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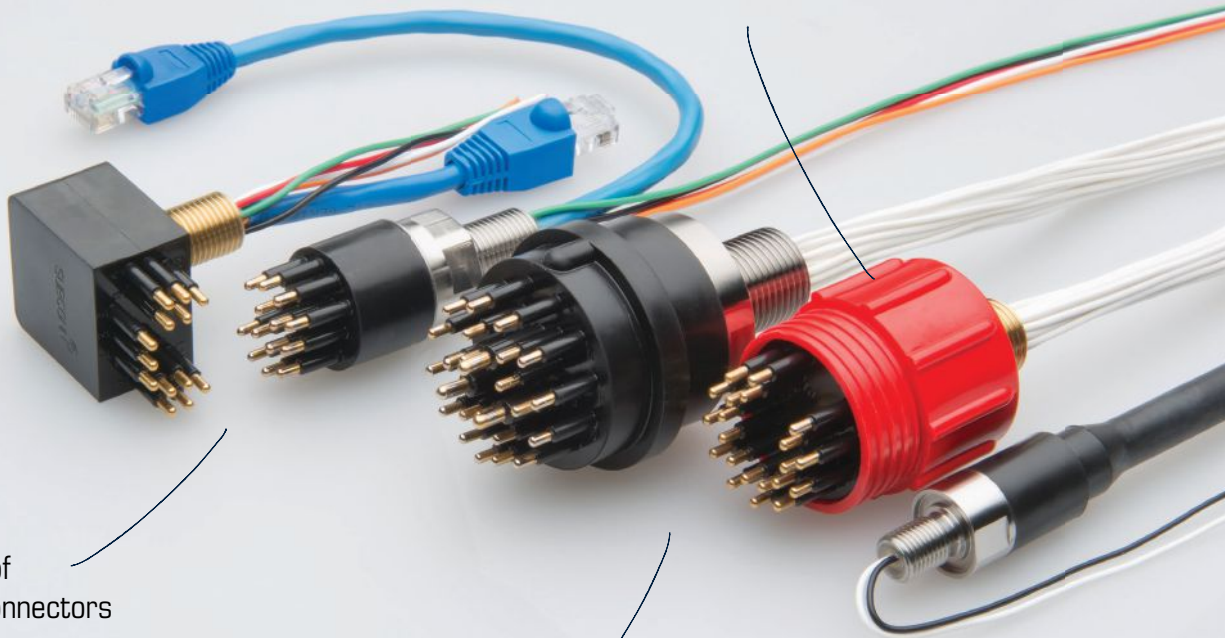
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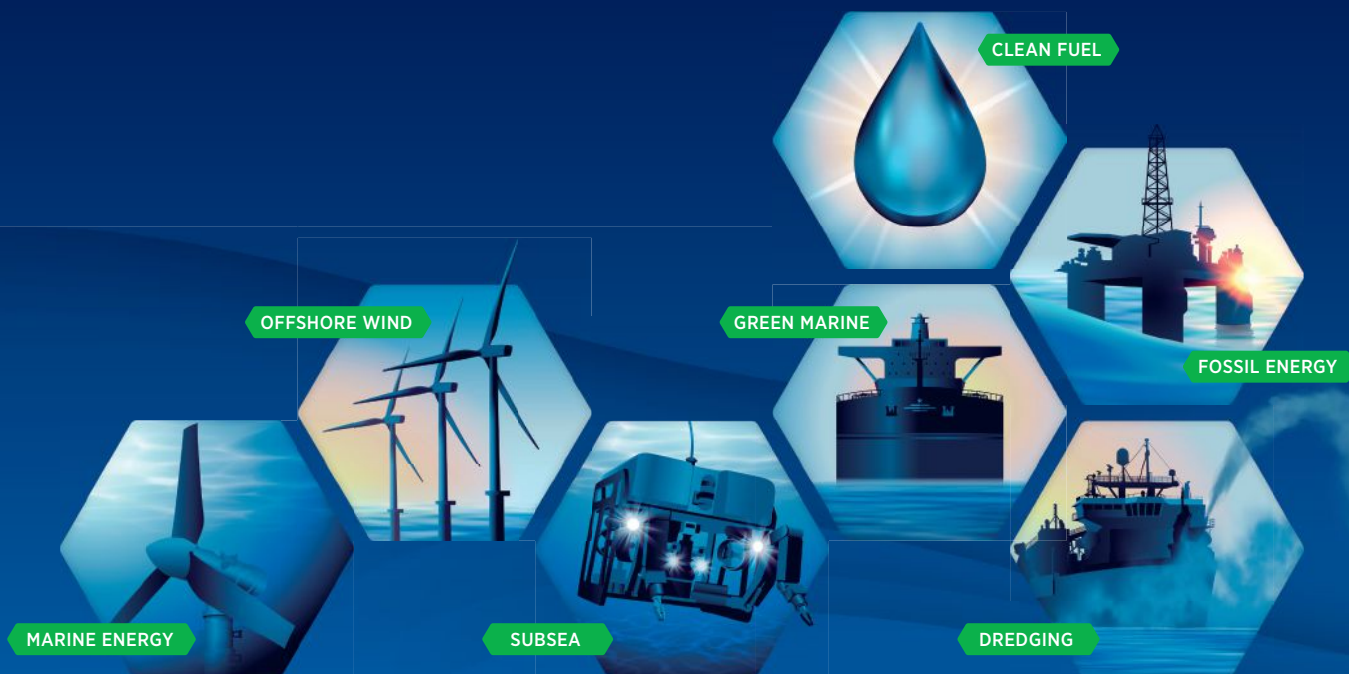
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CONTENTS

AUGUST 2020
Volume 61, No. 8



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FEATURES

10 SONARS TO DETECT GAS LEAKS

Dr. Ann E.A. Blomberg (*Norwegian Geotechnical Institute*) and Dr. Frank Reier Knudsen (*Kongsberg Maritime*) discuss acoustic technologies to monitor CO₂ storage integrity.

15 HYDROCARBON SEEPAGE

Jayme McBee, Bernie Bernard and James Brooks (*TDI-Brooks*) explain the hunt for insights into deep reservoirs via seafloor seeps.

19 DEEPWATER ATMOSPHERIC DIVING SYSTEM

Jon Regh and Mustafa Tunc (*Phoenix*) describe the use of the HARDSUIT ADS for mudline tree recompletion in the Gulf of Mexico.

23 DEEPWATER DRILLING MILESTONE

Elvira Jansen (*Barge Master*) introduces a motion compensation platform that enables offshore drilling from a vessel.

26 PREPARING FOR A WIND REVOLUTION

Andrew Cooper and Elena Starchenko (*Fugro*) detail how integrated site characterization reduces project risk and accelerates schedules.

ogulus

Multibeam Imaging Sonars
Single and Dual Frequency Operation



seatrac

Micro-USBL Tracking Beacons
Bidirectional Acoustic Data Modems



starfish

Portable Sidescan Sonars
Towed, OEM, Hull and Pole Mounted



DEPARTMENTS

7 Editorial

9 Soundings

30 International

32 Product Development

34 Marine Renewables

35 Ocean Research

36 Marine Electronics

37 Marine Resources

38 Meetings

39 Contracts/People

40 Professional Services Directory

41 Soapbox

43 Advertiser Index

COVER IMAGE

TDI-Brooks' RV Gyre during sunset at Niteroi Port on the southeastern coast of Brazil. The port is located on Guanabara Bay opposite the city of Rio de Janeiro. (Credit: Shannon Smith, TDI-Brooks)

NEXT MONTH

Seabed coring via ROV for cobalt crust survey ... Monitoring deep-sea mining's impact ... Custom ROV to hunt invasive lionfish ... Tackling invasive species in the Great Lakes ... Conference Preview: Offshore Energy.

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Kelvin Boot, STEMM-CCS, Plymouth Marine Laboratory

Carbon Capture, Storage As Climate Solution

Decades of research and political influence have brought climate change to the attention of the general public, yet even after many years of lobbying and discussion at international levels, the carbon dioxide threat remains. Reducing the global use of fossil fuels is one possible solution, but this is not easy to achieve in a world dependent on oil and coal. Developed countries continue to release massive amounts of CO₂ into the atmosphere as a by-product of their economies, while developing countries appear to be following similar routes as they aspire to improved conditions. In mid-June, NOAA recorded atmospheric CO₂ at 416.81 ppm, and the UN reports that ice core records indicate this level is the highest in the last 800,000 years.

Fortunately, there are those among us who are not content to sit and wait for disasters to occur, legislation to be applied, and CO₂ levels to drop; they are looking for ways to capture CO₂ at its source and prevent it from entering the atmosphere in the first place.

One promising method is carbon dioxide capture and storage (CCS), which entails storing atmospheric CO₂ back where it was formed as fossil fuels, in deep strata beneath the seabed. A challenge of CCS is how to ensure the gas stays stored. This requires technology and techniques to detect and monitor any leaks that may occur. Indeed, international and domestic legislation requires such assurance as part of any licensing agreements.

To develop the potential of CCS, the EU-funded Horizon 2020 Strategies for Environmental Monitoring of Marine Carbon Capture and Storage (STEMM-CCS) project had scientists, engineers and technicians from 13 European institutions, with industrial partner Shell, "develop a set of tools, techniques and methods to enhance our understanding of CCS in the marine environment."

The project was highly innovative and included unique field experiments close to Shell's Goldeneye platform in the North Sea. The site was carefully examined over the many months running up to the deployment, including benchmarking the seabed topography, sediment types, currents, benthic organisms and deeper underground through seismic profiling. Part of the project was to investigate how potential escaping CO₂ might make it to the seabed through pockmarks and pipe or chimney structures.

In this world-first experiment, a curved steel pipe was pushed into the seabed sediment 120 m below the sea surface, using a bespoke drill rig. About a tonne of CO₂, tagged with a cocktail of inert nontoxic tracers, was pumped 3 m below the sediment surface to mimic a leak lasting 11 days in order to test the leak detection technology.

The experiment was a great success, with gas collected for analysis to determine its origin, bubble screens to monitor emergent gas photographically, hydrophones for listening for the leak, and chemical sensors to detect escaping CO₂ at various distances from the leak. The deepwater field work has proven the ability to detect a leak and should provide confidence to those planning or regulating CCS now and in the future.

The STEMM-CCS project has developed and delivered a robust methodology for establishing environmental and ecological baselines under real-world conditions, as well as novel chemical sensors and other technologies. It has improved modeling techniques to project the fate of CO₂ in a real leak situation and serves as a decision support tool to help operators decide on the most appropriate suite of monitoring, mitigation and remediation activities in case of a leak. The success of STEMM-CCS gives the world a workable method to address climate change by reducing atmospheric CO₂. To learn more, visit: www.stemm-ccs.eu/stemm-ccs-research-highlights-publication. **ST**

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)) Green Light for New Jersey Wind Port. New Jersey Governor Phil Murphy has announced plans to develop the New Jersey Wind Port, a first-in-the-U.S. infrastructure investment that will provide a location for essential staging, assembly and manufacturing activities related to offshore wind projects on the East Coast. The Wind Port has the potential to create up to 1,500 manufacturing, assembly and operations jobs, as well as hundreds of construction jobs in New Jersey. “This is a vital step forward in achieving our goal of reaching 7,500 megawatts of offshore wind power by 2035 and 100 percent clean energy by 2050,” Murphy said. Construction is planned in two phases, beginning in 2021. Phase one will develop a 30-acre site to accommodate marshaling activities and a 25-acre component manufacturing site. Phase two will add another 150-plus acres to accommodate expanded marshaling activities and extensive manufacturing facilities for turbine components such as blades and nacelles. The New Jersey Economic Development Authority is leading development and is currently considering a range of public, private and public-private partnership financing options. The New Jersey Wind Port will be located on an artificial island on the eastern shores of the Delaware River.

)) More GHG Measurement Stations Certified. ICOS (Integrated Carbon Observation System) said that eight more greenhouse gas (GHG) measurement stations have passed the rigorous ICOS quality assurance process for standardized data production. The newly certified stations are located in five out of 12 ICOS member states. They include one station each in Finland, Germany and Italy; two stations in Belgium and France; and one station on board the German RV *Polarstern*. Currently, *Polarstern* serves as the main platform of MOSAiC, the biggest international expedition ever launched in the Arctic. Having an ICOS station on board a ship enables data gathering over vast areas of the ocean and evaluation of, for example, how much carbon dioxide the oceans have taken up. The oceans absorb approximately 25 percent of the human-generated carbon dioxide from the atmosphere. It is important to monitor the state of the oceans continuously because, should they suddenly absorb considerably less carbon, this would have drastic consequences for how quickly climate change proceeds and the actions needed to reduce it. ICOS measures greenhouse gases in an extensive network of over 140 stations. The data can be accessed openly and freely at the ICOS Data Portal: www.icos-cp.eu/data-services/about-data-portal.

)) Seafarer Pandemic Survey. Lloyd’s Register (LR), in partnership with the U.K. Chamber of Shipping, the Mission to Seafarers and Safety at Sea, and with the support of other leading maritime organizations, is running an industry-wide survey to evaluate the impact of the COVID-19 pandemic on employee wellbeing and operational practice: <https://info.lr.org/seafarers/industry-survey/covid-19>. The survey is open until late August, and results will be shared later this year. It is anticipated that this comprehensive body of work will also point to trends that could reshape the crewing landscape around disease management, healthcare and remote working, and that its findings will serve to enhance future practices.

)) UK Ocean Tech Roadmap. The U.K. National Oceanography Centre has published the National Marine Facilities (NMF) Technology Roadmap 2020-21, https://bit.ly/NMF_TRM, which outlines current capabilities and looks to the future of oceanographic science and the technology that will enable it. The NMF Technology Roadmap acts as a focus for the interactions between science and technology (“science pull and technology push”) in developing the National Marine Equipment Pool (NMEP) and associated supporting infrastructure. The roadmap highlights how these capabilities feed into the broader goals of an integrated observing system and how the data gathered can support the Global Ocean Observing System (GOOS) and its constituent parts. The 2020-21 refresh of the roadmap incorporates new components around deployment planning, data curation and the development of research ship capabilities. These elements were added to provide a full picture of the support provided to the U.K. marine science community by NMF and the British Oceanographic Data Centre (BODC).

)) Ports Pivotal to Energy Transition. Ports can play a pivotal role in the world’s decarbonization challenge and provide a blueprint for industries and governments to cut pollution and transition to a cleaner energy future, according to DNV GL’s new study “Ports: Green gateways to Europe - 10 Transitions to turn ports into decarbonization hubs.” By 2050, the total electricity generating capacity for industrial ports could increase more than tenfold. Renewable energy could account for at least 70 percent of the total electricity generation, compared to just 5 percent today. Expected deployment of offshore wind and the required grid enforcements for their connection will lead to an advantageous position for large industrial ports as a hub for renewable energy generation. For this to be realized, 10 Green Transitions will need to be made in and around ports: electrification of port-related activities; fuel switch for maritime transport; electrification of industry; integration of offshore wind; energy system integration; hydrogen as a feedstock and energy vector; phase-out of fossil-fueled power plants; carbon capture and storage; new regulations; and a circular and bio-based economy. You can learn more about the report at: www.dnvgl.com/power-renewables/themes/green-ports/index.html. **ST**

Sonars to Detect Gas Leaks

Acoustic Technologies Monitor CO₂ Storage Integrity

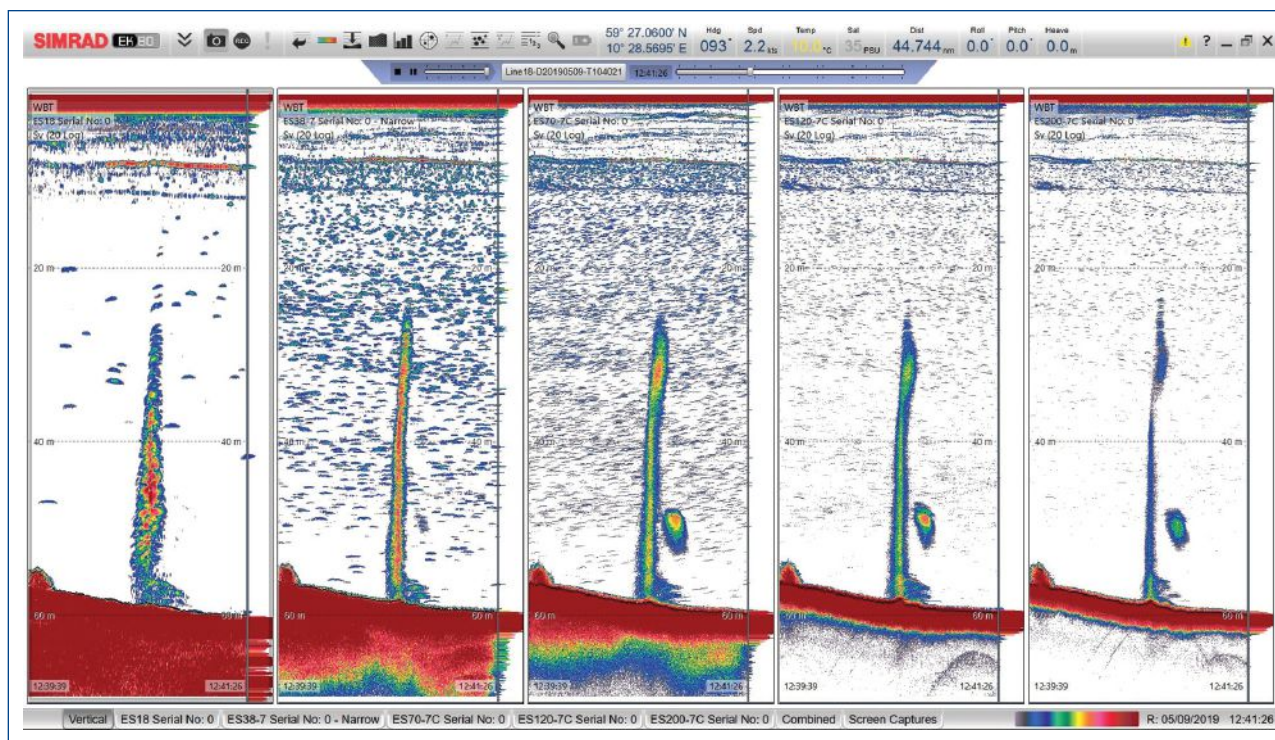
By Dr. Ann E.A. Blomberg • Dr. Frank Reier Knudsen

State-of-the-art scientific echosounders and multi-beams are capable of detecting and mapping marine gas seeps and are therefore promising technologies for monitoring geological carbon storage (GCS) sites.

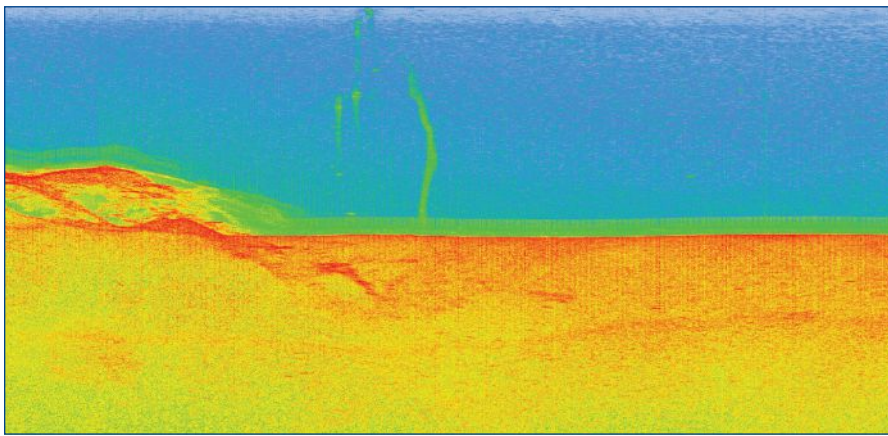
A simulated CO₂ leak site was established in the Oslo Fjord in the spring of 2019, and a range of acoustic instruments were tested for their ability to detect and quantify the gas releases. The instruments were operated either from a template on the seabed or from a surface vessel.

Background

GCS has emerged as a promising method for reducing greenhouse gas emissions and meeting international climate goals. There are currently a handful of operational offshore CO₂ storage sites worldwide, including the Sleipner field in Norway where more than 16 million tons of CO₂ are successfully stored in a sandstone reservoir 800 to 1,000 m below the seabed. A larger Norwegian project (Northern Lights) aims to demonstrate the feasibility of scaling up offshore GCS activities by



The EK80 shows the acoustic response of a CO₂ plume at different frequencies. The plume is observed nearly 40 m above the release point (60 m) at the seabed, with a leak rate of 1.3 lt/min.



capturing large amounts of CO₂ from several industrial sources and injecting into offshore geological formations, significantly reducing the CO₂ footprint of these industries. Once injected into a suitable reservoir, multiple natural barriers prevent the CO₂ from escaping.

Still, monitoring is recommended to ensure that there are no indications of leakage to the marine environment. The ACT4storage (Acoustic and Chemical technologies for environmental monitoring of geological carbon storage) project

is devoting significant efforts to improving environmental monitoring capabilities through better selection and use of available technologies. Its overall scope involves several monitoring technologies and sensor platforms, and this article focuses on the active acoustic technologies used during a controlled CO₂ release experiment in the Oslo Fjord.

Active Acoustic Instruments

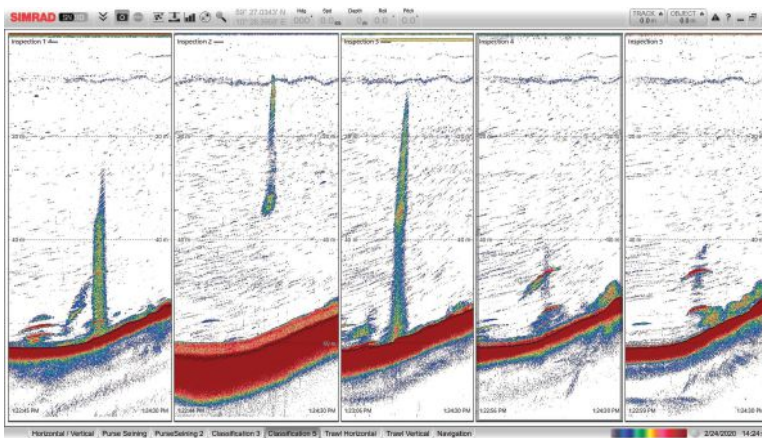
Active acoustic instruments can be classified as single beams, multibeam and sonars. The single beam is narrow for high-resolution quantitative water column or seabed measurements and is the global standard for fish stock assessment. It operates over a large frequency bandwidth and measures the biomass of fish resources, estimating fish size and classifying fish and plankton. It can also measure the direction and speed of targets in the acoustic beam, or map and classify the seabed.

The multibeam, as its name suggests, is an array of many single beams typically configured into a swath, increasing the water column sampling volume and seabed area coverage. It can image entire schools of fish and map the bottom in high resolution. The sonar, meanwhile, can look horizontally and vertically in wide sectors and map fish schools from just below the sea surface and down to the bottom.

During the ACT4storage controlled CO₂ release experiment carried out in May 2019, the following KONGSBERG active acoustic instruments were used: the single-beam EK80; the ME70, EM2040, EM710 and M3 multibeam; and the SN90 sonar. The EK80, M3 and EM2040 are smaller depth-rated units ideal for platforms such as AUVs, USVs, buoys and seabed templates, while the ME70, SN90 and ME710 are large units operated from traditional RVs.

Controlled CO₂ Release Experiment

The test site was nearshore Horten in the Oslo Fjord at about 60-m water depth. A leak template, and templates



(Top) The EM712 nicely captures a CO₂ plume reaching at least 35 m above the release point at the seabed. The two linear features to the left are ropes connecting seabed frames to buoys at the surface. The leak rate here is 1.3 lt/min. CO₂. (Middle) Data from ME70 presented in real time in the 3D visualization software Simrad TD50. (Bottom) Echogram showing the five different inspection beams of the SN90. The release rate is 1.3 lt/min. of CO₂. We observe the plume in inspection beams one, two and three, but only inspection beam two captures the top of the plume reaching as high as 50 m above the seabed.

“GCS has emerged as a promising method for reducing greenhouse gas emissions and meeting international climate goals.”

with acoustic, oceanographic and chemical (CO_2 , O_2 , pH, salinity and temperature) sensors, were installed at the site. The acoustic template was installed 64 m from the leak template, with the acoustic sensors pointing toward the simulated gas leak. A video camera was placed at the leakage point to verify and document the leak. CO_2 gas release rates varied from 0.13 to 35 lt/min.

The controlled release system developed by the Norwegian Geotechnical Institute (NGI) enabled the release of air or CO_2 , and it was also designed to release CO_2 either in gas phase or dissolved in seawater.

While the chemical sensors are able to detect elevated concentrations of dissolved CO_2 , the acoustic sensors are sensitive to gas bubbles. The release point was located on the seabed approximately 100 m from shore, at 60-m water depth. The CO_2 containers were located on land for ease of operation. CO_2 in gas phase was transported directly from the containers to the leak point through a hose, driven by the pressure inside the containers. Simulated leaks presented here consisted of controlled releases of gas phase CO_2 with varying release rates, and air bubbles. Release rates were careful-

ly controlled and logged with flow meters. As expected, the air bubbles could be observed at the surface while CO_2 bubbles were dissolved on their way to the surface.

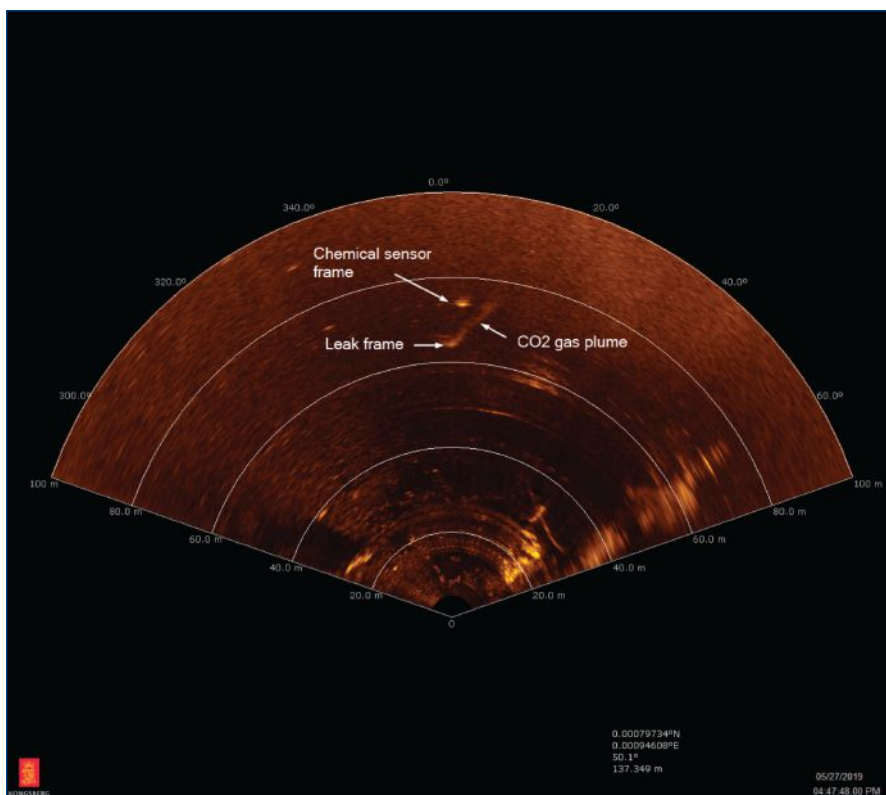
Acoustic sensors were operated from a template on the seabed or from the KONGSBERG surface vessel *Simrad Echo*.

Response to a Simulated CO_2 Gas Leak

Simrad Echo. The active acoustic sensors used on the *Simrad Echo* nicely documented the shape, intensity and spatial development of the plume of CO_2 bubbles rising through the water column. We consistently observed CO_2 bubbles rising at least 35 m above the leak point at the seabed, even for small leak rates. An important factor was the imaging geometry of the different systems. In some cases, the top of the plume was missed because the vessel was not directly above the plume: This can result in an underestimation of the plume height. Observations of CO_2 and air release using the EK80 single-beam echosounder, the several multibeam (ME70, EM2040, EM710) and the SN90 sonar were recorded.

EK80. The EK80 is a scientific, high-sensitivity, broadband, single-beam echosounder. It has proven capabilities when it comes to mapping and characterizing marine gas seeps. The EK80 transceiver unit can be hooked up to multiple transducers operating at different frequencies. The operating range depends on the transducer, with low-frequency transducers having a longer range than high-frequency transducers. Our observations from the stationary platforms, as well as with the EK80 mounted on the *Sim-*





An advantage of the EK80 is that it can be calibrated to obtain accurate measurements of whole gas plumes as well as individual gas bubbles. This is important for acoustic quantification of a CO₂ leak and bubble characterization.

A sample EK80 echogram shows the multifrequency response of 1.3 lt/min. CO₂ release. We observed the CO₂ plume at all frequencies, and observed rise heights were of nearly 40 m. We compared bubble rise heights and acoustic target strength of a plume of CO₂ bubbles and a corresponding plume of air bubbles. As expected, air bubbles rose higher (all the way to the surface) and displayed higher target strength since they dissolve at a slower rate in seawater than CO₂ bubbles.

EM2040. The EM2040 is a wide-band multibeam echosounder with a frequency range of 200 to 400 kHz, aimed at high-resolution seafloor mapping in relatively shallow water. It is flexible, allowing users to tailor beam widths, operating frequencies and area coverage to their needs. The maximum swath size is 200°.

EM712. The KONGSBERG EM712 high-resolution multibeam echosounder has an operating frequency range of 40 to 100 kHz. The maximum acquisition depth is 3,600 m, with an across-track area coverage of 5.5 times the water depth. During a simulation, a 1.3 lt/min. plume was detected reaching 35 m above the release point.

ME70. The Simrad ME70 is a high-resolution scientific multibeam echosounder dedicated for collection of data in the water column. The ME70 combines the large and flexible sampling volume of the multibeam swath with the accuracy of the quantitative scientific echosounder. The ME70 has up to 45 beams with distinct frequencies in the range of 70 to 120 kHz, forming a swath spanning at most 140°. It can be calibrated, so echo strengths can be related directly to target properties (i.e., fish species and abundance or bubble sizes).

The ME70 was configured with 10 beams pointing in distinct directions to cover a 30° vertical swath. The 10 beams transmitted at different frequencies to avoid interference. The release rate was 1.3 lt/min. of CO₂, and the bubble plume was visible in all beams, although beams one and three only captured part of the plume due to the different pointing directions.

Data from the ME70 and the other acoustic instruments can be displayed in KONGSBERG 3D software

Instrument	Beam type	Normal use	Platform	Frequency (kHz)	Max range (m)*	Beam/Fan width (°)	Depth rating (m)
EK80	Single	Fish research	All*	18-450	8,000	7-18	4,000
M3	Multi	Inspection	All*	500	150	120	4,000
EM2040	Multi	Bottom mapping	All*	200-400	600	200	6,000
SN90	Sonar/single	Fisheries	RV	70-120	900	5-160	20
ME70	Multi/single	Fish research	RV	70-120	900	2-140	20
EM712	Multi	Bottom mapping	RV	40-100	3,600	140	20

*(Top) M3 sonar image showing a 140° scene with leak frame with CO₂ plume (1.3 lt/min.) and the chemical sensor frame. (Bottom) A comparison of the KONGSBERG active acoustic instruments used in the nearshore simulated gas release test. "Max range" references the maximum bottom detection range. *AUV, USV, buoy, seabed template.*

rad Echo's hull, indicated that it could detect very small bubble releases (0.13 lt/min.), or larger releases at great ranges.

A potential challenge when using the EK80 mounted on a vessel is the limited area coverage rate, particularly in shallow waters. The acoustic beam is conically shaped, with an opening angle of approximately 7°. As a result, a bubble plume can easily be missed, or its height underestimated, unless the vessel passes directly above.

“Active acoustics is a sensitive method for marine monitoring, with the ability to detect and quantify even small gas leaks from virtually any platform.”

TD50 in real time. For example, the history of a short transect showed a school of fish near the surface at the start of the transect and the CO₂ plume just below the vessel.

SN90. The SN90 is a highly flexible system offering wide coverage both in the horizontal (160°) and vertical (60°) plane. It can be tilted between 0° and 60°, and five separate inspection beams can be adjusted to the operator's needs. This system makes it easy to find and map an object or feature in the entire water column.

Using the EK80, EM2040, EM712 and ME70, we observed bubble rise heights of approximately 40 m above the seabed. An SN90 echogram shows bubble rise heights as high as 50 m above the seabed (10 m below the sea surface). This may be related to the SN90 beam pattern and the resulting field of view, indicating that the other systems were not able to capture the top of the plume due to the imaging geometry. Note that since the plume bends according to ocean currents, it may not stay in a single beam. We observed CO₂ bubbles in inspection beams one, two and three, but only inspection beam two captured the top of the seep. Beams were tilted 10° forward. Each beam had 7° beam width, and the angle between each beam was 8°.

Stationary Template

EK80. CO₂ and air bubbles in water are strong acoustic scatterers and are thus easily visible using the EK80 echosounder, mounted either on an RV or on a stationary seabed template. When mounted on a stationary template it is essential to aim the acoustic beam in the intended direction using, e.g., a remote controlled pan/tilt unit. Without the possibility of adjusting the acoustic beam direction, a gas plume can easily be missed because of the 7° conically shaped beam of the echosounder. This is analogous to the challenge of missing the plume when the EK80 is mounted on an RV that does not pass directly above the plume.

Quantitative measures of CO₂ plume properties can be extracted from the EK80 echogram and used as a component in a monitoring and warning system. These measures include: location of the plume (distance from echosounder), density of the CO₂ plume, plume dispersion, plume width, mean target strength and total target strength. An additional relevant parameter would be the estimated leak rate (flux).

M3. The KONGSBERG M3 multibeam sonar provides an overview of the seabed at the region of interest. The 140° opening angle makes it possible to map a large region and detect multiple leaks as well as structures and

features of potential interest on the seabed. The placement of objects relative to one another can also be accurately determined.

A sample M3 sonar image of a 140° scene including the leak template and a second template shows the distance between the sonar and the leak is 64 m. CO₂ in gas phase was released, and the image was acquired during a 1.3 lt/min. release of CO₂ in gas phase. We observed that without dedicated processing, relatively large leak rates are detected while smaller leaks are not directly observable at this distance.

Conclusion

Active acoustics is a sensitive method for marine monitoring, with the ability to detect and quantify even small gas leaks from virtually any platform. Depending on the monitoring objective, relevant platforms include traditional RVs, USVs, AUVs and seabed templates. The large variety of acoustic instruments available cover monitoring scenarios from high-resolution quantification of individual bubble seeps to mapping spatial and temporal distribution of leak sites over large areas.

Acknowledgments

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Hydrocarbon Seepage

The Hunt for Insights into Deep Reservoirs via Seafloor Seeps

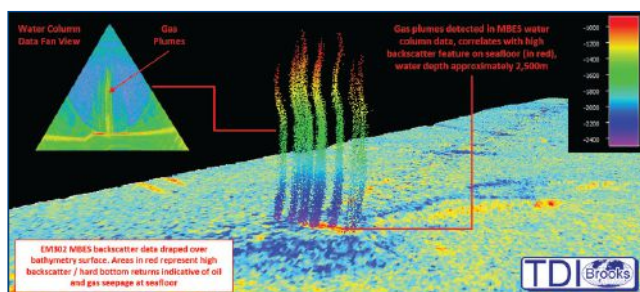
By Jayme McBee • Bernie Bernard • James Brooks

Surface geochemical exploration (SGE) is a petroleum prospecting tool based on the premise that traces of upwardly migrating petroleum from deep source rocks and reservoirs can be detected in selected seabed sediments and used to evaluate exploration potential. Deep seismic and multibeam surveys are used to select piston coring locations based on surface expression of deep faults and other features related to conduits for upward migration of hydrocarbons.

At the seafloor, hydrocarbon seeps occur as point sources or clusters of point sources due to the vertical migration of hydrocarbons focusing into chimneys. Hydrocarbons will follow a path of least resistance while migrating and therefore tend to form relatively small pathways compared to the overall volume of rock and sediments. As a result, surface expressions of seepage occur as discrete features, often with bathymetric character, such as a mud volcano or pockmark. Hydrocarbon seepages also frequently sustain chemosynthetic communities, where hard-shelled animals can be distinguished from the surrounding soft seafloor.

Surface Geochemical Exploration

Modern surface geochemical exploration campaigns utilize an integrated approach to identify seepage on the seafloor, pinpoint core locations and accurately characterize geochemical results. The science and art of this seep hunting involves: proper selection of core sites from the geophysical records; safe and skillful acquisition of seabed cores at these exact sites; analytically distinguishing promising samples from samples with varying levels of natural background concentrations; and properly in-



An example of MBES at work in Africa.

terpreting the geochemical results in a geologic context.

TDI-Brooks uses a sequence of specific procedures that we developed and improved over several decades. Our method consistently yields highly accurate identification and a quantitative evaluation of potential sites with migrated oil. Our

interpretation of survey results is made even more robust by comparison with our worldwide database of SGE survey results from 100,000+ samples we have collected, analyzed and interpreted over the years. We add our knowledge of historical background levels of the analytes for an area, environmental factors and any unique characteristics of the region being sampled. The process consists of the following sequential steps: core site selection, core acquisition, laboratory analysis and interpretation.

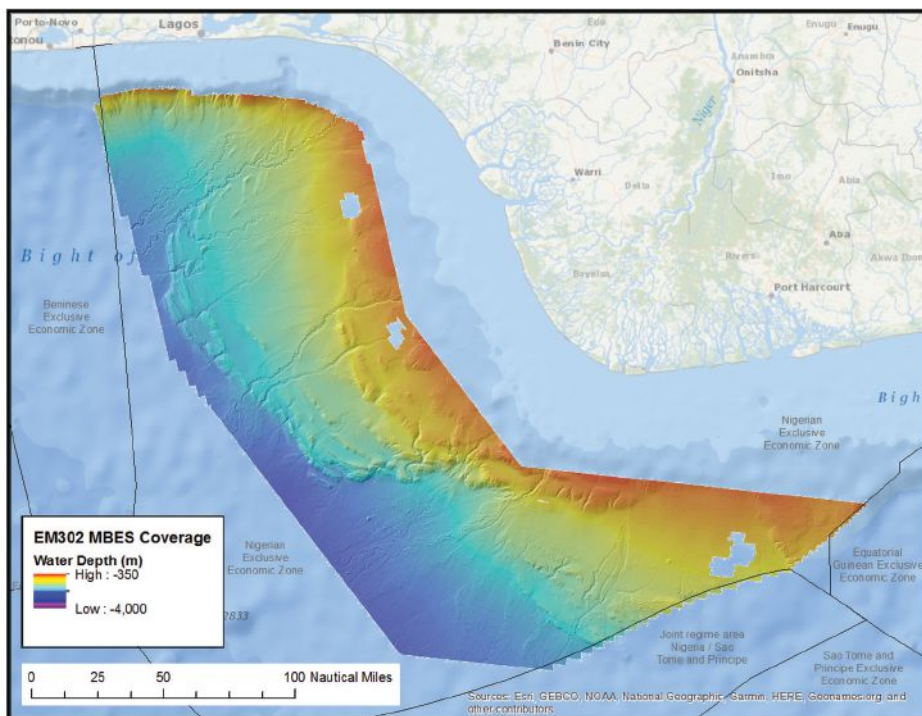
Integrating MBES Data with Sampling

TDI-Brooks utilizes high-resolution multibeam echosounders (MBES) and sub-bottom profilers to accurately image the water column, seafloor and shallow subsurface. This enables the examination of discharge plumes in the water column, seepage-related morphologies on the seafloor, and any gas accumulation or leakage pathways that can be detected in the shallow subsurface. When combined, MBES bathymetry, backscatter and water column data give trained interpreters a powerful and cost-effective tool for identifying potential hydrocarbon seep sites.

Bathymetry provides the shape of the seafloor, enabling us to decipher seepage-related morphologies. Backscatter adds a measure of the relative physical character of the seafloor and is defined as the amount of acoustic energy being received by the sonar after



Through careful scrutiny of newly acquired geophysical data, core targets are selected, and our vessels are deployed to sample the core targets. We typically collect additional acoustic data with a hull-mounted sub-bottom profiler prior to core acquisition. These real-time on-site surveys are used to correlate the seabed or sub-bottom feature to be cored with the corresponding seismic record used originally to high-grade the site. This process can refine the best core target location, and provides sub-bottom structure, bottom hardness and features associated with migrated petroleum on the seabed.



(Top) The RV Gyre. (Bottom) Final MBES coverage in Nigeria.

interaction with the seafloor. This data can be used to characterize bottom type, because different bottom types “scatter” sound energy differently. For example, a softer or smoother bottom such as mud will return a weaker signal than a harder or rougher bottom, like rock.

While some surface seeps have an easily identifiable surface expression, there are many more occurrences with either very subdued or absent bathymetric response. Hydrocarbon seepage provides nutrients to chemosynthetic fauna, and also leads to precipitates such as authigenic carbonate, and, in appropriate temperature and pressure conditions, seafloor or near-seafloor gas hydrate. All of these conditions have an impact on the acoustic properties of the seafloor or the shallow sub-surface and can be identified by an elevated backscatter response. This backscatter response is the reason seep hunting works so well in the marine environment.

We use USBL navigated piston coring to collect the precisely located sediment core samples. Piston coring offers several advantages over gravity coring: greater penetration depths, better core recovery and higher quality samples.

Using piston coring to sample depths up to 6 m significantly reduces intra-core variability due to bioturbation, loss by diffusion of gases, and mixing of natural hydrocarbon seepage or pollution in the top meter of seafloor sediments with deeper sections of the core. In particular, the quality of information gained from measurement of sediment gases increases dramatically in sections collected deeper than about 2.5 m. Sediment gas concentrations can change several orders of magnitude through the 2- to 5-m depth range in marine sed-

iments, greatly enhancing the type and quality of measurements that can be made on the samples.

A custom-designed and purpose-built clean ship-board laboratory area is used to process collected geochemistry cores in a hydrocarbon-free environment. Sections of the core are sampled based on a systematic sampling scheme dependent on core length. Geochemical, interstitial gas analysis and archive samples are collected from the bottom portion of each core and stored in a -20° C freezer until analysis in our Texas laboratory.

Interpreting Seep Geochemistry

Petroleum geochemistry is nuanced, and precision is key to meaningful results. Hydrocarbon levels at seeps are often very low, and such levels require specialized procedures and facilities to accurately complete these analyses. As a global leader in surface geochemical exploration, TDI-Brooks operates a custom-designed, purpose-built geochemistry laboratory that specializes in analyzing and interpreting these low-level hydrocar-

bons. All samples undergo specific geochemical screening analyses, and the highest-potential samples are selected for advanced analyses.

TDI-Brooks' processes of total scanning fluorescence (TSF), C_{15} +hydrocarbon gas chromatographic analysis (C_{15} +GC), and interstitial gas analysis (IG) are typically performed on each of the three core sections to evaluate them for the presence of migrated mature hydrocarbons. TSF provides information about petroleum-related aromatic hydrocarbons contained in sediment extracts. C_{15} +GC analysis quantifies petroleum-related normal alkanes ($n-C_{15}$ to $n-C_{34}$), isoprenoids (pristane and phytane), and the unresolved complex mixture (UCM) generally associated with sediment extracts that contain oil.

The determination of interstitial light hydrocarbon gases (including methane, ethene, ethane, propene, propane, iso-butane, n-butane, neo-pentane, iso-pentane and n-pentane) from canned sediment samples is useful because low molecular weight hydrocarbon gases are the most mobile phase of petroleum and, if present in the core section, are easily detected, quantified and distinguished from local background.

Samples that contain elevated concentrations of migrated petroleum based on the TSF, C_{15} +GC, and/or gas screening data can be further analyzed for saturate and aromatic biological markers and stable carbon isotopes. These more detailed analyses can usually confirm the presence of migrated petroleum and are often used to match hydrocarbons in the sediment extract with a spe-

cific produced oil and/or source rock. Upon completion of analyses, geochemical data are combined with geophysical and geological data sets to provide insight into migrated hydrocarbons, their type and maturity, and to prove up charge.

Surface geochemistry exploration campaigns are a low-cost exploration tool that provides insight into reservoirs at depth before a well is ever drilled.

SGE Campaigns Around the World

TDI-Brooks International Inc. (under contract to TGS) has recently completed the offshore "seep-hunting" surface geochemical analysis and geotechnical campaign of the MSGBC Basin, from northern Senegal through the Gambia and AGC zone, into Guinea-Bissau down to the Guinea transform fault.

TDI-Brooks' RV *Gyre* acquired 80,000 sq. km of high-resolution multibeam echosounder bathymetry and performed the offshore advanced analysis where 80 active hydrocarbon seeps were detected in the multibeam water column data to date. The RV *Proteus* completed phase two, performing the coring program, which included 289 piston cores, 23 jumbo piston cores and 23 heat flow measurements. Advanced geochemical analysis of samples is ongoing.

The RV *Gyre* is currently performing a further geochemistry analysis program offshore Nigeria. This is Nigeria's first regional multi-client multibeam and seafloor sampling (MB&SS) study. After just three days of field op-

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eration, two prominent water column anomalies and bubble plumes were observed in over 2,000-m water depth with associated surface slicks. The study will cover an area of approximately 80,000 sq. km of the offshore Niger Delta and will incorporate around 150 cores from the seabed, which target multibeam backscatter anomalies. To this date, the RV *Gyre* has collected 65,000 sq. km of multibeam data and iden-

tified 431 water column anomalies in the Nigeria study area.

These programs follow the successful multibeam and coring program in Brazil's Campos and Santos Basins in 2019 covering over 213,000 sq. km. This program included 342 piston cores, 29 jumbo piston cores and 33 heat flow measurements. Prior to that, TDI-Brooks completed the Gigante and Otos seep-hunting and offshore coring

programs in 2016 to 2017 in the Gulf of Mexico. The 2016 to 2017 programs covered approximately 289,000 sq. km, with TDI-Brooks executing over 250 navigated piston cores with 750 baseline petroleum advanced geochemistry analysis, 140+ 20-m jumbo piston cores for stratigraphic analysis and age dating, and 150 heat flow measurements for basin modeling.

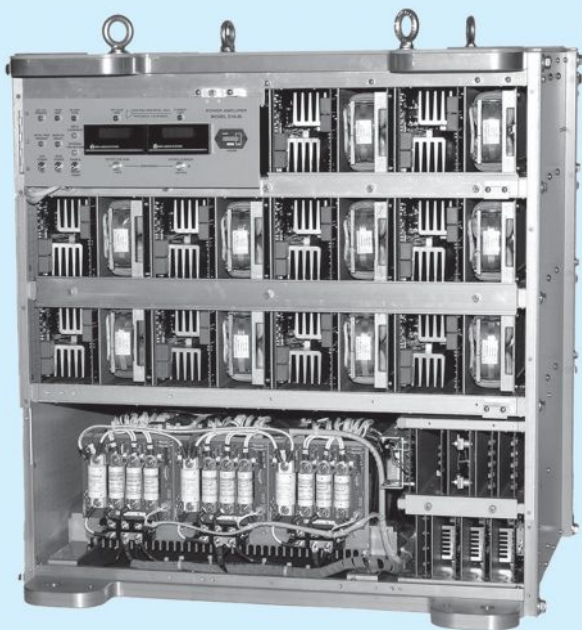
The *Gyre* is fitted with a Kongsberg EM 302 MBES (EM 304 upgrade pending). It has just been contracted for a three- to six-month charter for a cable route project from Spain to the Canary Islands and should then be available for programs off North, West and East Africa after September 2020.

The *Proteus* at this moment is scheduled to complete the geotechnical coring program off Nigeria and will then be available on the spot market for projects in West Africa during the fourth quarter of this year. **ST**

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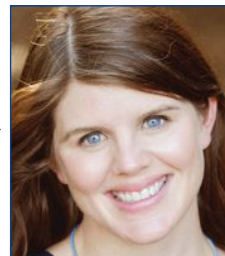
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Deepwater Atmospheric Diving System

HARDSUIT ADS for Mudline Tree Recompletion in Gulf of Mexico

By Jon Regh • Mustafa Tunc

The Phoenix International Holdings Inc. (Phoenix)-owned and operated HARDSUIT Atmospheric Diving System (ADS) has been successfully used in the oil and gas industry since 2003 for installations, inspections, maintenance, repairs and decommissioning. As methods and procedures continue to change and advance, there has also been a gravitation toward using the HARDSUITS for heavy installation work, including the installation of

risers, large connectors, pull tubes, SCR porches, guide frames and subsea trees.

Depth rated for works down to 1,200 ft., the one-person, 1-atmosphere suit offers clients a cost-effective alternative to saturation diving (as there are no decompression requirements), as well as several other advantages, including reduced exposure to personnel safety hazards, reduced mobilization/demobilization time, smaller





Ensco-75 drilling rig.

equipment footprint than saturation systems, better performance in high currents, and significantly lower operating cost due to smaller crew size and the ability to be deployed from a platform or rig, thereby eliminating the cost of a dive support vessel. Further, the suit has unlimited depth excursion in water columns, it can fit into tight spaces, and ADS pilots can manually operate diver-related underwater required tooling with its manipulators.

In addition to its operating advantages, the HARDSUIT encapsulates several design features that contribute to its safety and reliability, including being outfitted with high-quality, real-time, dual redundant communication systems; two onboard independent life support systems consisting of a 42-hr. reserve; an air recirculation system with automatic oxygen injection; and fan-powered CO₂ scrubbing capabilities for pilot safety should a disconnect occur.

ADS in Gulf of Mexico

In the fourth quarter of 2019, Phoenix was awarded a mudline tree recompletion project from Walter Oil & Gas in West Delta Block 107 in the U.S. Gulf of Mexico, specifying the use of Phoenix's HARDSUIT ADS. Walter

awarded the mudline project to Phoenix's ADS instead of a saturation dive vessel because of the ADS's small footprint, which made it possible to use the drilling rig Ensco-75 as a dive platform, thereby providing valuable cost savings to Walter for the project.

Phoenix mobilized the ADS to the Ensco-75 within 24 hours, and the Phoenix team assembled on an elevated platform area on the starboard side of the drilling floor for close proximity to the mudline tree.

Using two atmospheric suits (one for diving and one for standby) and surface-supplied standby divers for shallow-water rescues, Phoenix completed the project in two phases. In the first phase, Phoenix provided a total of 16 personnel on the platform, working 24 hours in two, 12-hr. increments of eight personnel per shift. The second phase was completed in one shift consisting of one supervisor, two ADS pilots, one ADS technician, two surface-supplied divers and two tenders.

In addition to the ADS and associated crew, the Phoenix team also used four hydraulic impact wrenches, two hydraulic power units (HPUs) with 600-ft. hydraulic hoses, and two 4,000-lb. utility air winches to successfully complete the project.



ADS 29 and 30 on the Ensco-75 platform, and the subsea mudline tree.



Project Specifications and Completion

Working under Walter's direction, the project took place over 15 days, with operations at a water depth of 200 ft. The first phase of the project saw the successful removal and recovery of the subsea tree from the wellhead and installation of a new radial bolt adapter. In the second phase, the bolt adapter was removed, and a new mudline tree was installed. In both phases, Phoenix connected, tested, monitored and then removed an Installation and Workover Control System (IWOCs) umbilical.

The first step of phase one was to remove the Big Bowen cap from the tree and use a utility winch to bring the cap to the surface.

The second step was to install the riser string onto the Big Bowen connector on the tree, then tighten the connector. After setting the riser on the connector, the ADS then secured the Big Bowen connector to the subsea tree using the connector arms.

After completing numerous pressure tests on the riser string and blowout preventer (BOP), Walter directed the ADS team to connect the IWOCs umbilical to the mudline tree junction plate to allow for control of the tree from the drilling rig, enabling safe and efficient installation, intervention and completion of the work on subsea wells. To achieve this task, the Phoenix team redesigned the IWOCs' dual-handled locking mechanism device to be ADS friendly, thereby allowing our team to make the connection more quickly than this task could have been performed by divers.

The third dive task was to remove the subsea mudline tree from the wellhead. To back out the radial bolts on the tree connector, Phoenix initially used an IW12 hydraulic

impact wrench (250 to 1,200 ft.-lb. of torque, within the required torque range for tree connector radial bolts). During pre-dive, the ADS team had arranged for the impact wrench to be neutrally buoyant at 200-ft. depth using flotation balls. This tool successfully removed two of the 16 radial bolts. The team then switched to the IW16 impact wrench (500 to 2,500 ft.-lb. of torque) to remove the remaining stubborn bolts. Once all the bolts were removed, the subsea mudline tree was raised from the wellhead using the riser.

On the last dive of the first phase of the project, Phoenix successfully installed a Dril-Quip radial bolt adapter on the wellhead despite high currents. After aligning the adapter, using our ADS riser alignment procedure, the ADS pilot secured all the radial bolts with an IW12 hydraulic impact wrench. The drilling rig personnel then installed a surface tree on the riser on the rigging platform to allow oil and gas exploration work to continue until Dril-Quip was ready to install the new mudline tree.

After four weeks of exploration work, Walter called the Phoenix ADS team back to the drilling rig. Since equipment layouts on the rig had been maintained and work procedures were already in place, Phoenix was prepared and ready to dive in under 24 hours.

The second phase of the project consisted of removing the radial bolt connector and installing the new Dril-Quip subsea mudline tree to the wellhead. During the first dive with the ADS, the IW12 impact wrench was used, and all the bolts were backed out in short order.

After the drilling rig crew brought the radial bolt connector to the surface, it was time to install the new mudline tree to the wellhead. There were five hydraulic

quick-disconnect fittings on the mudline tree that the ADS had to secure between the wellhead and the IWOCS after securing the tree to the wellhead. Before the tree was launched, all quick-disconnects were modified for ADS use by attaching a lanyard to each quick-disconnect collar. The ADS pilot was then able to hold one end of the quick-disconnect with one of the manipulators and pull from the lanyard with another manipulator hook, thereby allowing the pilot to easily open the quick-disconnect locking mechanism.

The drilling rig deployed the new subsea mudline tree, and the IWOCS umbilical was held 4 to 5 ft. above the wellhead while the ADS inspected the tubing head reaction ring for mud and debris. After inspecting the tubing head, the drill rig slowly lowered the tree to the wellhead while the ADS ensured the tree was properly oriented and stabbed into the tubing head correctly. The surface diving crew deployed the IW12 impact wrench to 200-ft. depth via the utility winch, and the ADS used it to tighten all the radial bolts on the subsea tree. The ADS then connected the hydraulic quick-disconnect hoses to the tubing head, which were modified earlier to be ADS friendly.

The subsea mudline tree was now installed to the wellhead, and the drilling platform pressurized the riser to ensure the gasket and seals were not leaking. The drilling rig actuated the hydraulic valves on the tree, while the ADS visually confirmed that they were all working correctly. The ADS was also able to complete this task for

“The ADS performed a total of 13 dives during this project, with the bottom time of each of these dives ranging from 30 min. to 6 hr.”

valves requiring manual activation. The drilling rig performed numerous tests on the mudline tree before the ADS removed the riser and IWOCS umbilical from the tree.

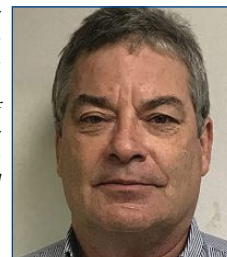
When it came time for riser removal, the ADS first removed the IWOCS from the tree and then loosened the Big Bowen adapter to remove the riser. The ADS then placed the Big Bowen cap back on the tree and performed an as-built inspection.

Conclusion

Visibility remained at 2 to 3 ft. during the entirety of the project, and only one day of current higher than 2 kt. was experienced. The ADS performed a total of 13 dives during this project, with the bottom time of each of these dives ranging from 30 min. to 6 hr. The Phoenix ADS team successfully performed each task assigned without any injuries, problems or delays.

In addition to subsea mudline tree recompletion, the Phoenix ADS team can perform platform inspection, anode replacement, crack detection, riser installation and removal, clamp installation, pipeline inspection, marine salvage, inland water inspection, cathodic protection and thickness readings, and many other underwater tasks down to 1,200 ft. deep. **ST**

Jon Regh is both the Houston area manager and the ADS program manager for Phoenix International Holdings Inc. He has been actively involved in commercial diving and subsea construction since 1980, and his 40 years of experience includes several major deepwater oil and gas projects around the world. He is a certified Project Management Professional (PMP) and Lean Six Sigma Black Belt (LSSBB).



Mustafa Tunc is an ADS technician at Phoenix International Holdings Inc. Originally from Turkey, he joined Phoenix in 2019 after serving 14 years as a first-class diver and ADS technician in the Turkish Navy. Tunc received his M.B.A. degree from Bahcesehir University and currently lives in Houston, Texas. In his spare time, he enjoys volunteering with Big Brothers Big Sisters of America and the American Turkish Association.



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Deepwater Drilling Milestone

Motion Compensation Platform Enables Offshore Drilling from Vessel

By Elvira Jansen

Large Diameter Drilling (LDD) and Barge Master have combined their expertise to complete a world's first: drilling operations from a diving support and construction vessel (DSCV) in water depths in excess of 270 m. By integrating LDD's reverse circulation LD2500 drill rig with Barge Master's motion compensation platform (BM-T700), they have successfully completed the installation of seven anchor mooring piles for a catenary anchor leg mooring (CALM) buoy. The unique technique employed has potential for industry-wide application.

The project was executed in the Caribbean Sea, off the coast of St. Croix, part of the U.S. Virgin Islands, for Imodco Services, a subsidiary of SBM Offshore. The Limetree Bay refinery needed a new CALM buoy installed,

which is used as an offshore loading terminal. A CALM buoy consists of a floating buoy anchored to the seabed by catenary chain legs, which are secured to anchors or piles. This allows for the system to move freely so that a tanker can take up the position of least resistance to the prevailing weather. In this case, the CALM buoy is connected by a submarine pipeline to the onshore production refinery. The CALM Buoy needed seven anchor piles drilled, in water depths ranging from 80 to 270 m.

Alternative Method

Conventionally, this sort of drilling would be done using a jack-up barge (JUB), or from the pile top itself, but this project had particular challenges. One was the



The SBM installer equipped with the Barge Master motion-compensated platform, stabilizing the LDD reverse circulation drill.



(Clockwise from top left) The drilling operation in the Caribbean Sea, off the coast of St. Croix, U.S. Virgin Islands. The LDD drill rig was cantilevered off the Barge Master motion-compensated platform. The drilling location had a rough swell, and the drill combination worked in weather conditions up to Hs 2.5 m. Top view of the drill rig on the motion-compensated platform.

large water depths ranging up to 270 m, combined with a sloped seabed of up to 17°. Another was the seabed conditions, consisting of sand at the shallower locations and limestone at the deeper locations. Additionally, the physical attributes of the anchor pile design made sure that typical methods were impossible.

Therefore, an alternative, floating method needed to be found. The swell at the location is strong, so a normal drilling vessel would be unreliable because it would need to wait for optimal weather. To address the location's challenges, LDD and Barge Master teamed up to provide a solution using Barge Master's motion-compensated platform (BM-T700) with LDD's reverse circulation drill rig (LD2500).

Barge Master had already executed a floating drilling operation for the Wiking wind farm installation in

the North Sea off the coast of Germany. The project proved that the motion-compensated platform was suited to keep high-precision equipment stable for the job, with operations lasting over 27 hr.

The motion-compensated platform has the capacity to stabilize 700 tons of equipment or cargo at up to Hs 2.5 m (significant wave height). It compensates the heave, pitch and roll motions, relying on the vessel to hold position in the horizontal plane. The system is completely containerized and can be mobilized easily on any barge or vessel to serve as a stable working base. The motion-compensated platform has been used for many different applications, ranging from lifting operations with a normal land-based crane on top to feeding solutions.

The LD2500 from LDD, a company with over 30 years of experience in difficult nearshore and offshore projects, is a reverse circulation drilling rig, capable of drilling through almost any soil and rock type. The rig can accommodate standard LDD drill bits up to 2,500 mm, with under-reaming options allowing the drilling of much larger holes. The LD2500 has up to 539 kNm of torque.

Together, the motion-compensated platform with the drill rig on top made the perfect solution for the challenging project. The equipment was mobilized on SBM Offshore's diving support and construction vessel SBM installer. The mobilization took place in Rotterdam in early 2019, and then the equipment was partly demo-

bilized again for the sail out to St. Croix, where the final setup was mobilized.

Drilling System

For the project, seven anchor piles needed to be drilled, ranging from 80 to 270 m. During the drilling operations, the compensation mode of the motion-compensated platform remained active. The LDD2500 drill rig has a drill string of 3 m; thus, at every 3 m of drilling, a new drill string had to be attached. When a new drill string had to be attached during the drilling operations, while maintaining active compensation mode, the motion-compensated platform was moved 500 mm upward in order to provide clearance between the seabed and the bottom hole assembly. Once the new drill string was added, the motion-compensated platform moved back to its mid-stroke.

The drilling system is self-sufficient; it is able to feed pipe without the vessel's crane. The setup included a full grouting spread deployed from the rear of the vessel. During the project, the drill system used a variable diameter drill bit and fully shrouded stabilizer. The sockets for the anchor piles were drilled to a diameter of 2.3 m and a depth of 20 m.

Conclusion

The project was successfully completed in the second quarter of 2019. Offshore drilling workability increasing from 13 percent without motion compensation to 90 percent with the motion-compensated platform. There were zero safety incidents during the project and an uptime of over 90 percent.

The combined systems operated for over 24 hr. straight, without any loss in performance, in sea states up to Hs 2.5 m. The process of drilling, anchor pile installation and grouting took approximately one week per pile.

The completion of this project demonstrates that large-diameter drilling can be achieved from a floating asset with motion compensation.

This is the second motion-compensated drilling project, but the first at large water depths. The two successful projects, combined with the track record of other projects with the motion-compensated platform, prove that this solution is ready for market-wide implementation. It provides an alternative for jack-up barges and a solution for large water depths. This can be beneficial for the installation works of all offshore markets, from renewables to oil and gas, as well as the civil sector. In addition, this setup can be used for floating motion-compensated rig-less well intervention or coiled tubing. **ST**

Elvira Jansen obtained a master's degree in building engineering at the Technical University of Delft. After working abroad, she joined the Barge Master team four years ago, where she is responsible for business development and communications.





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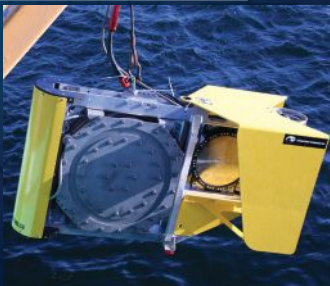
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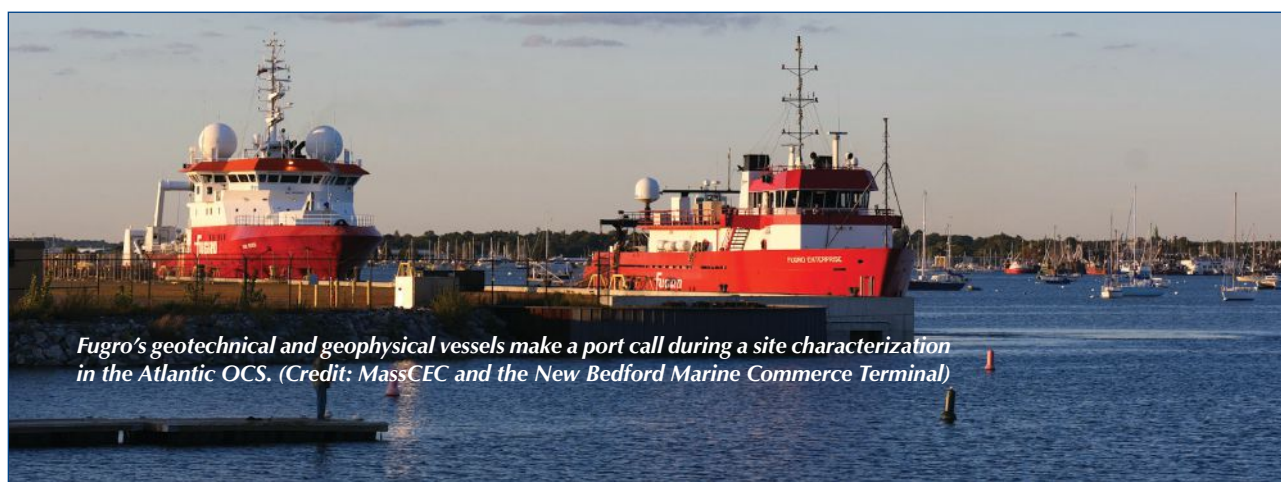
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Preparing for a Wind Revolution

Integrated Site Characterization Reduces Project Risk

By Andrew Cooper • Elena Starchenko



Fugro's geotechnical and geophysical vessels make a port call during a site characterization in the Atlantic OCS. (Credit: MassCEC and the New Bedford Marine Commerce Terminal)

The United States is primed for an offshore wind energy boom. Falling costs, technology advancements and state policies are driving investments in this burgeoning industry all along the Eastern Seaboard. While the Block Island Wind Farm in Rhode Island is the only U.S. wind farm in operation today, 15 active offshore wind leases in various stages of development promise to provide more than 25 GW of clean, renewable energy to Atlantic coastal states over the next couple of decades.

In addition to offshore oil and gas projects, the Bureau of Ocean Energy Management (BOEM) is responsible for overseeing offshore wind lease activities in federal waters. A fundamental piece of that oversight is site characterization, which details surface and subsurface conditions to help identify and mitigate potential geohazards in the lease area, and inform the design, construction and installation of wind turbine foundations, cabling and related infrastructure.

Drawing on nearly 40 years of delivering site characterization services to BOEM standards in support of oil and gas development, Fugro has, for the last 11 years,

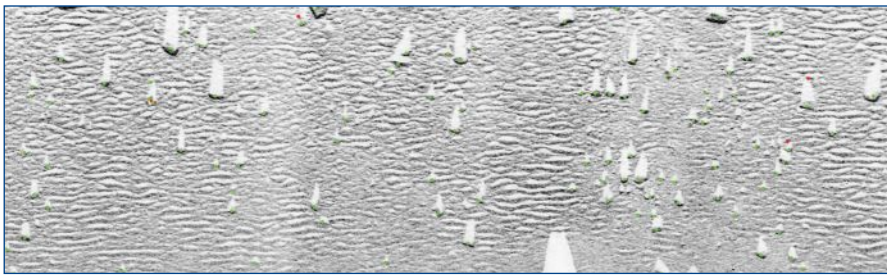
provided similar services to offshore wind farm customers in support of their development activities. Along the way, the company has acquired regional expertise on the Atlantic Outer Continental Shelf (OCS), while implementing technology innovations and process improvements designed to increase safety, reduce carbon footprint and accelerate project schedules.

Geophysical Data for Engineering Insights And Hazards Identification

The Atlantic OCS is described by BOEM as a “frontier region,” due to the lack of knowledge regarding the area’s geologic makeup compared to mature development areas such as the Gulf of Mexico. This absence of information makes geophysical campaigns critically important to the engineering phase of projects, providing information about site conditions, geologic constraints and geohazards. Standard data sets collected include bathymetry, side scan sonar, high-resolution seismic and magnetometry. Traditionally, bathymetry data are acquired using high-resolution multibeam echosounder systems from a



Fugro's modular C25 marine drill rig mobilized on a vessel of opportunity for an offshore wind development project in the Atlantic. (Bottom) Fugro uses artificial intelligence on a neural network to interpret boulders in side scan sonar data. The green marks indicate accepted interpretations, while the red marks indicate rejected interpretations.



geophysical survey vessel. The resulting water depth and seafloor elevation data are used to inform a wide range of design parameters, such as structure height; seabed conditions, such as sand waves; and geohazards and anthropogenic hazards, such as boulders and shipwrecks. To augment vessel-based data collection, Fugro has developed two specialized platforms: Fugro RAMMS (Rapid Airborne Multibeam Mapping System) and the FAS-900 (Fugro Autonomous Surveyor 900).

RAMMS is a next-generation airborne LiDAR mapping system that delivers industry-leading depth penetration and point densities for fast and accurate bathymetry in nearshore and coastal waters. Lightweight and compact, the system can operate either from small aircraft of opportunity or uncrewed aerial vehicles. The FAS-900 is an uncrewed surface vessel that can collect multibeam echosounder data in full autonomy, semi-autonomy, or by remote control in offshore and coastal waters. In addition to improving data collection rates, these systems help improve project safety and sustainability by limiting the number of crew needed in the field and significantly reducing fuel demands.

For additional insight into seafloor conditions and potential hazards, Fugro relies on side scan sonar technology. Acquired by geophysical vessel, side scan sonar generates an acoustic picture of the seafloor by measuring the amplitude of the backscattered return signals. The collected data are rendered to provide a photo-like image of the seafloor, which can be used to identify sediment type, hard-bottom areas, rock outcrops and boulder zones. This latter feature is particularly important in the

North Atlantic, where boulders abound as the result of past glacial processes.

To improve the accuracy and efficiency of boulder zone mapping, Fugro is applying a machine-learning solution for side scan sonar data interpretation. The method identifies boulders, maps their footprints, and determines length, width and height. This approach improves accuracy and efficiency, and effectively maps targets in boulder zones. A boulder data set is created that provides a quantifiable means of determining boulder population densities that can be highly valuable in cable routing, assessing the probability of encountering boulders during cable installation, foundation installation or leg penetration of installation vessels.

Shallow penetrating seismic technology is used to further characterize the seafloor, imaging the shallow subsurface to inform activities such as foundation design and cable burial. Fugro has developed a proprietary method for using 2D and 3D seismic to perform subsurface boulder mapping. The approach relies on plane wave disruption theory to isolate, map and characterize seismic diffractions in the subsurface to identify higher and lower risk areas within the survey area for siting wind turbines and scoping the geotechnical site investigation.

Boulders are not the only concern when it comes to mapping lease areas in the Atlantic. Unexploded ordnance (UXO) is a major concern in the Atlantic, which was a munitions dumping ground along the East Coast until 1972. To identify these hazards, Fugro is using its Geowing system, which can detect even low-ferrous UXO items in challenging marine environments. The system collects high-resolution magnetic data using a two-row configuration that allows the data to be analyzed as gradiometer, which has proven superior to traditional magnetometer methods. The Geowing identifies other ferrous objects in addition to UXO, including abandoned ships, pipelines and other marine debris.

Geotechnical Data for Safe, Cost-Effective Design

After conducting geophysical surveys for offshore wind, Fugro performs preliminary geotechnical site investigations to ground-truth the developing ground model. This is then used to inform the positions of wind turbines, interarray cables and proposed export cable routes, and a subsequent detailed geotechnical site investigation provides site-specific data for engineering design of wind turbine foundations (e.g., jackets and monopiles) and optimal methods for cable installation (e.g., jet-plowing and trenching). High-quality data allow conservatism to be removed from the engineering design, which translates to significant material and cost savings.

To acquire high-quality in-situ data in offshore wind farm areas, Fugro operates a piezocone penetration test

“While the Block Island Wind Farm in Rhode Island is the only U.S. wind farm in operation today, 15 active offshore wind leases in various stages of development promise to provide more than 25 GW of clean, renewable energy to Atlantic coastal states over the next couple of decades.”

(PCPT) system known as the SEACALF Mk IV. This seabed unit pushes a piezocone at the end of a coiled rod for hands-free rod handling. It can also be ballasted up to 20 tons submerged weight for deeper penetrations in competent soils while still being deployed from smaller vessels, which is significantly more economical for site-specific investigation at each proposed wind turbine location. By incorporating a combination of novel technology, the SEACALF Mk IV provides higher efficiency, more compact handling and improved safety compared to conventional seabed PCPT systems.

Also included on the SEACALF Mk IV, and other Fugro PCPT systems, is a thrust machine known as the continuous drive system. Special clamping blocks improve the force transmission to the PCPT rod, resulting in an efficient system with a push and pull capacity of 200 kN and a constant penetration rate aligned with industry best practices. This rate of penetration is maintained even through hard layers such as those encountered on the Atlantic OCS, resulting in a higher quality of PCPT data. The continuous drive system consists of simple components, making it reliable and easy to maintain.

In addition to PCPTs, the Fugro SEACALF Mk IV can perform in-situ tests using a seismic cone, temperature cone and thermal needle cone. The temperature cone penetrometer allows testing for deriving values of initial temperature, thermal conductivity and volumetric heat capacity. Thermal conductivity and volumetric heat capacity rely on a temperature rise in the steel of the penetrometer during a cone penetration test (CPT) and subsequent measurement of temperature decay during a pause in penetration. Values can be derived by correlation with CPT results, using a temperature or a conventional cone penetrometer. The temperature cone penetrometer is identical to a cone penetrometer deployed for CPTs, except for an additional temperature sensor positioned just above the conical part of the tip. Thermal conductivity, in particular, is an important soil property for offshore wind farm export cable design.

Fugro has developed another geotechnical tool, the High-Performance Corer (HPC), to use during offshore wind site investigations with the SEACALF Mk IV along proposed export cable routes. The HPC answers the demand for longer sample recovery in dense granular and stiff cohesive materials. It is a self-contained system that can either be launched from a vessel's A-frame or using a crane on board any offshore platform. The HPC contains an electric motor that applies more than twice the pow-

er and five times the vibration amplitude of a standard vibrocorer. This motor design allows for deeper penetration using core barrel lengths of 3, 6 or 8 m.

However, it is advisable to also perform deeper boreholes with sampling and in-situ testing along the shore approach for the export cable route. Fugro typically acquires this geotechnical data using a jack-up in the shallower water depths. The data are then used to inform horizontal directional drilling (HDD) requirements to mitigate potential cable exposure. Another important aspect for cables is understanding how deep they should be buried to reduce other risks, such as dropped anchors in highly trafficked navigation channels, as part of a cable burial risk assessment. In combination, these studies result in cable installations that drastically reduce the likelihood of costly remedial cable protection (e.g., rock berms and concrete mattresses) or reburial requirements.

The geotechnical campaign is followed by a large in-house laboratory program that includes advanced testing to characterize ground conditions by determining soil strength and strain properties, dynamic soil properties, and detailed ground layering. Fugro's onshore laboratory in the U.S., one of the largest private geotechnical laboratories in the world, has recently doubled its advanced soil testing capacity for three-way bender element triaxial and cyclic simple shear testing to meet the growing demand from offshore wind projects.

Incorporating Remote Technologies for Efficiency Gains

Fugro is committed to increasing remote and automated technologies into its business practice as a way of increasing efficiency, improving communication and meeting sustainability goals. The company's Office Assisted Remote Services (OARS) is one such example. OARS is a cloud-based system that enables qualified staff in strategically located command centers to perform offshore survey tasks as if they were physically on board the work vessel. The technology is currently being used for navigation and positioning, survey data acquisition, PCPT processing during surveys, monitoring and planning operations, and providing survey solutions.

Another major challenge in the project development phase is sorting through endless data types. Seismic data, daily progress reports, borehole logs, in-situ tests, locations, laboratory documents, project data and reports are often stored in multiple systems. To resolve this data management issue, Fugro has developed an interactive web-based GIS tool that provides clients with 24-hr. ac-

cess to a single repository of project data. The interactive digital platform is hosted in the cloud and allows clients to observe key project information such as vessel tracking, geophysical and geotechnical progress, UXO, archaeology, obstruction, and environmental permitting clearance and approvals.

Data are available in a centralized location easily accessible from various devices, which is used to obtain the latest ground model and field work progress. This remote access helps to reduce project schedules and costs. Powered by a Microsoft SharePoint environment, a project can be tracked from award to report delivery. With this tool, the entire project team can seamlessly search, update and share files. It provides near-real-time soil data to inform project decisions sooner, including the rerouting of export and interarray cables due to geohazards and obstructions, siting wind turbine generator locations, and informing foundation design considerations.

Field Examples

Given the large size of lease areas and the desired information about seafloor conditions in the region, site characterization projects tend to require extensive survey coverage with work phased over multiple field seasons to support varying stages of development. Fugro's projects often include multiple geophysical and geotechnical vessels operating simultaneously within a single lease area and are managed from the company's U.S. Center of Expertise for Renewable Projects, located in Norfolk,

Virginia. In 2020 alone, the company is supporting six different offshore wind projects in the region. Work on one of these originally began in 2017 with a reconnaissance survey, meant to provide an initial site framework and geologic model. In 2018 and 2019, Fugro returned to the site to perform export cable route studies. Offshore investigations were completed this year, capturing the full complexity of the site.

Conclusion

The Atlantic OCS is the starting point for offshore wind-based energy projects in the U.S. By adapting proven strategies for delivering integrated site characterization services to the specific needs of offshore wind clients in the region, Fugro is helping to ensure responsible stewardship of natural resources and the sustainable development of large capital assets in the marine environment. **ST**

Andrew Cooper earned a B.S. in civil engineering from the Georgia Institute of Technology, specializing in both geotechnical and structural engineering. He is a certified Engineer-in-Training and Applied Project Management Professional. As Fugro's offshore wind lead, he manages the marine site characterization branch office on the U.S. East Coast.

Elena Starchenko earned an M.S. in transportation engineering from Moscow State Automobile and Road University. She has seven years of experience in the infrastructure, energy and renewable sectors. She is responsible for marketing and coordinating Fugro's business development activities within the company's Norfolk, Virginia, office to support the U.S. offshore market.



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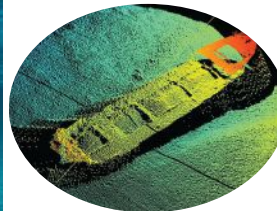
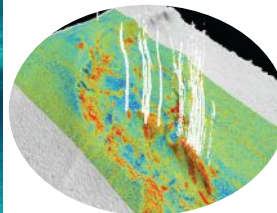
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- Oil Spill Response
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New Infection Prevention Certification

DNV GL has launched a new certification in infection prevention to help the maritime industry resume operations with better preparation for COVID-19 or other emerging pathogens. Genting Cruise Lines is the first customer working toward the CIP-M certification for its vessel *Explorer Dream* under the Dream Cruises brand.

CIP-M certifies that a company has the procedures and systems in place for the proper prevention, control and mitigation of infection to protect customers and crew.

CSS Enhances Offshore Capabilities

Connector Subsea Solutions (CSS) of Bergen, Norway, has completed the acquisition of Isotek Oil and Gas Ltd. The acquisition adds Isotek's remote welding technology to CSS's existing range of subsea pipeline repair capabilities, which are primarily focused on mechanical clamp and connector pipe joining solutions.

The deal strengthens CSS's position as a complete solutions provider for critical offshore connections and is part of a strategic drive to meet growing industry demand for technologies that offer lighter, smaller and more reliable pipeline repair methodologies for complex subsea and remote intervention.

Carnival Cruises to Use Silverstream ALS

A "carpet of micro-bubbles" developed by U.K. tech firm Silverstream Technologies to improve fuel efficiency in the shipping industry has landed the business a £1 million deal with Carnival Cruises.

The Silverstream System, a type of air lubrication system (ALS), pumps tiny bubbles through vents on the hull to reduce friction between the vessel and the water, helping it glide through the ocean. The technology has been independently proven to reduce fuel consumption by 5 to 12 percent, which in turn cuts running costs.

Business Alliance to Manage Biofouling

The GloFouling Partnerships Project has launched a private sector alliance to accelerate solutions to improve management of marine biofouling and reduce its role relative to invasive species and greenhouse gas emissions. The Global Industry Alliance (GIA) for Marine Biosafety is a partnership of leading companies from industries affected by biofouling, e.g., shipping, aquaculture, offshore oil and gas, and offshore renewable energy. The World Ocean Council is engaging the ocean business and investment community in the five-year GEF-UNDP-IMO GloFouling Partnerships Project.

Sonardyne FLS for DDU

Underwater obstacle avoidance technology from Sonardyne International Ltd. has been chosen for a new design diver delivery unit (DDU) being built by SubSea

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Craft. Sonardyne's Vigilant forward-looking sonar (FLS) will provide a critical hazard avoidance capability for the crew and embarked divers of the VICTA Class DDU when navigating on or below the surface. Using a compact bow-mounted transducer arrangement, Vigilant FLS displays water depth and subsurface obstacles and features by creating an accurate 3D model of the underwater environment.

USS Surveys Infrastructure

Unmanned Survey Solutions (USS) was recently commissioned by Conwy County Borough Council to undertake a multibeam echosounder and mobile laser scan survey of Conwy quay wall, Conwy bridge, Conwy cob and Tal Y Cafn bridge structures located within Conwy River. As detailed by the Wales Coastal Monitoring Centre, the purpose of the survey was to assess the scour extents at the structure's foundations and to provide additional information on the above-surface structure.

Korean Register Turns 60

The Korean Register (KR), an IACS member classification society, is celebrating its 60th anniversary.

Looking ahead, digitalization and positioning KR as the leading digitalized classification society are the focus. KR intends to deliver 10 practical digital technologies before the end of 2020. These already include condition-based monitoring, drone surveys and a 3D-based approval system. AI technologies are the next area of focus as autonomous vessels increase.

Full Remote Survey of Singapore Harbor Tug

Bureau Veritas Marine Singapore (BV), in collaboration with PSA Marine (Pte) Ltd., has successfully completed a remote marine survey for PSA *Aspen*, an LNG dual-fuel PSA Marine harbor tug. Supported by the Maritime and Port Authority of Singapore, the project marks the first time a harbor tug registered under the Singapore Registry of Ships has undergone a fully accredited annual survey conducted fully remotely.

Resolve Refloats Grounded Vessel

Resolve Marine has successfully refloated the grounded cargo vessel *KAAMI*, completing response operations with it in tow to a drydock in Loch Kishorn, Scotland. The vessel held 1,900 tons of solid recovered fuel pellets. Response included patching of ruptured cargo holds and ballast tanks, lightering of the cargo, and refloat operations. Resolve salvage teams and equipment mobilized from bases in Europe, Africa and the United States.

Mitcham Evolves

Mitcham Industries Inc. is seeking shareholder approval for a reincorporation from Texas to Delaware, which will include rebranding and renaming the company MIND Technology Inc.

The company is focusing on its marine technology products business, as well as recent changes in the global energy markets, and is further de-emphasizing its land seismic leasing business. **ST**

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Flaw Detector



M2M Mantis offers UT, PAUT, TOFD and TFM. It addresses both general and advanced inspection requirements without compromising productivity and is ideal for applications such as high-speed corrosion mapping, butt weld and long seam weld inspections. Eddyfi Technologies Inc.

Remote Performance Evaluation

ABB Ability Tekomar XPERT now has a continuous evaluation function that allows the software to use engine data gathered by edge-computing services, which enhances Tekomar XPERT's monitoring, reporting and advisory capabilities. ABB Turbocharging.

Voyage Planning

MyFleet is the shipping industry's first free-of-charge, cloud-based tool for due diligence on voyage planning. It is an easy-to-use web-based tool designed to support on-shore teams to check and assess risk in a ship's voyage plan. ChartWorld GmbH.

Multiparameter Monitoring

Sea@vanced Sound is a real-time service using a solar-powered buoy to record underwater sound with up to four hydrophones. It can host optional sensors such as a CTD, current meter or weather station. Applications include marine mammal monitoring and long-term water quality studies. SUEZ and RTSYS.

Scrubber for Small Vessels

PureSOx Express makes it simple for smaller vessels like handymax

bulkers or product tankers to continue using HFO and comply with SOx regulations. It is an open-loop PureSOx system, delivered as a fully enclosed module. Alfa Laval AB.

Pan and Tilt Positioner

Accu-positioner features a reliable and rugged design and computer-controlled accuracy to $\pm 0.1^\circ$. It is controlled with COTS controllers, devices and ROS GUI, and is depth-rated to 6,000 m. Remote Ocean Systems.

New Laser Wavelengths

Models SB10 and SB20 Sea Beam Laser Scalers now feature the laser colors red for minimum biologic awareness; green for greater brightness in turbid water; and blue for long-distance penetration in clear water. Sea Beams are waterproof to over 600 ft. Laser Tools Co. Inc.

Real-Time Measurement



WebDAQ 904 features four, simultaneous universal analog inputs, capable of measuring voltage (up to ± 60 V), thermocouples, RTDs, current, resistance, strain gages and other bridge-based sensors. Users can log and view data in real time from anywhere on an internet-enabled device. Measurement Computing Corp.

Sustainable Mooring

Seafloatech Pod is an environmentally friendly seabed-to-surface mooring system that can be adapted to any marine environment. It comprises a singular fixed mast articulated at its base and a hydraulic piston that allows the upper part to

swing in line with the swell of the ocean. Seafloatech.

UUV

Iver4 580 features advanced mission capability in a portable package, with hot-swappable battery sections that can be changed in the field without any special tools. A full suite of sensors and small mission footprint make it ideal for commercial and defense survey missions. L3Harris Technologies.

Waterproof HDMI Cable



Rugged, IP67-rated HDMI cable assemblies feature a waterproof coupler and gold-plated contacts that stand up to repeated mating cycles at operating temperatures of -24° to $+85^\circ$ C. An IP67-rated HDMI panel-mount coupler can be used with these cable assemblies. MilesTek.

Benchmarking Application

Vessel Insight Benchmark introduces a new data-driven approach for gaining insight into historical vessel performance, enabling fleet managers and maritime executives to access key metrics for their vessels and compare them against vessels in the same segment. Kongsberg Digital.

At-Sea Connectivity

Smaller vessels, like those used in fishing industry, can have easy access to connectivity with Thuraya MarineStar. This terminal with built-in handset and small antenna operates using Thuraya's extensive satellite network, providing dependable voice communications. IEC Telecom Group.

Cleaner Engine Tech

Intelligent Control by Exhaust Recycling (iCER) is the first development to be introduced as part of X-DF2.0, a second-generation dual-fuel en-

gine platform that will enable improved engine performance with both LNG and future carbon-neutral fuels. The iCER system delivers enhanced combustion control that reduces methane slip emissions by up to 50% when using LNG. Fuel consumption is reduced by 3% in gas mode and 5% in diesel mode. Winterthur Gas & Diesel Ltd.

VSAT Internet-of-Things Service

Remote Expert Intervention is a satellite-optimized video collaboration application to enable on-demand high-throughput remote support sessions between vessels at sea and experts onshore. Maritime equipment manufacturers can give real-time guidance to onboard crew for troubleshooting, repair and identification of necessary replacement parts. KVH Industries Inc.

Disease Control, Prevention

My Care assesses, manages and mitigates infection risk in management systems, business processes and operations. It incorporates local regulations and guidelines for any vessel or terminal. DNV GL.

Deepwater Camera System

Dropcam weighs less than 50 kg and is a user-configurable autonomous platform with cameras (full HD, 4K or even higher resolution), high-performance LED cluster lighting systems, rechargeable batteries, control electronics and multiple sensors. It is depth-rated to 2,500 m. Mariscope Meerestechnik.

Portable Fluorometry System

LabSTAF monitors phytoplankton for measurements in extreme oligotrophic waters, open oceans, coastal waters and lakes. This automated platform runs continuous fluorescence light curves. Chelsea Technologies Group Ltd.

Remote Sensing, Data Control

Compressed Remote Command and Control works with bandwidths of just 6 kbps. Data can be collected offshore and stored on the sensor or topside computer for leak detection, static field scans and metrologies. 3D at Depth Inc. **ST**

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More Collaboration on UK Energy Test Site

The European Marine Energy Centre (EMEC), based in Orkney, Scotland, has signed an agreement with Marine Energy Wales to provide further support to the Marine Energy Test Area (META) in Pembrokeshire, Wales. This builds on an initial collaboration between the two parties in 2018, which resulted in EMEC providing input into the initial feasibility stage of the META project. EMEC guided the development of META by providing strategic advice on site selection, developer requirements, operational procedures and commercial development, drawing on EMEC's 17 years of experience and knowledge in setting up and operating ocean energy test sites.

META consists of eight pre-consented, nongrid connected sites located in and around the Milford Haven Waterway, derisking the development of marine energy projects by providing the opportunity to test scaled devices, subassemblies and components.

Phase one of the project launched in September 2019.

MacGregor to Equip Offshore Wind Service Vessels

MacGregor, part of Cargotec, has received equipment orders for a total of four offshore wind service vessels, which will expand the Edda Wind fleet, the offshore wind segment of the Østensjø Group. The first vessel will enter into service the first quarter of 2022.

Two of the equipment packages were awarded by the shipbuilder Astilleros Gondán in Asturias, Spain, for Edda Wind's zero-emission commissioning service operation vessels, the first of which will enter into a firm charter period of 11 years. Each vessel will be equipped with a Horizon all-electric walk-to-work gangway, including the largest integrated passenger lift ever fitted to a wind service vessel, which is interconnected to a Colibri 5-tonne 3D motion-compensated crane.

The other two equipment packages were awarded by Astilleros Balenciaga, which is building Edda Wind's second-generation service operation vessels, also prepared for zero-emission hydrogen fuel. The first of the two vessels will enter into service on a 15-year charter agreement in the second quarter of 2022 and will also be equipped with a Horizon all-electric walk-to-work gangway system and Colibri 3-tonne 3D motion-compensated crane.

SMD Plough to Install Cable

Soil Machine Dynamics Ltd. (SMD) recently handed over a purpose-built pre-lay plough to Boskalis for use at Ørsted's offshore wind farm Hornsea Two. It will be used to install 380 km of export cables, which will ultimately connect Hornsea Two's offshore substation to the site's onshore substation.

Once complete, Hornsea Two will host an array of 165 wind turbines, each standing over 190 m above sea level. The wind farm will generate 1.4 GW and will be able to power well over 1.3 million homes in the U.K.

Turbines for WindFloat Atlantic

Following the supply and installation of the mooring lines, Bourbon Subsea Services towed and connected the third 8.4-MW floating wind turbine of the WindFloat Atlantic project, located 20 km from Viana do Castelo on the Portuguese coast. These turbines have a total capacity of 25 MW.

Bourbon, responsible for the project management and engineering of the installation at sea, provided all the naval assets and necessary personnel for the offshore operations for the three turbines.

Hybrid AUV for Survey

Modus Seabed Intervention Ltd. has completed a high-speed bathymetric and depth of burial survey of the interarray cable routes on the Innogy-operated Gwynt-y-Môr offshore wind farm, utilizing the

Modus HAUV-2 (hybrid AUV). The Gwynt-y-Môr offshore wind farm comprises 160 Siemens 3.6-MW wind turbine generators (WTGs) located approximately 8 mi. from the North Wales coast in Liverpool Bay in water depths ranging between 12 and 28 m. The WTGs are connected by 161 interarray cables totaling circa 147 km in length.

Modus mobilized its HAUV-2 system, equipped with Optimal Ranging Orion Cable Tracking System and dual-head R2Sonic 2024 multibeam echosounder, on a chartered DP2 vessel at the work site, which has currents up to 2 kt. Despite the high currents experienced, survey speeds achieved were approximately four times faster than incumbent ROV-based solutions.

Diving Work for Virginia Offshore Wind Farm

Aqueos Corp. recently completed a diving contract for support of the Coastal Virginia Offshore Wind (CVOW) Generation Project development on the U.S. East Coast.

Aqueos deployed an IMCA-compliant diving system and personnel onto a 175-ft.-class lift boat to support the work, which consisted of trenching the HDD pull in conduit, installation of sealing flanges, pull-in monitoring operations, and protecting the HDD exit site by installing 45 tons of washed local gravel.

UXO Survey for Kincardine

UXOcontrol has completed the UXO identification campaign for the Kincardine offshore wind farm.

Located approximately 15 km off the southeast coast of Aberdeen, at water depths ranging 60 to 80 m, Kincardine has a nominal capacity of 50 MW, comprising offshore floating wind turbine structures, an offshore export cable, a landfall and an onshore export cable.

Following geographical survey works, the identification campaign mobilized UXOcontrol's UXO clearance vessel at water depths from 13.9 to 87 m over four weeks.

UXOcontrol's first U.K. contract as the rebranded joint venture of N-Sea and BODAC was awarded by Cobra Wind International Ltd. **ST**

Wetter Climate Could Intensify Global Warming

A study published in *Nature* indicates the increase in rainfall forecast by global climate models is likely to hasten the release of carbon dioxide from tropical soils, further intensifying global warming by adding to human emissions of this greenhouse gas into Earth's atmosphere. The study was conducted by an international team led by Dr. Christopher Hein of William & Mary's Virginia Institute of Marine Science. Major funding was provided by the U.S. National Science Foundation.

Shifts toward a warmer and wetter climate in the drainage basin of the Ganges and Brahmaputra Rivers over the last 18,000 years enhanced rates of soil respiration and decreased stocks of soil carbon. This has direct implications for Earth's future, as climate change is likely to increase rainfall in tropical regions, further accelerating respiration of soil carbon and adding even more CO₂ to the atmosphere than that directly added by humans.

Soil respiration refers to release of carbon dioxide by microbes as they decompose and metabolize leaf litter and other organic materials on and just below the ground surface. Roots also contribute to soil respiration at night, when photosynthesis shuts down and plants burn some of the carbohydrates they produced during daylight.

The team's study is based on detailed analysis of three sediment cores collected from the ocean floor seaward of the mouth of the Ganges and Brahmaputra Rivers in Bangladesh. Here, the world's largest delta and submarine fan were built by the prodigious volume of sediments eroded from the Himalayas. The two rivers carry more than a billion tons of sediment to the Bay of Bengal each year.

The cores record the environmental history of the Ganges-Brahmaputra drainage basin during the 18,000 years since the last Ice Age began to wane. Analysis shows a strong correlation between runoff

rates and soil age—wetter epochs were associated with younger, rapidly respiring soils; while drier, cooler epochs were linked to older soils capable of storing carbon for longer periods.

Fugro Helps Ifremer

A Fugro vessel heading from the Netherlands to South Africa has made a 10-day detour to support Ifremer, the French Research Institute for Exploitation of the Sea, in monitoring a giant active underwater volcano off the east coast of Africa.

Ifremer's latest research mission to the volcano was affected by the COVID-19 pandemic and associated travel restrictions.

Fugro diverted the specialist hydrographic survey vessel *Fugro Gauss* to Mayotte in the Mozambique Channel to support Ifremer's vital hydrographic survey.

3D Laser Models of Deep-Sea Larvaceans

Living in an essentially zero-gravity environment, many deep-sea animals have evolved soft, gelatinous bodies and collect food using elaborate mucus filters. A new study describes a laser-based system for constructing 3D models of diaphanous marine animals and the mucus structures they secrete. Kakani Katija, MBARI principal engineer, is lead author of the study.

The researchers focused on one of the most prolific mucus architects, deep-sea animals called larvaceans, which are abundant throughout the world's ocean basins and range from less than 1 cm to about 10 cm long. "Giant" larvaceans create balloon-like mucus webs that can be up to 1 m across. Inside these outer filters are smaller, fist-sized inner filters that the animals use to feed on tiny particles and organisms, ranging from less than a micron to a few millimeters in size. Larvaceans remove vast amounts of carbon-rich food out of the surrounding water. When their mucus filters become clogged, the animals release the mucus, which

sinks rapidly to the seafloor. This helps the ocean remove carbon dioxide from the atmosphere and carries microplastics from the water column down to the seafloor.

An instrument called DeepPIV (particle imaging velocimetry) was developed and mounted on an ROV to project a sheet of laser light to illuminate particles in the water. By recording the movement of these particles on video, researchers can quantify tiny currents around marine animals, as well as water flowing through their filters and their transparent bodies.

Combining 3D models of larvacean filters with observations of flow patterns through the filters, the researchers were able, for the first time, to identify the shape and function of different parts of the larvacean's inner filter. This could help design better 3D printers or build complex inflatable structures that could be used underwater and in outer space.

Microplastics Threaten Marine Biodiversity

New research from Queen's University Belfast and Liverpool John Moores University reveals how the microplastic pollution crisis is threatening biodiversity. Up to 10 percent of global plastic production ends up in the sea. The research focused on the impact of plastics on hermit crabs, which play an important role in balancing the marine ecosystem. They eat decomposed sea-life and bacteria; play host to more than 100 invertebrate species; and are prey for commercially valuable species such as cod, ling and wolf-fish.

Hermit crabs take shells from snails to protect their soft abdomens. As a hermit crab grows over the years, it needs to find larger and larger shells to replace the ones that have become too small. These shells are vital in protecting and enabling hermit crabs to grow, reproduce and survive.

The researchers found that when hermit crabs were exposed to microplastics, they were less likely to later touch or enter high-quality shells. **ST**

Forum Chooses China Rep

Forum Energy Technologies has announced that Wuxi Haiying-Cal Tec Marine Technology Co. Ltd. will represent Forum for the sale of the company's extensive range of ROVs in China, including its recently launched XLe Spirit electric ROV.

The vehicle, which recently completed successful sea trials in Norway, is the first of a new generation of electric observation-class ROVs. It is the smallest in the new range and powerful enough to perform subsea maintenance and repair work.

Forum continues to see strong demand for its products in China and the wider Asian market and recognized the need for a local partner to support its long-term growth strategy.

Australia Invests in Comms For Autonomous Systems

Australia's Defence Science and Technology Group (DST) has acquired a BlueComm undersea communications system from Sonardyne International Ltd. as part of its ongoing program in maritime autonomous systems (MAS).

According to Sonardyne, BlueComm is the only commercial-off-the-shelf technology that enables wireless transmission of high-bandwidth tactical data, including video, over ranges of a few tens to hundreds of meters, at rates of up to 10 megabits per second.

With it, forces can vastly increase the communications capability of their underwater systems to drive faster, safer and better informed decision making in theaters of operation. It could be considered for use with swarms of autonomous vehicles mapping areas for mine-like objects, for USVs acting as surface communication gateways or as part of emerging MAS networks.

Because they use light to transmit and receive data instead of the acoustics traditionally used for communications underwater, BlueComm modems can deliver higher data rates with lower laten-

cy. They're also undetectable by sonar listening devices, making them highly suitable for covert, secure communications. Configurations are available for all operating environments, including shallow waters with high levels of ambient light and on underwater vehicles equipped with powerful lighting.

DST seeks to understand the operational implications of optical data transmission and its dependence on water clarity, geometry and ambient illumination.

Fast Craft Simulators For Singapore Police

Kongsberg Digital (KDI) has delivered the first K-Sim Fast Craft simulators to the Singapore Police Coast Guard (SPCG) Training Centre in Singapore. The four installed simulators reproduce a variety of high-speed vessel types and are supplied under the terms of a landmark contract with the Singapore Ministry of Home Affairs.

The simulator enables highly realistic vessel simulation at speeds exceeding 50 kt. and integrates with an advanced eye-tracking system, in addition to weapons capabilities. It will provide new recruits with the most life-like, high-speed tactical and rapid interception training program possible. The simulator training will enable exercises to be carried out and professionally assessed in controlled conditions of complete safety, avoiding risk to personnel and removing the prospect of equipment damage. In addition, the exercises are repeatable, so trainees can undertake them as many times as necessary in order to achieve the required high standard of competence.

The highly adaptable K-Sim Fast Craft simulator uses an advanced physics engine and customizable hydrodynamic modeling, derived from and validated against recorded vessel performance data, to duplicate the ways in which high-speed vessels behave in the real world when affected by factors such as wave movements or impacts with

other crafts and floating objects, in a range of sea states and at different speeds.

The simulator supports training in advanced boat handling, navigation and interception techniques, escalation of force and weapons engagement, including mission planning, rehearsals and full-scale debriefing/after-action reviews.

Data Management Testing

The China Navigation Co. (CNCo) has partnered with Dualog in the testing phase of the Dualog Drive application, a maritime-optimized file and folder replication service, designed to simplify the collection and distribution of large data volumes between ship and shore.

Founded in 1872, CNCo is the oldest operating entity and deep shipping arm of the Swire group. CNCo planned to have Dualog Drive fully operational across CNCo's entire fleet by the summer.

TDI-Brooks Gets WINGHEAD

TDI-Brooks has added to its toolbox the first U.S.-based NORBIT WINGHEAD system, supplied and supported by Seahorse Geomatics. This is the first dual-head WINGHEAD sold in North America.

WINGHEAD is a high-resolution multibeam echosounder with tightly integrated 1,024 beams, 0.5 by 0.9° resolution and frequency of 200- to 700-kHz. Its weight in air is less than 7 kg, including mounting brackets and GNSS/INS.

WINGHEAD will enable TDI Brooks to expand services in the renewable energy sector. In the offshore, nearshore and inland markets, the WINGHEAD will allow for high-resolution, shallow-water geohazard and river surveys, along with bridge inspections.

The WINGHEAD bathymetry can also be combined with an integrated LiDAR to collect data above and below water.

The combined multibeam and LiDAR solution provides a complete 3D georeferenced image. All data are collected simultaneously, and 3D images can be obtained in real time. **ST**

JW Fishers' Tech in the Field

JW Fishers' underwater metal detector Pulse 8X is in use worldwide by law enforcement, military, fire and rescue departments, public safety dive teams, commercial divers, and wreck hunters. The recent addition of the SAR-1 underwater metal detector complements the Pulse 8X when zero-visibility conditions make the SAR-1's vibration feature and ultrabright LED display a necessity. The SAR-1 is contained in a wireless, "snareless," vibrating casing.

The Royal Canadian Mountain Police (RCMP) uses the Pulse 8X detector at the RCMP National Underwater Recovery Training Centre in Nanaimo, BC. The RCMP dive teams across Canada utilize the Pulse 8x when searching for small pieces of evidence at underwater crime scenes.

The dive team of the Thurston County Sheriff's Office, in Olympia, Washington, uses JW Fishers' SAR-1 underwater metal detector.

Another offering from JW Fishers is the SeaOtter-2 ROV. Thames Water Utilities Inc., the U.K.'s largest water and wastewater services provider, uses the SeaOtter-2 to inspect underwater pipe and machinery.

New i911 System for PNW

The 13th U.S. Coast Guard District has implemented a groundbreaking technology to assist mariners in distress on the waters of the Pacific Northwest (PNW). Across Washington and Oregon, mariners can provide vital location information to Coast Guard rescue crews from their smartphones without having to download an application. In addition to common life-saving devices known to mariners, such as electronic position indicating radio beacons (EPIRBs) and VHF radios, the Coast Guard now has the i911 application as an additional tool to provide vital information from a mariner's cell phone.

The i911 system is a free service developed by Callyo Inc. It provides

fast and accurate location data to the Coast Guard in a simple web-based interface. If a mariner has recently or is actively connected to a cell tower, the user's smartphone could provide GPS information, potentially up to 20-nautical mi. offshore. The Coast Guard has the ability to send a text message to the mariner's cell phone requesting permission to access the GPS location information; all the mariner needs to do is enable location information in the smartphone settings and click the link provided in the text message. The Coast Guard can then utilize the provided positions to direct search assets to the mariner's location.

This tool is readily available to first responder agencies across the U.S. (<http://i911.zendesk.com>).

Florida Nautical Charts Update

Fugro has begun work on its first task order under a recently awarded multi-year hydrographic services contract with NOAA. Located off the northwest coast of Florida, the project involves acquisition of high-resolution bathymetry data over four sites totaling approximately 1,475 km². Deliverables will be issued to NOAA by December to update charted depths and features in the region, many of which pre-date the 1950s.

To streamline the data collection, Fugro will deploy its new FAS-900 USV as a force multiplier on the project. The fit-for-purpose USV is equipped with multibeam echosounder technology and designed to increase the rate of data acquisition on medium- to large-scale mapping programs.

Ship Recycling Guidance

DNV GL has launched a new guidance on recycling to help shipowners navigate a regulatory environment that is becoming increasingly complex. With the IMO Hong Kong Convention not yet in force, strict enforcement of the EU Ship Recycling Regulation and the

EU Waste Shipment Regulation means shipowners must carefully plan for the end of life of their vessels. Shipowners looking to make informed, economic and responsible decisions on how to deal with vessels at the end of their life cycles face a much stricter and more complex set of international, regional and national requirements than in the past. With regulators targeting shipowners with significant financial penalties, even criminal offenses, shipowners need a careful and considered strategy for dealing with ship recycling.

The new guidance, "Ship Recycling: Navigating a Complex Regulatory Landscape" (tinyurl.com/yb3sje9c), aims to give a better basis for decisions on the recycling of vessels. It sets out the main recycling options, the legal, reputational and financial risks, and provides a process that can help to assess whether an individual yard is likely to carry out recycling to an acceptable level, in line with recognized regulations and standards. This process has been designed by DNV GL to provide owners a template for action, in the absence of internationally accepted certifications outside the EU scheme, when they are dealing with yards not on the EU approved list.

NATO CMRE Open Library

The NATO Science and Technology Organization (STO) Centre for Maritime Research and Experimentation (CMRE) library of scientific literature is a free and open repository of knowledge including technical papers, published articles and reports. It's now available online to members of the scientific community worldwide: <https://openlibrary.cmre.nato.int>.

The library holds more than 800 technical reports, conference papers and presentations, and journal articles. Communities and collections are easily searchable by subject, date, title or author. The CMRE Open Library uses the DSpace open-source software solution familiar to many researchers, providing a familiar search interface either directly or through academic search engines such as Google Scholar. **ST**

meetings

Note: The coronavirus (COVID-19) could affect event dates. Check event websites for the latest updates.

SEPTEMBER

September 7-9—Oceanology International Middle East, Abu Dhabi, United Arab Emirates. +971 2 491 7615, firas.abultaif@reedexpo.ae or www.oceanologyinternationalmiddleeast.com/en-gb.html.

September 9-11—Noia Oil & Gas Conference & Exhibition, St. John's, Canada. kmorrissey@noia.ca or www.noia.ca.

September 14-17—Fleet Maintenance and Modernization Symposium, Virginia Beach, Virginia. www.navalengineers.org/Symposia/Fleet-Maintenance-and-Modernization-Symposium-2020.

September 21-25—NMEA/RTCM Conference & Expo, Orlando, Florida. 410-975-9425 or www.nmea.org.

September 21-25—Portugal Shipping Week, Lisbon, Portugal. +44 1295 814455, LBH@petrospot.com or www.petrospot.com/events/psw-2020.

September 23-24—Oil Spill India, Mumbai, India. +91-8287955348, kamna@itenmedia.in or www.oilspillindia.org.

September 23-24—Remote Hydrography Conference, Southampton, England. tinyurl.com/y7v95eeg.

September 27-October 2—Underwater Mining Conference, St. Petersburg, Florida. 727-631-9579, lazevedo@immsoc.org or www.underwatermining.org.

September 28-October 2—SNAME Maritime Convention, Houston, Texas. 703-997-6701 or www.sname.org.

September 29-30—Teledyne Ma-

rine Canadian Users Conference, Halifax, Canada. www.teledyne-marine.com/events/Teledyne-Marine-Users-Conference-Canada.

September 29-October 1—National Coastal and Estuarine Virtual Summit. <https://estuaries.org/summit>.

OCTOBER

October 5-8—AUVSI XPONENTIAL Virtual. meetings@auvsi.org or www.xponential.org.

October 5-30—Global OCEANS 2020: Singapore – U.S. Gulf Coast Virtual. <https://global20.oceansconference.org/participate/register-now>.

October 6-8—World Conference on Floating Solutions, Rotterdam, Netherlands. admin@pavingthewaves.blue or www.pavingthewaves.org.

October 11-16—SEG, Houston, Texas. exhibits@seg.org or <https://seg.org/AM/2020>.

October 12-14—Climate Risk Summit, London, England. +44 (0)20 7576 8118, events@economist.com or <https://events.economist.com/events-conferences/emea/climate-risk-summit-2020>.

October 14-15—OilComm, Houston, Texas. www.oilcomm.com.

October 14-15—World Ocean Tech and Innovation Summit, Halifax, Canada. oceanspeakers@economist.com.

October 20-23—EURONAVAL, Paris Le Bourget, France. www.euronaval.fr.

October 21-22—NOIA Fall Meeting Virtual. www.noia.org.

October 26-28—Offshore Energy, Amsterdam, Netherlands. +31 (0) 10 209 2600, service@offshore-energy.biz or offshore-energy.biz.

NOVEMBER

November 2-4—MAST Asia, Tokyo, Japan. warren.edge@mastconfex.org.

org or <https://mastconfex.com/asia2020>.

November 3-5—Marine Renewables Canada Conference, Halifax, Canada. amanda@marinerenewables.ca.

November 5—North American Marine Environment Protection Association Annual Conference, New York City. <https://namepa.net/event/2020-annual-conference-and-awards-dinner>.

November 10-12—Marine Autonomy & Technology Showcase, Southampton, England. dcook@noc.ac.uk or <https://noc-events.co.uk/mats-showcase-2020>.

November 16-20—BlueTech Week, San Diego, California. www.tmabluetech.org/bluetech-week.

DECEMBER

December 1-3—Oceanology International London, London, England. +44 (0)1202 669244, j.riegal@saltwater-stone.com or www.oceanologyinternational.com.

December 1-3—Pacific Marine Expo, Seattle, Washington. 206-282-6858, Ken@SaundersonMarketingGroup.com or www.PacificMarineExpo.com.

December 2-3—LNG Latin America & the Caribbean, Buenos Aires, Argentina. <http://LNGlatinamerica.com>.

December 8-10—UDT, Rotterdam, Netherlands. www.udt-global.com.

December 16-17—West Coast Defense Contracting Summit, San Diego, California. 202-552-0179 or marketing@defenseleadershipforum.org.

2021

January 19-20—Floating Wind Solutions Conference & Exhibition, Houston, Texas. 832-862-3390 or <https://floatingwindsolutions.com>.

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

contracts

The World Ocean Council (WOC), Honolulu, Hawaii, has signed a memorandum of understanding to strengthen and promote the effectiveness of sustainability efforts through the development and deployment of digital technology. The focus will be on UN Sustainable Development Goal (SDG) 14: conserve and sustainably use the oceans, seas and marine resources. Global Enabling Sustainability Initiative.

Kongsberg Digital, Kongsberg, Norway, has won a contract for delivery of a K-Sim Cargo Handling Simulator, interfaced to a KONGSBERG K-Chief 600 marine automation system. Gungen Maritime & Trading A/S.

Alfa Laval, Lund, Sweden, has signed two frame agreements, running over the coming three years, for ballast water treatment systems. The agreements comprise firm orders to deliver Alfa Laval PureBallast 3 to about 40 vessels, with options covering another 40 systems. Undisclosed.

Fugro, Mumbai, India, has won a three-year inspection, repair and maintenance (IRM) contract to support an asset management project for ONGC off the west coast of India. Fugro will provide work-class ROV services, with the option of a two-year extension. Seamec Ltd.

ABSG Consulting Inc. (ABS Consulting), Houston, Texas, has been selected to implement the recently launched Restart Risk Model to help resume operations safely at a facility in Athens, Greece, and mitigate COVID-19 risk. ABS Consulting will help virtually assess the inherent risk of each site area, select recommended controls and develop enterprise-level policy and training. Prime Tanker Management.

V.Group, Glasgow, Scotland, a global provider of ship management and marine support services, has entered a strategic partnership for best-in-class e-learning for V.Group personnel and customers. Ocean Technologies Group.

Norsepower Oy Ltd., Helsinki, Finland, has made an agreement to install two of its largest Rotor Sails on board the *SC Connector*, a side door Ro-Ro. The agreement also heralds the installation of the world's first tiltable Rotor Sail. SEA-CARGO.

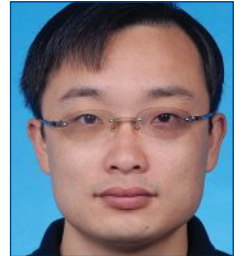
Damen Shipyards Group, Gorinchem, Netherlands, has delivered a Damen RHIB 975 inboard to conduct rescue operations on the Gooimeer, IJmeer and southern Markermeer lakes in the Netherlands. Naarden Lifeboat Brigade (Reddingsbrigade Naarden).

exactEarth Ltd., Cambridge, Canada, has expanded an alliance agreement with an existing channel partner, extending the current agreement by 3.5 years, through

December 2023. The partner may deploy exactEarth's exactView RT advanced real-time satellite-AIS data services in its full range of advanced maritime analytics products, derived services and international data customers. The agreement also provides both parties with expanded reseller rights. Undisclosed. **ST**

people

Sercel-GRC has named **Song Hu** as a new sales and support manager. Hu will be based in Tianjin, China, and will be responsible for managing and growing relationships in the region, while assuring satisfaction for Sercel-GRC's Asian client base. Hu previously served in a variety of technical support and operational supervisory roles for companies including GE, Baker Hughes and Zenith Oilfield Technology.



Todd Carey has joined PCCI as a chief engineer based in Ventura, California. He will be responsible for providing engineering, design, installation and program/project management services to U.S. government and commercial clients in the ocean facility and offshore energy industries. Carey is a mechanical engineer with experience supporting U.S. Navy and upstream oil and gas clients on the U.S. West Coast.

Sterling PBES Energy Solutions has announced **Ian Robinson** as director of engineering. He is a chartered naval architect who comes to the company with far-reaching design, shipyard, operational and management experience.

Acteon Group Ltd. has appointed **Dr. Carl Trowell** as group CEO, succeeding **Richard Higham**, who stepped down after 30 years with the company. Higham will remain on the board of Acteon as a nonexecutive director and senior adviser.

Tina Hjort Lykke has joined Teledyne Marine as HR director for imaging in Europe. She brings over 20 years of experience in human resources. She is based in Teledyne's headquarters in Denmark.

AGU (American Geophysical Union) has named **Randy Fiser** its CEO and executive director. Fiser is a skilled executive with strong collaborative and administrative skills, has a proven track record of working with membership organizations to advance their mission, and has worked throughout his career to advance sustainability practices. **ST**

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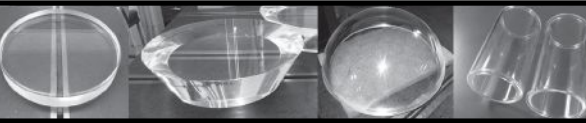
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Looking Back on 34 Years at the Helm of RV *Shana Rae*—Jim Christmann

After sailing much of the eastern North Pacific for fun, Jim Christmann operated a UC Santa Cruz coastal research vessel for 11 years (and so understands the constant need for funding), before making the jump to the RV *Shana Rae* in 1986. He will probably retire his current two-vessel service firm in three to five years. He welcomes any constructive feedback at: jaxmann@shanarae.com.



I've run several 40- and 50-ft. research vessels on Californian, Alaskan, Mexican and Tongan waters since 1976, and one of them, the RV *Shana Rae*, is special. She works in a mostly unseen niche, and since she can't toot her own horn, I'd like to do it for her.

RVs are tasked with more different kinds of service than any other general class of vessels. Most vessels support this or that agency or institution, and many seem to have service lives of only 10 to 20 years.

As a privately owned RV that came down from Alaska to California in 1986, *Shana Rae* has supported an astonishing range of coastal marine efforts for clients in academic, government, commercial, industrial and even military circles. *Shana Rae* just might be the most broadly experienced 50-ft. work vessel anywhere (www.shanarae.com).

An unsubsidized workboat must scramble constantly to pay formidable bills, and there weren't many choices around when this boat got started here in California's complex economy. Over the years, this old workhorse has deployed smoked-glass bathythermographs only seen in museums now, as well as multimillion-dollar prototype AUVs, some of the earliest CTDs, ADCPs for the U.S. Army Corps, small ROVs, and a prototype arm for a Mars Rover. *Shana Rae* once worked over VHF with U2 pilots at

80,000 ft. to coordinate weather balloon launches. National Geographic had this boat in close behind the manned deep-ocean research submersible Alvin and the twin Russian Mir submersibles, filming during launches. *Shana Rae* even goes back to when seabird gut-content studies were conducted with a shotgun on the bow, and live capture of Pacific white-sided dolphins for display was still a practice.

With the *Shana Rae*, we recovered most of a mile of 2-in.-diameter nearshore armored sonar cable for the U.S. Navy Seabees, supported hardhat divers on pipeline and bridge inspections, airlifted and vibracored archaeological and Superfund sites, towed surface, mid-water and benthic trawls for critters microscopic to meters in length, and launched instrumented elephant seal pups for recorded dives. I've had Navy SEAL divers under my supervision and ex-submarine and aircraft-carrier skippers in my wheelhouse as project consultants, and *Shana Rae* surely must be the only boat anywhere that's ever put a 26-ft. gray whale calf carcass in a towed bag for preservation and study.

The dinette table was used for nighttime surgery for one of the earliest transmitter implants on live marbled murrelets, which helped reveal where they nest in coastal old-growth forests; one of those old banded birds was just recaptured from *Shana Rae* in 2018, for a new species longevity record. We spent a month at San Nicolas Island, supporting the large experimental transplant of a subpopulation of southern sea otters, and have towed sub-bottom profiling systems on in-shore fault zones, side scan sonars on salvage jobs, magnetometers and numerous acoustic systems. The Monterey Bay Aquarium and Monterey Bay Aquarium Research Institute continue to bring me my most exciting technical challenges.

I've had a ball since taking the helm of *Shana Rae* and met many unforgettable people on this remarkable boat, some of them true giants. I sometimes wonder where *Shana Rae* will be after I've hung up my slicker in three to five years. It might well be back seining for salmon on Prince William Sound where I found it, unless trends change.

I did a piece on this page in 2003 about what I felt (and feel) is sometimes improper use of university RVs by nearly (or clearly) commercial entities, which has only become more entrenched. There are so many subsidized coastal RVs operating now that I don't have much confidence that a younger version of myself would thrive at this moment, even on *Shana Rae*. I'm still working enough to pay the bills, but I get pushed out of jobs by subsidized boats every now and then, while most of those projects never even come to my attention.

I'm a little saddened about the state in which I'll eventually leave this peculiar niche. I'd hope that more room could be made for small, private operations on a more level field, which might pay off with better service for all. My clients have come to trust that *Shana Rae* is offered with utmost flexibility, sometimes on zero notice, and that we'll go to extreme lengths to figure out whatever's called for on a project. This leaner, more highly incentivized RV service mentality is unique to small, private business. I could not have sustained this often exhausting personal approach, certainly not across 34 years, had I been operating somebody else's vessel with that institution's expectations and limitations. I've helped clients accomplish a lot of great work with *Shana Rae* in the last three decades, and I'm not quitting yet. I'd like to thank the many friends who have trusted *Shana Rae* with their important field efforts since '86. They know who they are. **ST**

august advertiser index

Blueprint Subsea.....	5
www.blueprintsubsea.com	
CLEAN GULF.....	30
www.cleangulf.org	
*EvoLogics GmbH.....	44
www.evologics.de	
General Oceanics, Inc.	22
www.generaloceanics.com	
GeoSpectrumTechnologies Inc.....	25
www.geospectrum.ca25	
Global OCEANS 2020: Singapore & U.S. Gulf Coast.....	6
https://global20.oceansconference.org	
*Instruments, Inc.	18
www.instrumentsinc.com	
International Federation of Hydrographic Societies.....	31
www.hydrographicsociety.org	
Knudsen Engineering Limited.....	12
www.knudseneng.com	
Offshore Energy20.....	4
www.offshore-energy.biz	
SBG Systems S.A.S.....	17
www.sbg-systems.com	
SubConn.....	3
www.macartney.com	
SubCtech GmbH	31
www.subCtech.com	
*Subsalve USA Division	25
www.subsalve.com	
TDI-Brooks International, Inc.....	29
www.tdi-bi.com	

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