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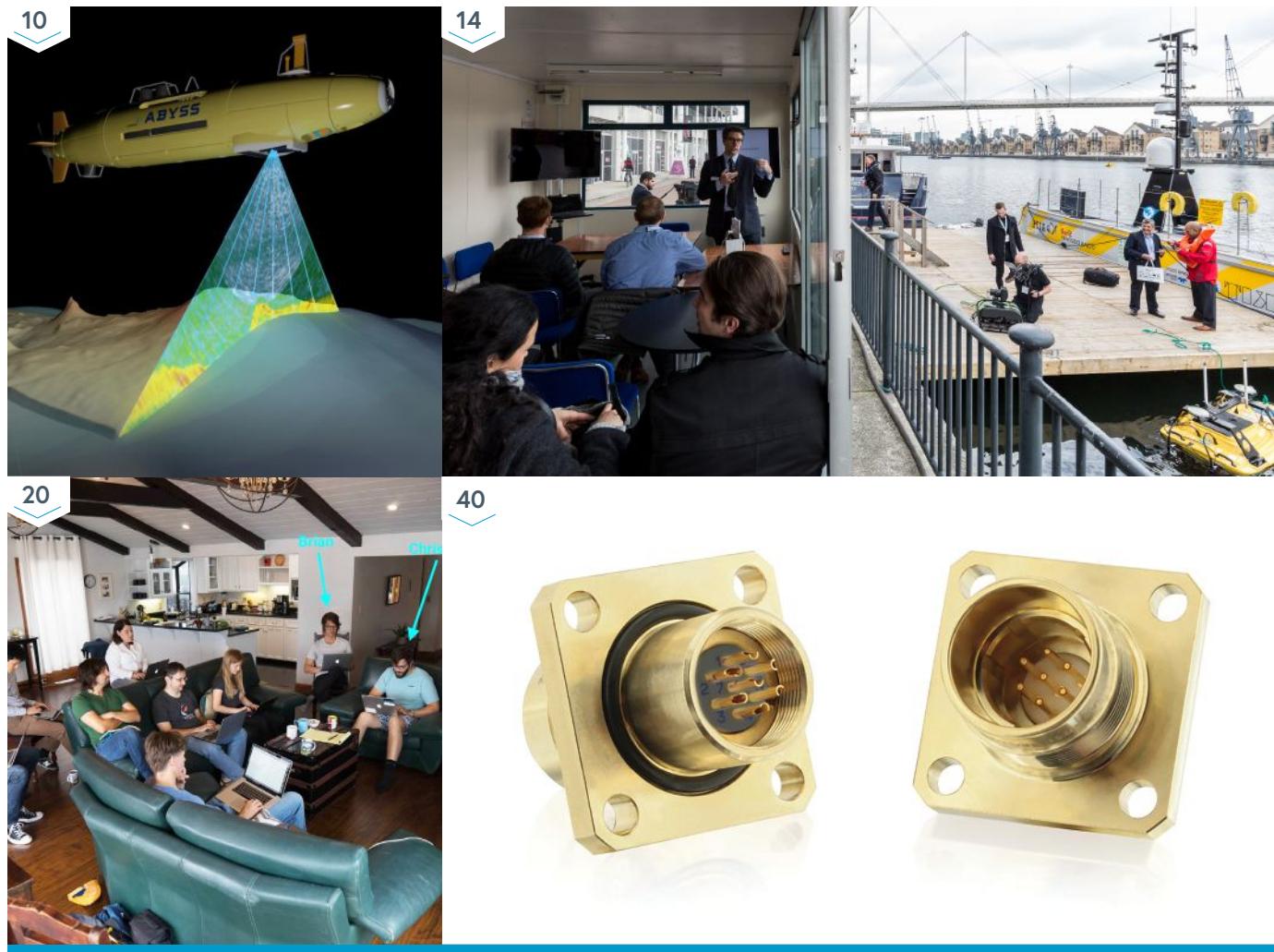
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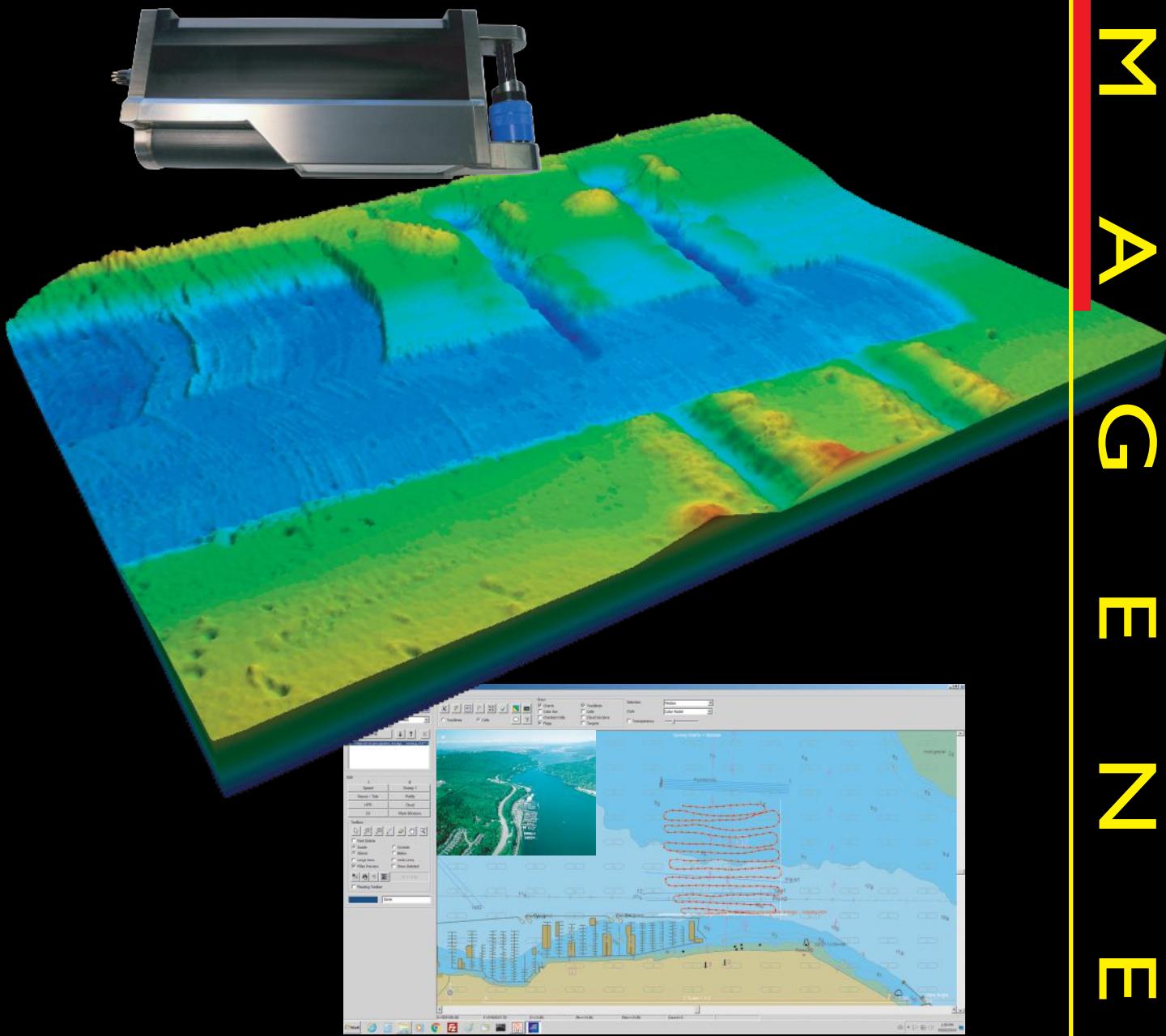


ON THE COVER:

The Fugro Scout is a geotechnical drilling vessel specifically designed to address the varied demands of both the shallow and deep water survey markets. Photo courtesy of Fugro.

DT101Xi Multibeam

Survey of dredged area, including removal of two old pipelines,
near Reed Point Marina in Vancouver Harbour



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INDUSTRY PARTNERS PLAY CRITICAL ROLE IN SEABED 2030 EFFORTS

BY GREG LEATHERMAN,
Editor in Chief, ON&T

The **Nippon Foundation-GEBCO Seabed 2030 Project**, the international collaborative project to produce a high-resolution, freely available, complete map of the seafloor by the year 2030, continues to progress, thanks to the participation of some very committed partners. According to Dr. Graham Allen, Acting Director, the project has already mapped 15% of the ocean floor, doubling its coverage from the 6.4% mapped in 2014, and making real progress toward 100%. But that's just the beginning.

Seabed 2030 provides vessels around the world with data loggers installed to record bathymetric information, increase mapping capacity and capability and establish new connections between Seabed 2030 and owners of vessels including fishing fleets, tourist boats, and pleasure craft. Seabed 2030 also champions the development of innovative, scalable new solutions to increase the efficiency, safety, and cost-effectiveness of deep-sea mapping.

In some of the most remote and poorly mapped frontiers of the ocean, Seabed 2030 will fund additional dedicated mapping days for already scheduled expeditions, and create a pool of experienced multibeam echosounder (MBES) operators that can assist expeditions lacking this data acquisition capability to ensure that vital data are collected at all times, including during transit. This model was employed in Seabed 2030's partnership with the

Five Deeps Expedition, which gathered detailed bathymetric information at each of its dives to the five deepest points in the world's oceans.

Overall, more than 100 organizations are engaged in Seabed 2030, but let's look at two companies making major contributions by leveraging what they already do well.

Fugro: Fugro leads the private sector in support of Seabed 2030, from participating in the project's early planning stages, to helping to define a workflow for integrating third party datasets into the global project database.

In 2017, Fugro devised a method of operating its vessel-based multibeam echosounder systems autonomously while transiting between marine survey projects. To date, the company has contributed over 450,000 square km of high-resolution crowd sourced bathymetry to Seabed 2030.

PGS: Another company supporting crowdsourced bathymetry is PGS. Beginning in 2020, all vessels in the PGS fleet will share bathymetry information collected using echo sounders with Seabed 2030.

PGS' fleet of seismic vessels traverse the world's oceans and work in regions ranging from the developed to the unchartered. The fleet represents a unique opportunity to collect ocean data as the vessels not only conduct long transits between projects

but also undertake detailed surveying and data collection over time in the areas where PGS acquires seismic surveys.

ON&T applauds companies such as Fugro and PGS who advance our understanding of a frontier that remains largely unknown.

For more information, visit www.seabed2030.gebco.net.

The image shows a screenshot of the ON&T website. At the top, there's a navigation bar with links for "Top Stories", "Search", and "Email". Below that is the ON&T logo. The main content area features several news items. One story is titled "Fugro Robot Tested to Go on Watch in the Deep Seas" with a sub-headline "A robot built for mining share oil and gas fields in the North Sea. That fuel reserves have to be laid in evidence the robot can go down to 3,000 meters and stay there for 10 hours in between 2,000 and 3,000 meters deep - ...". Another story is titled "Seabed 2030 Scales - Integrated Dual Head" with a sub-headline "The Seabed 2030 team has integrated dual head sonar into the same hull, reducing required processing times." There are also sections for "TOP STORY", "SCIENCE & TECHNOLOGY", and "DIVE".

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TECHNOLOGIES FOR MAPPING THE SHAPE OF THE SEAFLOOR

High-quality bathymetric data is essential to accurate ocean mapping. Here are some of the main tools used in gathering data for ocean mapping



» Figure 1: According to NOAA's Trackline Geophysical Data Viewer, there have been far more SBES surveys (5514) than any other type. Screen capture courtesy of the NOAA National Centers for Environmental Information.



SINGLE BEAM ECHO-SOUNDERS (SBES) - (Figure 1)

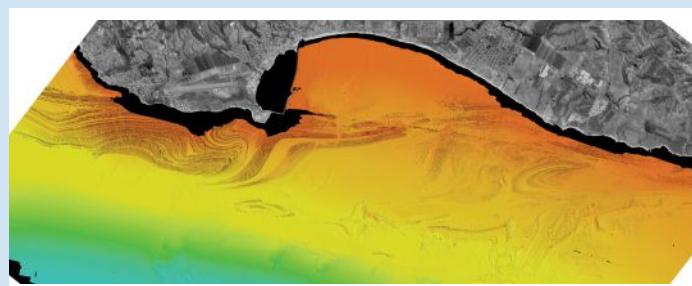
Single beam echo sounders (SBES), also known as depth sounders or fathometers, determine water depth by measuring the travel time of a short sonar pulse, or ping. The sonar ping is emitted from a transducer positioned just below the water surface, and the SBES listens for the return echo from the bottom. The first patent for an SBES was filed in 1913. Since the first commercial multibeam echo sounder was not available until 1977, much of the world's legacy hydrographic data was gathered using SBES.

Single beam echo-sounders offer cost savings compared to multibeam echosounder systems and are especially useful in water under 5-10 m depth. SBES equipment may be operated by less experienced personnel than multibeam echo-sounders and the results are easier to interpret.

Hydrographic survey grade single beam echo sounders distinguish the real bottom from any spurious signals in the returned echo (e.g. fish, debris, aquatic vegetation and suspended sediment). Survey-grade hydrographic single beam echosounders record a digital water column echogram or echo envelope, that provides a graphical representation of the return echo. For surveys when suspended particulates are very high, low frequency sonar is able to penetrate the thick resuspended layer and measure the undisturbed hard bottom beneath. Transducers may be selected with different beam widths, which determines the size of the ping footprint on the bottom, as well as its accuracy.

MULTIBEAM ECHO-SOUNDERS (MBES) - (Figure 2)

Multibeam echo-sounder systems emit sound waves in a fan shape beneath a vessel's hull and listens to the returning echoes in narrow sectors perpendicular to the signal fan. This results in the mapping of a swath of seafloor instead of just a line. MBES devices collect higher-resolution bathymetric data and increase the efficiency of mapping efforts compared to SBESs. Modern systems can achieve swath angles between 120 and 150 degrees, using hundreds of beams. Because the beams expand as they travel through the water column, resolution decreases with increasing depth. For deep-water applications, autonomous or remotely operated vehicles equipped with MBES and operating near the seafloor can improve resolution



» Figure 2: Colored shaded-relief bathymetry map of Offshore of Half Moon Bay map area, generated from multibeam echosounder data. Colors show depth: reds and oranges indicate shallower areas; light blues, deeper areas. Illumination azimuth is 300°, from 45° above horizon. Captured circa 2014. Image courtesy of the United States Geological Survey (USGS).

SATELLITE-DERIVED BATHYMETRY (SDB) - (Figure 3)

Satellite-derived bathymetry (SDB) uses multispectral satellite imagery to survey shallow waters. Water depth estimations are based on the attenuation of radiance as a function of depth and wavelength in the water column. In contrast to other survey methods, it requires no mobilization of persons or equipment, and can be accessed rapidly. It is, however, limited by water clarity.

LIGHT DETECTION AND RANGING (LIDAR) - (Figure 4)

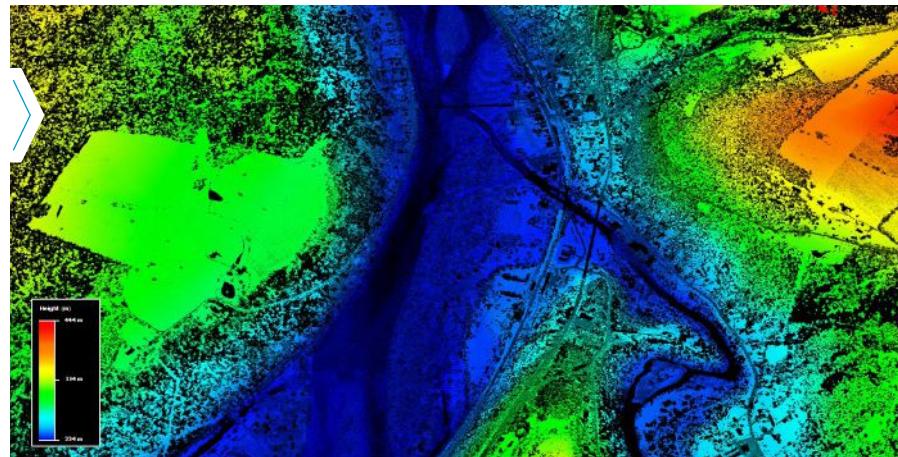
Bathymetric LIDAR is an acquisition technology that transmits laser pulses, usually from an airborne platform, and measures their return. The water depth is calculated from the time difference between the reflection from the water surface and the reflection from the seafloor. While airborne topographic LIDAR uses an infrared wavelength, bathymetric LIDAR systems use a green wavelength to penetrate the water column for measuring the seafloor. However, as an optical solution, it is still limited to shallow areas with optimal water clarity. LIDAR is frequently used to produce more accurate shoreline maps, make digital elevation models for use in geographic information systems, to assist in emergency response operations, and many other applications. An online course for using LIDAR is available at <https://coast.noaa.gov/digitalcoast/training/intro-lidar.html>

SATELLITE ALTIMETRY - (Figure 5)

Altimetric satellites measure the height of the ocean's surface, rather than ocean depth. The surface height is affected by the gravitational effects of topographic features on the seafloor, among other things. Altimetry data have far lower horizontal resolution than ship's bathymetry and provide depth estimates which are inherently under-determined. They can, however, reveal large geomorphological features of the ocean floor. Resolution of features with horizontal scales as small as 6–9 km can be achieved under ideal conditions in the deep ocean published a topographic map of the world's oceans with a resolution between 1 and 12 km, by combining depth soundings from ships and marine gravity data from satellite altimetry.



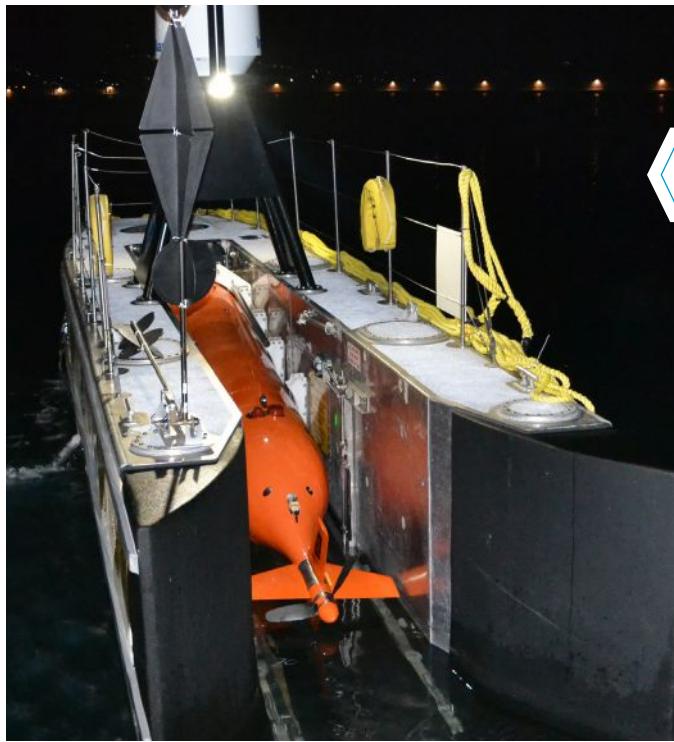
» Figure 3: SDB provider EOMAP provides SDB data in very high (2 m), high (10 m) and moderate (15-30 m) spatial resolutions. Turnaround times range from hours (using EOMAP's bathymetric archives) to a few weeks, depending on project location and size.



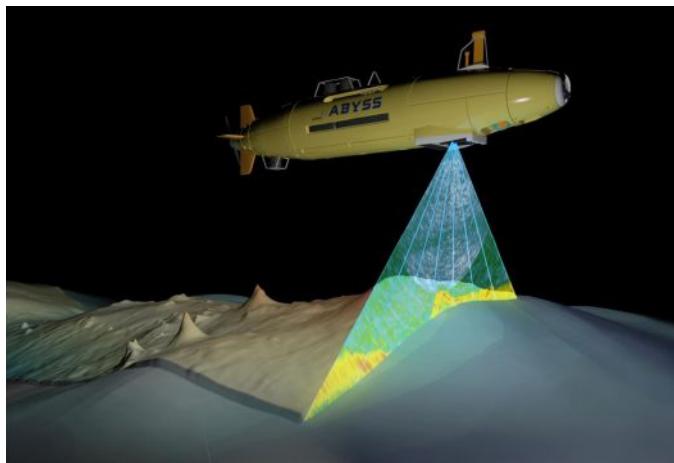
» Figure 4: A section of the Delaware River near Callicoon, NY showing results of bathymetric mapping using the EAARL-B green light LiDAR system. Image courtesy of USGS.



» Figure 5: NASA Altimetry missions 1992-Present. Image courtesy of NASA.



» Figure 6A: The 12 M SEA-KIT is an unmanned mothership for remote vehicles that can also be fitted with sensors for bathymetry. It supports long-range, long-endurance mapping missions. Data can be transmitted via broadband link or satellite following on-board processing and compression. Alternatively, data can be stored on-board for retrieval at a later date. SEA-KIT is developing automatic AUV charging to allow multiple missions to be undertaken without human interaction. This technology was part of GEBCO-NF's winning entry for the Shell Ocean Discovery XPRIZE for Advancements in Autonomous Ocean Exploration, when it was combined with a cloud-based data processing system for rapid seabed visualization.



» Figure 6B: Artistic impression of an AUV performing a deep-sea multibeam survey. Image courtesy of Tom Kwasnitschka/Nico Augustin, GEOMAR.

» Figure 7: USGS scientist Pete Dartnell processes multibeam data collected from off the Pacific Northwest coast on a research cruise aboard NOAA ship Rainier. Captured in 2018. Photo credit: Janet Watt, USGS Pacific Coastal and Marine Science Center.

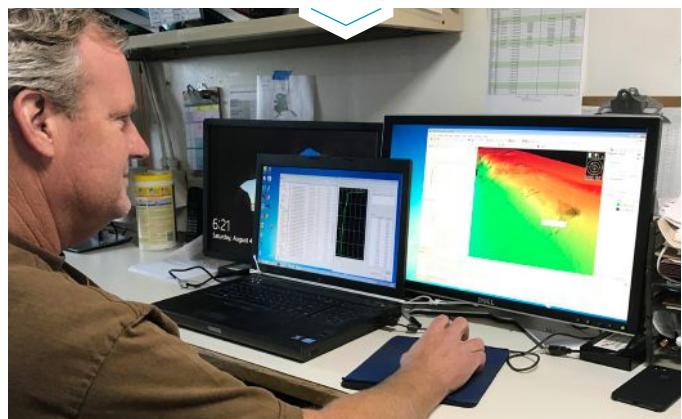
AUTONOMOUS VESSELS - (Figure 6A and 6B)

Autonomous surface vehicles (ASV) and autonomous underwater vehicles (AUV) equipped with such echosounders can reduce the cost expenditures and human resource requirements for mapping activities. Using vessel-to-shore communication capabilities, survey operations can be remotely controlled, while still ensuring the rapid and autonomous delivery of newly acquired multibeam data. On some vessels, data can also be processed automatically before it is communicated.

In deep water AUVs and remotely operated vehicles (ROV) can obtain multibeam data with a much higher resolution than ship-based systems, since they are not limited to the sea surface with the most advanced vehicles reaching water depths of almost 11,000 m. While ROVs are remotely piloted and powered from a ship, AUVs operate independently, with their range only limited by their onboard power supply. The deployment of these near-bottom mapping systems is currently still inefficient for the mapping of large areas, partly because of their slow speeds compared to ships. However, in the case of AUVs this can be compensated for by multiple vehicles working in tandem. Furthermore, the positioning accuracy for AUVs is still limited, and at present, they are not able to make ship-based surveys obsolete, since it is still essential to roughly understand the bathymetry of an area before a submersible can be sent down toward the seafloor.

AUTOMATED DATA PROCESSING - (Figure 7)

Bathymetry processing software automatically filters data, though careful human review of the resulting product is still needed to reduce errors and/or loss of information. A proven quality assurance (QA) process can verify and validate acquired data. The International Hydrographic Bureau developed Standards for Hydrographic Surveys (2008), which includes annexed guidelines for data processing and quality control.



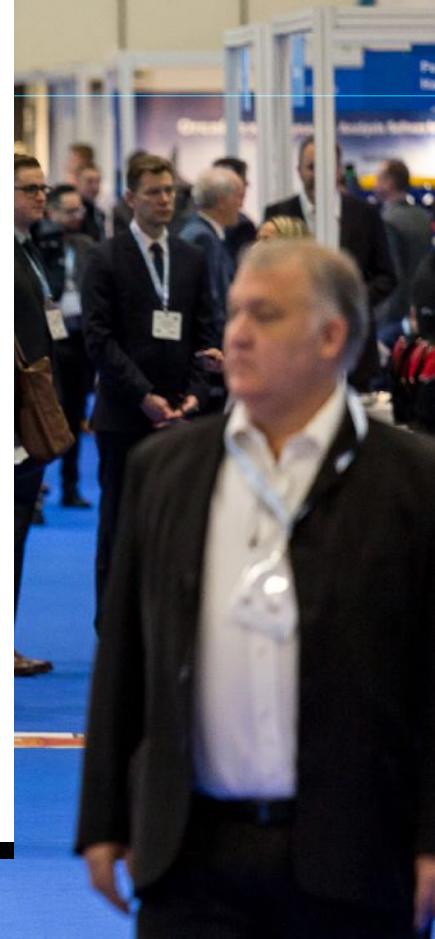


| FEATURE |

SHOW PREVIEW:

Oi LONDON 2020 GOES DEEP TO DELIVER VALUE

Special 50th Anniversary Oceanology International Event Promises More Conference Content, More Exhibitors, and More Networking Opportunities Than Ever Before



When the first Oceanology International exhibition and conference was staged half a century ago in Brighton, its organizers could scarcely have imagined that the brand would still be thriving two decades into the 21st century. With a mere 600 admittedly enthusiastic attendees at that initial expo, it's also unlikely that anyone could have foreseen the extent to which the Oi franchise would grow, with parallel events in China since 2013 and the Americas since 2017, and a Middle East-focused offshoot due for its inaugural outing in Abu Dhabi in September 2020.

Now, preparations are well under way for a momentous 50th anniversary Oi event at ExCel London (March 17-19, 2020). As befits such a watershed occasion, attendees can confidently anticipate an unprecedentedly extensive and expansive show, with a significant increase in the overall number of product launches and updates. Floorspace in the ExCel has been increased to over 17,000 m² to accommodate an expected 500+ exhibitors and more than 8,000 visitors from 90 countries, while the number of companies staging on-water product

demonstrations in the adjacent Royal Victoria Dock will double that of the last Oi London event in 2018. These live displays will be viewable from a covered private meeting area or from elevated viewing platforms on the dockside.

The most promising state-of-the-art technologies will be showcased by the Future Tech Hub, dedicated to promoting start-up companies or research institutes with fewer than 10 employees which have either developed or launched a ground-breaking new tech product between January 1, 2019 and the

and systems designed to deal with the acquisition, transfer, analysis and storage of ever-increasing amounts of ocean data. Also, in keeping with Oi's blossoming global profile, new pavilions for Italy and Massachusetts will be opened, taking their place alongside existing facilities to welcome returning representatives from countries including Germany, France, Canada, the Netherlands, Norway, and Ireland.

The upswing in the number and variety of products and services on display will be matched by an increased emphasis on strategic conference strands and targeted seminars. The Ocean Futures Forum (Tuesday, March 17, 2020) will discuss emerging technological requirements across offshore industries, including European and American perspectives on the future ocean economy, the implicit environmental implications of upcoming ventures and the role of science in delivering the United Nations' Sustainable Development Goals. Technological development also forms the central thrust of Catch the Next Wave (Thursday, March 19, 2020), which will consider advancements and projected improvements in areas of



show's opening date. The new Ocean ICT Zone, meanwhile, will be given over to examining the latest solutions

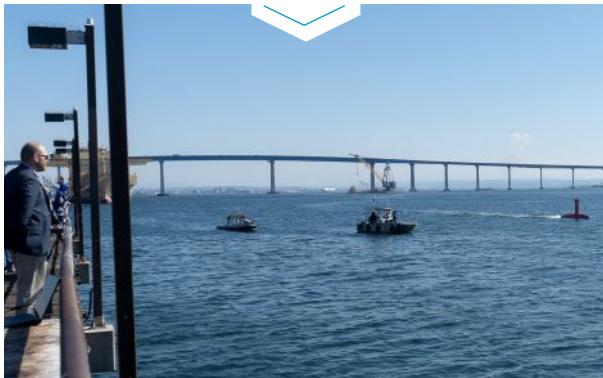
ocean science and exploration which have preoccupied the Oi community over the course of the last 50 years.

Among the key features of Oi events in recent years, pioneering initiatives in subsea robotics have proved to be a consistently pertinent topic as autonomous ocean research becomes an ever more legitimate and logical resource. At the previous London expo in 2018, both Catch The Next Wave and the Ocean Futures Forum were sponsored by Shell Ocean Discovery XPrize, a 36-month competition which invited global teams to present their most innovative technologies for the furtherance of autonomous, real-time and high-resolution ocean exploration. The finalists were announced at Oi London 2018, and the following year the \$4m grand prize eventually went to Gebcko-NF Alumni, an international team whose winning entry integrated the autonomous SEA-KIT USV with existing ocean-mapping technologies and a radical cloud-based data processing system.

Intrinsic to the SEA-KIT are KONGSBERG's K-MATE autonomous surface vehicle control system and HiPAP positioning system, and Kongsberg Maritime's long association with Oceanology International will be continued at the London 2020 event on stand D600, where company representatives will be on hand to supply details about solutions in a wide range of maritime contexts including simulation training and the subsea sector.

Other exhibitors with a committed stake in the future of subsea technology will be firms such as Tecnadyne (stand L700)

delegates can look forward to detailed and absorbing discussions on important topics including Unmanned Vehicles & Vessels, Ocean Observation & Sensing, Offshore Energy Development and Ocean ICT.



– a leading manufacturer of underwater thrusters, propulsion systems, pressure compensators and position sensors – and ECA Group (stand N200), delivering autonomous and unmanned systems to support commercial oceanographic and hydrographic missions. The 3D acoustic imaging specialists PanGeo Subsea (stand E400), meanwhile, will be sponsoring the Hydrography, Geophysics and Geotechnics conference track, tackling the most judicious methods of data retrieval, processing and analysis from the investigation of offshore environments, with a particular emphasis on the seabed and sub-seabed.

"The technical conferences run across all three days of the event," says David Ince, Event Director, Reed Exhibitions, "and, as has been shown time and again, remain largely unparalleled in the sheer breadth of expert knowledge they draw upon and the insights they provide, all under one roof. The London 2020 expo will of course be no exception, and

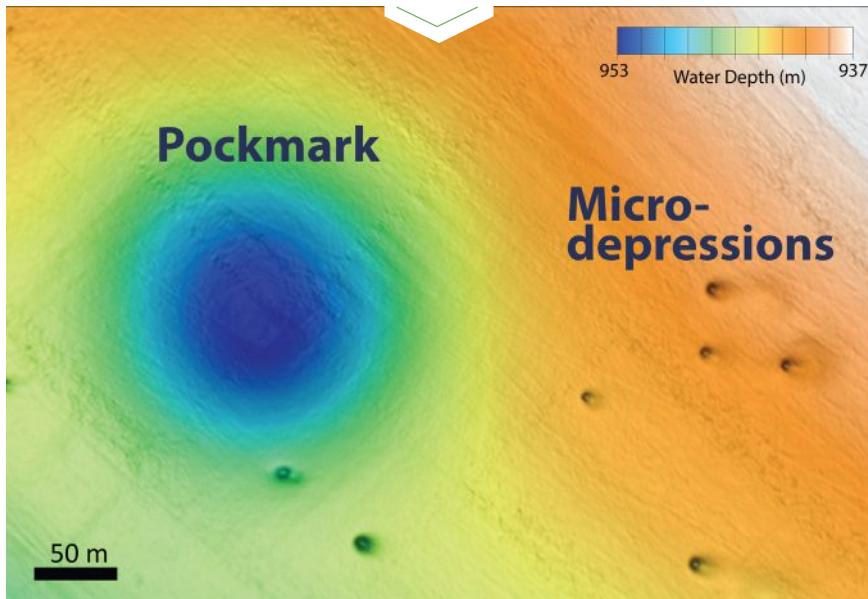
"As well as marking a meaningful milestone in Oi's history, our London 2020 presentation couldn't come at a more critical time, when all aspects of the embattled global environment are quite rightly at the forefront of our collective consciousness. Delegates will come away from the show not only with a bulging contacts book, but also with heartening first-hand evidence that myriad technological and conceptual solutions for the safeguarding of the world's oceans are already being implemented. These interlinked and beneficial principles perpetuate themselves: by attending, all exhibitors, speakers and visitors are helping to ensure that the ocean science community's commitment to innovation, exploratory research and analysis continues unabated, and we're looking forward to welcoming larger audience numbers than ever before through the doors."

To register, see: OCEANOLOGYINTERNATIONAL.COM

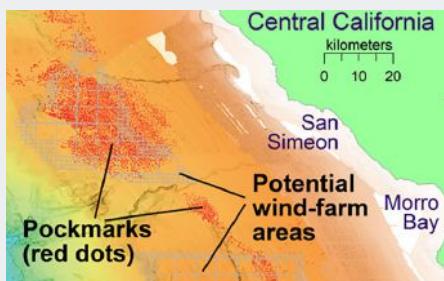


MYSTERIOUS HOLES DISCOVERED IN THE SEAFLOOR OFF CENTRAL CALIFORNIA

By Kim Fulton-Bennett, MBARI



» Seafloor map showing pockmark and micro-depressions in the seafloor off Big Sur.
Image credit: © 2019 MBARI.



» Map showing the locations of some of the pockmarks and proposed wind-farm areas off Central California. Image credit: © 2019 MBARI.

During a recent survey of the deep seafloor off Big Sur, MBARI researchers discovered thousands of mysterious holes or pits in the seafloor. Scientists and resource managers want to understand how these pits formed because this area is the site of a proposed wind-energy farm. Researchers Eve Lundsten and Charles Paull describe their discovery this week at the Fall 2019 meeting of the American Geophysical Union in San Francisco.

The researchers found two different sizes of holes. The larger ones, known as pockmarks, average 175 meters (almost 600 feet) across and five meters (16 feet) deep, and are nearly circular and fairly evenly spaced. Some of these pockmarks were initially discovered by MBARI scientists in 1999 during a seafloor survey using ship-mounted sonar. Over the last few years, additional surveys by MBARI and other organizations revealed

over 5,200 pockmarks spread out over 1,300 square kilometers (500 square miles), making this area the largest known pockmark field in North America.

More recently, MBARI conducted detailed seafloor surveys using sonar mounted on autonomous underwater vehicles. These surveys revealed thousands of smaller pits, which they termed micro-depressions. The micro-depressions average just 11 meters (36 feet) across and one meter (three feet) deep. They have steeper sides than the pockmarks and are often elongated in one direction.

Seafloor pockmarks have been found elsewhere around the world, and have been associated with releases of methane gas or other fluids from the seafloor. Such methane releases could potentially cause the seafloor to be unstable, which could pose risks for structures such as offshore oil platforms



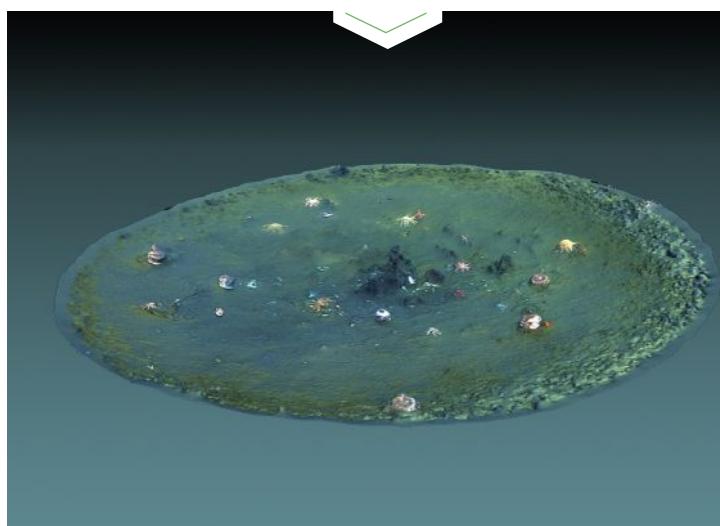
» Close-up view of the seafloor inside a micro-depression, showing trash, rocks, seafloor animals, and fish. Image credit: © 2019 MBARI.

or wind turbines. However, MBARI researchers found no evidence of methane in the sediment or seawater in this region. In fact, sonar data showing layers of seafloor sediments suggest that these pockmarks have been inactive for the last 50,000 years.

In contrast to the pockmarks, the micro-depressions formed in relatively young sediment. In addition, almost all of the micro-depressions contain objects such as rocks, kelp holdfasts, bones, trash, or fishing gear. Many micro-depressions also have "tails" of sediment that probably originated within the depression. In many areas, these tails are all oriented in the same direction.

Based on these observations, the researchers hypothesize that the micro-depressions are relatively recent features that were excavated by local seafloor currents. Because the sediment on the seafloor in this area is so soft and "fluffy," the researchers speculate that even the movements of fish hiding out in the micro-depressions could stir up the sediment, allowing it to be carried away by currents.

Summarizing this work, Lundsten said, "The pockmarks and micro-depressions in this area are both holes in the seafloor that occur in softer sediments, but they are morphologically distinct. The cause and persistence of the pockmarks still remains a mystery, but we find no evidence they were created from gas or fluid in the seafloor in the recent past. The micro-depressions are recently formed erosional features; they are not 'incipient pockmarks.' Overall, a lot more work needs to be done to understand how all these features were formed, and this work is in progress."



» Computer-generated 3D view of a micro-depression created using underwater video from MBARI's remotely operated vehicle Doc Ricketts. Image credit: Ben Erwin, © 2019 MBARI.

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ARCTIC RAYS RELEASES STANDALONE PROGRAMMABLE MAKO 4K MINI-CAMERA

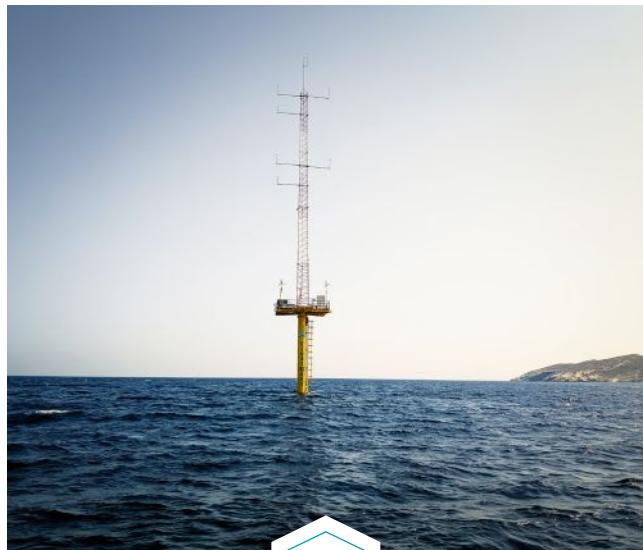
Seeing the need for a simple, ultra-compact standalone 4K UHD camera, Arctic Rays, LLC has released Mako for use on multiple platforms, including ROVs, HOVs, ASVs, landers and fixed platforms. Mako has an on-board real-time clock with scheduler, which can be programmed in advance and allowed to run independently off of its internal battery or external power. The internal scheduler can also be used to synchronize and control any of Arctic Rays' Dragonfish series lights. Scheduling, adjustments to camera settings, and downloading of video can be done via the standard MCBH connector, or via Wi-Fi. Recharging the battery is also accomplished through the connector so that the housing never has to be opened. Endurance varies depending on the duty cycle, recording resolution, and memory card size.

Although designed as a standalone camera requiring no connection to external power or data, Mako is capable of transmitting SD video out for real-time monitoring, and can be powered externally with 12 to 40Vdc. This is ideal for existing ROV systems which want to upgrade to 4K UHD video recording, but only have SD topside feeds for viewing.

In addition to recording 4K (3840 x 2160P) UHD video, the camera can capture 8MP still images at 3840x2160 resolution.

The compact lightweight design measures 70mm diameter by 140mm long. Housed in a 6061-T6 AHC aluminum housing, it is available in depth ratings of 2,000 or 6,000 meters.

For more information visit:
WWW.ARCTICRAYS.COM



FLOATMAST REACHES FIVE MONTH MILESTONE

In December 2019, FloatMast®, the world's first floating tension-leg platform (TLP) MetMast reached 5 months of continuous operation in the Aegean Sea. FloatMast combines a mini tension leg platform (TLP) with a short MetMast and a ZephIR 300 wind lidar.

The demonstration project will provide meteorological data for a period of 12 months. It was installed off the coast of the island of Makronisos, at a sea depth of 65 meters and at a distance of 250 meters from the shore.

The platform provides the wind measurements for fixed or floating offshore wind parks. It is the Mediterranean's first offshore wind infrastructure and its creators say that it is a complete environmental monitoring solution providing advanced capabilities for reducing the cost and design risks of offshore wind investments. It was developed by the Greek SMEs ETME and Streamlined Naval Architects, with the consultation of CRES MEASNET Institute. Project developers expect to deploy at least 15 FloatMast platforms by 2021 and reach a market share of up to 15%.

The structure is permanently moored by use of tendons that pull the structure towards the seabed. UK-based Balltec installed four subsea adjustable mooring connectors and H Links for the project on behalf of Streamlined Naval Architects. Balltec's subsea mooring line tensioning systems have previously been used on other projects including Guará-Lula in Brazil for Petrobras.

For more information visit:
WWW.FLOATMAST.COM.



EUROSEA: GATHERING MORE KNOWLEDGE FOR A SUSTAINABLE USE OF THE OCEAN

The oceans provide us with food and oxygen. They are trade routes and climate buffers. They serve as places for recreation, but often also as waste dumps. Storms, rising sea levels, tidal waves and pollution threaten people and ecosystems along the coasts. This is particularly true of Europe with its vast populated coastlines, marginal seas, gulfs and bays.

Yet, despite the immense importance of the oceans, there are still major gaps in our knowledge of the ocean interior, due to missing or insufficiently linked ocean observations. Such knowledge gaps make it difficult to assess the present ocean status, as well as predict how best to plan for future developments for a sustainable use of the oceans. An international consortium of 55 partners organized through the EuroSea project is set to change this.

EU funding of 12.6 million Euros will enable this major collaboration effort. The project, coordinated at the GEOMAR Helmholtz Centre for Ocean Research Kiel, will kick off in Brussels in December 2019.

"The aim of the project is to better combine existing capacities in the European marine observing system, to fill existing gaps and to make the resulting data and information available to users more easily," says coordinator Dr. Toste Tanhua from the GEOMAR Helmholtz Centre for Ocean Research Kiel.

The EuroSea consortium partners are scientific institutions, and non-public partners from 13 European countries, Brazil and Canada. In addition, intergovernmental organizations and networks, such as

the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), the European Marine Board and the European part of the Global Ocean Observing System (EuroGOOS) are supporting the project. Furthermore, partners from industry, for example those involved in the development of ocean observing technologies and services beyond the project are contributing.

Besides improving direct (or in-situ) ocean measurements, EuroSea focuses on the quality and usability of collective data, and on systems using the data for operational forecast services. "To this end, we are working closely with existing marine databases and data infrastructures and the EU Blue-Cloud project to improve capabilities in these areas and facilitate efficient data exchange," stresses the project coordinator. The ocean data should comply with the FAIR standard (findable, accessible, interoperable, reusable).

"Unfortunately, this is not always the case" says Dr. Tanhua.

The project builds on its predecessor AtlantOS which aims to establish an integrated Atlantic Ocean observing system to improve ocean observations for the entire Atlantic region. EuroSea will focus on European seas, including the Mediterranean, and its neighbors.

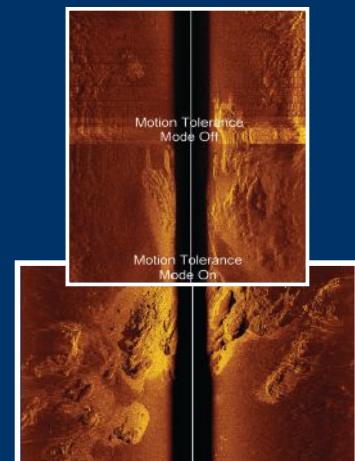
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SEE IT, CHANGE IT

SKYTRUTH IS MAPPING OFFSHORE INFRASTRUCTURE

**By Christian Thomas,
Geospatial Engineer, SkyTruth**

Mapping stationary structures in the ocean helps us track fishing vessels and monitor pollution more effectively

We're all accustomed to seeing maps of the terrestrial spaces we occupy. We expect to see cities, roads and more well labeled, whether in an atlas on our coffee table or Google Maps on our smartphone. SkyTruthers even expect to access information about where coal mines are located or where forests are experiencing regrowth. We can now see incredibly detailed satellite imagery of our planet. Try looking for your house in Google Earth. Can you see your car in the driveway?

In comparison, our oceans are much more mysterious places. Over seventy percent of our planet is ocean, yet vast areas are described with only a handful of labels: the Pacific Ocean, Coral Sea, Strait of Hormuz, or Chukchi Sea for example. And while we do have imagery of our oceans, its resolution decreases drastically the farther out from shore you look. It can be easy to forget that humans have a permanent and substantial footprint across the waters of our planet. At SkyTruth, we're working to change that.

Former SkyTruth senior intern Brian Wong and I are working to create a dataset of offshore infrastructure to help SkyTruth and others more effectively monitor our oceans. If we know where oil platforms, aquaculture facilities, wind farms and



more are located, we can keep an eye on them more easily. As technological improvements fuel the growth of the ocean economy, allowing industry to extract resources far out at sea, this dataset will become increasingly valuable. It can help researchers examine the effects of humanity's expanding presence in marine spaces, and allow activists, the media, and other watchdogs to hold industry accountable for activities taking place beyond the horizon.

WHAT WE'RE DOING

Brian is now an employee at the Marine Geospatial Ecology Lab (MGEL) at Duke University. But nearly two years ago, at a Global Fishing Watch research workshop in Oakland, he and I discussed the feasibility of creating an algorithm that could identify vessel locations using Synthetic Aperture Radar (SAR) imagery. It was something I'd been working on on-and-off for a few weeks, and the approach seemed fairly simple.

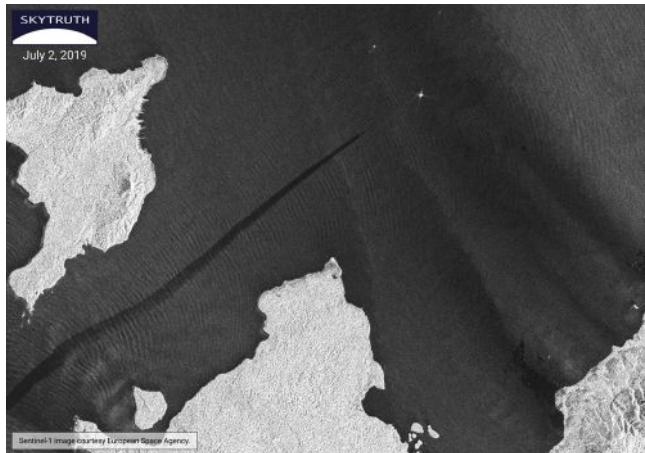


» Image 1: SkyTruth and Global Fishing Watch team members meet for a brainstorming session at the Global Fishing Watch Research Workshop, September 2017. Photo credit: David Kroodsma, Global Fishing Watch.

Readers who have been following SkyTruth's work are probably used to seeing SAR images from the European Space Agency's Sentinel-1 satellites in our posts. They are our go-to tools for monitoring marine pollution events, thanks to SAR's ability to pierce clouds and provide high contrast between slicks and sea water. SAR imagery provides data about the relative roughness of surfaces. With radar imagery, the satellite sends pulses to the earth's surface. Flat surfaces, like calm water (or oil slicks), reflect less of this data back to the satellite sensor than vessels or structures do, and appear dark. Vessels and infrastructure appear bright in SAR imagery because they experience a double-bounce effect. This means that—because such structures are three-dimensional—they typically reflect back to the satellite more than once as the radar pulse bounces off multiple surfaces.

If you're interested in reading more about how to interpret SAR imagery this tutorial hosted by the Centre for Remote Imaging Sensing & Processing is an excellent starting point: https://crisp.nus.edu.sg/~research/tutorial/sar_int.htm.

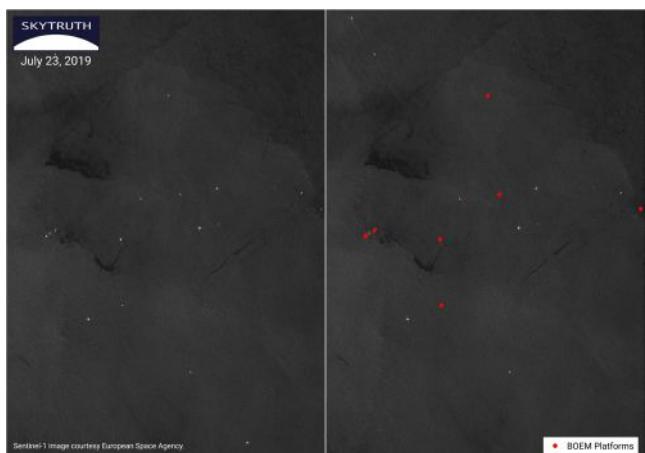




» Image 2: The long, dark line bisecting this image is a likely bilge dump from a vessel captured by Sentinel-1 on July 2, 2019. The bright point at its end is the suspected source. Read more at <https://skytruth.org/2019/07/more-oil-pollution-in-southeast-asia-suspected-bilge-dumping-off-indonesia-and-the-philippines/>.



» Image 3: The bright area located in the center of this Sentinel-1 image is Neft Daşları, a massive collection of offshore oil platforms and related infrastructure in the Caspian Sea.



» Image 4: Two versions of a single Sentinel-1 image collected over the Gulf of Mexico, in which both oil platforms and vessels are visible. On the left, an unlabeled version which illustrates how similar infrastructure and vessels appear. On the right, oil platforms have been identified using the BOEM Platform dataset located at <https://www.data.boem.gov/Main/Mapping.aspx>.

Given the high contrast between water and the bright areas that correspond to land, vessels, and structures (see the vessel at the end of the slick in Image 2 and Neft Daşları in Image 3), we thought that if we could mask out the land, picking out the bright spots should be relatively straightforward. But in order to determine which points were vessels, we first needed to identify the location of all the world's stationary offshore infrastructure, since it is virtually impossible to differentiate structures from vessels when looking at a single SAR image. Our simple task was turning out to be not so simple.

While the United States has publicly available data detailing the locations of offshore oil platforms (see Image 4), this is not the case for other countries around the world. Even when data is available, it is often hosted across multiple webpages, hidden behind paywalls, or provided in formats which are not broadly accessible or useable. To our knowledge, no one has ever published a comprehensive, global dataset of offshore infrastructure that is publicly available (or affordable).

As we began to explore the potential of SAR imagery for automated vessel and infrastructure detection, we quickly realized that methods existed to create the data we desired. The Constant False Alarm Rate algorithm has been used to detect vessels in SAR imagery since at least 1988ⁱ, but thanks to Google Earth Engine we are able to scale up the analysis and run it across every Sentinel-1 scene collected to date (something which simply would not have been possible even 10 years ago).

To apply the algorithm to our dataset, we, among other things, had to mask out the land, and then set the threshold level of brightness that indicated the presence of a structure or vessel. Both structures and vessels will have high levels of reflectance. So, we then had to separate the stationary structures from vessels. We did this by compiling a composite of all images for the year 2017. Infrastructure remains stationary throughout the year, while vessels move. This allowed us to clearly identify the infrastructure.

WHERE WE ARE NOW

Our next step in creating the infrastructure dataset was testing the approach in areas where infrastructure locations were known. We tested the algorithm's ability to detect oil platforms in the Gulf of Mexico, where the US Bureau of Ocean Energy Management (BOEM) maintains a dataset. We also tested the algorithm's ability to identify wind turbines. We used a wind farm boundary dataset provided by the United Kingdom Hydrographic Office to validate our dataset, as well as information about offshore wind farms in Chinese waters verified in media reports, with their latitude and longitude available on Wikipediaⁱⁱ.

Our results in these test areas have been very promising, with an overall accuracy of 96.1%. The methodology and data have been published by the journal *Remote Sensing of Environment*ⁱⁱⁱ.

Moving beyond these areas, we are continuing to work with our colleagues at MGEL to develop a full global dataset. What started as a project to identify vessels for Global Fishing Watch (GFW) has turned into an entirely different, yet complementary, project identifying offshore infrastructure around the world.

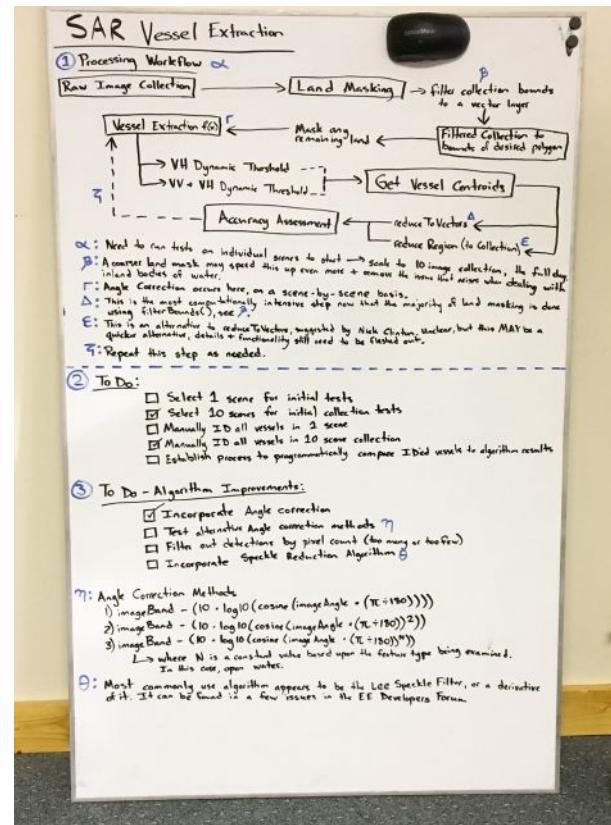
In addition to helping our partners at GFW identify fishing vessels, mapping the world's offshore infrastructure will help SkyTruth more effectively target our daily oil pollution monitoring work on areas throughout the ocean that are at high risk for pollution events from oil and gas drilling and shipping (such as bilge dumping). This is also the first step towards one of SkyTruth's major multi-year goals: automating the detection of marine oil pollution, so we can create and publish a global map of offshore pollution events, updated on a routine basis.

Be sure to keep an eye out for more updates on the www.skytruth.org website, as we will be publishing the full datasets once we complete the publication cycles.

ABOUT SKYTRUTH

SkyTruth uses the view from space to inspire people to protect the environment. We utilize technology, such as remote sensing and digital mapping, to identify and monitor threats to the planet's natural resources such as offshore drilling and oil spills, urban sprawl, fracking, mountaintop removal mining, and overfishing of the oceans.

We believe better transparency leads to better management and better outcomes. By sharing our findings – stunning imagery and robust science-based data – with the public for free, we move policy makers, governments and corporations towards more responsible behavior in the environment. We arm citizen activists with the tools they need to be more effective advocates. We also provide researchers and scientists with critical data that can inform groundbreaking work – and, notably, aid in the effort to begin asking a new set of questions. To learn more, visit www.skytruth.org.



» **Image 5:** An early version of our workflow for processing radar imagery to identify vessel locations. While the project shifted to focus on infrastructure detection first, many of the processing steps remained.



» **Image 6:** Wind farms in the Irish Sea, west of Liverpool.

ⁱ Touzi, R.; Lopes, A.; Bousquet, P.; "A statistical and geometrical edge detector for SAR images;" IEEE Transactions on Geoscience and Remote Sensing, Volume 26, Issue 6 November 1988.

ⁱⁱ List of offshore wind farms in China. From Wikipedia. https://en.wikipedia.org/wiki/List_of_offshore_wind_farms_in_China. Last accessed 2 December 2019.

ⁱⁱⁱ Wong, Brian A.; Thomas, Christian; Halpin, Patrick, "Automating offshore infrastructure extractions using synthetic aperture radar & Google Earth Engine," Remote Sensing of Environment, Volume 233, November 2019, 111412, <https://doi.org/10.1016/j.rse.2019.111412>

CHECK THE TECH: HIDDEN RESOURCES

The surface of the ocean conceals many secrets – unexplored depths, unique life forms, and precious resources. To find these resources, a Norwegian company has developed a technology for scanning the bottom of the ocean in greater detail

At a depth of 1000 meters, it is ice cold and dark. No natural light penetrates here. At first, only silhouettes are discernible in the glare of the underwater robot's floodlights. Then strange, three-legged objects appear on the bottom of the ocean.

They are receiver stations for electromagnetic waves transmitted into the seafloor, to visualize its geological strata and find resource deposits.

When oil companies want to find out whether drilling at depth is worth the cost, they often rely on Controlled Source Electro Magnetic (CSEM) technology. This technology exploits the differences in the electrical resistance of different bottom layers to provide clues about the location and size of oil fields.

The CSEM technology uses a very strong power source to generate an electromagnetic field, as well as several receivers to record the fields. These tripod receivers are placed on the sandy bottom and pick up electromagnetic signals that have been changed by the layers through which they passed.

5000 Meters Below The Seafloor

Since 2016, the Norwegian company PetroMarker is working with new tripods. The special thing about this measuring method is that, unlike other measuring methods, the company uses a vertical transmitter and receiver to find resources under the bottom. This enables a much more detailed resolution and data



measurement up to 5000 meters under the seafloor, the company claims.

The tripods are about 4 meters high and made from a combination of glass fiber and special foams. Due to the sensitive electronics, metal parts cannot be used. This far below the surface, the pressure is extreme, and the salt water is aggressive.

Underwater Drives For Vertical Alignment

A prerequisite for the exact capture of electromagnetic data is that the antennas are aligned perpendicular to the seafloor – or as close to perpendicular as possible, as the seafloor isn't always flat. To this end, the company has developed new receivers that enable a vertical alignment of the antennas at the center of the tripods with high precision. This is where the underwater drives from maxon come in. They are installed at the lower end of



the receiver antenna to align it vertically as needed. The maxon drive solution excels through its compact design and low weight. The centerpiece of the oil-filled underwater drive system is a motor-gearhead combination, comprising a brushless DC motor (BLDC) and planetary gearhead.

The system is completed by a controller (EPOS) and a compensator. The units are encased in plastic to protect them from corrosion. Several modifications were required to meet the specifications for this application: The EC-I 40 motor and the GP 42 planetary gearhead are customized, and the compensator isn't off-the-shelf either. A dual seal, imitating typical submarine technology, ensures that the system is able to resist the enormous water pressure. The control electronics of the underwater drive are housed in a pressure-neutral glass ball that is able to resist the pressures of up to 600 bar – one of the challenges of this extreme application.



» Photos courtesy of maxon.

LEADING COMPANIES EMPLOYING DRONES IN THE OIL AND GAS INDUSTRY

Drone makers are collaborating with oil and gas companies to develop custom drones with data collection technology to obtain real-time insights, according to GlobalData, a leading data and analytics company.

The company's report, 'Drones in Oil & Gas – Thematic Research,' reveals that British oil major BP was one of the early adopters of drones, conducting pilot studies in 2006 at its oilfields in Alaska. The studies evaluated the effectiveness of drones in monitoring gravel road conditions and helped to ensure safe and efficient movement of trucks supplying oilfield equipment. Here are the leading companies using drones in the oil and gas industry.

BP was the first oil and gas company in the US to receive a license to operate commercial drones in 2013, teaming up with AeroVironment to expand its drone usage within the country. BP now deploys drones, crawlers, and other robotic technologies to undertake risky tasks in their operational areas.

Chevron is leveraging the aerial data acquisition capabilities of drones for improving safety and productivity at oilfields. It is applying augmented reality (AR) to drone feeds for evaluating field equipment and infrastructure during inspection and monitoring operations. Chevron is also experimenting on the application of drones in the event of industrial accidents, particularly for assisting in oil spills.

ConocoPhillips is employing drones for the inspection and monitoring of its assets worldwide including the US, the North Sea, and Australia. At the Judy field in the North Sea, the company deploys drones to

inspect the unmanned offshore production platform. The company is also using drones to inspect oil tankers for defects on the exterior and in cargo storage, which has reduced overall inspection time by approximately 75%.

Equinor's drone usage is anticipated to grow as it embarks on automating oilfield operations in the North Sea with an aim to implement unmanned, and possibly fully-autonomous, production platforms.

ExxonMobil has deployed drones for aerial surveillance and inspection of operations in North America, the UK, and Australia. The company has mainly been targeting offshore platforms and refining and petrochemical complexes.

Russian oil and gas giant Gazprom is carrying out extensive trials to assess the performance of drones in the surveillance and monitoring of its assets under extreme cold conditions. The company is aiming to develop drones that could facilitate fast, safe and reliable data collection at lower costs. Gazprom intends to use drone technology for the exploration of hydrocarbon prospects in the Siberian region.

Royal Dutch Shell has been using drones from Aeryon Labs for performing flare stack inspections at its facilities. The company is also conducting pilot studies at its technology center in Houston. Shell intends to assess the capabilities of drones in conducting asset inspections using different combinations of sensing devices and drone technologies.

 WWW.GLOBALDATA.COM



»Photo credit: Cyberhawk Innovations



WES CALL AWARDS FUNDING FOR WAVE POWER DEVELOPMENT

Firms from the subsea and offshore engineering sectors were among the winners in a Europe-wide call to find new technologies to quickly and easily connect wave energy devices at sea.

The call from Wave Energy Scotland will award contracts to firms keen to bolster their involvement in the renewables sector.

Aberdeen-based offshore engineers Apollo, subsea specialists SRP and electrical components provider Ditrail Industrial feature in the seven winning projects totaling around £460,000 as part of a £2 million plus 'Quick Connections System' Wave Energy Scotland (WES) innovation workstream.

The announcement was made by Scotland's Minister for Energy, Connectivity and the Islands Paul Wheelhouse MSP on 5 December 2019.

Commenting on the awards, Elva Bannon, senior research engineer at WES said, "Finding ways to quickly connect a wave energy device to its moorings and electrical system in the harsh marine climate is one of the crucial elements in developing commercial wave technology. A successful solution to this challenge will reduce time, cost and risk in offshore operations."

The seven winners now have three months to deliver feasibility studies on their proposed technologies. They will then compete to pass through two further 'stage gates' to design and ultimately build and test their concept.

The Quick Connections Systems call is the fifth innovation call from WES.

Several technologies have already progressed through feasibility, design and development stages for these calls, including two wave energy companies developing half-scale devices which will be tested at sea in Orkney in 2020.

OCEANWISE CONTRIBUTE TO BIG MARINE DATA PROJECT

The Blue Marine Foundation, a charity dedicated to creating marine reserves and establishing sustainable models of fishing, has completed a project to investigate how data can be used to support safety in inshore waters. The focus of the project "has been the current lack of collated and integrated data to effectively inform safety and risk at the coast and inshore waters."

OceanWise provided the mapping data for situational awareness and to allow multiple sources of data to be integrated using location as the common link. The assembly of disparate datasets into a 'spatial data infrastructure' will inform safety and risk assessments and allow preventative measures to be established and resources used in emergency response to be more effective.

Tim Glover, UK Projects Director from the Blue Marine Foundation comments: "We were delighted to have OceanWise working with us on this ground-breaking Big Marine Data project. Together with the University of Southampton and Plymouth Marine Laboratory, they added huge value to extending the collection, modelling and application of data to better understand risk of life and property at sea."

Dr. Mike Osborne, OceanWise Managing Director, commented "Projects like those that the Blue Marine Foundation undertake are essential as the volumes, variety and velocity of data expands and presents us regularly with new dynamic challenges. Marine data has often been forgotten in the past behind its terrestrial counterpart, but now we are seeing more interest and focus on our Oceans than ever before."

More information on the Blue Marine Foundation and the Big Marine Data Project can be found at www.bluemarinefoundation.com.



For more information visit:
WWW.BLUEMARINEFOUNDATION.COM



MTS EVENT: FLORIDA TECHSURGE ON THE FUTURE OF COASTAL MONITORING

Join the Marine Technology Society and partners the Indian River Lagoon National Estuary Program and Florida Atlantic University's (FAU) Harbor Branch Oceanographic Institute for a 2-day TechSurge that will focus on technology and system design challenges and opportunities to help guide the development of comprehensive coastal monitoring systems for Florida's estuaries and nearshore coastal waters. Guidance and outcomes from this meeting will directly influence Indian River Lagoon monitoring network planning and may feed into the United Nations Ocean Decade Implementation Plan (2021-2030).

The event is scheduled for April 1-2, 2020 at FAU Harbor Branch Oceanographic Institute, Fort Pierce, Florida. Registration is now open. Learn more at <https://florida.mtsociety.org>.

Call for Abstracts

Submit your ideas for presentations that apply marine technology for coastal monitoring and water quality solutions. Topics of interest include but are not limited to:

- Technology innovations for remediation of nutrients and pollutants and habitat restoration coastal and water cleanup and restoration
- Transformative 21st century emerging technologies for ocean and coastal management
- Remote sensing from space and airborne systems
- Unmanned vehicles for automated monitoring
- Novel fisheries management
- Low size, weight and power sensors for long-term deployment
- Data management and big-data analytics for decision making

MTS is also seeking abstracts from authors that wish to develop full manuscripts, technical reports or commentaries to include in a special issue of the Marine Technology Society Journal to be finalized after the event.

Please email abstracts to mtsevents@mtsociety.org – DEADLINE January 15, 2020. Direct questions to MTS conference co-chairs, John Flynn, john.flynn@flynn-tech.com, or Donna Kocak, Donna.Kocak@L3Harris.com.



DAMEN AND VSTEP TO ESTABLISH SIMULATION RESEARCH LABORATORY

Damen Shipyards Group and VSTEP Simulation have joined forces to establish a laboratory to explore innovative new simulation solutions. The aim of the partnership is to develop software that will extend the capabilities of VSTEP's existing NAUTIS Maritime Simulation platform into engineering applications and so open up new research and development possibilities for Damen's numerous R&D programs.

The initial focus will be on ship design and engineering, where software will be developed that will allow naval architects and engineers to first model potential changes in a design and then view in virtual reality the impacts that these would have on other aspects of the vessel's performance.

Marcel Cleijzen, team leader at Damen R&D, said, "Costs per simulated vessel are currently high due to dependency on suppliers, high tariffs and limited re-usability as ownership remains with suppliers. This project is an investment that will drastically lower the cost per simulation by standardising the interface between components and making the completed simulations re-usable for future purposes."

Damen and VSTEP Simulation already work together via Damen's associate company 360-Control where NAUTIS Maritime Simulators are used to train crew in manoeuvring tugs and OSVs in a range of scenarios in a highly lifelike but zero risk environment.

The new laboratory will also explore the potential to create Digital Twins, i.e., virtual representations of existing vessel types that can then be manipulated to establish how they might perform in roles or conditions that they have yet to experience. That information will then be applied to optimising the designs to allow them to operate effectively in new markets. The laboratory will be based at Damen's headquarters in Gorinchem and operational from February 2020.

WWW.GLOBALDATA.COM



UNIVERSITY OF MIAMI BUILDS SCIENTIFIC DIVE TRAINING FACILITY

The University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science has completed construction of a state-of-the-art Scientific Dive Training Facility on its Virginia Key Campus.

As one of the few facilities of its kind in the U.S., it expands the school's capability to train scientists and students with scientific diving skills and technology in accordance with American Academy of Underwater Sciences (AAUS) standards. In addition, the school will be the first university to offer scientific freediving in accordance with new Professional Association of Diving Instructors (PADI) standards for freediving as a research tool. Freediving enhances underwater research activities such as experimental larvae research, coral outplanting, shark research and marine mammal observations. The 75-by-50 ft in-ground freshwater pool has a uniform depth of 15 ft and is located on the school's waterfront shoreline facing Biscayne Bay.

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NREL MODELS PREDICT LOWER COSTS FOR FLOATING OFFSHORE WIND



NREL's recently published "Oregon Offshore Wind Site Feasibility and Cost Study" indicates the cost of deploying floating offshore wind could be 30% to 40% less than previously estimated.

The study, funded by the Bureau of Ocean Energy Management, modeled the potential costs of floating offshore wind farms at least 10 nautical miles from Oregon's coast where wind speeds are some of the world's strongest. The levelized cost of energy (LCOE) for the hypothetical projects—600 megawatts each, outfitted with 15-megawatt turbines, and developed by 2032—ranged from \$74 per megawatt-hour in the north to \$53 per megawatt-hour in the south, near the California border.

The study builds off a similar NREL study published in 2016, which estimated the LCOE for floating offshore wind in California at \$100 per megawatt-hour or less by 2030.

"The Oregon study reflects lower LCOE than the 2016 California study because of new cost and technology data that support lower capital and operational expenditures than were previously modeled," said Walt Musial, NREL's lead offshore wind researcher and one of the authors of both studies. "These results mean that the market for floating offshore wind is growing rapidly and verify the assumptions we've made about floating offshore wind costs decreasing. This should encourage developers that the technology is driving in the right direction."

Floating wind energy technologies will be required to tap Oregon's 62 gigawatts of available offshore wind energy resource—97% of which is in waters deeper than 60 meters.

EQUINOR STRENGTHENS ITS PRESENCE IN THE POLISH OFFSHORE WIND MARKET

On 10 December 2019, Equinor completed the acquisition of a 50% interest in the offshore wind development project Bałtyk I in Poland from Polenergia. The company now has an interest in all three Bałtyk offshore wind development projects.

The Bałtyk I offshore location license allows for a development of a wind farm with a capacity up to 1560MW of which Equinor will hold 50%. Equinor will be the manager for the construction preparation and the potential construction and operational phases.

It was in 2018 that Equinor acquired a 50% interest in the offshore wind development projects Bałtyk II and Bałtyk III which have a combined planned capacity of 1,440 MW with the potential to power more than two million Polish households. Later that year, Equinor decided to exercise an option to acquire a 50% interest in the Bałtyk I offshore wind development project, and this transaction is now concluded.

The wind farm area is in the Baltic Sea in water depths of 25-35 meters, approximately 80 kilometers from the port of Łeba.

Equinor says that they welcome the recent progress in the development of a legal framework for offshore wind in Poland. Clearly defined targets for offshore wind, a robust and predictable framework that sets the right incentives and a streamlined permitting process will be key success factors to develop the offshore wind sector in Poland and to realize the Polish supply chain potential.

WWW.EQUINOR.COM



SIEMENS GAMESA INSTALLS ITS 1000TH OFFSHORE WIND TURBINE

When Siemens Gamesa Renewable Energy recently installed turbine 51 in the British 714 MW East Anglia One project, it reached a significant milestone: the installation of offshore Direct Drive wind turbine number 1,000, eight years on from the first.

Since being launched in 2011, the 1,000 units of the Siemens Gamesa Offshore Direct Drive wind turbine platform combined have avoided approximately 29 million tons of CO₂ compared to fossil fuel power generation—the equivalent of more than 6 million trips around the Earth in a car.

Siemens Gamesa's engineers pioneered the offshore sector back in 1991, contributing to the world's first wind power plant in Denmark. Since then, Siemens Gamesa has grown to become the global leader in offshore wind power generation with projects in numerous countries in Europe and Asia Pacific. Its reach is set to extend further with conditional contracts already signed in emerging offshore wind markets including the United States, Japan, and France. According to the International Energy Agency, offshore wind power capacity is set

to increase by at least 15-fold worldwide by 2040, becoming a \$1 trillion business.

"Installing the Siemens Gamesa offshore Direct Drive wind turbine number 1,000 is a remarkable achievement in many ways. Our contribution to combatting the effects of climate change becomes more tangible with the physical installation of this turbine along with its 999 predecessors," stated Andreas Nauen, CEO of the Siemens Gamesa Offshore Business Unit.

Two decades of experience in offshore wind has helped Siemens Gamesa to design the Direct Drive platform for safe, efficient installation and easy maintenance. The simplest drivetrain in the industry enables fewer moving parts, which is important in harsh offshore conditions where parts can wear more easily and are costly to replace. Additionally, the turbine's light weight enables low load impact on its tower and foundation, while further reducing requirements on transport and installation equipment.



According to performance data collected by Siemens Gamesa, its Direct Drive offshore wind turbine fleet has produced approximately 34.6 Terawatt hours of electricity since the first unit was installed in 2011. This output is the same as the annual consumption for every household in Denmark, or the power consumption of the city of Madrid including all industry for one year.

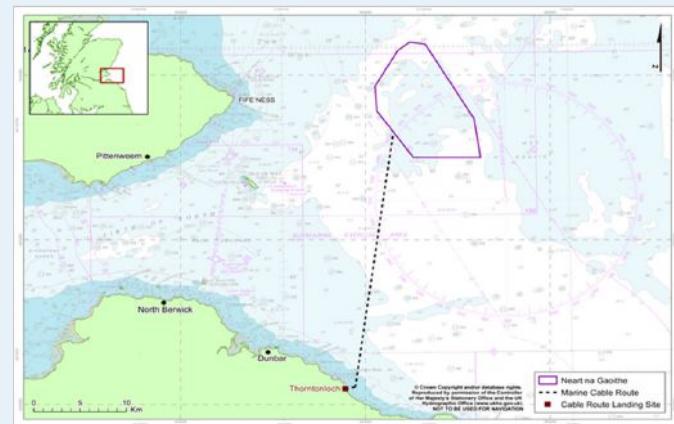
Nauen added: "The Levelized Cost of Energy from offshore wind has decreased rapidly over the last few years, fully establishing the technology as on-par with traditional industrial power generation methods. Our order backlog with an additional 1,000+ SGRE Direct Drive offshore turbines is a testament to this achievement, and to the trust placed in us by our customers."

WWW.SIEMENSGAMESA.COM

SAIPEM AWARDED OFFSHORE WIND FARM CONTRACTS IN SCOTLAND AND TAIWAN

Saipem has been awarded a contract by the French company EDF Renewables for the construction of the Neart na Gaoithe (NnG) wind farm offshore Scotland.

This is the first turn-key project awarded to Saipem in the offshore wind



» The Neart na Gaoithe (NnG) offshore wind farm will be located 15.5 km off the Fife coast and covers an area of approximately 105 km². EDF Renewables UK acquired the project in May 2018 as part of a competitive bidding process. Image credit: NnG Offshore Wind.

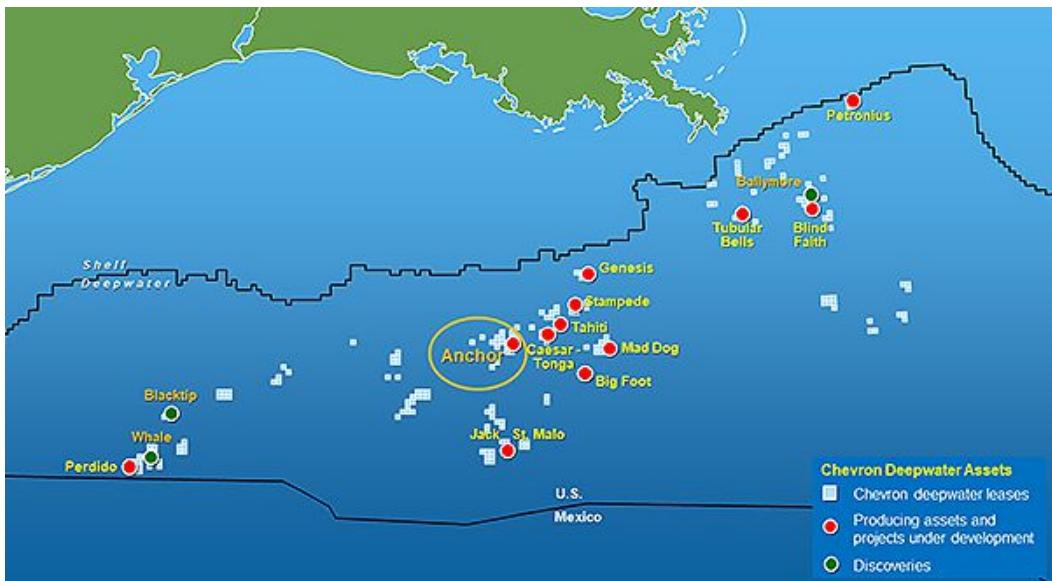
farm sector. The scope of work consists of the engineering, procurement, construction and installation of 54 steel foundation jackets for an equivalent number of wind turbines with a capacity of around 8MW each, 2 steel foundation jackets for the offshore electrical substations and the transportation and installation of the relevant topsides. These jackets will be manufactured partly at a Saipem owned yard and partly in fabrication facilities located in Scotland. The jackets will be placed on piles at depths ranging from 40 to 60 meters. Offshore installation activities will be carried out by the crane vessel Saipem 7000, which has a consolidated track record of operations in the North Sea.

The NnG offshore wind farm, 15 km off the east coast of Scotland, will be deployed over an area of 105 km² and will be capable of generating around 450 megawatts of electricity.

Furthermore, Saipem has been awarded a new contract for the Formosa 2 offshore wind farm project. The scope of work entails the supply of material and fabrication of 32 foundation jackets for an equivalent number of wind turbine generators. The wind farm is being developed by a partnership between Macquarie's Green Investment Group and Swancor Renewable Energy, offshore Miaoli County on the West coast of Taiwan. Construction works for the project are scheduled to commence early 2020.

The overall amount of these two new contracts corresponds to approximately 750 million euro, representing more than 15% of the E&C Offshore Division order intake year-to-date, thus consolidating Saipem position as a global solution provider to the extended energy sector.

For more information, visit WWW.SAIPEM.COM



» Map courtesy of Chevron.

CHEVRON SANCTIONS ANCHOR PROJECT IN THE DEEPWATER U.S. GULF OF MEXICO

Chevron Corporation announced on 12 December 2019 that it has sanctioned the Anchor project in the U.S. Gulf of Mexico. This marks the industry's first deepwater high-pressure development to achieve a final investment decision. Delivery of the new technology, which is capable of handling pressures of 20,000 psi, also enables access to other high-pressure resource opportunities across the Gulf of Mexico for Chevron and the industry.

"This decision reinforces Chevron's commitment to the deepwater asset class," said Jay Johnson, executive vice president, Upstream, Chevron Corporation. "We expect to continue creating value for shareholders by delivering stand-alone development projects and sub-sea tie backs at a competitive cost."

"For new projects in the Gulf of Mexico, we have reduced development costs by nearly a third, compared to our last generation of greenfield deepwater investments," said Steve Green, president of Chevron North America Exploration and Production. "We're doing this by standardizing equipment, utilizing fit-for-purpose surface facilities that require less capital and employing drill to fill strategies. At Anchor, we streamlined our front-end engineering and design phase and are utilizing more industry standards in our designs and equipment to lower costs while maintaining Operational Excellence."

The Anchor Field is located in the Green Canyon area, approximately 140 miles (225 km) off the coast of Louisiana, in water depths of approximately 5,000 feet (1,524 m). The initial development of the project will require an investment of approximately \$5.7 billion. Stage 1 of the Anchor development consists of a seven-well subsea development and semi-submersible floating production unit. First oil is anticipated in 2024.

The planned facility has a design capacity of 75,000 barrels of crude oil and 28 million cubic feet of natural gas per day. The total potentially recoverable oil-equivalent resources for Anchor are estimated to exceed 440 million barrels. Chevron, through its subsidiary Chevron U.S.A. Inc., is operator and holds a 62.86% working interest in the Anchor project. Co-owner TOTAL E&P USA, Inc. holds 37.14% working interest.

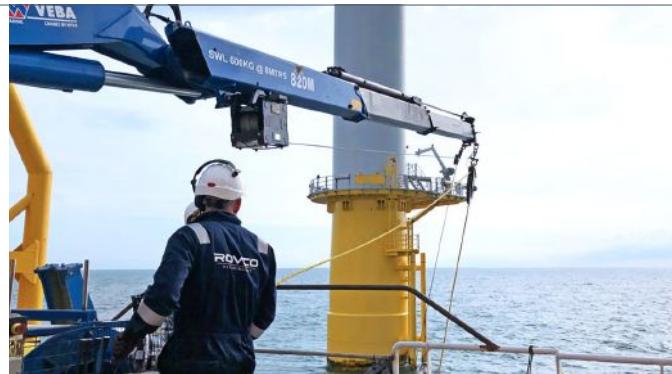
For more information, visit
WWW.CHEVRON.COM

ROVCO COMPLETES ROV INSPECTION PROJECT AT GALLOPER OFFSHORE WIND FARM

Subsea technology specialist Rovco has successfully completed an extensive ROV inspection contract. The circa £1 million contract has resulted in completion of the baseline asset integrity survey at the newly constructed Galloper Offshore Wind Farm, a 353MW installed capacity wind farm which lies 30 km off the coast of Suffolk, UK.

The project, which was awarded by Innogy Renewables UK, began in September 2019—with 24-hour ROV operations provided over a four-week period. Rovco deployed a Cougar XT ROV fitted with both 3D imaging sonar and their SubSLAM 3D technology to complete planned asset inspection activities. The project was performed from the DP2 support vessel, Atlantic Voyager. A second ROV inspection campaign to assess internal foundations was to mobilize in December.

The Bristol-headquartered firm has utilized its state-of-the-art technology and much-respected subsea expertise to inspect



all 56 turbines at the Galloper Wind Farm, which generates enough green electricity to power the equivalent of 380,000 homes.

Data for this project is being delivered via Rovco's in-house Data Command Centre, a proprietary software system which allows for all the various datasets collected to be combined and presented through a simple internet browser. Within the platform, Rovco's clients view survey data libraries, reports, videos and 3D point clouds, as well as utilize intuitive tools to measure point-to-point distances, surface areas and volumes, providing a streamlined workflow for future asset management.

For more information, visit WWW.ROVCO.COM

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UK BUSINESSES CAN PARTNER WITH US CONSORTIUM FOR SHARE OF OFFSHORE WIND FUNDING

The UK offshore wind energy sector is world-leading and has seen huge growth in the last few years. Advances in technology have led to a reduction in costs that have allowed the industry to make a significant contribution to reducing UK carbon emissions from energy.

However, it is estimated that the UK will need to see a ten-fold increase in energy production from wind to 75GW if it is to meet its target of net zero emissions by 2050.

Further innovation will be needed to reduce costs and improve the performance of offshore wind farms. Many other countries also have the potential to supply large amounts of energy through offshore wind farms and face the same challenges.

Innovate UK, part of UK Research and Innovation, has up to £1.5 million to support UK businesses working with partners in the United States on innovative offshore wind technologies. Businesses and research organisations must first express an interest in applying.

The deadline for expressions of interest is at midday on 15 January 2020. Businesses of any size can apply but all projects must include at least 1 UK SME. The total UK project costs must be between £150,000 and £600,000.

UK projects must work with a US consortium that intends to or has applied to the \$40 million US national offshore wind research and development program managed by the New York State Energy Research and Development Authority.

The aim of the competition is to reduce technical barriers facing offshore wind farms including cutting costs. Project areas in the US program include:

- array performance and control optimization
- cost-reducing turbine support structures for the US market
- floating structure mooring concepts for shallow and deep waters
- power system design and innovation
- comprehensive wind resource assessment
- development of a meteorological and oceanographic reference site
- heavy lift vessel alternatives
- offshore wind digitization through advanced analytics
- technology solutions to accelerate US supply chain

For more information, visit <https://www.gov.uk/guidance/innovation-apply-for-a-funding-award>.

REUTERS EVENTS RELEASE 2020 DECOMMISSIONING MARKET REPORT

DecomWorld — subsidiary of Reuters Events — has released their 2020 Decommissioning Market Report and International Supply-Chain Decommissioning Roadmap.

The report pinpoints contractual opportunities and provides project pipelines in global decommissioning markets. It further provides a list of assets poised to embark on decommissioning within the next 1-2 years across both the GOM and North Sea.

The report assesses market values for decommissioning expenditures across the globe, including AsiaPac and Norway, with insight being shared on when contracts will roll out and when tenders will begin.

In addition, the Supply-Chain Roadmap critically analyzes six international marketing's, including the GOM, UK and Thailand, investigating value, project pipeline and characteristics. With forecasts indicating the global decommissioning market will value at \$82 billion by 2030, the paper allows industry to mobilize around emerging hotspots within traditional decommissioning regions as well as newly emerging waters.



"The paper is a brilliant tool for anyone involved directly in or considering tenders within the industry. With decommissioning hotspots on every continent it's crucial that supply-chain begins to operate cross-border. This report provides the basis for such expansion." Owen Rolt, Director – Global Projects, DecomWorld.

The report is available at https://eloqua.decomworld.com/LP=25905?extsource=ext_whitepaper_pressrelease.

DecomWorld is now part of Reuters Events, after its parent company FC Business Events was acquired as part of the Reuters news and media division of Thomson Reuters. The Report was produced in collaboration with the 12th Annual Decommissioning and Abandonment Summit (March 31 – 1 April, Houston, Texas).

SHELL VP FOR OFFSHORE WIND WARNS OF SAFETY SHORTFALLS



According to an article appearing in Recharge, a senior Shell executive recently told the WindEurope Offshore industry conference in Copenhagen that offshore wind is lagging well behind the oil & gas industry over safety, with only luck preventing a fatality in the sector last year.

Dorine Bosman, Shell's vice president for offshore wind, said the fast-growing sector quickly needs to follow the lead of oil & gas, which

"learned lessons the hard way through tragedies such as Piper Alpha," the devastating oil rig fire that killed 167 in the UK North Sea in 1988.

Bosman told the WindEurope Offshore industry conference in Copenhagen that offshore wind experienced 256 high-potential incidents – with the possibility of death or life-changing industry – in 2018. "Only luck stood between something worse happening," she said.

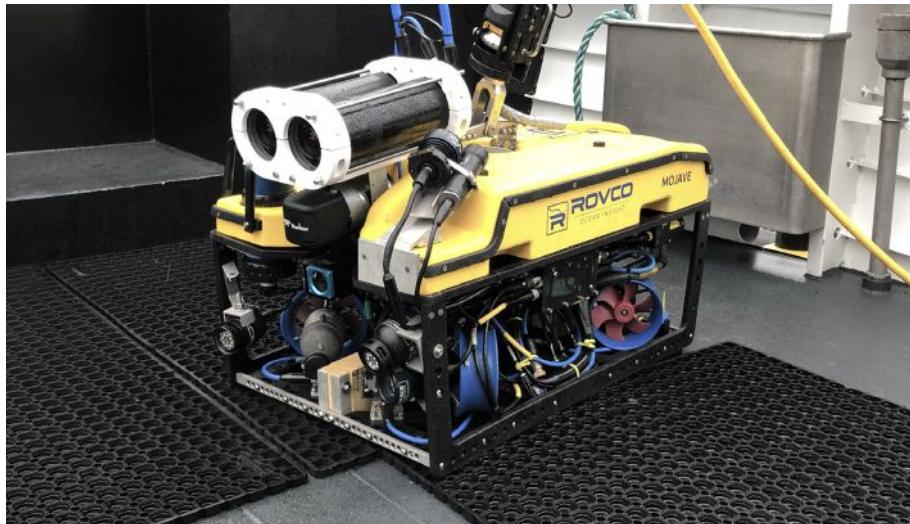
Wind at sea's rate of total recordable incidents was 4.55 per million hours worked, compared to 0.9 per million in oil & gas, she added. And Bosman warned that the sector's steep growth trajectory, and the millions of hours of extra work it will involve, makes the issue even more urgent.

"If you make these numbers work in your head, are you still convinced you'll have zero fatalities? Would you recommend this industry to a friend?"

The figures quoted by Bosman come from 2018 safety data produced by G+ Global Offshore Wind, a sector safety organization backed by major players such as Orsted, Vattenfall and ScottishPower. The data showed the 256 high-potential incidents represented a 13% drop on 2017's level, with no fatalities in either year. When the statistics were released in June, G+ chairman Paul Cowling said other key safety metrics also saw "a remarkable improvement in 2018".

Read the rest of the original article at www.rechargenews.com/wind/top-shell-executive-slams-offshore-wind-over-safety-record/2-1-713152.

ROVCO LAUNCHES LIVE 3D SUBSEA STREAMING TECHNOLOGY



Rovco has launched SubSLAM Live: a 3D Streaming technology which allows clients to video and live stream 3D underwater pointclouds to any device in the world. Their CSO says it is the first of its kind.

The stereo camera technology system sends images and 3D models of assets from the seabed to a computer browser in any location globally. This offers customers instantaneous access to information as an inspection or construction activity is taking place. Rovco trialed the technology earlier in the year with an oil and gas super major, at a renewable wind farm, and more recently in 0.5 m of visibility at an ex-naval dockyard owned by Offshore Renewable Energy Catapult.

Iain Wallace, Rovco's CSO said: "To our knowledge, this technology is the first of its kind, anywhere in the world, to live stream from the seabed to a desk. We have been utilizing our SubSLAM technology for one year so far but with our ongoing investment in research and development, our latest capability of the system has revolutionized how subsea work can be carried out."

During the final trials, the technology was lowered into a sea-water filled dock which contains sample assets from the subsea industry. Rovco Engineers were using the state-of-the-art stereo camera system to capture high-definition video, which allowed them to use the SLAM (Simultaneous Localization and Mapping) system to build highly accurate 3D point cloud models while staff back in their

office 300 miles away, directed the ROV while keeping track of the ROV location and operations via their phones and laptops.

The capabilities of this new technology can reduce time, cost and revolutionize the way engineers process data, allowing for faster data-driven decisions to be made regarding the integrity of subsea infrastructure.

Iain added: "The model is compressed and progressively sent over a low-bandwidth <256Kb network link to a cloud server along with the ROV's position. Authorized clients can then log into our highly secure Data Delivery Platform and view the live model, pulling the data from the cloud on-demand."

The accurately calibrated stereo camera system model is automatically scaled. This means Rovco clients can not only view the model but can also take live measurements of the assets. There are no specialist tools required as it works within a standard web browser.

More than 20 engineers in the Rovco research and development team have worked on the new technology, Iain Wallace added: "We are now able to deliver higher quality and faster results to our customers with this technology than is possible with any other subsea 3D system. It is also a step towards proving that our online Data Delivery Platform is the perfect tool for hosting, viewing and manipulating all varieties of subsea data."

For more information, visit
WWW.ROVCO.COM

2G ROBOTICS OFFICIALLY RELEASES MICRO INSPECTION SKID

2G Robotics has officially released the Micro Inspection Skid, a new laser survey skid for Inspection Class ROVs developed in partnership with iXblue and Nortek. This all-in-one integrated skid delivers high accuracy inspection capabilities with subsea dynamic laser scanning to enable survey and inspection by low cost vehicles. Such high-resolution asset inspection was previously only available on work-class ROVs.

The Micro Inspection Skid is available for industry leading vehicles including the Saab Seaeye Falcon and the Seatronics VALOR. The plug-and-play design comes fully calibrated and only requires mounting and connection to the vehicles auxiliary power and communication channels. The 2G Robotics ViewLS Data Module enables users to easily combine navigation and laser data, and extract targets of interest into 3rd party point cloud analysis software.

The skid includes the 2G ULS-500 Micro laser scanner, iXblue's Rovins Nano Inertial Navigation System, Nortek's DVL1000, and Valeport Depth Sensor to deliver high accuracy geo-referenced laser inspections. The skid is neutrally buoyant to maintain vehicle maneuverability. Simply fly the vehicle over the target to generate a 3D model in real-time.



» Micro Inspection Skid

"The release of the Micro Inspection Skid is a milestone in the evolution of small, cost effective vehicles. We are excited to see what operators will be able to accomplish with this new sensor package" states Chris Gilson, Product Development Manager for 2G Robotics.

The product is now available globally for new and existing inspection class ROVs.

For more information, visit
WWW.2GROBOTICS.COM



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FUGRO AWARDED 5-YEAR HYDROGRAPHIC SERVICES CONTRACT BY NOAA

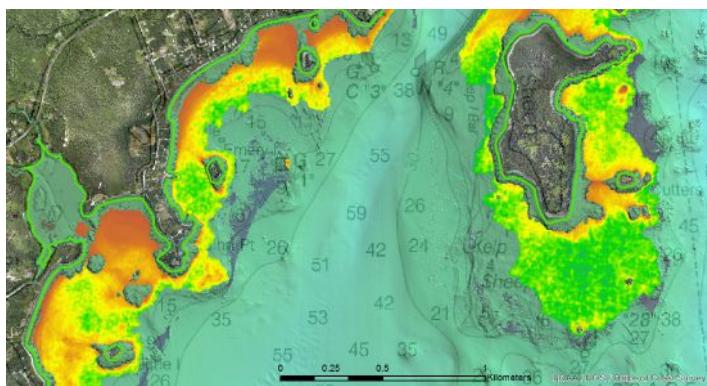
Fugro has been awarded a 5-year Indefinite Delivery Indefinite Quantity (IDIQ) contract by the National Oceanic and Atmospheric Administration (NOAA) to provide hydrographic surveying services in the US. The contract was issued by NOAA's National Ocean Service, Office of Coast Survey, to support the creation and maintenance of highly accurate nautical charts. Recognized by NOAA as a top-ranked hydrographic surveying firm, Fugro has worked continuously with the agency on similar IDIQ contracts since 1998.

"Over the past 20 years, NOAA has been one of Fugro's key clients in the US," said Mark MacDonald, Hydrography Director for Fugro in the Americas. "Through this long and valued partnership, we have pioneered the use of multiple bathymetric surveying techniques, such as airborne lidar bathymetry, to improve the efficiency, quality and safety of shallow water surveys. We are honored to help NOAA fulfill the country's hydrographic data needs and look forward to continuing innovation and delivering on future NOAA task orders."

Fugro will manage all work associated with the new IDIQ award from its Houston-based Hydrography Centre of Excellence in the Americas. Fugro established the center in 2017 to address the region's growing need for hydrographic services. Since then, the center has successfully developed innovative data acquisition systems, which are complemented by remote processing and large data transfer capabilities. These technologies allow Fugro to deliver high quality hydrographic services with increased safety and efficiency, and a significantly reduced carbon footprint.

Two new technologies available to NOAA for upcoming task orders include RAMMS, a next-generation airborne lidar bathymetry system already used by the United Kingdom Hydrographic Office and the Canadian Hydrographic Service, and an uncrewed surface vessel (USV) designed for coastal surveys in challenging areas of shallow water, uncharted shoals and/or water clarity issues.

The new IDIQ contract will run from 1 January 2020 to 31 December 2024. Fugro is one of seven contractors who will receive task orders under the new IDIQ contracting program. The total maximum value of work to be shared among all contractors is USD 250 million.



» Example of hydrographic survey data provided to NOAA by Fugro for updated nautical charts covering the busy maritime area of Penobscot Bay.

FINALISTS ANNOUNCED FOR SUBSEA UK AWARDS

The finalists have been announced for the 2020 Subsea UK awards, which recognize the companies and individuals leading the way in the UK's £7.5 billion subsea sector.



» Neil Gordon, Chief Executive
of Subsea UK

Enpro Subsea, TechnipFMC and JFD have been announced as the finalists for the subsea company of the year award, which is sponsored by the Oil & Gas Authority. The best small company award will see Archer Knight (Holdings) Limited, Crondall Energy and KW Designed Solutions Ltd compete for the sought-after honor, which is sponsored by Viper Innovations.



➤ Neil Gordon, Chief Executive of Subsea UK

Ardent, PanGeo Subsea Scotland and ROVCO have been recognized for their developments in new technology and have been shortlisted for the innovation and technology award, sponsored by Simmons & Co International. The innovation for safety award, which is sponsored by Boskalis, will be contested by Helix Robotics Solutions Ltd, Halliburton and TechnipFMC.

New talent within the industry will be recognized with Sam Fraser from Neptune Subsea Engineering; Etteke Roebroeks from Fugro GB (North) Ltd; and Nicolas Lefebvre from Aquatec House being shortlisted for the emerging young talent award, which is sponsored by SMD.

An individual who has made a lasting impact on the subsea sector throughout their career will also be recognized on the night with the outstanding contribution award.

The black-tie event will take place on 12 February 2020 at P&J Live in Aberdeen, UK during Subsea Expo — Europe's largest subsea focused exhibition and conference. Olympic medallist, presenter and author Kriss Akabusi MBE will be the guest speaker on the night. This year's event has the theme of New Perspectives and will debate and examine key industry topics including how the sector is evolving with the energy transition.

For more information, visit
WWW.SUBSEAEXPO.COM/SUBSEA-UK-AWARDS

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HYDROID INTEGRATES HISAS 2040 MODULE ON REMUS UUV



» REMUS 600 Unmanned Underwater Vehicle (UUV) with High Resolution Interferometric Synthetic Aperture Sonar (HISAS)

Hydroid, Inc., a subsidiary of Kongsberg Maritime and a leading manufacturer of marine robotics systems, have integrated an in-mission processor on a REMUS 600 Unmanned Underwater Vehicle (UUV) with the KONGSBERG High-Resolution Interferometric Synthetic Aperture Sonar (HISAS) 2040 for a customer. By integrating the in-mission processing, the high-resolution images from the HISAS module can be quickly downloaded when the vehicle returns from its mission.

HISAS 2040 provides up to 2 cm by 2 cm resolution across a 300-meter swath. When combined with the onboard EM2040 it provides a complete, gap-filled image. Synthetic aperture sonar uses algorithms to synthetically lengthen the aperture, providing consistent resolution across the entire swath, both along and across track, as opposed to traditional real aperture side-scan sonars. Because of the high resolution of HISAS, the files are very large and can take several hours to download.

With the in-mission processor, HISAS data are processed and compressed in real-time

along with the navigation data, allowing immediate download of the sonar imagery when the vehicle returns from its mission through a 10 Gb ethernet switch. This is ideal for time-sensitive missions like mine countermeasures, where faster data access means safer, more efficient operations. Other HISAS applications include hydrographic surveys, pipeline inspection and rapid environmental assessment.

"The integration is the first of its kind at Hydroid, allowing faster processing of data to shorten post-mission analysis timelines," said Duane Fotheringham, President of Hydroid.

To integrate the in-mission processing onto the vehicle, two powerful processors were added to the module. With this solution, customers can rapidly obtain the quality data they need, increasing their operational flexibility and assisting with improved decision making.



» REMUS 600 High Resolution Interferometric Synthetic Aperture Sonar (HISAS) 2040 Image. Image is 20 m x 20 m and has a resolution of 2 cm x 2 cm.

For more information, visit
WWW.HYDROID.COM

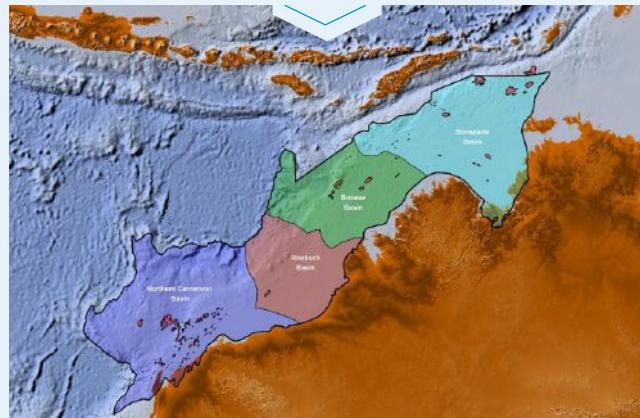
KRAKEN TO SUPPLY THRUSTERS FOR MPI'S ROBOTIC NET CLEANERS

Kraken Robotics subsidiary, Kraken Power GmbH, has signed a multi-year supply agreement with Multi Pump Innovation ("MPI") of Norway. Under the agreement, MPI will purchase RIM-driven thrusters and control systems for use in MPI's new JetMaster automated cage cleaners used for fish farming. While JetMaster is a new product for MPI, its leading position in fish farming cleaners and the growth of the aquaculture industry, gives MPI confidence it will purchase at least \$2 million worth of Kraken thrusters per year going forward. In addition, the companies expect to partner on further developments in the aquaculture industry that may require batteries and underwater charging products from Kraken Power.

Karl Kenny, Kraken's President and CEO, said, "While best known for pressure tolerant batteries, Kraken Power's rim driven thruster products have been sold to a variety of commercial, defense, and research customers over the last 10 years. Kraken is excited to partner with MPI, a world leader in net cleaning robots. This is another example of Kraken developing innovative new technology and growing it into new markets and geographies. Besides MPI, Kraken is also engaged with a number of other aquaculture stakeholders, including industry and government agencies, via our OceanVision Ocean Supercluster project. We see significant opportunities for our thruster and battery technology and our AquaPix sonar sensors, SeaVision laser scanners, and SmartCam products within the global aquaculture industry."

Thore Standal, MPI's Chief Operating and Chief Commercial Officer, said, "We have tested a wide variety of competitive thrusters and selected Kraken for their winning price and performance value proposition. We are pleased to enter into this multi-year partnership with Kraken. In addition to thrusters, we believe there is an opportunity to use Kraken's underwater batteries and charging systems in additional developments for the aquaculture market."

For more information, visit
WWW.KRAKENPOWER.DE



» Map of basins encompassed by the NWS JumpStart package (courtesy of CGG).

CGG COMPLETES JUMPSTART™ MULTI-CLIENT GEOSCIENCE PACKAGES

CGG has completed JumpStart™ multi-client geoscience packages for the North West Shelf (NWS) of Australia and the Banda Arc in the Asia-Pacific region. Both packages enhance understanding of the prospectivity of these two high-potential regions, allowing the assessment of exciting new plays.

JumpStart packages mobilize the full suite of CGG's geoscience capabilities to accelerate and support exploration efforts. They integrate all available data in a specific geographical area and frame it within a geological context. Clients can then easily access, in one place, the reviewed, validated, calibrated and interpreted data, in a consistent and ready-to-use format in order to evaluate petroleum systems.

The NWS JumpStart package encompasses the Northern Carnarvon, Roebuck, Browse and Bonaparte basins, where recent Triassic discoveries have heightened industry interest. The new study fills key knowledge gaps regarding the region's Triassic paleogeography and petroleum systems and mitigates exploration risk for clients evaluating Triassic plays in this region.

The Banda Arc JumpStart package provides insight into this complex and challenging tectonic region at the collision zone between continental Australia and the Indonesian archipelago where historically little data was available. With new seismic data and interpretation from CGG's 16,300 km BandaSeis 2D BroadSeis survey, the study addresses significant imaging challenges relating to the complex overburden and below the fold and thrust. It sheds new light on structuring and petroleum system development, including a significant amount of newly identified and evaluated leads and prospects.

For more information, visit
WWW.CGG.COM



INNOVATIVE PRODUCTS FOR VERY-HIGH-PRESSURE AND LOW-PRESSURE APPLICATIONS

SOURIAU has developed considerable expertise in the design and manufacture of robust and extremely reliable submersible connectors. Its dry-mate product ranges for out-of-water mating—formerly known as Jupiter connectors—have been proven in civil and military underwater applications for over 50 years. Now, SOURIAU also offers connectors that can be mated underwater. For maximum safety and service life, the connectors, known as wet-mate, feature a special method of ejecting water from the connection interface, thus reducing the possibility of short-circuits or contact corrosion. SOURIAU offers a very wide range of innovative products, responding to the evolving needs of applications in very deep water, but also in shallow water, at very high and low pressure.

M-Series: The Range Of Submersible Connectors For Deep Water

The challenges associated with the marine environment are numerous, because the equipment has to operate at depths down to 7000 m and may remain submerged for long periods. In these extreme conditions, underwater connectors must withstand increasingly high pressures, resist corrosion and stay reliable, since maintenance operations at these depths are very tricky to perform. Resistance to high pressure is a feature commonly found in the submersible connectors available on the market.

SOURIAU's M-Series connectors, widely recognized as the most robust underwater dry-mate connectors, are made from marine grade bronze, which resists corrosion

and biofouling. They are also available in stainless steel (316L), titanium and even Super Duplex, a stainless steel with a high chromium content, for even longer immersion times. These connectors, initially developed for military applications, provide extreme resistance to pull out or transverse forces on the cables as well as vibration and shock. For cable termination, sealing is ensured in several ways: for example, with a cable gland (pressure resistance up to 100 bar / 1500 Psi). This method eliminates the need for any resin glue or potting, so it has the advantage of being repairable. It can withstand depths of about - 1000 m. For waterproofing down to 7,000 m, overmoulding is preferred. These connectors are designed for applications such as remotely operated underwater robots, commercial diving, offshore oil and gas subsea production systems and military submarines.

A new version of the M+ connectors has just been announced for depths down to 7,000 m (pressure resistance up to 700 bar / 4350 Psi on open face and coupled connectors), currently available in size 10 and in size 14 at the start of 2020. SOURIAU has developed them to respond to the evolving requirements of the ROV (Remotely Operated Vehicle) and AUV (Autonomous Underwater Vehicle) and UUV (Unmanned Underwater Vehicle) submarine robot markets.

SWIM, For All-Round Reliability At Low Pressure

SOURIAU's specificity is to offer reliable connectors both in high pressure environments at great depth and in low-

pressure environments at low depth. Manufacturers of shallow water immersible equipment have to confront problems of sealing, contact corrosion and connector installation. With its SWIM half-harnesses and harnesses introduced in 2016, SOURIAU provides reliable solutions for depths up to 300 m at a competitive cost. The design of the connectors enables this versatility: the plug is screwed into the receptacle to lock both parts together and two O-rings at the mating interface ensure the connection stays watertight even at low pressure. The compression of the two seals ensures tightness and not pressure, in contrast with most competitors.

Manufactured in thermoplastic material, SWIM connectors are lightweight and watertight. They are corrosion- and UV-resistant, and are not subject to cathodic delamination phenomena, which enables a long service life in the marine environment. The screw mating, the scoop proof feature and the polarization keyways make it easy and safe to mate the plug with the receptacle, whatever the number of pins.

The SWIM range meets the needs of ocean surface drones used for oceanographic missions, oil exploration or more military applications such as maritime surveillance. They also meet the needs of met-oceanographic buoys, remotely operated underwater observation robots and a wide variety of equipment integrating sensors (hydrophones, temperature, salinity, etc.) and electronic devices.



M-Series Connectors

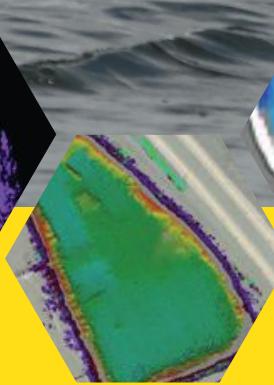
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M7000**



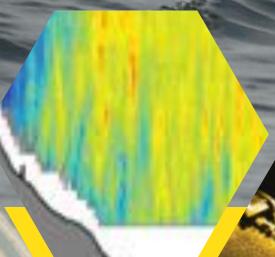
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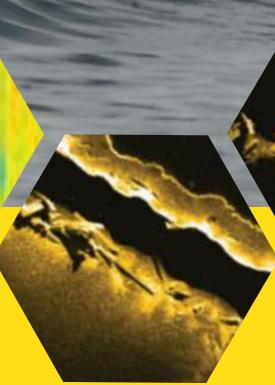
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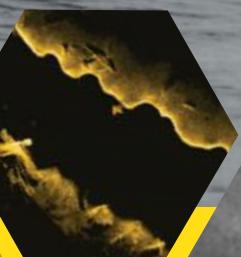
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Bathymetry



ADCP
Discharge
Measurement



550 kHz
Side Scan Sonar



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Motion
Tolerant
Side Scan
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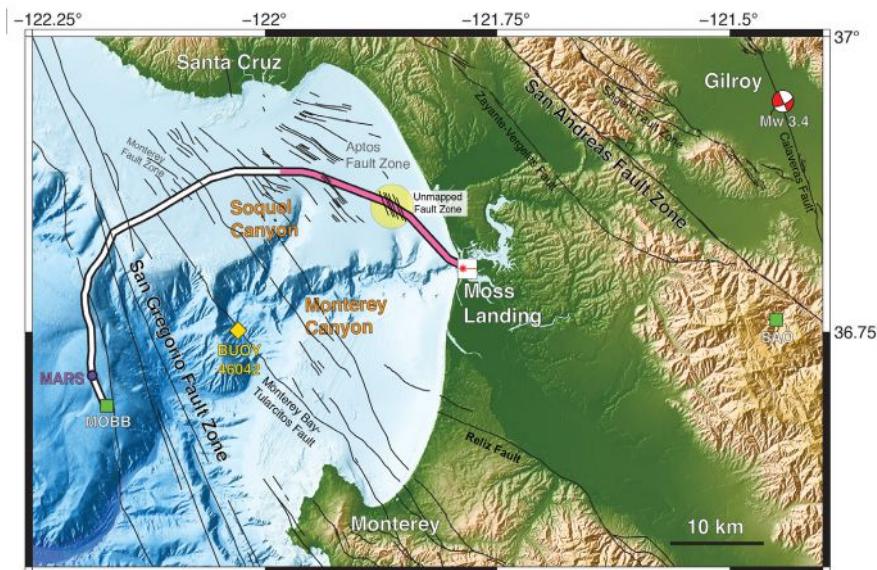
The SR-Surveyor M1.8 simplifies hydrographic survey in shallow and hard-to-navigate waters.

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ASVs for hydrographic survey and marine operations



SEAFLOOR CABLE USED TO DETECT EARTHQUAKES, FAULTS, AND STORM WAVES



Map shows the MARS observatory cable in Monterey Bay. The section of the cable shown in red was used as a high-definition seismic array to study faults underneath the seafloor. The red and white circle in the upper right corner of the image marks the epicenter of the magnitude 3.5 earthquake that was detected during the experiment. A previously uncharted fault zone is shown inside the yellow circle. Image credit: Nate Lindsey/UC Berkeley.

In a paper appearing 29 November 2019 in the journal *Science*, researchers describe an experiment that turned the seafloor cable on MBARI's MARS ocean observatory into the equivalent of 10,000 seismic stations on the ocean floor. During a four-day experiment in Monterey Bay, the researchers recorded a 3.5 magnitude quake, detected storm waves and internal waves, and discovered a new fault zone.

The technique, which was initially tested using fiber-optic cables on land, could provide much-needed data on quakes that occur under the sea, where few seismic stations exist. Eventually the technique could be applied to seafloor telecommunications cables around the world, helping scientists learn about offshore earthquakes and geologic structures hidden deep beneath the ocean surface.

The study was a joint effort by researchers from MBARI, the University of California, Berkeley, Lawrence Berkeley National Laboratory (Berkeley Lab), and Rice University.

"There is a huge need for seafloor seismology," said Nate Lindsey, a UC Berkeley graduate student and lead author of the paper. "Any instrumentation you get out into the ocean, even if it is only for the first 50 kilometers from shore, will be very useful."

Lindsey and Jonathan Ajo-Franklin, a geophysics professor at Rice University in Houston and a faculty scientist at Berkeley Lab, led the experiment with the assistance of Craig Dawe, the manager of MBARI's MARS observatory in Monterey Bay.

The MARS (Monterey Accelerated Research System) observatory is like a giant underwater USB port, supplying electricity and a high-speed data connection to instruments on the deep seafloor just outside Monterey Bay. The observatory is connected to shore by a 52-kilometer-long (32-mile-long) seafloor cable.

The experiment, described in the recent *Science* paper, was conducted over four days

in March 2018, when the observatory was off-line for maintenance. The researchers used just the first 20 kilometers (12.4 miles) of the cable for their test.

Photonic Seismology

The researchers used a new technology called Distributed Acoustic Sensing, sending ultrashort pulses of laser light down the cable and timing millions of tiny reflections (backscatter) from different parts of the cable. This allowed them to measure infinitesimal changes in the length of each two-meter (six-foot) section of cable. In effect, they turned the 20-kilometer length of cable into 10,000 individual motion sensors.

"These systems are sensitive to changes of nanometers to hundreds of picometers for every meter of cable," Ajo-Franklin said. "That is a one-part-in-a-billion change."

Changes in the length of the cable can be caused by many different things, including

ocean waves, seafloor currents, and earthquakes.

"The beauty of fiber-optic seismology is that you can use existing telecommunications cables without having to put out 10,000 seismometers," Lindsey said. "You just walk out to the site and connect the instrument to the end of the fiber."

During the underwater test, they were able to measure seismic waves from a magnitude 3.4 earthquake that occurred 45 kilometers (28 miles) inland near Gilroy, California. They also mapped several submarine fault zones in Monterey Bay, including one that was previously unknown. They were also able to detect ocean waves both at and beneath the sea surface.

According to Lindsey, there is rising interest among seismologists to record Earth's ambient noise field, which is caused in part by interactions between the ocean and the land—waves sloshing around near coastlines.

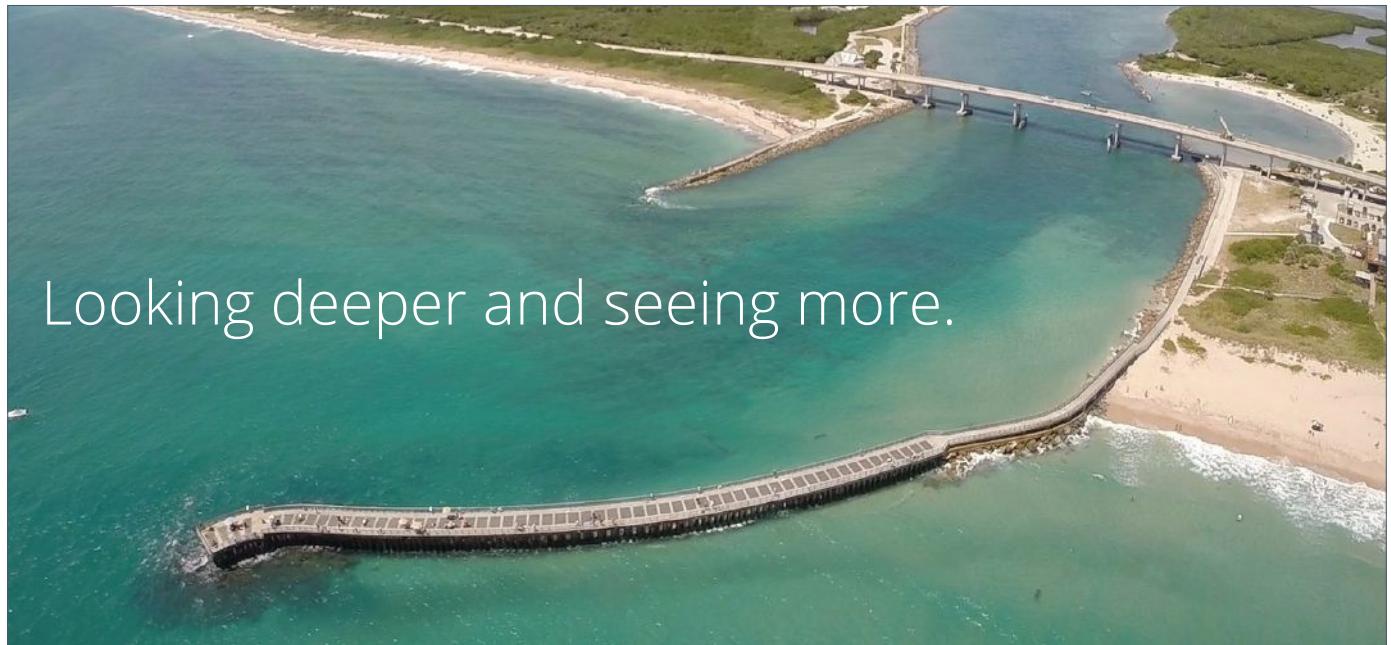
The tests so far have all used cables that are "dark," meaning they are not actively carrying data. To make use of the world's active fiber-optic cables, Lindsey and Ajo-Franklin need to show that they can ping laser pulses through one channel in a fiber without interfering with other channels that carry independent data packets. The researchers are currently conducting experiments with such "lit" fibers, while also planning fiber-optic monitoring of seismic events in a geothermal area south of Southern California's Salton Sea.



» The "main science node" of the Monterey Accelerated Research System (MARS) ocean observatory in Monterey Bay, California. On the left side of the image is the main cable connecting the observatory to shore. Part of this cable was used for the "dark fiber" experiment. Photo credit: MBARI.

Reference:

Lindsey, N.J., Dawe, T.C., Ajo-Franklin, J.B. (2019). Illuminating seafloor faults and ocean dynamics with dark fiber distributed acoustic sensing. *Science*, 366, 6469, 1103-1107, DOI: 10.1126/science.aay5881 (28 November 2019)

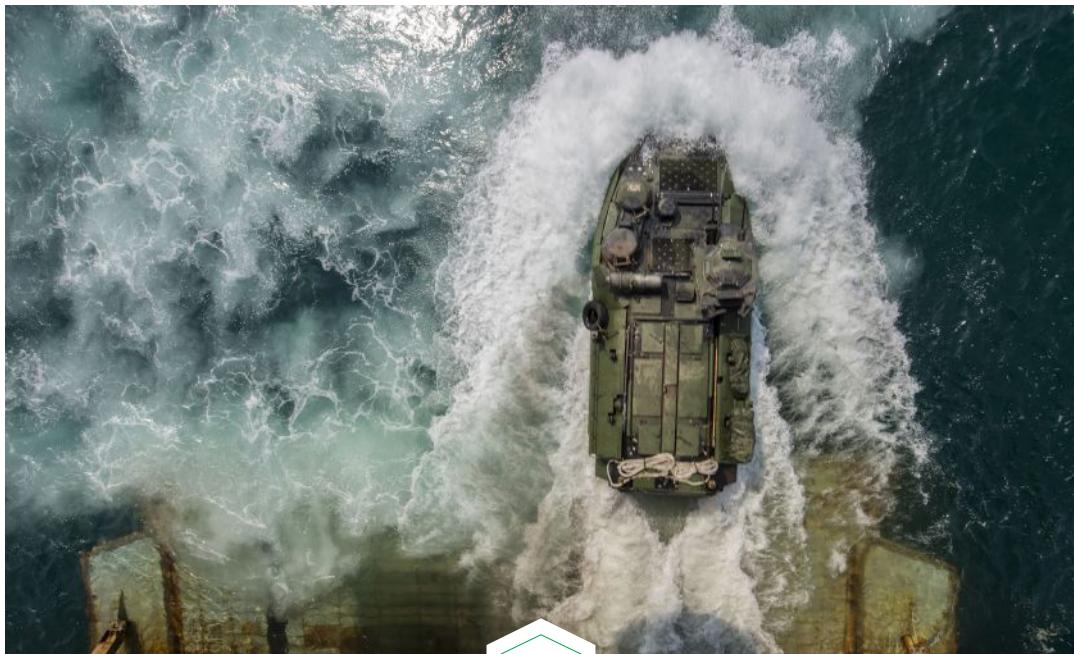


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THE NEXT STAND OF THE TIN CAN SAILORS: BUILDING A STAND-IN NAVAL FORCE

By Lt. Col. Roy Draa
via the Center for International Maritime Security (CIMSEC)



» Marines aboard an amphibious assault vehicle depart the well deck of the amphibious assault ship USS Bataan (LHD 5) in 2014. Photo credit: Mass Communication Specialist 1st Class RJ Stratchko, U.S. Navy.

For almost two decades the United States Marine Corps has focused on a counterinsurgency fight through almost exclusively ground-based combat. While the Marine Corps has always met the demands of the nation, recent history has presented a challenge to its character as a naval service that requires a reinvigorated relationship with the U.S. Navy. The Commandant of the Marine Corps (CMC) and the Chief of Naval Operations have signaled to the Naval Service that force design will be conducted along complementary, parallel, and coordinated paths toward transforming into future naval expeditionary and fleet forces.¹

The Marine Corps, as a service, must be prepared to operate inside actively contested maritime and littoral spaces in support of fleet operations or wherever its role as the nation's naval expeditionary force-in-readiness takes it. In similar fashion, given its understandable reticence to risk capital ships, the Navy must be comfortable with and capable of operating with regional partners and projecting power within a given adversary's weapons engagement zone (WEZ) in a command and control degraded/denied environment. As stated in the Commandant's Planning Guidance (CPG), these "Stand-in" forces must be, "designed to generate technically disruptive,

tactical stand-in engagements that confront aggressor naval forces with an array of low signature, affordable and risk-worthy platforms and payloads."²

In his planning guidance, the CMC further states, "I will continue to advocate for the continued forward deployment of our forces globally to compete against the malign activities of China, Russia, Iran, and their proxies – with a prioritized focus on China's One Belt One Road initiative and Chinese malign activities in the East and South China Seas. *This is not intended to be a defense of the status quo as our forces currently forward deployed lack the requisite capabilities to deter our adversaries and persist in a contested space to facilitate sea denial.*"³

Additionally, the CMC has identified investment in large unmanned surface vessels, extra-large sub-surface vessels, and Expeditionary Advanced Bases (EABs) as critical in countering the local numerical superiority of adversaries in great power competition. While significant exercises and experimentation has been conducted by the Fleet Marine Force (FMF) to address peer threats in the high arctic and western Pacific, it must be understood that the Naval



» Marines aboard an amphibious assault vehicle approach the well deck of the amphibious assault ship USS Bataan (LHD 5). Photo credit: Mass Communication Specialist 1st Class RJ Stratchko, U.S. Navy

Service does not at present have the capabilities required to execute Expeditionary Advanced Base Operations (EABO) as envisioned. The Naval Service must take immediate steps to strengthen its forward posture in the littorals through stand-in forces.

The Naval Services must develop and train a naval expeditionary force that is tailored to support stand-in forces within the adversary's weapons engagement zone. A near-term approach doesn't necessarily entail a departure from the three-ship Amphibious Ready Group (ARG) and associated Marine Expeditionary Unit (MEU). But new force packages that are better aligned with future missions and force structure will make for a more preferable interim solution. One solution is a set of stand-in force constructs that are complementary to current formations and fleet tactics – the Littoral Combat Team (LCT), the Littoral Combat Group (LCG), and Littoral Strike Squadron (LSS).

THE LITTORAL COMBAT TEAM

A naval expeditionary unit for stand-in forces would be comprised of multiple maneuver elements: embarked troops and their associated support, combatant vessels, and small craft. This is not intended as fully meeting the CMC and CNO's desired end state with respect to LOCE or EABO. Rather, it is a bridging solution as the Naval Service endeavors to move toward a modern fleet.

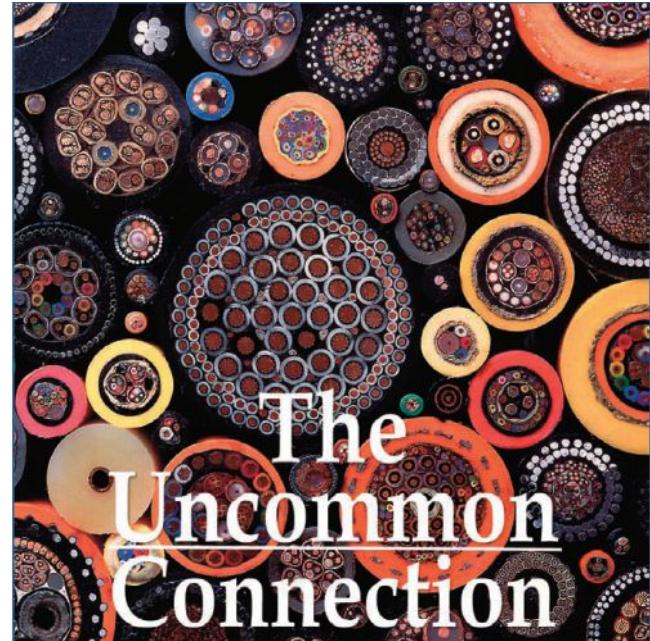
It must be understood that the Littoral Combat Team (LCT) is an integral part of this concept as a bridge to future EABO. The LCT consists of Marine and naval forces deployed to key maritime terrain throughout partnered nations' Economic Exclusion Zones (EEZ). These LCTs are essentially inshore weapons platforms and Forward Arming and Refueling Points (FARP). The LCTs perform the missions of Theater Security Cooperation (TSC), deterrence, and ultimately, disruption of adversary freedom of access to key maritime terrain. They are comprised of task-organized Marine forces, including electronic warfare, unmanned aviation systems, engineers and construction battalions, and missile batteries, to name a few.

Supported by host nation forces, the LCT would also lower the fleet's signature, distribute its networked combat power, and reduce the requirement for L-class shipping. They must be virtually self-sufficient, leveraging a small, but diversified logistics element capable of contracting and advanced manufacturing, drawing upon

pre-positioned stockpiles of all classes of supply and operating autonomous logistics resupply platforms. In their dual role as FARPs, LCTs extend the range and sortie generation of fleet rotary wing and unmanned aviation assets and their ability to penetrate an adversary's weapons engagement zone.

THE LITTORAL COMBAT GROUP

Given the fiscal constraints of building the additional amphibious ships required to support the creation of multiple ARGs in the Pacific, a Littoral Combat Group (LCG) may provide a similar capability. A heavy variant of an LCG could be comprised of an L-Class ship and an Expeditionary Sea Base (ESB) *Montford Point*-class ship, supported by a composite Littoral Strike Squadron comprised of Littoral Combat Ships (LCS). These ships would embark the aforementioned littoral combat teams and their associated equipment sets. Augmenting these ships as UAS launch/recovery platforms could be Cyclone Class patrol craft and Small Water Plane Area Twin Hull (SWATH) vessels (i.e. FSF-1), and support vessels/small craft, such as Navajo-class salvage ships, Mark VI patrol boats and Landing Craft, Utility (LCU) to aid in mobility/counter-mobility.



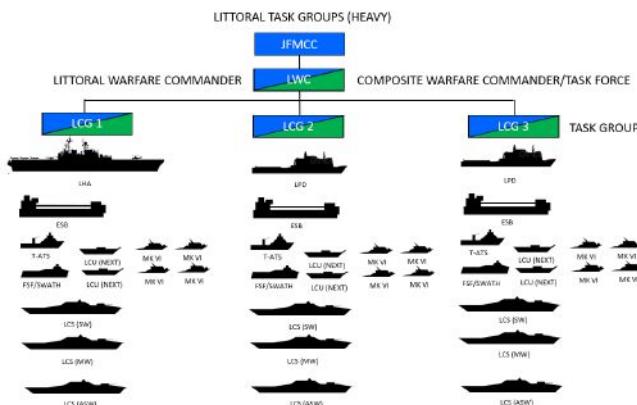
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» Heavy variant of a littoral task group

The purpose of these ships would be to distribute warfighting capabilities throughout the stand-in force's area of operations, with their lighter drafts permitting in-shore mobility. Lighter options for LCGs would drop the L-Class vessels, relying on an ESB, four LCS (performing various composite warfare functions) and multiple smaller support/ inshore vessels (FSF/SWATH, T-ATS, LCU x2, Mark VI x4). The LCGs would, in turn, be supported by the ARG and carrier groups operating from outside the adversary's WEZ. Survivability of these vessels within the WEZ is dependent upon coordinated efforts between the stand-in forces warfare commanders.

THE LITTORAL STRIKE SQUADRON

Current organizational tables for the Navy are heavily reliant upon the capital ships of the Expeditionary Strike Groups and Carrier Strike Groups to provide for the defense of the Amphibious Task Force and fleet, as well as strike missions in support of fleet action. The much-maligned LCS may be an answer to the rational hesitancy to risk cruisers within an adversary's WEZ. While all naval vessels and small craft must be armed for close-in defense, (not to mention some limited offensive capability) they will still require surface and subsurface combatants to act in the role of picket ships. This Littoral Strike Squadron could be optimized with an embarked

Marine Air Defense Integration System (MADIS), MAGTF Unmanned Expeditionary (MUX) UAS, and Extended Range Active Missile (ERAM) or Mine Warfare (MW) modules.

The LCS fits the role of power projection and LCG defense without the cost and risk that comes with building and employment of guided missile cruisers and destroyers. Common Unmanned Surface Vessels (CUSV), the Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV), and Orca Unmanned Undersea Vessels (UUV), coupled with the MQ-8B Fire Scout would support LCS MW and Anti-Submarine Warfare (ASW) missions, respectively. By operating with a diversity of unmanned platforms and electronic warfare systems, this force "erodes an adversary's advantage by complicating their surveillance and targeting."⁴

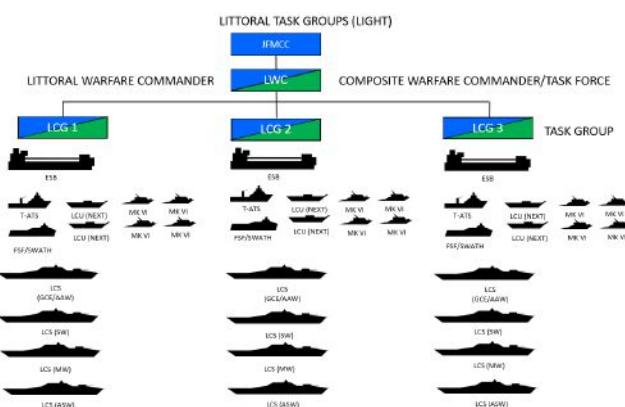
A cursory glance at the U.S. Navy's list of ships and small craft reveals a shortfall in capacity and capability to support the formation of stand-in naval forces. Investment in a Heavy LCG is not insignificant, requiring multiple ship types. Given the Navy's shipbuilding program focus on carriers, DDGs, and SSNs, building toward these new force packages is not a likely course of action. Light LCGs, relying on ESBs, LCSs, and smaller support vessels and craft would undoubtedly be a more economical bridging option. Additionally, employment of the U.S. Coast Guard's (USCG) Long Range Interceptor (LRI) 11 and Legend-class Cutter WMSL-758 in RIMPAC and PACIFIC BLITZ exercises demonstrated those platforms' and crews' relevance in littoral operations. The LRI-11 and WMSL-758 should be considered for future acquisition by the U.S. Navy and (more importantly) as a USCG detachment within the LCG, given the utility of the vessel's hull form and the capability the USCG brings with respect to TSC, maritime policing, and low-intensity conflict.

A final question that confronts the Naval Service is who should invest and man small craft and connectors in support of stand-in naval forces. Traditionally, with the exception of the now-deactivated Marine Small Craft Companies and 31st MEU's boat company, the Marine Corps has deferred to the Navy in the programming for and operation of small craft. Given the reliance of the LCTs on small craft for logistics and maneuver, the Naval Service would do well to revisit this situation to determine where efficiencies are to be gained (i.e. Royal Dutch Marine crews' manning of surface connectors).

CONCLUSION

The Navy has been in this existential fight before in these very same seas. "Tin Can Sailors" have disrupted a more powerful fleet due to the training and leadership of its crews, as well as the enemy's uncertainty as to what sort of naval force they were facing. The LCG, with that in mind, is a purpose-built Tin Can Navy; an interim solution until such time as a more operationally effective fleet is fiscally possible. It gives the Fleet a forward presence in times of peace and leading up to conflict; the ability to be present and to compete within a contested maritime environment.

As with any well-intentioned concept, additional discussion must be fostered to address the potentially costly training and sustainment of new force packages and force structure. Furthermore, significant analysis remains to wargame potential PRC operational and strategic



» Light variant of a littoral task group

reactions to coalition efforts, lest we overlook requirements to address likely adversary responses to this force design and employment concept.

About the Author: Lt. Col. Roy Draa is a career infantry officer with 19 years of active duty service in the United States Marine Corps. He is currently stationed at Quantico Marine Corps Base with Training and Education Command (TECOM). He is a charter member of the TECOM Warfighting Society, the Commanding General's working group that explores and evaluates future warfare concepts, applications in maneuver warfare and mission command in improving professional military education. These are presented in a personal capacity and do not necessarily reflect the views of the U.S. government.

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



» 190913-N-YI115-3096 PACIFIC OCEAN (Sept. 13, 2019) The Independence-variant littoral combat ship USS Gabrielle Giffords (LCS 10) transits the Pacific Ocean. Gabrielle Giffords is on a rotational deployment to Southeast Asia and is the fifth littoral combat ship to deploy to the region. Fast, agile and networked surface combatants, LCS are optimized for operating in near-shore environments. Photo credit: Mass Communication Specialist 3rd Class Josiah Kunkle, U.S. Navy.

References

- [1] Joint Memorandum: Integrated Naval Force Structure Assessment, 6 Sep 19
- [2] 38th Commandant's Planning Guidance, 17 Jul 19
- [3] *ibid.*
- [4] Surface Force Strategy: Return to Sea Control, 2018.



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ATLANTIC WIND TRANSFERS SIGN U.S. OFFSHORE WIND VESSEL DEAL



U.S. offshore wind farm support company Atlantic Wind Transfers has signed a multi-million-dollar, market-first order for two state-of-the-art Chartwell 24 Crew Transfer Vessels (CTVs), developed by Chartwell Marine. The vessels, to be deployed in support of new wind farms off the East Coast, will be built by Blount Boats for delivery in 2020.

Meeting the demands of U.S. offshore wind developers and asset owners requires domestic supply chain firms to capitalize on existing technology, lessons learnt and best practice, while responding to the unique requirements of operating in American waters.

Atlantic Wind Transfers meets these challenges with the Chartwell 24. Chartwell Marine has taken end user considerations into account to provide a CTV with advancements gained from operation in the European market, but tailored for the U.S. The new vessels will be a specialized model of the Chartwell 24, modified to comply with American environmental regulations and operational conditions. In particular, the vessels will be compliant with legislation protecting the migration route of the protected Right Whale off the

north-eastern seaboard, with a specially adapted 65-foot hull. This hull has been further adapted to handle the Atlantic sea conditions, mandating the highest standards in design and construction.

These modifications have been introduced without compromising the proven attributes that make the Chartwell 24 one of the safest and most capable vessel designs in the offshore wind market – including a hull configuration that minimizes 'wet deck slamming', a large, step-free foredeck and superior transit performance.

Andy Page, Managing Director of Chartwell Marine, added: "Based on our knowledge of the conditions off the coast of New England, we made modifications to our design to ensure optimal performance. Compliance with maritime regulations is only second to the safety of personnel, so we have ensured that Atlantic Wind Transfers and its clients will benefit from a vessel that ticks all of these boxes, while attaining the highest possible standards of safety and technical availability."

Charles Donadio, CEO of Atlantic Wind Transfers, said: "Our Crew Transfer Vessel company was the first to support offshore

wind here in Rhode Island, with the first and only CTV currently operating in the United States. This is another major milestone for us as we expand our operation and aim to support the local supply chain along the East Coast of the United States."

Blount Boats built the first ever U.S. flagged Crew Transfer Vessel for Atlantic Wind Transfers in 2015 – *Atlantic Pioneer* – which was commissioned to service the first U.S. offshore wind farm off Block Island, Rhode Island. The central location of the Blount Boats shipyard in Warren, Rhode Island, makes them optimally placed to supply CTVs to companies like Atlantic Wind Transfers.

Marcia Blount, President and Chief Financial Officer of Blount Boats, concluded: "As the offshore market grows, so too does the demand for American-made CTVs. Building vessels to Chartwell's proven design enables us to couple European design expertise with American engineering and support the domestic supply chain as it goes from strength to strength."

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WÄRTSILÄ SOLUTIONS

MAKING NEW STATE-OF-THE-ART VESSELS SUPER-EFFICIENT

Wärtsilä has been selected to supply a comprehensive package of solutions for two new state-of-the-art vessels being built for the Netherlands-based shipping company Spliethoff. The ships are under construction at the Fujian Mawei Shipbuilding yard in China.

The design of the two DP2-B-type ships combines the intake of a multi-purpose vessel with Dynamic Positioning station-keeping ability, thus making them ideal for supplying cargo to offshore installations. The versatile characteristics give the ships a unique position on the market. The design parameters specified high fuel efficiency and a minimal environmental footprint, and the contract with Wärtsilä was based on these requirements.

The full scope for each vessel includes a Wärtsilä 32 main engine, four Wärtsilä 20 engine generator sets, selective catalytic reduction (SCR) systems for all the engines to abate their nitrogen oxide (NOx) emissions, four transverse and two retractable thrusters, and a controllable pitch propeller (CPP). Wärtsilä will also supply its Pro-Touch propulsion control system to enable user-friendly control in both free-sailing and dynamic positioning operations.

The ships will comply with the IMO's Tier III regulations.

"Having single-source supplier capabilities allows us to deliver fully integrated solutions that create real value for the owner. Such is the case with this order, added to which we have been able to utilize our experience and in-house know-how by partnering in the concept design," says Luuk Hijkema, Account Manager, Wärtsilä Marine.

The Wärtsilä equipment for these two 141 meters long vessels is scheduled to be delivered to the yard commencing in Q3 2020.



» Wärtsilä will supply a comprehensive package of solutions for two new state-of-the-art DP2 B-Type vessels being built for the Netherlands-based shipping company Spliethoff. Image courtesy of Spliethoff.

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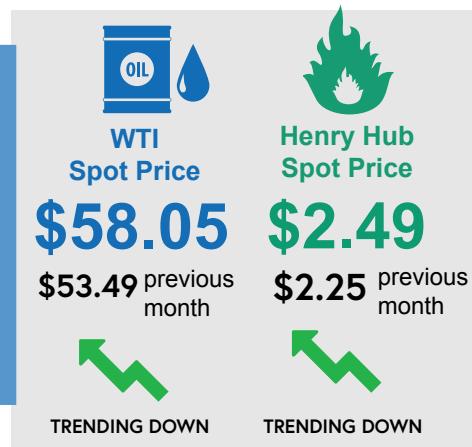
CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF NOVEMBER 29, 2019

Oil prices again saw significant gains in the past month, closing at \$58.05 per barrel on the WTI Spot Prices at the close of November. This is up from \$53.49 per barrel in the previous month. Since the beginning of June 2019, the WTI has been largely steady, rarely exceeding \$58 per barrel or dropping below \$53 per barrel. The International Energy Agency (IEA) continues to report high supply in the market as a result of slowing economic growth, especially in China. There is optimism, however, that the December OPEC meeting will result in production cuts, with IEA chief Fatih Birol

calling upon OPEC to "make the right decision for the global economy."

The Henry Hub natural gas spot price increased significantly in early November, surpassing the \$2.80-mark before dropping back to \$2.49 per million BTU at the end of the month. High levels of supply have been reported as the main contributor to the low prices. Forecasts of a relatively warm December for the US also are keeping prices low, according to Yahoo Finance.



KEY EQUITY Indexes

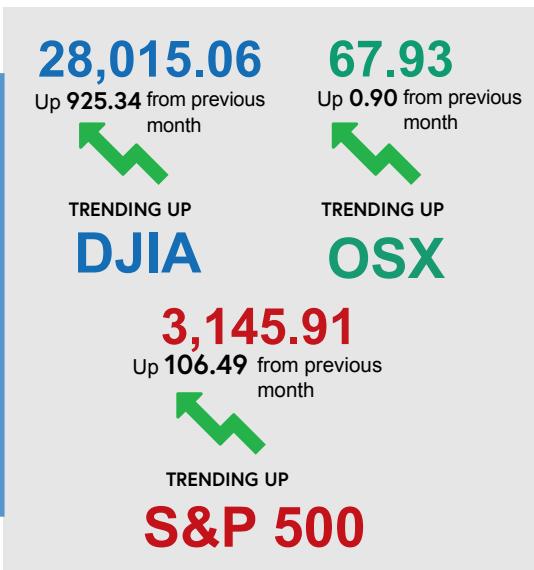
PRICES IN US DOLLARS AS OF DECEMBER 2, 2019

EQUITY INDEXES CONTINUED to show volatility in the past month

Equity indexes continued their steady upward movement in the past month, with the Dow Jones Industrial Average and S&P 500 reaching record territories. The Dow Jones gained nearly 1,000 points during the month to move above the 28,000-point mark, while the S&P 500 gained nearly 100 points and surpassed the 3,100-point mark. The upward movement was largely attributed to continuing US-China trade talks as the markets hope that these talks will end the current trade war between the two countries.

The Philadelphia Oil Services Index (OSX) rose modestly in the past month. The OSX neared the 70-point mark at its close on November 25 before dropping back slightly. It has spent most of the last two months in the 60s. This is still well down from the April high when the OSX briefly surpassed the 100-point mark.

SELECTED EQUITY INDEXES





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SORTING OUT THE PRESSURES INFLUENCING COMMODITY PRICES FOR 2020

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

CRUDE OIL:

As this is written, OPEC and its fellow traveler Russia are jockeying over whether the world will have less oil available from this group early next year, or not. The group's current output agreement has the group lowering its output by 1.2 million barrels per day through March 31, 2020, below what it could fully produce. Entering the final day of the OPEC meeting in Vienna, the focus was on a 500,000 b/d cut for the first quarter of 2020, the end date for the current agreement. The deeper output reduction will have little impact on world oil supply, as the OPEC+ group is already below its agreed supply. The issue is that some members, Saudi Arabia in particular, have shouldered a larger share of the output cut, which has enabled other producers to cheat on their quotas. Getting everyone to comply with the new cut will become the battleground. Unless the cut is extended farther into 2020, the market will fear a supply glut developing in the second quarter, which is the weakest demand period of the year. That will not be good for oil prices.

The media is reporting that to secure the support of Russia, OPEC had to agree to exclude condensate from Russia's quota. This has been a fast-growing component of Russia's oil exports, something the government is pushing aggressively in order to boost its economy and generate revenues for the government.

The troubling issue for OPEC+ is that U.S. oil production continues to grow. While U.S. E&P companies are being pressured to demonstrate capital discipline in their drilling spending, the slowing of U.S. oil output is only now beginning to be observed. If the OPEC+ agreement lifts global oil prices, will U.S. E&P companies

adhere to their capital discipline in 2020? If they don't, look for U.S. output to resume growing, and oil prices coming under downward pressure.

The physical reality of the global oil market is that increasing the magnitude of production cut for OPEC+ reinforces the view that the world has plenty of supply. This is despite geopolitical tensions, the collapse of Venezuelan output, and the redlining of Iran's supply. More offshore oil supply is arriving and U.S. shale production growth is only slowing. Unless global economic activity revives, a cosmetic increase in the OPEC+ output cut may not prevent oil prices from falling. Levitating oil prices are at risk of dropping if OPEC doesn't truly cut its supply.

NATURAL GAS:

Predictions of early cold weather for November, and then again for early December, lifted natural gas futures prices. Temperatures turned out not to be as cold as predicted. They were followed by more mild weather. The result was that gas prices dropped. During this period, gas storage grew as production continued increasing. Storage grew at the same time liquefied natural gas shipments increased.

This year's storage injection season, which extends from April to October, experienced the second largest increase in the past five years. The 2,569 billion cubic foot storage build was second only to the 2014 increase of 2,727 Bcf. This took gas storage from nearly the bottom of the 5-year average volume to the 5-year average. With the market less concerned about adequate gas for the balance of winter, gas prices have moved lower.

When we examine natural gas prices in 2018 and 2019 compared to gas storage volumes, one sees an inverse relationship in the second half 2019, while there was mostly a parallel relationship last year. The surge in storage recently has convinced gas traders that supply growth is unstoppable, meaning prices do not need to rise to encourage greater gas supplies.

This year has been challenging for natural gas. Gas prices are the lowest they have been in over a decade. In fact, prices are now where they were in the late 1990s. The reason for the low gas prices is that gas supply has overwhelmed demand even though it has grown with the assistance of increased pipeline exports to Mexico and the emergence of LNG exports. As we show, gross gas withdrawals from wells, which includes both all marketable gas plus gas used in well operations, has climbed steadily since 2008 when the gas shale business took off. What is impressive was the jump in gas production in 2018, which continued to increase this year, driven by associated gas from shale oil wells.

When new gas pipelines begin operating, some of this associated gas will be shipped to consumers rather than being flared. The prospect for greater gas supply puts gas prices at risk, virtually regardless of what winter weather and additional LNG exports do. Cheap natural gas will continue to gain market share in the power generation market as it undercuts coal prices. The problem is that electricity demand is growing very slowly, not offering a great outlet for the additional gas supply.

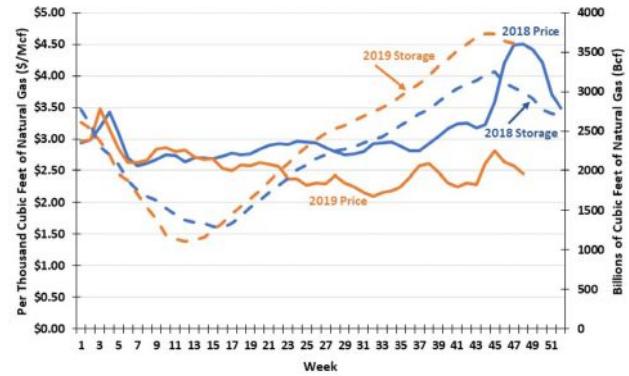
Geopolitical
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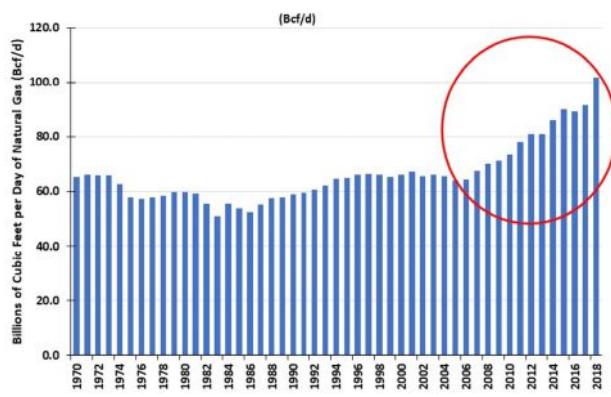
Natural Gas Prices
Struggle To Prevent
1990s Repeat



Natural Gas Prices:
2018 vs. 2019 YTD



Natural Gas Gross
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www.blueinnovationsymposium.com

PTC

Honolulu, HI » January 19-22

www.ptc.org/ptc20

SubSea Cables

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www.offshorewindus.org/criticalconnection

Offshore Wind Executive Summit

Galveston, TX » February 4

www.offshorewindsummit.com

Underwater Intervention

New Orleans, LA » February 4-6

www.underwaterintervention.com

Subsea Tieback

San Antonio, TX » February 18-20

www.subseatiabckforum.com

Canadian Hydrographic Conference

Quebec City, Canada » February 24-27

www.chc2020.org

CABSEC/SAMSEC

Cartagena de Indias, Colombia

» March 24-26

www.defenceiq.com/events-cabsec

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Houston, TX » March 31 – April 1

www.decomworld.com/gom

IPF

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www.offshorewindus.org/2020ipf

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2020.otcnet.org

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www.defenceiq.com/events-surfacewarships

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www.tekna.no/en/events/seabed-mapping-and-survey-38497/

Oceanology International

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www.emc-cyprus.com

Deep Sea Mining Summit

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www.apmaritime.com

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www.2020.otcasia.org

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Singapore » April 6-9

www.singapore20.oceansconference.org

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Dubai » September 8-9

www.terrapinn.com/conference/telecoms-world-middle-east

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www.terrapinn.com/conference/submarine-networks-world

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JULY		
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WORLD'S FIRST INVESTMENT FUND TO PREVENTING OCEAN PLASTIC IN ASIA

A USD 106 million (SGD 144 million) fund dedicated to preventing plastic from entering the Asian oceans was launched on 4 December 2019. The Circulate Capital Ocean Fund (CCOF) is the world's first investment fund dedicated to address Asia's plastic crisis. The Singapore-based fund is also one of the ten largest ASEAN-based Venture Capital Funds in the market.

With 60% of ocean plastic originating from the region, Asia is the biggest source of plastic leakage into global oceans. A recent Ocean Conservancy Report identified a net financing gap between USD 28 and USD 40 per ton for plastic waste collection in the five top ocean polluting countries in the world—China, Indonesia, Philippines, Thailand and Vietnam.

CCOF is launched by Circulate Capital, a Singapore-based and MAS licensed venture capital fund management company with founding investors and partners among the world's leading companies; PepsiCo (the first investor), Procter & Gamble, Dow, Danone, Unilever, The Coca-Cola Company, and Chevron Phillips Chemical Company LLC. To address the gap between available private capital and resources needed by Asia's waste sector, CCOF will provide both debt and equity financing to

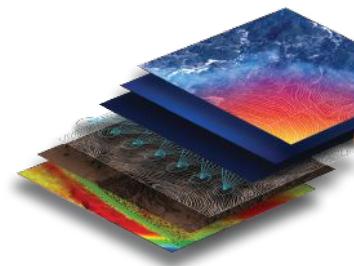


waste management, recycling, and circular economy start-ups and SMEs in South and Southeast Asia focused on preventing plastic pollution. Circulate Capital has identified more than 200 investment potential opportunities in the region.

Circulate Capital has partnered with nonprofit organizations, including Ocean Conservancy, Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), and The Circulate Initiative (TCI), a nonprofit organization launched in October 2019 dedicated to ending ocean plastic pollution and building thriving, inclusive economies.

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VALEPORT AWARDED CYBER ESSENTIALS PLUS CERTIFICATION

Valeport has been awarded Cyber Essentials Plus certification, the more rigorous level of accreditation in the Government backed scheme that helps organizations protect against a range of the most common cyber attacks. The certification provides reassurance to Valeport's customers that the company treats the threat of cyber crime, and the protection of their personal information, with all seriousness.

Cyber Essentials provides a set of security processes and policies to adhere to, while the Cyber Essentials Plus programme includes a penetration test at least every year to assess the vulnerability of the company's data. The verification of Valeport's cyber security is carried out independently by a Certification Body.

Peter Adams, head of IT for Valeport, commented: "Obtaining Cyber Essentials Plus involved completing an online assessment followed by a technical audit of the systems that were in-scope for Cyber Essentials Plus. This included a representative set of user devices, all internet gateways and all servers with services accessible to unauthenticated internet users. This comprehensive process has taken many months and the checks and tests we

undertook will become part of our ongoing practices to maintain this rigorous accreditation."

Research by IoD has demonstrated that UK businesses are collectively attacked more than seven million times a year, that on average it takes 120 days for a business to know that its data has been compromised, and that Cybercrime accounted for almost 30% of all crimes recorded in the UK from July 2016 to July 2017.

For more information, visit www.cyberstreetwise.com/cyberessentials.





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DESIGN & ENGINEERING**HYDRO LEDUC NA, INC.**

19416 Park Row, Ste. 170
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Hydro Leduc is a specialist in the design and manufacture of hydraulic piston pumps, hydraulic motors, hydro pneumatic accumulators, and customized hydraulic components satisfying customer needs with reliable products from a reliable source. As the leader in micro hydraulics, it is feasible to obtain several tons of force from a minimal power source within a restricted space envelope. The techniques of micro hydraulics allow simple solutions to problems that are often beyond the limits of traditional mechanical options. Hydro Leduc's expertise is at your service in varied applications such as oil service tools, oceanographic instrumentation, aeronautics, and any extreme working condition of temperature, pressure, medium, and environment.

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Doubletree Court, Cavendish St.
Ulverston, Cumbria
LA127AD
E-mail: john@digitaledgesubsea.com
Website: www.digitaledgesubsea.com
Contact: John Benson



DIGITAL EDGE SUBSEA

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

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

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

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Website: www.atlinc.com
Contact: David Dack



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

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NAVIGATION & POSITIONING SYSTEMS

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E-mail: sales@evologics.de
Website: www.evologics.de



EvoLogics provides the world's most advanced spread-spectrum underwater communication systems (S2C) with multi-channel data management, networking capability, built-in tracking and positioning functions with USBL. Data loggers, acoustic wake-up module and releasers optionally included. Deployments in offshore platforms (FPSO, ABS), environmental monitoring, defense systems, ROV and AUV operations and more. Applications include simple positioning and sensor information to transmission of underwater photos.

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 E-mail: sales@rjeint.com
 Website: www.rjeint.com
 Contact: Bruce O'Bannon



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

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OCEANOGRAPHIC INSTRUMENTS/SERVICES

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- Manufacturer's Representative:** Teledyne RD Instruments, Deep Water Buoyancy, WERA Northern Radar.

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 Website: https://rbr-global.com/



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

ROMOR OCEAN SOLUTIONS

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 Contact: Darrin Verge, President & CEO



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

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 Fax: +1 425 643 9945
 E-mail: info@sea-birdscientific.com
 Website: www.sea-birdscientific.com
 Contact: Calvin Lwin, Sales



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 Contact: Baldur Sigurgeirsson



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

SONAR SYSTEMS

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

EDGETECH

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E-mail: info@edgetech.com
Website: www.edgetech.com
Contact: Amy LaRose



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

KLEIN MARINE SYSTEMS, INC.

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International: 603 893 6131
E-mail: sales@kleinmarinesystems.com
Website: www.kleinmarinesystems.com



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

MARINE SONIC TECHNOLOGY

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Toll Free: +1 800 447 4804
E-mail: Regan.Lipinski@na-atlas.com
Website: www.marinesonic.com



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

SOUND VELOCITY PROBES/CTDS**SAIV A/S**

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SUBSEA FABRICATION**NEW INDUSTRIES**

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Contact: Bill New



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

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Safe and reliable Li-ion subsea batteries made in Germany for subsea oil & gas applications, measurement systems and vehicles (AUV/ROV). Marine measurement and monitoring technologies, such as high precision pCO₂ gas analyzer and autonomous underway systems (FerryBox). SubCtech provides customized solutions to high industrial standards such as IPC-A-6xx class 3 and qualifications according to MIL-STD, ISO 13628-6 and API 17f.

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

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KONGSBERG

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

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Contact: Adam Mara



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

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

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

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- Communications and real-time control system

L3 OCEANSERVER, INC.

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Tel: +1 508 678 0550
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E-mail: sales@ocean-server.com
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L3 OceanServer, Inc. is one of the leading manufacturers of unmanned underwater vehicles (UUVs) with over 300 units delivered to customers around the world.

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OUTLAND TECHNOLOGY

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Contact: Jeff Mayfield



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Contact: Jamie Carrig



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

TELEDYNE SEABOTIX

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Website: www.teledynemarine.com
Contact: Jamie Carrig



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

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With more than 3,700 ROVs in service around the world, VideoRay is the global leader in Observation ROV technology. VideoRay's underwater robot systems are extremely versatile, portable, affordable, and reliable solution for underwater operations including surveys, offshore inspections, search & recovery, homeland & port security, science & research, aquaculture, and many other underwater applications. The latest Mission Specialist systems provide solutions for particularly difficult underwater challenges. VideoRay is available on the General Services Administration (GSA) Schedule.

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

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