And Organisms

The researchers have taken samples of seawater, sediments and organisms that have set up home on the wreck itself. The freezers and refrigerators on G.O. Sars are now full of samples that will be further analyzed later.

"We will study the samples even more thoroughly when we get home," says Heldal.

### Minimal Impact On Fish And Seafood

"What we have found during our survey has very little impact on Norwegian fish



» The ROV taking a water sample from the ventilation duct. Photo courtesy of IMR.

and seafood. In general, cesium levels in the Norwegian Sea are very low, and as the wreck is so deep, the pollution from Komsomolets is quickly diluted," explains Heldal.

The IMR has previously modelled what would happen if all of the radioactive cesium in the wreck were to leak out at once. The conclusion was that the impact on fish in the Barents Sea would be negligible, in part because there are not large fish stocks in the area where Komsomolets is located.



» The ROV surfaces, bearing water samples.  
Photo credit: Stine Hommedal/IMR.

"This is one of several cruises the Institute of Marine Research regularly undertakes to monitor the environmental state of the oceans - this time with the top-notch technological equipment in the form of the ROV Ægir 6000. We have comprehensive programs in place to monitor environmental status and marine resources in the North Atlantic. We can follow any changes and influences in everything from large ocean systems to the seafood being served on our dinner tables. It is reassuring that the findings from this cruise do not seem to represent any danger for Norwegian seafood," says Sissel Røgne, director at the Institute of Marine Research.

Both the IMR and DSA still believe that it is vital to continue monitoring the only known source of radioactive pollution in Norwegian waters.

"We need good documentation of pollution levels in seawater, seabed sediments and, of course, fish and seafood. So, we'll continue monitoring both Komsomolets

in particular and Norwegian waters in general," concludes Heldal.

Along with as scientists from the IMR and DSA, researchers from the Norwegian University of Life Sciences (NMBU)/Centre for Environmental Radioactivity (CERAD) and Research and Production Association Typhoon (RPA Typhoon) took part in the survey, which ended in Tromsø on Wednesday, 10 July.

- The Soviet nuclear submarine Komsomolets sunk southwest of Bjørnøya in the Norwegian Sea, 7 April 1989, after an onboard fire.
- 42 people lost their lives in the accident.
- The wreck sits at a depth of almost 1,700 meters.



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## BACK IN THE PATCH: THE OCEAN CLEANUP DEPLOYS AGAIN



» System 001/B has been deployed. Photo courtesy of The Ocean Cleanup.

The Ocean Cleanup aims to rid the world's oceans of plastic. Having fine-tuned its passive drifting technology, the team faces several milestones in 2020. If all goes according to plan, fleets of their plastic-devouring devices will soon turn pollution into products that fund future cleanup efforts. First, though, they need to prove it works.

### **Wilson - The "Beta Test" of 2018**

In September 2018, the Dutch non-profit organization launched its first ocean cleanup system test from the San Francisco Bay: System 001. Nicknamed Wilson, the U-shaped floating barrier was designed to be propelled by wind and waves, allowing it to passively catch and concentrate plastic debris by funneling it to the center of the system.

During this first rollout, the team learned a lot, both positive and, well, unscheduled.

### **Unscheduled Learning Opportunities**

"We were able to confirm many of the key assumptions behind the design," says The Ocean Cleanup's CEO, Boyan Slat. "What we saw was that the system was able to go into the U-shape, the system was able to orientate itself when the direction of the wind changed, the system was stable in waves, and we also saw that the system was able to catch and concentrate plastic . . . However, while we were offshore, we also saw two of what we euphemistically refer to as unscheduled learning opportunities. The first one was that yes, we saw that the system was catching plastic, but it was also able to lose the plastic again. This was because, basically the system wasn't moving fast enough yet, so occasionally, the system actually moved slower than the plastic, which caused the plastic to leave the system again. Secondly, what we saw was a fatigue factor of the main floater causing (an) 18-meter end section to disconnect from the rest of the system."

As a result, Wilson returned to port earlier than planned. While the malfunctions were a setback, Slat says, "It's important to note that both the 580-meter main section and the 18-meter end section are both completely stable; all bulkheads are intact, and the end section has two stabilizers affixed to it, so rollover is not possible. Also, because no material was lost, there have been no safety risks for the crew, environment or passing marine traffic."

However, since Wilson's sensors and satellite communication were compromised, the team came ashore and accepted the challenge to advance their proof of design.

### **The Need for Speed**

Following six months of onshore work, The Ocean Cleanup re-sent its upgraded passive drifting system to the Great Pacific Garbage Patch in late June 2019. The latest version, dubbed System 001/B, arrived in the patch after eight days of transit.

The quick turnaround speaks to the team's sense of urgency. Plastic has been accumulating in the Great Pacific Garbage Patch for over six decades, where it breaks down into smaller and smaller pieces. Eventually, these nano- and microparticles will become too small to collect. Therefore, the team prioritizes time efficiency.

*"The quicker we are there, the more we can learn, the faster we can learn, and the sooner we have a working system in the water," says Bart Bruggeman, Project Engineer for The Ocean Cleanup.*

## Design Lessons Learned

"We didn't just learn technical things during the last offshore campaign, but we also learned lessons when it comes to the process of innovation. And this led to two things that we're going to do differently this time," said Boyan Slat.

Those differences are shrinking the system and a modular design, and they impact everything from choosing a launch location to how long the testing will take.

## A Canadian Assembly Yard

While preparing for Wilson, the team had leased and built up a new assembly yard in Alameda, California. This time, because the revised system approximately one quarter the size of Wilson and more modular, they had more options.

After scouting for locations, the team found a former pulp factory in Campbell River, Vancouver Island, Canada that is adjacent to an inlet of water and located near the equipment required to assemble the system. The procurement process proceeded swiftly and once the materials arrived on-site in early June 2019, construction was completed in just five days; the welding of the high-density polyethylene (HDPE) floater lasted two days, after which System 001/B was ready for launch.



» Roll-out of the smaller device went smoothly. Photo courtesy of The Ocean Cleanup.

## Maersk Transports the System

System 001/B was connected to a Maersk Transporter, an anchor handling tug supply vessel, for transport. The partnership with The Ocean Cleanup is a continuation for Maersk Supply Service who also supported the 2018 effort.

System 001/B is 160 meters long rather than Wilson's 600 meters length. Once the team has a proven concept, they plan to increase the size of future systems, but this smaller version has some advantages. It allowed the team to speed up procurement, assembly, and transport of the system. Because they were not towing with the skirt attached to the system and had a smaller load, transit time to the Great Pacific Garbage Patch was approximately one week, considerably less than in 2018. Upon arrival, the crew deployed the system into the patch and arranged it in its operational configuration (U-shape).

## Testing

During the deployment of System 001/B, the team is trial testing modifications to speed the system up or slow it down, with the goal of a consistent speed that allows them to effectively capture and retain the plastic catch. The first tests will attempt to slow down using a parachute sea anchor as the main testing component. Should the slow-down prove ineffective, they will face the system in the other direction and speed it up using inflatable bags or fenders. The modifications will not necessarily be the final design – they are essen-



» The system was connected to a Maersk Transporter. Photo courtesy of The Ocean Cleanup.

tially a first phase of possible alterations. If either the slow-down or the speed-up option works, they will then pursue a more permanent solution.

The tests will be conducted over two months. The modular approach allows the team to reconfigure the system while offshore, significantly improving iteration cycle time and allowing for rapid adaption.

## Monitoring

AutoNaut Unmanned Surface Vessels (USVs) have been collecting vital environmental monitoring data in support of The Ocean Cleanup. See page 34 for a full description.

## Ambitious Plans for 2020

The Ocean Cleanup plans to launch System 002 in early 2020, followed by the scale-up to a fleet of 60 systems in the Great Pacific Garbage Patch. System 002 will be built on the lessons learned from System 001 (Wilson) and System 001B, with the additional focus of preparing the design for full-scale roll-out. After that, they aim to expand cleanup operations to the remaining four ocean garbage patches. By recycling the collected plastic into products, and partnering with sponsors, the team aims to make the cleanup fleet financially self-sustainable. Their objective is a zero-waste operation, with no debris ending up in a landfill. How soon they can reach this goal will depend a great deal on what happens this summer during the adaptive testing of System 001/B. For more information, visit <https://theoceancleanup.com>.



» Trial testing is being conducted this summer. Photo courtesy of The Ocean Cleanup.

# CHECK THE TECH:

## HIGH-TECH CRITTER GETTER: DEEP DISCOVERER'S NEW SUCTION SAMPLER

by Karl McLetchie, Global Foundation for Ocean Exploration,  
Ocean and Mechanical Engineer;  
and LTJG Christopher "J" Dunn, NOAA Office of Ocean  
Exploration and Research, Sample Data Manager

From May 30 through July 12, 2019, NOAA and partners conducted a two-part, telepresence-enabled ocean exploration expedition on NOAA Ship Okeanos Explorer to collect critical baseline information about unknown and poorly understood deepwater areas of the southeastern United States. The expedition was Windows to the Deep 2019.

It was the first live-streamed expedition during which the remotely operated vehicle (ROV) Deep Discoverer (D2) used a new suction sampler designed and built over the past winter by the Global Foundation for Ocean Exploration's (GFOE) engineering team.

A suction sampler is an underwater vacuum for collecting biological samples that are too small, too delicate, or too quick to pick up using the jaws of D2's hydraulic manipulator. Some of these deep-sea animals could include pelagic animals, fish, and other mobile fauna, like squat lobsters.

Once the samples are suctioned into the holding jars, they remained within D2 until the ROV is brought back on-board NOAA Ship Okeanos Explorer. At this point, the samples were transferred to the ship's wet lab. Each of the sample jars was intended for a single suction event, but often multiple biological or geological samples could be suctioned into one jar. In the wet lab, all samples, both suction samples and traditional samples, were separated and investigated.

For the summer 2019 expedition, the lead scientists handling the samples were geologist Amy Wagner (California State University Sacramento) and biologist Alexis Weinig (Temple University). The samples were imaged in the lab and paired with ROV images. All of the associated information for each sample was entered into a database



» A squat lobster was sampled around 722 meters (2,369 feet) using the suction sampler during the first dive of the Windows to the Deep 2019 expedition. Image courtesy of the NOAA Office of Ocean Exploration and Research, Windows to the Deep 2019.

and shared with the public. The samples themselves are preserved for transportation to data centers such as the Smithsonian National Museum of Natural History and made available to the public.

The new suction sampler was successfully tested during an engineering dive as part of the Shakedown and Seatrials 2019 expedition. On May 12, NOAA Ship Okeanos Explorer set out for this 13-day expedition in the Gulf of Mexico. On May 16, while conducting an engineering dive to test new ROV equipment and control interfaces, ROV Deep Discoverer's sonar picked up an unexpected image: the wreck of what is likely a mid-19th century wooden sailing vessel.

A look at the sampler's components highlights the complexity of the system. Mechanical, electrical, software, and video engineers all collaborated to design and build the system – from the two six-kilometer-rated electric motors that drive the rosette and pump to the graphical user interface (GUI) that allows the pilots to select the active sample jar and adjust pump speed and direction.

When a benthic sample is requested by the science community, the pilot first grabs the nozzle with the hydraulic manipulator. The nozzle is attached to 12 feet of flexible hose so that the pilot can reach a sample anywhere in the field of view of D2's camera. Once the nozzle is in place for a sample, the pilot rotates the rosette to select one of the 2.7-liter jars to suck the sample into. There are five sample jars outfitted with filters to prevent the sample from being sucked into the pump. The sixth jar is a "bypass" jar. It has no filter and is used to flush contaminants after each sample. Finally, the pilot turns up the flow on the suction pump until the sample moves through the nozzle and appears in the active jar in view of the dedicated jar camera.

Additional options and features include a variety of filter mesh sizes from five microns up to the standard half inch holes; a variety of nozzles including clear polycarbonate for standard samples, titanium for hydrothermal samples, and clear cone for midwater samples; and a variable speed pump with forward and reverse. Link to Windows to the Deep 2019.

<https://oceanexplorer.noaa.gov/okeanos/explorations/ex1903/welcome.html>

» This squat lobster was collected during the first dive of the Windows to the Deep 2019 expedition. It was collected using the suction sampler and placed in a tank on NOAA Ship Okeanos Explorer, allowing scientists the opportunity to take detailed imagery for identification. Image courtesy of the NOAA Office of Ocean Exploration and Research, Windows to the Deep 2019.



## OKEANUS DELIVERS NEXT GENERATION OF AUTONOMOUS TOW WINCHES AND LARS

Okeanus Science & Technology, LLC, was formed in 2013 with one thing in mind – to provide high quality tools and services to the oceanographic professional. Toward that end, Okeanus, aided by their acquisitions of Sound Ocean Systems, Inc (SOSI) and DT Marine Products, Inc., took the industry lead in providing oceanographic winches, LARS and handling systems to the commercial, academic and government markets.

As autonomous technology increasingly expands into disparate industries, the military, in particular the United States and foreign navies, are allocating substantial resources into autonomous programs. As a leading designer and provider of Unmanned Surface Vessel (USV) based winches Okeanus focuses on developing winches and Launch and Recovery Systems (LARS) for USV's, specifically for mine hunting and mine countermeasures.

Working closely with USV users and manufacturers, Okeanus designs and builds custom winches and launch and recovery systems (LARS) for a variety of commercial and military applications. Case in point is the MCM-015.

"We built the MCM-015 winch specifically for Northrop Grumman's AQS-24 mine hunting system," said Don Brockett, COO of Okeanus. The MCM-015 winch incorporates a number

of new features developed specifically for autonomous USV winches, such as slack-line prevention control and failsafe break-away systems and it represents the newest in a long line of USV based winches built for the military.

Okeanus' USV deck equipment is designed to withstand the extremes of high-speed naval craft and the harsh marine environment in which they operate. These winches and LARS operate autonomously except for electrical or hydraulic power supplied by the host vessel and the command signals sent from a remote command and control system. Aluminum construction is optimized using Finite Element Analysis (FEA) to reduce system weight which can be critical for most USV applications. When appropriate, equipment can also be optimized for and tested to MIL standards such as temperature, humidity, vibration, shock, EMI/EMC, and noise.

Okeanus winches can be supplied with a series of relevant auxiliary functions such as constant speed, constant tension, slack line mitigation, rendering, tension limits, system health monitoring, and system failsafe features. Custom modifications are available as well as offering options such as grooved drum covers by Lebus, cable data measurement and display for cable scope, speed and tension, spare drums, GUI's, slip rings, and

wireless and tethered remote controls. All components and enclosures are rated IP67. In addition to standard and custom designs for purchase, Okeanus also has an extensive pool of leased equipment available.

Not a company to rest on their laurels, Okeanus continues moving forward as industries evolve and need new tools. Okeanus has clients worldwide, and that translates into products that need to operate anywhere, even under the most inhospitable conditions.

"We are actively improving our current products and working on our next iteration of USV-based autonomous tow winches and launch and recovery systems. We continue to take on new and exciting projects, such as an active-heave compensated LARS for a sea-floor drill. We're also designing and building a customized winch designed for deep ice core sampling in the extreme cold of the Antarctic," Ted Brockett said.

Okeanus winches are created for a wide range of research and data collection related projects and are available in a variety of optional features depending on a client's needs. Okeanus rents, sells and services a wide range of deck and subsea equipment from its offices in Houma, LA, Houston TX and Redmond, WA.

To find out more about the latest oceanographic, ocean survey & marine scientific research rental equipment, visit [WWW.OKEANUS.COM](http://WWW.OKEANUS.COM)

# THE DISCOVERY OF THE CAPITANA SAN JOSE

By Garry Kozak / GK Consulting

The War of Spanish Succession (1701 – 1714) resulted in a period when no treasure from South America was sent to Spain, but on 10 February 1708, a fleet of 17 ships arrived at Portobelo, Panama to transport the enormous treasure that had been amassed. The *San José*, being the flagship, was loaded with the largest amount of this treasure. The fleet departed for Cartagena, Colombia.

In the afternoon of 8 June 1708, sailing close to the Islands off Barú, Colombia, and a only few hours from the Port of Cartagena, the Tierra Firme Armada sighted the English squadron under the command of Commodore Charles Wager. At sunset the Capitana *San José* confronted the *HMS Expedition*, Wager's flagship. Many exchanges of artillery fire followed and there was an explosion on the Capitana resulting in her disappearance. Of the 600 people onboard, only 11 survived. So the legend begins of what is estimated to be one of the largest single losses of Spanish treasure in the world. Estimates of its value are in the billions of dollars.

When an old colleague, Roger Dooley, told me he was going to look for the *San José* and asked if I would join his team, I knew there would be significant hurdles. How was he going to get Colombia to grant a permit for the search? How would he get financing? What technology was needed? That would be part of my contribution to the project, selecting the right search kit and overseeing the search strategy, as well as data processing and analysis.

I knew Roger from searches for other historically significant ship wrecks. He is a mesmerizing character, with a colorful background, having lived in Cuba under the Castro regime, where he became a historian and archeologist with a wealth of knowledge on Spanish shipwrecks, especially the *San José*.

To my surprise, Roger found financing and met with the President of Colombia, Juan Manuel Santos. This led to an agreement, which would allow the project to proceed. MAC (Maritime Archaeology Consultants) was formed with Roger as the Project Director. MAC would partner with the Colombian government to see if the elusive *San José* could be located.



» Colombian Navy Ship Malpelo - Photo Credit: GK Consulting



» WHOI Remus 6000 AUV - Photo Credit: GK Consulting

In February 2015, we had a meeting at WHOI (Woods Hole Oceanographic Institution). WHOI operates a REMUS 6000 AUV, which was a perfect search kit since it already had an EdgeTech 2200 side scan sonar operating at 100/400 kHz installed on it. Since it was unknown what would be left of the *San José* on the seafloor after all the years since its loss, we needed the absolute best sonar that would produce the highest resolution data. The EdgeTech systems have a proven deep-water track record and would be the perfect sonar for the project.

May 2015, WHOI arrives in Cartagena and mobilizes the AUV aboard the Colombian Navy ship, *Malpelo*. Roger and I set up an onshore headquarters (HQ) where mission planning would be done, as well as data processing and analysis. HQ also served as the central meeting place for Colombian government and Navy officials monitoring the search, and to give them daily project updates. From his research, Roger had defined the area he thought had the highest probability of where the wreck may be. The EdgeTech 2200 side scan would use the 100 kHz frequency set to a 350 meter range scale so we could cover a 700 meter swath per AUV pass. A staggered line spacing of 500 m x 225 m x 500m x 250m etc. was used to ensure the nadir region was fully covered. AUV start position, survey line pattern and spacing, AUV altitude, etc., were conveyed to the WHOI team to allow them to program the AUV to our specified area and search parameters.

The search began. The *Mapelo* steamed from Cartagena to the first search box and proceeded to deploy acoustic beacons for the AUV navigation. The AUV was launched and started "mowing the lawn". On mission completion, the sonar data was downloaded and transferred to the HQ for processing and analysis.

Search operations continued for 10 days, covering part of the area for which Colombia had given MAC a search permit. Disappointingly, no anomaly which could have been the *San José* was found. Since a modification to the Colombian search permit to expand the search area would take time, the decision was made to end operations, so the AUV was de-mobilized and the team departed Colombia.

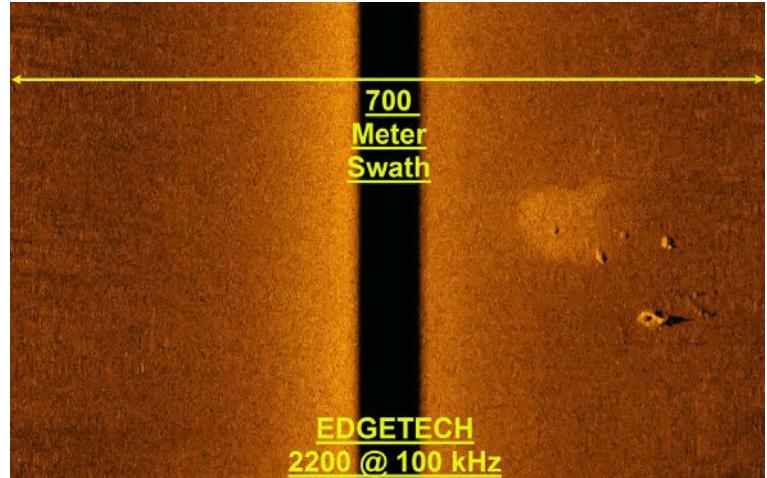
Roger was convinced that the *San José* had to be just outside the search permit area. For the next several months MAC negotiated with Colombia to issue a new search permit to allow expanding around the original permitted area. The permit was given and WHOI again contracted for the AUV services. In November 2015, the team arrived back in Cartagena, and the AUV was again mobilized onboard the Malpelo. The search was expanded seaward of the original area. On November 27, the first block of the new search area was completed, and the data processed and analyzed for targets. There it was, in the NW corner of the block, an anomaly that was almost surely the remains of an old shipwreck.

The sonar signature was so interesting that we decided to use the high frequency sonar to get high resolution images of the target and to also run the AUV at a low altitude to capture photographic images of the anomaly as the AUV survey lines crossed over it. Everyone waited impatiently. Roger and I were scanning through the mission data when high resolution sonar and photos of a shipwreck appeared showing wreckage and cannons scattered around. It was a moment of team jubilation and I watched Roger's reactions as it sunk in that the many decades of dreaming, research and careful planning had finally paid off.

New AUV missions were run in the following days with the focus to collect sufficient overlapping geo-referenced photographic images to create a complete photo-mosaic of the *San José* site. The photographic images showed how amazing and preserved the objects were sitting on the seafloor more than 2,000 feet down. The upper decking had decomposed but there were bronze cannons everywhere, intact ceramics and many glass bottles scattered around. The hull remains (sides) of the ship were clearly evident in the images with some cannons sticking out of what were once gun ports; probably last fired during the battle. Roger was analyzing each set of photographic images, measuring the cannons, looking at the construction, ceramic types, and so on. He wanted to be sure that there was no doubt that this was in fact the *San José*. The evidence grew quickly and it reinforced the initial conclusion that this was in fact 100% the long lost *San José*. Gold bars and coins were in plain view in some of the images. The photo mosaic is an impressive view clearly showing the magnificent state of the *San José* remains after 300+ years on the seafloor.

President Santos was notified and presented the evidence that the *San José* had been found. A press conference was scheduled and on December 5, 2015 he announced to the world the discovery of the *San José*. For Roger Dooley, it was a life time accomplishment that many believed was not possible.

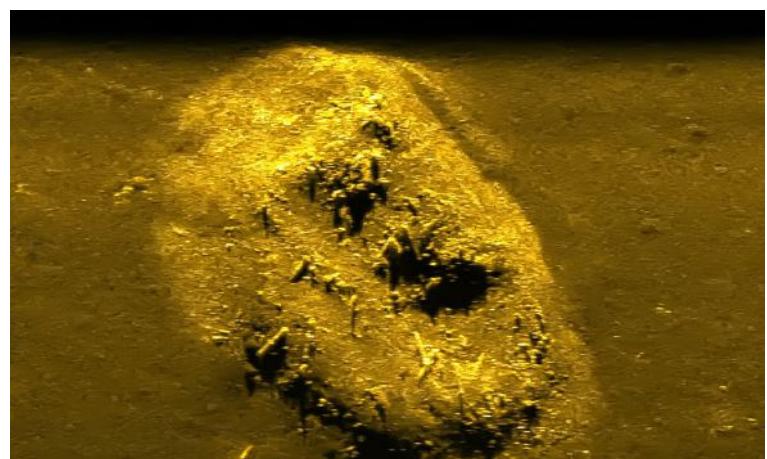
The future of the *San José* is still in flux. Roger's vision is a complete excavation using remotely operated vehicles (ROVs) and adhering to strict archeological standards. The *San José* is a big part of Colombian heritage, so the future plan is to build a marine conservation lab and a new museum in Cartagena to house and display the recovered artifacts for the world to see. The wheels of government move slowly, so the timeline is in doubt, but I look forward to visiting Cartagena to see their display of the amazing *San José*.



» 1st detection 100k @ 350m range scale San Jose - Photo Credit: Colombia



» Roger Dooley & Garry Kozak at moment of Discovery - Photo Credit: GK Consulting



» EdgeTech Hi-Resolution Side Scan Sonar Image of San Jose - Photo Credit: Colombia



» Photo Credit Colombia

## NY COMMITS TO LARGEST OFFSHORE WIND PLAN IN U.S.



» July 18, 2019, New York Governor Andrew M. Cuomo announces the nation's largest offshore wind agreement and the single largest renewable energy procurement by any state in U.S. history. Photo credit: Kevin P. Coughlin/Office of Governor Andrew M. Cuomo.

On 18 July 2019, New York Governor Andrew M. Cuomo executed the nation's largest offshore wind agreement and the single largest renewable energy procurement by any state in U.S. history—nearly 1,700 megawatts—with the selection of two offshore wind projects, that his office says will create enough energy to power over 1 million homes, create more than 1,600 jobs, and result in \$3.2 billion in economic activity.

To jump-start these efforts, Governor Cuomo announced the winners of New York's first comprehensive offshore wind solicitation: the Empire Wind and Sunrise Wind development projects of Equinor US Holdings, Inc. and Bay State Wind LLC, a joint venture of Ørsted A/S and Eversource Energy, respectively.

The Governor's office says that this offshore wind announcement "is expected to catalyze the first generation of major United States supply chain investments by the fast-growing offshore wind sector, positioning New York to be the hub of the nation's burgeoning offshore wind industry."

The project developers have committed to make additional investments in manufacturing and port infrastructure, on top of the commitments in Governor Cuomo's 2019 State of the State address. A total of \$287 million will be invested in cutting-edge infrastructure in multiple regions of the state, including the Capital Region, Brooklyn, Staten Island and Long Island.

For example, Equinor will invest over \$60 million in port upgrades in New York that will support future offshore wind projects and further strengthen the state's position as the U.S. hub for offshore wind. Further, Equinor will commit at least \$4.5M to community benefits and workforce development, which will further the goals of New York's National Offshore Wind Training Institute and Community and Workforce Benefits Fund.

Governor Cuomo also signed the Climate Leadership and Community Protection Act, or CLCPA, which adopts ambitious and comprehensive climate and clean energy legislation and advances the Governor's

mandate of procuring 9,000 megawatts of clean energy by 2035.

Christer af Geijerstam, President of Equinor Wind US, said, "Being selected in this highly competitive field of bidders shows the confidence that New York leadership has in Equinor's capabilities of developing large offshore energy projects, delivering affordable renewable energy while also providing significant economic benefits locally. We are now looking forward to working with our partners throughout New York State to bring this project forward."

Martin Neubert, Executive Vice President and CEO of Ørsted Offshore, said, "New York State has set an ambitious goal to be 100% powered by clean energy by 2040. We fully share that vision, and we're proud to bring more than two decades of offshore wind expertise to the state and to be fronting the offshore wind build-out in New York with a combined 1,000MW capacity via our South Fork and Sunrise Wind projects."

Alicia Barton, President and CEO, NYSERDA said, "At nearly 1,700 megawatts, the

selection of Empire Wind and Sunrise Wind under NYSERDA's inaugural offshore wind procurement is nothing short of a watershed moment for the development of large-scale offshore wind in the United States, and by bringing thousands of jobs and billions of dollars in economic activity, these projects will also secure New York's status as the U.S. hub for this industry."

Liz Burdock, CEO & President of the Business Network for Offshore Wind, said, "The offshore wind projects will protect our environment, generate good-paying jobs and keep ratepayers' costs as low as possible. This is happening in New York today, thanks to the Governor's goals of ending carbon emissions, diversifying the state's energy resources and accelerating the transition from fossil fuel electricity generation to renewables. At the Governor's direction, New York is leading the race to develop offshore wind, and its residents will reap the environmental and economic benefits. Now it's time for the U.S. to move on offshore wind and follow Governor Cuomo's lead.

"These historic contracts with Ørsted and Equinor mean that New York is now fully into the offshore wind marketplace and will supercharge the local and regional supply chains of companies that can now seek to become offshore wind industry suppliers. As members of the Business Network for Offshore Wind, Ørsted and Equinor have helped the industry grow immensely from their successes in many European countries. They bring both experience and knowledge to U.S. shores."

#### Background On Developers:

Equinor's project, called Empire Wind, is about 14-35 miles south of Long Island in the New York Bight. This contract proves that Equinor's move to win the auction for this Wind Energy Area and become the first developer to hold a lease in the NY Bight area has paid off. Equinor also currently holds a Wind Energy Area south of Martha's Vineyard that it won in the triple auction held by BOEM last December.

Ørsted's Sunrise Wind project is located in the waters off Massachusetts and Rhode

Island, about 30 miles from Montauk Point. This project is now added to the existing Block Island wind farm, the Revolution Wind and Bay State Wind farms off of Rhode Island and Massachusetts, the 1100MW Ocean Wind project located 15 miles off of Atlantic City, NJ, and the Coastal Virginia Offshore Wind (CVOW) project 27 miles off the Virginia coast in the company's portfolio of U.S. projects.

#### About Business Network for Offshore Wind

The Business Network for Offshore Wind is a 501(c)(3) organization dedicated to establishing an offshore wind supply chain in the United States. The Network is focused on delivering education, creating partnerships and advancing the industry. The Network hosts the annual International Offshore Wind Partnering Forum (IPF), the leading technical conference for offshore wind in the United States dedicated to moving the industry forward. Ocean News & Technology Magazine is a member of the Network, as well as an official media partner of the organization.

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## BOEM TO OFFER 77.8 MILLION ACRES FOR LEASE IN GULF OF MEXICO

The Bureau of Ocean Energy Management (BOEM) will offer 77.8 million acres for a region-wide lease sale scheduled for 21 August 2019. The sale would include all available unleased areas in federal waters of the Gulf of Mexico.

Lease Sale 253, scheduled to be livestreamed from New Orleans, will be the fifth offshore sale under the 2017-2022 Outer Continental Shelf (OCS) Oil and Gas Leasing Program. Under this program, a total of ten region-wide lease sales are scheduled for the Gulf. Two Gulf-wide lease sales are scheduled to be held each year and include all available blocks in the combined Western, Central, and Eastern Gulf of Mexico Planning Areas.

Lease Sale 253 will include approximately 14,585 unleased blocks, located from three to 231 miles offshore, in the Gulf's Western, Central and Eastern planning areas in water depths ranging from three to 3,400 meters. Excluded from the lease sale are: blocks subject to the congressional moratorium established by the Gulf of Mexico Energy Security Act of 2006; blocks adjacent to or



beyond the U.S. Exclusive Economic Zone in the area known as the northern portion of the Eastern Gap; and whole blocks and partial blocks within the current boundaries of the Flower Garden Banks National Marine Sanctuary.

The Gulf of Mexico OCS, covering about 160 million acres, is estimated to contain about 48 billion barrels of undiscovered technically recoverable oil and 141 trillion cubic feet of undiscovered technically recoverable gas. All terms and conditions for Gulf of Mexico Region-wide Sale 253 are detailed in the Final Notice of Sale (FNOS) information package, which were available 18 July 2019 at: <http://www.boem.gov/Sale-253/>.

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## SIEMENS GAMESA AWARDED LARGEST U.S. OFFSHORE WIND POWER ORDER

Siemens Gamesa Renewable Energy (SGRE) has conditionally received a record order for 1,714 MW from Ørsted and Eversource. Encompassing three offshore wind power projects, the contract is the largest U.S. offshore wind power order to date. It encompasses the supply, delivery, and installation of SG 8.0-167 DD wind turbines including service agreements in federal waters off the northeastern coast. All deliveries are subject to Ørsted and Eversource's final investment decision.

SGRE has been conditionally awarded the contract to deliver offshore wind turbines totaling 880 MW for the Sunrise Wind project. The project is expected to be operational in 2024. The 704 MW Revolution Wind offshore project and is expected to be online by 2023. Once operational, it will deliver power to Rhode Island and Connecticut.

Additionally, SGRE was conditionally awarded the contract to deliver turbines for the 130 MW South Fork project, expected to be operational by the end of 2022 and deliver power to the Long Island Power Authority.

For more information, visit  
[WWW.SIEMENSGAMESA.COM](http://WWW.SIEMENSGAMESA.COM)

# US OFFSHORE WIND WILL REQUIRE VAST AMOUNT OF CABLE BY 2028

The leading news and information service for the submarine cable industry, SubCableWorld (SCW), has published an analysis of US offshore wind cable demand for a 10-year period from 2019 through 2028. The free report, US Offshore Wind Plans Reliant on Ready Supply of Power Cables, is available for download at [www.subcableworld.com](http://www.subcableworld.com).

As there are still many variables in the US offshore wind market, SubCableWorld generated three scenarios to model demand for offshore wind cable. These scenarios suggested demand ranging from 6,500 kilometers to 12,000 kilometers of cable to be contracted for by 2028.

The market for offshore wind cable in the US is beginning to take shape. The clear commitment by the Northeastern states to develop offshore wind on an ambitious timetable has generated strong momentum for the industry after years of frustration.

As the US has no domestic offshore wind cable manufacturing at this time, the impact of a strong US market on the supply chain needs to be understood.

"Our models began with a baseline using the procurements that already have been announced by the states. This alone resulted in 6,500 kilometers, much of which will be contracted for in the next five years," said John Manock, editor of SubCableWorld and author of the research. "We then factored in the variables such as future state procurements and the deployment of floating wind technology and saw demand shoot up to 12,000 kilometers over 10 years. For the US offshore wind market to fully blossom, a domestic supply chain will have to be developed, particularly for cable, to meet demand on this scale. The first steps towards this are being taken, but it is important for the industry to understand the full magnitude of the



potential US offshore wind cable market in order to build an adequate supply chain.

Liz Burdock, CEO and President of the Business Network for Offshore Wind said, "We are very excited to be working with John Manock and SubCableWorld on this critical element of the US offshore wind energy supply chain. As John states in his report, there is currently just one US offshore wind cable (OWC) manufacturer, but a cable supply chain can be created relatively quickly if the industry understands the growing demand and moves quickly to meet it. We thank SCW for starting this important conversation, and urge everyone interested in the US offshore wind market and supply chain to read it and act accordingly."

To download US Offshore Wind Plans Reliant on Ready Supply of Power Cables, visit [www.subcableworld.com](http://www.subcableworld.com).

A red Nekton Seamount 2 ROV with a clear dome hatch suspended in the ocean. A large watermark graphic in the center of the image reads "Total Vehicles".

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**Image: Nekton First Descent Mission**

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# THE CHALLENGES OF AUTOMATION IN THE OIL AND GAS SECTOR

By Claudia Jarret, EU Automation

Norwegian oil and gas major, Equinor, made headlines last year when it launched the fully automated wellhead platform, the Oseberg H. Oseberg H is completely unmanned, with no living quarters—not even a restroom. It is remotely operated from the central depot, with manual maintenance carried out once or twice a year.

Equinor's platform was developed with unmanned production in mind from the outset. It has the bare essentials and was delivered far below the original budget, but the platform has a mammoth predicted volume capacity of 110 million barrels of oil equivalent. What else can be learned from the Oseberg H approach?

Developing a structure like this is not as easy as ripping out restrooms and sending workers to the main depot. For existing oil and gas facilities, transforming aging sites into completely unmanned structures would not be financially wise. Luckily, automation strategies aren't black and white, but shades of grey. Many facilities can gain automation advantages with relatively small investments.

Oseberg H was built using established technologies to monitor every aspect of the platform. For instance, SCADA software continuously monitors operations and detects faults and anomalies. Should a leak be identified, for instance, the system could raise an alarm which alerts maintenance engineers. Using remote monitoring technology, the fault location can be identified immediately.

Equinor's motto of 'think big, build small' reinforces the concept of small changes making a huge difference. What that small change should be however, depends on the individual needs of the business in question. Going back to the example in question, this could be as simple as connecting PLCs to SCADA software.

To advance this, the SCADA software could also incorporate additional data points in the facilities, from retrofit sensors, energy consumption meters and market forecasts. This interface could then be made accessible from mobile devices, so that processes can be monitored and controlled from a remote location.

As businesses creep towards the fully automated side of the spectrum, they are will be faced with a few hurdles. For example, cybersecurity will always be a concern for high risk industries like oil and gas. However, many of today's SCADA



» In October 2018, the Oseberg Vestflanken 2 field in the North Sea came on stream. The Oseberg H platform is the first unmanned platform on the Norwegian Continental Shelf. Photo courtesy of Equinor.

software providers have stringent protection in place with data encryption, firewalls, and consistent patch management.

General risk management is another concern of automated operations. In the event of a malfunction, being unmanned could increase the time it takes for maintenance and this concern is heightened due to the aging infrastructure in these facilities and the risk of obsolescence. Should an essential part break down, replacements that are compatible with existing systems and legacy equipment may have been discontinued. Establishing relationships with automation parts suppliers will prove crucial to minimise maintenance downtime on an unmanned site.

Equinor set an example for full-automation in the oil and gas sector, but even the smallest automation investment can provide improved efficiency, boosted profits and better overall insight into facility health. By appreciating the shades of grey, businesses, can adopt the best automation level for their needs.

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# RHODE ISLAND OFFSHORE WIND DEVELOPMENT UPDATE

*ON&T chats with Hilary Fagan, Executive Vice President of Business Development for the Rhode Island Commerce Corporation*

By now, most people have heard that Rhode Island is home to the first U.S. offshore wind farm. The capabilities, partnerships, and best practices they have developed should continue to benefit the development of offshore wind in New England and the Mid-Atlantic states for decades to come.

One of the key challenges for offshore wind in the U.S. is the development of a supply chain, a skilled workforce, and industry-specific capabilities. Rhode Island is well-positioned to solve these challenges. For example, the state connects companies through its Supply Rhode Island initiative and its dedicated Offshore Wind Supply Chain Database. It's no surprise that a place called the Ocean State succeeds at bringing new industries together. Rhode Island has long been home to a wide range of maritime industries, including boat building and servicing; development of advanced materials; ocean sciences and engineering; and the development of unmanned underwater vehicles. For example, it's easy to imagine how the expertise developed by companies working with

the Naval Undersea Warfare Center in Newport, in testing both undersea systems and unmanned vehicles, can translate to off expertise in offshore wind inspection and survey. ON&T chatted with Hilary Fagan of the Rhode Island Commerce Corporation about the next steps for offshore wind in her state.

**ON&T:** What is the Rhode Island Commerce Corporation doing to ensure that your state has the technical workforce to remain at the forefront of this industry?

**FAGAN:** The Rhode Island Department of Labor and Training has provided the resources for us to build and specially train our offshore-wind talent pool. We are also utilizing a number of grants and initiatives—for example, Real Jobs Rhode Island, which offers certificate programs in our high schools. Made possible by an initial \$100,000 grant through Real Jobs Rhode Island, the Wind Win RI program offers courses on everything from marine safety to engineering, with the goal of getting students to graduate with an offshore wind energy certificate equivalent to nine college credits. The class of 2020 will be the first to graduate with the energy certification, which will include special licenses, marine safety certification, first aid and more. Then, students can pursue a trade out of high school, or continue on to college for further education in wind energy.

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The University of Rhode Island and Community College of Rhode Island are also part of a consortium of education partners helping with the curriculum and course work needed to develop offshore wind talent in Rhode Island.

**ON&T:** How is Rhode Island partnering with other states to advance our nation's offshore renewable energy portfolio?

**FAGAN:** The demand from New England states for offshore wind energy is strong and growing, so the entire region will benefit from the growth of this industry. One way we're interested in coordinating is through our port infrastructure. We want to further explore ways we can collaborate to successfully develop offshore wind opportunities off the New England coastline.

**ON&T:** In the fall of 2018, Deepwater Wind was acquired by Ørsted. What did this mean for its existing projects (like the Block Island Wind Farm) and future projects in the region?

**FAGAN:** We're hugely supportive of Deepwater Wind, now Ørsted. What is exciting is that Ørsted is an industry leader, so its acquisition of Deepwater Wind brings additional in-depth and technical knowledge into our state, especially since it named Providence its U.S. co-headquarters. This relationship with Ørsted benefits our supply chain, mostly recently with GEV Wind Power, which recently made Rhode Island the home of its U.S. headquarters, and strengthens our renewable energy supply chain and will enable Rhode Islanders to further access clean energy careers. This is the latest announcement that is putting Rhode Island at the forefront of the U.S. offshore wind industry.

**ON&T:** In June, General Dynamics' Electric Boat broke ground on a \$792 million expansion of its submarine-building

facilities in North Kingstown, Rhode Island. What attracted General Dynamics to North Kingstown, and what is your office doing to bring more maritime construction to your state?

**FAGAN:** We've worked very closely with Electric Boat to help it train the talent and develop the workforce it needs in our state. In anticipation of the thousands of jobs it will create here in the next decade, we partnered Electric Boat with six of our career and technical schools, which are now training Rhode Island high school students in advanced welding and shipfitting. The program begins in a student's freshman year and grows more advanced each year, ultimately leading to paid internships during senior year and to the possibility of a good-paying job at Electric Boat after graduation.

And to ensure that Rhode Islanders of all stages are being trained to fill the Electric Boat jobs, 500-plus people of all ages will also be hired and then trained through the company's partnership with the Community College of Rhode Island and the New England Institute of Technology. An additional \$2 million has been allotted to the new Job-ready Workplace Learning Program, which provides refundable job training tax credits on a competitive basis to support job training.

Our Real Jobs Rhode Island initiative has now trained hundreds of Rhode Islanders to fill maritime manufacturing jobs at Quonset Business Park, which 200 companies call home.

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# AUTONAUT'S ADVANCED USVs PROVIDE ENVIRONMENTAL MONITORING FOR THE OCEAN CLEANUP



» AutoNaut USV conducting close-pass operations on The Ocean Cleanup system.

AutoNaut Unmanned Surface Vessels (USVs) have been collecting vital environmental monitoring data in the Great Pacific Garbage Patch in support of The Ocean Cleanup.

Beginning in November 2018, a 5-meter AutoNaut accompanied the 600-meter plastic removing device, System 001 or "Wilson" in a series of missions of up to 30 days in duration in the Pacific. This summer, AutoNaut's new boat EVE (see front cover) is at sea alongside System 001/B helping the offshore crew monitor the marine life through 2019 and beyond.

The wave-propelled USV has two roles. First, it acquires data on ocean current, meteorological and oceanographic parameters. Second, it is equipped with live streaming, under- and above-water cameras to visually inspect the

System and the environment surrounding it. The autonomous vessel is also fitted with cutting edge sensors, including a YSI Xylem EXO2 multi-parameter water quality sonde, an Aanderaa Motus wave sensor, and a Nortek Signature 1000 ADCP. Transmission of data streams in near real-time assists operational decision-making in the field, and the data is vital because the area known as the Great Pacific Garbage Patch has not been extensively studied. The information also increases the team's understanding of interactions between aggregations of plastic litter and, the clean-up system's structural integrity.

AutoNaut USV has shown resilience operating in testing conditions. Even with sea states up to Beaufort 6 and surface currents of up to 1 knot, AutoNaut operates in close proximity to the clean-up System. With consistent track-keeping within 5 meters, the AutoNaut has delivered data that would have been prohibitively hazardous and costly by other means.

Complete reliability is required, not just mechanically but of the command and control system and working procedures for remote operation. In daylight, remote operators on a supporting vessel utilized wireless comms and often kept line-of-sight for close-pass manoeuvres. Shore-based remote operators located in AutoNaut's UK headquarters (in a



» Inspecting the barrier using an underwater camera mounted on AutoNaut's hull.

different time zone), oversaw USV operations during night-time periods over iridium satellite link, during which time protocols switched in favour of data collection in the far field to ensure safe operation at sea.

EVE is also fitted with an enhanced AIS-based autonomy system. This allows the USV to complete transects in a "track-follow" pattern—remaining at a consistently safe distance from the System. By autonomously tracking AIS transceivers on the system, dynamic waypoints are generated, which are followed at an appropriate distance and which enables switching between survey modes according to behaviour/direction of the offshore asset.

The AutoNaut is built to remain at sea for many weeks but, for The Ocean Cleanup operations, the USV is frequently launched and retrieved directly to the support vessel. The simplicity and robustness of the design ensures this is a straightforward and safe operation, though the craft is quite capable of returning independently to an onshore slipway.

EVE is one of a new generation of 5-meter AutoNaut USVs that have completed projects around the world for oil and gas, defence and marine science applications, including close pass operations and deployment in otherwise inaccessible regions. The versatile USV boasts a high-power balance in a modular, renewable energy-based platform, along with a sizeable payload capability.

Flexibility remains a guiding ethos for both sensors and data delivery. Data services are offered to meet client needs, be that for direct secure transfer of raw files or full analysis and reporting. Instruments for ADCP, fisheries sonar, passive acoustic monitoring, MetOcean, communications gateway, and surveillance have been installed and integrated. Projects on the horizon include endurance missions to harsh environments—from equatorial waters to polar seas. The new-generation fleet is complemented by the 2019 launch of the AutoNaut 3.5, built to be even easier to deploy and retrieve.

Through projects such as The Ocean Cleanup, UK-based AutoNaut Ltd has undergone rapid development in the last two years.

For more information, visit  
[WWW.AUTONAUTUSV.COM](http://WWW.AUTONAUTUSV.COM)

# DEEP SEA MINING REGULATIONS DEBATED BY ISA DELEGATES



» The ISA Council meets in Kingston for its third day on 17 July 2019 in Kingston, Jamaica.  
Photo credit: Diego Noguera, IISD/ENB.

In late July 2019, the International Seabed Authority (ISA) held its latest meetings in Kingston, Jamaica. These meetings, which were the second part of the ISA's 25th annual session, had the primary goal of developing draft exploitation regulations on deep-seabed mining for areas beyond national jurisdictions. One thing that was different about this particular session, according to ISA, was that the public has become increasingly aware of deep sea mining, which has led to increasing interest in the ISA's work.

During the sessions, delegates debated how restrictive the Mining Code regulations should be, as well as the need to balance the timeliness with the goal of ensuring that its provisions serve all stakeholders. These delegates come from the nations of the world as well as non-governmental organizations such as the Deep Sea Conservation Coalition (DSCC).

Daily summaries released by ISA indicate that while there was a consensus that "environmental protection is as a general principle and as a component of the Plan of Work," opinions differed on the pace of negotiations, with some advising caution, while other delegations "expressed frustration with the slow pace that pushes the finish line further into the future."

For example delegates from the Netherlands flagged that there is no mention of a clear timeline for completion of the draft exploitation regulations, and, along with delegates from Japan, Australia, Nauru Mexico, Belgium, the UK, Thailand, and Italy, expressed support for the adoption of the draft high-level action plan and its associated indicators.

According to the ISA, the final version of these regulations will "govern future activities in the world's oceans, yet will need to ensure environmental protection while simultaneously balancing stakeholders' interests."

ISA reports that these latest sessions were successful in advancing "calls for environmental protection in deep sea mining, operationalizing the Authority's Strategic Plan, and shaping the organizational culture towards more participation and transparency."

ISA delegates expressed their intention to "ensure a thorough and timely development of the regulations, bearing in mind that necessary standards and guidelines should be developed before their adoption."

In addition, there were reminders through the Council meeting that "the regulations' development does not take place in a vacuum."

They are influenced by the strategic direction of the Authority, which for the first time in its history has begun implementing a Strategic Plan. This Plan, in turn, decides the ISA's positioning in the global oceanic realm and in environmental governance. The regulations are also affected by its underlying culture, including considerations related to public participation and transparency. Deliberations in the Assembly offered useful insights into those directions.

Participants commemorated the 25th anniversary of the ISA with a special session on Thursday, 25 July, attracting national delegations from more than 70 countries.

## Other Highlights

- » ISA adopted a set of guidelines for observer status of non-governmental organizations (NGOs) with the Authority;
- » a memorandum of understanding (MOU) between the ISA and the Ministry of Natural Resources of China on the establishment of a joint training and research center was signed;
- » ISA launched its deep seabed and ocean database (DeepData);
- » high-level panel deliberated on capacity building, stressing its importance to achieve the ISA's mandate and highlighting the contractor training program, which assists in building the capacities of developing country scientists;
- » discussion on timelines for draft high-level action plan, key performance indicators (KPIs), and the Strategic Plan;
- » inaugural lecture on the role of the UN Convention on the Law of the Sea (UNCLOS) and the ISA in contributing to the rule of law;
- » growing support and interest for workshops on regional environmental management plans (REMPs);
- » calls for increased transparency, including via the development of the new ISA website and the launch of the Authority's database management strategy;
- » and emphasis on the operationalization of the common heritage of humankind regime (editor's note: while there is a debate about the specifics of this concept, it has been generally linked to sustainable development).

## About the ISA:

The ISA is an autonomous international organization established under the 1982 United Nations Convention on the Law of the Sea and the 1994 Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea. It is the organization through which States Parties to the Convention shall, in accordance with the regime for the seabed and ocean floor and subsoil thereof beyond the limits of national jurisdiction (the Area) established in Part XI and the Agreement, organize and control activities in the Area, particularly with a view to administering the resources of the Area. Currently there are 168 member states participating in the ISA, along with 25 non-governmental organizations that range from industry associations (e.g., the World Ocean Council) to environmental protection advocates (e.g. The Pew Charitable Trusts).

# MMT TO PERFORM GEOPHYSICAL SOIL INVESTIGATION AT OFFSHORE WIND FARM

Rijksdienst voor Ondernemend Nederland (RVO.nl) has awarded MMT a contract to perform a geophysical soil investigation of the Ten Noorden van de Waddeneilanden Wind Farm Zone.

The objective of the investigation is to contribute to the bathymetrical, morphological and geological understanding of the area. Ultimately the data will be used by offshore wind farm developers to prepare bids for this site. A high resolution and accuracy ground model ensure that developers can prepare their bids with the least amount of uncertainty, which helps lower the price on developing these OWFs. Project preparations are currently underway, with the fieldwork planned to be performed in July and August from MMT's survey vessel Franklin.

The geophysical survey comprises of the collection of high-resolution bathymetry and seabed imagery, in addition to determining the exact, current position of existing (in service & out of service) cables and pipelines. A geological ground model of the site will be established by using both a parametric



echosounder and a 2D/3D UHRS system.

**MMTs CCO Nils Ingvarson comments:** The contract award underscores the capabilities of MMT within the renewables energy sector. We are delighted to be awarded this highly demanding survey assignment.

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## RTSYS STEPS UP THE PACE IN MICRO-AUV COMPETITION

After years of development, French Acoustics specialist RTSYS has unveiled its latest versatile micro- AUV named NemoSens.

Small (less than 1 meter long), easy to carry and launch (less than 20 pounds including payload), micro-AUV NemoSens can host any kind of payload, be it a CTD probe, sidescan sonar or any other sensors. Thanks to an open LINUX architecture it can be programmed from a ROS or MOOS interface to complete various kind of missions. Its battery provides wide autonomy (up to 8 hours at 4 knots) with speed range from 2 to 8 knots and its robustness allows it to dive over 300 meters.

Several AUV can maneuver in swarm (+10) thanks to acoustics; beacons on the surface could also be used for real-time repositioning. Navigation is accurate thanks to integrated INS along with a GPS and a flasher in the mast for smooth recovery. Therefore, NemoSens is in every way flexible and will perfectly fulfill numerous civil applications such as seabed imagery, environmental monitoring or wreckage localization.



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## FUGRO MAKES NEW SEEP SURVEY LICENSE SALES OFFSHORE NEWFOUNDLAND

Fugro and partner Amplified Geochemical Imaging (AGI), are reporting recent success selling multiple licenses for data from frontier regions offshore east coast Canada. The data were acquired during two separate hydrocarbon seep surveys in the Orphan Basin (2017) and Carson Basin (2018), both situated on the continental margin of Newfoundland.

The comprehensive data packages are being licensed by Fugro and include multibeam echo sounder data (bathymetry, backscatter intensity and water column), sub-bottom profiler data, heat flow measurements and shipboard geochemical screening analyses; advanced geochemical analyses, including biomarkers on select samples, are also included.

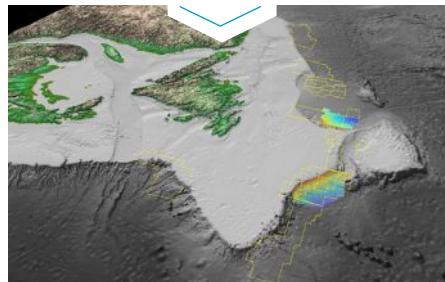
The Orphan Basin package covers an area of 11,000 square kilometers and the Carson Basin package covers an area of 18,880 square kilometers; each survey was followed by heat flow and geochemical sampling and analysis. Both programs were planned so

that purchasing clients would have the data in advance of the upcoming lease rounds, so data could be used in de-risking their potential investment. Purchase post lease round is also advantageous from numerous perspectives including guiding—and potentially reducing the scope of—expensive 3D seismic surveys.

Geochemical datasets (shipboard, conventional shore-based and AGI adsorbent-based analyses) all suggest the presence of thermogenic hydrocarbons.

"With the keen interest in these licenses to international E&P companies, and recent record-breaking bids in the Orphan Basin, it is clear to us there is much excitement surrounding Canada's growing offshore industry and Newfoundland and Labrador's licensing rounds," said Keith Kneale, Fugro's Business Development Director for the Americas.

These data will continue to be useful throughout the life of the field. A variety of



▲ High-resolution bathymetric map, viewed in Fledermaus, of the Orphan and Carson Basins, offshore Newfoundland; lease blocks are outlined in yellow. The Fugro Searcher acquired the data with its hull-mounted, Kongsberg EM302 MBES system.

further investigations—such as establishing environmental baselines, evaluating seafloor geohazards and preliminary planning for field development—ensures the data will deliver long-term value. Nalcor Energy Oil and Gas was a partner in these work programs.

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## OCEANEERING MOVES ROVs INTO OPERATION FASTER WITH VORTEX STUDIO



CM Labs Simulations Inc. has announced that leading subsea engineering and applied technology company, Oceaneering Inc., has integrated Vortex Studio into their planning and prototyping workflows for offshore tools.

Based in Houston, Texas, Oceaneering is a global player in engineered services and products for the offshore energy industry. With clients looking for a long-term partner to deliver safe and stable maintenance operations for multiple-years to decades at a time, Oceaneering's Digital Innovation Design Team was tasked with reassuring potential customers through simulation-based demos.

"Our artists excel at creating 3D models, but the systems in place did not let us move to the next level where we could simulate unique scenarios or make changes on the fly," said Mark Stevens, Digital Innovation Operations Director at Oceaneering. "Even the smallest change required the scene to be re-rendered, easily taking five days or more."

As CM Labs' advanced suite of real-time simulation and visualization software, Vortex Studio offered Oceaneering the platform they were looking for; a fast-paced, user-centric prototyping tool, streamlined for the deployment testing, training, and customer engagement simulations.

Offering high-fidelity dynamics, cable-systems and hydrodynamics, Vortex Studio

presented a robust feature set, perfect for the marine focused company.

"With increasingly complex projects, the Oceaneering team wanted to refocus their resources," explained Lisa Barbieri, CM Labs VP of Marketing & Customer Experience. "Vortex Studio allowed them to leverage their existing 3D artists in completely new ways."

### Advanced Training Applications

Free to add different difficulty levels to the simulated missions via Vortex Studio, crews are now able to start with basic skill building tasks and then progress to the same types of real-time challenges they will face while working onsite.

"ROVs have demanding deployment schedules and operating environments," elaborated Barbieri. "It was important for the company to limit delays caused by damage during training and ensure maximum performance the moment they deployed the robot."

This new type of training program is already gaining traction with Oceaneering's Norwegian office, who are looking to leverage simulation-based training for their globally deployed ROV pilots.

"Based on preliminary data, Oceaneering is expecting hot-stab operations 30% faster and an increase in mobilization time of at least 20%."

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## ANOTHER SUCCESSFUL C-KORE DEPLOYMENT IN AUSTRALIAN WATERS

C-Kore Systems has successfully completed another offshore campaign off the West Australian North West Shelf. C-Kore's subsea testing tools quickly located the faulty subsea equipment allowing it to be replaced to make the field operational again.

C-Kore's subsea testing tools are used on fault-finding operations to quickly evaluate the health of the subsea equipment. Their Cable Monitor tool measures the insulation resistance and continuity of electrical lines. When used in conjunction with the Subsea TDR tool, faults can be localised with a precision of 10 cm.

Stephen Leung, Subsea Controls Engineer commented, "Our customer was extremely pleased how the C-Kore units worked. We were able to quickly locate and replace the faulty equipment much quicker than traditional testing methods. The training and support provided by the C-Kore team was exceptional."

Greg Smith, General Manager of C-Kore Systems added, "With our tools being so small, we can quickly deploy our units to our customers no matter where they are located. We take great pride in providing the best service with customised training and 24hr support. It is very satisfying to hear such great reviews from our customers!"



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## MCDERMOTT RELOCATES ITS SUBSEA CENTER OF EXCELLENCE IN THE UK

McDermott President and CEO speaks on positive impact Bedfont Lakes relocation will have for company clients.

The move follows the recent award of the Greater Tortue Ahmeyim Natural Gas Project, located offshore Mauritania and Senegal. McDermott and BHGE were awarded subsea umbilicals, risers and flowlines (SURF) and subsea production system (SPS) equipment contracts by BP. The subsea engineering team as well as other support office areas from McDermott will be located in the new office.

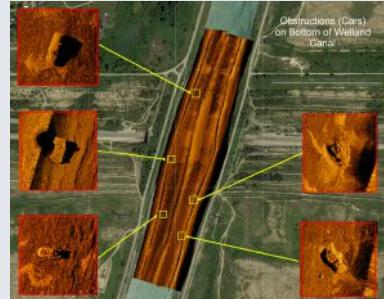
"The relocation of our subsea office positions us well for the successful execution of recent project awards and enables us to expand our subsea offering to meet projected growth," said Tareq Kawash, McDermott's Senior Vice President for Europe, Africa, Russia and Caspian. "Our new office ensures we can deliver comprehensive solutions to our existing and future clients."

McDermott is leasing approximately 4,180 sqm (45,000 sqf) of office space. The building features a canteen, a gymnasium and surrounding parks and lake. There are currently 260 employees relocating with the potential to grow to approximately 350.

Bedfont Lakes office park is a business community served by a modern and efficient infrastructure which is home to a number of national and international companies. It provides an ideal working environment and offers a wealth of recreational opportunities for McDermott employees.

McDermott also has an office with approximately 300 employees in Paddington, London.

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## EDGETECH 4125 SIDE SCAN SONAR FOR CANAL MAPPING

EdgeTech was recently involved in an intriguing demonstration of the effective use of high-resolution side scan sonar imaging for the important work of canal inspection and mapping.

The Welland Canal connects Lake Erie to Lake Ontario and is key to the St. Lawrence and Great Lakes Waterway System. The 27-mile waterway allows ocean going ships access to the Midwest which would not be possible without the Welland Canal. The St. Lawrence Seaway Management Corporation manages and maintains the canal and recently invited EdgeTech to demonstrate a method to quickly survey canal crib wall structures as well as map the canal bottom for obstructions. A survey was performed with an EdgeTech 4125 system operating at 600 & 1600 kHz. The 1600 kHz frequency was used to image the Crib Walls and the resulting images were of extremely high resolution allowing full viewing of timbers, missing or damaged timbers, concrete capping deterioration as well as any other features. The second requirement was general imaging of the canal bottom to look for obstructions and debris that could be a hazard to transiting ships. In one area over a highway tunnel crossing several abandoned vehicles were located. The EdgeTech system not only showed its value at mapping the canal bottom but was very affective at producing near photo quality of vertical cribbing surfaces.

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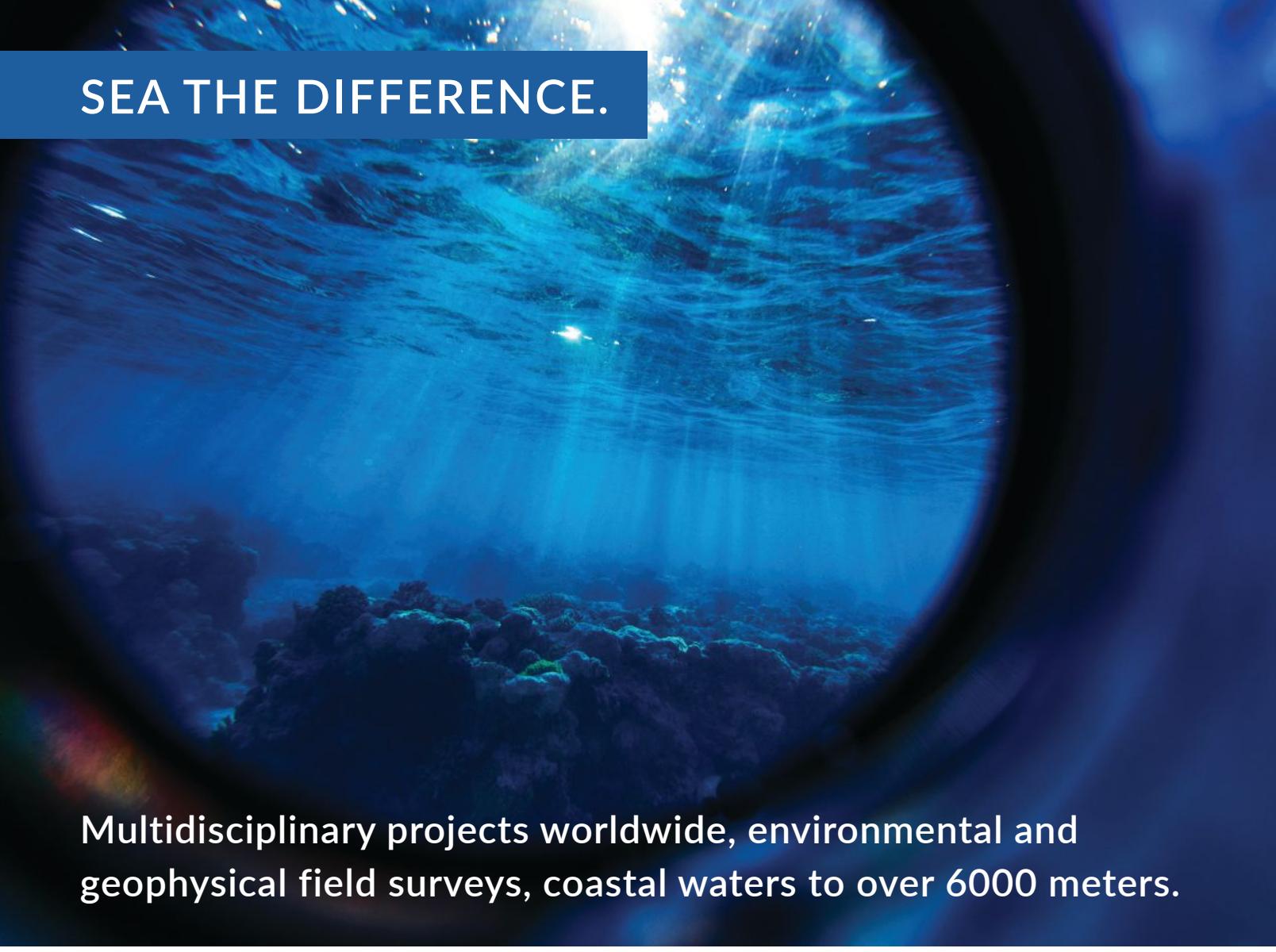
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# EXPRO AWARDED SUBSEA CONTRACT OFFSHORE MAURITANIA

Expro's Intervention Riser System (IRS)



International oilfield services company Expro has been awarded a contract by Pacific Drilling LLC's subsidiary, Pacific Santa Ana, Ltd, for the provision of an Intervention Riser System (IRS) for PETRONAS's Chinguetti Field Phase II plug and abandonment (P&A) contract, offshore Mauritania.

The contract, valued at \$20 m, will see Expro provide its IRS system with associated surface support equipment, to be deployed from Pacific Drilling's drillship, Pacific Santa Ana. The contracted work will take place for an estimated 360 days.

Worldwide Oilfield Machine (WOM) will support Expro with the provision of the subsea well access system and technical support team.

The IRS safely establishes and maintains well access throughout riser to surface operations, replicating the functionality of the blow-out preventer and providing a safe and reliable means of well control,

connected directly to the production tree. With increased coiled tubing cutting and disconnect capability, the IRS system provides an alternative dual barrier, through-tubing system.

The award includes supplying a range of services, including the subsea well access system, lubricator valve, surface flowhead, umbilicals, topsides control equipment and IWOCS (installation and workover control system) package. Expro will also provide an onshore project management team to support Pacific Drilling throughout the project planning and execution phases, based in Expro's office in Kuala Lumpur and then locally onshore in Mauritania.

Expro recently expanded its subsea intervention capabilities with the introduction of the IRS system and a Riserless Well Intervention (RWI) system, which provides a through-water integrated solution for carrying out cost effective intervention and abandonment operations on all types of subsea wells.



Colin Mackenzie, Subsea Vice President at Expro said:

"Following the recent news that we have expanded our subsea intervention capabilities with two new well access solutions, we're delighted to announce this significant contract award."

"This contract allows Expro to continue to expand our service offering to clients, and provide well access through our existing landing string technology, or now through-riser or riserless systems."

"We welcome the opportunity to support Pacific Drilling by providing our technology and services, which will enhance the efficiency and cost-effectiveness of the field P&A process from their high specification drillship."

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# BROADCASTING THE SECRETS OF THE DEEP

*Live transmissions from unexplored regions deep below the Indian Ocean underline the role that reliable high-speed broadband at sea is playing in expanding knowledge and promoting a more sustainable future.*



The remote setting creates challenges for scientists in what are increasingly collaborative endeavours, involving multi-disciplinary teams that are disparately located. Furthermore, researchers are often using advanced instruments that have never before been deployed in the field; if something goes wrong, troubleshooting can be a drawn out and frustrating process.

Until recently, a major aggravating factor has been the lack of decent communication when a research vessel is situated at some remote oceanic outpost. However, advances in satellite infrastructure and the associated onboard equipment such as antennas and terminals mean ships can now communicate in real time allowing shore-based partners to follow the excitement of a mission as it happens.

The extent to which connectivity can transform science missions at sea is clear in the Nekton Mission, which among other things marries communications with innovations in AI and Big Data to accelerate exploration and conservation of the Indian Ocean. The initial expedition in the First Descent series took place off the Seychelles in 2018. Despite having an ocean territory of 1.37 million square kilometres,

to date little research has been undertaken beneath scuba depth (30 m). A primary goal of the expedition – and those to follow – is to help establish a baseline of marine life and measure the state of the ocean, with particular focus on the bathyal zone (200 m to 3000 m) – depths richly populated with fish and other marine fauna.

The submersibles and remotely operated vehicles involved in the Nekton Mission bristle with an array of research, sampling, survey and video technologies, including 15 different camera systems that will enable scientists to create the first 3D maps of newly discovered deep sea ecosystems.

## Inmarsat Fleet Xpress Delivers

Inmarsat's Fleet Xpress maritime broadband service delivers enough performance and reliability to allow live audio and video streaming between vessel and shore, important for both research and outreach activities. High throughput makes it easier to transmit and share large datasets, while the ability to deliver real-time updates matches expectations for the hyper-connected audiences of today, raised on accessing media on-demand.

In fact, sharing footage taken from the subsea cameras in real time is an integral part of the project—and not just among fellow specialists. Images have been distributed live by media outlets including Associated Press along with a series of live subsea programmes produced by Sky News and Sky Atlantic. At one point, pictures were even beamed to the giant screens positioned above the concourses of London's major railway stations, offering commuters a live 'feed' to events unfolding deep beneath the waves on the other side of the world.

Inmarsat's VP for Offshore Energy, Eric Griffin, explains how the technology worked: "The mothership for the mission, *Ocean Zephyr*, was fitted with two high-power SAILOR100 GX antennas supplied by Cobham SATCOM that were configured to run simultaneously. One was dedicated to getting broadcast quality images back to broadcasters, while the other was reserved for data transfer and operational communications."

With a satellite-enabled link, everyone can watch the livestream—from the public to scientists who cannot participate in person. Enhanced connectivity can help the onboard team respond to the unexpected or unknown. By allowing large volumes of raw data to be speedily shared among the scientific community, the high-throughput of Inmarsat Fleet Xpress can help accelerate research. Shore-based research teams can set about analysing data while the mission is still underway, and report back to the ship if they spot something that merits follow-up.

The Nekton Mission has teamed with the University of Oxford to develop artificial intelligence tools, for example, to accelerate analysis and publication. Data will be made available through OCTOPUS – Ocean Tool for Public Understanding and Science. The Nekton Mission's organizers also create opportunities for marine scientists based in the Seychelles to participate in the expedition. This capacity-building fosters the leadership, tools, skills, knowledge and networks needed to empower long-term sustainable ocean governance. Together with datasets and research findings emerging from the expedition, this inclusive approach is intended to support the Seychelles in implementing a Marine Spatial Plan, which will see around one-third of its national waters protected. To learn more about the Nekton Mission, visit: [nektonmission.org](http://nektonmission.org).

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# THE CASE FOR UNMANNED SURFACE VEHICLES IN FUTURE MARITIME OPERATIONS

*A common unmanned surface vessel could accomplish a broad set of missions by swapping out mission-specific equipment.*

By Wayne Prender via the Center for International Maritime Security (CIMSEC)



» Common Unmanned Surface Vehicle. Image courtesy of Textron.

As U.S. naval forces further develop and implement distributed maritime operations concepts to address great power competition with Russia and China, more ships spread across wider distances will be required. This, in turn, will lead to a changing fleet composition with larger numbers of small ships and vessels of all types, as well as provide the additional required logistical support over expanded distances. Far greater participation of unmanned surface vehicles (USVs) of all types will be needed as a part of this new construct due to budgetary necessity and operational imperative.

While new unmanned ships, such as those planned under the Medium USV and Large USV programs, are expected to be fielded in the dozens, smaller unmanned vessels and craft numbering in the hundreds can play vital complimentary roles. Already, the Navy has USV programs underway that will help remove humans from dangerous operational environments, such as minefields. Additionally, concepts are under development for similar platforms to extend the fleet's reach through a range of networked sensors and weapons.

The quickest, best value, and lowest risk path forward to developing long-term solutions for new missions is to adapt existing, proven, and already paid-for unmanned vehicle designs by swapping out their mission-specific equipment. The idea is to use a common unmanned vessel that can easily and quickly incorporate a variety of payloads for diverse mission sets, or haul people and material in the payload bay area.

In the case of the Textron Systems' Common Unmanned Surface Vehicle (CUSV), which was selected under competition as the platform for the Navy's Unmanned Influence Sweep System (UISS) program, payloads are rapidly interchangeable. Much like a standard International Standards Organization (ISO) shipping container that can be quickly moved via crane onto and off of a tractor trailer, the CUSV uses ISO locks and standard electrical interfaces so that payloads can be changed rapidly, allowing mission flexibility. Unmanned craft such as the CUSV, which offer large amounts of electrical power as well as 5,000 pounds of payload capacity, can serve as the basic "trucks" for carrying a wide variety of potential mission packages that are tailored for specific tasks.

## New Missions: Endless Possibilities

To date, naval plans for such USVs have been limited to the mine-countermeasures (MCM) mission areas, with the UISS initially intended for mine-sweeping. With that program being subsumed into the MCM USV program, mine-hunting payload options are being added and mine-neutralization equipment is being envisioned, which would facilitate the entire detect-to-engage process in a single MCM sortie.

While taking the man out of the naval minefield was a natural first mission to address, U.S. naval forces have only begun to scratch the surface of what USVs of all sizes can accomplish. In 2017, Textron Systems and the Naval Surface Warfare Center-Dahlgren established a Cooperative Research and Development Agreement (CRADA), which allows for the exploration of advanced missions, concepts, and capabilities. Initial explorations have evaluated different payloads for a Surface and Expeditionary Warfare Mission Module that could counter fast-attack craft and swarming boats, as well as provide armed escort. Payloads, such as an



» Medium Displacement Unmanned Surface Vehicle (MDUSV) prototype Sea Hunter pulls into Joint Base Pearl Harbor-Hickam, Hawaii on Oct. 31, 2018. Photo courtesy of US Navy.



» An Expeditionary Warfare Unmanned Surface Vessel (USV) autonomously navigates a predetermined course through the water during Advanced Naval Technology Exercise 2019 at Camp Lejeune, N.C. July 12, 2019. ANTX East 2019 is an event designed to test new technology with academic, industry and Navy participants. Photo credit: LCpl. Nicholas Guevara, USMC.

integrated remote weapon station (RWS) armed with .50 caliber machine gun, have already shown during mock intercepts that the craft can identify, lock, and maintain a fix on a moving target. Integration of a Hellfire missile is planned, and other lethal payloads such a 30 mm cannon, low-cost loitering munition, or even larger systems like the Naval Strike Missile, could be considered.

Such capabilities would allow the USV to support a wide array of missions. For example, a USV carrying a mix of armament, such as .50 cal RWS, combined with non-lethal capabilities would give operators a range of engagement escalation options during the conduct of harbor patrol, port security, or counter-piracy escort duties. For more stressing force protection, armed interdiction and escort missions, those payloads could be exchanged for a launcher carrying Hellfire missile or other armaments.

The craft does not need to carry a mission package to be useful. Its empty payload areas can haul cargo for resupply and logistics – a capability that will be in greater demand as part of distributed operations. Similarly, a USV in "cargo configuration" could be of significant utility during humanitarian operations, delivering supplies to needy areas, and evacuation of people under duress.

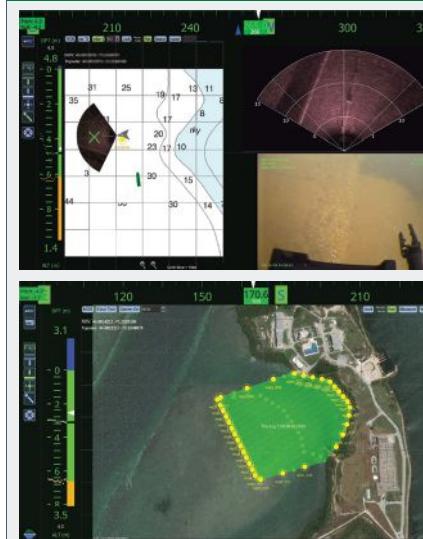
With significant excess onboard power and substantial available space and weight, such USVs could also be equipped to conduct electronic warfare; pull an anti-submarine warfare sensor array; host intelligence, surveillance and reconnaissance sensors; or carry a communications relay payload. This is just the beginning of exploring the art of the possible. The best way to quickly determine the most promising technologies and concepts is to get a number of the craft into the water for experimentation.

#### Not Just for Littoral Combat Ship (LCS)

Consideration needs to be given regarding how a CUSV-sized craft can support a variety of new roles and missions. Although the MCM USV program envisions the craft as being initially operated from the LCS, recent demonstrations have shown such USVs are not limited to just that class. In fact, the Royal Fleet Auxiliary Ship *Mounts Bay* successfully operated the CUSV during a recent naval experiment. The USV can also been deployed off the shore, as well as from additional platforms which have a crane or wet dock. For example, the CUSV has demonstrated this concept operating off the Expeditionary Transfer Dock USNS *John Glenn*. While a forward operating base or mothership is needed for the craft of this size to be forward deployed, several options are worth considering. Depending on the specific mission profile, such craft typically operate for approximately eight-hour sorties between refueling.



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» Combatant Craft Division, a detachment of Naval Surface Warfare Center, Carderock Division, demonstrates the Unmanned Surface Vehicle Lab Afloat on July 17, 2019, during the Advanced Naval Technology Exercise (ANTX) East in Camp Lejeune, N.C. The USV Lab Afloat is a key component to the USV Autonomy Lab and Integration Center, and while at ANTX East, the boat docked itself autonomously. Photo credit: Kelley Stirling, U.S. Navy.

Additionally, refueling does not need to be provided by specific manned ships, but could instead come from a wider variety of places. Imagine, for example, a future destroyer escorted by 10 to 20 armed USVs operating as part of a distributed operating concept. Each of those USVs could, in turn, be a mothership for additional smaller unmanned craft (unmanned aerial systems, unmanned underwater systems and USVs), that are netted together to create a truly layered defense. These smaller craft, if autonomously refueled, including by the larger medium and large USVs, could potentially stay on station for days, weeks, or even months without needing to return to port.

#### Ready Technology: Powered by Artificial Intelligence (AI)

The basic building blocks of AI technology that will enable such operations already exist. USVs have demonstrated during naval experimentation that they are fully capable of autonomous navigation and seakeeping operations, collision avoidance, and International Regulations for Preventing Collision at Sea (COLREGs) compliance, and that evolution continues. At the upcoming Advanced Naval Technology Experiment (ANTX) at Camp Lejeune this summer, the CUSV was put through its paces to demonstrate that these craft possess operational maturity in their ability for autonomous basic operations, as well as advanced concepts such the hand-off of control of the craft to another platform to test manned-unmanned teaming concepts.

Improvements and evolution of AI technology will add capabilities to these craft in many areas. It will help increase the level of autonomy in the craft such that it can be operated without need for human intervention in its basic movements and navigation. This will, in turn, reduce the operational burden on a craft operator and could lead to additional manpower reductions. While most missions will require one person to operate the vessel and another operator for the payload, decision tools enabled by AI could make a single operator feasible.

Consider, for example, how commercial companies like Waymo plan to use a controller to oversee a fleet of road vehicles. Future control technologies could also enable one operator to control multiple craft simultaneously, allowing their teammates to focus on the payload sensor or weapons. These control technologies do not have to be restricted to USVs. Textron Systems' Synturian family of multi-domain control and collaboration technologies can control craft such as CUSV, as well as various unmanned aircraft systems, raising the possibility of seamless control for a multitude of different systems.

Advances in AI will also be vital in providing USVs with self-diagnostic technologies for predictive maintenance. Combined with increase component reliability, these technologies will enable craft to go longer between maintenance periods while more predictably knowing when that maintenance is needed. Such logistical schemes, in addition to autonomous refueling, are a key to the future ability of USVs to stay on station for longer durations.

#### Ramp Up Experimentation

Technological advances, fiscal pressures, and rising peer competitor capabilities suggest that the Navy must adapt its core warfighting strategies and concepts, and a changing fleet composition to one that uses unmanned platforms of all types and sizes to a greater degree. For all the excitement that USVs and the attenuate technologies bring, the details of how best to leverage those vessels are still in their infancy. Experience has repeatedly shown that the best way to generate and test new warfighting concepts ideas is through experimentation, specifically done at sea by Sailors themselves. Fortunately, the Navy has the Other Transactional Authorities (OTA) mechanism at its disposal, a ready-made and proven means to quickly procure prototypes for such experimentation while longer-term concepts and requirements are refined.



» Vice Adm. Rich Brown, Commander, Surface Force, U.S. Pacific Fleet, passes through sideboys during the establishment ceremony of Surface Development Squadron (SURFDEVRON) ONE at Naval Base San Diego May 22. SURFDEVRON ONE will integrate unmanned surface vessels (USV) and support fleet experimentation to accelerate delivery of new warfighting concepts and capabilities to the fleet. Photo credit: Mass Communication Specialist 1st Class Woody S. Paschall, U.S. Navy.

Specifically, getting USVs of all types into the hands of Sailors and planning for increased experimentation will provide insights into key questions such as which missions the various unmanned craft should undertake, and how those vessels best fit into the wider naval tactical and operational construct. Development of those new doctrines, strategies, and tactics is needed, and with rapidly developing technologies and capabilities of potential adversaries, we no longer have the luxury of time to go through the traditional, decade-long requirements and acquisition process just to get the first iteration of new systems to the fleet for experimentation.

While it is encouraging to see Navy plans to move quickly to bring initial Medium and Large USVs into the fleet, other unmanned platforms are equally ready for such an approach. Innovation is the key to shaping tomorrow's Navy, and getting USVs of all shapes and sizes to the fleet for Sailors to try out is the best approach to achieving it.

**ABOUT THE AUTHOR:** Wayne Prender is Senior Vice President of Applied Technologies & Advanced Programs (ATAP), as well as a member of the Textron Systems Executive Leadership Team. Prior to assuming his current position, Prender served as Vice President, Control & Surface Systems for Textron Systems' Unmanned Systems business, focusing on programs including the Common Unmanned Surface Vehicle (CUSV), Cased Telescoped (CT) weapons and ammunition, and Command and Control (C2) Technology programs. He also served in the U.S. Army as a Platoon Leader, Shop Officer, Battalion Intelligence Officer in Iraq, where he was awarded the Bronze Star, and Aide-de-Camp for the Commanding General of the U.S. Army's 20th Support Command (CBRNE). Prender holds a Bachelor of Science degree in Mechanical Engineering from St. Louis University, and a Master of Science degree in Technology Management and an MBA from the University of Maryland (UMUC).

**EDITOR'S NOTE:** Ocean News & Technology is partnering with the Center for International Maritime Security (CIMSEC) to increase awareness of defense technology topics. ON&T reprints this article, which first appeared on the CIMSEC website, with permission. CIMSEC is a 501(c)3 non-partisan think tank with over 800 members in more than 30 countries. CIMSEC does not take organizational positions and encourages a diversity of views in the belief that a broad range of perspectives strengthens our understanding of the challenges and opportunities in the maritime domain. To learn more, visit [cimsec.org](http://cimsec.org).

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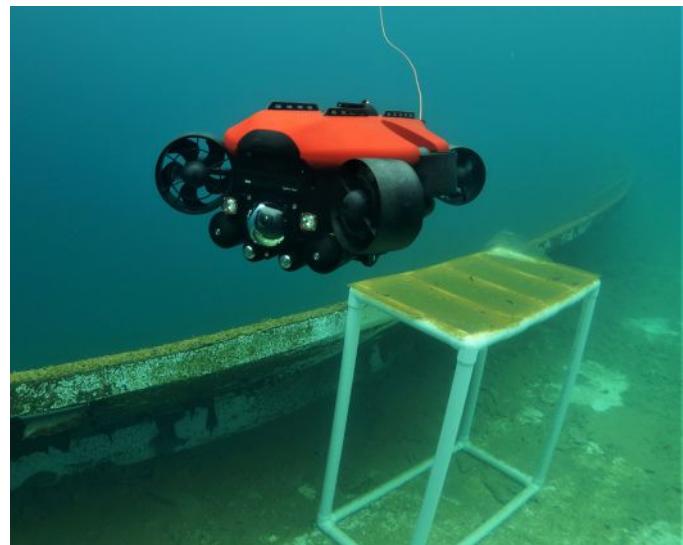


## SRS FUSION, THE U.S. NAVY'S NEXT GENERATION ROV

Strategic Robotic Systems (SRS) is pleased to announce the United States Navy has chosen to procure the company's FUSION unmanned underwater vehicle to be their future explosive ordnance disposal (EOD) remotely operated vehicle (ROV) with initial deliveries commencing in the third quarter of 2019.

The SRS FUSION represents the next generation in expeditionary-capable, compact, remotely operated underwater systems. As a fully battery powered system the FUSION has an ultra-compact footprint, rapid setup and extended excursion capability. Advanced supervisory control, expandable payload bay and benchmark intuitiveness combine to enhance the warfighters field readiness.

While primarily developed for this application, the capabilities of the FUSION vehicle make it highly suitable for a variety of roles in both the defense and security arenas including very shallow water (VSW), littoral mine counter measures (MCM), lost object search, hull survey, damage assessment, and



casualty recovery. Military and civil end users include special forces, ship's husbandry units, Coastguard and salvage units.

Through an extensive characterization process conducted by the U.S. Navy, the FUSION underwent a series of tests to determine its viability as a future system to aid in a variety of EOD related missions. Tests included empirically led trials and reliability/maintenance assessment; all at the hands of fleet operators that exercised the system against simulated missions. FUSION was evaluated to verify its simplicity of deployment, ease of operation and mission execution capabilities. The evaluation team comprised technical experts, field operators, trainers and EOD specialists.

The specification, characterization and procurement process was facilitated through the Defense Innovation Unit (DIU) which allowed SRS to openly communicate with the end user throughout the process. This communication ensured the FUSION met the requirements set forth by PMS-408 (Expeditionary Missions) and the fleet. Throughout the resultant five-year contract SRS will be honored to support the U.S. Navy's warfighter and other Department of Defense agencies.

SRS President Jesse Rodocker commented "FUSION is the culmination of many years spent developing ROV's for military applications. Having been heavily involved in the design of the U.S. Navy's previous underwater vehicle, it is a particular honor to see the next generation adopted into service. Listening to the operators and working alongside them has helped SRS understand the key requirements for effective EOD operations, and FUSION embodies all of that important learning. We look forward to continuing to develop the capability as new technologies become available and commit ourselves to the effective execution of this contract."

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# U.S. NAVY AWARDS BAE SYSTEMS \$70 MILLION CONTRACT

BAE Systems will deliver five Mk 45 naval gun systems to the U.S. Navy under a recently issued \$70.6 million contract to upgrade existing guns to the Mod 4 configuration, increasing their firepower and extending their range.

The Mk 45 is the lightest, most compact, and most widely deployed 5-inch fully automatic naval gun in the world, with more than 260 deliveries to the U.S. Navy and the navies of 10 other allied nations. The Mod 4 configuration consists of a structurally strengthened gun mount that increases firing energy by 50 percent, enabling munitions to travel faster and farther. A new fully digitized control system provides significantly greater computing power and features a touch-screen user interface.

The Mod 4 upgrade is a cost-effective solution to increase capability and adaptability for advanced munitions. The modernization of these gun systems will keep them in service for decades to come. Mk 45 guns are deployed on the Navy's fleet of guided-missile Ticonderoga-class cruisers and Arleigh Burke-class destroyers.

Work on the Mk 45 Mod 4 upgrades will be performed at the BAE Systems facility in Louisville, Kentucky, with support from the company's supplier base, and is expected to be completed by the end of 2023.

For more information, visit  
[WWW.BAESYSTEMS.COM](http://WWW.BAESYSTEMS.COM)



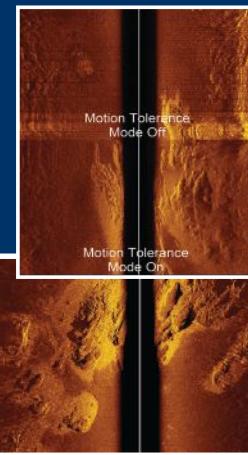
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# THE STRUGGLE BETWEEN SUPPLY AND DEMAND, WITH A PINCH OF GEOPOLITICS

## Trade Tariffs, Iranian Aggression And Opec Deal Each Having Impacts On Oil Prices

BY G. ALLEN BROOKS | Author, *Musings From the Oil Patch* | [www.energymusings.com](http://www.energymusings.com)

### Oil Market

The past month saw an intriguing struggle between the forces of oil supply growth and demand, as well as those of geopolitical events. This wrestling match produced days when oil prices rose sharply and days when they fell equally as hard. In the end, the weight of geopolitical developments reversed oil price's downward momentum, lifting prices by roughly 10% by mid-July. Thank the mullahs of Iran for higher prices.

The dominant event shaping the investment world this year has been the trade tariffs the Trump administration has levied on many of the United States' major trading partners. Regardless of whether this negotiating strategy is appropriate or not, their implementation and threats of additional tariffs has chilled global trade, producing a slowdown in global economic activity. Concomitant with the economic slowdown has been weakening oil consumption growth. Without a corresponding reduction in global oil supply, the pendulum in the oil market is poised for lower prices as the global oil glut grows.

The tone of the oil market dramatically changed when news reports told of attacks by Iran's Islamic Revolutionary Guard against two western oil tankers traveling in international waters in the Persian Gulf. Geopolitical tensions escalated. The drumbeats for a Middle East war grew louder and global oil prices jumped. Experienced oil forecasters and traders were surprised prices didn't go higher. In fact, adding to the geopolitical tension was a budding Gulf of Mexico hurricane that eventually shut in one million barrels a day of U.S. oil output, while also delaying oil shipping traffic. Despite all these pressures, crude oil prices failed to reach or exceed their recent high, let alone the peak price experienced in the past 52 weeks. This event has experts wondering what message they should take away from the oil price action of the past few weeks in light of events.

The late June agreement between Russia and OPEC to extend the existing 1.2 million barrel a day production cut, this time for nine months, carries the reduction through the first quarter of 2020. A disagreement emerged among the parties over the possibility of further production cuts being required, or at least a longer extension of the current cut. The disagreement was over OPEC members needing higher oil prices to satisfy their budget needs, while Russia desires to expand its oil exports. In reality, this debate is core to the question about future oil demand and supply dynamics. Remember, output in the U.S. continues growing, adding to the current global oversupply. At the same time an oil

glut exists, Iran's exports are sanctioned so their volumes are lower, Venezuela's output is at historical lows, and sporadic interim production outages in Nigeria and Libya continue. If demand fails to grow, and global financial institutions are already marking down their economic growth forecasts for the balance of 2019 and 2020, the oil market has a serious problem.

### Natural Gas

For a brief period, the natural gas market came to life - at least when measured by the rise in Henry Hub gas prices. At the end of the third week of June, natural gas prices fell from the \$2.30's per thousand cubic feet per day to \$2.15. They then jumped into the \$2.40s as a heat dome settled over the middle of the U.S. before spreading eastward.

Gas prices gained momentum, reaching nearly \$2.50 when Hurricane Barry formed and began making its way toward the Louisiana coast. What was dramatically different this time from prior hurricanes was that gas prices barely moved. In 2005 and 2008, when hurricanes Katrina and Rita landed on the Gulf Coast, gas prices soared to \$10/mcf. This different price performance says volumes about how the natural gas market has changed in the past decade due to the shale revolution.

Another example of the changed gas market was the Energy Information Administration's report that 90% of the gas consumed in the U.S. last year was produced domestically. That trend came at the same time the U.S. was sharply growing shipments of liquefied natural gas. In January 2018, LNG exports accounted for 2.4% of daily gas production. That share increased by December 2018 to 3.7%, at the same time total gas production grew by over 13% during the year. Through April 2019 (the latest data available), LNG exports represented 3.9% of production that had increased from last December by 1.6%.

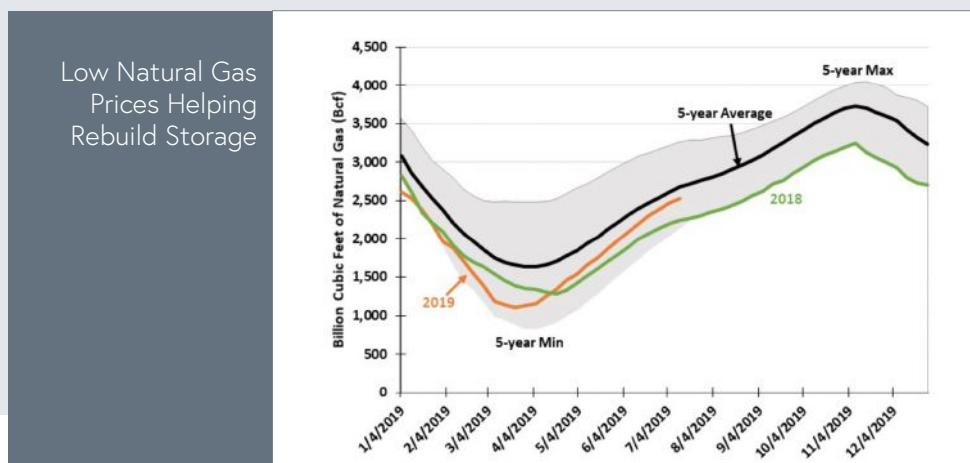
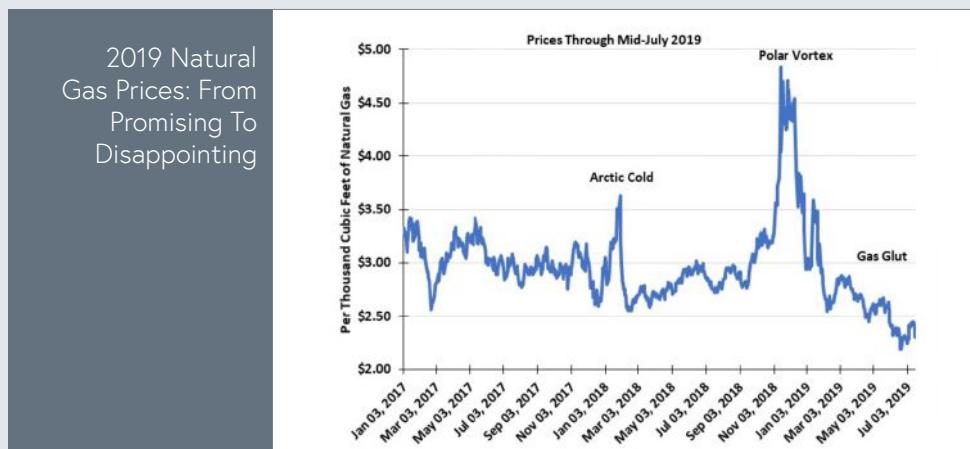
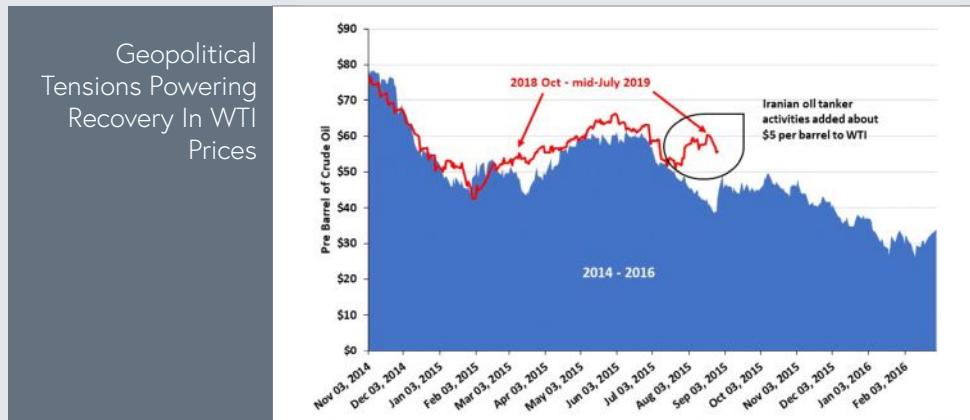
Absent growing LNG export volumes, combined with increased supplies being shipped by pipelines to Mexico and Canada, gas prices would have been weighed down even more. With the heat dome gone and temperatures more in line with traditional summer weather, people are worried gas prices may break the \$2/mcf mark, an issue we had raised earlier.

As Permian Basin crude oil drilling fell throughout the last half of 2018 and so far in early 2019, associated natural gas volumes are being limited. Without sufficient pipeline capacity to move

the greater gas output from the basin to market, gas flaring remains high. With new pipelines, that flared volume will become marketable, further pressuring gas prices.

With healthy gas production growth and only reasonable demand increases – both for electricity generation due to hot weather and pipeline and LNG exports – gas storage has been the beneficiary. Low gas prices are encouraging producers to

stuff more of it into storage, hoping for increased profitability in the upcoming winter. Given these market trends, gas storage is coming closer to the 5-year average, suggesting we will end the injection season with greater gas volumes in storage than last year. While "boring" may continue to characterize the natural gas market, many will be watching to see if the \$2/mcf barrier is breeched.

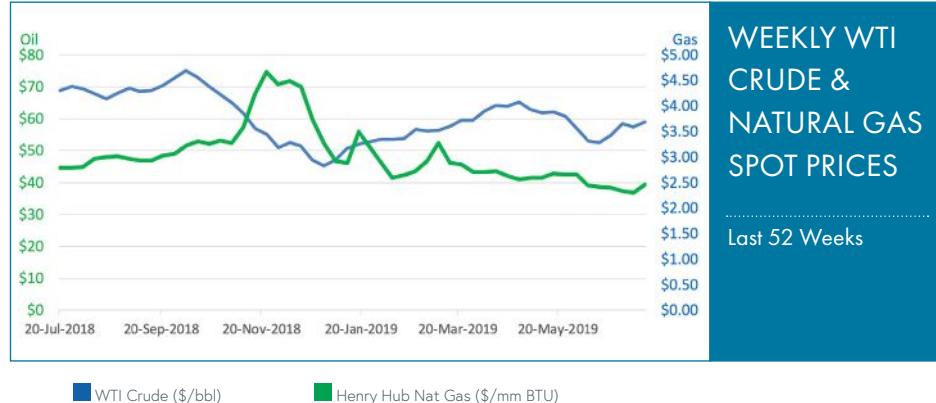


# CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF JULY 12, 2019

Oil prices moved upward in the last month after a steep drop the previous month, regaining most of the losses. Prices closed on July 15 at just below \$60 per barrel. Tensions between the United States and Iran caused some of the increase, but Morgan Stanley said that prices will remain "relatively benign" in spite of the tensions.

Natural gas prices were largely flat for the past month. The Royal Bank of Canada projected that the current supply oversupply will continue into the 2020s.



## KEY EQUITY Indexes

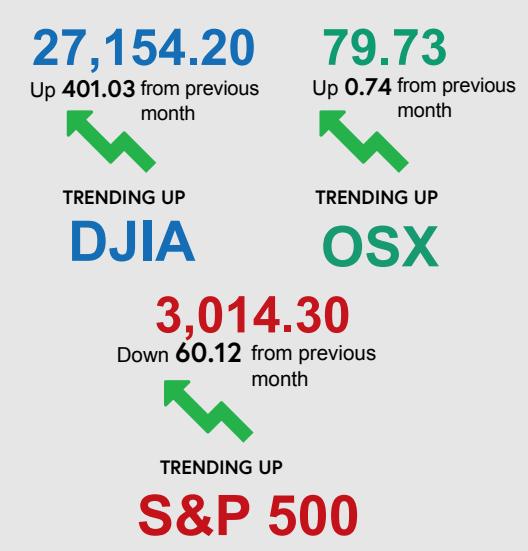
PRICES IN US DOLLARS AS OF JULY 15, 2019

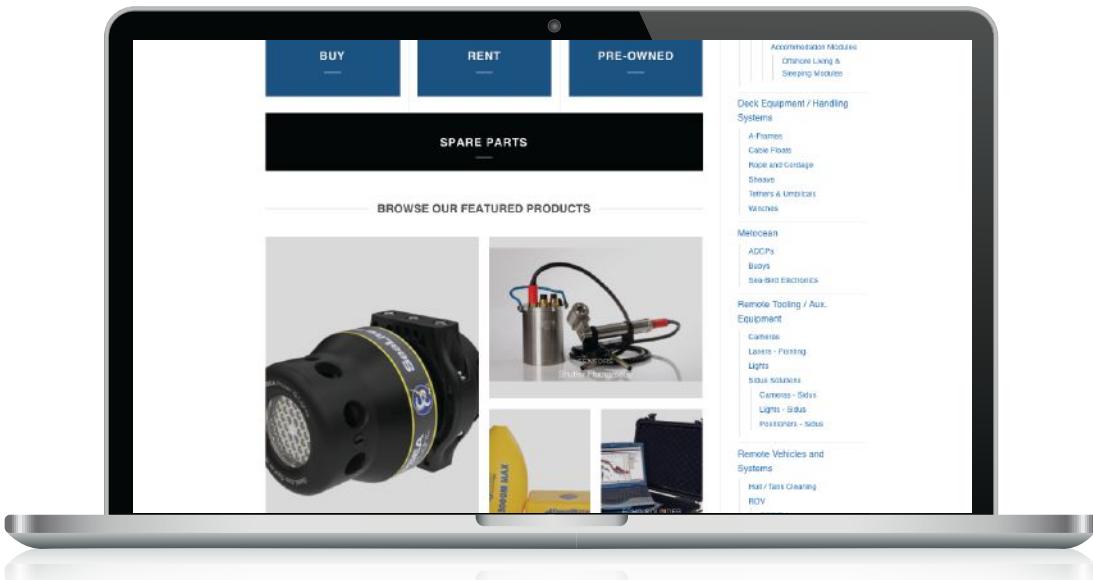
### THE DOW JONES INDUSTRIAL AVERAGE AND S&P 500 have fallen significantly in the past month

The Dow Jones reached record highs in July as the index passed the 27,000-point mark. Strong second quarter corporate earnings accounted for much of the gains. The S&P 500 also reached record levels and surpassed the 3,000-point mark in early July.

In spite of the strong gains in the Dow and S&P, the Philadelphia Oil Service Sector Index (OSX) was mostly flat for the last month. The OSX briefly passed the 80-point mark but slipped back to just below 80 points by the middle of the month. The overall trend for the last two months, however, has been up from the mid-70s in June.

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[www.mari-techconference.ca](http://www.mari-techconference.ca)

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[www.2019.otcnet.org/](http://www.2019.otcnet.org/)

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### **OMAE**

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[www.event.asme.org/OMAE](http://www.event.asme.org/OMAE)

### **OCEANS '19 Europe**

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[www.oceans19mtsieemarseille.org](http://www.oceans19mtsieemarseille.org)

### **European Wave and Tidal Energy Conference**

Napoli, Italy » September 1-6  
[www.ewtec.org/conferences/ewtec-2019](http://www.ewtec.org/conferences/ewtec-2019)

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[www.gssummit.org](http://www.gssummit.org)

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## AUSTRALASIA

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[www.terrapinn.com/conference/submarine-networks-world/index.stm](http://www.terrapinn.com/conference/submarine-networks-world/index.stm)

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<b>OCTOBER</b>		
» Ocean Science & Technology	Acoustic Modems; Acoustic Releases, Transponders, Command & Control Systems; Technical Schools, Training Programs	OCEANS » October 28-31 BlueTech Week » November 18-22
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# innovation out of the blue

January 14 - 16, 2020

Salve Regina University, Newport, Rhode Island

The Blue Innovation Symposium is New England's premier event for connecting the marine technology industry. 2020's agenda is set to gather leading-edge marine technology companies to discuss key trends in the industry, showcase start-up companies and emerging technologies, and connect key stakeholders from industry, research organizations, and state and federal agencies.



[blueinnovationsymposium.com](http://blueinnovationsymposium.com)

## BLUE INNOVATION SYMPOSIUM TO HIGHLIGHT EMERGING OFFSHORE TECHNOLOGY

One of the premier ocean technology gatherings in the Eastern United States will be held January 14 - 16, 2020 in Newport, Rhode Island.

Organized by Salve Regina University and sponsored by the Consulate General of Canada in Boston, the Blue Innovation Symposium is the largest event in New England for connecting the marine technology industry for education, networking and facilitating partnering opportunities.

### Connecting Key Stakeholders

The symposium brings together leading-edge marine technology companies with programming aimed at providing an overview of current trends in the industry, and a showcase of start-up companies to discuss their new technologies. As with previous years, organizers anticipate more than 200 attendees with three dozen corporate sponsors. Also, the government of Canada will bring a delegation of marine technology companies to participate in the conference.

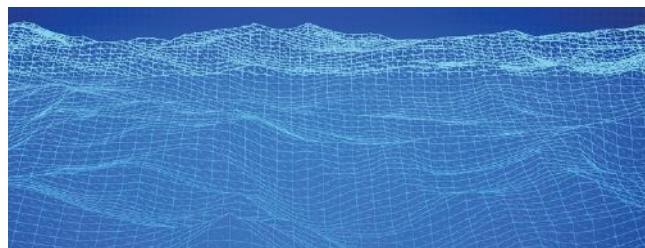
The Blue Innovation Symposium is organized by Salve Regina's Office of Graduate Studies and Continuing Education as part of their effort to connect the University with industry, organizations, state and federal agencies, and other key stakeholders in order to grow the region's economy.

### Where Start-ups Meet Major Players

Event founder Tobias Stapleton, who also serves on the Editorial Board for ON&T, has long championed technology incubation and partnership. For example, before coming to Salvia Regina, Stapleton rebranded and reinvigorated the UMass Center for Innovation and Entrepreneurship. That center graduated numerous successful start-ups who developed innovative technology, such as underwater vehicle manufacturers OceanServer (acquired by L3) and Aquabotix, and renewable energy pioneers Ocean Renewable Power Company (ORPC) and Resolute Marine.

This success led to Stapleton founding what was then called the Maritime Innovations Conference, and which has since morphed into the Blue Innovation Symposium. Aside from notable speakers, expert panels, and topical workshops, the event provides numerous opportunities for startup companies to discuss their own innovative technologies, including exhibition space, 'flash talks,' and networking events. It's a can't miss event for ocean technology companies interested in fostering partnerships.

Information about how to register for the event will be posted at [www.blueinnovationsymposium.com](http://www.blueinnovationsymposium.com). You can also stay informed by reading the ON&T newsletter. As official partners of the event, our staff looks forward to meeting the innovative companies, both small and large, at the Blue Innovation Symposium.



## NEW AWARD FOR STUDENTS NAMED TO HONOR FAMED OCEANOGRAPHER WALTER MUNK

This week at the MTS-OES OCEANS Marseille conference, in France, the Marine Technology Society and the Walter Munk Foundation for the Oceans announced their establishment of the Walter Munk Scholar Award.

The newly created award honors centenarian Walter Munk's legacy of daring exploration and discovery through ocean science and technology research as well as his dedication to ocean education and conservation.

Munk authored more than 200 scientific research papers from 1941 ("Internal Waves in the Gulf of California" in the Journal of Marine Research) to his last publication, 2015's "Multipurpose Acoustic Networks in the Integrated Arctic Ocean Observing System." His seminal work in wave forecasting was instrumental in planning the Allied Forces invasion of Normandy (D-Day) which hastened the end of World War II.

The award will be presented annually to a scholar enrolled in an undergraduate, graduate, or postdoctoral program in ocean science, technology, exploration or conservation, recognizing their outstanding achievements.

"MTS is honored to memorialize Walter's legacy and help nurture the next generation of ocean leaders," said Rick Spinrad, president of MTS.

The inaugural award was presented to Alfredo Giron at the OCEANS Conference in Marseille. Giron received his Ph.D. in March from the Scripps Institution of Oceanography. After receiving the award, Giron presented his commemorative lecture, "The Risk of Oversimplification in Fisheries Management." This lecture was the first in what will become the annual Commemorative Walter Munk Scholar Lecture Series, presented by the award recipient at the annual conference.

"Reading about his life and his scientific achievements seemed like the greatest science novel ever written. And yet, all these biographies and research papers were only a very small part of what Walter truly represented (and still does). I feel very honored and humbled to receive an honor in his name," said Giron.

Learn more about the Walter Munk Scholar Award and Commemorative Lecture. Nominations for next year's award will be accepted from January 1 – May 31, 2020. For eligibility and nomination instructions, visit [www.mtsociety.org/awards-honors](http://www.mtsociety.org/awards-honors).

### About the Marine Technology Society

Founded in 1963, the Marine Technology Society is a nonprofit international community of ocean engineers, technologists, policymakers and educators that provides the ocean community with forums for the exchange of information and ideas through international conferences, its peer-reviewed MTS Journal, newsletters and website, [www.mtsociety.org](http://www.mtsociety.org).

## BAE SYSTEMS ACQUIRES RIPTIDE AUTONOMOUS SOLUTIONS BUSINESS

BAE Systems, Inc. has purchased the key assets of Riptide Autonomous Solutions (Riptide), a Plymouth, Massachusetts-based provider of innovative, affordable unmanned underwater vehicle (UUV) technology and solutions. Specializing in small UUVs, Riptide's platforms are sophisticated yet simple, efficient, and highly flexible, offering performance discriminators within this domain that include greater depth, range, endurance, and speed.

Riptide employees will join the BAE Systems Electronic Systems sector, many as part of the FAST Labs™ organization, where our scientists and engineers innovate capabilities to address some of the toughest challenges in the defense, aerospace, and security domains. The FAST Labs team looks forward to maturing Riptide's platform technology,

demonstrating new solutions, and scaling manufacturing production. This is consistent with our strategy to acquire and incubate small business innovations that can yield disruptive technology breakthroughs for BAE Systems programs of record.

In an official press release, BAE said that they expect to maintain the Riptide facilities in Plymouth, Massachusetts, further expanding their footprint in the New England area.

Headquartered in Nashua, New Hampshire, BAE Systems Electronic Systems is a premier provider of commercial and defense electronics for flight and engine control, electronic warfare, surveillance, communications, geospatial intelligence, and power and energy management.



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## MORGAN & EKLUND NAMES DIRECTOR TO OVERSEE MARKET EXPANSION

Morgan & Eklund, Inc (M&E), a Florida-based land and hydrographic survey firm specializing in coastal and nearshore areas, have hired Robert Collaro, GISP, as the Director of Hydrographic and Land Survey Business unit.

"2019 has been extremely busy for us and we want to continue that inertia. And to do that, we need to bring in talent. We are thrilled that Robert is joining our team and his experience will help us to continue growing our business," said John Morgan II, president of M&E.

Collaro brings over 15 years of experience in Coastal Engineering and Hydrographic Surveying to M&E. Collaro has worked on a variety of high-profile project such as harbor deepening projects for large domestic dredging companies, to private equity funded, multi-organizational projects. He also has experience on dredges and hydrographic survey vessels

in addition to FEMA, USACE and State agency projects. Prior to joining M&E, Collaro was a Senior GIS Analyst and Environmental Specialist. Collaro is a Certified GIS Professional and has his Remote Pilot Certification (sUAS) as well as numerous industry certifications.

"I am well aware of M&E's reputation for high quality and I'm more than happy to bring my experience to a team that is equally passionate about growth, success, and customer service," Robert said.

Morgan and Eklund continues to grow as they leverage their experience in Florida surveying and Robert's presence will allow M&E to develop and take advantage of emerging opportunities outside of Florida and Puerto Rico. For more information, visit [www.MorganEklund.com](http://www.MorganEklund.com).



» Robert Collaro, Director of Hydrographic and Land Survey Business unit



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## OCCIDENTAL COMPLETES ACQUISITION OF ANADARKO

Occidental Petroleum Corporation has announced the successful completion of its acquisition of Anadarko Petroleum Corporation in a transaction valued at \$55 billion, including the assumption of Anadarko's debt.

"With Anadarko's world-class asset portfolio now officially part of Occidental, we begin our work to integrate our two companies and unlock the significant value of this combination for shareholders," said Vicki Hollub, President and Chief Executive Officer. "We expect to deliver at least \$3.5 billion annually in cost and capital spending synergies and the focus of our Board and management team is on execution to achieve the promise of this exciting combination. We look forward to updating the market on our continued progress in the months ahead."

The closing of the transaction follows approval of the transaction by Anadarko's shareholders at a Special Meeting held earlier today. More than 99% of the shares voted at the Special Meeting were in favor of the Occidental merger agreement.



Anadarko shareholders are receiving \$59.00 in cash and 0.2934 shares of Occidental common stock per share of Anadarko common stock in the transaction. Going forward, Anadarko's common stock will no longer trade on the New York Stock Exchange.



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Website: www.hightechincusa.com

Contact: Glenn Pollock



Experts in rugged marine sensor systems utilized in geophysical surveys, anti-submarine warfare, marine mammal monitoring and downhole applications. Products include data acquisition systems, hydrophones, array cables, pressure vessels and peripherals related to marine systems.

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Teledyne Marine is a group of leading-edge subsea technology companies that are part of Teledyne Technologies Incorporated. Through acquisitions and collaboration over the past ten years, Teledyne Marine has evolved into an industry powerhouse, bringing Imaging, Instruments, Interconnect, Seismic, and Vehicle technology together to provide total solutions to our customers.

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Nortek excels in the development and manufacture of acoustic Doppler instrumentation. Doppler Velocity Logs (DVLs) are used for subsea navigation. Acoustic Doppler Current Profilers (ADCPs) are used to understand physical processes in the ocean, rivers, lakes and laboratories. We pride ourselves on being innovative in product development and production processes. Nortek provides solutions to engineers and scientists by offering real-time data collection and support from our responsive technical team.

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Website: www.rdinstruments.com

Contact: Paul Devine



Teledyne RD Instruments, Inc., located in Poway, CA USA, specializes in the design and manufacture of underwater acoustic Doppler products and oceanographic sensors for a wide array of commercial, academic, and defense applications.

Originally founded in 1982, RD Instruments developed the industry's first Acoustic Doppler Current Profiler (ADCP). Through the years, this innovation has spawned a full line of ADCPs for current profiling in environments ranging from the shallowest stream to the deepest ocean. Expanding on this technology, the company also offers their industry-leading Doppler Velocity Logs (DVLs) for precision underwater navigation onboard manned and unmanned submersibles.

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MetOcean Telematics designs and manufactures drifting buoys, environmental platforms, and the world renowned NOVATECH locator beacon product line. In addition to providing complete end-to-end telematics services, and one of the few manufacturers in the world to achieve ISO 9001 certification. MetOcean Telematics' drifting buoy family consists of environmental and weather monitoring, oil spill response, and search and rescue drifters: NOVA profiling float, Iridium SVP (iSVP), iSPHERE, Argosphere, SLDMB, and iSLDMB.

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DeepWater Buoyancy Inc. is the world's largest producer of subsea buoyancy products for the oceanographic community and has a vast product line of buoyancy solutions for offshore oil & gas, energy and technology companies. This product portfolio has been built over the course of 35 years serving these industries. Though products are offered for shallow water applications, the company specializes in deepwater, providing solutions to depths of 6000 meters and beyond.

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Cathx Ocean design and manufacture advanced subsea imaging and precision measurement systems for subsea operations.



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The range includes the Hunter system (AUV Imaging and Laser), the Scout system (Observation Class ROV Imaging and Laser Profiling), the Pathfinder system (Work Class ROV Imaging and Laser Profiling) and the Prowler I & II systems (Towed Vehicle Imaging Range and Scale Measurement).

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For over 30 years, DeepSea Power & Light has provided high-quality and innovative products to the oceanographic community. The company's expertise and product line has grown to include underwater video systems, lighting solutions, pressure relief valves, and lasers.

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Since 1957, South Bay Cable Corp has designed and manufactured specialized electrical, electro-mechanical and electro-optical-mechanical cables for use in demanding marine environments. Cables are designed to meet customer requirements and include tether and umbilical cables for ROVs, tow cables, video inspection, faired cables and a host of other customer specific applications.

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BIRNS has served the subsea industry since 1954, and is an ISO 9001:2015 certified global leader in the design and manufacturing of high performance connectors, cable assemblies and lighting systems. With a NAVSEA PRO-020 certified molding facility, it offers sophisticated connector lines, including 6km-rated electrical, electromechanical, coaxial, electro-coax, optical, electro-optical and electro-opto-mechanical hybrids. BIRNS provides the industry's highest volume of cost-effective hydrostatic and helium pressure testing, and has a wide range of ABS Product Design Assessment (PDA) certified fiber optic and electrical penetrators. BIRNS' LED and tungsten-halogen marine, chamber, security and commercial diving lights are trusted in the world's most extreme environments.

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Teledyne Marine Interconnect Solutions integrates the resources of ODI, DGO, Impulse, and Cable Solutions into a single organization that supplies innovative, high-performance solutions for harsh environment interconnect. Solutions for these harsh environments include wet-mate, splash-mate and dry-mate connectors, pressure boundary penetrators, cable assemblies, cable terminations, and custom-engineered encapsulation and molding. TMIS contains a broad portfolio of field-proven, time-tested electrical, optical, and hybrid interconnect capabilities optimized for applications where performance and reliability are imperative. Products are available as stand-alone items, or as complex solutions that integrate technologies into advanced, value-added systems.

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The EdgeDVR is currently used worldwide by most of the major ROV and Diving contractors. With our present Version 4 software, we have 6 models. The EdgeDVR has become an essential part of any ROV and Diving system offshore, easy to use and reliable. The system is capable of recording simultaneous High Definition and Standard Definition video, together with auto creation of Dive, Video, Photo and Anomaly logs. Multi channel digital overlay is also available for all recorded channels, logos and real-time survey data can be displayed. With around 500 systems now offshore, we have a proven record of reliability.

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Okeanus is the premier rental provider for oceanographic and marine scientific research equipment utilized in nearshore and offshore projects around the world. Focused on providing industry-leading customer service, Okeanus offers advanced, high-quality technology coupled with knowledgeable and experienced staff that can deliver dedicated support regardless of a project's location.



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Ocean Specialists, Inc. (OSI) is a system development and advisory firm for undersea cable projects and technology with global capabilities. OSI works with clients during all project phases of subsea network development, from planning and design to procurement and implementation. Our customers, primarily representing Oil and Gas, Telecommunications and Ocean Observing, recognize the value of fiber optic networks to their field and services solutions, and look to OSI to deliver the skills and experience that developing these networks require.

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N-7462 Trondheim, Norway  
Tel: +47 73 54 55 00  
Fax: +47 73 51 50 20  
E-mail: km.seatex.sales@kongsberg.com  
Website: www.km.kongsberg.com/seatex  
Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



KONGSBERG

Kongsberg Seatex is a leading international marine electronics manufacturer specializing in the development and production of precision positioning and motion sensing systems. Our commitment is to provide quality products and solutions for safe navigation and operations at sea in the commercial offshore, maritime, hydrographics and defence industries.

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ATL specializes in the design/manufacture of custom bladder-type fluid containment systems, including tanks, inflatables, pillows and bellows for surface and subsea. ATL's flexible fluid containers boast unparalleled chemical tolerance, abrasion resistance, and remarkable durability - used with methanol, diesel fuel, gases, ethylene glycol, hydraulic fluids and chemical cleaning cocktails. Expedited deliveries are also available.

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8502 SW Kansas Avenue  
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Tel: +1 772 219 3000  
Fax: +1 772 219 3010  
E-mail: gstevens@conshelf.com  
Website: www.csaocean.com  
Contact: Gordon Stevens



CSA Ocean Sciences Inc. (CSA) is a marine environmental consulting firm specializing in multidisciplinary projects concerning potential environmental impacts of activities throughout the world. With extensive experience in environmental sciences and technical field operations, CSA is staffed and equipped to offer a complete range of services for projects in offshore, nearshore, estuarine, wetland, and freshwater environments.

## MARINE VENTURES INTERNATIONAL, INC. (MVI)

8524 SW Kansas Avenue  
Stuart, FL 34997  
Tel: +1 772 419 9627  
Fax: +1 772 419 9628  
E-mail: bpudney@marineventures.com  
Website: www.marineventures.com  
Contact: Bruce Pudney



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## MOTION SENSING EQUIPMENT

## KONGSBERG SEATEX AS

Pirserteret  
N-7462 Trondheim, Norway  
Tel: +47 73 54 55 00  
Fax: +47 73 51 50 20  
E-mail: km.seatex.sales@kongsberg.com  
Website: www.km.kongsberg.com/seatex  
Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



KONGSBERG

Kongsberg Seatex is a leading international marine electronics manufacturer specializing in the development and production of precision positioning and motion sensing systems. Our commitment is to provide quality products and solutions for safe navigation and operations at sea in the commercial offshore, maritime, hydrographics and defence industries.

## NAVIGATION &amp; POSITIONING SYSTEMS

## ADVANCED NAVIGATION

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Ackerstrasse 76  
13355 Berlin, Germany  
Tel: +49 (0) 30 4679 862-0  
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E-mail: sales@evologics.de  
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EvoLogics provides the world's most advanced spread-spectrum underwater communication systems (S2C) with multi-channel data management, networking capability, built-in tracking and positioning functions with USBL. Data loggers, acoustic wake-up module and releasers optionally included. Deployments in offshore platforms (FPSO, ABS), environmental monitoring, defense systems, ROV and AUV operations and more. Applications include simple positioning and sensor information to transmission of underwater photos.

## KONGSBERG SEATEX AS

Pirserteret  
N-7462 Trondheim, Norway  
Tel: +47 73 54 55 00  
Fax: +47 73 51 50 20  
E-mail: km.seatex.sales@kongsberg.com  
Website: www.km.kongsberg.com/seatex  
Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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**RJE INTERNATIONAL, INC.**  
 15375 Barranca Parkway, Ste I-112  
 Irvine, CA 92617  
 Tel: +1 949 727 9399  
 E-mail: sales@rjeint.com  
 Website: [www.rjeint.com](http://www.rjeint.com)  
 Contact: Bruce O'Bannon



RJE International offers product design, development, evaluation and marketing for military divers, offshore and marine scientific communities, search and rescue teams, and more. RJE has become the industry leader in diver navigation and acoustic relocation. Our team has an extensive background in developing, manufacturing, and supplying underwater acoustic marking and relocation systems, diver navigation platforms, and other subsea equipment.

#### NETWORK & DATA COMS

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Pirsenteret  
 N-7462 Trondheim, Norway  
 Tel: +47 73 54 55 00  
 Fax: +47 73 51 50 20  
 E-mail: km.seatex.sales@kongsberg.com  
 Website: [www.km.kongsberg.com/seatex](http://www.km.kongsberg.com/seatex)  
 Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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#### OCEANOGRAPHIC INSTRUMENTS/SERVICES

##### ASL ENVIRONMENTAL SCIENCES, INC.

Victoria, BC, Canada  
 Tel: +1-250-656-0177  
 E-mail: asl@aslenv.com  
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- **Metcean Equipment Leasing:** Acoustic Doppler Current Profiler ADCPs (including StreamPro & RiverRay), Ice Profilers, AZFP, acoustic releases, wave/tide gauges, pingers, satellite beacons, CTD+DO+Tu profilers, DO & turbidity loggers, weather station, cages, flotation, bottom frames.
- **Oceanographic Products:** Acoustic Zooplankton Fish Profiler (AZFP), Ice Profiling Sonar (IPS5) & shallow water Ice Profiler (SWIP), Imagenex scanning sonar logger (IRIS), instrument cages, bottom frames. Custom acoustic products and system integration.
- **Consulting:** Field work, data collection, analyses, numerical modelling, acoustics, remote sensing, oceanographic mooring design and system integration.
- **Manufacturer's Representative:** Teledyne RD Instruments, Deep Water Buoyancy, WERA Northern Radar.

##### NKE INSTRUMENTATION

rue Gutenberg  
 56700 Hennebont, France  
 Tel: +33 2 97 36 41 31  
 Fax: +33 2 97 36 10 12  
 E-mail: info.instrumentation@nke.fr  
 Website: [www.nke-instrumentation.com](http://www.nke-instrumentation.com)



- Fresh and marine waters multiparameter probes: CTD, dissolved oxygen, turbidity, chlorophyll, Phycocyanin, Phycoerythrin, CDOM, detection of hydrocarbons, pH, Redox.
- Dedicated monitoring data loggers and equipment for: sediment transport, underwater systems behavior, marine corrosion, pCO<sub>2</sub> sensor (stand alone or on drifting buoy), density, absolute salinity.
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- Drifting surface buoys with temperature and GPS receiver for Surface velocity project.

**RBR**  
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 E-mail: info@rbr-global.com  
 Website: <https://rbr-global.com/>



RBR creates instruments to measure the blue planet. From the ocean abyss to the polar ice caps, our sensors track water parameters – temperature, depth, salinity, dissolved gases, pH, and many others. With design and manufacturing centrally located in Ottawa, Canada, our team works in a fast-paced, dynamic atmosphere to serve customers all over the globe.

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 B0N 1Z0  
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 E-mail: Sales@romor.ca  
 Website: [www.romor.ca](http://www.romor.ca)  
 Contact: Darrin Verge, President & CEO



ROMOR Ocean Solutions provides instrumentation solutions for the geophysical, oceanographic, defense, security, oil & gas, and renewable energy industries. By partnering with world renowned manufacturers, ROMOR is able to offer technical knowledge, value added services, logistics expertise, and the most reliable instrumentation on the market.

#### SEA-BIRD SCIENTIFIC

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 Bellevue, WA 98005  
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#### STAR-ODDI

Skeidaras 12, 210  
 Gardabaer, Iceland  
 Tel: +354 533 6060  
 Fax: +354 533 6069  
 E-mail: baldur@star-oddi.com  
 Website: [www.star-oddi.com](http://www.star-oddi.com)  
 Contact: Baldur Sigurgeirsson



A manufacturer of miniature data loggers with sensors as temperature, depth/pressure, salinity, tilt/acceleration, compass direction/magnetometer, light levels, acoustic receiving/transmitting. The loggers are used for various researches, including oceanography, fishing gear studies, equipment behavioral monitoring and fish tagging.

## SONAR SYSTEMS

**ECHOLOGGER**

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Echologger represents the best quality sonar products in the market. We are a leading developer/manufacturer of high-end ultracompact echosounders and high resolution scanning sonar that are equipped with state-of-the-art features and essential functionalities to match customers' needs in affordable price.

Founded in 2009 and a company located in South Korea, and with a brand name Echologger, EoFE Ultrasonics Ltd. is a knowledge-based company that continuously designs, develops and manufactures high technology sonar devices and solutions to meet the changing needs of the customers. Having been in the industry for years, the company understands how the industry operates and what works best for the benefit of our valued customers.

**EDGETECH**

4 Little Brook Rd.  
West Wareham, MA 02576  
Tel: +1-508-291-0057  
E-mail: info@edgetech.com  
Website: www.edgetech.com  
Contact: Amy LaRose



EdgeTech designs, manufactures and sells industry-leading side scan sonars, sub-bottom profilers, bathymetry systems and combined sonar systems. Additionally, the company produces world class underwater actuated and transponding solutions including deep sea acoustic releases, shallow water and long life acoustic releases, transponders, reliable USBL acoustic tracking and positioning systems, and custom-engineered acoustic products.

**KLEIN MARINE SYSTEMS, INC.**

11 Klein Drive  
Salem, NH 03079  
Tel: +1 603 893 6131  
International: 603 893 6131  
E-mail: sales@kleinmarinesystems.com  
Website: www.kleinmarinesystems.com



Celebrating over 50 years in the marine technology industry, Klein Marine Systems continues to be a world leading sensor technology manufacturer of high-resolution side scan sonar equipment and radar-based security and surveillance systems. Klein Marine Systems has developed a worldwide reputation of excellence in the industry by providing quality products and excellent customer service. Klein sonar systems are deployed by government agencies, navies, port authorities, surveyors, oil companies and universities worldwide. Visit our web site at [www.KleinMarineSystems.com](http://www.KleinMarineSystems.com) and discover how Klein is Making the Oceans Transparent!

**MARINE SONIC TECHNOLOGY**

120 Newsome Dr. Suite H, PO Box 1309  
Yorktown VA 23692-1309  
Toll Free: +1 800 447 4804  
E-mail: Regan.Lipinski@na-atlas.com  
Website: [www.marinesonic.com](http://www.marinesonic.com)



Marine Sonic Technology builds high quality, high resolution side scan sonar systems. Located in Yorktown, Virginia, Marine Sonic has been in business for more than 25 years. Our towed systems are rugged, easy to deploy and simple to operate. We also offer highly efficient AUV/ROV embedded systems, which occupy minimal space and low power consumption.

## SOUND VELOCITY PROBES/CTDS

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Laksevag, Norway  
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• STD/CTD, Sound Velocity probes/recorder with optional multi-parameter facilities; Turbidity, Fluorescence, Oxygen etc. The new CTD/STD model SD208 with wireless communication and high accuracy: 0.002 mS/cm, 0.002 °C.

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## SUBSEA FABRICATION

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New Industries provides quality fabrication services to the offshore oil & gas and marine industries focusing on large diameter pressure vessels, suction piles, DNV buildings and deepwater subsea production equipment such as jumpers, PLETs, PLEMs and manifolds.

## SUBSEA TECHNOLOGY

**KONGSBERG MARITIME AS – SUBSEA DIVISION  
(DIVISION OF KONGSBERG GROUP)**

Strandpromenaden 50  
NO-3183 Horten  
Norway  
Tel: +47 33 03 41 00  
Website: [www.km.kongsberg.com](http://www.km.kongsberg.com)



KONGSBERG

Kongsberg Maritime is a marine technology company providing innovative solutions for all marine industry sectors including merchant, offshore, subsea, naval and fisheries. The company delivers systems that cover diverse maritime applications. Within subsea, Kongsberg Maritime's sonars, Sub-bottom profilers, multibeam and single beam echo sounders, cameras, positioning and underwater communication & monitoring systems, instruments, software and Marine Robotics are used in survey and inspection operations worldwide. Working closely with customers to develop technology that pushes the limits in subsea applications, Kongsberg Maritime is also dedicated to developing innovative environmental monitoring solutions such as the K-Lander system in addition to cutting-edge Marine Robotic platforms such as the futuristic Elume vehicle.

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[underwater-vehicles/bluefin-robotics](http://underwater-vehicles/bluefin-robotics)  
Contact: Adam Mara



General Dynamics Mission Systems' Bluefin Robotics products provide undersea capabilities for defense, scientific and maritime customers worldwide. Bluefin Robotics products offer a range of systems and configurations that can operate in the open ocean and in constrained waterways. Our core autonomous product line includes Bluefin SandShark, Bluefin-9, Bluefin-12, and Bluefin-21, Hovering Autonomous Underwater Vehicle (HAUV), and Subsea Power technologies.

The Bluefin Robotics AUV family shares a free-flooded, modular, and open architecture backbone that has enabled the integration of 70+ sensors. We have developed and delivered AUVs worldwide to research institutes and industry and have provided AUVs to the United States' and International Navies.

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Tel: 1-604-942-5223  
E-mail: info@ise.bc.ca  
Website: <https://ise.bc.ca/>

International Submarine Engineering Ltd. (ISE) is a world leader in the design and integration of autonomous and remotely operated robotic vehicles and terrestrial robotics. Over our 40+ years in business, we have accumulated a great deal of expertise in the design, manufacture, and maintenance of:

- Autonomous Underwater Vehicles (AUVs)
- Remotely Operated Vehicles (ROVs) for subsea operation
- Human Occupied (HO) submersibles
- Customized systems for the offshore oil industry
- Customized systems for the Military-Naval sector
- Hydraulic, pneumatic, and electric robotic manipulators
- Teleoperated and autonomous robotic systems
- Robotic systems for nuclear Industry applications
- Communications and real-time control system

**L3 OCEANSERVER, INC.**

275 Martine Street  
Fall River, MA 02723 USA  
Tel: +1 508 678 0550  
Fax: +1 508 678 0552  
E-mail: [sales@ocean-server.com](mailto:sales@ocean-server.com)  
Website: [www.iver-auv.com](http://www.iver-auv.com)  
Contact: Jim Kirk

L3 OceanServer, Inc. is one of the leading manufacturers of unmanned underwater vehicles (UUVs) with over 300 units delivered to customers around the world.

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IVER3-580 Autonomous Underwater Vehicle

**OUTLAND TECHNOLOGY**

38190 Commercial Ct.  
Slidell, LA 70458 USA  
Tel: 985-847-1104  
Fax: 985-847-1106  
E-mail: [jeff@outlandtech.com](mailto:jeff@outlandtech.com)  
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14020 Stowe Drive  
Poway, CA 92064  
Tel: +1 858-842-2600  
E-mail: [oceanscience.sales@teledyne.com](mailto:oceanscience.sales@teledyne.com)  
Website: [www.teledynemarine.com/oceanscience](http://www.teledynemarine.com/oceanscience)  
Contact: Jamie Carrig



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Teledyne Oceanscience manufactures unmanned deployment platforms for echosounders and environmental monitoring instrumentation. Our major products are remotely-controlled Q-Boats and tethered instrumentation deployment Riverboats for echosounders and ADCPs, remotely-controlled Z-Boats for hydrographic surveys in shallow or hard to access areas, the Underway CTD that provide affordable and compact profiling from a moving vessel, and the popular Sea Spider and Barnacle seafloor platforms.

**TELEDYNE SEABOTIX**

14020 Stowe Drive  
Poway, CA 92064  
Tel: +1 619 450 4000  
Fax: +1 619 450 4001  
E-mail: [inquiries@teledyne.com](mailto:inquiries@teledyne.com)  
Website: [www.teledynemarine.com](http://www.teledynemarine.com)  
Contact: Jamie Carrig



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Teledyne SeaBotix is a world leading manufacturer of capable underwater MiniROVs that perform a multitude of tasks including maritime security, search and recovery, hull and pipeline inspection, hazardous environment intervention, aquaculture, sensor deployment and oceanographic research. The Little Benthic Vehicle systems have become the benchmark in compact ROVs around the world and ROV equipment for over 30 years. We recognize that no two jobs are the same and specialize in products that are customizable for your specific applications.

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212 East High Street  
Pottstown, PA 19464  
Tel: +1 610 458 3000  
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E-mail: [sales@videoray.com](mailto:sales@videoray.com)  
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With more than 3,700 ROVs in service around the world, VideoRay is the global leader in Observation ROV technology. VideoRay's underwater robot systems are extremely versatile, portable, affordable, and reliable solution for underwater operations including surveys, offshore inspections, search & recovery, homeland & port security, science & research, aquaculture, and many other underwater applications. The latest Mission Specialist systems provide solutions for particularly difficult underwater challenges. VideoRay is available on the General Services Administration (GSA) Schedule.

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Tel: +1 800 637 3430  
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17455 NE 67th Court, Suite 120  
Redmond, WA 98052  
Tel: +1 (425) 869-1834  
Fax: +1 (425) 869-5554  
E-mail: [info@oceanus.com](mailto:info@oceanus.com)  
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# SMART SUBSEA SOLUTIONS

## S2C TECHNOLOGY: COMMUNICATION AND TRACKING COMBINED

- time, space and cost-saving solutions
- low power consumption for autonomous operations
- advanced data delivery algorithms, addressing and networking, remotely configurable settings
- extendable platform with multiple configuration options: power-saving Wake Up module, acoustic releaser, additional sensors, custom solutions, OEM versions available

### USBL POSITIONING SYSTEMS

**simultaneous** positioning and communication - no need to switch between positioning mode and modem mode

- flexible SiNAPS positioning software
- reliable data transmissions
- range: up to 8000 m
- accuracy: up to 0.04 degrees

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- depth: up to 6000 m
- data rate: up to 62.5 kbps

### LBL POSITIONING SYSTEMS

highly accurate, precise and stable performance, simultaneous positioning and data transmissions

- flexible SiNAPS positioning software
- reliable data transmissions
- range: up to 8000 m
- accuracy: better than 0.01 m

**NEW!**  
**ULTRA-COMPACT**  
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S2C M (left) and the new S2C T "tiny" modem - 20% smaller and lighter



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Actual Size (L x W x H) 19.8" x 15.1" x 14.7"



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Actual Size (L x W x H) 27" x 15.1" x 16"

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Nanaimo, BC  
V9S 3B5 Canada

t **250-729-8899**  
tf 888-729-8890  
e [sales@seamor.com](mailto:sales@seamor.com)

[seamor.com](http://seamor.com)