October 2019

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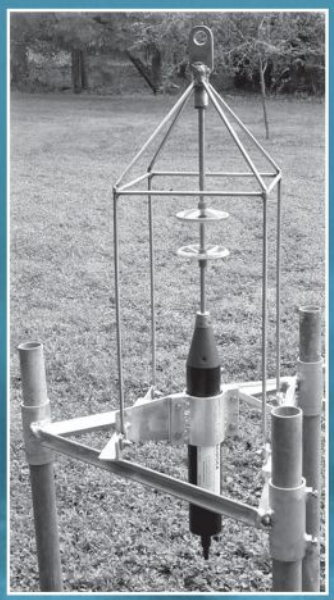
MAVS-5DL	✔	✔	✔	✔	✔	✔	6000 m. Logging
MAVS-5WTG	✔	✔	✔	✔	✔	✔	Directional Wave/Tide
★ MAVS-5-90DEG	✔	✔	✔	✔	✔	✔	90 Degree Bent Sensor
★ MAVS-5MMP	✔	✔	✔	✔	✔	✔	Moored Profiler MAVS



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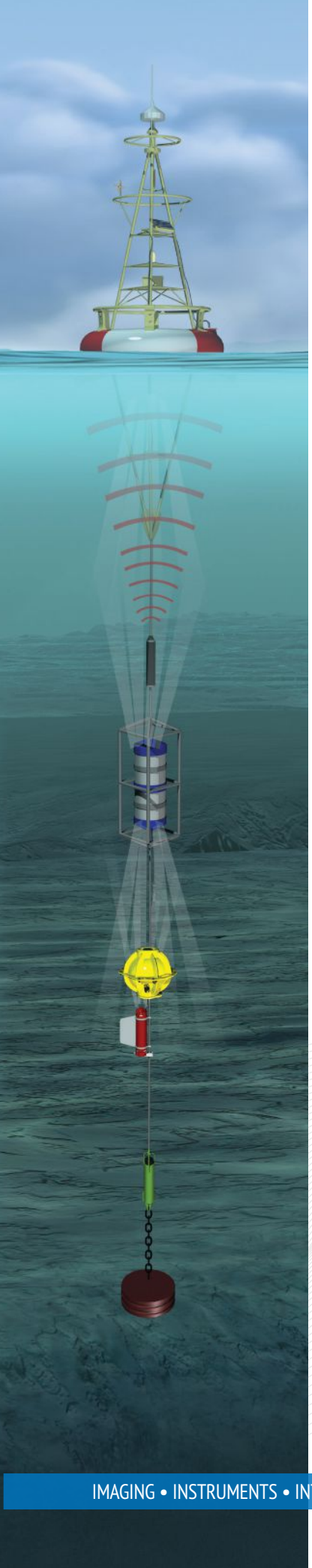

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Teledyne Benthos **Acoustic Modems** allow for real-time, wireless communications in shallow or deep water environments.

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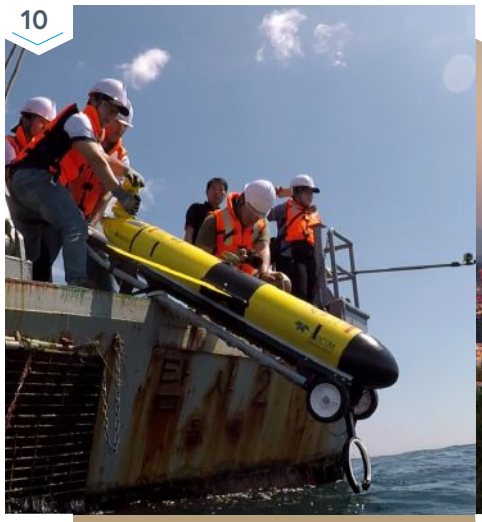

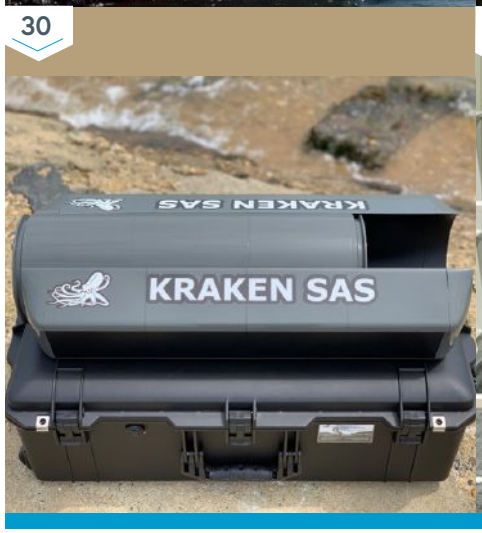

FEATURES

DEPARTMENTS

IN EVERY ISSUE

ON THE COVER:
The NOAA Office of Ocean Exploration and Research (OER)'s remotely operated vehicle, Deep Discoverer, being recovered during the Windows to the Deep 2019 expedition. Image courtesy of NOAA OER, Windows to the Deep 2019.

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GETTING THE MOST OUT OF OCEANS 2019

BY GREG LEATHERMAN,
Editor in Chief, ON&T

Each October, maritime professionals from around the globe attend the annual OCEANS Conference and Exhibition. This year, we are gathering in Seattle. I hope to see you there.

For the team at ON&T, OCEANS is a vital part of our business model. It provides in-person context for press releases and websites and helps keep us abreast of the field. Most importantly, it gives us an opportunity to meet with new contacts and long-standing friends. In fact, OCEANS is one of the best ways to connect with ON&T. Not only are print copies distributed via the publication bins, but we also occupy a stand (315) where we hope attendees will stop by to share their own latest news.

We know that navigating a conference that attracts so many of the top experts in your field can be daunting, so here are some tips that can help attendees get the most out of Oceans. We know you will walk the exhibition floor and listen to the keynote speakers. And we hope to see you at the Gala, as well. But what else can you do to enhance your OCEANS experience?

Become a Member: The Marine Technology Society (MTS) partners with the IEEE Oceanic Engineering Society (IEEE-OES) to present OCEANS. MTS offers members, education and networking; a peer-reviewed scientific journal; news and information; technical resources; and professional development through local sections and professionals committees. Joining MTS also puts you in contact with leaders who are shaping the debates that you care about. You even receive discounted pricing for events like OCEANS.

Join a Professional Committee: MTS Professional Committees bring together members with common interests and enhance a sense of community through events and activities, such as specialized conferences, workshops, technical sessions and special issues of the MTS Journal. You can learn more on the MTS website, but the bottom line is that if you are attending OCEANS, one of their thirty-three Committee options is bound to align with your goals.

Attend the Awards and Honors Program: Each year at OCEANS, MTS honors professionals, committees, regional sections, or student sections in one of 10 categories. They also bestow the prestigious MTS Fellow designation. ON&T participates in this event by presenting the Young Professional Award, but that's just one reason to attend, because the list of winners MTS has honored reads like a who's who of the marine technology sector.

Check out the Papers and Posters: OCEANS sessions include engaging and cutting-edge presentations (including workshops and tutorials), that are must-see events. The abstracts are reviewed by multiple members of the IEEE-Ocean Engineering Society (IEEE-OES) and MTS, so you know they are worth your time.

Don't Skip the Networking: This may seem obvious, but sometimes people only man their exhibition station, attend a session or two, and skip the rest of the conference. This is a lost opportunity. Grabbing a refreshment with a new contact should be part of your goals during the conference. Networking events including the pre-conference Icebreaker Reception, an Exhibitor's Reception, and the OCEANS Gala at the Museum of Pop Culture (MoPop). There will also be additional events for students and young professionals. And of course, I want to invite each of you to stop by the ON&T stand (315), to network with us!

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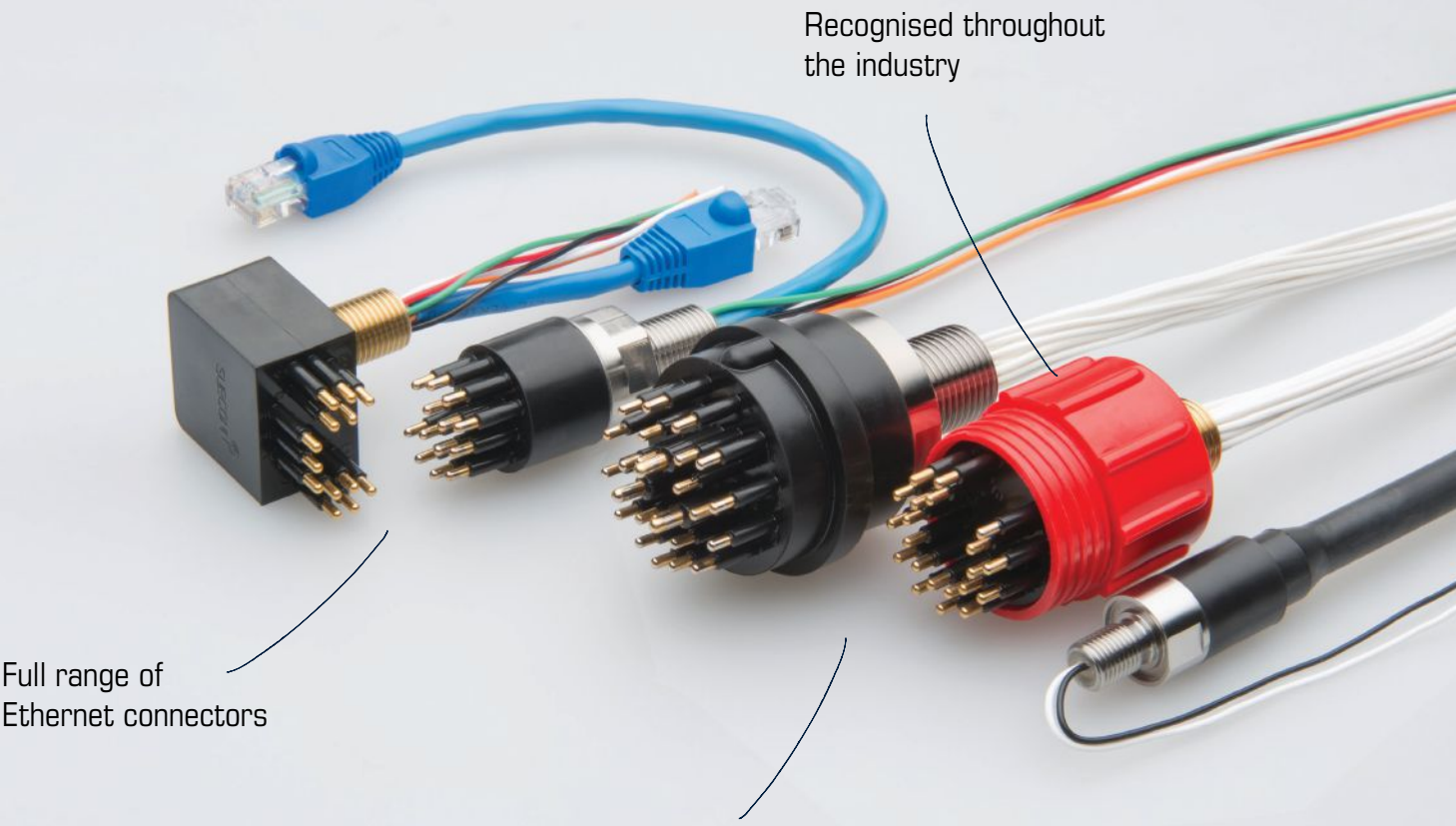

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THE TELEDYNE MARINE ADVANTAGE: A SEA OF SOLUTIONS FROM A SINGLE PROVIDER

Recently, ON&T sat down with representatives from Teledyne Marine to gain some insight into how the 23 branded companies that operate under the Teledyne Marine banner work together, as well as learning more about some recent product releases. What we heard sounded a lot like the way championship teams operate.

From the 1927 Yankees to the 2004 Red Sox, winning baseball teams have one thing in common; they assemble the right mix of talent, experience, and character. Of course, each player brings formidable abilities to the field, but there have been countless other teams that did not succeed, even with superstar talent on the roster. Why? Because it takes more than individual stars for a team to succeed. It takes teamwork, coordination, and skilled management to truly make a whole greater than the sum of its parts. It takes veterans who are willing to share knowledge with rookies, and specialists, like pinch-hitters and utilitymen, who can offer assistance on an as-needed basis.

Teledyne Marine understands this formula for success. Through acquisitions and collaboration, they have evolved into an industry powerhouse. For example, in 2005 they acquired RD Instruments, Inc., a leader in the design and manufacture of state-of-the-art acoustic Doppler instrumentation. According to Darryl Symonds, Marine Measurements Product Line Manager for Teledyne RDI, the combined, diverse expertise of the companies operating under the Teledyne Marine banner allows them to make informed, experience-based recommendations to clients.

> *"We have a lot of experience within the Teledyne Marine group. For any given application, we collectively represent hundreds of years of experience," said Darryl Symonds, who's been with RDI for 35 years.*

In fact, Symonds says, "The first-self-contained ADCPs that RDI sold were delivered in 1984. Within two years, they were accepted as the industry standard for accuracy, reliability, and field-proven data quality."

In those early days, RDI developed both shipboard and moored Acoustic Doppler Current Profilers (ADCPs). Moored ADCPs sample currents at many depths, replacing several single-point current meters and eliminating false shears stemming from compass and velocity calibration errors at different levels. It was a groundbreaking advancement.

"When those historical moorings would go out," adds Paul Devine of Teledyne Marine, "they would have a small number

» *RDI's ADCPs made quite a splash when first introduced; and the next-generation long-range Pinnacle ADCP from Teledyne Marine sets a new standard. Photo courtesy of Teledyne Marine.*

of single point current meters clamped to the wire—let's say 10—and now over the same range the ADCP provided them one hundred measurements. So, they provided 10 times more data, allowing users to see minor changes and abrupt shears in the current. If, for example, you were trying to study the upper mixed layer of the water column, maybe you had 2 or 3 current meters installed, but you didn't know exactly how thick that layer was. With an ADCP, since you can measure very high-resolution currents, you can see the edge in the bottom of the upper mixed layer and you know that it's 25 meters thick, due to the higher quality of the velocity data that the customer acquired."

As an example, RDI's narrow-band ADCPs were used in the World Ocean Circulation Experiment (WOCE), which ran from 1990 to 2002. The project aimed to establish the role of the world ocean in the Earth's climate system by measuring temperature, salinity and other tracer measurements along with direct velocity measurements with floats and moorings. The project resulted in the most comprehensive data set ever collected from the global ocean.

According to Symonds, RDI's ADCPs made a big impact on WOCE during the second half of the data collection.

"The ADCPs could measure a profile of currents," he says, "which meant that people could see important details they've never seen before. They were measuring from research vessels, from moorings, mostly in open oceans, but also in coastal areas."

EVERYWHERE YOU LOOK

These days, Teledyne Marine products are everywhere you look. But just as importantly, they can provide a comprehensive list of solutions for large complex projects.

For example, in the case of the Ocean Observatories Initiative (OOI) funded by the National Science Foundation, Teledyne Marine products are the backbone of a highly integrated system, which includes sensors and gliders, as well as infrastructure for underwater networks. More than 50 ADCPs and Doppler Velocity Logs (DVLs) from Teledyne RDI have been supplied to OOI. ADCPs equip each of the seven OOI nodes, in order to remotely measure ocean currents at many depths. At the four global sites, 75 kHz ADCPs measure long ranges in the deep sea. A similar number of higher frequency ADCPs are measuring currents at sites across the US continental shelf.

In addition to that, more than 60 gliders from Teledyne Webb Research also support OOI. They include both coastal and deep options. Coastal gliders dive and rise through the upper 200 m, whereas the deep variety reach to 1000 m. Installed on these Webb Research gliders are Teledyne RDI's Explorer ADCPs, which contribute to navigating and measuring water currents.

But that's not all. Working around the Pioneer Array off New England are a couple of AUVs. These also carry DVLs from Teledyne RDI. Underpinning OOI's network system are power, data, and communication capabilities, also supplied by Teledyne Marine. Data collected at the nodes can be stored at sea or transmitted in real-time to shore. These links contain connectors, cables, and fiber optic assembly solutions from Teledyne ODI.

Many of OOI's nodes also use deep-sea flotation in mooring lines. For these applications, Teledyne Benthos supplies evacuated glass spheres. At some sites, acoustic modems from Teledyne Benthos provide a key link in sending data ashore. Their acoustic messages are picked up by Teledyne Webb Research gliders that act as gateway

communication tools. In other coastal nodes, gliders routinely transit the region. They can deliver control data to the system.

And that's not the only example. China's Western Pacific Ocean System (WPOS) is studying ocean currents in this region at depths ranging from 400 to 6,000 meters depth. Six arrays, comprising 29 moorings, form the core of the effort. Each mooring includes Teledyne RDI's 75 kHz Long Ranger ADCP, as well as extra Workhorse ADCPs ranging from 150 to 600 kHz. Research cruises will complement the moorings. Teledyne RDI's 38 kHz shipboard ADCP will collect transects of deep profiles of ocean currents.

Another example is Teledyne Marine's support for real-time, moored deepwater current profiles around oil platforms. You see, within the Gulf of Mexico, the U.S. Bureau of Ocean Energy Management (BOEM) requires the collection of current profiles around deepwater oil platforms. For profiling currents from moorings in these deep waters, the Long Ranger ADCP from Teledyne RD Instruments is the established choice. The ADCPs collect data for at least one year. One operator devised a cost-effective approach to meet the reporting schedule. They opted for real-time wireless communication of the ADCP data. Acoustic telemetry modems from Teledyne Benthos were selected. These modems are uniquely addressable, which simplified communicating with two ADCPs. From each ADCP, one averaged velocity profile was sent every 20 minutes. The message comprised about 1200 bytes of data. Two moorings were deployed. The one on the seabed was deployed for two years, while, the mid-water mooring held an ADCP in a syntactic foam float and operated for a year.

The examples don't end there, but you get the point. Teledyne Marine's customers have single point access for all of their mooring instrumentation needs, saving time and money during the sourcing and procurement process, while providing them with the peace of mind that comes from working with the industry's leading experts in their fields.

EXPERIENCE MATTERS

The level of experience described above adds value for both new and existing Teledyne Marine customers, explains Symonds.

"Even if we don't have inside knowledge of a specific project at Teledyne RDI, we have access to other people within other Teledyne brands that do. We can bring that together to give a really informed message to a customer. For example, if your project requires a 3D-printed connector, which is outside of what RDI does, we can recommend who you should get it from to match your requirements, whether or not the solution comes from a Teledyne Marine company, because we want the best solution for your project, even if it comes from a competitor."

The pool of available resources that Symonds describes is vast. Worldwide, Teledyne Marine employs 1600 persons working in sales manufacturing and service centers around the globe for 23 branded companies. Some of these companies were around for decades before being acquired by Teledyne. Other Teledyne Marine companies are industry innovators with shorter, but still impressive histories. All of these experts work together to provide one-stop purchasing capability, world-wide customer support, and the technical expertise to solve the marine industries' toughest challenges.

TWO NEW STARS JOIN THE TELEDYNE MARINE PRODUCT LINE

This past spring, two Teledyne Marine companies released two impressive technology advancement.

Pinnacle 45

This past spring, Teledyne RD Instruments released its next-generation long-range Pinnacle ADCP —which builds upon the 20-year success of Teledyne Marine's industry standard Workhorse Long Ranger. Rated to a depth of 2000 m, the 45 kHz phased array Pinnacle ADCP delivers a 1000 m current profiling range with a decreased size and weight, a game-changing field-swappable

» *More than 60 gliders from Teledyne Webb Research support the Ocean Observatories Initiative (OOI). Installed on these gliders are Teledyne RDI's Explorer ADCPs. Photo courtesy of Teledyne Marine.*

» *The highly versatile Pinnacle 45 can be used for real-time applications, moving boat applications, or self-contained applications. Photo courtesy of Teledyne Marine.*

system configuration for real-time or self-contained applications, independent or interlaced long-range and high-resolution modes, as well as many other innovative new features and product enhancements.

The highly versatile Pinnacle 45 can be used for real-time applications, such as oil rig monitoring; moving boat applications, such as mid to deep water oceanographic studies; or self-contained applications, such as bottom-mounted, mid-column, or surface buoys used to collect long range, precision current profiling data.

"There are a few things we've done with regards to this hardware design," says Darryl Symonds, "that are in direct response to customer feedback. If you are doing a mooring, and you want to replace the batteries, you have to open up the instrument. But if you open up the instrument, you take a chance of pinching an O-ring or creating a leak path. The last thing a customer wants to do is have that happen, but if it does, they would like to have the instrument sustain as little damage as possible. So, starting with our last ADCP release, the Sentinel V, we made a compartment within the housing to separate the electronics from the battery compartment. That way, if a battery compartment floods, only the battery is lost. With the Pinnacle, we've just expanded that modular concept."

GNSS/NAV Upgrade for Acoustic Modems/Releases

Two weeks later, Teledyne Benthos announced the availability of a new GPS option for their feature-rich UTS-9000 series Universal Topside Unit, which is used to command their full line of acoustic modems and releases.

This new feature saves users valuable time and money by allowing them to survey in, and record, precisely where their acoustic releases and/or modems are deployed using only the topside unit and a dunking transducer. This allows for fast and easy detection and recovery using a minimal set of hardware.

The 2.0 upgrade, which includes an intuitive and flexible GUI, is fully self-contained, removing the need for an additional laptop, something particularly useful for deployments from RHIBs or smaller vessels. The real-time operation provides users with the ability to set destinations and waypoints, mark and record exact locations of deployed assets, and download field data to a USB card for safe and easy data storage and review. The upgrade also allows the system to take an "acoustic snapshot" of noise in the environment to help diagnose and overcome difficult deployment conditions.

A COORDINATED APPROACH TO RELIABILITY AND SERVICE

Teledyne Marine is committed to a coordinated approach to systems. To make this happen, Teledyne Marine's test plans are designed to demonstrate how an assemblage of Teledyne products operate as a system. The clear benefit is improved compatibility and reliability when compared to using multiple vendors.

Customers are also rewarded with a streamlined experience. Because Teledyne Marine companies operated under a common banner, customers can utilize a single point of contact, including a single point of origin for terms and conditions, warranties, and purchase orders—across multiple product brands.

Teledyne Marine's selection of mooring solutions include:

• Teledyne Benthos ACOUSTIC MODEMS allow for real-time, wireless communications in shallow or deep water environments.

• Teledyne RDI ACOUSTIC DOPPLER CURRENT PROFILERS (ADCPS) deliver highly accurate current data in up to 6000M of water.

• Teledyne Benthos GLASS HOUSINGS can house other instrumentation and/or relieve dangerous mooring strain.

• Teledyne Benthos ACOUSTIC RELEASES ensure that you get your mooring and critical data back.

And again, it bears repeating: Each of the companies of Teledyne Marine can tap into Teledyne-wide resources. In fact, individual field sales/business development teams and technical field teams from Teledyne Marine are trained to recognize applications where the expanded Teledyne Marine solutions set can add value to customers for bundled and integrated solutions. These field teams act as consultative technical sales resources and can bring subject matter experts (SME) into the conversation, or consult with them as needed behind the scenes.

"For example, Darryl at Teledyne RDI is an ADCP expert, while someone over at Teledyne Benthos is the release expert. I can get those people on the line with me and put the information into a digestible format for the client, or I can set up an advanced meeting with the client as needed," says Paul Devine, "so that someone putting together an observational program saves time and money by having a single point of contact."

"If a client has questions for a moored application, like how long they should deploy, how it should be moored, or which sensors they should have to collect the data they need, we'll have worked with a customer or one of our strategic partners that's done it before," says Darryl Symonds. "We can connect them to communicate, and the confidence level soars for the customer."

But that's not all. Teledyne Marine also leverages strategic partners, such as mooring designers and flotation providers, who share another layer of expertise.

In short, Teledyne Marine truly offers a sea of solutions from a single provider.

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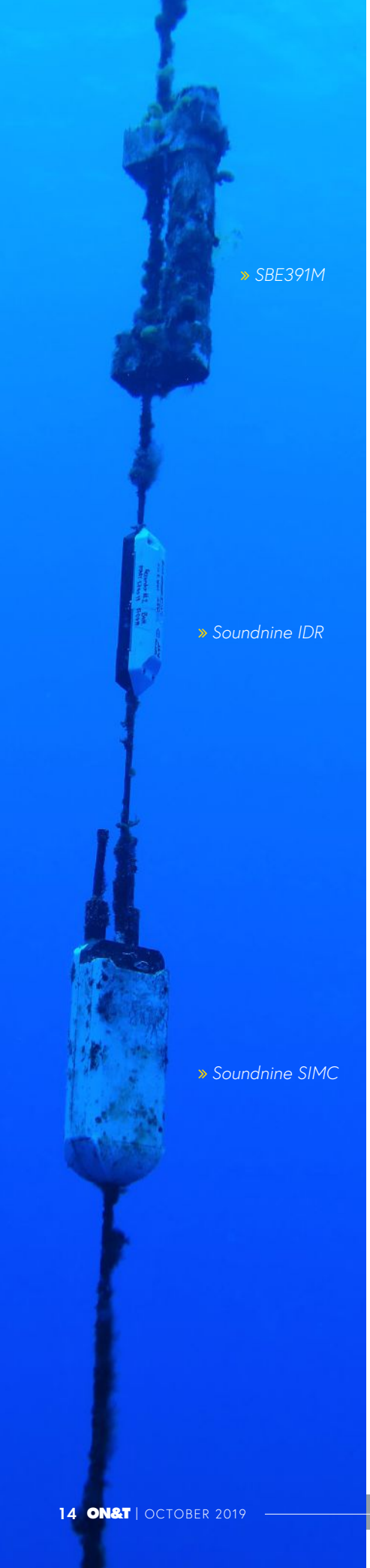

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INDUCTIVE TELEMETRY AND INNOVATIVE MOORING DESIGN ENABLES COST-EFFECTIVE CORAL REEF MONITORING SYSTEM

Researchers at the University of the Virgin Islands (UVI) have long studied mesophotic coral reefs and fish spawning aggregations at the shelf break of the Grammanik Bank south of St. Thomas. Fixed bottom temperature measurements collected since 2005 showed variability at semidiurnal to interannual scales impacting coral and fish populations. More information was needed to understand the vertical structure, sources, and other characteristics of the observed fluctuations.

UVI and CARICOOS (the US IOOS Caribbean Coastal Ocean Observing System) recruited ocean observing consultants Caribbean Wind LLC to develop a water temperature monitoring system to resolve structure spanning the upper mixed layer and along-slope depths to 70 meters. The system required deployment and service using small boats, easy periodic data recovery by a diver without connecting to the mooring, and options to upgrade to real-time data reporting after a pilot deployment. Low power, low maintenance and affordability were also paramount, of course.

Caribbean Wind turned to Soundnine Inc., Kirkland, WA (S9) to develop a solution. S9 worked with Mooring Systems Inc., Cataumet, MA (MSI) to deliver the mooring components including subsurface float, vertical and horizontal wire rope sections and wire rope "Hammerhead" terminations. These cable terminations were coupled to a steel T-joint connected to the first anchor. A loop of steel cable electrically connected the two hammerhead cable terminations allowing inductive communications through both cable sections. (Figure 1, inset photo).

Soundnine (S9) previously developed advanced underwater inductive telemetry products including modems, buoy controllers, inductively coupled sensors and small turnkey buoy systems. S9 leveraged its existing technology to create new instrumentation; a Subsurface Inductive Mooring Controller (SIMC) and Inductive Data Recorder (IDR). The SIMC clamps to the mooring wire, coordinates sampling inductively and logs instrument data. It also includes two serial ports to enable integration with ADCPs or other instruments. The SIMC is powered by a rechargeable battery pack that can be replaced underwater. The IDR, powered by a single AA lithium cell, also clamps to the wire and records all the inductive communications between SIMC and the sensor array, creating a backup data set.

The key to making the system diver-serviceable is the location of the SIMC and IDR just below the surface float at 20 meters. Periodically, a diver equipped with a spare IDR simply swaps a new recorder for old (4 screws each, a 10-minute job). Sensor data are retrieved from the IRD's memory card on shore. About once a year, a diver swaps the SIMC battery pack with a freshly charged one.

Conveniently, the university had three Sea-Bird Electronics SBE 39-IM temperature recorders and one SBE 37-IMP MicroCat CTD. S9's inductive telemetry system is fully compatible with these Sea-Bird inductively coupled instruments. Because of their weight, the Sea-Bird instruments were distributed along the vertical mooring line from below a subsurface float to just

above the T-connection. The horizontal mooring line held four S9 Enduro AT sensors (reporting temperature and three axis accelerometer data) and an Enduro APT, which also includes a pressure measurement. These were distributed along the 80-meter downslope section as seen in Figure 1. The downslope section is anchored at the terminal end and sets of small fishing floats every 3 meters on the cable kept it suspended approximately 1 meter off the bottom, not impacting any corals in the path.

The power-efficient SIMC, Enduro sensors and Inductive Data Recorder have deployment endurances of 2+ years when each instrument is queried consecutively at 15-minute intervals. Technicians configured the SIMC to initiate sampling and retrieve data from all instruments on the two wire-rope sections.

The mooring was deployed 25 July 2018. Divers lowered the anchors (500- pound main, 250-pound secondary) into place with buoyancy bags. The most recent IDR recovery on 29 July 2019 completed a nearly year-long data set. (There was a two-week gap in March 2019 for a preventive SIMC battery replacement and delays in redeployment.) Data return was excellent, although one Enduro (APT) stopped reporting 7 months after deployment (February 2019).

The most notable data feature is the presence and amplitude of the semidiurnal variability in salinity and temperature. When present – in warmer months, below the upper mixed layer – temperature and salinity at a fixed depth can fluctuate as much as 2 PSU and 2° C (Figure 2). The temperature fluctuations tend to keep the mesophotic corals from being constantly subjected to dangerously warm upper ocean summer temperatures in excess of 29° C .

Future Upgrade

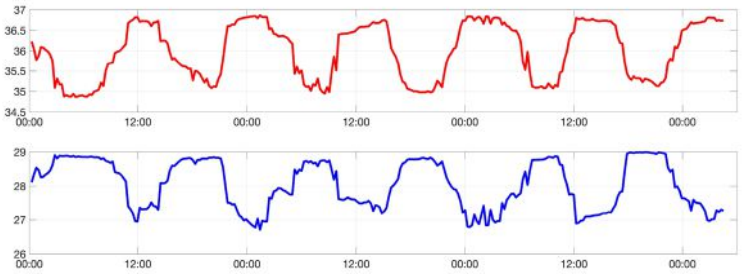
The mooring is scheduled to be upgraded to real-time reporting in early 2020. Divers will add a third wire rope section connecting the deep anchor to a Soundnine Ultibuoy, which will transmit data via cellular modem. The Ultibuoy system consists of a small surface buoy, wire rope mooring, solar-powered buoy controller with inductive modem, GPS and cellular or Iridium telemetry modem and software. Data are delivered to the users' desktop via S9's cloud-based data servers.

Summary

The S9 inductive controller, sensors, and recorders with MSI mooring connectors provided an innovative, robust, low-cost, low-power solution in this instrument string monitoring system. The equipment proved itself in this application by providing accessible low-maintenance long-term temperature and salinity monitoring for coral researchers studying effects of warming ocean temperatures in the US Virgin Islands.

» *MSI T-joint & Hammerheads*

» *Figure 1*



» *Figure 2 - Example of typical semidiurnal fluctuation of salinity (red) and temperature (blue) recorded during September 2018 at 44m depth.*

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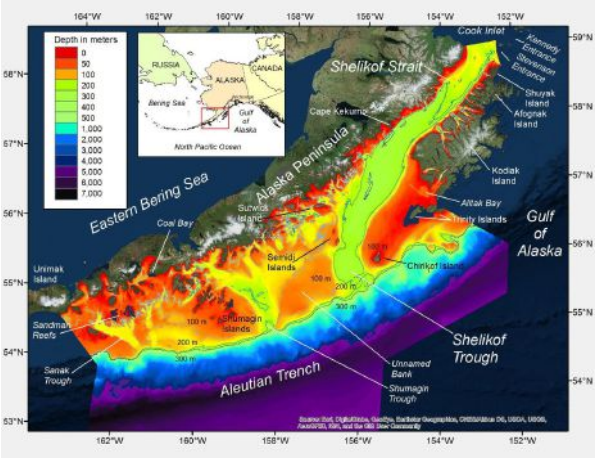
NEW SEAFLOOR MAPS REVEAL HABITAT SCULPTED BY ANCIENT GLACIERS



» *New bathymetric map of the western Gulf of Alaska.*

New seafloor maps show for the first time the course of ancient ice masses and how they shaped essential habitat for the western Gulf of Alaska's abundant fish, seabirds, and marine mammals.

Scientists wove historical and modern data—from century-old hand-drawn charts to modern multibeam surveys—to create a highly detailed view of the seafloor and its geological features. The results will help scientists better understand the habitat requirements of many species and the oceanographic processes that influence their success.

Mapping History and Habitat

The western Gulf of Alaska is both ecologically and economically important. Shelikof Strait, a major feature of the region, holds special importance as spawning ground for the Gulf's biggest stock of walleye pollock. Together with other Alaska pollock stocks, they are the target of the world's largest fishery. Shelikof Strait is also home to rare species like the mysterious Pacific sleeper shark. Within the Gulf of Alaska bottom trawl survey area, almost half of all sleeper shark occurrences are in Shelikof Strait.

Despite its importance, until now much of the western Gulf of Alaska had not been mapped in sufficient detail to describe the geological features of this vital habitat. To create and analyze new maps, NOAA Fisheries and U.S. Geological Survey scientists teamed up to bring together geographical and geological expertise.

"You need very high-quality bathymetric maps to analyze geological features, but it is really rare to have that kind of detail in Alaska. To get it, we pulled together close to 500 individual datasets. Each one was a tiny little puzzle piece. We carefully edited them into a seamless map on which we could very clearly see seafloor features— we just didn't know what they were. That's where Peter came in," said Mark Zimmermann, the NOAA Fisheries Scientist who led the project with colleague Megan Prescott.

Peter Haeussler, a geologist with the U.S. Geological Survey, did know what the seafloor features were. He identified many features of glacial origin including:

- moraine crests—narrow ridge top bulldozed by the forward edge of glaciers
- glacial scour marks—smooth gullies created by the flow of thick ice layers
- eskers— deposits of sediments under the former location of a glacier, trending in the same direction as glacier flow
- relic or submerged shorelines—underwater features showing extent of ocean when more of the world's water was locked up in ice
- two kinds of pockmarks—small, generally circular pit on the seafloor possibly created by the expulsion of fluids from the beneath the seafloor
- and iceberg keel marks—narrow, linear troughs caused by icebergs grinding along the ocean bottom.

The new maps had uncovered a rich record of glaciation, which likely dates between 13,000 to 25,000 years ago. The features reveal evidence of the flow direction, extent, and thickness of multiple glaciers. They clearly show that the glacier that filled Shelikof Trough was the most extensive of any in the region, extending for hundreds of kilometers.

"Our maps show the first comprehensive view of glaciation in the Alaska Peninsula region," said Haeussler. "Until now, there had been little work looking at submarine landforms and how they were shaped in the Western Gulf of Alaska."

This higher definition view of the seafloor will also allow scientists to better describe and understand habitat needs of the region's fish, marine mammals, and seabirds.

Specifically, the improved maps could help scientists to:

- Model how bathymetry steers the flow of water, and better understand how that affects spawning success of pollock in Shelikof Strait
- Explain the unique importance of Shelikof habitat to the Pacific sleeper shark
- Describe Essential Fish Habitat for many commercially important species
- Identify coral and sponge habitats
- Define untrawlable areas for fisheries assessment surveys

Building a Better Map

Several previous global and regional bathymetric mapping efforts included the western Gulf of Alaska. However, by creating new maps with much higher resolution, the team was able to correct previously published bathymetry.

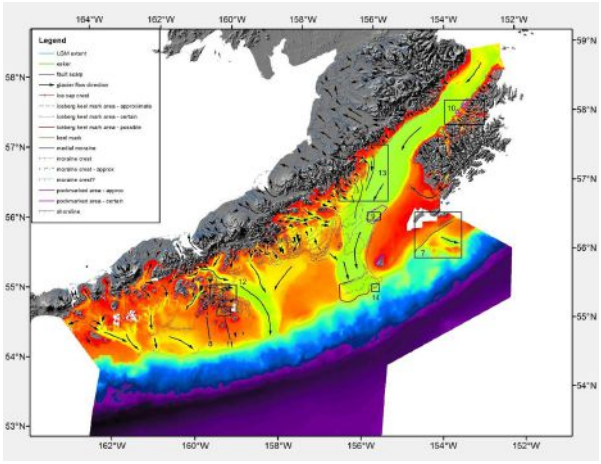
"GEBCO (General Bathymetric Chart of the Oceans) has been making seafloor maps of the world for a century. But they don't have access to a lot of the local fisheries research cruise soundings that we have here at the Alaska Fisheries Science Center. As a global organization it is difficult for GEBCO to focus on these detailed features. For example, in one western Gulf of Alaska location their map showed a big hole, 4200 meters deep. When we analyzed new data for this area, we found the hole does not exist and the area is only about 140 meters deep," Zimmermann explains. "We were able to make these kind of corrections because we had much more detail to work with, and we are happy to contribute our data to GEBCO's new global mapping effort."

The team achieved this high-resolution coverage by carefully combining bathymetric data from multiple sources and checking data against original source documents, rather than the less detailed navigational charts derived from them.

Data were pieced together from three main sources:

1. Historical National Ocean Service paper charts called "smooth sheets" created from methods as primitive as hand-sounding with lead-weighted lines and as sophisticated as single beam echosounders. Much of the shallower areas are still best described by smooth sheets, some over a century old.

2. Newer, highly-detailed data sets created from multibeam echosounders and LIDAR datasets from National Ocean Service and other sources for limited areas.



» *Geological features of the western Gulf of Alaska.*

3. Single beam echosounder files from AFSC fisheries research cruises that have criss-crossed the region over many years filled in the gaps.

"The western Gulf of Alaska map was the 6th large, regional seafloor map of Alaska we have created this way, though it was the first to be geologically analyzed" said Zimmermann. "In the future we are hoping to integrate these six maps into a single map, a single database. We'd like to do this for all of Alaska."

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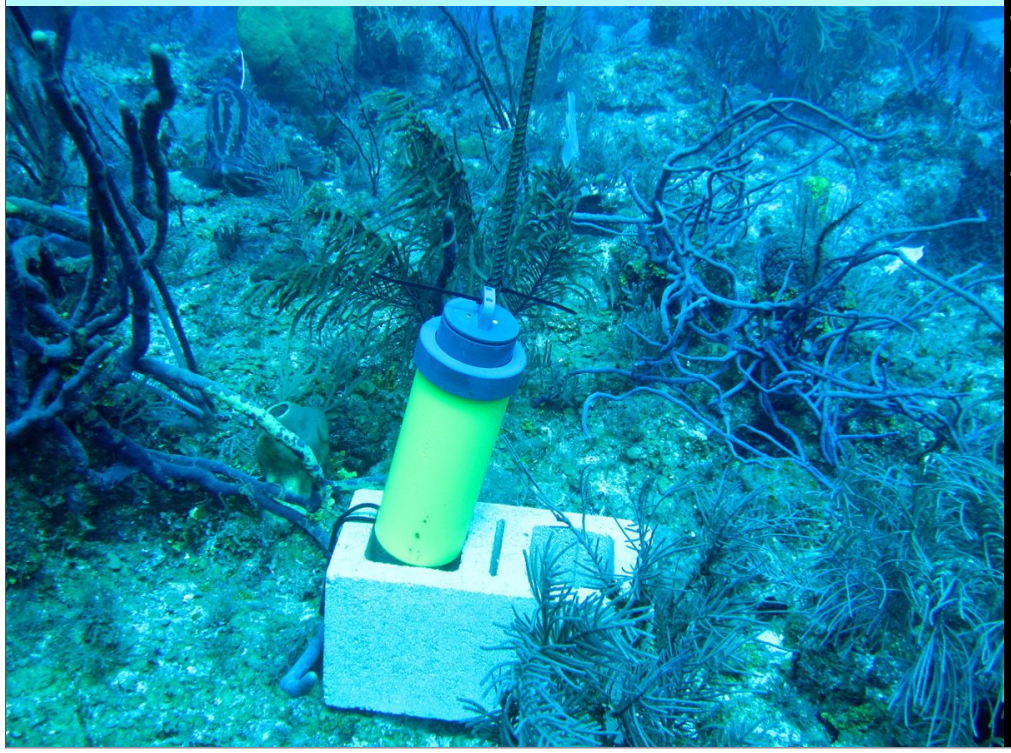

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GAME-CHANGING NEW OCEAN BOTTOM NODE FROM SERCEL

CGG announces the launch by Sercel of GPR, a new Ocean Bottom Node (OBN). GPR leverages the performance of Sercel's QuietSeis® broadband digital sensor technology to collect superior data for accurate seismic imaging compared to data collected by conventional sensors. Sercel has jointly developed GPR in partnership with BGP.

» *The GPR ocean bottom node. Image courtesy of Sercel.*

The launch of GPR coincides with the continuing growth and maturity of the global node market and further strengthens CGG's extensive portfolio of innovative products and services, all designed to reduce the risks and increase the success of its clients' reservoir exploration and development efforts.

Sercel and BGP have drawn on their longstanding partnership and complementary seismic expertise and experience to design, develop and deploy GPR. The new node has successfully completed sea trials and valuable input from BGP from the field has ensured GPR's performance is precisely tailored to meet today's industry requirements. It has a compact design and benefits from the fidelity and ultra-quiet performance of QuietSeis as well as flexible deployment options.

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THE OCEAN CLEANUP SUCCESSFULLY CATCHES PLASTIC IN THE GREAT PACIFIC GARBAGE PATCH

On 02 October 2019, representatives from The Ocean Cleanup announced that System 001/B is successfully capturing and collecting plastic debris. After one year of testing, they have succeeded in developing a self-contained system in the Great Pacific Garbage Patch that is using the natural forces of the ocean to passively catch and concentrate plastic, thereby confirming the most important principle behind the cleanup concept that was first presented by Boyan Slat at a TEDx conference in October 2012.

Launched from Vancouver in June, System 001/B is The Ocean Cleanup's second attempt to prove its concept of collecting garbage from the Great Pacific Garbage Patch, the largest accumulation zone of plastic in the world's oceans. In addition to collecting plainly visible pieces of plastic debris, as well as much larger ghost nets associated with commercial fishing, System 001/B has also successfully captured microplastics as small as 1mm—a feat the team says they were pleasantly surprised to achieve.

"After beginning this journey seven years ago, this first year of testing in the unforgivable environment of the high seas strongly indicates that our vision is attainable and that the beginning of our mission to rid the ocean of plastic garbage, which has accumulated for decades, is within our sights," said Boyan Slat.

"Our team has remained steadfast in its determination to solve immense technical challenges to arrive at this point. Though we still have much more work to do, I am eternally grateful for the team's commitment and dedication to the mission and look forward to continuing to the next phase of development."

New Design Leads To Improved Performance

The aim of System 001/B was to trial modifications, which addressed known complications, primarily aimed at correcting the inconsistent speed difference between the system and the plastic. Consistency was achieved by slowing down the system with a parachute sea anchor, allowing for faster-moving plastic debris to float into the system. Once this main challenge was resolved, prominent plastic overtopping was observed, becoming the next technical challenge to solve. Due to the modularity of System 001/B, a modification to increase the size of the cork line was designed and implemented while the system was offshore. With the new cork line, minimal overtopping is now being observed, thus allowing the system to capture and concentrate the plastic.

The Mission Continues

Despite the early success of System 001/B, there is still much work to do. With new lessons learned and experience derived from the successful deployment of System 001/B, The Ocean Cleanup will now begin to design its next ocean cleanup system, System 002; a full-scale cleanup system that is able to both endure and retain the collected plastic for long periods of time.

Once fully operational, The Ocean Cleanup will return plastic to land for recycling. The timing of that phase of the mission is contingent upon further testing and design iteration.

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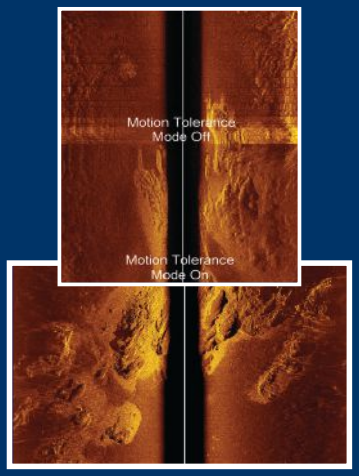

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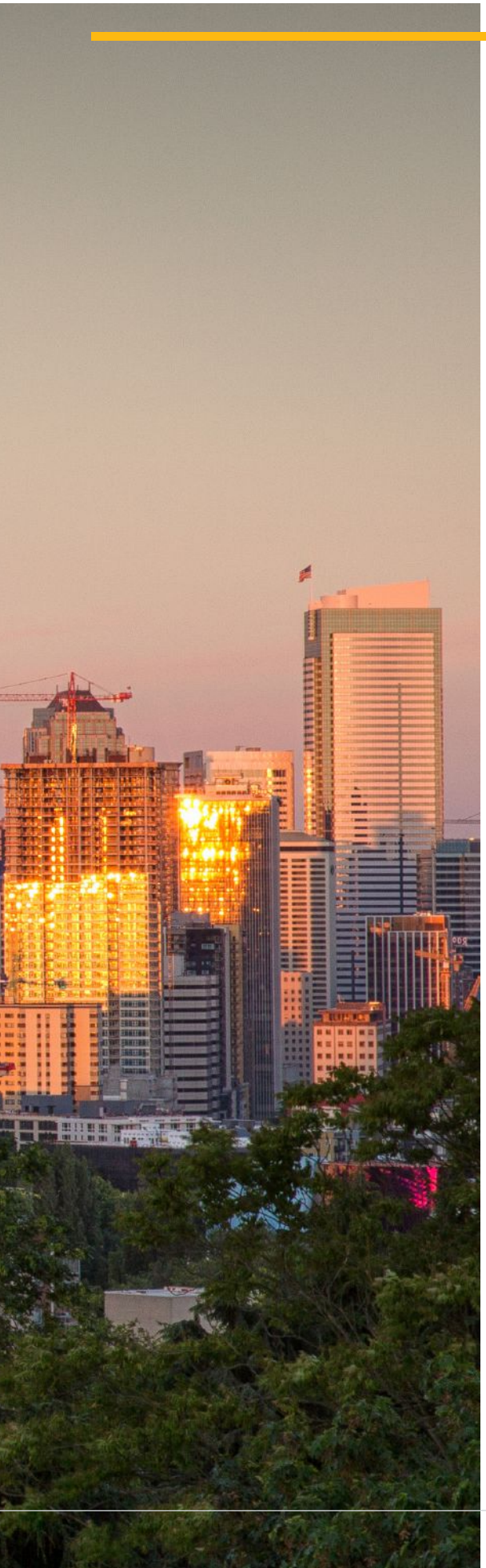
AN INTERVIEW WITH **DR. RICHARD SPINRAD, MTS PRESIDENT**

Dr. Richard W. (Rick) Spinrad serves as the President of The Marine Technology Society (MTS). ON&T interviewed him in advance of the 2019 Oceans Conference & Exposition in Seattle.

» *The Local Organizing Committee for the OCEANS 2019 Seattle Conference and Exhibition (27-31 OCT 2019) has put together a timely, relevant, and exciting program of presentations and exhibits.*



ON&T: Your professional experience gives you insight into how technology and research contribute to good governmental policies. What role does an organization like MTS play as a nexus between practitioners, researchers, and policy makers?

Dr. Spinrad: Beyond the obvious roles of a professional society—publishing new research results in our journal, convening conferences, providing long-standing members the venues for exchange of ideas and young professionals with critical networking opportunities, and affording businesses the forum for demonstrating new products and services—MTS also serves critical roles as a risk mitigator and community organizer. More specifically, MTS has demonstrated that we can provide venues (such as our tech surges) for discussing novel new technologies and looking at market opportunities in a semi-formal but very effective manner. We also give technologists the tools to engage other communities to both "sell" our capabilities, while learning what other technologies may be available for applications in the marine domain. Through our various formal agreements with groups like the Oceanic Engineering Society of IEEE, and the Society of Underwater Technology, we are giving researchers, operators and policy/decision makers easy access to each other.

ON&T: The upcoming Oceans Conference and Exhibitions is the flagship event for MTS. What are you most excited about for the October 2019 edition in Seattle?

Dr. Spinrad: Wow, where do I start? The Local Organizing Committee (Dr. Fritz Stahr, General Chair) for the OCEANS 2019 Seattle Conference and Exhibition (27-31 OCT 2019) has put together a timely, relevant, and exciting program of presentations and exhibits. With the theme of "Blue sea. Blue sky. Blue tech," we're hoping to emphasize the integrated nature of technologies, earth system science, operations, policy, and research.

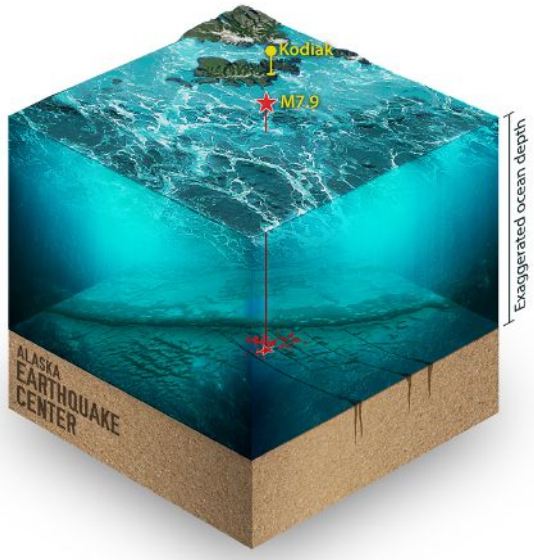
In addition to the standard topics for OCEANS (e.g. underwater acoustics, ocean observing, ocean vehicles and structures), the conference will include a number of special topics, such as: Coordinated Multi-Vehicle Teams for Marine Applications (Air, Surface, Underwater); Polar and Under Ice Stationary and Mobile Observing Systems; Offshore Earthquakes—Measuring and Mitigating Their Impact; Wave, Current, Wind, and Gradient Energy Harvesting; Best Practices in Sensor Design and Use, Systems Operations, and Data Management; Plastics in the Ocean: Observation and Mitigation Methods; Aquaculture: Technology for Management, Monitoring, and Mitigation; Electrification of Marine Propulsion Systems and Digitalization of Marine Handling Systems.

Exhibitors (we are expecting about 100) will have a water tank for demonstrations, and there will be an Innovation Theater. We're also doing things a little differently this time around, with the exhibits opening on Monday evening, and the tutorials and workshops at the end of the conference (Thursday).

ON&T: What are some of the recent or near-term milestones at MTS you are most excited about?

Dr. Spinrad: Obviously, I'm most proud of MTS's nearly 60 years of continuing service to the professional community of marine technologists. We've grown and diversified as the industry has changed. Expanding beyond traditional economies of oil & gas, and defense, into emerging fields of aquaculture, renewable

and defense, into emerging fields of aquaculture, renewable energy, and earth system observations, for example, we've been able to maintain our traditional membership base, while providing benefits for new classes of technologists and the next generation of professionals. I'm particularly excited about what we do for students (see below), but am also quite enthusiastic about our current efforts to build the community to be even more influential and relevant; for example, our current effort to build a professional certification program (with our partners at the Society for Underwater Technology) for marine technologists could be a seminal "sea change" for our community. We try very hard to be nimble and responsive to member/community needs; for example, we've just "stood up" our newest technical committee, "Unmanned Maritime Systems", to provide a critical forum for discussing future needs and opportunities associated with autonomous (surface, undersea, airborne) vehicles.



» *One of the special topics at the 2019 Oceans Conference is Offshore Earthquakes. This artistic rendering of the seafloor (not to scale) shows where the offshore Kodiak M7.9 earthquake occurred in January 2018. Red dots on the ocean floor represent aftershocks. Image courtesy of the Alaska Earthquake Center at the University of Alaska Fairbanks.*

ON&T: For many years, our publication has sponsored the ON&T Young Professional Award, in conjunction with MTS. We make the presentation during the Oceans Conference. What else is MTS doing to attract young professionals as members?

Dr. Spinrad:: We have a big and effective portfolio in our service to young professionals (including some VERY young—some might say 'larval'—professionals). The ON&T Young Professional Award has been an extremely important vehicle for publicizing the role these newest members of our community play and we are very appreciative of your sponsorship. For our youngest community members MTS has actively supported the MATE International ROV Competition and the National Ocean Sciences Bowls (Consortium for Ocean Leadership) since their inception. We offer multiple scholarships, mentorship, leadership, networking, and summer camp opportunities for undergraduates and graduate students, as well. Our student sections are active around the world, and afford these young professionals the opportunities to network and engage in tradecraft with the more seasoned technologists. And, of course, we have a long history of conducting the Student Poster Competition (with support from the Office of Naval Research) at the OCEANS Conference every year. I should add that just this year we worked with the Walter Munk Foundation for the Oceans to create the Walter Munk Scholar Award and Commemorative Lecture for scholars currently enrolled in an undergraduate, graduate or postdoctoral program.

ON&T: You played a key role in the development of our nation's first-ever ocean research priorities. How have these priorities changed the way federal agencies conduct and/or fund research?

Dr. Spinrad: That plan was titled "Charting the Course for Ocean Science in the United States for the Next Decade," and it was published by the White House on January 26, 2007 (and has since been updated twice). I think it is safe to say that prior to the publication of that report (and the passage just prior to that of the National Ocean Partnership Act), the federal agencies interacted in a purely opportunistic manner, without a lot of strategic forethought. Historically, one agency might develop a program to meet their particular operational needs, and might share their plans with another agency if the opportunity availed itself. Any collaboration, then, was mostly coincidental. After the research priorities plan was published, the agencies had a forum and a set of general areas of focus (not specific to any particular agency) around which they could plan investment, and with which they could defend appropriations requests. The plan also made clear the need for agencies to foster active integration of academic research interests with private sector and governmental capabilities. The result was a whole set of important and impactful programs addressing issues related to natural disaster mitigation, food/energy/water security, national/homeland defense, and global climate change. One additional benefit was the creation of a much more active and dynamic dialogue among and between federal agency program managers.

» *In June 2019, the Marine Technology Society and the Walter Munk Foundation for the Oceans announced their establishment of the Walter Munk Scholar Award. Seen here, from left to right: Rick Spinrad (MTS President), Alfredo Giron, Mary Munk, Andy Clark (MTS Vice President of Research, Industry and Technology. Alfredo Giron was the first recipient of the award.*

ON&T: You established the U.S. Navy's environmental research strategy and championed efforts to improve our ability to forecast the intensity of hurricanes. You were also instrumental in our nation's participation in the establishment of a global tsunami warning system. Are you seeing continued progress in these efforts?

Dr. Spinrad: YES, YES, YES. And I'd go even farther, to suggest that our portfolio of capabilities for addressing a full spectrum of natural hazards (harmful algal blooms, sea level rise, coral bleaching, etc.) has improved dramatically. While we still have a lot of work to do, for example in improving predictions of hurricane intensity, our track forecasts are much more accurate than they were 10 years ago. A lot of that comes from the observational technologies (gliders, satellites, ARGO floats, etc.) developed by many in the MTS community, as well as the scientific improvements to our models, and the access to ever-more powerful high performance computing. Twenty years ago, the idea of providing operational forecasts of harmful algal blooms was a dream, today it's a reality. When a quarter million people were killed by the Indian Ocean tsunami of 2004, we knew that the technological development for open ocean detection of tsunamis had to be accelerated (along with the efforts in modeling and simulation). Now most areas of the world that are subject to tsunamis have some form of warning system in place (few, if any existed in 2004) and we've already seen a number of life-saving benefits from these systems. I am confident that our progress in the area of natural hazard mitigation will continue, largely as a result of the marine technology community.

ON&T: How did your experience at Oregon State University prepare you for your Chief Scientist Post at NOAA?

Dr. Spinrad: Having spent the bulk of my career in government (at four different offices of the US Navy and NOAA) prior to becoming the Vice President for Research (VPR) at OSU I was well-versed in understanding how research results were applied to operational needs. At OSU I learned a lot about the concepts of operations, values, and principles in the academic research community. For example, the academic research community can be much more nimble than government labs. University researchers also have a very tight network of research colleagues. Both of these aspects were important to consider how best to coordinate the needs and capabilities of NOAA with the strengths of the academic community. I also think my time at OSU gave me a new respect for, and understanding of the world of young professionals (undergraduate and graduate students, as well as post-docs). That world had changed a lot since my time as a grad student in the 1970s. Without those four years at OSU as VPR, I would not have understood both the constraints, and opportunities for engaging students in developing the research agenda for NOAA.

ON&T: When it comes to oceanography saving the planet, what's next?

Dr. Spinrad: We could write a book on that question alone. At the most general level, I'd say that if we consider the areas of potential impact to be lives, livelihoods and lifestyles, then oceanography and marine technology will be front and center. Areas where our knowledge base and skills will apply will include food security (think sustainable aquaculture), energy security (think marine hydrokinetic energy), water security (think low-cost desalination), national security (think acoustic and non-acoustic monitoring and tracking systems), safety (think harmful algal bloom forecasts), and health (think cancer cures from marine-derived products). If that's not saving the world, I don't know what is!

marine technology SOCIETY

» *MTS President, Dr. Richard Spinrad, is an internationally recognized scientist and executive with more than 40 years of experience.*

ABOUT DR. RICHARD SPINRAD

An internationally recognized scientist and executive with more than 40 years of experience, Dr. Spinrad has served as the Chief Scientist for NOAA under the Obama administration, and previously as the Vice President for research at Oregon State University (OSU) in Corvallis, Oregon. From 2005 until 2010, he served as the head of NOAA's Office of Oceanic and Atmospheric Research and the head of the National Ocean Service. Dr. Spinrad is past president of The Oceanography Society.

He is a fellow of the American Meteorological Society, the Marine Technology Society, and the Institute of Marine Engineering, Science and Technology (IMarEST), and an IMarEST Chartered Marine Scientist.

Dr. Spinrad has extensive experience in environmental research, management, and teaching. He was a leader in the development of the nation's first-ever ocean research priorities and established the U.S. Navy's environmental research strategy. He has directed federal research programs at the Office of Naval Research and NOAA, and served on the faculty of three major universities. He has been published in pre-eminent peer-reviewed journals and awarded highest honors from three international professional societies and two Presidents of the United States.

Dr. Spinrad received his bachelor of arts degree in earth and planetary sciences from The Johns Hopkins University in Baltimore, Maryland. He received his master of science and doctoral degrees in oceanography from Oregon State University.

CHECK THE TECH:

'FLYING FISH' ROBOT USES WATER-REACTIVE FUEL TO JUMP AND GLIDE

By Hayley Dunning, Imperial College of London

A bio-inspired bot uses water from the environment to create a gas and launch itself from the water's surface. The robot, which can travel 26 meters through the air after take-off, could be used to collect water samples in hazardous and cluttered environments, such as during flooding or when monitoring ocean pollution.

Robots that can transition from water to air are desirable in these situations, but the launch requires a lot of power, which has been difficult to achieve in small robots.

Now, researchers at Imperial College London have invented a system that requires just 0.2 grams of calcium carbide powder in a combustion chamber. The only moving part is a small pump that brings in water from the environment the robot is sat in, such as a lake or ocean.

The water and the calcium-carbide powder then combine in a reaction chamber, producing a burnable acetylene gas. As the gas ignites and expands, it pushes the water out as a jet, which propels the robot clear of the water and into a glide of up to 26 meters.

The details of the robot were published on 11 September 2019 in *Science Robotics*.

Only One Moving Part

Lead researcher Dr Mirko Kovac, Director of the Aerial Robotics Laboratory at Imperial, said: "Water-to-air transition is a power-intensive process, which is difficult to achieve on a small-scale flying vehicle that needs to be lightweight for flight.

"We have used water-reactive chemicals to reduce the materials that the robot needs to carry. Since the chamber fills passively and the environmental water acts as a piston, we can create a full combustion cycle with only one moving part, which is the pump that mixes the water with the fuel."

The team tested the robot in a lab, in a lake, and in a wave tank, showing that it can escape from the water's surface even under relatively rough conditions. While similar robots often require calm conditions to leap from the water, the team's invention generates a force 25 times the robot's weight, giving it a greater chance of overcoming the waves.

> "These kinds of low-power, tether-free robots could be really useful in environments that are normally time- and resource-intensive to monitor, including after disasters such as floods or nuclear accidents."
> — Raphael Zufferey

Next: Field Trials

The robot, which weighs just 160 grams, can 'jump' multiple times after refilling its water tank. This could allow it to float on water and take samples at multiple points without additional power, saving energy over longer distances compared to an electrically powered robot.

The team are now working with partners in Switzerland to build new vehicles using advanced materials and begin field trials of the robot in a range of environments, including monitoring the oceans around coral reefs and offshore energy platforms.

Raphael Zufferey, first author on the paper said: "These kinds of low-power, tether-free robots could be really useful in environments that are normally time- and resource-intensive to monitor, including after disasters such as floods or nuclear accidents."

The tests were carried out in the Brahmal Vasudevan Multi-terrain Robotics Arena, which was founded on a philanthropic gift from Mr Brahmal Vasudevan.

Reference: 'Consecutive aquatic jump-gliding with a water-reactive fuel' by R. Zufferey, A. Ortega Ancel, A. Farinha, R. Siddall, S. F. Armanini, M. Nasr, R. V. Brahmal, G. Kennedy, and M. Kovac is published in Science Robotics.

IN OCEANS DEEP:
NEW BOOK TAKES READERS BENEATH THE WAVES

"This book is not a diving manual."

So begins the disclaimer that kicks off Bill Streever's latest book, *In Oceans Deep: Courage, Innovation and Adventure Beneath the Waves*.

There's a good reason for this disclaimer. From his youth as an oil field diver to his days as a science writer extraordinaire, Streever has ventured under the sea in every way, to almost every depth, and he admits surviving a few close encounters with mortality.

Befitting a book that takes us beneath the waves, Streever's prose is anything but dry.

For example, in his chapter about Trieste's astonishing descent to the bottom of the Marianas Trench, Streever does far more than recount facts. His tight, entertaining prose is eminently readable, and it invites us to get to know Don Walsh. It enables the reader to witness the great risk and the greater triumph, while also appreciating the science of depth.

For example, in his chapter about freediving, Streever recounts his own training, while also explaining how he copes with the fact that freediving could kill a human by entering a meditative state, and even composing haiku:

On descent lungs shrink
At depth wrung dry nothing left
Boyle stole my air.

Robert Boyle, explains Streever, discovered the law that "governs the lungs and the air they hold as a free diver submerges, or for that matter, the amount of air in a scuba tank, or the amount of air needed to purge the ballast tanks of a submarine at any particular depth."

Streever writes, "Somewhere around one hundred feet, your lungs are no longer anything like full. In fact, they are almost as empty as you can make them by forcefully exhaling on the surface. They have compressed to something approaching residual volume.

"Keep going. You may begin to feel uncomfortable, as if your chest is being squeezed. And, of course, it is. The weight of seawater is pushing in from all sides. But continue downward anyway knowing that you may damage your lungs or your airways. That damage may be nothing more than mild pain and coughed up blood, but it may also be far worse. Never mind. Chase those few extra feet, that personal best depth, or, if you are good and from a relatively small nation, push for that national record. Then experience a full lung squeeze, a lung squeeze bad enough to fill your alveoli, at least some of them, with fluid, with blood."

Mankind and its Marvelous Machines

Streever recounts the entire history of surviving pressure underwater, from the first dive helmets to saturation diving, from submarines to today's submersibles. All of the famous examples are there, but also obscure ones, like the riveting tale of teenagers who built their own diving gear from discarded boilers and garden hoses in the 1930s or the trailblazing men who voluntarily breathed experimental gases at pressures sufficient to trigger insanity.

Just shy of 300 pages, with illustrations, Streever explores every aspect of what he calls "humanity's presence underwater" in "the part of our world that is shrouded by depth." It's a must-read for anyone interested in this fascinating topic.

If Streever's name seems familiar to you, it's probably because he contributes to ON&T and ECO magazines. Or perhaps you know him from his bestselling books Cold, Heat, or And Soon I Heard a Roaring Wind. Whatever the case, his latest book—available from Little, Brown, and Company—gets ON&T's strongest recommendation.

IPCC: FUTURE OF OCEAN AND CRYOSPHERE DEPENDS ON CRITICAL CHOICES

» *Image courtesy of IMarEST.*

The latest Intergovernmental Panel on Climate Change (IPCC) Special Report, published 25 September 2019, highlights the urgency of prioritizing timely, ambitious and coordinated action to address unprecedented and enduring changes in the ocean and cryosphere.

The Institute of Marine Engineering, Science & Technology (IMarEST), holding the privileged position of Observer Status at the IPCC, was in attendance at the 51st Session of the IPCC to approve the report, held in the Principality of Monaco from 20-23 September 2019. They summarized the session as follows.

The session saw scientists and policymakers from the 195 IPCC member governments refining the Summary for Policymakers (SPM) of the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), and then formally approving this and the underlying full report, which is available for download at www.ipcc.ch/srocc/download-report/.

The SROCC report represents the work of 104 scientists from 36 countries, referencing nearly 7,000 publications, and receiving a total of 31,176 comments from expert reviewers and governments in 80 countries. Here is a brief synopsis with comment from the IMarEST delegation present.

Observed Changes And Impacts

The report initially confirms and corroborates the findings of the 3rd Ocean State Report, recently published in the IMarEST's Journal of Operational Oceanography. The planet has witnessed significant climatic changes since pre-industrial times and the SROCC highlights considerable warming of the ocean, not just at its surface but also extending down to great depths with a greater prevalence of marine heatwaves.

Ongoing loss off oceanic oxygen and acidification are further described, alongside sea level rises that are stated to have been accelerating in recent decades due to increasing loss of ice from the Greenland and Antarctic ice sheets at rates of 278mm ± 11 yr-1 and 155mm ± 19 yr-1 respectively.

Whilst detrimental impacts on ecosystems and human have already been witnessed the report elaborates on the effects on the abundance and distribution of ecologically, culturally and economically important animal and plant species.

Geographical shifts of marine species ranging from plankton and fish to mammals and seabirds have been occurring at alarming rates as a result of ocean warming with estimated range shifts of 52± 33km decade-1 (some plant groups) and 29± 16km (some animal groups) since the 1970s. This has already resulted in reduced ecosystem functioning and altered ecosystem structures.

Shallow coastal ecosystems are confirmed to be under huge strain, with the report detailing a 50% decline in wetlands coverage over the 20th century. Seagrass meadows and kelp forests have also been hit hard.

Projected Changes And Risks

Expanding on the grim tidings portrayed by the observations up to the current day, the SROCC delivers the IPCC's projected changes in the future ocean system. The cutting-edge scientific research delivers still more saddening outlook, as the pattern of warming seen since the 1970s is likely to continue. Further loss of Arctic sea ice, deoxygenation, increased acidification and a heightened frequency of marine

heatwaves are some of the notable consequences that can be expected by the turn of the century.

Further sea level rise is an apparent inevitability, with the previous figures cited by the IPCC under their fifth assessment cycle report (AR5) guidance released in 2010 being revised upwards due to a larger than expected contribution from the Antarctic ice sheet. Coastal wetlands could be all but wiped out by the turn of the century, with a global loss of 20-90% predicted by 2100.

Such a dire outlook will undoubtedly have extensive impacts for the planet and for modern-day human life, with physical risks to low-lying coastal communities in cities, small islands and other regions. All types of responses to sea level rise such as protection and ecosystem-based adaption will have a role to play in an integrated and sequenced response to rising sea levels.

However, vulnerable communities, especially those in coral reef and polar environments will face adaption limits well before the end of the century—even under a low greenhouse gas emission pathway. Without major adaptation, flood damage every year can be expected to increase by two to three orders of magnitude by the turn of the century.

The consequences for human livelihoods and wellbeing will be further exacerbated by the decreases in abundance, distribution shifts of species and depleted fish catches. Global-scale biomass of marine animals is projected to drastically decrease by 15.0+/-5.9%, with maximum catch potential of fisheries decreasing by 20.5-24.1% by 2100 under a high-emissions scenario – 3-4 times larger than a low-emissions scenario, placing significant strain on incomes and food security.

Options For Climate-Resilient Development

While making for a sobering read, the report injects some optimism with a discussion on the viable options for best mitigating the climatic effects and preserving the marine and cryosphere ecosystems. The development of extensive networks of protected areas is suggested as a means to help maintain existing ecosystem services and facilitate the poleward and altitudinal movements of populations, species and ecosystems—shifts already occurring in response to sea-level rise and global warming.

However, the SROCC warns that while effective, the cost of coastal habitat restoration will be considerable, ranging from thousands to hundreds of thousands of US$ per hectare and that its effectiveness will be limited to low emission scenarios.

Such strategies can be supported by well-managed coastal blue carbon ecosystems like seagrass meadows, mangroves and tidal marshes that will provide coastal protection and support fisheries. However, again, the effectiveness of such strategies is modest, with their global potential likely to only offset <2% of current emissions.

Care must also be taken when deciding the appropriate mitigation strategies for coastal communities as the IPCC states the technical limits of some protection measures, such as hard coastal protection, will be reached under a high-emissions scenario by 2100 and the biophysical limits of softer ecosystem-based adaptation will be reached well within that time period.

The report concludes with a plea for the critically urgent, ambitious and coordinated implementation of low-emission pathways and adaptation actions to reduce the climatic impact on the ocean and cryosphere.

NOAA AND DOE ANNOUNCES $3 MILLION OCEAN OBSERVING PRIZE COMPETITION

NOAA, along with the U.S. Department of Energy (DOE), have announced a $3 million prize competition to generate innovation in marine renewable energy-powered ocean observing platforms. The Powering the Blue Economy™ Ocean Observing Prize will draw upon American innovators to accelerate technology development through a series of contests to demonstrate renewable energy-powered ocean observing platforms.

"Ocean-based scientific instruments provide data critical to our understanding of the environment that benefits public safety and our economy," said Neil Jacobs, Ph.D., acting NOAA administrator. "This prize will help spur technological innovation so our next generation of ocean observing instruments have the power they need to deliver more high quality and timely ocean data over a longer period of time."

The Ocean Observing Prize is the second prize challenge under DOE's Powering the Blue Economy initiative, a portfolio of projects that explores self-sufficient applications of marine renewable energy to power desalination, ocean observing, and offshore aquaculture, among others.

The Prize will provide innovators a pathway from concept to design to construction, with two separate competitions and prize awards during each phase. The first competition—"Ideation"—will solicit novel concepts that pair ocean observing technologies with marine energy systems to address five broad themes: charging unmanned systems; communications and underwater navigation; extreme environments; buoys, floats, and tags; and innovative ideas. The prize will then have follow-on "Design" and "Build" competitions to bring innovators' ideas to reality.

The Ocean Observing Prize is led by the Office of Energy Efficiency and Renewable Energy Water Power Technologies Office at DOE and NOAA's Integrated Ocean Observing System program. The Prize is administered by the National Renewable Energy Laboratory on the American Made Challenge platform. This prize builds on the success of DOE's Waves to Water prize, which aims to demonstrate small, modular, cost-competitive desalination systems that use the power of ocean waves to provide clean drinking water for disaster recovery and for remote and coastal communities.

www.energy.gov/eere/water/water-power-technologies-office-prizes-competitions

EQUINOR AND SSE TO DEVELOP WORLD'S LARGEST OFFSHORE WIND FARM

On 20 September 2109, Equinor and its partner SSE were awarded contracts to develop three large scale offshore wind projects in the Dogger Bank region of the North Sea. This will be the world's biggest offshore wind farm development with a total installed capacity of 3.6 GW. The projects are expected to produce enough energy to power the equivalent of 4.5 million UK homes.

The Dogger Bank wind farm will consist of three projects, Creyke Beck A, Creyke Beck B and Teesside A. The clearing prices for the projects are GBP 39.650 per MWh for Creyke Beck A and GBP 41.611 per MWh for the Creyke Beck B and the Teesside A projects (all in 2012 real prices).

The auction results reflect the continued cost reductions and technological developments and the increasing competitiveness of bottom-fixed offshore wind. The contracts offer a fixed price for the first 15 years of operation, providing the projects with a long-term predictable revenue stream.

"Excellent wind speeds, shallow waters and scale make Dogger Bank well positioned to deliver low cost renewable electricity to UK homes and businesses," says Eldar Sætre, CEO of Equinor.

The Dogger Bank projects are estimated to trigger a total capital investment of approximately GBP 9 billion between 2020 and 2026. The joint venture will be seeking non-recourse project financing to fund the Dogger Bank development. A preliminary market sounding of potential lenders has demonstrated very strong interest for UK offshore wind assets.

The partners are planning for final investment decision for the first project during 2020 and first power generation is planned for 2023. Further phases of the Dogger Bank project will be developed thereafter. The joint venture has selected SSE as the lead operator during the project construction phase and Equinor the lead operator for operations. Both companies will second personnel into the execution and operations teams.

The awards were given under the Contracts for Difference (CfD) competitive auction held by National Grid on behalf of the UK's Department for Business, Energy and Industrial Strategy (BEIS) which has successfully commissioned 6 GW of offshore wind to reach a target of 30 GW of offshore wind by 2030.

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MAN-PORTABLE SAS: THE FUTURE OF SHALLOW WATER SURVEYING

Mapping of the nearshore and surf zone environments is vital for marine safety, security, and environmental/archeological protection. The conventional method of surveying in shallow water with manned survey vessels is challenging and often hazardous because the risk of running aground is high.

Utilizing unmanned vehicles such as Autonomous Underwater Vehicles (AUVs) significantly reduces the risks while increasing operational efficiency. Man-portable AUVs are quickly becoming recognized as ideal shallow water survey platforms due to their ease of handling and rapid deployment. Operators can deploy several unmanned AUVs at once, which decreases both the deployment and survey time. For shallow water operations, the ideal imaging sonar must fit on a small AUV while providing the sophisticated technology needed to operate in the shallow water environment.

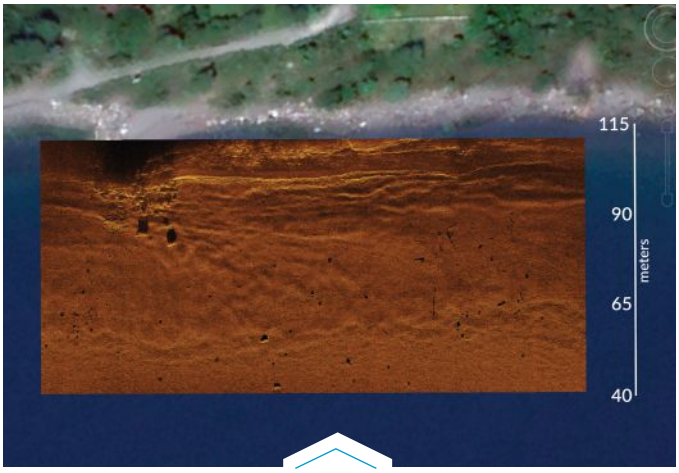
Shallow water poses significant challenges for both imaging and bathymetric sonars. The nearshore environment is typically characterized by sloping seabeds, multipath reverberation (interference in the received signal due to sound bouncing between the seabed and surface), complicated and rapidly changing sound velocity profiles, and strong water column returns from fish or other marine life. All these factors diminish the received Signal-to-Noise Ratio (SNR), which reduces image contrast and impairs target detection. Shallow water also typically features strong currents and turbulent conditions, which cause significant nonlinear platform motion that can lead to image distortion, poorly registered imagery, and artifacts in the measured bathymetry.

Synthetic Aperture Sonar (SAS) exploits the forward motion of the vehicle to combine successive pings from a small sonar array, achieving the resolution gains of a much larger array while dramatically increasing the area coverage rate relative to conventional sidescan sonar. Until recently, most SAS systems required large AUVs as host platforms to accommodate large, low frequency sonar arrays and to avoid the nonlinear trajectories of smaller vehicles. Now, miniaturized high frequency SAS systems can suppress multipath using narrow vertical beams and correct for nonlinear trajectories using sophisticated motion estimation algorithms. Miniaturized high frequency SAS is particularly advantageous in shallow water conditions where ping-to-ping integration enhances the seabed signal in strong multipath conditions.

» *SAS payload module with embedded real-time processor designed for 7.5"-9" diameter man-portable AUVs. Photo courtesy of Kraken.*

The enhanced range and resolution achieved by SAS allows for the collection of imagery and bathymetry all the way into the nearshore environment up to the air/water interface (Figure 1). Outfitting man-portable AUVs with SAS requires a new generation of light-weight miniaturized components with low power consumption. The payload needs to be designed so that it can be easily installed, removed, and swapped between vehicles in the field (Figure 2). To expedite post-mission analysis for military applications, it is essential to have onboard GPU-accelerated real-time SAS processing and automatic target recognition algorithms to enable in-stride target detection, classification, and localization.

Surveying in shallow water with man-portable AUVs reduces the safety risk to operators while increasing survey efficiency. With SAS, the survey area coverage rate, resolution, and data quality are improved over standard sidescan sonar payloads. By equipping man-portable AUVs with miniaturized SAS payloads and onboard real-time processing, operators can provide the capability of larger vehicles without the additional weight and handling requirements.



» *Example SAS image from Kraken's miniature synthetic aperture sonar overlaid on a Google Earth image showing data collected all the way to the shoreline. Image courtesy of Kraken.*

For more information, visit
WWW.KRAKENROBOTICS.COM

Kraken will be presenting papers and exhibiting at OCEANS 2019 Seattle. Stop by booth 127 to learn more.

EXXONMOBIL TO SELL NORWAY UPSTREAM OPERATIONS FOR $4.5 BILLION

On 26 September 2019, ExxonMobil signed an agreement with Vår Energi AS for the sale of its non-operated upstream assets in Norway for $4.5 billion as part of its previously announced plans to divest approximately $15 billion in non-strategic assets by 2021.

"Our objective is to have the strongest, most competitive Upstream portfolio in the industry," said Neil Chapman, senior vice president of ExxonMobil. "We're achieving that by adding the best set of projects we've had in many years and divesting assets that have lower long-term strategic value. This sale is an important part of our divestment program, which is on track to meet our $15 billion target by 2021."

The transaction includes ownership interests in more than 20 producing fields operated mostly by Equinor, including Grane, Snorre, Ormen Lange, Statfjord and Fram, with a combined production of approximately 150,000 oil-equivalent barrels per day in 2019.

The transaction is expected to close in the fourth quarter of 2019, subject to standard conditions precedent, including customary approvals from regulatory authorities. The majority of the ExxonMobil employees impacted by the sale will transfer to positions at Vår Energi.

In 2017 the company sold its ownership interests in the ExxonMobil-operated fields Balder, Jotun Ringhorne and Ringhorne East to Point Resources.

The ExxonMobil refinery in Slagen and network of approximately 250 independently owned Esso-branded retail sites are unaffected by the agreement.

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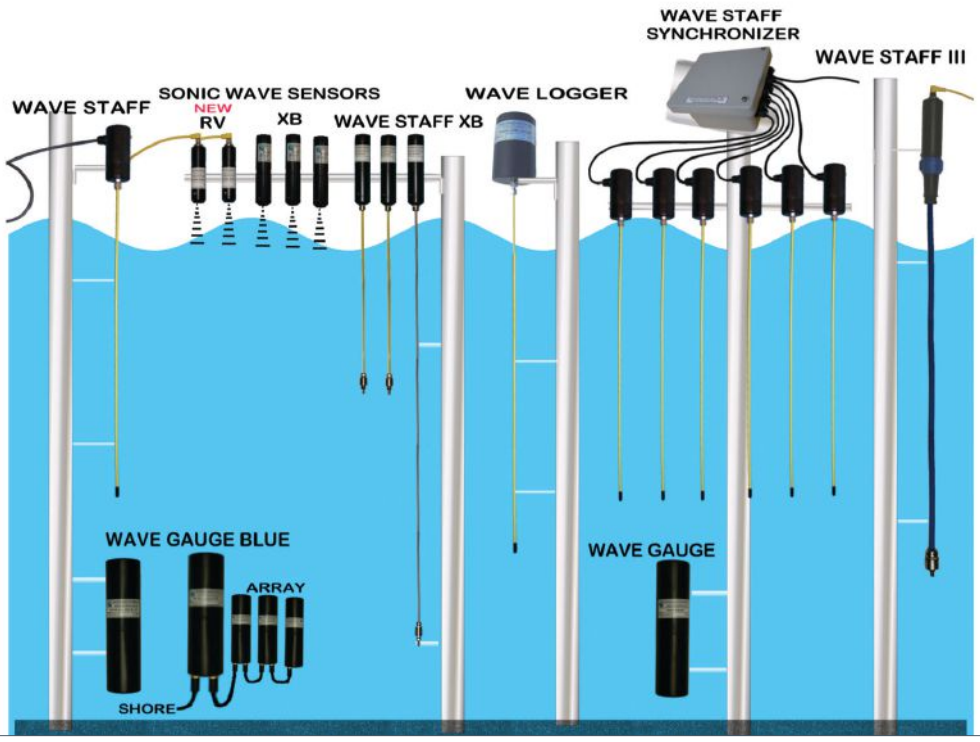


ØRSTED SELECTS GE RENEWABLE ENERGY FOR TWO US OFFSHORE WIND FARMS

Ørsted has selected GE Renewable Energy as the preferred turbine supplier for two of its US offshore wind farms which marks the world's first commercial deployment of GE's Haliade-X 12MW offshore wind turbine.

Subject to final agreement, Ørsted will deploy Haliade-X 12MW wind turbines on the two offshore wind farms constituting Ørsted's Mid-Atlantic cluster:

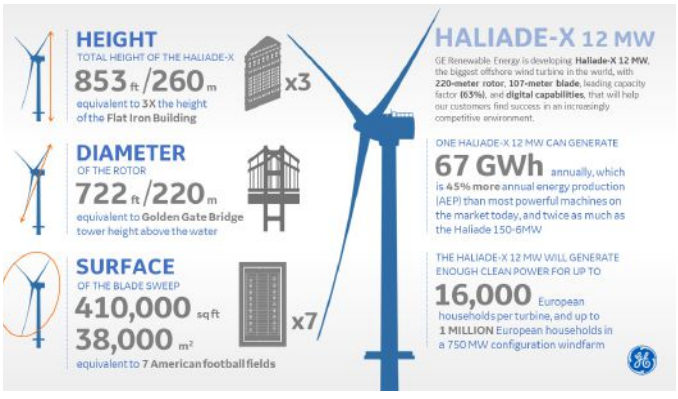
• Skipjack (120MW) off the coast of Maryland. Expected commissioning: 2022.

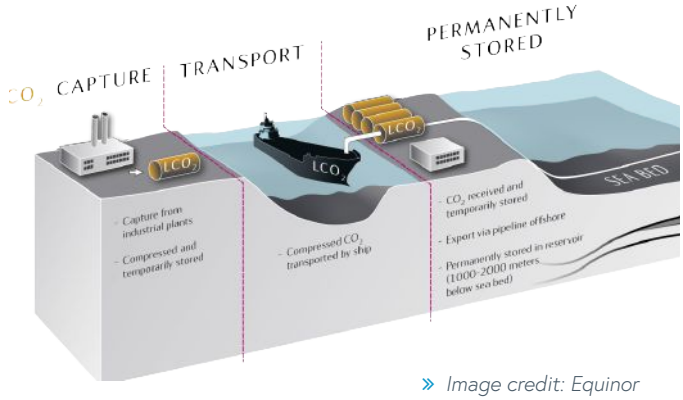
• Ocean Wind (1,100MW) off the coast of New Jersey. Expected commissioning: 2024.

In the US alone, seven states on the east coast have committed to building a total of 20GW of offshore wind capacity by 2035, emphasizing the need for a broad and diverse supplier base.

Martin Neubert, Executive Vice President and CEO of Ørsted Offshore, said, "We look forward to introducing the next generation offshore wind turbine to the market. For decades, Ørsted has pioneered the introduction of new technology and new suppliers which has been fundamental to drive down the cost of electricity, and today offshore wind is a competitive source of homegrown clean energy that can help countries and states achieve their climate targets while creating long-lasting economic activity. We are delighted to see GE's long-term commitment to offshore wind and to partner with them on our Mid-Atlantic cluster."

Following the 30MW Block Island Wind Farm—America's first offshore wind farm, which pioneered the 6MW Haliade turbine—Skipjack and Ocean Wind will be Ørsted's second and third offshore wind farms to deploy turbines from GE Renewable Energy. In the US, Ørsted has been awarded the rights to build offshore wind farms to serve the markets of Maryland, New Jersey, Rhode Island, New York, and Connecticut. These wind farms will have a total capacity of approx. 2.9GW and will be commissioned by 2024. *www.us.orsted.com*





» *Image credit: Equinor*

EUROPEAN COOPERATION ON CARBON CAPTURE AND STORAGE

On behalf of the partners of the Northern Lights project, Equinor has signed memoranda of understanding (MOUs) with seven European companies to develop value chains in carbon capture and storage. In cooperation with its partners Shell and Total, Equinor is studying the possibilities for developing a CO_2 storage on the Norwegian continental shelf (NCS).

The Northern Lights project includes transport, reception and permanent storage of CO_2 in a reservoir in the northern part of the North Sea as part of the Norwegian State's demonstration project "Full-scale CO_2 handling chain in Norway."

MOUs have been signed with, Air Liquide, Arcelor Mittal, Ervia, Fortum Oyj, HeidelbergCement AG, Preem, and Stockholm Exergi. According to the agreements the parties will cooperate on possible CO_2 handling at relevant third-party's premises and on transport to the Northern Lights project. The memoranda of understanding imply that the parties will evaluate solutions for CO_2 deliveries and transport, develop a timeline for possible final investment decision and start of operations, and cooperate on the CCS dialogue with national authorities and the EU.

The partners are currently reducing costs and further developing the Northern Lights project aiming for an investment decision in 2020. At the end of 2019, the partnership plans to drill a confirmation well for CO_2 storage in the Johansen formation covered by the Aurora license to study the reservoir's suitability and capacity for CO_2 storage. Earlie in 2019, authorities decided to help fund the work on this well.

www.equinor.com

OIL AND GAS CLIMATE INITIATIVE MAKES PROGRESS

The Oil and Gas Climate Initiative (OGCI) has announced initiatives to accelerate the reduction of greenhouse gas emissions and support the goals of the Paris Agreement.

First, OGCI launched a new initiative to unlock large-scale investment in carbon capture, use and storage (CCUS), a crucial tool to achieve net zero emissions. OGCI's CCUS KickStarter initiative is designed to help decarbonize multiple industrial hubs around the world, starting with hubs in the US, UK, Norway, the Netherlands, and China. The aim of the KickStarter is to create the necessary conditions to facilitate a commercially viable, safe and environmentally responsible CCUS industry, with an early aspiration to double the amount of carbon dioxide that is currently stored globally before 2030.

Second, OGCI showed progress towards its methane intensity target announced last year. Members are on track to meet the methane intensity target, having reduced collective methane intensity by 9% in 2018. In addition to the methane intensity target, OGCI is now working on a carbon intensity target to reduce by 2025 the collective average carbon intensity of member companies' aggregated upstream oil and gas operations.

Third, all OGCI member companies have pledged to support policies that attribute an explicit or implicit value to carbon. Acknowledging the role that attributing a value to carbon plays as one of the most cost-efficient ways to achieve the low carbon transition as early as possible, OGCI supports the introduction of appropriate policies or carbon value mechanisms by governments.

OGCI Climate Investments, OGCI's US$1 billion-plus fund, has nearly doubled the number of investments in promising clean technologies over the year. The fund now has a total of 15 investments in its portfolio. Climate Investments actively supports these companies in deployment and scale-up as well as continuing to search for additional opportunities in its focus areas.

In a joint statement, the heads of the OGCI member companies said: "We are scaling up the speed, scale, and impact of our actions in support of the Paris Agreement. Accelerating the energy transition requires sustainable, large-scale actions, different pathways and innovative technological solutions to keep global warming well below 2°C. We are committed to enhancing our efforts as a constructive partner with governments, civil society, business and other stakeholders working together to transition to a net zero economy. The progress towards our methane intensity target makes us confident that the actions we are taking deliver results. We are on track to reach our methane intensity target of 0.25% by 2025. Encouraged by our experience of working together on reducing methane emissions, we are now working on a target to reduce by 2025 the collective average carbon intensity of our aggregated upstream oil and gas emissions."

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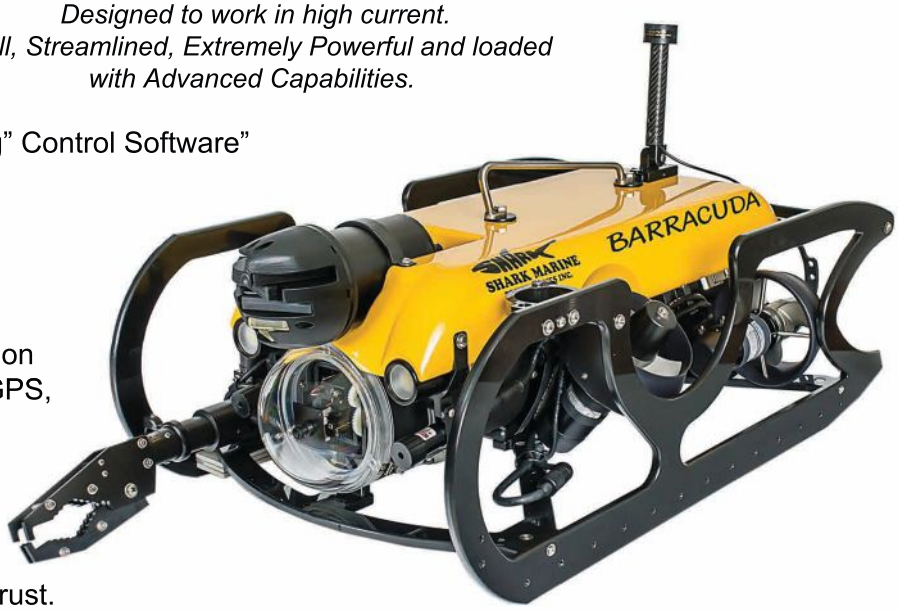


Shark Marine Technologies Inc. www.sharkmarine.com sales@sharkmarine.com Ph: (905) 687 6672

SEAWATER SENSOR CALIBRATION IN A HYDROSTATIC PRESSURE CHAMBER

By Dr. Mirjam Glessmer, Nautilus Marine Service GmbH,
Steffen Pausch, Nautilus Marine Service GmbH,
and Dr. Mark Halverson, RBR Ltd.

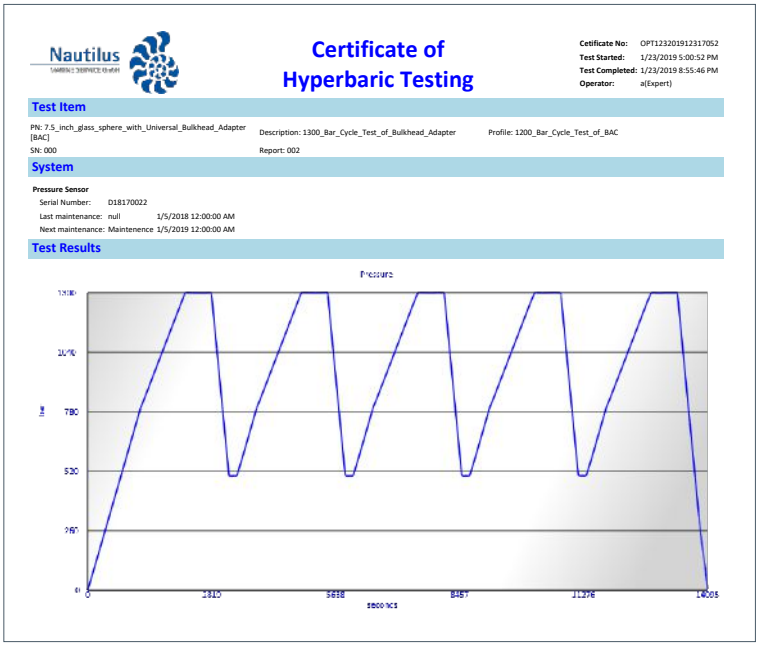
» *Fig. 1 - Pressure test facility by Nautilus Marine Service.*

Working in the deep sea is challenging for many reasons, not least the enormous pressure that quickly accumulates with every meter below the surface. Instrumentation has to withstand the high pressure and not implode or have water leak inside. If measurements are to be taken at depth, sensors also have to work accurately over a wide range of pressures. This task has engineering as well as calibration aspects, and for both, pressure testing is necessary to provide reliable instrumentation. Pressure testing can be conducted in-situ, but testing facilities provide more efficient environments with lower cost and carefully controlled conditions for such tests, as well as support for many different customers and applications.

The pressure test facility operated by Nautilus Marine Service GmbH in Germany (Fig. 1) can create pressures from 1 bar to 1300 bar—equivalent to the pressure at the sea surface down to the deepest parts of the Mariana Trench. The pressure change rate can be set from 10 bar/min to 60 bar/min, and the pressure profile to follow over time can be specified exactly. Depending on the purpose of the test, stepwise increases with wait times at every step, or rapid cycling of pressure increase and decrease, or even sinusoidal pressure curves might be desirable.

The test sequence can either be operated and monitored by a Nautilus engineer on site or by remote access, which means that a client who wishes to run a pressure test, does not necessarily need to be present in person (Fig. 2).

Recently, the Canadian company RBR Ltd. sent two oceanographic instruments for seawater pressure testing at the Nautilus facilities in Buxtehude, Germany. These instruments, RBR*concerto*^{3} CTDs (Fig. 3 and Fig. 4), measure the electrical conductivity of water, temperature, and pressure (and, with additional sensors, many other variables). From the conductivity, temperature and pressure measurements, a variety of other variables can be derived, such as salinity, depth, density, and sound velocity. The data are used to characterize oceanic conditions for a multitude of



Nautilus

Certificate of Hyperbaric Testing

Cetificate No: OPT123201912317052
Test Started: 1/23/2019 5:00:52 PM
Test Completed: 1/23/2019 8:55:46 PM
Operator: a(Expert)

Test Item

PN: 7.5_inch_glass_sphere_with_Universal_Bulkhead_Adapter [BAC]
Description: 1300_Bar_Cycle_Test_of_Bulkhead_Adapter
Profile: 1200_Bar_Cycle_Test_of_BAC
SN: 000
Report: 002

System

Pressure Sensor
Serial Number: D18170022
Last maintenance: null 1/5/2018 12:00:00 AM
Next maintenance: Maintenence 1/5/2019 12:00:00 AM

Test Results

» *Fig. 2 - Pressure profile example.*

» *Fig. 3 - RBRconcerto³ CTD.*

purposes, from optimizing fish farming to providing baseline data for climate predictions. Since conductivity sensors are sensitive to hydrostatic pressure, this sensitivity must be quantified to achieve RBR's high accuracy specifications. It is difficult and expensive to do this work with vessel-based deep-sea measurements. Using a constant salinity pressurized tank is the ideal experimental configuration to quantify the effect of hydrostatic pressure on the conductivity sensor.

The pressure chamber operated by Nautilus Marine Service GmbH is primarily designed to meet the challenging demands for conducting tests on VITROVEX® glass enclosures and related products and has been optimised in terms of speed, accuracy and robustness over traditional pressure test facilities.

Although computer-based calculations and sophisticated simulation algorithms are available today and certainly help to shorten the development process for such parts, only a test can really prove that the design is according to specification, the right material has been chosen, and that no signs of fatigue over the planned operation period will occur. Additionally, pressure tests are often mandatory as part of the certification process to be accomplished by a notified body.

» *Fig. 4 - RBR conductivity sensors: 750 dbar, 2000 dbar, 6000 dbar models.*

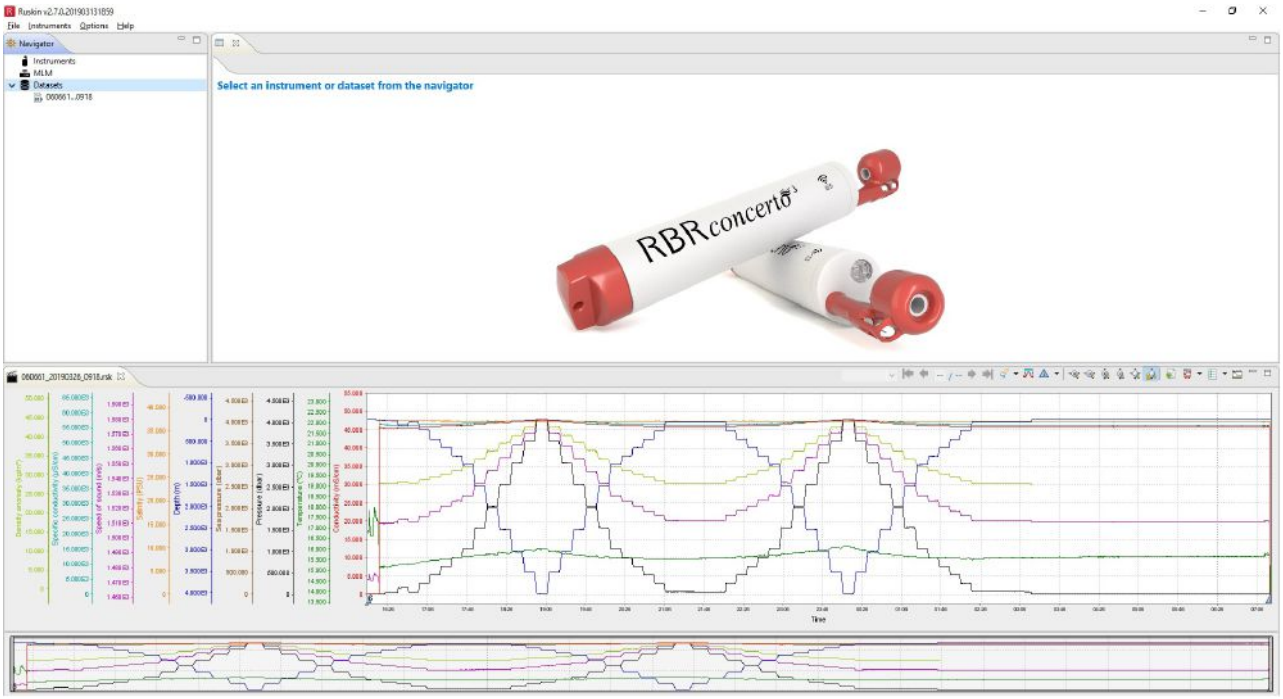
This complex field of activity opens up seemingly endless areas of applications for the Nautilus pressure testing facilities and related services.

For RBR's tests, for example, pressure was cycled between atmospheric pressure and 400 bar at varying rates of change. During a test, the volume of the pressure chamber stays constant and the pressure change is created by pumping water in or out. Even though we tend to think of water as incompressible, to increase pressure from 0 bar to 400 bar in the 700 Ltr. pressure chamber, an additional 12.6 Ltr. have to be added. And of course, a change in pressure also results in temperature changes – increasing pressure by 400 bar causes temperature to increase by 1.5°C.

Salinity inside the pressure chamber can also be set to customers' specifications. For the RBR tests, artificial seawater was prepared by Nautilus engineers from distilled water and aquarium sea salt. The sea salt is commercially available, and its chemical composition is designed to mimic seawater and therefore the conditions in which the instruments will operate.

During the CTD tests, data were recorded internally by the test instruments and downloaded afterward.

Figure 5 shows a screenshot of the RBR Ruskin software interface to the instrumentation with data of several parameters collected during pressure testing in different settings—slow, stepwise increase and decrease of pressure and later rapid cycling between low and high pressures.



» *Fig. 5 - Recorder test data in RBR Ruskin software.*

RBR scientists analysed the data to meet two test objectives. The first objective was to determine how well the conductivity cell can withstand repeated exposure to high pressures. The second was to compute a pressure-dependent conductivity correction factor. The correction factor is necessary to offset the impact that hydrostatic pressure has on the conductivity measurement; correctly doing so ensures the sensor meets RBR's high accuracy specifications.

» *Fig. 6 - Lid of pressure chamber with interfaces.*

In other applications real-time access to data measured inside the pressure chamber might be desirable. This is also possible with the Nautilus pressure chamber as several leads through the lid can connect instrumentation inside the pressure chamber to computers on the outside. For example, if metal housings are to be tested, it could make sense to monitor in real-time if and how they are deforming. This can also be directly observed via cameras and lights available inside the pressure chamber.

Figure 6 shows the lid of the pressure chamber connected to a frame loaded with the instrumentation that is lowered inside the pressure chamber for testing.

Note: The cable feedthroughs in the lid enable the instruments inside the pressure chamber to be connected to computers in the lab for real-time observations.

SUMMARY

High pressure saltwater testing proved to be highly valuable for characterizing the metrological and mechanical performance of RBR CTDs. The two most desirable aspects of this testing were the scientific benefits of a controlled salinity environment, and the lower cost relative to field studies. RBR will continue to rely on these tests as an effective way to characterize instrument and sensor performance.

Nautilus Marine Service GmbH operates a pressure test chamber with capability that extends to full ocean depth and beyond, and it has the pressure test chamber available to outside clients also to carry out contracted pressure testing.

For further information on RBR products and pressure test services from Nautilus Marine Services, please visit *www.nautilus-gmbh.de*

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JW FISHERS ROV HELPS RECOVERY DIVE TEAMS LOCATE DUMPED CAR

» James City County PD

» Sea Otter

After over 50 years in business, the JW Fishers team has heard just about every story possible concerning sunken ships, hidden treasures, scientific experiments, unexploded ordinance, location of drowning victims, and missing evidence recovery. The tools the company provide to the operators undertaking these tasks vary from metal detectors and sonar systems to Remote Operated Vehicles (ROVs).

According to The Remotely Operated Vehicle Committee of the Marine Technology Society, "exactly who to credit with developing the first ROV will probably remain clouded, however, there are two who deserve credit. The PUV (Programmed Underwater Vehicle) was a torpedo developed by Luppis-Whitehead Automobile in Austria in 1864, however, the first tethered ROV, named POODLE, was developed by Dimitri Rebikoff in 1953." In late 1960's, the US Navy began developing robots to help locate and recover underwater ordinance.

By the 1980's, commercial companies began utilizing the technology to aid in the oil and gas industry. Now, ROVs are used in all manner of exploration and commercial applications from dam and water tank inspections, evidence recovery, pipeline maintenance, aquaculture, and drowning victim recovery.

James City County, located in the Commonwealth of Virginia, has an estimated population of 67,000 citizens. The county has a Marine Patrol and Underwater Search and Recovery Team that employs their JW Fishers' SeaOtter-2 ROV whenever mission accomplishment is of the utmost importance. Many of the local waterways are low visibility and the need to use an ROV is minimal. There are, however, several areas in which an ROV is absolutely the right tool for the job. Local retention ponds, a county reservoir, the Chesapeake Bay, and a very brackish river are all waterways that the team are able to operate the ROV in without hesitation. Lt. William T.

McMichael recently shared one experience that highlighted the versatility of JW Fisher's ROVs.

"One operation we were called to was a submersed vehicle in a retention pond behind a hospital. A grounds employee observed the top of a vehicle as he glanced out over the pond. We arrived on scene and sent in the SeaOtter-2 ROV. We were able to circle most of the vehicle with great visibility and obtain the vehicle tag. We were able to discover that the vehicle had been stolen two years earlier. It was unknown how long it had been in the pond. We were also able to send the Sea Otter-2 inside the vehicle as the window was down. We could see in the front seat and the back seat to see that no bodies were inside. This helped our divers see the make and model of the vehicle and the condition of most of the vehicle prior to getting in the water."

Lt. McMichael went on to say "we also utilized the SeaOtter-2 in a regional public safety dive training event assisting with surveying in an archeological dive for the ships scuttled by General Cornwallis along the York River in Yorktown, VA. The ROV was used to identify any visible ship remains from the Revolutionary War. We absolutely love the Sea Otter ROV. Given the right conditions and clarity, the ROV gives us a tool to send in and scout the underwater environment prior to sending in any public safety divers."

EQUINOR AWARDS SAIPEM PIONEERING WIRELESS SUBSEA DRONE CONTRACT

Equinor, on behalf of the Njord licence, has awarded Saipem a subsea service contract using a wireless underwater intervention drone and an ROV. This contract will make Equinor the first user of technology expected to be completed in 2020.

"This is a historic contract in the oil and gas industry. It is the first contract signed for the use of advanced wireless drone services. We are pleased to secure a contract that will bring subsea technology a big step forward. Equinor aims to help shape the development of this type of technology, which this contract underscores," says Anders Opedal, executive vice president, Technology, Projects & Drilling.

The services from Saipem Limited Norway Branch will be employed when the Njord field resumes production in 2020. Lasting for ten years, the contract has five 2-year options for additional extension. The value of the fixed part of the contract is estimated at about EUR 40 million. The contract lays down requirements for permanent presence in Norway and Norwegian-speaking personnel.

The new technology employs an underwater intervention drone (Hydrone-R) and an all-electric work class ROV (Hydrone-W). The drone may be autonomous below Njord for months between scheduled maintenance, whereas Hydrone-W will be connected to the platform like a traditional ROV. Both are electric and can be operated without a surface vessel. The use of this technology will therefore contribute to significant carbon reduction. In addition, the response time will be reduced. Furthermore, the operations will not be dependent on weather conditions.

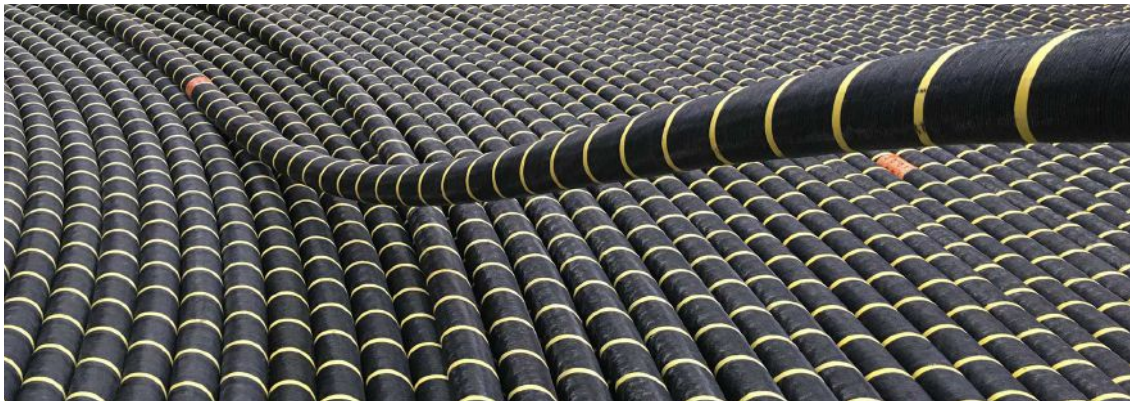
"It is very exciting to be a pioneer for this type of technology offshore. Enabling personnel to plan and perform operations from shore rather than being flown offshore, this pathbreaking technology will also reduce costs," says Olav A. Godø, operations manager, Njord.

Equinor's proprietary docking station for data transmission and subsea induction charging will be installed below Njord and used by the underwater drone.

» *Roberto Di Silvestro (left), head of Sonsub at Saipem, Giovanni Chiesa, head of subsea engineering and underwater technologies at Saipem, Sophie Hildebrand, chief technology officer Equinor, Hans Henrik Nygaard, procurement Equinor, and Gry Lindboe, manager procurement Equinor. (Photo: Arne Reidar Mortensen)*

OFFSHORE WIND FARM CABLES: A CRITICAL CONNECTION

By Liz Burdock,
President and CEO, Business Network for Offshore Wind



When you think of an offshore wind project, the first image that comes to mind is a soaring white structure, spinning against a deep bluea ocean and sky. Turbines are technological marvels deserving attention, but without subsea cables buried deep beneath the ocean floor they are a stranded asset.

"Cables are a critical component for offshore wind farms, but in the past they have not always received the attention they deserve," as John Manock, editor of SubCableWorld, has pointed out.

With more than 23,000 megawatts of offshore wind expected to be built and producing power from Virginia to Massachusetts, making sure cables are installed correctly and maintained is paramount. The ocean bottom is a harsh environment, and cable damage accounts for as much as 80% of insurance claims at offshore wind farms. If something does go wrong with a subsea cable, divers often have to plunge more than 100 or 150 feet to the ocean floor to make the repair.

Of course, offshore wind cables are also a major business opportunity as a vital piece of the supply chain, which is why my organization is encouraging the top global cable manufacturers to set up shop in the U.S. to serve this market. As a part of that effort, we are partnering with SubCableWorld to hold the first conference focusing specifically on offshore wind cable supply chain issues in the United States.

We had intended to hold the conference, titled "Subsea Cables: A Critical Connection," in October, but we have moved it to January 23, 2020, in order to incorporate some new, exclusive marketing intelligence based on a SubCableWorld-Business Network joint report that forecasts the growth of the U.S. cable market from 2020 to 2030.

The event, which will be held at the Houston Aquarium in Houston, Texas, will also cover issues related to the development of the U.S. cable supply chain, including the following:

- Insurance and risk management
- Trends and challenges for the U.S. market
- Technological advances in cable designs
- Lessons learned from European wind farms
- Subsea cables and floating wind turbines
- Offshore wind grid integration, and other topics.

Some of the presenting companies include:

- Nexans
- Global Marine
- JDR
- Siemens
- Carbon Trust
- Anbaric
- LS Cables

Visit www.offshorewindus.org/criticalconnection/ for information on this conference. We encourage those who follow offshore wind to sign up early because registration is now open, and space is limited.

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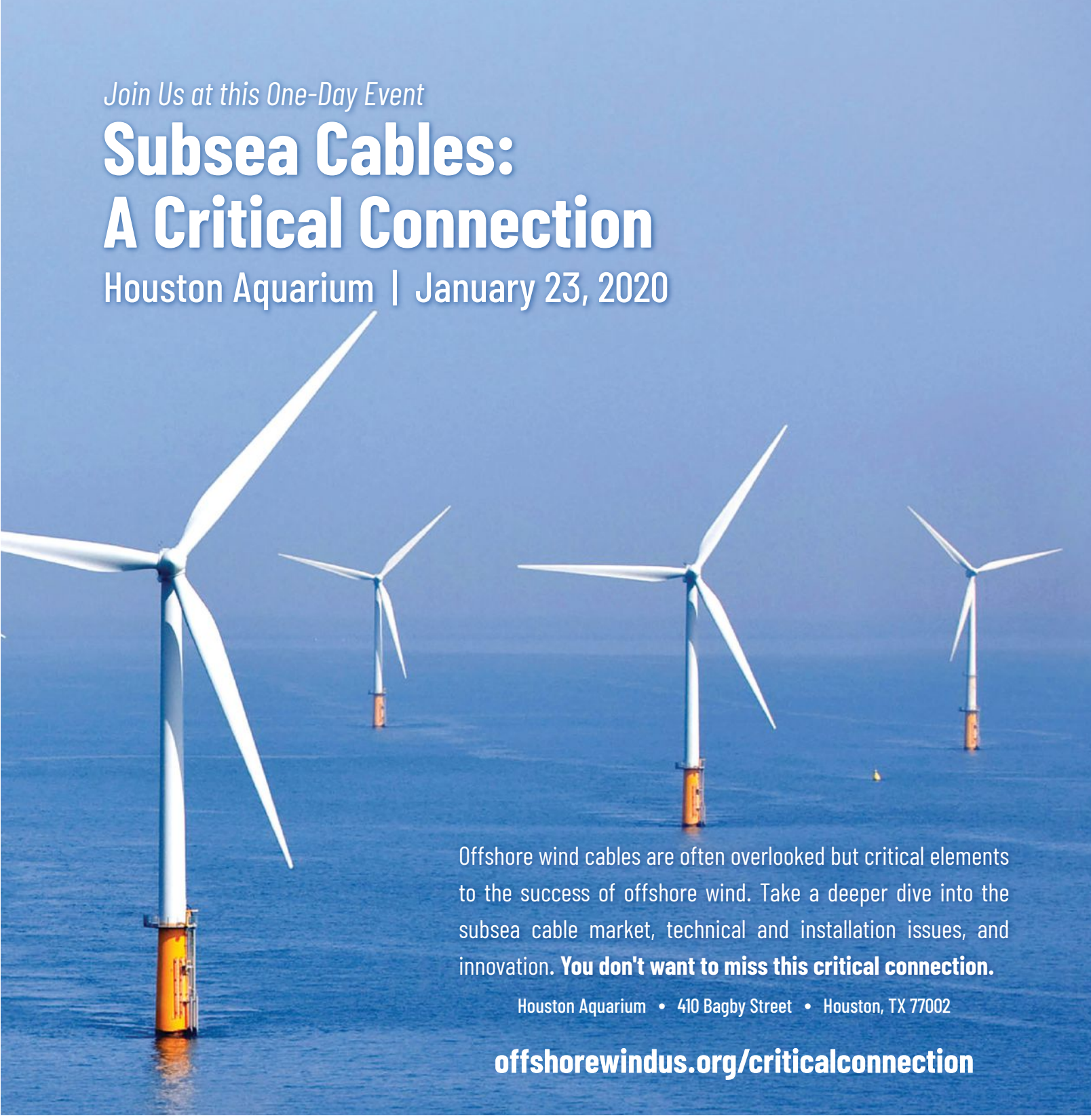

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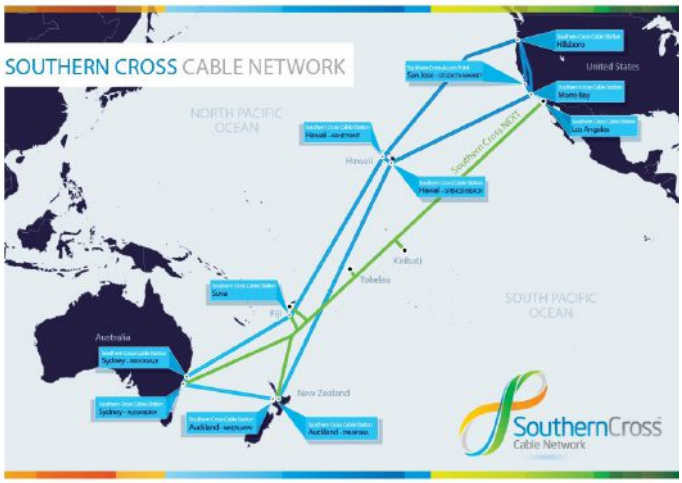
PIONEER CONSULTING TO PROVIDE SUPPORT TO SOUTHERN CROSS NEXT SYSTEM

Southern Cross Cable Network (SCCN) has entered the construction phase for its planned NEXT submarine cable network, and the leading international telecommunications firm, Pioneer Consulting, will continue to provide support throughout the implementation period.

With the ready for service date (RFS) scheduled on or before Q1 2022, Pioneer Consulting's expert team will provide a full suite of project management and engineering support related to the construction and delivery for Southern Cross' NEXT system that will connect Australia, New Zealand and California, USA—including spurs to Fiji, Tokelau, and Kiribati. Southern Cross NEXT will be the largest capacity link providing data-center connectivity between Sydney, Auckland and Los Angeles and the planned 16,148km system will be the lowest latency path from Australia and New Zealand to the USA, as well as provide trunks and diversity for the intermediate locations.

Mr. Laurie Miller, President and CEO of Southern Cross noted: "The addition of the Southern Cross NEXT route will provide a connectivity to our existing and future customers with increased resiliency, redundancy and capacity between the regions, and we are pleased to once again have Pioneer Consulting on board to assist with our endeavor. Pioneer's expertise has been instrumental in complimenting the experience in the Southern Cross team in the design and delivery of the Southern Cross NEXT project to date, and we look forward to continuing the teamwork for the successful implementation of this significant project."

Pioneer Consulting will also support the marine engineering, manufacturing and assembly, factory acceptance, installation, testing and commissioning for both the subsea and terrestrial components of the project through to the system being ready for service.



NKT COMPLETES POWER CABLE SYSTEM FOR SCOTTISH CAITHNESS-MORAY LINK

NKT has successfully completed the Caithness-Moray turnkey project of a 320 kV high-voltage direct current (HVDC) XLPE off- and onshore power cable system covering a total transmission length of 160 km. The link has been in commercial operation since end-2018. For this project, the cable-laying vessel NKT Victoria made her maiden installation voyage, successfully and with high precision installing the bundled HVDC power cables and fiber optics on the seabed.

The Caithness-Moray power link connects the electricity grid on either side of the Moray Firth inlet using world-leading and well-established HVDC power cable technology from NKT with a minimal visual impact. With associated reinforcement of the existing onshore transmission network, the power connection represents the largest investment in the north of Scotland's electricity network since the hydro development era of the 1950s.

"We are proud to be part of the green transformation of Scotland together with our customer Scottish Hydro Electric Transmission (SHET). This project has also been special to us as it showed impressive performance of our purpose-built cable-laying vessel NKT Victoria," says NKT's Claes Westerlind, Executive Vice President and Head of HV Solutions Karlskrona.

NKT has ramped up the safety management execution, setting a new internal health and safety standard. As an example, NKT ensured that all vessels used during an offshore operation had defibrillators and training as part of the standard equipment. This procedure is now standard in all NKT offshore installation projects and part of the contractor requirements for emergency preparedness.

www.nkt.com

PRYSMIAN AWARDED MAJOR CONTRACT BY TENNET

Prysmian Group has achieved an important milestone in its PowerLink Cable Solutions strategy, which aims to provide comprehensive management solutions for submarine and land cable systems.

The Group has just been awarded a 3-year service level agreement by the Dutch-German grid operator TenneT for reactive maintenance operations for its HVAC and HVDC submarine and land assets.

"We are delighted to support TenneT in fulfilling its asset management strategy, designed to reduce to the minimum the cable downtime during the asset lifetime. This award confirms the Group's leadership in HVAC and HVDC asset management solutions, proving its experience and expertise," stated Raul Gil, VP Submarine Business Unit, Prysmian Group.

The Group will provide experienced and qualified jointers, advanced equipment and tools for the Prysmian HVDC and HVAC cables operated by TenneT, within a guaranteed time and at pre-agreed rates. Some of the projects included in the service agreement are BorWin2, BorWin3, DolWin3, SylWin1, HelWin1 and HelWin2. This service level agreement falls within the scope of the PowerLink Cable Solutions service, under which Prysmian delivers a comprehensive asset management solution for critical connections, including monitoring, periodical maintenance and repairs: a one-stop-shop solution approach enabling an unparalleled reduction in power cable downtime and total cost of ownership.

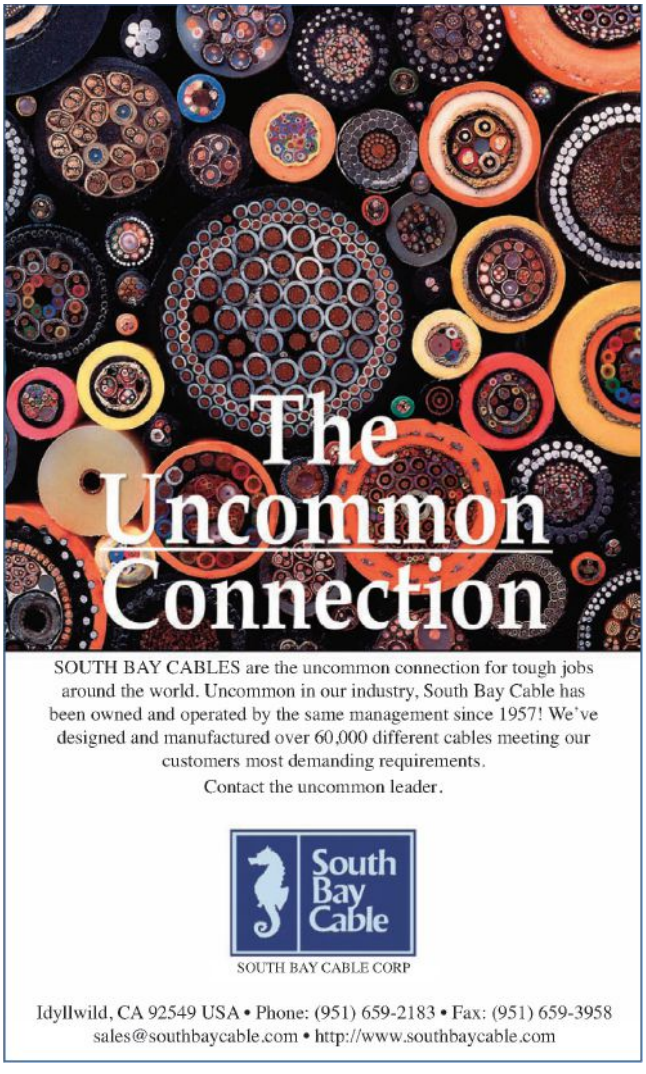
This agreement is the latest of a series of contracts awarded by TenneT, who have recently awarded Prysmian the DolWin5 grid connection project, supporting the growth of clean energy in Northern Europe.

www.prysmiangroup.com/en

SEABORN AND EDGEUNO PARTNER TO DELIVER MANAGED CLOUD SERVICES

Seaborn Networks is an independent developer/owner/operator of submarine fiber optic cable systems, and Latin American managed cloud services and datacenter company EdgeUno have announced the launch of their Latin American managed cloud and datacenter services.

The move comes amid Seaborn's expansion into the Latin American market. Seaborn launched IP and SD-WAN networks in Brazil in the past few months and, in partnership with EdgeUno as its managed cloud service provider, the two companies have deployed unique virtualized cloud infrastructure technology to provide clients with both physical and virtual infrastructure as a service—not just in Brazil, but throughout the region.



| DEFENSE |

PREPARE FOR AUTONOMOUS UNDERSEA CONFLICT

A NOTE TO THE U.S. NAVY'S NEW CHIEF OF NAVAL OPERATIONS, ADMIRAL MICHAEL GILDAY

By David Strachan via the Center for International Maritime Security (CIMSEC)

» *An unmanned surface vehicle (USV) is brought aboard Military Sealift Command's expeditionary sea base, USNS Hershel "Woody" Williams, after the ship's crew launched it into the Chesapeake Bay on 14 September 2019. The USV is a mine counter measure platform and the event marked the first time a USV has been launched and recovered by a Military Sealift Command ship. Photo credit Bill Mesta, U.S. Navy.*

Undersea warfare is entering an era of profound transformation due to the increasing sophistication and proliferation of unmanned systems. But while their roles, missions, and concepts of operation have been thoroughly analyzed, the ultimate deployment of autonomous, expendable vehicles in a shadowy, hostile environment could unfold in ways that have yet to be fully imagined. When this is considered against the current geopolitical backdrop of hybrid warfare and gray zone operations (with the line separating competition from conflict growing blurrier by the day), conditions are ripe for the emergence of a new front in great power rivalry that could redefine the very nature of undersea warfare.

Operating within an opaque, clandestine domain, autonomous undersea vehicles (AUVs) will employ kinetic and non-kinetic means to disrupt, degrade, and destroy, subsuming every aspect of undersea warfare under the umbrella of autonomous undersea conflict, including:

- **ISR:** AUVs will conduct *and actively counter* covert monitoring of maritime operations on the high seas, in the littorals, and within ports, coastal facilities, and inland waters.
- **Mine Warfare:** No longer simply "weapons that wait," AUVs will surveil, penetrate, blockade, stalk, strike, *and defend against* such operations by adversary vehicles.
- **ASW:** AUVs will detect, classify, track and engage adversary submersibles, *and will actively disrupt and degrade* adversary ASW operations.
- **Seabed Warfare:** AUVs will disrupt, infiltrate, strike *and defend* critical seabed infrastructure, such as undersea cables, recharging and data exfiltration stations, and listening posts.

In order to prepare for autonomous undersea conflict, future force investments should emphasize the counter-UUV (CUUV) mission, specifically:

- **Artificial Intelligence:** CUUV operations will require highly advanced AI, as they will occur in a complex, dynamic, communications-denied environment, and under intense conditions that demand rapid-fire decision-making based on real-time situational and contextual awareness.
- **Energy:** The complexity of CUUV operations will demand high levels of stored energy to power advanced processing and sophisticated payloads, as well as the propulsive power and maneuverability required for kinetic engagements.
- **Collaboration:** Pods of AUVs working together will provide expendability, redundancy, wide operating coverage, and will provide tactical overmatch during CUUV engagements.
- **Miniaturization:** Small, expendable, agile, and lethal AUVs will be preferable to slower, larger, high-value AUVs which will be vulnerable to adversary CUUV operations.
- **Weaponization:** CUUV operations will include non-kinetic effects to deceive, disrupt and degrade, and to infiltrate adversary undersea networks. Kinetic effects will include proximity and contact detonation for near or complete target neutralization, or "true" kinetic energy strikes to achieve mission kills.

For now, autonomous undersea conflict is the stuff of science fiction, and perhaps this vision may not come to fruition within the next few years. But an autonomous undersea revolution is coming, and with it the need to anticipate and prepare for the myriad operational scenarios that could ensue. The plans laid today will ensure that the Navy stands ready to confront the challenges and opportunities of tomorrow.

About the Author: David R. Strachan is a naval analyst and founder of Strikepod Systems LLC (www.strikepod.com), a provider of current and strategic fiction intelligence (FICINT) on global naval affairs, with an emphasis on unmanned undersea systems.

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

L3HARRIS TECHNOLOGIES DELIVERS ADVANCED AUTONOMOUS VEHICLE CAPABILITY TO UK'S DEFENCE SCIENCE AND TECHNOLOGY LAB

L3Harris Technologies has delivered a new class of Autonomous Surface Vehicle (ASV) with advanced capabilities to enable the United Kingdom's Royal Navy to understand how to maintain a technical advantage over potential adversaries. The Maritime Autonomy Surface Testbed (MAST) 13 is a 13-meter (41-foot) long high-speed system capable of fully autonomous navigation. The ASV uses L3Harris' ASView proprietary autonomous control system and advanced algorithms developed for the U.K.'s Defence Science and Technology Laboratory (DSTL).

Designed, built and commissioned by L3Harris' Unmanned Maritime Systems team based on the south coast of the UK, MAST 13 was officially launched on 11th September at DSEI in London.

The system carried out unmanned surveillance and force protection in the Victoria Dock at DSEI.

"MAST 13 reflects the increased use of unmanned systems in the military domain. This vehicle serves as a test platform to support new concepts for the Royal Navy, allowing them to exploit unmanned systems and maintain a technical advantage," said Alasdair Gilchrist, Above Water Systems Program Manager, DSTL.

"Our long-standing collaboration with DSTL enables us to provide the Royal Navy with the industry's most advanced autonomous capability. MAST 13 combines fit-for-purpose design with integrated advanced autonomy," said Mark Exeter, Managing Director, L3Harris Unmanned Maritime Systems UK.

Since 2014, L3Harris and DSTL have collaborated to develop ASVs that support new concepts for the Royal Navy and act as a testbed for innovative technologies.

Predecessor MAST systems developed by L3Harris and DSTL have carried out numerous high-profile operations, including the Royal Navy's Unmanned Warrior in 2016 and the Australian Defence Showcase, Autonomous Warrior in 2018. MAST 9 is currently in Portugal for the NATO exercise 'REPMUS.' The high-speed vessel is operating autonomously, beyond line-of-sight, to carry out reconnaissance, interdiction and patrol tasks.

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JOINT EXERCISE SUPPORTS **NATO'S MARITIME UNMANNED SYSTEMS INITIATIVE**

» *A sensor buoy is taken off the Portuguese Navy survey vessel NRP Dom Carlos I during exercise REP (MUS) 19.*

Dozens of unmanned underwater, surface and air vehicles from NATO countries gathered in Portugal from 11 to 27 September 2019 to test new technological advances in unmanned maritime systems networks. The exercise—Recognized Environmental Picture, Maritime Unmanned Systems 2019, a.k.a. REP(MUS) 19—tested the ability of NATO Allies to integrated and share information gathered by unamend systems in operational contexts.

New maritime unmanned systems technologies can be a game-changer in countering multiple threats in the maritime domain. Using Maritime Unmanned Vehicles can help effectively counter new submarines armed with more powerful weapons. They can also prevent military personnel from moving into risky situations in countering threats like sea mines.

Kevin Moyer, Steering Board Chairman, NATO Maritime Unmanned Systems Initiative talked about why unmanned systems are important to NATO allies, "We can't cover everything with manned assets. One, it's a cost problem. And number two, you want to keep the man out of that danger zone. So that's a huge asset, having that unmanned system out there. It's a cost thing. The system's probably going to be lighter, cheaper, easier to get there than sending guys in. So, you know, that safety factor. You might not care if you lose that unmanned system; you're going to care if you're putting those guys in danger. So unmanned system, it's cheap—relatively—so you don't necessarily care if you lose it as long as you get the data back that you're sending it out there for a mission."

Andrea Bell-Miller, International Director, US Navy Program Executive Office, Unmanned and Small Combatants, added, "In a wartime scenario, you want to be able to make... you want to be able to have the force projection which you get from working with our Allies. You want to be interoperable, because that has obvious synergies. And you want to be able to have the most relevant, up-to-date information consolidated into a decision-making tool, which is what we've done here."

Around 800 personnel from the Portuguese Navy, as well as from Belgium, Italy, Poland, Turkey, the United Kingdom and the United States, and the NATO Centre for Maritime Research and Experimentation contributed to the exercise, which was also supported by academia and industry.

NaxyX, the Royal Navy's experts in getting unmanned technology rapidly to the frontline spent time in Portugal working with a dozen NATO allies to develop

» *NaxyX have been working with NATO allies on an unmanned exercise in Portugal. Photo credit: L3Harris.*

» *Wave Glider, an unmanned system operated by the NATO Centre for Maritime Research and Experimentation, rises from the sea during exercise REP(MUS) 19. Image courtesy of NATO.*

tactics and techniques so autonomous vessels can be deployed to their full potential on future operations. This is the first time NaxyX has worked with allies like this and it played an important role in the two-week exercise.

Commander Sean Trevethan, Fleet Robotics Officer for the navy, said, "NaxyX has been at the heart of this exercise—delivering multiple unmanned surface vessels and the Command and Control Architecture known as MAPLE. Marworks provided the communications network with all the systems and assets which included a US navy destroyer and a Portuguese frigate. This is the Royal Navy learning by doing, delivering in the real world and developing capability that will be ready for operations."

» *Aerographer's Mate 2nd Class Christopher York, assigned to Naval Oceanographic Mine Warfare Center and a native of Seattle, and Petty Officer 1st Class Antonio Cernicchiaro, a REMUS Team Sailor from the Italian Mine Countermeasures Forces Command, deploy a Remote Environmental Measuring Units (REMUS) 100 unmanned underwater vehicle (UUV) during exercise REP(MUS) 2019. Photo credit: Chief Mass Communication Specialist Travis Simmons, U.S. Navy.*

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GETTING TO ZERO: MARITIME INDUSTRY GETS SERIOUS ABOUT EMISSIONS

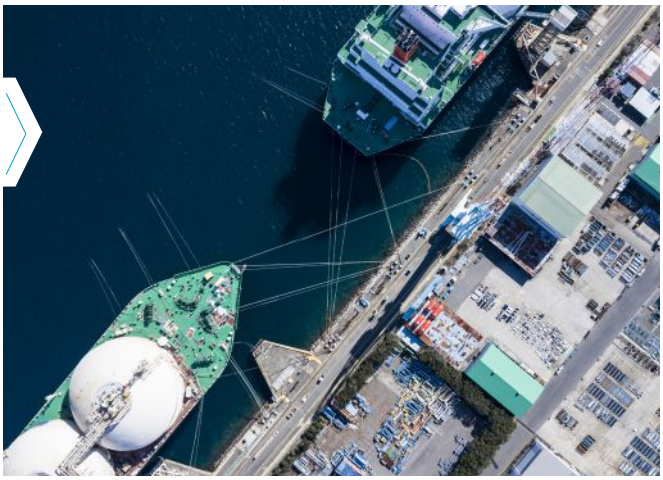
THE GETTING TO ZERO COALITION WILL LEAD THE PUSH FOR SHIPPING'S DECARBONIZATION WITH THE MUTUAL GOAL OF HAVING COMMERCIALLY VIABLE ZERO EMISSION VESSELS OPERATING ALONG DEEP SEA TRADE ROUTES BY 2030.

Before heads of state and government at September's UN Climate Action Summit in New York, members of the Getting to Zero Coalition—a powerful alliance representing senior leaders within the maritime, energy, infrastructure and finance sectors, supported by decision-makers from government and IGO's—announced, that they will lead the push for international shipping's decarbonization.

The ambition of the Getting to Zero Coalition is closely aligned with the UN International Maritime Organization's Initial GHG Strategy. The strategy prescribes that international shipping must reduce its total annual greenhouse gas emissions by at least 50% of 2008 levels by 2050, while pursuing efforts towards phasing them out as soon as possible in this century. This will ultimately align greenhouse gas emissions from international shipping with the Paris Agreement. The Coalition is committed to making this ambitious target a reality by getting commercially viable deep sea zero emission vessels powered by zero emission fuels into operation by 2030. International shipping carries around 80% of global trade and accounts for 2-3% of global greenhouse gas emissions annually. Emissions are projected to grow by between 50 and 250% by 2050 if no action is taken.

The Getting to Zero Coalition is a partnership between the Global Maritime Forum, the Friends of Ocean Action, and the World Economic Forum. The Coalition is supported by more than 70 public and private organizations.

"Decarbonizing maritime shipping is a huge task with no simple answer, but it



has to be done," say Ben van Beurden, CEO of Royal Dutch Shell. "We intend to be part of the long-term, zero-carbon, solution by seeking out the most feasible technologies that can work at a global scale. Starting now is essential because ships built today will stay on the water for decades."

"Energy efficiency has been an important tool which has helped us reduce CO2 emissions per container with 41% over the last decade and position ourselves as a leader 10% ahead of the industry average. However, efficiency measures can only keep shipping emissions stable, not eliminate them. To take the next big step change towards decarbonization of shipping, a shift in propulsion technologies or a shift to clean fuels is required which implies close collaboration from all parties. The coalition launched today is a crucial vehicle to make this collaboration happen," says Søren Skou, CEO of A.P. Møller Mærsk.

Shipping Can Accelerate The Broader Energy Transition

If international shipping becomes a reliable source of demand for zero emission fuels, the Getting to Zero Coalition may prove to be a catalyst for the broader energy transition. Steady demand can increase confidence among suppliers and translate into an increased supply of feasible zero emission fuels, thus bolstering an important point of leverage for change across other hard-to-abate sectors.

New marine fuels, derived from abundant untapped renewable resources, could also bring substantial development gains. Ports and shipping already underpin many countries' economic growth; if shipping becomes a reliable source of demand for zero emission fuels, it has the potential to drive investment in energy projects in developing and middle-income countries, according to the Getting to Zero Coalition.

"Climate change is a serious social and economic challenge that requires urgent action from both the public and private sectors," says Michael Corbat, CEO of Citigroup, and coalition member. "We are hopeful that the work of the Getting to Zero Coalition will inspire other hard-to-abate sectors to work together towards accelerating the decarbonization of their industries as global trade flows—and consequently carbon emissions—continue to rise."

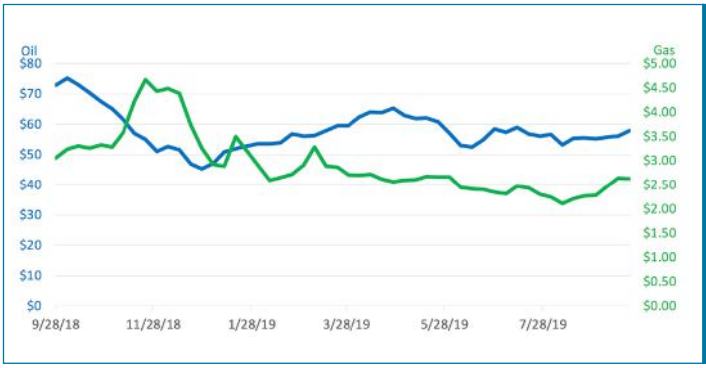
www.globalmaritimeforum.org/getting-to-zero-coalition

CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF SEPTEMBER 20, 2019

Oil prices were little changed in the past month, increasing only $2.61 during the month. This was in spite of the attack on the drone and missile attack on the Saudi Aramco Abqaiq and Khurais oil facilities that took out 5.7 million barrels per day of crude. Initial fears over a major increase in oil prices due to the attack did not materialize and Reuters reported on September 30 that Saudi oil output had returned to pre-attack levels. Prices have remained very steady throughout the year, ranging from $50-$60 per barrel on the WTI Spot Prices for almost the entire year. At press time, however, Bloomberg and other sources reported concerns that prices could drop due to recession fears and high inventories.

Natural gas prices rebounded from a 10-year low level in mid-August to over $2.60 per million BTU on the Henry Hub Spot Prices by late September. This is the highest price level for natural gas since April. As with oil, however, news sources were expressing concerns that prices might fall again, due to high inventories.



WEEKLY WTI CRUDE & NATURAL GAS SPOT PRICES

Last 52 Weeks

WTI Spot Price

$57.92

$55.31 previous month

TRENDING DOWN

Henry Hub Spot Price

$2.63

$2.27 previous month

TRENDING DOWN

KEY EQUITY Indexes

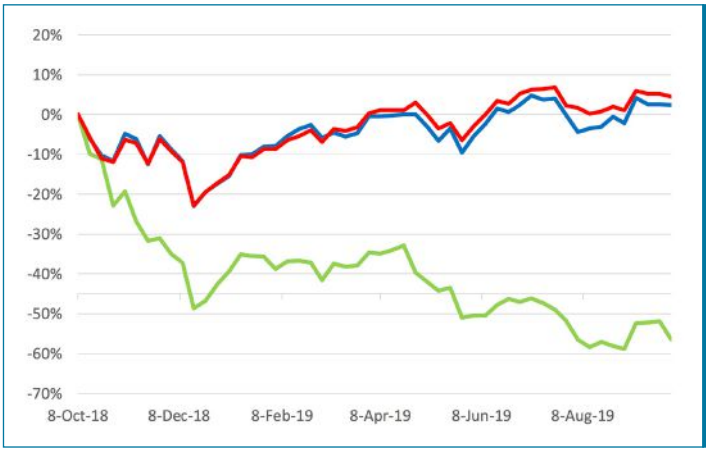
PRICES IN US DOLLARS AS OF SEPTEMBER 30, 2019

EQUITY INDEXES CONTINUED
to show volatility in the past month

Equity indexes continued to show volatility in the past month. While the Dow Jones saw mostly gains in September, including a huge gain of over 1,000 points in one week early in the month due to easing of fears the US-China trade war. At this point, the Dow was again over the 27,000-point mark, before drifting do to just under 27,000 by September 30. Although the market trended upward throughout September, indications at press time were for a downturn in early October due to recession fears. The S&P 500 showed a similar pattern, with a one-week gain of over 100 points in September to surpass the 3,000-point mark, before dropping under that threshold by the end of the month.

The Philadelphia Oil Services Index (OSX) also had gains during most of September, but began a downturn in the last week of the month. The OSX ended September near the lowest point of the year in the mid-60s.

SELECTED EQUITY INDEXES



CUMULATIVE PERCENTAGE CHANGE

Last 52 Weeks

26,916.83

Up **798.81** from previous month

TRENDING UP

DJIA

65.50

Up **61.97** from previous month

TRENDING UP

OSX

2,976.74

Up **70.47** from previous month

TRENDING UP

S&P 500

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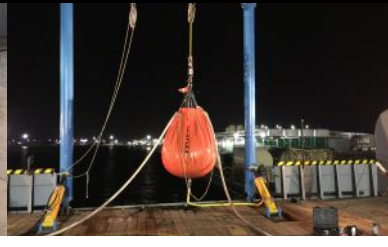


OKEANUS
SCIENCE & TECHNOLOGY

EVENTS BEYOND BASIC SUPPLY & DEMAND DOMINATE COMMODITY MARKETS

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

Crude Oil

In recent weeks, crude oil prices have been volatile. The volatility was magnified by an attack on Saudi Arabia's largest petroleum processing facility and a significant oil field. The drone and cruise missile attack inflicted meaningful damage, initially shutting down 50 percent of Saudi Arabia's oil production, the equivalent of roughly five percent of the globe's total supply. The market shock, along with uncertainty about the duration this supply would be off-line, sent oil prices soaring.

The attack occurred on a Saturday morning. By the time commodity markets opened for trading Sunday night, global oil prices were up as much as 20 percent. This was a natural response to uncertainty, as prices signal suppliers to increase their output and consumers to cut consumption. Without both responses, the globe's supply/demand will become and remain unbalanced.

Chaos ruled the first day of oil trading. Saudi Aramco declared it would sustain its export volumes, but importantly, that full operation of the damaged facilities would be restored within days and weeks, not months. With the fires snuffed out, damage assessments began and the optimism of an early return of production caused oil traders to sell, after their panic buying had driven WTI up 15 percent. Over the next two days, WTI's price fell nearly eight percent before stabilizing, as traders believed the optimism for an early return of supply.

Since then, oil prices have fluctuated based on commodity traders' interpretation of the latest news from Saudi Aramco. Prices rose when news emerged that the Saudis were seeking to obtain crude oil and refined petroleum products for its own use, as it seemed Saudi's optimism about the speed of its output return was premature. The Kingdom reaffirmed it would meet all its export obligations, however, customers were told of adjustments to the mix of grades of oil they would receive. This was necessitated by the loss of the processing facility's capacity to upgrade oil volumes.

Where do oil prices go from here? The world is in the midst of its weak demand period. That means oil inventories will likely grow. The attack raises the possibility of future attacks, raising geopolitical tensions, yet surprisingly, the risk premium in oil prices that came with the Iranian tanker attacks, has largely disappeared. Thank the U.S. shale industry for altering that historical pattern.

For the foreseeable future, the oil market is likely to function much as it was doing before the attack. Global economic growth forecasts by the IMF were cut once again, which means reduced oil demand projections. The brief spike in oil prices will not alter producer drilling and production plans. In fact, oil price stability in the mid-$50s has prompted an increase in offshore and international activity that will bring more oil to market in 2020 and beyond. The yin-and-yang of supply and demand will control oil price moves in the near-term. It revolves around the question: Will there be a recession, or not? Sentiment on that question will drive global oil prices.

Natural Gas

A month ago, natural gas prices were flirting with $2 per Mcf. Despite growing LNG and pipeline exports, the lack of power and industrial demand growth had the market struggling to deal with growing gas supplies. That struggle has contributed to rapidly rising storage volumes, which are now essentially at the 5-year average and likely headed higher. Last month's conditions shifted, driving gas price higher. Today, we are at $2.50 per Mcf, significantly higher than last month.

The gas market has been impacted in recent weeks by a number of factors – some positive and others negative – but the latter ones are capping prices and likely sending them lower. That view is tied to the seasonal temperature change underway - shifting from hot to cold. During the transition, the number of cooling days falls while heating days don't grow to offset the gas demand loss.

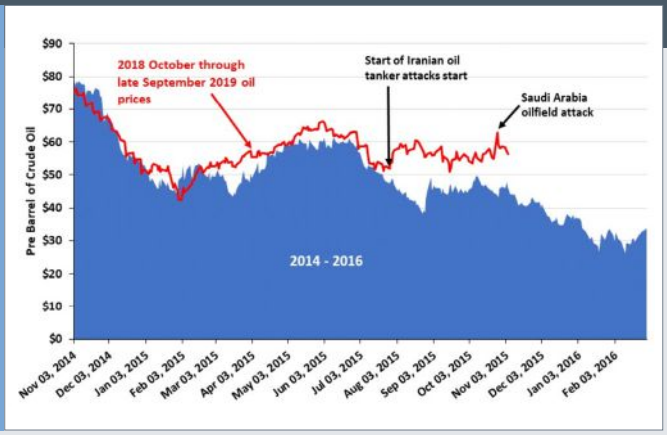
Amazingly, gas production continues to grow, although the rate of increase is slowing, primarily due to the downturn in oil drilling and its associated gas output. Without a resumption of gas production growth, when demand peaks this winter, we could see sharply higher gas prices in response.

LNG prices are now higher than gas prices in Europe, the favorite target for spot sales. As a result, Gulf Coast LNG storage tanks are nearly full, meaning that any disruptions such as in tanker operations or finding LNG buyers, pipeline flows to the Gulf Coast could slow, backing up supplies and pushing prices down. At the same time, nuclear plant outages are lower than normal, wind speeds and hydro volumes are up helping renewables, but critically, coal prices have fallen below natural gas prices, boosting coal-to-gas switching. The cumulative impact has seen lower gas demand, which has stopped prices from rising, and potentially causing them to start sliding.

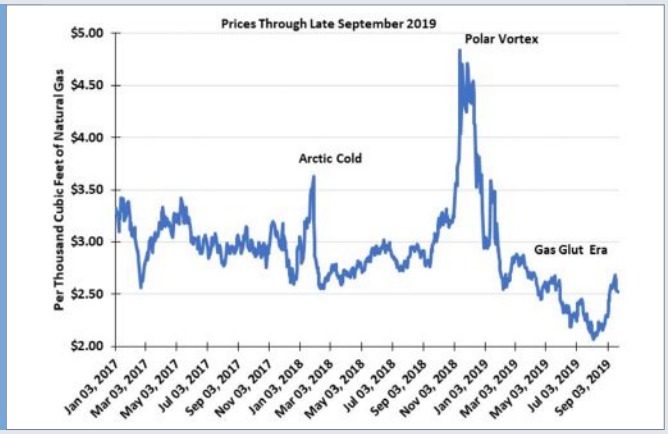
Near-term, natural gas prices are not impacted by the climate change debate. Efforts to stop gas from growing are increasing. Studies highlighting increased natural gas leaks in urban areas and from fracking activities have been published. Several studies have questionable foundations, but they help environmentalists argue for ending natural gas use in favor of more expensive wind and solar power. Once considered the bridge fuel to a cleaner world, gas is now viewed as the enemy of renewables due to its lower cost and dispatchability. Without natural gas-fired generators to back up renewable power sources, electricity grids will become less stable, increasing disruptive and expensive blackouts.

Natural gas prices are likely heading lower in the near future, which will further widen the divergence with crude oil prices. Wildcards that could alter our view of the future of gas prices include LNG storage, hurricane supply disruptions and slower supply growth. The greatest threat to, and hope for, gas prices is LNG exports, as U.S. prices must be lower to improve spot LNG sale economics. Lower prices will help consumers and LNG operators, but hurt producers. That may be the environment until the winter snows arrive.

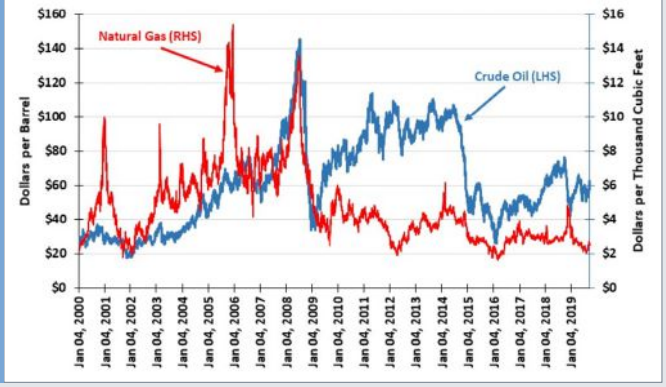
Geopolitical Tensions Have Supported Oil Prices Higher Than Fundamentals Would Dictate



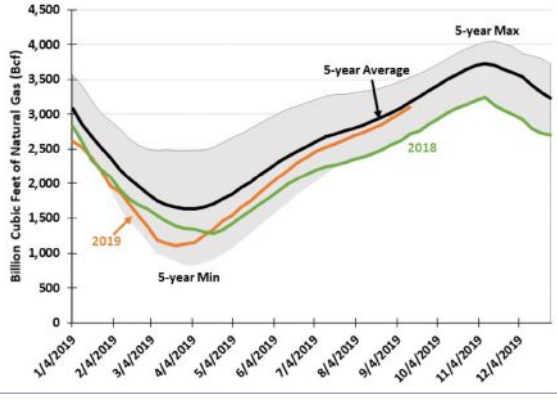
2019 Natural Gas Prices: After Disappointing Are Rising



Since 2009, Oil & Natural Gas Prices Have Diverged



Low Natural Gas Prices Helping Rebuild Storage





AMERICAS

GIPEX
Georgetown, Guyana » November 6-8
www.guyanaoilexpo.com

BlueTech Week
San Diego, CA » November 18-22
www.bluetechweek.org

Workboat
New Orleans, LA » December 4-6
www.workboatshow.com

Blue Innovation Symposium
Newport, RI » January 14-16, 2020
www.blueinnovationsymposium.com

PTC
Honolulu, HI » January 19-22, 2020
www.ptc.org/ptc20

Offshore Wind Executive Summit
Galveston, TX » February 4, 2020
www.offshorewindsummit.com

Underwater Intervention
New Orleans, LA » February 4-6, 2020
www.underwaterintervention.com

Subsea Tieback
San Antonio, TX » February 18-20, 2020
www.subseatiebackforum.com

Canadian Hydrographic Conference
Quebec City, Canada » February 24-27, 2020
www.chc2020.org

Decommissioning & Abandonment Summit
Houston, TX » March 31 – April 1, 2020
www.decomworld.com/gom

EUROPE

WindEurope Offshore
Copenhagen, Denmark
» November 26-28
www.windeurope.org/offshore2019

Surface Warships
London, UK » January 28-30, 2020
www.defenceiq.com/events-surfacewarships

Euromaritime
Marseille, France
» February 4-6, 2020
www.euromaritime.fr

Subsea Expo
Aberdeen, UK
» February 11-13, 2020
www.subseaexpo.com

Submarine Networks EMEA
London, UK » February 18-19, 2020
www.terrapinn.com/conference/submarine-networks-world-europe

Undersea Defense & Security
Southampton, UK » March 3-5, 2020
www.defenceleaders.com/home/events-page/underwater-defence-security

Seabed Mapping and Survey
Geilo, Norway » March 4-6, 2020
www.tekna.no/en/events/seabed-mapping-and-survey-38497/

Oceanology International
London, UK » March 17-19, 2020
www.oceanologyinternational.com

Eastern Mediterranean Offshore
Cyprus » April 7-9, 2020
www.emc-cyprus.com

OTHER REGIONS

East Africa Oil & Gas
Dar-es-Salaam, Tanzania
» November 7-9
www.expogr.com/tanzania/oilgas

ADIPEC
Abu Dhabi » November 11-14
www.adipec.com

Oceanology International China
Shanghai » November 13-15
www.oichina.com.cn/en/home

Asia-Pacific Deep Sea Mining Summit
Singapore » December 4-5
www.asia.deepsea-mining-summit.com

Asia Defense Expo & Conference Series
Singapore » February 4-5, 2020
www.asia-decs.com

Asia Pacific Maritime
Singapore » March 18-20, 2020
www.apmaritime.com

OTC Asia
Kuala Lumpur, Malaysia
» March 24-27, 2020
www.2020.otcasia.org

OCEANS '20
Singapore » April 6-9, 2020
www.singapore20.oceansconference.org

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The Blue Innovation Symposium is New England's premier event for connecting the marine technology industry. 2020's theme, ***Sensors and the Next Wave of Data***, is set to gather key stakeholders from the Blue Tech community to discuss the trends shaping the industry, whilst also showcasing the start-ups and breakthrough technologies making sensors smarter, more reliable and cost effective for the maritime industry, research organizations, and state and federal agencies.

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information and registration at:
blueinnovationsymposium.com

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TSC STRATEGIC

BLUETECH WEEK TO INTEGRATE UN AGENDA FOR SUSTAINABLE DEVELOPMENT, INNOVATION CLUSTERS AND THE TRIPLE HELIX

Attendees at BlueTech Week 2019 in San Diego California 18-22 November 2019 will not only be exposed to opportunities via the United Nations (UN) 2030 Agenda for Sustainable Development, they can exchange ideas with representatives from academia, industry, and policymakers about how to develop innovation clusters that support this agenda.

Sustainable Development with a Triple Helix Twist

Maintaining healthy oceans is a fundamental precondition for business to operate in the long-term, and addressing this challenge provides a significant business opportunity for those who are willing to engage. One framework for engagement is the UN 2030 Agenda for Sustainable Development, which was adopted in 2015, and which will continue to drive innovation via related initiatives. One of the things the Agenda does is provide a framework for identifying which sustainability goals match an organization's mission.

In this context, while representing themselves at BlueTech Week 2019, organizations from each strand of the Triple Helix—Academia, Industry, and Policymakers—will be encouraged to identify which of the 17 global Sustainable Development Goals (SDGs) fit their own mission.

These could include SDG6: Clean Water & Sanitation, SDG7: Affordable & Clean Energy, SDG 13: Climate Action, SDG14: Life below Water, or SDG17: Partnerships for the Goals. Displaying the relevant SDG symbol, encourages networking opportunities.

Two of BlueTech Week's keynote speakers—Ariel Troisi, Chair of the IOC (International Oceanographic Commission, part of UNESCO) and Erik Giercksky, Head of the UN Global Compact's Action Platform for Sustainable Ocean Business—should have plenty of insight when it comes to this exciting agenda. Numerous agenda items for other speakers will touch on related topics, such as how the Triple Helix model (university-industry-government relationships) can support innovation clusters and initiatives, building a workforce, and more.

Other Topics

Of course, that's not all, it's just the framework. Within this framework will be an entire agenda of speakers and presentations including:

- Aquaculture/BioMarine/Biomimicry/Fishing Technologies
- Blue Economy Workforce of Tomorrow; Defense, Security & Robotics
- Offshore Renewable Energy
- Smart Ports, Smart Transportation and Ocean Protection
- Water/Wastewater Technology
- UN Decade of Ocean Science

» *Conceição Santos, University of Porto, speaks about a sustainable ocean economy during BlueTech Week 2018.*

Also, Green Connections 2019 will be co-located with BlueTech Week 2019 for the very first time and Thursday registration to the BTW2019 BlueTech Summit & Tech Expo includes registration to GC2019.

Plan Your Networking with the App

If you want to get the most out of this event, you need the app. Aside from a personal event agenda, interactive map, document sharing, note taking, and other logistics, it includes networking options, attendee profiles, and messages. Of course, it also allows you to interact with event activities through comments, ratings, live polling, tweeting, and more. It even provides access to information about ridesharing and local attractions through the app's Community Board. All of this makes the official app of BlueTech Week and Green Connections an essential download.

Attendees and Exhibitors

The event's organizers are expecting 700+ attendees from 18-20 countries including representatives of 150+ companies and investment groups and 45-50 tabletop exhibitors showing innovative BlueTech technologies and services at BTW2019.

BTW2019 also includes a 2-day Tech Expo as part of the BlueTech Summit, on Wednesday, November 20th and Thursday, November 21st. BlueTech Week is not a trade show, but the tech expo provides an opportunity for 40-50 table-top exhibitors to showcase their organization during breaks, lunches and networking sessions among key participants.

Accommodations & Travel

BlueTech Week includes 7 events over 5 days in various locations around San Diego, California. Guests should arrange to land at San Diego International Airport (SAN), which is located in the center of San Diego and less than 10 minutes from the hotel venue for Wednesday-Friday events.

Just a half-mile from the airport, the Sheraton San Diego Bay Tower Hotel & Marina is the venue for the BTW2019. Guests are encouraged to book a hotel room at the Sheraton Bay Tower Hotel & Marina at the BTW2019 discounted rate, but space is limited.

For more information about how to attend, exhibit at or sponsor BlueTech Week, visit *bluetechweek.org*.

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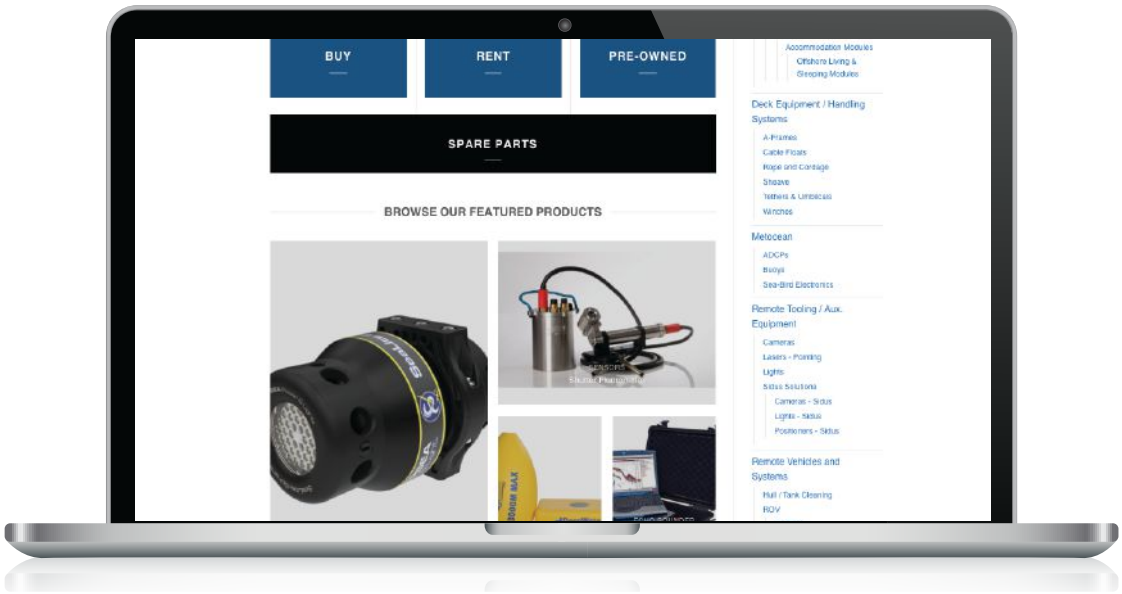

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Contact: Paul Devine

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Fax: +1 207 221 5718
E-mail: sales@deepwb.com
Website: www.DeepWaterBuoyancy.com
Contact: Dan Cote, Sales Manager

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

NAUTILUS MARINE SERVICE GMBH

Alter Postweg 24
Buxtehude, 21614, Germany
+49 (0) 41618 66250
info@nautilus-gmbh.com
Website: www.vitrovex.com
Contact name: Steffen Pausch

Nautilus Marine Service provides the finest VITROVEX® glass housings that are capable of operating in the most extreme regions of the Earth. VITROVEX® glass enclosures offer the dual advantage of buoyancy and pressure proof housings - a perfect combination for small and autonomous underwater instrumentation packages.

Simple, reliable and affordable.

SUBSALVE USA

P.O. Box 2030
North Kingstown, RI 02852
Phone: 401-884-8801
Fax: 401-884-8868
E-mail: richard@subsalve.com
Website: www.subsalve.com
Contact: Richard Fryburg

Since 1977 Subsalve USA has been America's #1 manufacturer of standard and custom flotation devices and we are the innovators in buoyancy and engineered inflatables. Our products include: Professional, Commercial, Standard, Shallow Water, Enclosed Flotation Bags, Cable & Pipeline Floats, Water Load Test Bags, Rapid Recovery & Mark V/ORCA EOD Systems.

CAMERAS / LIGHTS / LASERS

ARTIC RAYS LLC

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E-mail: lee@articrays.com
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Contact: Lee Fray

Arctic Rays LLC is a specialist in the design and manufacture of deep sea lighting and imaging products specifically for use on AUVs, but also prove ideal for manned vehicles and all other underwater, surface vehicles or platforms. Our designs feature the smallest possible size and lowest power consumption available.

CATHX OCEAN

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Newhall, Naas,
Kildare W91F780
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Ireland: + 353 (0) 45 252 786 / UK: +44 (0) 1224 432 180 / USA: +1 (832) 808-3403
E-mail: apastor@cathxocean.com
Website: www.cathxocean.com
Contact: Alberto Lopez Pastor

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

Designed to meet stringent technical, operational and integration requirements associated with various subsea applications and vehicle types, Cathx Ocean's systems offer precision, reliability and peace of mind. Products include advanced still imaging, colour laser point cloud and video systems, designed to deliver precision subsea data in a way that allows automation for subsea vehicle operations.

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

DEEPSEA POWER & LIGHT

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Email: sales@deepsea.com
Website: www.deepsea.com

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

Design criteria for products include ease of service, reliability, high performance, and cost effectiveness. Products are rigorously tested in both the initial design process and manufacturing stage to perform in the harsh marine environment–from wet/dry surface applications to full ocean depth deployments. DeepSea Power & Light offers a versatile product line while developing new designs to continue exceeding market expectations.

SIDUS SOLUTIONS, LLC

7352 Trade Street
San Diego, CA 92121
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Email: info@sidus-solutions.com
Website: www.sidus-solutions.com

SIDUS Solutions LLC, 'SIDUS' is a worldwide company that designs, manufactures and installs systems in the most extreme of environments. SIDUS products include Cameras, Pan & Tilts, Lights and Lasers for use in hazardous areas for and SUBSEA, serving the, energy, scientific, military, nuclear, and shipping industries. Engineering experience makes us the perfect choice for application specific surveillance systems to provide end to end safety and security. SIDUS provides complete integration, design, documentation, and commissioning for all systems. From sea-floor observation platforms, to surveillance systems on drilling rigs, or sonar deployment systems - SIDUS is a field proven solution.

CABLES

CORTLAND COMPANY

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Website: www.cortlandcompany.com
Contact: Marco Cano

Cortland has more than 30 years of manufacturing experience supplying custom-designed electro-optical-mechanical cables. We provide solutions that meet the challenges posed by harsh environments, hydrostatic pressures, and high mechanical stresses.

We manufacture custom EOM cables assemblies for various subsea applications which include CTDs, hydrophones, magnetometer, tow cables, ocean bottom, ROV cables, and other custom application. Our global presence and industry-leading design engineers, manufacturing facilities, and management teams, work together to implement integrated solutions with unsurpassed reliability that support the needs of customers worldwide. Visit us online at cortlandcompany.com

SOUTH BAY CABLE CORP

54125 Maranatha Drive
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Idyllwild, CA 92549
Phone: (951) 659-2183
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E-mail: Sales@southbaycable.com
Website: www.southbaycable.com
Contact: Gary Brown, Sales Manager

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

CONNECTORS

BIRNS, INC.

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Fax: +1 805 487 0427
USA: +1 888 BIRNS 88 (+1 888 247 6788)
E-mail: service@birns.com
Website: www.birns.com
Contact: Eric Birns

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

BIRNS AQUAMATE LLC

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E-mail: sales@birnsaquamate.com
Website: www.birnsaquamate.com
Contact: Eli Bar-Hai

Birns Aquamate design and manufacture underwater electrical connectors, cable assemblies, and cable terminations. The company produces a wide range of standard industry products such as the **5500 Series, SC, MC, LP, FAWL/FAWM, NANO, TC, Rubber Molded, etc.** Birns Aquamate is the only manufacturer to guarantee compatibility with other uw connectors. Birns Aquamate also specializes in fast turn-around for custom design of special connector solutions. All connectors are manufactured under DNV ISO 9001:2000 certification. Dealers in Canada, Brazil, UK, Belgium, Holland, Norway, Germany, South Africa, Holland, Italy, and China.

SEACON

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El Cajon, CA 92020 USA
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E-mail: elcajonsales@te.com
Website: www.seaconworldwide.com

For the widest range of connectivity and sensor solutions designed for subsea applications, TE Connectivity (TE)'s portfolio includes over 2,500 underwater electrical and fiber optic connectors, and complete connectivity systems to give you a wide range of advanced connectivity options. The portfolio includes not only SEACON products, but DEUTSCH connectors, Rochester engineered cables, and TE sensors — giving you one-stop access to rugged, reliable solutions.

TELEDYNE MARINE

1026 N. Williamson Blvd.
Daytona Beach, FL 32114
Tel: 386-236-0880
E-mail: TeledyneMIS@teledyne.com
Website: www.teledynemarine.com

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

DESIGN & ENGINEERING

HYDRO LEDUC NA, INC.

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Houston, TX 77084
Tel: 281-679-9654
E-mail: bogden@hydroleduc.com
Website: www.hydroleduc.com

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.

DIGITAL VIDEO RECORDING SYSTEMS

DIGITAL EDGE SUBSEA, LTD

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

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.

Our version 5 software is currently in development and full details will be released soon...

EQUIPMENT RENTAL

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Fax: 985-346-8444
E-mail: Bleblanc@okeanus.com
Website: www.okeanus.com
Contact: Benton LeBlanc

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

SeaCatalog Vendor

FIBER OPTIC PRODUCTS/SERVICES

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Fax: +1 772 219 3010
Email: contact@oceanspecialists.com
Website: www.oceanspecialists.com

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.

GYRO COMPASSES

KONGSBERG SEATEX AS

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Fax: +47 73 51 50 20
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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.

LIQUID STORAGE

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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.

MARINE ENVIRONMENTAL CONSULTING SERVICES

CSA OCEAN SCIENCES INC.

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Contact: Gordon Stevens

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

MARINE VENTURES INTERNATIONAL, INC. (MVI)

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Contact: Kevin Comer

Marine Ventures International, Inc. (MVI) provides high quality, marine environmental and technical experts to conduct coastal and offshore field operations worldwide. We leverage our wealth of talent and resources to bring you a customized team of independent contractors, subject matter experts and specialized equipment to get the job done. Our professionals work in a variety of sectors from submarine cable projects and engineering services to protected species observation and environmental consulting.

MOTION SENSING EQUIPMENT

KONGSBERG SEATEX AS

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NAVIGATION & POSITIONING SYSTEMS

ADVANCED NAVIGATION

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E-mail: sales@advancednavigation.com.au
Website: go.advancednavigation.com/ONT

Advanced Navigation is a privately owned Australian company that specialises in the development and manufacturing of navigation technologies and robotics. The company has a focus on generating products of the highest quality standard, both in terms of hardware and software. Advanced Navigation has specialised expertise across a broad range of fields including sensors, GNSS, inertial navigation, RF technologies, acoustics, robotics, AI and algorithms. Advanced Navigation is an ISO 9001 certified company and maintains a strict quality control system across the two research facilities and three manufacturing facilities that they operate in Australia. Advanced Navigation is a carbon neutral company, offsetting all emissions due to energy use through the planting of trees.

EVOLOGICS GMBH

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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.

KONGSBERG SEATEX AS

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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.

RJE INTERNATIONAL, INC.

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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.

NETWORK & DATA COMS

KONGSBERG SEATEX AS

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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.

OCEANOGRAPHIC INSTRUMENTS/SERVICES

ASL ENVIRONMENTAL SCIENCES, INC.

Victoria, BC, Canada
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E-mail: asl@aslenv.com
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• **Metocean Equipment Leasing:** Acoustic Doppler Current Profiler ADCPs (including StreamPro & RiverRay), Ice Profilers, AZFP, acoustic releases, wave/tide gauges, pingers, satellite beacons, CTD+DO+Tu profilers, DO & turbidity loggers, weather station, cages, flotation, bottom frames.

•**Oceanographic Products:** Acoustic Zooplankton Fish Profiler (AZFP), Ice Profiling Sonar (IPS5) & shallow water Ice Profiler (SWIP), Imagenex scanning sonar logger (IRIS), instrument cages, bottom frames. Custom acoustic products and system integration.

• **Consulting:** Field work, data collection, analyses, numerical modelling, acoustics, remote sensing, oceanographic mooring design and system integration.

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

RBR

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

SEA-BIRD SCIENTIFIC

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Website: www.sea-birdscientific.com
Contact: Calvin Lwin, Sales

Sea-Bird Scientific provides best-of-class sensors and systems for oceanographic research and environmental water quality monitoring of physical and biogeochemical properties. Sea-Bird Scientific is the leader in accurate, stable ocean instruments for measuring conductivity (salinity), temperature, pressure, oxygen, pH, chlorophyll, CDOM, turbidity, beam attenuation, irradiance, radiance, PAR, nitrate, and phosphate. Our CTD profilers, water samplers, moored CT recorders, wave/tide recorders, DO sensors, and optical sensors are used by research institutes, ocean observing programs, government agencies, and navies globally.

STAR-ODDI

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Website: www.star-oddi.com
Contact: Baldur Sigurgeirsson

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

SONAR SYSTEMS

ECHOLOGGER

303 Venture Center,
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Goyang-Si, Gyungki-Do, 10540, Korea
Tel: +82-2-3158-3178
Email: info@echologger.com
Website: www.echologger.com
Contact: Doowon Choi

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

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

EDGETECH

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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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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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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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Fax: +47 56 11 30 69
E-mail: info@saivas.com
Website: www.saivas.no
Contact: Gunnar Sagstad

- STD/CTD, Sound Velocity probes/recorder with optional multi-parameter facilities; Turbidity, Fluorescence, Oxygen etc. The new CTD/STD model SD208 with wireless communication and high accuracy: 0.002 mS/cm, 0.002 °C.
- Precision pressure /depth (0.01% accuracy) and temperature sensors/recorders. Applications: hydrographic profilings, installation on ROVs and towed systems, etc. Robust and compact designs are combined with accuracy and "plug and play" compatibility. Output format for sonar equipment, e.g. EM1002, EM3000, SSP, HiPAP and Reson 8125.

SUBSEA FABRICATION

NEW INDUSTRIES

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E-mail: bill.new@newindustries.com
Website: www.newindustries.com
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.

SUBSEA TECHNOLOGY

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

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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.

UNMANNED MARITIME VEHICLES

GENERAL DYNAMICS MISSION SYSTEMS' BLUEFIN ROBOTICS PRODUCTS

553 South Street
Quincy, MA 02169
Tel: +1 617 715 7000
E-mail: adam.mara@gd-ms.com
Website: gdmissionsystems.com/underwater-vehicles/bluefin-robotics
Contact: Adam Mara

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

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

INTERNATIONAL SUBMARINE ENGINEERING LTD. (ISE)

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Port Coquitlam, BC, V3C 2M8
Tel: 1-604-942-5223
E-mail: info@ise.bc.ca
Website: https://ise.bc.ca/

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

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

L3 OCEANSERVER, INC.

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E-mail: sales@ocean-server.com
Website: www.iver-auv.com
Contact: Jim Kirk

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

The Iver UUV is an affordable, simple to operate commercial system for military, survey, water quality, and research applications.

OUTLAND TECHNOLOGY

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E-mail: jeff@outlandtech.com
Website: www.outlandtech.com
Contact: Jeff Mayfield

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Tel: +1 858-842-2600
E-mail: oceanscience.sales@teledyne.com
Website: www.teledynemarine.com/oceanscience
Contact: Jamie Carrig

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Contact: Jamie Carrig

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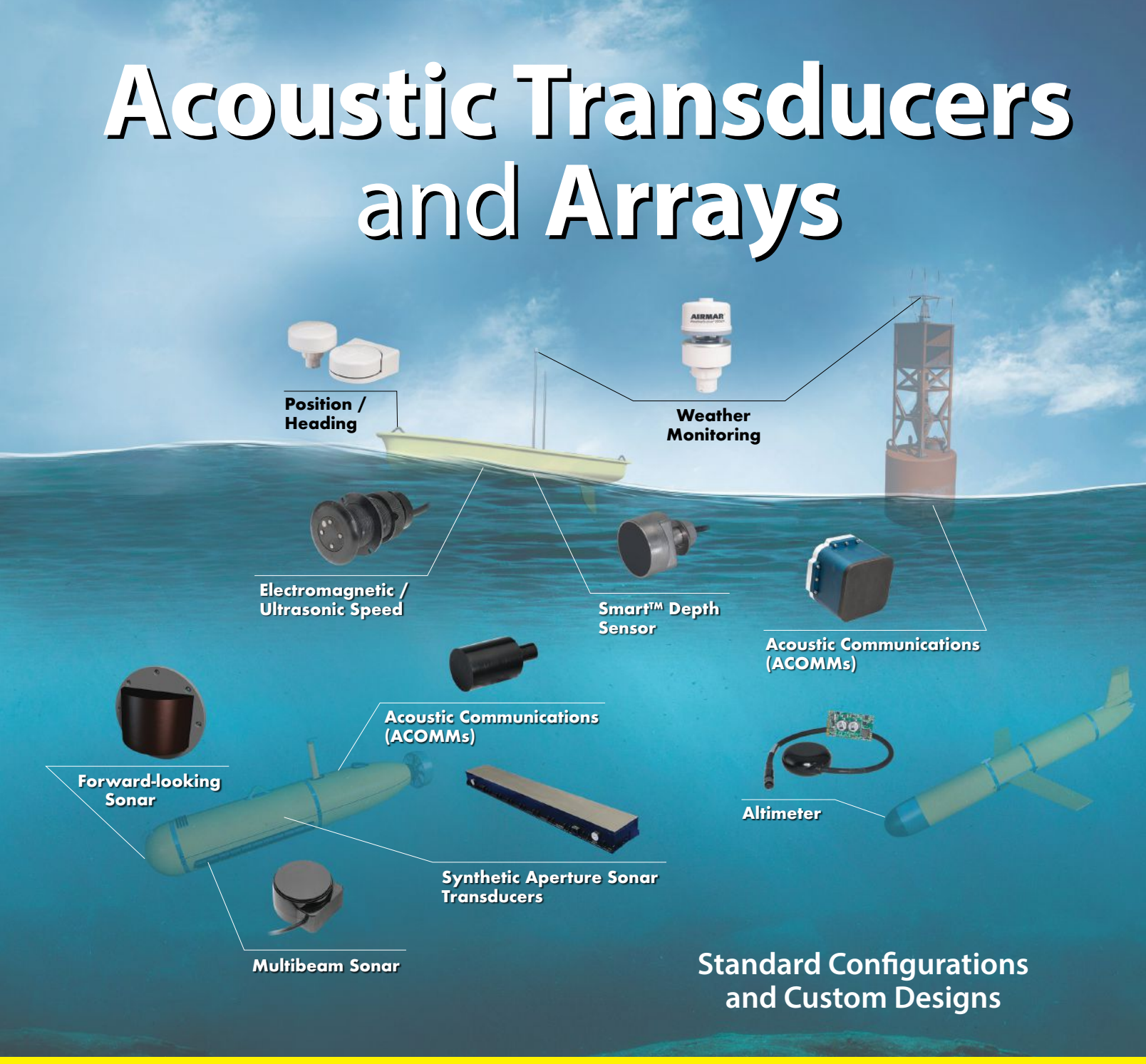

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