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NAVY STORM CHASERS

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submarines teach us about
forecasting hurricanes?

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EDITORIAL

Offshore Industry Automation as An Opportunity for Growth

BY JASON MIDDLETON,
Vice President, Ray Products


Automation has permanently altered the way many industries operate – and the maritime industry is no exception. Understandably, this is cause for concern among many skilled laborers, who fear that their jobs will be rendered obsolete by robots.

This is not a completely irrational fear. A 2017 report estimated that by 2030, one-third of the U.S. workforce could be replaced by machines, while a University of Oxford study characterized it in even direr terms: Up to 47% of current jobs could be replaced by automation. Statistics like this paint a grim picture, but are a tiny part of a more nuanced reality.

First, there are serious limitations to automation. As the U.S. Navy discovered in 2017 when multiple ships on autopilot collided, resulting in deaths and equipment damage on a massive scale, automation can have disastrous consequences.

In order to achieve the speed, efficiency and savings for which they are designed, robots must be operated by engineers and other highly skilled workers. In addition to being thoroughly trained, these employees must also be familiar with the industry and the environment, and have the ability to creatively problem-solve – qualities that simply cannot be replicated by machines.

For example. I'm the Vice President of a plastics manufacturer that makes thermoformed plastic parts for a wide range of clients, including the maritime industry. A few years ago, we invested in our first fully automated machine: a six-axis trimmer. Prior to that acquisition, the trimming process was done by hand, by highly skilled employees. Even so, robots were faster, more accurate and more efficient.

But here is an important fact: Not one of our employees lost their job to a robot. When we

invested in automation, we decided to keep every employee on board. The skills that made our trimmers good at their jobs – efficiency, precision, problem-solving – made them well-suited for a wide range of positions. Some ended up transitioning to similar tasks, while others trained for different roles. The takeaway isn't just that we kept our workforce intact – we were also able to show our employees, investors and customers that automation presents an opportunity for growth. In fact, our early adoption of automation led to growth that ultimately required more employees; our workforce is about 20% larger today than it was then.

Our experience is not an anomaly. A recent report from the Brookings Institution showed that German manufacturers use three times more robots than their American counterparts, but they're also employing more people. German manufacturers integrated more robots into their workforce than any other country between 1999 and 2007. And while manufacturing jobs in Germany declined by 19% from 1999 to 2012, manufacturing jobs in the United States declined by 33% – in spite of implementing far less automation.

Maritime automation and jobs are not mutually exclusive – in fact, growth and efficiency depends on them both. The reality is that automation will replace some human labor in the maritime industry. But the more robots we implement, the more skilled people we need to operate them and provide the analysis, communication and problem-solving that robots cannot.

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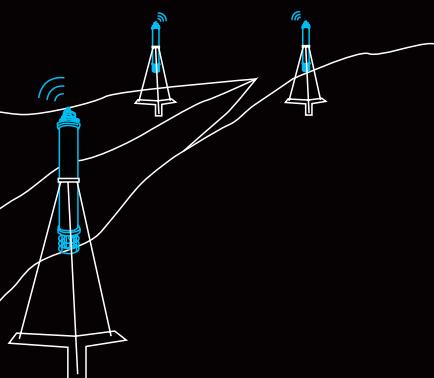
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USING UUVs TO IMPROVE HURRICANE PREDICTIONS

Hurricane forecasting was a hot topic during the October 2018 Oceans Conference & Exposition in Charleston, South Carolina. With devastation wrought by several major storms in recent years, ocean innovators are actively looking at ways to use unmanned underwater vehicles (UUVs), improved sensors, advanced modelling technologies, and more to improve our understanding of the ocean environment and hurricane predictions. Presenters from government, academia, and industry all gave presentations on related topics. ON&T even teamed up with the Marine Technology Society (MTS) to give one of these innovators—Dr. Travis Miles—an award.

RAPID INTENSIFICATION

When a storm's wind speeds accelerate 35 mph (56 kph) or more in 24 hours or less, scientists call this increased energy "rapid intensification." Storm forecasters have come a long way in predicting where a hurricane will make landfall. What's still lacking, however, are reliable storm intensity prediction models. Most of the time, the models work, but about five percent of the time, a storm strengthens faster than the models predict.

For example, Hurricane Michael, which devastated parts of the Florida panhandle right before the Oceans Conference, defied forecasts when its wind speeds doubled over the course of two days before it slammed into the coastline. This final stage intensification increased risks to both life and property because it reduced the amount of time communities had to prepare for an even stronger storm than the one they had heard was coming.



Hurricane Michael defied forecasts when its wind speeds doubled over the course of two days before it slammed into the coastline.

It's happened before. In 2016, the National Hurricane Center also failed to adequately predict the rapid intensification of Hurricane Matthew to a Category 5 storm and Hurricane Katrina underwent two periods of rapid intensification before slamming into New Orleans. These aren't the only examples, either. So, why don't the models anticipate rapid intensification?

SEA SURFACE TEMPERATURE VS. DEEP OCEAN HEAT

Atmospheric scientists tell us that the fuel for rapid intensifications comes from very warm water in the storm's path. They are not wrong. However, according to Scott Glenn, a distinguished professor at Rutgers' Department of Marine and Coastal Sciences, while hurricane models are still too reliant on a two-dimensional view of Earth's oceans.

Currently, NOAA and other forecast agencies around the planet combine hundreds of millions of data points ranging from atmospheric wind to sea surface temperatures, as gathered by satellites, aircraft, balloons, buoys and more. These data points are fed into super computers to build advanced models at every usable scale.

While the models look at sea surface temperature, Dr. Glenn says that observations of upper ocean heat content are essential to understanding how storms evolve. And the tool best equipped to make these observation is the UUV.

At Oceans 18, Dr. Glenn kicked off the organizational meeting for the Marine Technology Society (MTS) UUV Professional Committee. Because MTS already has a very active ROV and

manned underwater vehicle committees, the organizers of this new group wanted to include vehicles that are both fully-autonomous or remotely controlled, subsurface or surface, motorized or buoyancy controlled, and so forth. The MTS UUV committee covers all of those categories and is seen as a complimentary group to manned vehicles and tethered vehicles. If you are interested in the MTS UUV committee, the group's next gathering will take place at the Underwater Intervention Conference in New Orleans in February.

TRAVIS MILES WINS 2018 ON&T/MTS YOUNG PROFESSIONAL AWARD

With hurricane prediction comprising such a large number of presentations at this year's Oceans Conference, it makes sense that Dr. Travis Miles of Rutgers University is the 2018 Ocean News and Technology/Marine Technology Society Young Professional Award recipient.

Dr. Miles has been in a lot of hurricanes. By his count, he's experienced a dozen throughout his life. His father is a career military officer, so he moved a lot growing up. His first Hurricane was Hugo in Wilmington, NC. Next came Andrew. He moved to Hawaii, where he was in Hurricane Iniki. Back in North Carolina he was in Fran, Bertha, Bonnie, and basically any storm that hit North Carolina. He now attends college at Rutgers in New Jersey and experienced Irene and Sandy there. As if that wasn't enough, this past year, Travis deployed a glider in Jeju Island, South Korea where he found himself in a typhoon. You could say he was born to do this work.

Dr. Miles' projects at Rutgers' Center for Ocean Observing Leadership have included the rapid deployment of Teledyne Webb Research Slocum Gliders ahead of coastal storms.

"During Hurricane Sandy we purposely flew a glider out on the continental shelf ahead of that storm. Now, that's grown into this bigger program where the Navy provided gliders for hurricane research for the 2018 hurricane season. And that network was able to capture data from Hurricanes Michael and Florence, and was basically a standing picket line for any storms that came through, which is a big difference from when we were running around trying to get one glider deployed in front of a storm. Considering that Hurricane Michael came up in four days, having the gliders already deployed made a big difference."

"We're trying to represent what we're calling 'essential ocean features' not just essential ocean variables. To improve hurricane forecasting, you need to know not just what the sea surface temperature is, but what the big features like the Loop Current in the Gulf of Mexico and the Atlantic Warm Pool are doing. In the mid-Atlantic Bight, you need to know what the bottom cold pool is doing. All of these things have subsurface structure and have to be measured at-depth because they aren't fully represented by the surface temperature."

His work fits perfectly into a NOAA-Navy partnership to improve hurricane forecasting. During the summer of 2018, when thirty gliders were deployed in known hurricane development tracks, he personally supervised five glider deployments out of St. Thomas and then his group at Rutgers worked to get the data from the Navy into the public, by working with IOOS.

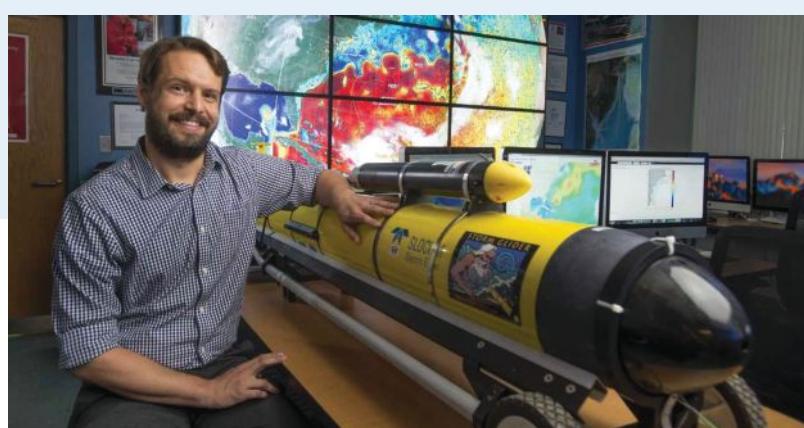
So, what's in the works for the 2019 hurricane season?

"In an ideal world," Dr. Miles says, "what we're striving for is to have a national hurricane ocean glider backbone that's operational and funded full-time. So, it would be like five gliders operating for about four months straight in the mid-Atlantic and each region having that. And also connecting the people to look at that data, use it, interpret it, and make sure that it's having an impact on modelling, and really trace all the way through."

Speaking to ON&T about being recognized, Dr. Miles said, "It feels great. There are not that many opportunities for early career scientists in academia to gain this type of recognition."

Travis Miles received his B.S. in Marine science and Meteorology from North Carolina State University (NCSU) in 2007. In 2009, he completed a Master's in Physical Oceanography also at NCSU under the direction of Professor Ruoying He. He received his PhD from Rutgers University in 2014 studying sediment resuspension and transport during Nor'easters and Hurricanes, specifically Sandy in 2012. His PhD adviser was Dr. Scott Glenn.

Currently, he is an Assistant Research Professor in the Rutgers University Center for Ocean Observing Leadership (RUCOOL), where he co-teaches Ocean Methods and Data Analysis, a hands-on class that introduces undergraduates to oceanographic equipment and data processing techniques.



Travis Miles with the Teledyne Webb Research Slocum 'storm glider' that he and Greg Seroka deployed in front of superstorm Sandy in 2012. Photo courtesy of Nick Romanenko, Rutgers University.



Naval Oceanographic Office personnel prepare to launch 10 littoral battlespace sensing gliders from USNS Maury in the Eastern Atlantic Ocean in support of NAVOCEANO's successful mission to deploy more than 50 gliders globally in July 2018. Photo credit: Rebecca Eckhoff, Naval Oceanographic Office.

This award which recognizes an MTS Member, 35 years old or younger, who has demonstrated leadership in MTS and work in a professional capacity in management, engineering or research and development in a marine technology field. Assistant Professor Miles was selected based on his work adapting autonomous underwater gliders for use in hurricane intensity research. The use of these systems has enabled new understanding of how our coastal oceans can intensify or weaken Hurricanes in the critical last hours before landfall. This work has led to the enhancement of coastal ocean observing networks across the eastern US, Gulf of Mexico, and Caribbean Sea. In addition to research, Dr. Miles has contributed numerous papers and proceedings to the MTS journals, regularly supported student engagement, and developed a new MTS summer course on glider training with colleagues at Rutgers.

NAVY PARTNERS WITH NOAA FOR HURRICANE RESEARCH USING UUVS

The Navy has taken several big steps advancing the utilization of unmanned underwater vehicles (UUV) since Rear Admiral John Okon took command of the Naval Meteorology and Oceanography Command (NMETOC) in 2017. In April 2018, the command became the first entity to simultaneously command 50 ocean gliders. Before that milestone, it was a major accomplishment to deploy a dozen simultaneously under one command.

This summer, NMETOC deployed 108 gliders at once. They had command and control of over 100 gliders for those two days and we were able to maintain over 90 deployed for a few weeks. At the time of the Oceans 18—a full seventy days after launch—50 of the gliders were still deployed. But, why do it?

One goal was to demonstrate the value of the data the gliders provide. The data is only as good as how recently it was provided, and the ability of gliders to provide real-time

sensing is especially important for submarine detection. The Gulf of Mexico may not be an area where enemy submarine threats are prevalent, but it is a dynamic region that acts as the perfect venue for training and testing. In fall of 2018, the Navy allowed NOAA to use one of the gliders deployed in the Gulf of Mexico to gather data on Hurricane Michael. But that's just part of the story. In the summer of 2018, in cooperation with NOAA, NMETOC introduced thirty Navy UUVs into areas of known hurricane development tracks in the Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea.

At the launch of the operation, Rear Adm. John Okon, commander, Naval Meteorology and Oceanography Command, said, "This is the first time Navy ocean gliders will be placed in advance of historical tropical cyclone tracks to collect critical oceanographic information in real-time."

These UUVs were loaded with sensors to provide information regarding the heat transfer between the ocean and the overlying atmosphere. The collected temperature data was fed into high performance atmospheric and oceanographic models to help improve hurricane intensity forecasts. Such observations improve our understanding of the heat content of the upper portion of the ocean, critical to understanding how intense tropical systems might become.

NOAA's National Data Buoy Center assisted with this effort by ensuring the environmental data collected from these gliders, along with the NOAA gliders in the program, was disseminated through the Glider Data Assembly Center to the world's Global Telecommunications System. The gliders were piloted by the Naval Oceanographic Office's Glider Operations Center, located at Stennis Space Center, Mississippi.



1



2



3

ROV AT WORK: PHOTO CONTEST WINNERS

ON&T proudly rewards each of the following readers for winning our 2018 #ROVatWork photo competition by including their photos in this, our end of the year issue. Our selected winners from our inaugural contest were submitted by Oceaneering, Deep Ocean Engineering and Glenn Underwater Services. All three entries drew praise from our staff and are included below in no particular order, because they are all great!

To everyone else who entered this year, thanks! We enjoyed seeing your photography skills and your ROVs. To participate in next year's contest, look for an announcement in ON&T's weekly digital newsletter, by subscribing at <http://eepurl.com/b2qc-5>.

1 » This vertigo-inducing image from Rich Glenn of Glenn Underwater Services, LLC shows a **SeaBotix LBV200** sitting above Cheoah Dam, North Carolina. The Teledyne SeaBotix LBV200-4 is a compact, affordable MiniROV system for general observation and light work that is simple to setup and operate. It is the most basic SeaBotix unit that can accept additional external sensors, such as sonar and tracking systems. Like all SeaBotix MiniROVs, the LBV200-4 is capable of true 4-axis maneuverability including lateral (sideways) flight, allowing the operator to keep the object of interest in view while continuing to maneuver around it.

2 » A cool view from photographer James McClure, with edits by Jack Woepke, shows a **Phantom T-Series ROV**. This advanced platform provides powerful maneuverability, incorporates an open architecture, integrates with a wide variety of sensors. It's hand-built on a rugged, resilient, non-corroding polypropylene chassis that can accommodate heavier payloads. The design can be configured with up to five Tecnadyne thrusters that provide significant control and propulsion in current to maneuver efficiently in all directions. The Phantom T5 Defender comes equipped with the patent-pending Disrupter, Deep Ocean Engineering's electrically-initiated underwater breach for explosive ordinance disposal. Militaries and law enforcement agencies have found the Phantom T5 Defender to be the most effective tool for locating limpet mines on ship hulls or piers and destroying them, using the Disrupter to flood the mines with pressurized water.

3 » "The cold never bothered us anyway!" A **Millennium ROV** gets frosty during winter conditions. This chilling photo was submitted by Oceaneering. The latest entry in the Millennium series, the Millennium Plus ROV, is a side entry cage deployed, dual manipulator 220 hp heavy work class ROV. The cage or Tether Management System (TMS) supplies an additional 110 hp and is capable of powering skids. It also has thruster control and auto heading. Key features include a Fly-by-wire station keeping system, 10,000 fsw / 3,000 msw depth rating (13,000 fsw / 4,000 msw optional), and 220 hp.

Low Cost Ocean Observing of Critical Biogeochemical Parameters: The OceanCubes Project

By Scott M. Gallager, PhD., Scientist, Woods Hole Oceanographic Institution and President, CoastalOceanVision, Inc.

The goal of this project is to develop and deploy inexpensive cabled seafloor observatories—called OceanCubes (oceancubes.whoi.edu)—in low and high latitudes where extended, high frequency information is needed to characterize the aquatic environment. This may be for understanding the impact of seafloor, midwater, or surface deployed Hydrokinetic Energy Production systems, wind farm towers and their cables, or oil drilling and production rigs.

We have been using OceanCubes to study the upwelling of cold, nutrient rich and hypoxic water at several locations worldwide: Western Pacific Ocean (Okinawa and Tokyo, Japan) and in the Eastern Pacific Ocean (near Coiba Island, Panama) and in the Caribbean (Bocas del Toro). The four-cornered control volume design of the OceanCube allows for the measurements of materials and energy flux from the water column to the benthos at a rate of several times per second (Fig. 1).

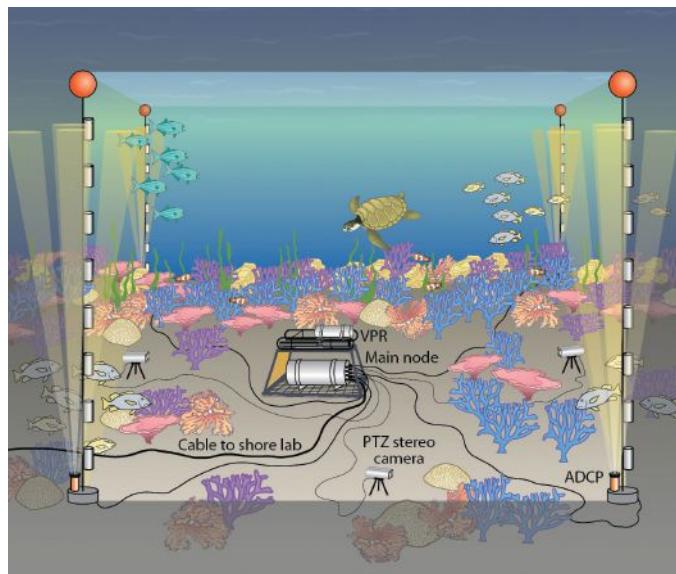


Figure 1. OceanCube observatory deployed at a depth of 20m showing four corners defined by thermistor strings and uplooking ADCPs, and a CPICS (VPR) particle imaging system in the center.

Each of the observatories consist of an instrument package on the seafloor 2 to 10 km from shore at depths from 20 to 1000 m. The package is connected by electro-optical cable to shore providing the capability for internet-based teleoperation by scientists and engineers from anywhere world-wide. The main observatory node consists of a CTD to measure temperature, salinity, and pressure, sensors for chlorophyll and CDOM fluorescence to detect the presence of oil, oxygen, nitrate, pCO₂, pH, a bio-optical package for irradiance and radiance, a Continuous Plankton Imaging and Classification Sensor

(CPICS), several hydrophones for acoustic characterization of the underwater environment and sound production from underwater installations, a Raman spectrometer to detect and classify Harmful Algal Bloom species and their toxins, and pan and tilt stereo cameras to observe, measure and track fish communities (Fig. 2).

CPICS is a darkfield microscope with magnification to image plankton and particulates 10 µm to 2 cm in size, and may be used in conjunction with CTD rosette, AUVs, ROVs, gliders and other autonomous platforms. A Deep Learning Neural Network runs on an embedded GPU computer and classifies the particle and plankton field in real-time. Telemetry can be by WiFi in air, Ethernet or serial while submerged. The use of the

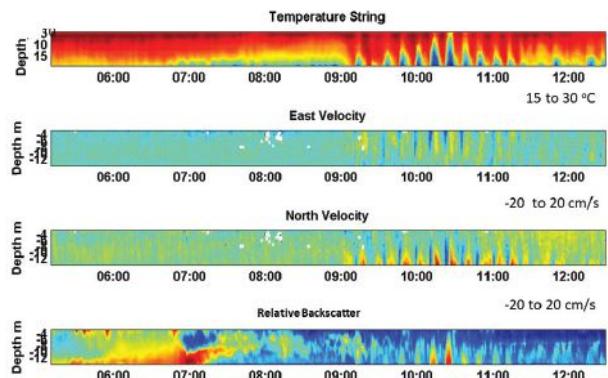
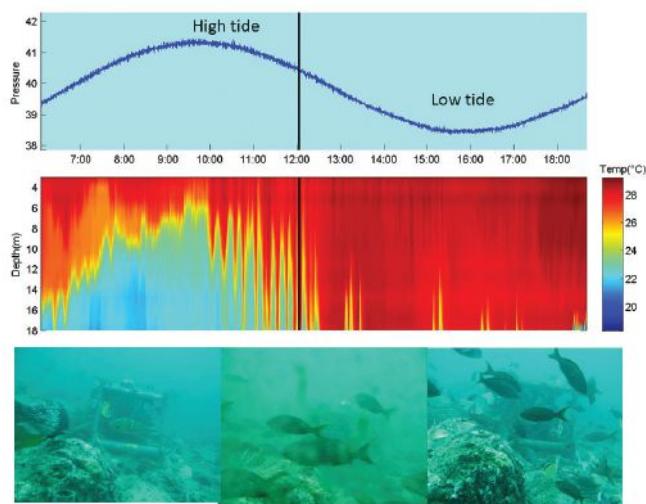


Figure 2. TOP: Water column temperature at 1m intervals over time showing distinct internal wave pattern as upwelled cold water intrudes into warm surface water. East water velocity, north water velocity and relative acoustic backscatter also shown. Arrow indicates enlargement on bottom where tidal pressure, temperature, and images from the OceanCube indicate strong changes in thermal conditions and reef fish communities as internal waves pass.



CPICS particle and plankton imaging system to characterize biodiversity in the plankton over extended periods of time is allowing us to capture not just the mean diversity but the variance as well, the latter being a good descriptor of stability in the plankton community (Fig. 3).

The four corner nodes of an OceanCube each have a temperature string with sensors at an interval of 1 m and an uplooking Acoustic Doppler Current Profiler (ADCP). Vertical profiling packages can also complement water column measurements. The node is located in the center of a control volume through which the flux of material (plankton, carbon, oil, sound energy) is measured. A control volume is established by virtue of temperature strings and the ADCP sensors at each corner, ~100m to 1 km on a side.

The node, and its sensors are part of an extensive underwater Local Area Network (LAN) with each sensor provided with an exclusive IP address or port, along with voltage and ground fault monitoring and power control. All data from the sensors and cameras stream to shore where computers log the data and provide initial processing for web visualization and Quality Control. All data both raw and processed are accessible over the internet through a web-enabled Graphical User Interface (GUI).

The OceanCube observatories are providing year-round data to support monitoring, research and educational objectives related to understanding the impacts of Hydrokinetic Energy Production systems, wind farms, and oil rigs on the biodiversity, biophysical and biogeochemical processes, particularly Ocean Acidification, of seafloor, coral reef fish and plankton communities.

To study carbonate saturation state and the impact of Ocean Acidification on coral reef systems, information on four primary variables (total dissolved inorganic carbon, total alkalinity, carbon dioxide, and pH) are required. Thermodynamic relationships between these variables allow for the measurement of two variables and the calculation of the other two. The OceanCube observatories measure pH and CO₂, thereby allowing inorganic carbon and alkalinity to be calculated along with the Aragonite saturation state, which provides an index of the ability for organisms to form calcium carbonate shells and exoskeletons (clams, oysters, scallops, lobsters, corals, etc.). In addition, we are experimenting with Raman spectroscopy to measure carbonate ion directly, thereby eliminating the need for pH and alkalinity measurements. The OceanCubes also monitor primary (phytoplankton and chlorophyll), secondary (mesoplankton) and tertiary (fish) production to provide a means for observing the impact of corrosive water on planktonic, coral, and reef fish communities. Measurements of these variables and parameters within a control volume where the motion of water through the volume is known allows for calculation of biogeochemical flux (carbon cycle) of materials through the volume and into the benthos.

The observatories are designed to provide extensive expansion by adding experimental sensors as they become available. In

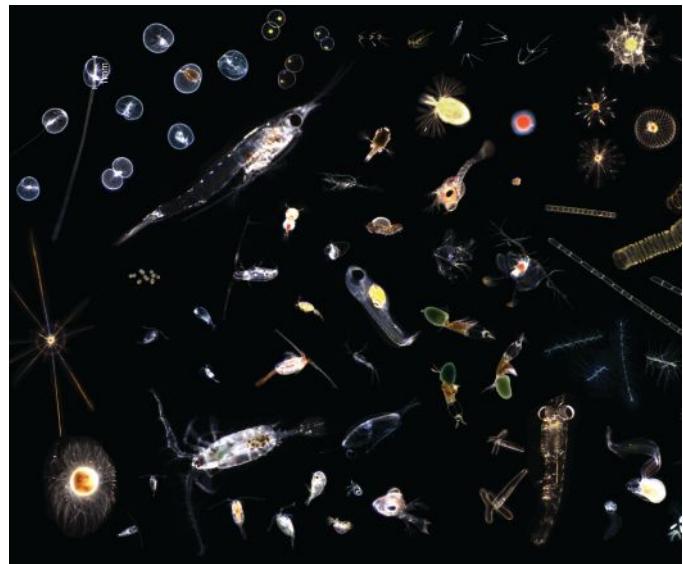
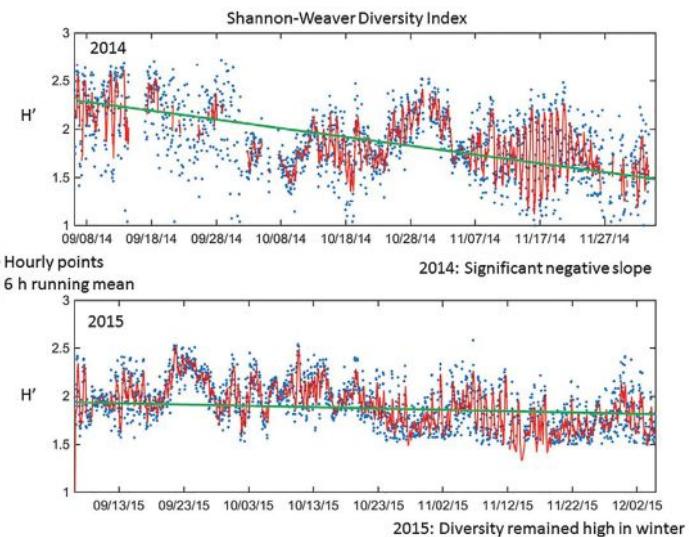


Figure 3. TOP: Darfield images produced by a CPICS mounted on an OceanCube 80 km south of Tokyo at a depth of 20m (Scale bar bottom right: 1 mm). BOTTOM: Time series of biodiversity of 21 species of plankton over a two-year period. Note the expected decrease in diversity in 2014 as winter approaches. But not in 2015 suggesting warming.



combination with an array of cabled observing systems such as NEPTUNE and VENUS (<http://www.oceanetworks.ca/>), and MARS (<http://www.mbari.org/at-sea/cabled-observatory/>) in the Eastern Pacific Ocean, and uncabled systems across the Tropical Pacific (<http://tpos2020.org/>), our unique approach to measuring components of the carbon cycle at high frequencies comparatively between many sites is providing a transformative view of the impact of upwelling due to ENSO and Ocean Acidification on coral reef dynamics.

OceanCube Observatories were developed by biologists, chemists, and engineers at the Woods Hole Oceanographic Institution and the technology was licensed to CoastalOceanVision, Inc., (www.coastaloceanvision.com) for commercial production.

NASA Pushes Exploration of Oceans in Solar System



Scripps' Jeff Bowman collects "frost flowers" at a site off Greenland, 2009. Photo credit: Matthias Wietz.

NASA has navigated the solar system with spacecraft and landers, but still, our celestial neighbors remain vast frontiers, particularly in the search for life. Now, an alliance of researchers including scientists at Scripps Institution of Oceanography at the University of California San Diego will accelerate the quest to find it.

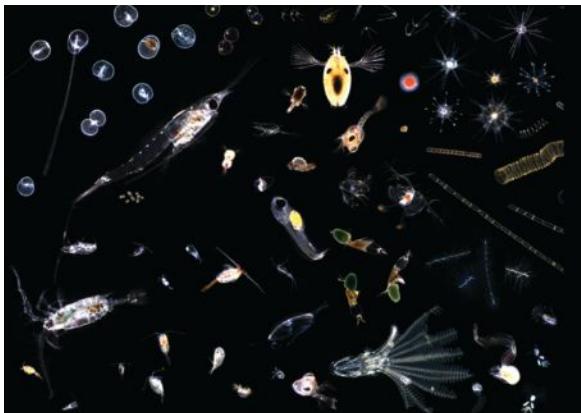
The NASA Astrobiology Program has announced the establishment of the Network for Life Detection, N-FoLD, which connects researchers to pursue the detection of life and clues thereof on our neighboring planets and their moons.

N-FoLD includes an oceanic research alliance led by the Georgia Institute of Technology.

The alliance is called Oceans Across Space and Time (OAST) and has received a \$7 million NASA Astrobiology grant with the long-range goal of extracting secrets from present and past oceans on Mars, Jupiter's icy moon Europa, and Saturn's moon Enceladus. But OAST will also ramp up the study of the conditions that spawned first life in Earth's oceans.

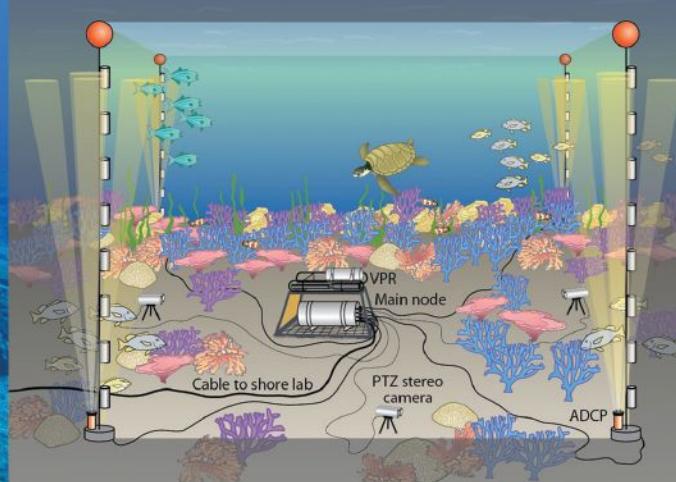
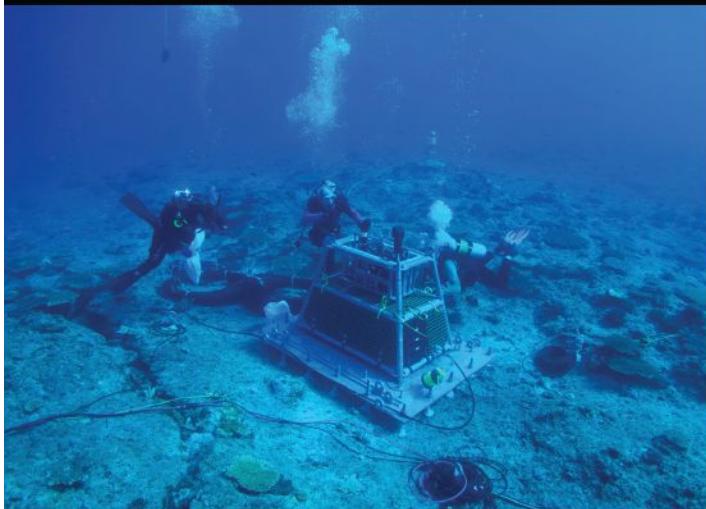
N-FoLD is one of five new Research Coordination Networks (RCNs) announced by NASA's Astrobiology Program. The other RCNs pull together research communities that include the study of early Earth and its chemistry, evolution, distant habitable worlds, and exoplanet systems.

Oceans Across Space and Time could one day help NASA put a submarine on a rocket to Europa to look for life in the ocean beneath its ice crust. Or OAST could join N-FoLD colleagues to help NASA explore parched Martian landscapes that once were oceans.



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Siemens' Subsea Power Grid Passes Shallow Water Test

Siemens has successfully concluded the first phase of its Subsea Power Grid shallow water test in Trondheim, Norway. Siemens, in collaboration with partners Chevron, Equinor, ExxonMobil, and Eni Norge, is in the final stages of developing a system that will become the world's first Subsea Power Grid designed for distribution of medium voltage power using pressure compensated technology.

"There will be more subsea compressors, pumps, processing plants, and in the future entire production facilities placed on the seabed, all of which require power," said Frode Tobiassen, Head of Subsea at Siemens. "This development is what we are preparing for with the Subsea Power Grid system."

The system consists of a subsea transformer, subsea switchgear, subsea variable speed drive (VSD), subsea wet mate connectors, and a highly reliable remote control and monitoring system that includes cloud-based user dashboards and data analytics.

The Subsea Power Grid is an enabling technology for subsea processing with multiple seabed power consumers. The system



is ideally suited to support enhanced recovery in subsea brownfield projects and tie-back fields, benefitting from single- or multiphase boosting to increase oil recovery.

During the initial test phase, the system operated in a ring loop topology at full load and a predetermined test and verification program was performed. The initial results from the shallow water testing were positive and all units operated within their design parameters.

In agreement with its program partners, Siemens now moves into the next phase with an extended shallow water test to build operational experience and verify long-term reliability. The goal is to accumulate 3,000 hours of runtime on the equipment while performing further system testing. In parallel, preparations are ongoing for a deep-water pilot program where the equipment will be installed and used on a subsea field.

For more information, visit WWW.SIEMENS.COM



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VITROVEX® Sets the Industry Standard

for Floatation & Instrument Pressure Housing

Nautilus Marine Service GmbH is a German-based specialist company that produces pressure housing made of glass, under the brand name VITROVEX®, for use in the deep sea.

Nautilus Marine Service is closely associated with regional distributors around the world and exports over 90% of its VITROVEX® glass products to more than 30 countries. VITROVEX® is the scientific standard for pressure housing and Nautilus Marine Service counts every well-known marine research facility around the globe among these customers.

Nautilus Marine Service pursues long-term goals and partnerships with its customers, employees and business partners and acts sustainably in accordance with the best interests of its customers without losing sight of its long-term viability. The company was founded in 1985. Ever since, they have invested continuously in people and technology to maintain their technical leadership in the products on offer.

The main product range of the company are VITROVEX® floatation and instrument housings. VITROVEX® glass belongs to the group of borosilicate glasses, which are characterized by their low sensitivity to temperature changes (due to the low temperature expansion) and their high resistance to chemical agents.

Nautilus Marine Service offers floatation and instrument housings in different shapes (spherical, cylindrical, and capsular) and in a great variety of sizes from approx. 2" up to 20" outside diameter. They're also durable. Depending on wall size and diameter, they can withstand pressures of up to 1200bar.



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» VITROVEX® full ocean glass enclosure.

In addition, these glass housings can be integrated with metal or plastic parts (e.g. made of Titanium) to meet the diverse needs of primarily scientific customers. Examples include alternate sealing techniques, flanges to separate or connect them or protection items against mechanical impact. Further, there is often a need to incorporate third-party items such as bulkheads, feedthroughs, transponders etc. into pressure housings. Nautilus Marine Service has developed appropriate interfaces and procedures to this effect and supports also its implementation.

Nautilus Marine Service GmbH operates its own fully computer-controlled pressure test chamber (inner diameter: 700mm, length 1400mm) with capability that extends to full ocean depth and beyond, and it has the pressure test chamber available to outside clients also to carry out contracted pressure testing.

In the business of ocean research and exploration, pressure housings are often acquired in small quantities, and often only after intensive consulting talks with the engineers of Nautilus Marine Service to capture customer-specific requirements and to support decision-making.

The wide range and variability of the products in combination with the mentioned services make the company Nautilus Marine Service special and unique. A fact that was also honored with the awarding of the Compass International Award 2015 and in turn, motivates all employees of Nautilus Marine Service to continuously strive for the highest quality and reliability of products, services and work processes.

For more information, visit
WWW.VITROVEX.COM

GEBCO-Nippon Foundation Alumni Team Completes Successful XPRIZE Testing

The GEBCO-Nippon Foundation Alumni Team successfully completed an extensive week of testing in the port city of Kalamata, Greece, ahead of the final round of the Shell Ocean Discovery XPRIZE. Final testing runs until 1 February 2019. Winners will be announced in March. Eight teams are vying to be crowned champions of the \$7 million global competition that aims to advance deep sea technologies for autonomous, fast, high-resolution ocean exploration.

<https://www.oceannews.com/news/science-technology/gebco-nippon-foundation-alumni-team-completes-successful-testing>



The GEBCO-NF Alumni Team with their SEA-KIT™ Unmanned Surface Vessel, USV Maxlimer, in the port city of Kalamata, Greece.

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Field Demonstration of Underwater Mining Technology

In October, during iVAMOS! technology Demonstration Day, at the Magcoabar flooded mine pit, in Silvermines, Ireland showcased "EVA", an automated underwater vehicle that is used to assist in precise positioning, navigation and situational awareness of mining vehicles and the surrounding environment, as well as executing preliminary surveys of underwater mine sites. <https://www.oceannews.com/news/science-technology/field-demonstration-of-vamos-technology-in-ireland>

NOAA Ship Okeanos Explorer Explores Deep-Sea Habitats of Puerto Rico and the U.S. Virgin Islands

From October 30 through November 20, 2018, NOAA and partners conducted a telepresence-enabled ocean exploration expedition on NOAA Ship Okeanos Explorer to collect critical baseline information about unknown and poorly understood deepwater areas surrounding Puerto Rico and the U.S. Virgin Islands. The expedition included remotely operated vehicle (ROV) and mapping operations. <https://www.oceannews.com/news/science-technology/noaa-ship-okeanos-explorer-explores-deep-sea-habitats-of-puerto-rico-and-the-u-s-virgin-islands>



ROV Deep Discoverer being launched off the back deck of NOAA Ship Okeanos Explorer. Image courtesy of Art Howard, GFOE, Exploring Deep-sea Habitats off Puerto Rico and the U.S. Virgin Islands.



Earth's Oceans Have Absorbed 60% More Heat Than Previously Thought

For each year during the past quarter century, the world's oceans have absorbed an amount of heat energy that is 150 times the energy humans produce as electricity annually, according to a study led by researchers at Princeton and the Scripps Institution of Oceanography at the University of California-San Diego. The strong ocean warming the researchers found suggests that Earth is more sensitive to fossil-fuel emissions than previously thought. <https://www.oceannews.com/general/earth-s-oceans-have-absorbed-60-more-heat-than-previously-thought>

Teledyne Benthos Acoustic Modems Continue to Evolve to Meet the Industry's Changing Needs

The Teledyne Benthos ATM-900 Series Acoustic Telemetry Modems are the culmination of over twenty-five years of experience in the design and manufacture of advanced acoustic communication technology. This core technology, which was pioneered at the Woods Hole Oceanographic Institution (WHOI), and initially commercialized under Datasonics, has continued to evolve and expand under Teledyne Benthos, resulting in the successful implementation of thousands of highly robust and reliable acoustic modems delivered around the globe for commercial, academic, and most notably - defense applications.

Today's ATM-900 Series Modems deliver an extensive list of highly sought after features and enhancements spanning well beyond basic underwater communication. Flexible system architecture combined with a universal topside system allows for the seamless addition of positioning and/or acoustic release technology, offering users the ability to expand their capabilities as their needs evolve. The newly released Compact Modem also offers users a low-price entry point to build upon for their shallow water needs.

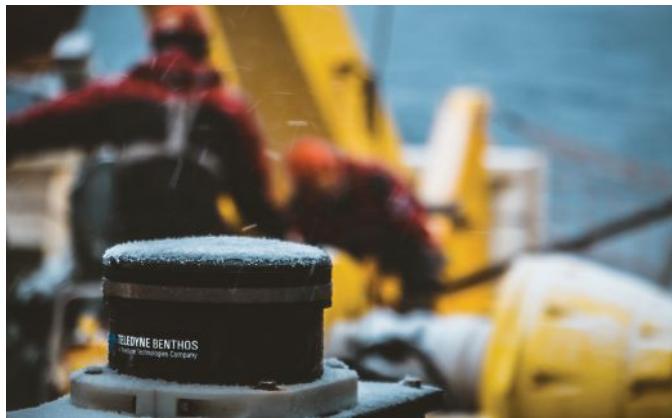
Notable recent modem applications of Teledyne Benthos communications/ positioning capabilities include:

- **L3 Oceanserver** was an early adopter of Teledyne Benthos combined acoustic modem and tracking capabilities for their IVER AUV, and has integrated this technology into a large number of AUVs currently deployed around the globe.
- **Riptide**, one of the industry's newest entries to the micro AUV market, worked closely with Teledyne Benthos' engineers to design and install a custom nose cone equipped with Benthos combined positioning and acoustic communications technology, which was field proven at the recent ANTX demonstrations in Newport, RI.
- **Sea Trac's** self-driving, solar powered boats have installed and utilized Teledyne Benthos acoustic modems for vehicle tracking and communications. This system has been proven out numerous times, including at the ANTX demonstrations.
- **Azimuth's Diver6** Diver/Dive operations mobile support system provides up to date information on location and status of divers in the water allowing the dive master to make faster, safer, and more accurate decisions. Teledyne Benthos acoustic modems provide the core enabling technology for this unique system.
- **JANUS Compatibility:** Teledyne Benthos acoustic modems were recently tested at a JANUS Interoperability Fest



ATM-960-Series-Modem

hosted by the NATO STO Centre for Maritime Research and Experimentation (CMRE), and were the only acoustic modem to prove their ability to provide an interoperable real-time implementation of the JANUS protocol utilizing commercial-off-the-shelf acoustic communication hardware. JANUS is a digital underwater coding standard aimed at providing a baseline common denominator for all underwater acoustic communications.



Teledyne Benthos acoustic modem mounted on a deep-sea mooring on board of icebreaking research vessel ARAON as part of a collaborative research project. Photo credit: Jack Pan, Scripps



Teledyne Benthos acoustic modem installed on deep water ROV
Photo credit: Marcus Ogle, Fugro

For more information on Teledyne Benthos acoustic modems, visit WWW.TELEDYNEMARINE.COM/BENTHOS

IoT Bundle for Oil & Gas and Maritime Launched

Arundo Analytics, a software company enabling advanced analytics in heavy industry, and Dell Technologies announced the launch of the IoT Bundle at The Royal Norwegian Consulate Shipping Conference held in Houston, Texas. The bundle consists of Dell Edge Gateway 5100 series devices combined with Arundo Edge Agent software.

Dell Edge Gateway 5100 devices are hardened and maritime class-certified, specially designed for advanced computing in remote or rugged environments. Arundo Edge Agent enables crews and operations and maintenance professionals to quickly and easily select, buffer, stream, compute and run advanced analytics on a range of signal data from critical equipment and systems, especially in maritime, oil & gas, and similarly distributed field environments. Paired, the products have the capacity to drive greater revenues and efficiency among businesses operating in shipping as well as offshore energy production.

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For more information, visit
WWW.ARUNDO.COM

Diver6 Releases New ENC Chart Overlay Features

Diver6, a diver and dive operations mobile support system, has released a new ENC chart overlay software feature that allows Dive Masters to see where their divers are located on a chart during an active dive.

One of the issues with providing ENC charts, is that online mapping and chart options require users to have an internet connection. The mobile and remote

features of Diver6 make it very difficult to maintain an internet connection on a dive. Small vessels do not have the expensive communication options needed for online content provisions.

Diver6 v2.0 includes the new ChartServer add-on. The ChartServer is a locally run application that serves ENC S57 charts to Diver6. International S63 charts are also supported in the new application. With the addition of ChartServer, Diver6 users can load nautical charts for any location in the world to support their dives.

All new Diver6 systems are shipped with the new features and applications.



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SINN Power Wants to Bring Wave-Hybrid Energy to Guinea

German wave energy company SINN Power has installed an autonomous measurement station to gather data for making site specific-recommendations for a renewable energy hybrid system that optimally meets the needs of a customer in Guinea.

On behalf of local company Guinea Gold, SINN Power is gathering the necessary data to evaluate the renewable energies potential in Conakry, considering wave wind and solar resources.

Launched in mid-October 2018, the second stage of the project will see a proprietary measuring system installed at the previously selected site, which will record wave, wind and solar data to support the ongoing feasibility study.

The aim of the study is to recommend an ideal off-grid renewable energy hybrid system for Guinea Gold, that will be supported by the evaluation of the collected data, said to be one of the study's key components, according to SINN POWER.

The installation of the measuring system, developed by the



Installation of the measuring system developed by SINN Power.

German company, was carried out without problems, SINN power said. The data from the system will be transferred by mobile communication to Gauting i Germany, where SINN Power's headquarters is located.

The German company offers hybrid systems that combine its own proprietary technologies with proven, standard market solutions. In addition to the expertise in the field of wave energy, SINN Power also offers solar plants, small wind parks and kinematic hydropower parks.



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Underwater Search Equipment it PAYS to Own



Minesto Generates Electricity with Commercial-Scale Marine Kite

Europe's leading ocean energy developers gathered in Edinburgh, Scotland for the annual Ocean Energy Europe (OEE) conference during the first week of November. Marine energy developer Minesto participated at the Welsh Government's exhibition stand and CEO Dr. Martin Edlund presented at a Tidal Energy Showcase session.

Earlier this fall, Minesto achieved initial electricity generation with its first commercial-scale marine energy kite during the commissioning program of the company's ground-breaking low-flow tidal energy project.

Operating Minesto's marine energy converter is very similar to flying a stunt kite in the air. By "flying" the subsea kite faster than the actual tidal flow, the Deep Green technology enhances the energy conversion compared to other tidal technologies. This makes it

a commercial proposition applicable in vast areas around the world where no other known or verified technologies can operate cost effectively.

The first utility-scale system of this patented Deep Green technology is commissioned at the Holyhead Deep site off the coast of North Wales. Minesto has entered the second commissioning phase and has achieved initial electricity generation from the kite.

Dr. Edlund said, "The achievements in Wales over the last few months makes us confident that our unique technology can operate in low-flow tidal streams and ocean currents, offering predictability and reliability to the energy mix. This is the first step towards full power production. Our focus now is on enhancements of the power production capacity . . ."

COO David Collier said, "What's most pleasing with the commissioning of this first device at a larger scale is that we have shown that we have safe and efficient procedures for handling the system and that it performs as it was designed to do."

For more information, visit
WWW.MINESTO.COM



Installation of the measuring system developed by SINN Power.

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Deepwater Wind

Ørsted Acquires Deepwater Wind

Ørsted has entered into an agreement with the D.E. Shaw Group to acquire a 100% equity interest in Rhode Island-based Deepwater Wind at a purchase price of USD 510 million. The two companies' offshore wind assets and organizations will be merged into the leading US offshore wind platform with the most comprehensive geographic coverage and the largest pipeline of development capacity.

Deepwater Wind, the leading US offshore wind developer, has built an attractive and geographically diverse portfolio of projects along the US East Coast. Deepwater Wind's portfolio has a total potential capacity of approx. 3.3GW comprising:

- Block Island (30MW), the only operational offshore wind farm in the US.
- Three offshore wind development projects in Rhode Island, Connecticut, Maryland and New York totaling 810MW of capacity with long-term revenue contracts in place or pending finalization.
- Approximately 2.5GW of offshore wind development potential across three well-sited BOEM lease areas in Massachusetts and Delaware. Of these 2.5GW, 1.2GW is developed through an equal joint venture with PSEG, a leading New Jersey utility.

Ørsted's current US offshore wind portfolio has a total capacity of approx. 5.5GW comprising:

- Development rights for up to 2GW at the Bay State Wind site off the coast of Massachusetts owned in a joint venture with Eversource.
- Development rights for up to 3.5GW at the Ocean Wind site off the coast of New Jersey.
- In Virginia, Ørsted will be constructing two 6MW wind turbine positions for phase one of Dominion Energy's Coastal Virginia Offshore Wind Project. Ørsted has exclusive rights with Dominion Energy to discuss the potential development of up to 2GW of offshore wind capacity.

With the combined organization and asset portfolio, Ørsted will be able to deliver clean energy to the seven states on the US East Coast that have already committed to build more than 10GW of offshore wind capacity by 2030.

Trump Administration Delivers Historic Progress on Offshore Wind

On Wednesday, October 17, U.S. Secretary of the Interior Ryan Zinke announced three major developments in American offshore wind energy spanning from coast to coast. Continuing with the Trump Administration's all-of-the-above energy policy, the Secretary spoke at the American Wind Energy Association's Offshore Wind Conference and announced 1.) much-anticipated wind auction in federal waters off the coast of Massachusetts; 2.) the environmental review of a proposed wind project offshore Rhode Island; and 3.) the next steps to a first-ever wind auction in federal waters off of California.

Wind Auction Offshore Massachusetts

The Bureau of Ocean Energy Management (BOEM) will hold the next offshore wind auction – to include nearly 390,000 acres offshore Massachusetts – on 13 December, 2018. Nineteen companies have qualified to participate in the auction for the Massachusetts Wind Energy Area, demonstrating continued strong commercial interest in the U.S. offshore wind market. For more information, visit the BOEM website at <https://www.boem.gov/Commercial-Wind-Leasing/Massachusetts/Lease-Sale-4A/>.

Environmental Review of Wind Project Offshore Rhode Island

In October, BOEM published a Notice of Intent to prepare an Environmental Impact Statement for the Construction and Operations Plan for the South Fork Wind Project offshore Rhode Island. If approved, the plan would allow construction and operation of up to 15 turbines that connect via a transmission cable to a grid in East Hampton, New York - the east end of Long Island. The project is approximately 19 miles southeast of Block Island. The comment period has closed.

Call for Information and Nominations Offshore California

In October, BOEM published a Call for Information and Nominations (Call) to identify companies interested in commercial wind energy leases within three proposed areas off central and northern California. This is the first step towards offering a location for wind leasing. For more information, visit: <https://www.boem.gov/California/>.



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BP Starts Thunder Horse Northwest Expansion Project Ahead of Schedule

BP announced in October that it has started up the Thunder Horse Northwest Expansion project in the deepwater Gulf of Mexico, four months ahead of schedule and 15 percent under budget.

This is the fourth Upstream major project to begin production for BP globally so far this year, following seven that started up in 2017 and six in 2016. BP expects that new projects beginning production between 2016 and 2021, part of its strategic focus on growing gas and advantaged oil production, will provide it with 900,000 barrels of oil equivalent a day (boe/d) of new production by 2021.

The new project is expected to boost production at Thunder Horse by an estimated 30,000 boe/d at its peak, taking gross output at one of the largest oil fields in the Gulf of Mexico to over 200,000 boe/d. Originally planned for start-up in early 2019, the project is the latest sign of BP's continued momentum in the US offshore region.

The project, which achieved first oil just 16 months after being sanctioned, adds a new subsea manifold and two wells tied into existing flowlines two miles to the north of the Thunder Horse

platform. It comes after two other major field expansions at Thunder Horse in recent years. In 2017, an expansion of Thunder Horse's south field – a four well tie-back to the floating hub – boosted gross production at the field by over 50,000 boe/d. The year before, BP started up a major water injection project at Thunder Horse to further enhance oil production at the field.

Developed with partner ExxonMobil, the Thunder Horse platform sits in more than 6,000 feet of water and began production in June 2008. It has the capacity to handle 250,000 gross barrels of oil and 200 million gross cubic feet of natural gas per day.

In the deepwater Gulf of Mexico, BP operates four large production platforms – Thunder Horse, Atlantis, Mad Dog and Na Kika – and holds interests in four non-operated hubs – Mars, Olympus, Ursa and Great White.

Over the last five years, BP's net average daily production in the Gulf of Mexico has increased from under 200,000 boe/d in 2013 to over 300,000 boe/d and is set to grow further with the addition of the Mad Dog Phase 2 platform in 2021 and other upcoming projects.

Letter of Award Submitted for Johan Sverdrup Phase 2 High-Voltage Power Cables

Equinor and the Johan Sverdrup partnership have submitted a letter of award to NKT for fabrication and installation of two high-voltage cables supplying power from shore for the second phase of the Johan Sverdrup development.

The award is for the engineering, procurement, fabrication, installation and testing of two high-voltage power cables to the Johan

Sverdrup field center from shore. The high-voltage cables are 200 kilometers long and designed for a supply capacity of 200 MW/80 kV. This covers the power requirements for the second phase of the Johan Sverdrup field development scheduled for start-up in Q4 2022 and will also enable the supply of power from shore to other fields at Utsira High. The total contract value is just over NOK 1 billion.

NKT was also responsible for the fabrication and installation

of the power cables for the first phase of the Johan Sverdrup development, which were installed in the spring of this year.

Fabricated at NKT's plant in Karlskrona, Sweden, the high-voltage cables will be laid from Haugsneset in Tysvær municipality north of Stavanger to the Johan Sverdrup field center on the Utsira High. There the power cables will be pulled up to the second processing platform, to be installed in 2022, at the Johan Sverdrup field center. The cables will be buried into the seabed or covered by rocks, as required.

This contract is the last of the three major contracts covering power from shore in phase 2 of the project. The first contract was awarded to Siemens for delivery of high-voltage direct current (HVDC) transformer equipment.

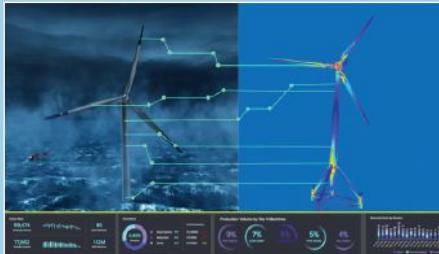
The second covers all construction work related to the onshore converter station at Haugsneset, awarded to Aibel. The first phase of the Johan Sverdrup development will also be operated with power from shore. Production start-up of Johan Sverdrup phase 1 is planned for November 2019.

Power from shore to Johan Sverdrup helps make the giant field one of the most carbon efficient oil and gas fields worldwide. Total emission savings from the Johan Sverdrup field are estimated at 460,000 tonnes of CO₂ per year, which is equivalent to annual emissions from 230,000 private cars.

The award is subject to Norwegian government approval of the plan for development and operation for Johan Sverdrup phase 2 submitted on 27 August 2018.



The cable-laying vessel NKT Victoria at the Johan Sverdrup converter station at Haugsneset near Kårstø. (Photo: Øyvind Gravås - Woldcam / Equinor)



Innogy and Shell Back Predictive Digital Twin Pioneer with \$10 Million Investment

Predictive digital twin pioneer, Akselos, has announced the completion of a \$10 million financing round led by Innogy Ventures, with Shell Ventures as Co-Investor. The new round of financing will be used to help increase the sustainability of critical assets in the energy sector, by empowering predictive maintenance with structural analysis software, big data analytics and machine learning. www.oceannews.com/news/energy/innogy-and-shell-back-predictive-digital-twin-pioneer-with-10-million-investment



First Power Milestone Reached for Kincardine Wind Farm

What will be the world's largest floating offshore wind farm, Kincardine Offshore Windfarm Ltd (KOWL), started generating power off the coast of Kincardineshire on 26 September 2018. Assembled in Dundee before being moved and anchored in place, it is a watershed moment for the six turbine 50MW test and demonstration project. The remaining five turbines will be installed over the next two years. <https://www.oceannews.com/news/energy/first-power-milestone-reached-for-kincardine-wind-farm>



NKT Delivers High-Voltage Cable System to Rentel Offshore Wind Farm

The high-voltage cable system from NKT is now ready to transmit renewable energy from the Rentel offshore wind farm to the Belgian power grid. When in operation the offshore wind farm will provide green energy to 300,000 households. www.oceannews.com/news/energy/nkt-delivers-high-voltage-cable-system-to-rentel-offshore-wind-farm

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Engineering a Robust ADCP Mooring System Using a Design-Of-Experiments Approach

By: Michael T. MacNicoll, Tobias Dewhurst, PhD, Richard Akers, P.E., Maine Marine Composites LLC and David A. Capotosto of DeepWater Buoyancy, Inc.

The following is excerpted from a paper presented by the authors at Oceans 18 in Charleston, South Carolina. To read the full paper, access the conference's online proceedings at <http://deepwaterbuoyancy.com/adcp-mooring-design/>.

Maine Marine Composites (MMC) collaborated with DeepWater Buoyancy to develop an oceanographic mooring system for a subsea Acoustic Doppler Current Profiler (ADCP) that addresses the specific deployment depth, environmental conditions, and seafloor characteristics of a site in the Gulf of Maine. Additional design criteria included the wire rope safety, chain load safety, ADCP pitch and knockover (set down), anchor sliding, and the recoverability of the acoustic release.

The buoy shape, buoy volume, gravity anchor mass, chain size, acoustic release buoyancy, and wire rope diameter could be adjusted independently to meet the design goals. However, design changes that improve one objective often have negative effects on other objectives. As a result, a "model-based system engineering" approach, which combines the results from multiple simulators and algorithms into one integrated package, is required.

A Design of Experiments (DoE) framework approach could evaluate each candidate mooring system for how well they satisfied all competing design objectives while minimizing cost. This allowed for efficient optimization for performance, survival, and cost over a large design space. In the DoE approach, an initial design is proposed, design constraints are quantified, and design factors are identified. DoE-driven computer simulations are run, and the results are used to develop a model for constrained optimization. If the optimal design does not satisfy design constraints, a revised DoE is developed, and the process is iterated until a satisfactory design is reached.

MOORING SYSTEM INITIAL DESIGN

The design approach is demonstrated with a hypothetical ADCP mooring design based on typical mooring system deployments. The arrangement consists of an anchor, connected with chain to an acoustic release (used to retrieve the ADCP) with some added buoyancy, and a wire rope from the acoustic release to a buoy that keeps the ADCP in position. The ADCP is attached to the top of the buoy and is positioned 100 meters below the surface to avoid the most extreme wave motions. The buoy has the dual objectives of (1) providing reserve buoyancy to keep the ADCP upright and in position to minimize pitching and knockover (set down) motions, and (2) to bring the mooring string to the surface when the release is activated. The arrangement is summarized in TABLE I.

TABLE I. SUMMARY OF INITIAL DESIGN

Factor Name	Value
A Reserve Buoyancy Shape	Spherical
B Reserve Buoyancy Lift	3,900 N
C Anchor Mass	1,500 kg
D Chain Diameter	10 mm
E Acoustic Release Buoyancy	0.237 m ³
F Wire Rope Diameter	10 mm

ENVIRONMENTAL CONDITIONS AND DESIGN CONSTRAINTS

The ADCP deployment site is in 300 m of water. MMC has performed a robust study of this site to determine the most severe ocean conditions with a return period of 50 years using Principle Component Analysis and the inverse first-order reliability method.

Using DoE methodology, an experiment was designed to identify factors that drive the system performance and cost. The results were used to optimize the system, accounting for both first-order interactions between factors and competing design objectives. The following seven design objectives were identified:

- Prevent uplift and sliding of the anchor
- Minimize knockover of the ADCP
- Minimize pitch of the ADCP
- Maintain minimum safety factor of the wire rope of at least 1.7
- Maintain minimum safety factor of the anchor chain of at least 1.7
- Acoustic release must have enough buoyancy to be recoverable if the wire rope fails and the acoustic release is disconnected from the upper buoy.
- Minimize the cost of the system

DESIGN FACTORS



Fig. 1. ADCP reserve buoyancy options: spherical & elliptical buoys (source: www.deepwaterbuoyancy.com).

Six design factors were identified to be tuned by the DoE simulations. These design factors and their corresponding higher and lower levels are summarized in **TABLE II**.

TABLE II. SUMMARY OF DOE INPUT FACTORS

Factor Name	Levels	
	-1	+1
A Reserve Buoyancy Shape	Spherical	Elliptical
B Reserve Buoyancy Lift	2,800 N	3,900 N
C Anchor Mass	600 kg	1,500 kg
D Chain Diameter	6 mm	10 mm
E Acoustic Release Buoyancy	0.02 m ³	0.237 m ³
F Wire Rope Diameter	6 mm	10 mm

COMPUTER SIMULATION

A computer simulation of the ADCP and its mooring system was developed and run for each row of the fractional factorial matrix during the 50-year return period storm with a steady current of 1.75 m/s. Three phases of deployment were investigated in the DoE simulations, including (1) deployment in calm water, (2) survival in 50-year return period storm event, and (3) retrieval using the acoustic release.

RESULTS

The results of the simulations were used to optimize design. A linear regression model was fit to each design objective and normalized with a logistic function. The global objective function is the minimum of each of the sub-objectives. This approach allows all objectives to be optimized simultaneously and allows design criteria such as safety factors to be accounted for by adjusting the steepness of the logistic normalization.

Fig. 2 shows the objective function as a surface plot with respect to the chain diameter and the wire rope diameter. There is a trade-off between safety factor and cost that suggests that the optimal wire rope and chain diameters are roughly halfway between the upper and lower DoE levels.



Fig. 2. Objective surface plot shown with respect to chain diameter (x-axis) and wire rope diameter (y-axis). Yellow regions show the peak objective values.

Fig. 3 shows the objective function with respect to the buoy shape and size. The buoyancy must be optimized to balance reduction in cost

with increase in wire rope strength. As buoyancy decreases, ADCP pitch increases. An elliptical buoy shape better mitigates ADCP pitch than a spherical buoy.

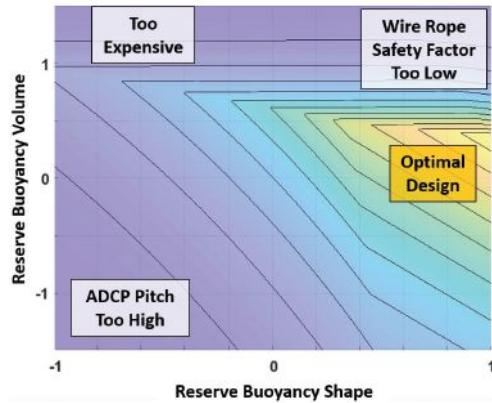


Fig. 3. Objective surface plot shown with respect to reserve buoyancy shape (x-axis) and buoy volume (y-axis). Yellow regions show the peak objective values.

The optimal design inputs are summarized in **TABLE III**.

TABLE III. SUMMARY OF OPTIMAL DESIGN

Factor Name	Optimal Design	
	Level	Value
A Reserve Buoyancy Shape	1.00	Elliptical
B Reserve Buoyancy Lift	-0.44	3,108 N
C Anchor Mass	1.43	1,694 kg
D Chain Diameter	-0.01	8.1 mm
E Acoustic Release Buoyancy	0.55	0.18 m ³
F Wire Rope Diameter	1.50	7.6 mm

The initial design is compared with the optimized design in **TABLE IV**. The optimal design meets all objectives, substantially reduces knockover of the ADCP compared with the initial design and reduces cost by 16%. This result was achieved in a single design iteration and demonstrates that the DoE-based simulation approach can be used to efficiently examine a broad design space and develop robust, cost-effective mooring systems for ADCP and oceanographic applications.

TABLE IV. COMPARISON OF INITIAL AND OPTIMAL DESIGN RESULTS

Objective	Initial Design	Optimal Design
Wire Safety Factor	2.9 ✓	3.0 ✓
Chain Safety Factor	3.2 ✓	2.5 ✓
ADCP Pitch	8 deg ✓	9 deg. ✓
ADCP Knockover	25 m ✗	12 m ✓
Anchor Sliding	None ✓	None ✓
Acoustic Release Recovered?	Yes ✓	Yes ✓
Cost	100% ✗	84% ✓

Using VideoRay ROVs for Hydropower Inspection: THE ADVANTAGES OF CUSTOMIZATION



The Defender ROV that Dagfin Skaar purchased is customized for the inspection of hydropower facilities.

In September 2018, representatives from Dagfin Skaar of Norway spent three days at VideoRay's headquarters completing factory acceptance testing on their new custom Mission Specialist Series (MSS) Defender. The custom MSS Defender was accepted by Oyvind Skaar, Chief Executive Officer, of Dagfin Skaar. ON&T asked Oyvind Skaar about why his company chose this product, and what their plans were for using the MSS Defender ROV. This is what we learned.

The Defender ROV that Dagfin Skaar purchased is customized for the inspection of hydropower facilities. In particular, the company will use it to inspect water tunnels. Such tunnel inspection can be quite challenging.

Without advanced ROV technology, they have to shut down the power station, then tap the tunnel to drain it, and wait for a week to go in with persons to secure the area by removing rocks and any other debris. Under this scenario, one inspection can take two or three weeks. But Dagfin Skaar can go in with the VideoRay ROV as soon as ten minutes after the power station is shut down. This reduces cost for the power operators because their equipment is down for a shorter period of time. And because it reduced the need for divers, it is also a safer approach in human terms.

This isn't the first time Dagfin Skaar has used VideoRay ROVs. They bought their first ROV for underwater inspections from VideoRay in 2008. In May 2017, they upgraded to a VideoRay Pro 4. After nine years of the Pro 3 and only one year of the Pro 4, why upgrade?

First of all, the company wanted an ROV with a long tether, because the tunnels are 1500 to 2000 meters long. In the past, inspection ROVs were limited to around 600 meters of tether, but the new Defender allows inspection to reach the full length of the tunnels in a single deployment. Another important selection factor was Defender's light weight relative to other systems. Other systems that are available for

tunnel inspections at such depths are very heavy. A crane or helicopter are required in order to move such heavy systems out in the field. But the Defender can be transported out in the field with an ATV or snowmobile. Even the tether for the Defender is much thinner and lighter. The whole system is smaller and lighter.

Another advanced feature VideoRay provided is customized imaging capabilities. The Defender is specifically configured for underwater imaging tasks that include both a real-time camera function and dual sonars.

Inspectors needed sonar imaging, so that if the visibility is low, they could still navigate. The Tritech Micron DST Sonar used on the Defender is ideal for obstacle avoidance. It dramatically improves the range resolution compared with conventional scanning sonars and, in fact, it's a feature normally associated with much larger, more expensive systems.

But that's not all. Dagfin Skaar also wanted a second sonar, in order to scan 360 degrees of the tunnel, so that they can capture the profile of the tunnel all the way along inspection, without interruption. The Tritech Gemini 720i multibeam imaging sonar provided by VideoRay captures real-time, crisp imagery of the underwater scene ahead. With a wide 120° field of view, it is ideal technology for target detection. And when it comes to the visual inspection of hydropower water tunnels, this means determining whether there are any rocks or debris that fall down in the tunnel, which might impede the flow of water. Dagfin Skaar captures the scan to create an inspection profile. During post-inspection analysis, they use this profile to identify any changes or anomalies in the tunnels.

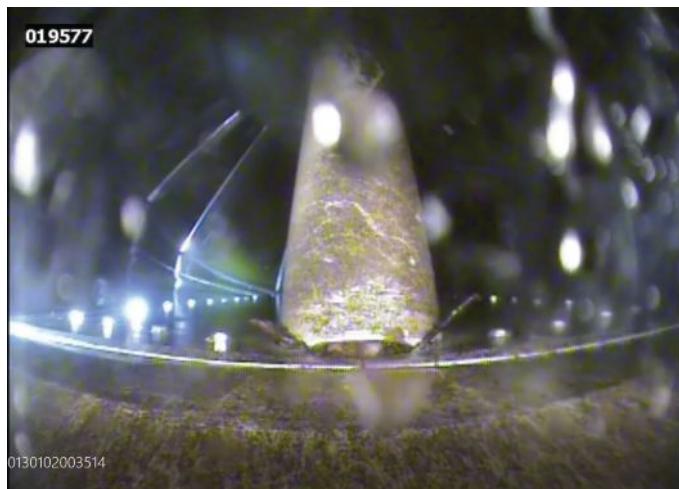
This custom built dual-sonar capability represents the first time VideoRay's engineering team have placed these two sonars on the same ROV, but the two not only complement one another, they work seamlessly together, including zero interference between the two systems.

Another key feature for inspectors is autonomous control. Dagfin Skaar can pre-plot the inspection route and let the ROV travel along the plot, without having to manually steer all the time. That frees up one of the operators to have their hands free, which allows them to take notes, resulting in a more thorough report.

In fact, all VideoRay MSS ROVs include waypoint finding, so that customers can set points on GPS. This can be critical when you need to document a large area, in particular where an inspection (or search) has already occurred. The Defender's positioning system allows users to precisely document their position and mark it on a map, which is critical when it comes time to remove documented debris.



This grid prevents logs and other objects to get into the turbine. This be inspected (and cleaned) on a regular basis.



Dagfin Skaar conducted an inspection to determine what was causing vibrations and noise in a new turbine. By filming inside the turbine, they discovered that some of the blades were making contact with the turbine walls.



Dagfin Skaar's system. From left to right is: Chris Gibson, VP of Sales & Marketing of VideoRay, Oyvind Skaar, CEO of Dagfin Skaar, and Scott Bentley, CEO of VideoRay.

The positioning capabilities are also extremely helpful in support of law enforcement. For example, if someone throws a knife or a gun in the water, even the smallest VideoRay ROV can search with sonar or visual, depending on visibility. And once it finds the item, it can even retrieve it.

Many VideoRay ROVs, including the Defender, include a rotating manipulator arm that attaches underneath the ROV and reaches out the front. While not used in the inspection of hydropower tunnels, it is vital during search operations in support of law enforcement or rescue teams.

VideoRay's remotely operated vehicles (ROVs) are a proven tool when it comes to reducing the risks and costs involved in hydropower inspection. What's more, they can be customized to accomplish high-tech tasks that no human dive team could. These advanced vehicles are pushing the envelope when it comes to inspection class machines that can be deployed and controlled by one person. They can be equipped with sonars, radiation detectors, manipulators, water samplers, hull crawlers, positioning systems, and much more. VideoRay has multiple technology partners that standardized their equipment to the VideoRay ROV for seamless integration.

About VideoRay

VideoRay is a global leader in ROV technology. Established in 1999, VideoRay has worked with technology and mission partners throughout the world to develop and prove the small ROV tool for a wide range of applications. With units delivered to a wide range of organizations for a wide range of missions, hundreds of VideoRays work every day throughout the world underwater keeping us free from terrorism, finding and retrieving objects, inspecting infrastructure both inland and offshore, and keeping divers safe from hazardous conditions.

About Dagfin Skaar

Established in August 2000, Dagfin Skaar AS is a consulting engineering company working in construction and engineering and is a Member of Advisory Engineers' Association (RIF). With more than 20 employees and over 40 years of experience, Dagfin Skaar undertakes assignments in building and construction engineering, project and construction management, subsea inspections, condition analysis, rehabilitation of building constructions, and fire engineering. Since 2008 Dagfin Skaar has been using VideoRay ROVs for inspections. Along with the ROV, four of Dagfin Skaar's engineers are also divers with license to provide commercial diving. The divers do inspections of infrastructure like keys, bridges, and hydropower plants.

For more information, visit
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General Dynamics Launches Bluefin-9 Robotics Vehicle

General Dynamics Mission Systems released the new Bluefin-9 autonomous unmanned underwater vehicle (UUV) at OCEANS 2018 in Charleston, SC. Featuring a full carbon fiber body, this completely redesigned vehicle combines high navigational accuracy and outstanding sonar resolution to deliver highly-detailed subsurface data in minutes. The two-man portable UUV provides the same data collection capabilities of larger UUVs, and can be deployed and recovered from piers, a rigid-hulled inflatable boat (RHIB) or other vessels of opportunity.

The Bluefin-9 includes a removable data storage module (RDSM) which stores high-definition images, video and sonar data that can be accessed within minutes of the vehicle's recovery. It delivers mission endurance of up to eight hours at a speed of three-knots, and can reach speeds of six-knots and dive to 200 meters. Because of its modularity, customers can exchange both the RDSM and battery to redeploy the Bluefin-9 in 30 minutes or less. These capabilities align with environmental surveying, water quality measurement, search and recovery,



Members of the General Dynamics team unveil the Bluefin-9 during the Oceans18 conference.

security, intelligence, surveillance and reconnaissance, and other tactical missions.

"We're very proud to release the Bluefin 9," said Michael Gay, product manager for General Dynamics' undersea systems business. "It's very important to us that we come out with a turnkey product focused on best in class data quality in a two-man portable package. Traditionally, for Bluefin Robotics products, we would use ABS plastic, but to make the new design compelling for a two-man product offering, we used carbon fiber, which resulted in a vehicle that only weighs 155 pounds (70 kg)

"Another aspect of its two-man portability, the front handle," added Mr. Gay, "was a deliberate design decision that we made to accommodate a small vessel of opportunity where a single operator can dump the vehicle in the water and recover it over the gunnel of a ship. It can be easily deployed and recovered without a launch and recovery system."

"The nose of the vehicle is reinforced with four times the carbon fiber than the rest of the vehicle, so it's extra resistant of strikes. The Bluefin 9 can be recovered with both handles, but the entire vehicle is designed to support the fully entrained water weight of the vehicle as you hold that front handle."

"What we're talking about with data quality is the Sonardyne Solstice Multi-Aperture Sonar system coupled with an incredibly precise navigation and timing solution, along with our standard Bluefin Robotics dynamic control really maybe the Solstice shine in this application."

To see what else is new on the Bluefin-9, visit <https://gdmissionsystems.com/products/underwater-vehicles/bluefin-9-autonomous-underwater-vehicle>.

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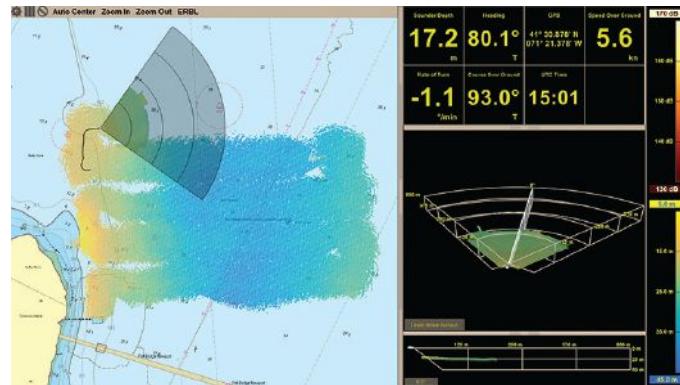
32 ON&T | NOVEMBER/DECEMBER 2018

FarSounder Joins NOAA Bathymetry Initiative

FarSounder is the most recent company to join the International Hydrographic Organization's Crowd-Sourced Bathymetry (CSB) initiative by becoming a "trusted node" with NOAA. This project enables mariners to voluntarily contribute seafloor depths measured from their vessels to NOAA's data repository.

FarSounder's customers regularly travel to remote areas with poorly maintained nautical charts, using a FarSounder 3D-FLS for real-time navigation. Due to the development of FarSounder's Local History Mapping™ (LHM), the latest feature of its SonaSoft software, users now have the ability to create a real-time chart of the seafloor of where they recently sailed and collect this bathymetric data. Collecting these LHM™ data-sets and contributing them to the IHO Data Centre for Digital Bathymetry (DCDB) hosted by NOAA's National Centers for Environmental Information will allow worldwide use of this data for a variety of purposes including in the assessment and production of nautical charts in all waters.

FarSounder recently began a pilot project that will allow select customers to submit their standard single-beam echosounder (SBES) depth measurements, recorded along with other



navigational information through FarSounder's SonaSoft software, to the IHO DCDB database. If the vessel operators agree to contribute their location and depth measurements, hydrographic offices (HO), will have access to these data sets when updating and maintaining charts in these areas. One major benefit of these contributions is the HO's improved ability to provide an accurate diagram for all mariners to follow. Data contributed to the DCDB will be automatically archived and made freely available through the IHO DCDB Data Viewer for commercial, scientific, or personal use.

For more information, visit
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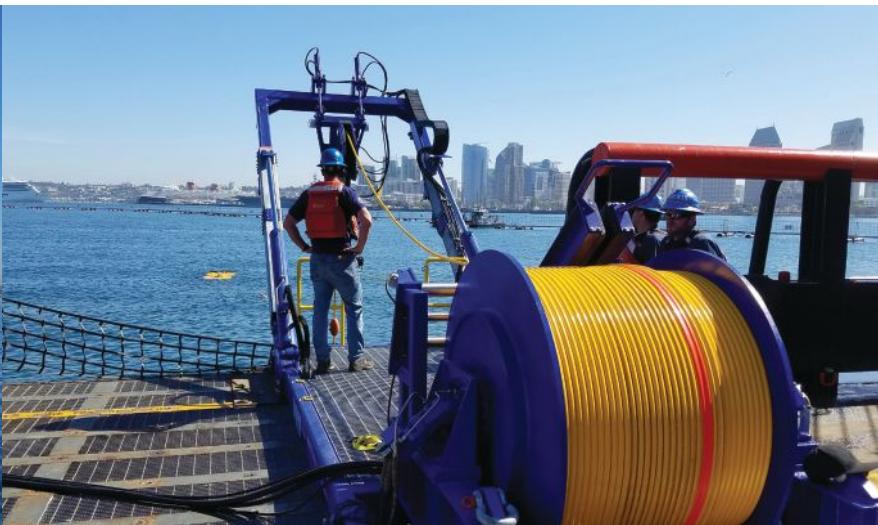
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FROM THE DECK TO THE SEAFLOOR: Okeanus Science & Technology Provides Fit-For-Purpose Solutions

Okeanus Science & Technology, LLC, provides oceanographic professionals with the tools necessary to complete a project on time and on budget, no matter the water depth or location.

Formed in 2013, this innovative company has grown its capabilities and experience through strategic acquisitions and key personnel hires. By acquiring Sound Ocean Systems, Inc. in 2016 and DT Marine Products, Inc. in 2017, Okeanus gained decades of world-class experience in the design and build of oceanographic winches, handling systems, LARS, buoys, and other products.

Clients with Vital Missions

Okeanus has supplied a number of key organizations in the mine hunting and mine countermeasures markets with both hydraulic and electric winches and handling systems for manned and unmanned vessels. In 2018, the company completed factory acceptance testing for a winch for an unmanned surface vehicle (USV)-based towed mine hunting system for Northrop Grumman. Ultimately, the mine hunting system will be towed through the water by surface vessels in areas where naval commanders believe enemy anti-ship mines may be present.

Okeanus also recently completed an engineering and design contract for a USV based all-electric launch and recovery system (LARS) for a mine hunting tow body.

This is important work that requires high-quality equipment. Okeanus' line of custom winches are designed to meet the deployment needs for researchers, operators and contractors, whether for permanent installation or mobilization on vessels.

Creating Value at Any Depth

Okeanus LARS are often designed for operation in Sea State 5, and carry the cable capacity for full ocean depth. In fact, all Okeanus products are primed for the challenges that come with working in extreme conditions—from rough seas to deeper water.

The Leasing Experts

Okeanus provides fit-for-purpose solutions that help its customers work in a safe, efficient, and cost-effective manner. This same commitment to quality and affordability extends to Okeanus' extensive pool of equipment available for lease, which can be paired with any of its winches and rapidly deployed. In fact, the company's rental business experienced record sales

in 2018 and they plan to continue to expand their extensive rental equipment pool.

Okeanus' turn-key solutions make mobilization easy and more efficient. By offering rental equipment alongside their complete design services, Okeanus truly provides all the tools needed to get the job done right. What's more, they can come to you. Okeanus' entire range of products can be shipped anywhere in the world.

Staff and Facilities

Okeanus employs a dynamic, experienced staff at three locations (Houma, Louisiana, Houston, Texas, and Redmond, Washington), each chosen to serve different regions and markets. In order to continue providing high quality products and services rapidly and affordably, the company plans to grow their already impressive capabilities. In 2019, Okeanus will complete the expansion of their Houston, TX facility and increase their engineering and production staff.

From the deck to the seafloor, Okeanus will continue providing customers with what they need to get the job done on time and on budget.

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ROV Discovers Source of White Rose Oil Spill

After an oil spill occurred on 16 November 2018 at the White Rose field approximately 350 km southeast from St. John's, Canada, Husky Energy deployed a remotely operated underwater vehicle (ROV) to inspect the subsea flowlines and confirm the source of the leak.

Subsea ROV inspections began 19 November and continued for (at least) a full week. The inspections revealed that the release came from a subsea flowline connection (pictured). Also observing the area have been five vessels on the water and (at least) ten overhead flights.

Husky Energy shut in oil production at the White Rose field Thursday, November 15, 2018 due to operational safety concerns resulting from severe weather. That weather is believed to have been a cause of the spill, but an investigation into the cause of this incident, led by Canada-Newfoundland Offshore Petroleum Board (C-NLOPB), is underway.

Husky's official website states that operations will remain suspended until a full inspection of all facilities is completed and Husky has received the support and approval of the C-NLOPB.



A remotely operated underwater vehicle (ROV) survey has shown the release came from this subsea flowline connection.

The chain in the photo is in the correct location and is part of the flowline restraint system. It is connected to a pile located outside the South White Rose Extension drill center, approximately 5.5km from the SeaRose (floating production, storage and offloading) FPSO vessel.

No human injuries were reported, but wildlife monitoring continues, and a wildlife treatment center is open. As of November 26, Husky was reporting that the number of impacted wildlife observed included 18 birds. Of these, 3 are being treated at the seabird rehabilitation center in St. John's and 5 (3 petrels and 2 murre) are deceased. Husky says that their focus remains the safety of both people and the environment.



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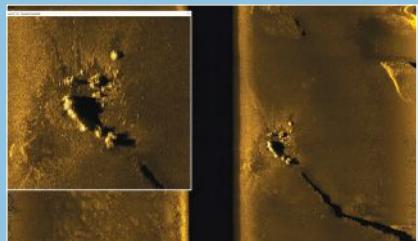


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MONTH IN REVIEW



EdgeTech 2205 sonar image of ARA San Juan 230kHz at 400m range scale Credit to Ocean Infinity.jpg

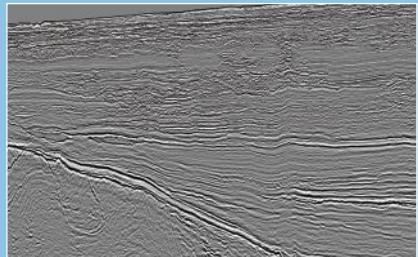
EdgeTech Sonar Technology Helps Find Missing Submarine

EdgeTech's side scan sonar technology was used to help find the missing Argentine submarine, ARA San Juan. The deep-water search was performed by Ocean Infinity and its advanced fleet of 6,000 meter rated autonomous underwater vehicles (AUV) equipped with EdgeTech 2205 Side Scan Sonars. The submarine, which has been missing for one year, was discovered in over 900 meters of water. <https://www.oceannews.com/news/subsea-intervention-survey/edgetech-sonar-technology-helps-find-missing-argentine-submarine>



Arctic Rays Releases Hammerhead

Seeing the need for a simple, low-cost, ultra-compact pan and tilt for moving its lights and cameras, Arctic Rays, LLC has released Hammerhead for use on multiple platforms, including ROVs, HOVs, ASVs, landers and fixed platforms. <https://www.oceannews.com/news/subsea-intervention-survey/arctic-rays-releases-hammerhead-low-cost-ultra-compact-pan-tilt>



Fast-Track 3D Data from CGG's Mozambique Survey Now Available

CGG announced during Africa Oil Week that the seismic data from its recent Mozambique multi-client survey in the outer Zambezi Delta Basin is now available for license. <https://www.oceannews.com/news/subsea-intervention-survey/fast-track-pstm-data-from-cgg-s-mozambique-survey-now-available>



Kreuz Glorious Mobilizes for Offshore Inspections

Kreuz Subsea and consortium partner Seamec Ltd, have completed mobilization of the Kreuz Glorious vessel for a two-year project with India's Oil & Natural Gas Corporation (ONGC) that includes the inspection of 27 offshore jackets off the coast of Mumbai in the Arabian Sea. The construction work barge is specifically designed to work around complex jackets which are often inaccessible by more traditionally utilized DP2 diving vessels. <https://www.oceannews.com/news/subsea-intervention-survey/mobilization-of-kreuz-glorious-for-two-year-ongc-project>

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Cable Snapshot: Submarine Power Cable Contract Awards, Jan-Oct 2018

This is the latest monthly review of submarine power cable contract awards for 2018 from our partners at SubCable World.

The demand for submarine power cable continued to experience solid growth since June. Through May, the total of all of the contract awards in 2018 was only 196 kilometers. Since June, however, 2,158 kilometers of cable have been awarded in contracts.

Nearly all of this new demand is being driven by the offshore wind industry. Of the 19 contract awards announced since June, 16 were for offshore wind projects. Overall for the year, 79% of the route-kilometers contracted are for offshore wind contracts.

The table below lists the contracts awarded in 2018.

Project	Application	Route-km	Month	Supplier
Kincardine Floating Offshore Wind Farm	Ocean Energy	17	January	Prysmian
BP Tanggu	Offshore O&G	58	January	ZTT
Capri-Naples	Interconnector	16	February	Prysmian
Deutsche Bucht Wind Farm	Ocean Energy	45	February	NSW
Chittagong-Sandwip Island	Interconnector	60	March	ZTT
Borssele III & IV Wind Farms	Ocean Energy	175	June	Prysmian
Formosa-1 Wind Farm	Ocean Energy	34	June	JDR
Lake Mjøsa Crossing	Interconnection	35	June	NKT
Hornsea-2 Wind Farm (export)	Ocean Energy	190	June	NKT
Windfloat Atlantic Wind Farm	Ocean Energy	18	July	Hengtong
Tianjin Wind Farm	Ocean Energy	75	July	Ningbo Orient
Jiangsu Wind Farm	Ocean Energy	70	July	Hengtong
Hornsea-2 Wind Farm (inter-array)	Ocean Energy	300	July	Prysmian
Fecamp Wind Farm	Ocean Energy	120	August	Prysmian
Courseulles-sur-Mer Wind Farm	Ocean Energy	110	August	Prysmian
Saint Nazaire Wind Farm	Ocean Energy	115	August	Prysmian
Hornsea-2 Wind Farm (inter-array)	Ocean Energy	100	September	JDR
Triton Knoll Wind Farm	Ocean Energy	144	September	NKT
Hollandse Kust (South) Alpha-Beta	Ocean Energy	42	September	Hellenic
Yangjiang Nanpeng Island	Ocean Energy	45	September	ZTT
Crete-Mainland Greece	Interconnector	135	October	Prysmian
Johan Sverdrup 2	Offshore O&G	200	October	NKT
Northwester 2	Ocean Energy	50	October	Nexans
Moray East	Interconnector	175	November	NKT
Total		2,354		



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JDR Cables Expanding into US Offshore Wind Market

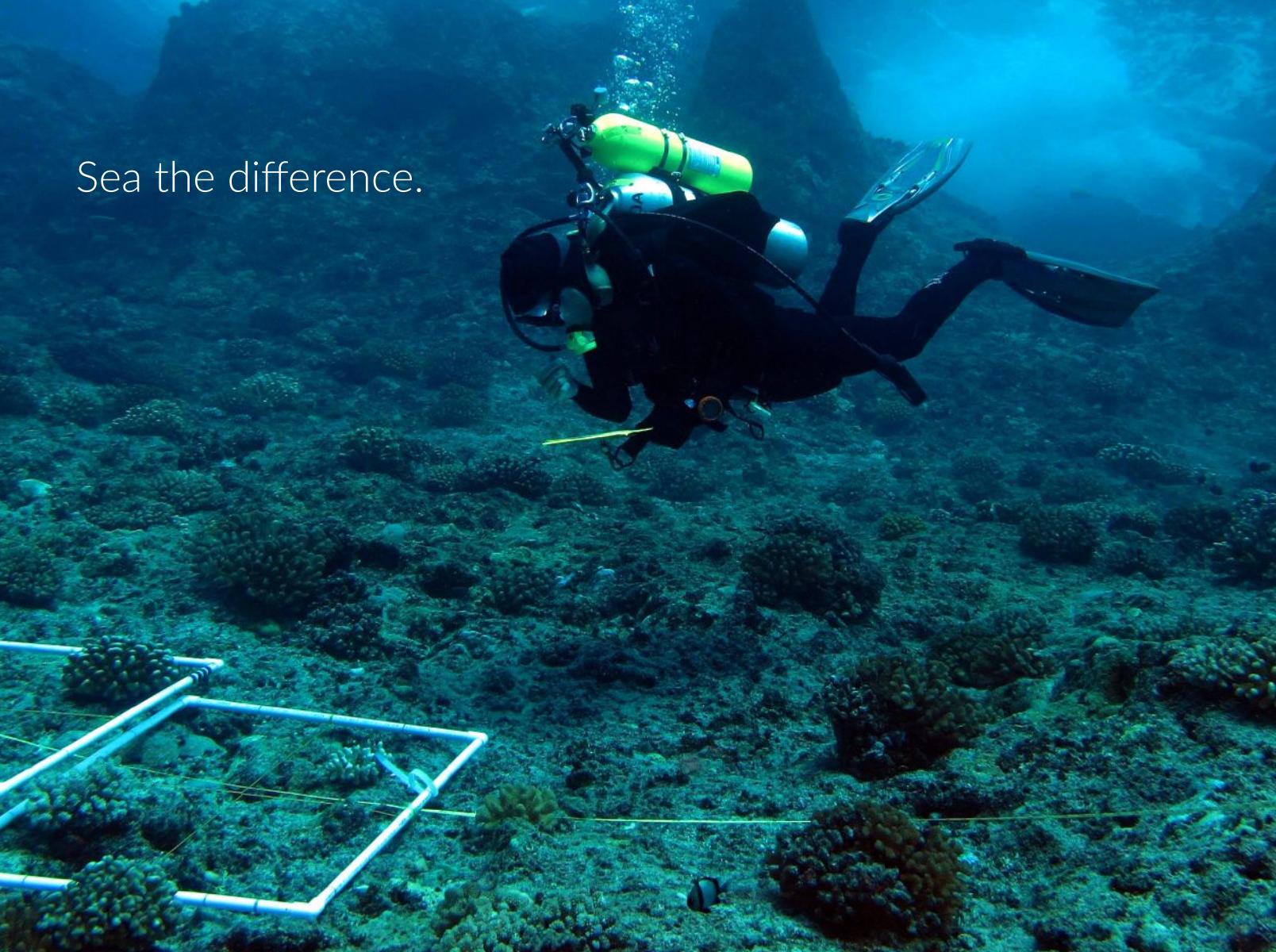
JDR Cable Systems and McAllister Towing have established a Memorandum of Understanding (MOU) for the development and collaborative operation of a US East Cost Offshore Wind subsea power cable service base with an integrated cable training center.

This new facility is being targeted to be developed on an existing McAllister quayside waterfront property in the northeastern United States. The site has been selected due to its proximity to the current offshore wind leases and the enormous potential of the region in the use of renewable energy sources. Initially this base will serve as a staging area for subsea power cables to enable local storage, maintenance and deployment to the offshore wind fields.

Longer term plans include the establishment of office, storage, workshop and training facilities to develop offshore high voltage electrical and fiber optic competencies to the local workforce. As the US offshore wind industry matures, this service base will transition to become the JDR Offshore Wind Life of Field Service Center. Some of the services to be provided will be asset management services, capital spare cable storage, preservation and maintenance as well as the JDR life of field service headquarters for the US Offshore wind market.

David Nemetz, Director for the Americas at JDR, said, "Our partnership with McAllister is one of several critical steps JDR Cables has towards establishing our market leading presence in the US offshore wind market. McAllister makes the perfect partner for JDR as their vessel and tug experiences will complement our strategy for development of services during the installation, commissioning, operating and decommissioning phases of this new industry. Establishing this first of its kind service facility in the US market will provide additional value for our customers thanks to the experience of our employees in the field of production, technology, and services."

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USNS Zeus Cable-Laying Ship to Undergo Overhaul

The U.S. Navy has given Colonna's Shipyard \$10.5 million for a four-month overhaul of the USNS Zeus cable-laying ship.

The contract, announced on November 9 by the Department of Defense, will include general ship services, main propulsion inspection, cable-laying equipment, sensors and other dry dock availability overhaul work. Additional options on the deal, if

exercised, would bring the total contract value to \$13.5 million.

Work on the contract is expected to be completed by April 2019.

The USNS Zeus is the first purpose-built undersea cable-laying ship developed by the U.S. Navy. Its missions include cable laying and repair, array-laying operations, projector towing and other operations.

The Zeus can lay 1,000 miles of cable in depths of up to 9,000 feet without resupply. It is also equipped with single-beam and multi-beam sonars for surface floor mapping and can deploy towed side scan sonars and camera sleds. Originally, the Zeus was planned to be the first of two ships of her class, however the second ship was not built, leaving Zeus as the only ship of her class to have been constructed.

Sensors on board include temperature, density, acoustic buoys and other environmental measurement systems. Two ships were planned for the Zeus-class but the second was canceled, leaving the Zeus as the lone member of the class.

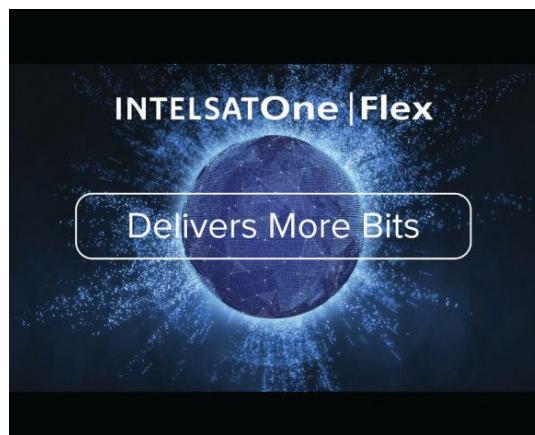
Intelsat and APSATCOM Launch IntelsatOne Flex for Maritime in Asia

Intelsat S.A., operator of the world's first Globalized Network and leader in integrated satellite communications, announces that APT Mobile Satcom Ltd. (APSATCOM) will become the first maritime solution partner to offer, in China, IntelsatOne Flex for Maritime services. This agreement will deliver a seamless global maritime network for APSATCOM's customers, providing unparalleled throughput, improved economics, and easier access to broadband services.

Under the new, multi-year agreement, Intelsat will provide IntelsatOne Flex for Maritime services, interconnection, and backhaul to APSATCOM's data centers. The award-winning IntelsatOne Flex for Maritime platform is a seamlessly integrated managed service that offers multi-layered global coverage by leveraging the power of the Intelsat EpicNG high-throughput satellites (HTS) and Intelsat's global network of wide beam satellites.

IntelsatOne Flex for Maritime provides a flexible infrastructure for solution partners looking to incorporate high-throughput services while avoiding the complexity of forecasting throughput requirements across the various beams. This

enables those solution partners to dramatically improve their economics while delivering higher performance broadband service more efficiently. APSATCOM and other solution partners are able, through this IntelsatOne Flex Service, to customize their solutions and, in turn, deliver a unique value proposition for each of their customers.



APSATCOM, which provides a suite of applications for maritime customers to manage business operations and provide crew services, will introduce its IntelsatOne Flex for Maritime offering with a 1-meter antenna solution focusing on Chinese vessels. About 90 percent of global trade is conducted via shipping, and China's role continues to grow, according to the International Chamber of Shipping. The global reach of IntelsatOne Flex for Maritime also enables APSATCOM to extend its offerings throughout the Asia Pacific region.

For more information, visit
WWW.INTELSAT.COM and
WWW.APSATCOM.COM



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SUBSALVE USA: BUOYANCY EXPERTS FOR EXCITING PROJECTS

Since 1977 Subsalve USA has provided buoyancy solutions and expertise for aircraft recovery, ship, yacht and boat salvage, marine construction, offshore oilfield diving and explosive ordnance disposal, as well as providing bags for crane testing, underwater habitats created for Discovery Channel's Shark Week and National Geographic.

Subsalve USA products have been used in many cable and pipeline projects, one recently during the installation of the United States' first off shore wind farm just off the coast of Block Island, Rhode Island. The installation was done by Kokosing Ind.

Subsalve USA has also made many custom items for NASA, Texas A&M, Oracle Team USA, Disney, Warner Bros., as well as for James Cameron's record-breaking solo dive to the bottom of the Mariana Trench in the Deepsea Challenger, which was documented by National Geographic.

Subsalve USA's projects have also included the use of buoyancy for several draft reduction applications including Group Ocean. They have supported large vessel salvage in Providence, Rhode Island with the U.S. Navy SUPSALV and the U.S. Army Corp. of Engineers Dive Team, raising a Russian K-77 submarine – Juliette 484, which sunk in 2007 after a spring storm and has since been converted into a museum.

Subsalve USA has also been part of several exciting projects in the field of underwater

archeology. Richard Fryburg (Subsalve founder) has been involved in developing the strategy for raising five-ton marble columns from a wreck off the coast of Turkey, as well as participating in the raising with Texas A&M. Subsalve USA buoyancy products were also used in raising Blackbeard's anchor and canons on The Queen Ann's Revenge Project. Their products were also featured on the Discovery Channel program Coopers Treasure with what was thought to be an anchor from a Christopher Columbus ship.

Aside from these projects Subsalve USA has developed cutting edge buoyancy control technology for use in Military and Commercial applications. This technology will be used in conjunction with their state-of-the-art Mark V/ORCA -Explosive Underwater Ordnance Disposal Systems used by the U.S. Navy along with at least 20 navies worldwide.

After 42 years in business, Subsalve USA is the worldwide leader in the design and manufacture of engineered inflatables. Each Subsalve USA product is tested prior to shipping and must meet rigorous U.S. Department of Defense requirements and compliance with IMCA Standards. What's more, these innovative solutions are all totally manufactured in the USA.

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Raising Blackbeard's Anchor from The Queen Anne's Revenge Project



Raising a Russian K-77 submarine



Kokosing Industrial – Block Island Wind Farm Project



James Cameron Deep Sea Challenger top view



Xtera® Conducts DISA's Guantanamo–Puerto Rico Final Splice

Xtera® announces completion of the final splice and marine operations on the Guantanamo – Puerto Rico submarine cable system for the Defense Information Systems Agency (DISA), an agency of the U.S. Department of Defense (DoD). The marine installation for the project was successfully performed by International Telecom's cable ship the IT Intrepid.

The new system will be fully commissioned as scheduled in December and placed into service in early 2019 after being fully integrated into the global DISN network. The contract for the 1,400 km long cable system was awarded in September 2017. The design, which uses Xtera's second generation low noise repeater, delivers a high-capacity solution at the lowest cost per Terabit/s.

Keith Henderson, Chief Executive Officer of Xtera, comments, "The success of this project is a credit to the professionalism of our expert team and their ability to work seamlessly with our industry-leading partners. Excellent collaboration between Xtera and the DISA project team has enabled the on-schedule delivery of the system despite regional weather challenges. Once again Xtera has demonstrated that it is the Supplier of choice for those seeking a high-quality innovative optical solution."

This is the second submarine cable system that Xtera has deployed for DISA, the first has been in the water and fully operational since 2015. Both system designs demonstrate Xtera's strength in the regional market based on its leading technology, which offers the highest-capacity and the longest reach subsea repeater available in the market today. When combined with the Nu-Wave Optima™ Submarine Line Terminal Equipment (SLTE), which utilizes patented Raman technology, Xtera can deliver more than 40 Terabits/s on a single fiber pair. Source: subcableworld.com.

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Intellian Awarded Contract by SPAWAR

Intellian has been awarded a contract by SPAWAR to deliver its new SPL100 antenna system to the U.S. Navy. The SPL100 antenna is a unique combined Ka- and L-band antenna system designed to provide the U.S. Navy with sustained information warfare capabilities. <https://www.oceannews.com/news/communication/intellian-awarded-contract-by-spawar-for-us-navy>



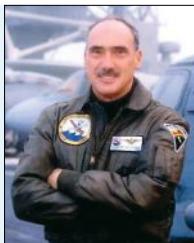
Inmarsat Wins Best Safety Service of the Year Award 2018

Inmarsat's new Fleet Safety service has been named Best Safety Service of the Year in the prestigious IHS Safety at Sea Awards 2018 by a judging panel of recognized authorities in ship ownership, insurance, crewing and training. <https://www.oceannews.com/news/communication/inmarsat-wins-best-safety-service-of-the-year-award-2018>



Offshore Wind Propels Subsea Cable Demand

In the latest Westwood Subsea Cable Tracker H1 report, global subsea cable demand is forecast to grow at a 17% compound annual growth rate over the 2018-2022 period. This represents a 71% growth compared to 2013-2017. Westwood says offshore wind cable demand will account for 45% of forecast demand. To access the full report, visit westwoodenergy.com.



Stealthy, Persistent, and Real-Time Intelligence

U.S. NAVY AND MARINE CORPS TEST AND EVALUATE UNMANNED MARITIME SYSTEMS

BY GEORGE GALDORISI | Director of Strategic Assessments and Technical Futures at the U.S. Navy's Command and Control Center of Excellence | www.georgegaldorisi.com

Unmanned systems are crucial to the future of the Navy and Marine Corps. Each of three studies commissioned by the CNO staff recommend dramatic increases in the number of unmanned systems in the Navy and Marine Corps inventory.

The importance of unmanned systems to the Navy and Marine Corps was highlighted in a memorandum from Assistant Secretary of the Navy for Research, Development and Acquisition, Mr. James Geurts. Mr. Geurts noted:

The United States Navy and Marine Corps have a strategic imperative to exploit emergent and rapidly developing unmanned and autonomous technologies. In order to accelerate the development and fielding of unmanned systems and to ensure an integrated and efficient effort, the Department of the Navy (DON) has established aggressive goals for the acceleration of the DON's unmanned systems and to ensure the DON remains at the forefront of these emergent capabilities.

While unmanned maritime systems have not had the decades of development that many unmanned air vehicles (UAVs) and unmanned ground vehicles (UGVs) have enjoyed, their potential rivals that of these air and ground systems. Under the stewardship of various Naval Sea Systems Command program offices, these systems have been the subject of a renewed focus and developmental imperative.

Operating as they do at the air-water interface on the surface of the oceans, unmanned surface vehicles not only have their own discrete—and growing—list of current and future naval and commercial missions, but also provide the connective tissue between unmanned aerial vehicles and unmanned underwater vehicles, as well as their manned counterparts.

Like all unmanned systems, unmanned surface vehicles are critical assets in all scenarios across the spectrum of conflict. Unmanned surface vehicles enable our warfighters to gain access to areas where the risk to manned platforms is unacceptably high due to a plethora of enemy systems designed to deny access. These unmanned surface vehicles provide excellent range and persistence on station, leading to enhanced situational awareness of an objective area.

Unmanned surface vehicles are especially adept at conducting intelligence, surveillance, and reconnaissance

(ISR) missions, and are typically better suited for this mission than their unmanned aerial vehicle counterparts for a number of reasons, particularly their ability to remain undetected by enemy sensors and their dwell time on station. By performing near-shore intelligence preparation of the battlespace (IPB), unmanned surface vehicles increase the standoff, reach, and distributed lethality of the manned platforms they support.

While the U.S. Navy and Marine Corps have embraced unmanned systems of all types as part of their future force structures, and a wide-range of studies looking at the makeup of the Sea Services in the future have endorsed this shift, it is the Navy-Marine Corps expeditionary forces that have been the most active in evaluating a wide variety of unmanned systems in various exercises, experiments, and demonstrations.

Events Highlight the Potential of Unmanned Naval Systems

Two important Navy-Marine Corps expeditionary events, based on the number of new technologies introduced, were the Ship-to-Shore Maneuver Exploration and Experimentation (S2ME2) Advanced Naval Technology Exercise (ANTX), as well as Bold Alligator. These events highlighted the potential of unmanned naval systems to be force-multipliers for expeditionary strike groups.

There are few missions that are more hazardous to the Navy-Marine Corps team than putting troops ashore in the face of a prepared enemy force. For this reason, S2ME2 ANTX concentrated on using unmanned surface vehicles to conduct critical ISR and IPB missions against enemy formations.

The S2ME2 ANTX demonstration focused on addressing gaps in capabilities that advanced unmanned maritime systems might close for the critical ISR and IPB missions needed before conducting the amphibious ship-to-shore mission. Thus, S2ME2 ANTX had a specific focus on unmanned systems—especially unmanned surface systems—that could provide real-time ISR and IPB of the battlespace.

During the assault phase of S2ME2 ANTX, the blue force used a USV to frustrate enemy defenses. The expeditionary commander selected an eight-foot MANTAS USV (one of

a family of stealthy, low profile, USVs). The USV swam undetected into the enemy port (the Del Mar Boat Basin on the Southern California coast), and relayed information to the amphibious force command center using its TASKER C2 system. Once this larger-scale ISR mission was complete, the MANTAS USV was driven to the surf zone to provide IPB information crucial to planners. This included obstacle location (especially mine-like objects) and beach gradient.

S2ME2 ANTX was a precursor to a major Navy-Marine Corps expeditionary exercise, Bold Alligator. This live exercise was designed to demonstrate maritime and amphibious force capabilities, and was focused on conducting amphibious operations, as well as evaluating new technologies that support the expeditionary force. For Bold Alligator, the 2nd Marine Expeditionary Brigade (MEB) directed events and was embarked in USS Arlington (LPD-24), USS Fort McHenry (LSD-43), and USS Gunston Hall (LSD-44).

The 2nd MEB used a 12-foot MANTAS USV, equipped with a gyro stabilized SeaFLIR230 EO/IR camera and a BlueView M900 forward looking imaging sonar, to provide ISR and IPB prior to the ship-to-shore amphibious assault. The sonar provided bottom imaging of the surf zone, looking for objects—especially mines—and other obstacles that could pose a hazard to the landing craft.

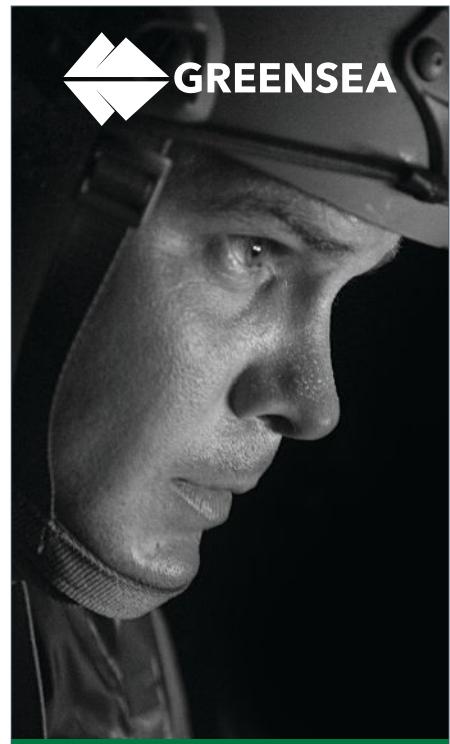
The early phases of Bold Alligator were dedicated to long-range reconnaissance. Operators at the exercise command center at Naval Station Norfolk drove the six-foot and 12-foot MANTAS USVs off North and South Onslow Beaches, as well as up the Intracoastal Waterway. Both USVs streamed live, high-resolution video and sonar images to the command center. The video images showed vehicles, personnel, and other objects on the beaches and in the Intracoastal Waterway. The sonar images provided surf-zone bottom analysis and located objects and obstacles that could present a hazard during the assault phase.

Bold Alligator underscored the ability of surface unmanned systems to provide real-time ISR and IPB. This allowed planners to orchestrate the amphibious assault to ensure that the landing craft passing through the surf zone didn't encounter objects that could disable—or even destroy—these assault craft. This linkage enabled decision-makers not on-scene to direct the assault with a high degree of confidence.

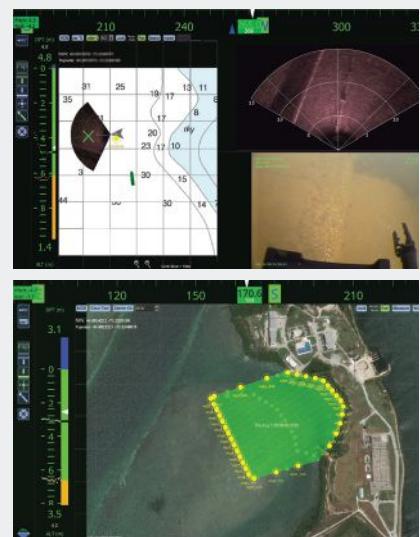
If my three tours in the amphibious assault navy taught me anything, it is that the ship-to-shore movement of an expeditionary assault force remains the most hazardous mission for any navy. Real-time ISR and IPB will spell the difference between success and failure—and failure means the loss of life. For this reason, the Navy and Marine Corps team is on a path to field unmanned maritime systems, and especially unmanned surface systems, to directly support our expeditionary forces. This initiative will ensure mission success while saving lives.

Note: The views presented are those of the author and are not intended to represent the views of the Department of the Navy or Department of Defense.

About the Author: George Galdorisi is a career naval aviator whose thirty years of active duty service included four command tours and five years as a carrier strike group chief of staff. In addition to his Rick Holden thrillers published by Braveship Books, he has written thirteen other books distributed by mainstream publishers, including several bestselling novels in the rebooted Tom Clancy's Op-Center series. He is also the author of *The Kissing Sailor*, which proved the identity of the two principals in Alfred Eisenstaedt's famous photograph; as well as over three-hundred articles in professional journals and other media. Learn more at www.georgegaldorisi.com.



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Wave Energy Converter Gets Tested at WETS

Navy Testing Proves Device Can Power Oceanographic Instrumentation

Naval Facilities Engineering Command (NAVFAC) Engineering and Expeditionary Warfare Center (EXWC) has announced the most recent round of Wave Energy Converter (WEC) testing at the U.S. Navy's Wave Energy Test Site (WETS) off Marine Corps Base Hawaii (MCBH), Kaneohe, Hawaii, on the Island of Oahu.

In October 2018, the Applied Research Laboratory (ARL) at the University of Hawaii, with funding from NAVFAC, and in partnership with the University of Washington, Fred. Olsen, Ltd., and Sea Engineering, Inc., began the second round of testing of the Fred Olsen (of Norway) "BOLT Lifesaver" WEC device.

The device uses three power take-off (PTO) units that convert the motion of the passing waves to electrical power by way of rotary electrical generators. Control and health-monitoring of these on-board systems is housed in the Control Center. The WEC is not connected to shore and the power generated is stored in a battery bank.

This phase of Lifesaver testing at WETS has two primary aims; first, to improve device reliability and power performance, through alterations to the device mooring strategy, and second, to demonstrate an alternative means of powering oceanographic instrumentation without using utility-supplied electrical grid power or single-use batteries.

The instrumentation, known as the Wave-powered Adaptable Monitoring Package (WAMP), is being tested on BOLT Lifesaver and was designed, assembled, and integrated with the WEC by the Pacific Marine Energy Center (PMEC), University of Washington, leveraging the capabilities of the Applied Physics Laboratory (a U.S. Navy University Affiliated Research Center) and the department of Mechanical Engineering.

Receiving its power from the Lifesaver, the WAMP provides persistent underwater sensing, and supports unmanned, undersea vehicle (UUV) recharge using a wireless power transfer system developed by Seattle startup Wibotic, Inc. The WAMP is the latest in a series of demonstrations of the core AMP technology and is being used in this application to better understand the marine environment around an operational WEC buoy.

The joint Lifesaver-WAMP test is funded by NAVFAC, the U.S. Department of Energy (DOE), and the National Science Foundation; the overall effort is part of a larger joint U.S. Navy, DOE, academic (University of Hawaii, Hawaii Natural Energy Institute, and University of Washington PMEC), and industry research, development, test, and evaluation (RDT&E) project. This is the world's first demonstration of the potentially transformative capability

for WECs to enable persistent oceanographic observation and UUV recharge without a cable to shore.

Testing WEC devices at WETS allows the Navy/Marine Corps to evaluate the technical and economic feasibility of various wave energy conversion configurations, which will in turn pave the way for the public/private sector's use and benefit once these devices become mature. Device developers will use the ocean test results to further calibrate their computer model simulations, refine their system designs, mature their technologies, and then move towards system commercialization. This same protocol will hold true for all companies testing their WEC device technologies at WETS.

The WETS infrastructure is unique in the U.S. in that it offers the capability to support operational tests of WEC devices in an energetic open-water environment with a connection to the local electrical grid. It is the goal of all ocean wave energy developers to convert ocean wave energy into useable electrical power for utility- or grid-scale applications. Wherever isolated grids, remote locations, high costs of energy, and energy security are of importance, wave energy conversion may become another distributed generation option for diversifying the energy system. For more information, visit www.navfac.navy.mil.



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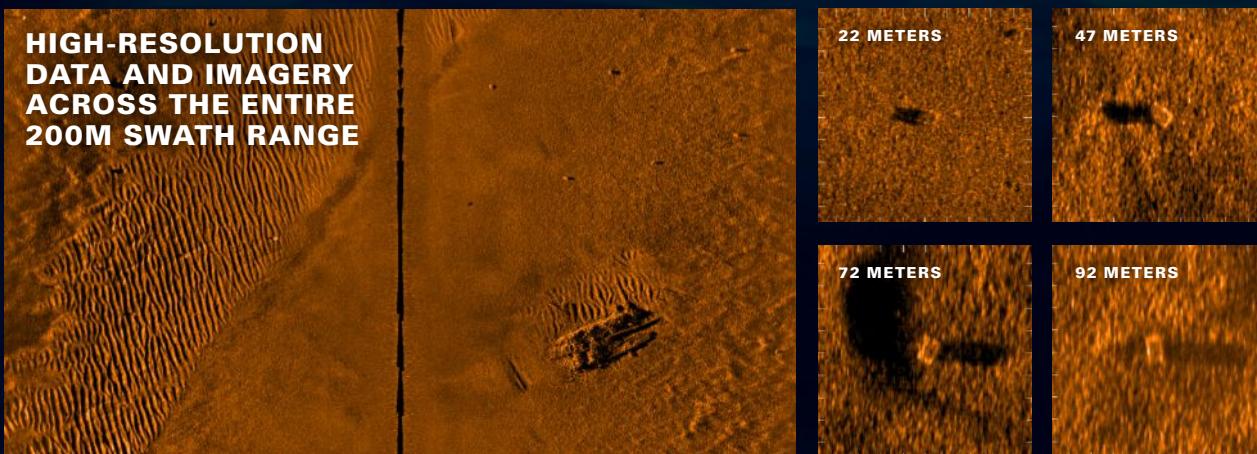
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USV with Pneumatic Gun to Help Deliver Fuel and Cargo

UAVOS has developed an unmanned surface vehicle (USV) designed to deliver a refueling hose to the land in remote and offshore locations beyond inhabited areas.

The USV will serve as an alternative to manned boats, which often can't come near the coast due to strong waves or other natural factors, UAVOS notes. UAVOS says that its USV is built to address the issue of delivering fuel or cargo to hard-to-reach coastal areas.



The USV is based on a SeaDoo water scooter, and UAVOS says that its automatic control system will be integrated into the water bike. Additionally, a "hermetic upper casing and a pneumatic gun with an inertia-free coil for the cable" will be manufactured.

Under the terms of the project, a USV comes out from the ship's board to tow the cable to the shore, by which the fuel supply hose will be forwarded. Without reaching the shore, the cable is fired with a pneumatic gun, and lands on a parachute at an appointed place.

Using a winch, an on-shore team pulls the fuel hose by the cable and fills the tanks with fuel. Freight delivery can be performed in the same way. Once the mission is complete, the USV returns to the ship, and is recovered with the assistance from the ship's crane beam.

Cable towing is currently carried out by main boats, but UAVOS says that often, the ship can't come close to the coastline because safe distance to the shore can be up to two kilometers. Other factors such as strong waves and surf lead to refueling ships often times having to wait long times for favorable conditions, which not only complicates mission planning, but also increases cost of operation.

For more information, visit
WWW.UAVOS.COM

Will Maritime Clashes Between China and U.S. Lead to Escalation in East Asia?

According to Ian Bowers of the Norwegian Institute for Defence Studies, there are reasons to be concerned over potential instability in maritime East Asia, but "sustained escalatory cycles are unlikely, because of the characteristics of the maritime strategic environment."

In an article entitled, *Escalation at Sea: Stability and Instability in Maritime East Asia*, published by U.S. Naval War College, Bowers argues that while "China's growing presence and actions in this strategic maritime arena are upending the post-World War II status quo," the strategic effect of individual clashes at sea are not likely to "trigger sustained escalatory cycles or be construed as a prelude to major conflict at sea or on land."

Why? Because, the author claims, despite the nature of disputed maritime

borders, "conflicts at sea typically do not present an existential strategic threat to the involved parties. Escalation arising from inadvertence or miscalculation is easier to control, owing to the realities of operating in a maritime environment."



Bowers sees parallels in U.S.-USSR maritime interactions during the Cold War. He also examines clashes between Chinese and Vietnamese forces in 1974 and 1988. He points out that none of

these examples led to escalation. Bowers does warn, however, that a lack of land forces in the region could "allow Chinese or U.S. commanders the freedom to escalate a clash, given that the potential strategic costs resulting therefrom would be lessened."

Based on his analysis, however, Bowers says that "the fear that escalation will result from an incident at sea is, by and large, overemphasized."

Reference:
Bowers, Ian (2018) "Escalation at Sea: Stability and Instability in Maritime East Asia," *Naval War College Review*: Vol. 71 : No. 4 , Article 5.

Available at: <https://digital-commons.usnwc.edu/nwc-review/vol71/iss4/5>

Icebreaker Funding in Partisan Crosshairs

In a 94-6 vote, the U.S. Senate has approved a bill authorizing \$10.6 billion for the Coast Guard in fiscal year 2019. The amount represents a 16 percent increase from 2017, but it must first be approved by the House of Representatives, and that's not a given.

If passed, the bill would help modernize an aging fleet of cutters and aircraft, but it could stall, as congressional Democrats are pushing for \$750 million in funding for a new polar icebreaker to be included in the final version. The large ship would be used for scientific research, as well as defense, and to break apart sheets of ice, allowing other vessels to traverse Arctic pathways.

Rep. Kevin Yoder of Kansas, the Republican chairman of the House's Homeland Security subcommittee, said the icebreaker funding is one of the biggest hold-ups in negotiating a compromise between the House and Senate, in particular because the Trump Administration wants to shift the same amount—\$750 million—from the USCG budget in order to help fund a border wall between the U.S. and Mexico.

Rep. John Garamendi of California, the top Democrat on the Coast Guard and Maritime Transportation subcommittee, said that adding more polar icebreakers to the region will help the U.S. to counter Russia's growing influence in the Arctic.

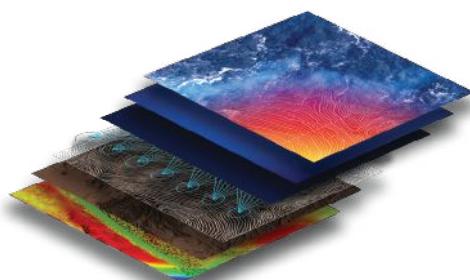
If passed, the funding bill would also boost efforts to place and maintain navigational aids and negotiate less expensive contracts. The Environmental Protection Agency would set national rules for ballast water and other water



discharges while the Coast Guard would enforce them. Other provisions would create a center to develop responses to oil spills in freshwater environments, boost border patrols, and build a National Coast Guard Museum in New London, Connecticut.

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WHAT'S THE OUTLOOK FOR OIL AND GAS COMMODITIES?

BY G. ALLEN BROOKS | Author, *Musings From the Oil Patch* | www.energymusings.com

Crude Oil Prices

Not many weeks ago, crude oil traders were salivating over prospects for global oil prices reaching triple-digit levels. How could it not happen? The U.S. was re-imposing economic sanctions on Iran, whose economy depends on oil exports for its health and government finances, and global oil markets were already tight. Additionally, world economies were continuing to grow in a synchronized global wave. The few economic distress points seen were brushed aside as minor problems, easily resolved. Higher oil prices had to happen.

In early November, that lovely scenario lay in tatters. On October 3, WTI traded near \$76 a barrel, but then the slide commenced. By November 9, oil prices were trading under \$60, marking the tenth consecutive trading session of falling prices, the longest downturn in 34 years. Traders foresee less Iranian oil being removed from the market by U.S. sanctions while domestic oil output roars ahead, barely constrained by pipeline capacity issues. Non-OPEC production is growing and there are signs demand may be weakening.

Oil prices entered "bear market territory," signifying to traders that recovery will first need weeks of lower or sideways trading. So far, the price decline has wiped out all the market gains of 2018.

Five straight weeks of oil price declines has unsettled a number of economists and investors. They see oil's decline, along with that of copper, as a sign of global economic weakness. While bad for those in the industry, wiping out prospects of another oil boom is not all bad. Lower prices ease the financial strain on oil importing economies. While lower prices hurt oil exporters, global prices are still higher than a year ago, meaning they have more money. The great unknown for the energy industry is how oil price volatility may impact the psychology of oil executives as they approach budget and capital spending decisions for 2019?

If the oil price drop is viewed as temporary, oilfield activity will continue recovering. But, if this imbalance reflects a disruption in global economic growth, then oil industry capital spending will be reined in. Long-term that could be a problem. As one investment bank recently suggested, energy markets may be heading for a global supply shortage as early as 2020 due to the low levels of capital spending in recent years, aggravated by any further cutbacks now.

This rapid oil price decline may become the straw that breaks the oil industry's back, forcing another round of consolidations and cost rationalizations. A smaller, but more profitable, oil industry might be the outcome if this correction is viewed as a greater long-term threat to the business. The oil market turmoil of the past five weeks means increased uncertainty.

Natural Gas Prices

As the summer gas injection season ends, the low storage volumes and impending cold weather have spurred an upward move in natural gas prices. This followed months with gas prices struggling to reach the \$3 per Mcf level after collapsing in February when winter weather disappeared. For most of the summer the mystery was why gas prices weren't higher given the low weekly gas storage injections. The popular explanation was that high natural gas production provided comfort the industry could handle an early blast of cold temperatures.

In early October, as we entered the waning weeks of the injection season, we faced a historically low beginning winter storage, causing gas prices to jump to the \$3.25 range. In recent days, as snow began falling in western and midwestern regions of the country, natural gas prices jumped higher, entering the \$3.50 range, and now spiking to \$3.75. After nine months of gas price slumber, are we now facing a panic?

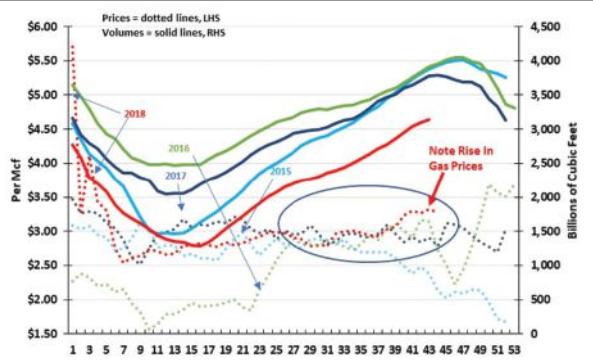
On November 2, the start of the winter gas withdrawal season, the U.S. had only 3.2 trillion cubic feet of natural gas in storage. That is the lowest beginning winter storage volume since 2003 – 15 years ago! The health of the domestic natural gas industry largely explains the recent period of weak prices. Between 2003 and 2017, domestic gas output has grown by nearly 9 trillion cubic feet, while consumption grew by about 5 Tcf. At the same time, natural gas imports declined by a quarter to 3 Tcf last year, while exports increased nearly five-fold to 3.2 Tcf. For the first time in modern history, U.S. net gas imports are negative. This attests to the power of the shale revolution to alter energy markets.

Given the health of the industry, one wonders why gas prices are spiking? The answer lies in the role gas storage plays in meeting surging winter demand. In January 2018, gas storage withdrawal accounted for 30 percent of total gas consumed. Storage has always been a key issue.

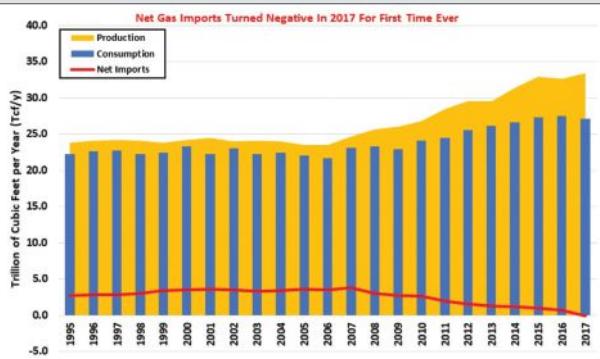
In the late 1970s, Arctic cold temperatures engulfed the entire eastern two-thirds of the nation, including the gas producing regions. Frozen valves curtailed production and stressed gas storage, forcing state governors to order schools and businesses shutdown to ensure adequate home heating supplies. People dying from a lack of gas to heat their homes was not an acceptable outcome.

While we have come a long way from those days, markets understand the stress on gas storage from bouts of cold temperatures. When the market perceives insufficient gas in storage, it will drive spot gas prices up sharply to both induce producers to inject more gas into storage and to pressure gas consumers to cut back their use. Prices work to keep the gas market functioning. Stand by for another market lesson!

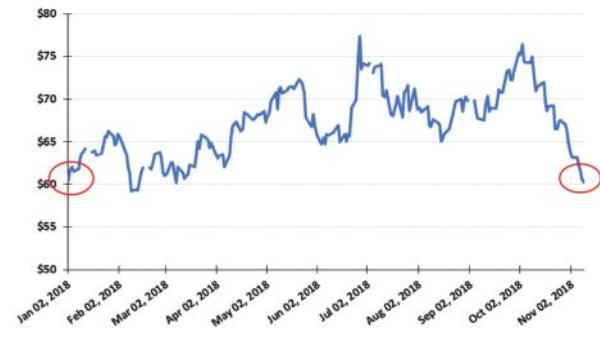
1. NATURAL GAS HH SPOT PRICES vs. STORAGE VOLUMES, WEEKLY



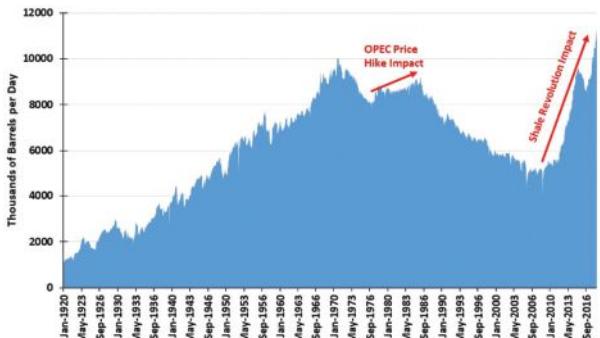
2. HOW SHALE GAS REVOLUTION HAS CHANGED MARKET



3. 2018 WTI PRICE: AFTER 10 MONTHS & 9 DAYS, BACK WHERE WE STARTED



4. SOARING OIL OUTPUT REFLECTS IMPACT OF SHALE REVOLUTION



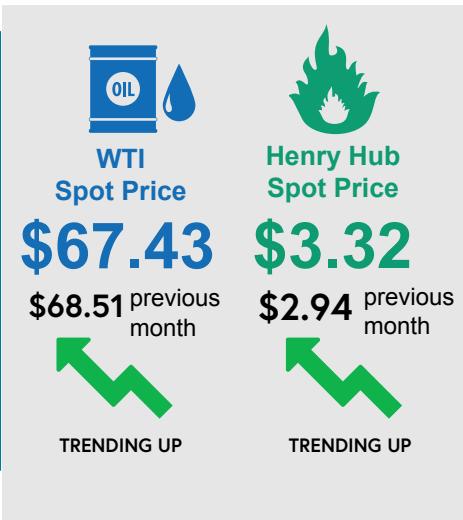
CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF OCTOBER 26, 2018

Oil prices have gained fairly steadily in 2018. The five-week period from mid-September to mid-October saw prices hold above \$70 per barrel on the EIA's WTI Spot Prices report. This is the longest stretch in which prices remained over the \$70 mark in 2018 and is up nearly 30% in the past 12 months. The rise has been attributed to US sanctions on Iran and the economic crisis in Venezuela. At the end of October, however, prices slipped due to increased U.S. stockpiles, according to CNBC.



Henry Hub Spot Prices remained over the \$3.00 per million BTU mark, reaching \$3.32 in late October. The six-week period over \$3.00 is the longest period for the year. Low U.S. gas stockpiles, higher-than-usual power demand during a warm autumn and nuclear power plant outages are driving the rally, according to Barclays' analysis.



KEY EQUITY Indexes

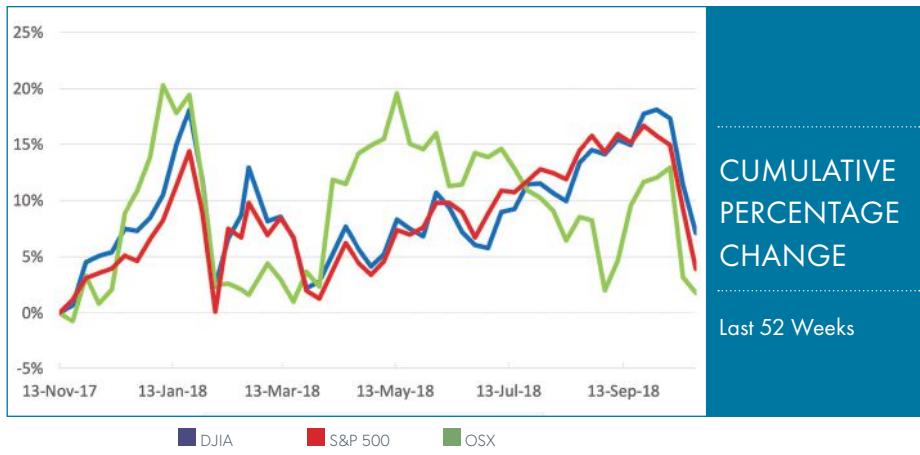
PRICES IN US DOLLARS AS OF NOVEMBER 5, 2018

THE DOW JONES INDUSTRIAL AVERAGE AND S&P 500 have been relatively stable in the past month.

Equity indexes steadily lost ground in October before rebounding a bit in November. After reaching record territories in late September and early October, the markets dropped steadily. The Dow Jones Industrial Average (DJIA) nearly reached the 27,000 point mark in the first days of October, but then dropped more than 1,000 point in the week from October 8 through October 15 and closed at just above 24,442 on October 29. Concerns over the possibility of rising interest rates and trade tensions between the US and China fueled the sell-off, according to TheStreet. The first week in November saw a rally, however, as the DJIA rebounded back over the 25,000 mark.

The S&P 500 followed a similar pattern while dealing with the same concerns. The index neared the 3,000-point mark before dropping back to just above 2,641 on October 29, with energy and financial stocks taking a hit, according to the New York Times. It also experienced a rebound to over 2,700 in the first days of November. The PHXL Oil Services Index (OSX) also suffered a hit in October. After a strong period of five consecutive weeks of gains, which put the index back up over 150 points, the OSX dropped all the way down to 117.51 by October 29. That is the lowest closing for the OSX in 2018. The OSX did see a rebound in early November, back above the 120-point mark.

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www.underwaterintervention.com

Oi Americas

San Diego, CA ➤ February 25-27
oceanologyinternationalamericas.com

Subsea Tieback

San Antonio, TX ➤ March 5-7
www.subseatiabckforum.com

Int'l Deepwater Drilling

Rio de Janeiro, Brazil ➤ March 19-20
www.iadc.org/event/2019-iadc-international-deepwater-drilling-conference-exhibition/

US Hydro

Biloxi, MS ➤ March 19-21
www.thsoa.org/US-Hydro-2019

Decommissioning & Abandonment Summit

Houston, TX ➤ March 26-27
www.decomworld.com/gom

SubOptic

New Orleans, LA ➤ April 8-11
www.suboptic2019.com

Int'l Offshore Wind Partnering Forum

New York, NY ➤ April 9-10
www.offshorewindus.org/2019ipf/

Mari-Tech

Ottawa, Canada ➤ April 23-25
www.mari-techconference.ca

AUFSI XPOENTIAL

Chicago, IL ➤ April 30 – May 2
www.xponential.org/xponential2019/public/Enter.aspx

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EERA DeepWind

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www.sintef.no/projectweb/eera-deepwind

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asia-decs.com/

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www.oilgastechasia.com

Singapore AUV Challenge

Singapore ➤ March 8-11
www.sauvc.org/

Australasian Oil & Gas

Perth, Australia ➤ March 13-15
www.aogexpo.com.au/about

China Cable Connectivity

Symposium ➤ March 25-27
 Shanghai
www.ulandiwcschina.org

Telecoms World Asia

Bangkok, Thailand ➤ March 25-27
www.terrapinn.com/conference/telecoms-world-asia/index.stm

Unmanned Systems Asia

Singapore ➤ April 9-11
www.unmannedsystems-asia.com

Underwater Technology

Kaohsiung, Taiwan ➤ April 16-19
www.ut19.tori.org.tw/webpage/index.aspx

ICCOE

Bangkok, Thailand ➤ April 25-28
www.iccoe.org

CALENDAR

AUGUST

EDITORIAL: ROV and AUV Technology
 FOCUS: Cameras, Batteries, Lights and Imaging Sonars;
 Vehicle Sensor Suites

SEPTEMBER

EDITORIAL: Offshore Wind Installation and Maintenance;
 Offshore Supply & Emergency Vehicles
 FOCUS: Offshore Support; Turbines;
 Offshore Wind Inspection Services

OCTOBER

EDITORIAL: Offshore Communications; Subsea Telecom;
 Subsea Inspection, Monitoring, Repair & Maintenance
 FOCUS: Marine Communications; Cable Installation Services

NOVEMBER/DECEMBER

EDITORIAL: Year in Review; Commercial Diving and Salvage;
 Ocean Observing Systems; Ocean Science & Exploration
 FOCUS: Acoustic Modems, Releases and Transponders;
 Diving Equipment and Services; Salvage;
 Buoyancy Materials

SHOW DISTRIBUTION

AUGUST

Submarine Networks World - September 24-26 *
 MTS Dynamic Positioning - October 9-10
 OCEANS '18 - October 22-25

SEPTEMBER

WindEnergy Hamburg - September 25-28
 AWEA Offshore Wind - October 16-17
 Teledyne Marine Tech Workshop - October 9-11 *
 Offshore Energy - October 22-24
 Ocean Energy Europe - October 30-31
 Pacific Marine Expo - November 18-20 *

OCTOBER

Offshore Well Intervention - November 6-8
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NOVEMBER/DECEMBER

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Cellula Awarded Next Phase of Long Range UUV Contract

Cellula Robotics Ltd. announces the approval to proceed with phase 3 of a contract under Canada's All Domain Situational Awareness (ADSA) Science & Technology (S&T) Program to develop and build a long range Unmanned Underwater Vehicle (UUV) that incorporates a fuel cell power pack and suction anchor. Known as Solus-LR, the UUV will have a target range of 2000 km and is designed to stay submerged for multi-month missions. The design phase will continue into early 2019 followed by the build and factory testing.

<https://www.oceannews.com/news/subsea-intervention-survey/cellula-awarded-next-phase-of-long-range-uuv-contract>

International Cable Protection Committee Marine Environmental Advisor Steps Down

The International Cable Protection Committee's (ICPC) current Marine Environmental Advisor, Professor Lionel Carter, will relinquish his formal role in the ICPC in June 2019 after a long, distinguished period of service. The IPC will interview candidates for the post to participate in a period of transition and take up the role from July next year. To apply for the position, which comes with a modest honorarium, visit <https://www.iscpc.org/news/>.

Oceaneering Announces the Promotion of Mark E. Peterson to Vice President

Oceaneering International, Inc. has promoted Mark E. Peterson to Vice President, Corporate Development and Investor Relations. In this position, Mr. Peterson will maintain his responsibility for Oceaneering's Corporate Development activities while expanding his role to include Investor Relations.

Mr. Peterson's career includes more than six years with Oceaneering in the role of Vice President, Corporate Development. Prior to joining Oceaneering, Mr. Peterson was with McDermott International, Inc., where he most recently held corporate development responsibility. His career includes significant business and financial experience throughout the energy value chain. For more information on Oceaneering, please visit www.oceaneering.com.



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New Underwater Acoustic Project Scientist at CSA Ocean Sciences, Inc.

Kayla Hartigan has joined CSA Ocean Sciences Inc. (CSA) as an underwater acoustic Project Scientist. She will utilize experience gained while studying for her Master's in Coastal Environmental Management from Duke University, and her expertise as a soundscape ecologist, to assist with CSAs projects that address underwater sound. For more information, visit www.csaocean.com.



Pioneer Consulting Announces New Partner in the Company

International submarine cable integration and consulting firm, Pioneer Consulting has added Gavin Tully as a Partner in the company. Previously, Gavin held the role Director of Submarine Solutions and provided international clientele with expertise ranging from market and business case analysis to system design, procurement, and implementation. With 11-years in the submarine cable industry, Gavin joins the existing partners, Howard Kidorf and Keith Schofield, as a member of the business leadership team. For more information, visit www.pioneerconsulting.com.



Xodus Group Strengthens Its Decommissioning Team

International energy consultancy Xodus Group has strengthened its decommissioning team with the appointment of Gareth Jones as Decom Lead. The appointment follows a successful year for Xodus' decommissioning division which has secured several new clients and won £2million of work in 2018.

An experienced principal consultant and project manager, Mr Jones will be responsible for advising and supporting operators in relation to environmental and societal impacts associated with decommissioning. He joins Xodus from BMT Cordah where he led the company's international decommissioning activities. Previously, he was a marine ecologist with Marine Scotland, providing advice and support in relation to commercial fisheries and marine fish species for oil and gas, renewables and infrastructure projects. For more information, visit www.xodusgroup.com.



MacArtney Hits a Hole in One with New Chief Commercial Officer

Once an elite amateur golfer who played for Denmark's National Team, Michael Behrens from Kolding, Denmark will now be driving the ball for MacArtney Underwater Technology from HQ in Esbjerg, Denmark. Michael is joining MacArtney from the largest steel and technical sales company in Denmark to embark on his new role as CCO. With a HD(O) in Organisational Leadership from the University of Southern Denmark, Michael's professional growth has seen him take on Sales Director and Business Management roles with leading technology companies from Saab to ABB. For more information, visit www.macartney.com.

Rovco Strengthens Business Development Team

Leading ROV and hydrographic survey company, Rovco, has established a dedicated business development team. Paolo Cattaneo, Brett Laurenson and Alex Pretty, collectively bring more than 40 years of business development experience to the company. While capitalizing on Rovco's latest 3D reconstruction technology, they will be responsible for strengthening the company's market presence, geographical reach, and global growth strategy.

Working alongside the offshore and R&D teams, they will help to develop future technology and services required to support clients in the oil, gas and renewable energy sectors. This will ensure the company continues to broaden its range of services in line with customer and industry demand. For more information, visit www.rovco.com

Left to right: Paolo Cattaneo, Brett Laurenson and Alex Pretty



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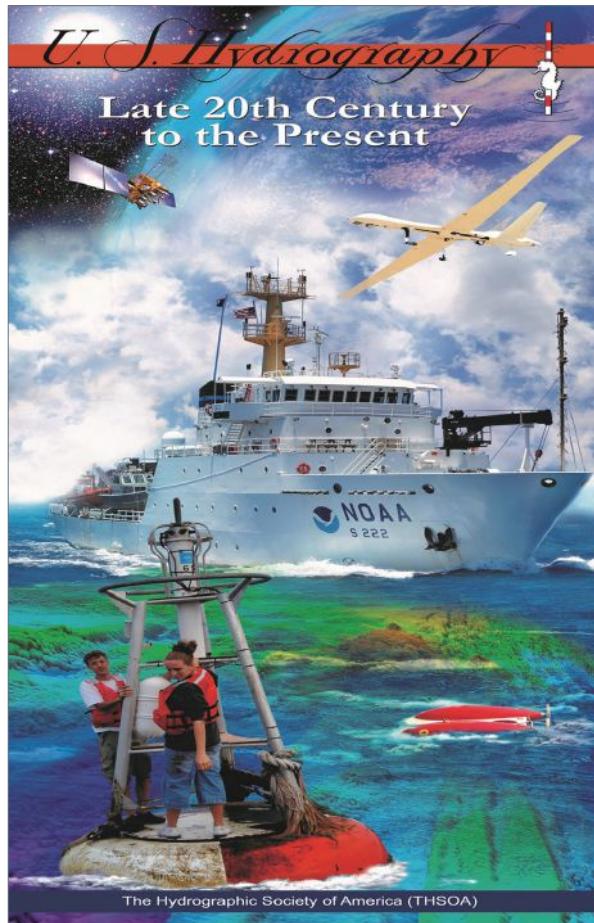
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Evo
Logics®

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

UNDERWATER ACOUSTIC MODEMS

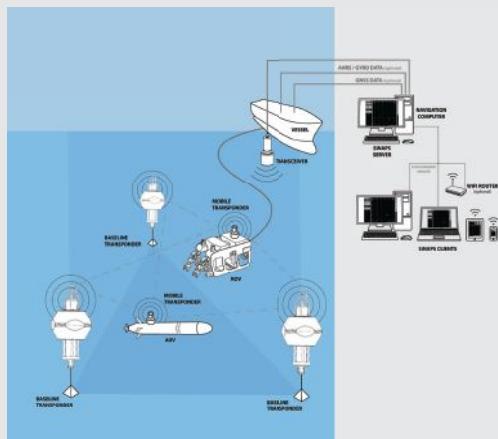
reliable data transmissions even in adverse conditions, customizable R-series modems, light and compact M-series "mini" modems, **new S2CM-HS high-speed modem**, special editions for developers, S2C communication and positioning emulator - remote access or standalone device

- range: up to 8000 m
- 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



OCEANHUB™ SUBSEA NODE

OSI'S SOLUTION FOR OCEAN OBSERVING NETWORKS



SUBSEA NODE

OSI's OceanHub™ enables common oceanographic sensors to be connected to a submarine cable, providing communications and power for long-term, in-situ observations.

Applications:

- Scientific observatories
- Oil/gas field instrumentation
- Renewable energy
- Tsunami and seismic warning systems
- Port/coastal security

OCEAN OBSERVING



Protecting the ocean environment.

TELECOM



Developing fiber optic networks.

OIL & GAS



Connecting onshore and offshore assets.

