MARINE TECHNOLOGY REPORTER

March 2020

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eDNA

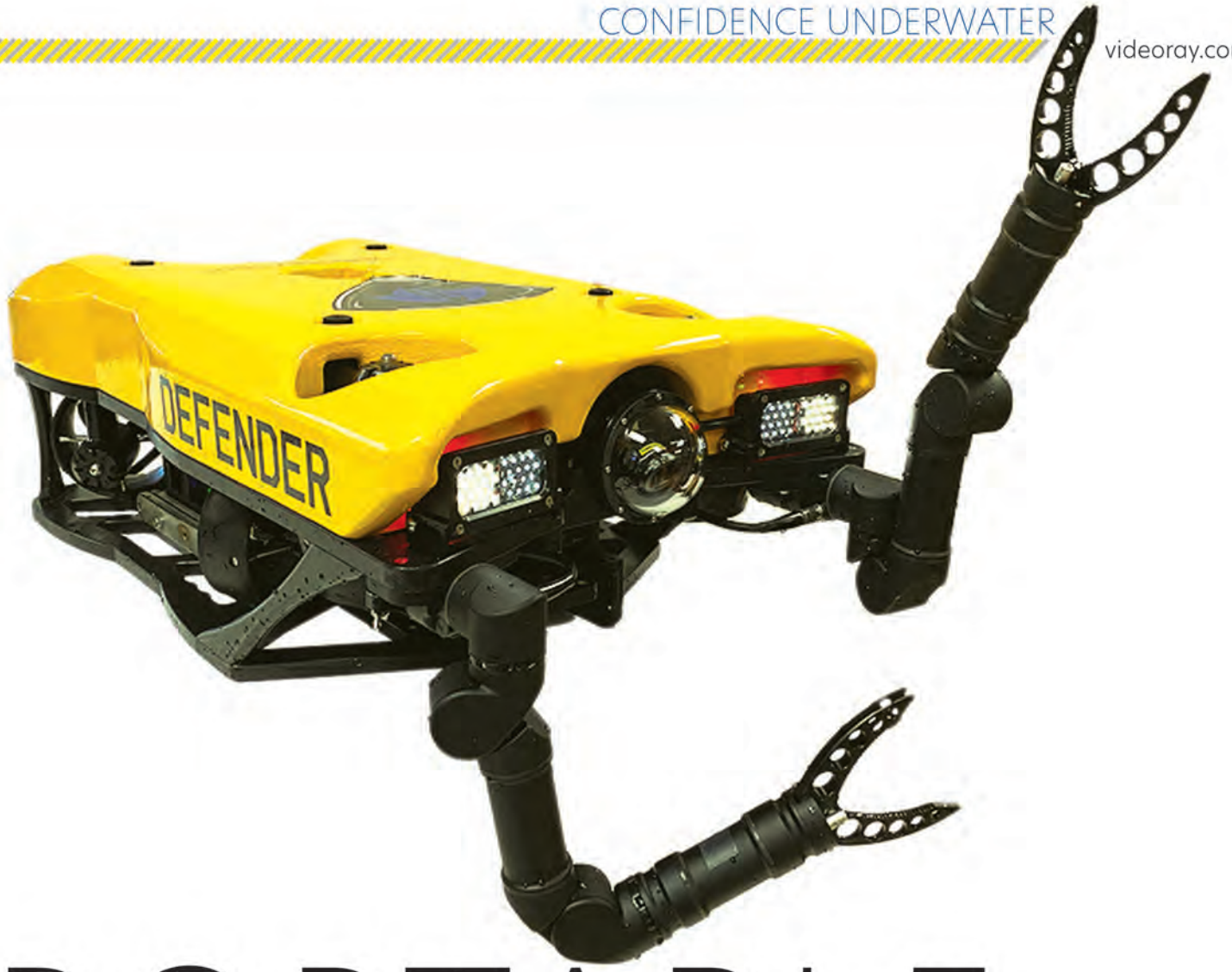
Understanding the ocean's complex biological web

MBARI Unlocking Ocean Biology

Marine Drones The Search for the sub San Juan

+ Oi '20 Tech Preview

Volume 63 Number 2



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Contents

Dartmouth Ocean Technologies Inc. and Sieben Laboratory Dalhousie University

Ecotone CEO, Oddbjoern Roedsten

Ocean Infinity

Credit: Chris Wahl (c) 2016 MBARI

On the Cover

(Photo by Thom Hoffman; Courtesy of Schmidt Ocean Institute. See story page 42.

18 Electric Motors
Considerations of partial load efficiency in electric motor selection for UUVs.
By Donald MacPherson

20 eDNA
There is a new buzzword in the ocean science/sensing community: eDNA, an abbreviation for environmental DNA.
By Justin Manley

26 An All-Seeing Eye
For survey-tech outfit, Ecotone, the business model is offering a faster, digital way to monitor the health of seabed environments and offshore infrastructure.
By William Stoichevski

34 Search for San Juan
Ocean Infinity helps to solve the mystery of a missing sub.
By Elaine Maslin

42 Unlocking Ocean Bio
Greater understanding of what goes on in the ocean is starting to become a reality – thanks to growing use of unmanned surface and underwater vehicles and developments in biological sensing.
By Elaine Maslin

4 Editor's Note
6 Authors & Contributors
8 **Tech Files**
14 **News Feature:** Next Generation
16 **News Feature:** Decom
18 **Tech Feature:** Next Generation
50 **Tech File:** The Gorilla ROV
50 **Tech File:** Ocean Instruments
54 **New Products**
56 Oi '20: The Conference
56 Oi '20: The New Technology
63 Classified
64 Advertisers Index

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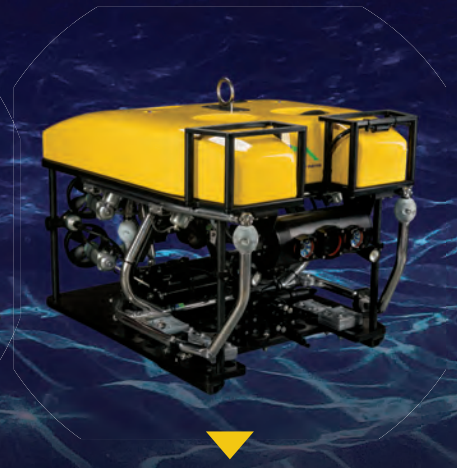

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NEW YORK
118 E. 25th St., New York, NY 10010
Tel: (212) 477-6700; Fax: (212) 254-6271

FLORIDA
215 NW 3rd St., Boynton Beach, FL 33435
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Editor's Note

Welcome to the March 2020 edition, our 'Oceanology International' edition with all eyes pointing to London and the 25th version of Oi since its founding in 1969 at the Hotel Metropole in Brighton. This is an 'interesting' year for sure, particularly with the current Coronavirus scare and its impact on meetings, particularly in Asia. Pandemic fears aside, Oceanology International is shaping to be the largest yet with 17,000 sq. m. of exhibition floorspace and 500 exhibitors from 90 countries. On display will be the requisite new technologies as only Oi presents, both on the show floor and on the water courtesy of its fleet of research vessels in for the event. Full coverage of the conference and new tech to expect on the show floor and on the boats starts on page 56.

Oceanographic Instrumentation is the feature focus of this edition, and to that end we have a pair of connected stories that fill the bill. Starting on page 20 Justin Manley explores "eDNA," an abbreviation for environmental DNA. This refers to DNA that can be extracted from environmental samples without first isolating any target organisms. In the maritime community such samples are taken from water. This is a powerful tool for understanding the complex biological web of an ocean or coastal ecosystem.

On page 42 Elaine Maslin offers "Unlocking Ocean Biology." Here we explore greater understanding of what goes on in the ocean with the growing use of unmanned surface and underwater vehicles and developments in biological sensing, taking a deep dive look at what a team at MBARI has been doing.

As anyone reading these pages knows well, a challenge to working efficiently underwater traditionally has, and continues to be, the ability to 'see.' William Stoichevski, our energy reporter based in Oslo, met recently with Ecotone, a company that offers an innovative, digital means to monitor the health of the seabed environment and offshore infrastructure. Specifically, the Underwater Hyperspectral Imager is proving its merit with tech that can ID and archive pipeline anomalies, sans x-rays and acoustic pings. His story starts on page 26.

Gregory R. Trauthwein
Associate Publisher & Editor

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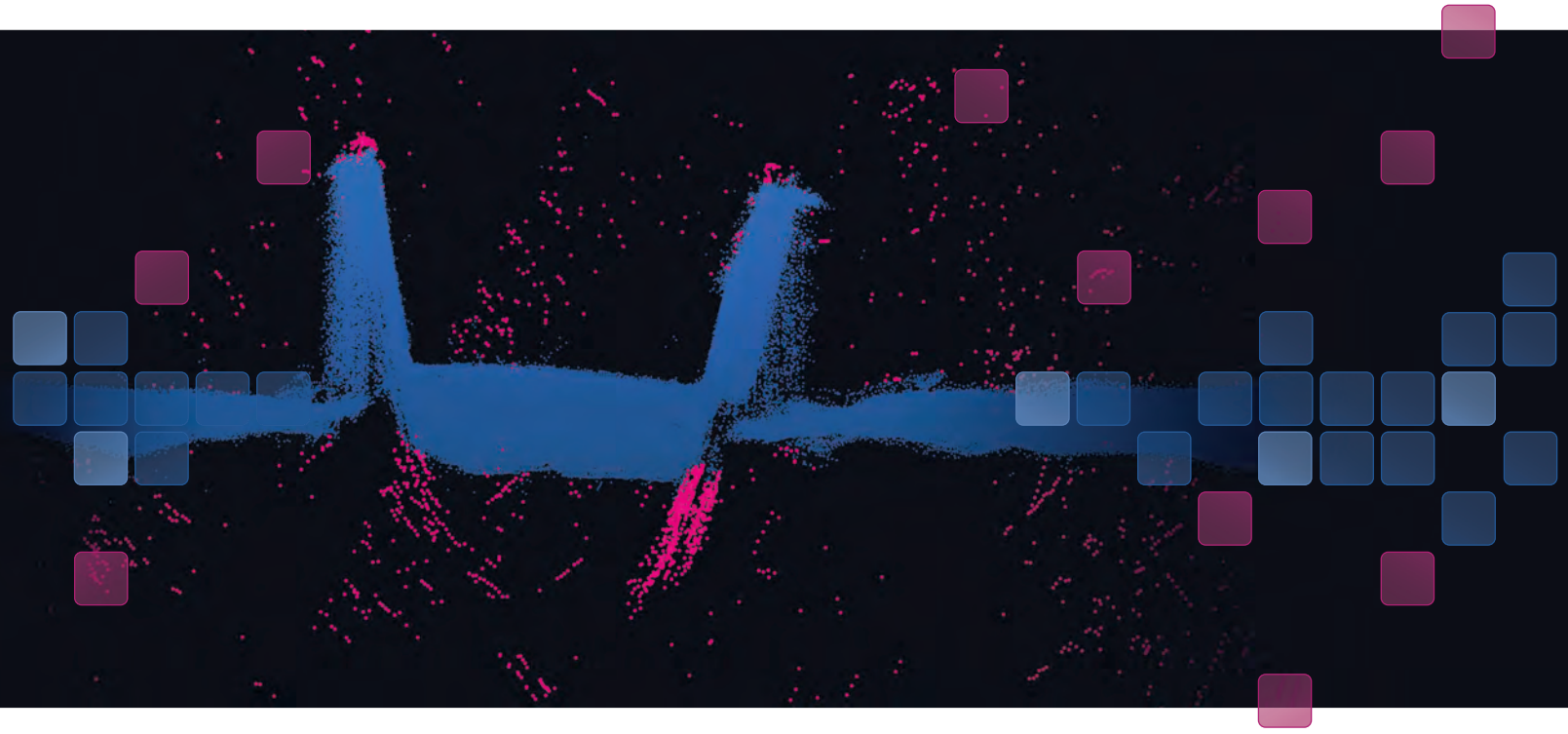

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Authors & Contributors

Manley

MacPherson

Maslin

Stoichevski

Manley

Justin Manley is a technologist and executive with experience in startups, corporations, academia, and government. At Just Innovation Inc. he supports clients with a focus on unmanned systems.

MacPherson

Donald MacPherson is Technical Director, HydroComp, Inc.

Maslin

Elaine Maslin is an offshore upstream and renewables focused journalist, based in Scotland, covering technologies, from well intervention to subsea robotics.

Stoichevski

William Stoichevski has written thousands of offshore-focused reports from his North Sea vantage point. William lives and works in Oslo. He started writing for Marine Technology Reporter in 2014.

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The Future of Mussel Farming

Damen Maaskant Shipyards Stellendam is coordinating a multi-party hybrid and electric propulsion research project for Dutch Mussel Farming Sector.

The project, which is called AQUACULTURe, is a collaborative effort between Damen and numerous parties such as equipment suppliers, service providers and local mussel farming companies. AQUACULTURe is part of the Damen Shipyards Group's long-standing hybrid and electric propulsion development program.

The Dutch mussel farming sector is an internationally recognized and economically important industry. The shallow and protected waters of the Wadden Sea and the Eastern Scheldt estuary provide the ideal conditions for quality mussel harvests. Mussel farmers grow the mussels either on the seabed or on ropes using the hanging method. They use specially designed flat-bottomed vessels, which are typically diesel-driven, for mussel handling activities. Damen Maaskant initiated the AQUACULTURe project in response to the ever-increasing significance of reduced exhaust emissions of CO2, particulate matter (PM), sulphur oxides (SOx) and nitrogen oxides (NOx). This, of course, relates to the stricter IMO regulations regarding SOx and NOx emissions and the European Union's stage V regulations concerning vessels operating on inland waterways.

The goal of the AQUACULTURe project is to:

- Develop a power supply system that enables fully electric sailing for at least 50% of the time;
- Improve energy efficiency of installations by a minimum of 15%;
- Reduce CO2, NOx, SOx and PM emissions by a minimum of 50% compared to current levels.

A key starting point for the project was to obtain up-to-date data about the energy needs and efficiency levels of vessels that are currently operating. To this end, Damen Maaskant is working with a number of local mussel farming companies, including Prins en Dingemanse and Neeltje Jans Mosselen that are sharing such crucial data. This includes information about the applicability of exchangeable batteries, the choice of battery and shore power.

Various industry stakeholders are also involved in the project. This includes Vripack (design and styling), SIPmarine (hull and propeller optimization), Maritiem Elektro Zeeland (electrical installation and battery selection), JVS/Technofisica (base measurements of current vessels) and Partners for Innovation (determining environmental impacts). The initial results of the AQUACULTURe project will be presented by Damen during the 6th edition of the International Shellfish Conference, which is being held on January 16 and 17 January at Deltapark Neeltje Jans, the Netherlands.

Photo courtesy of Damen Maaskant Shipyards Stellendam

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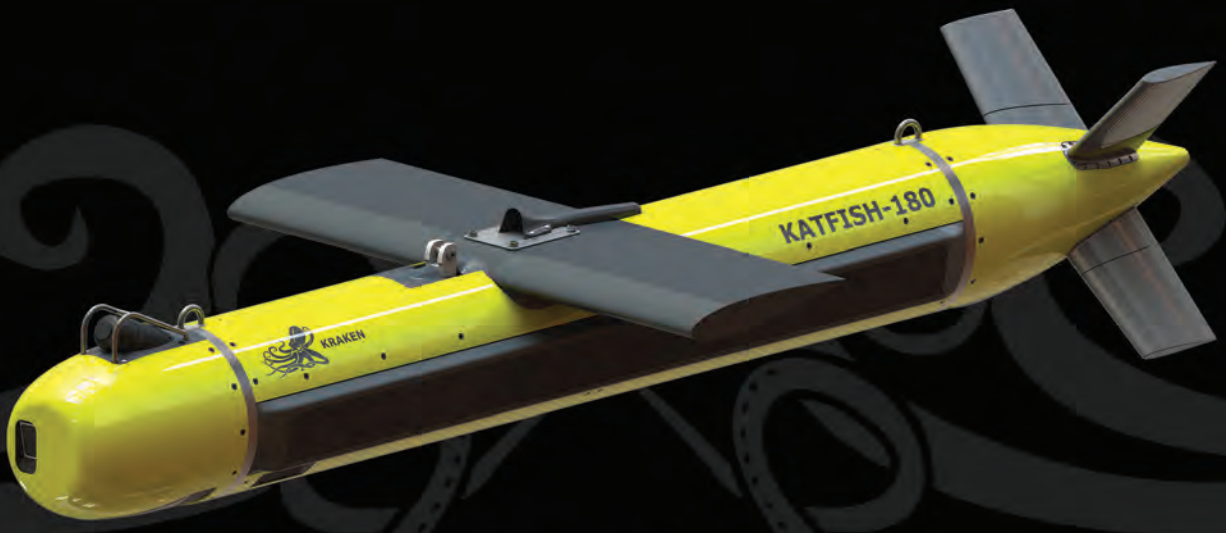

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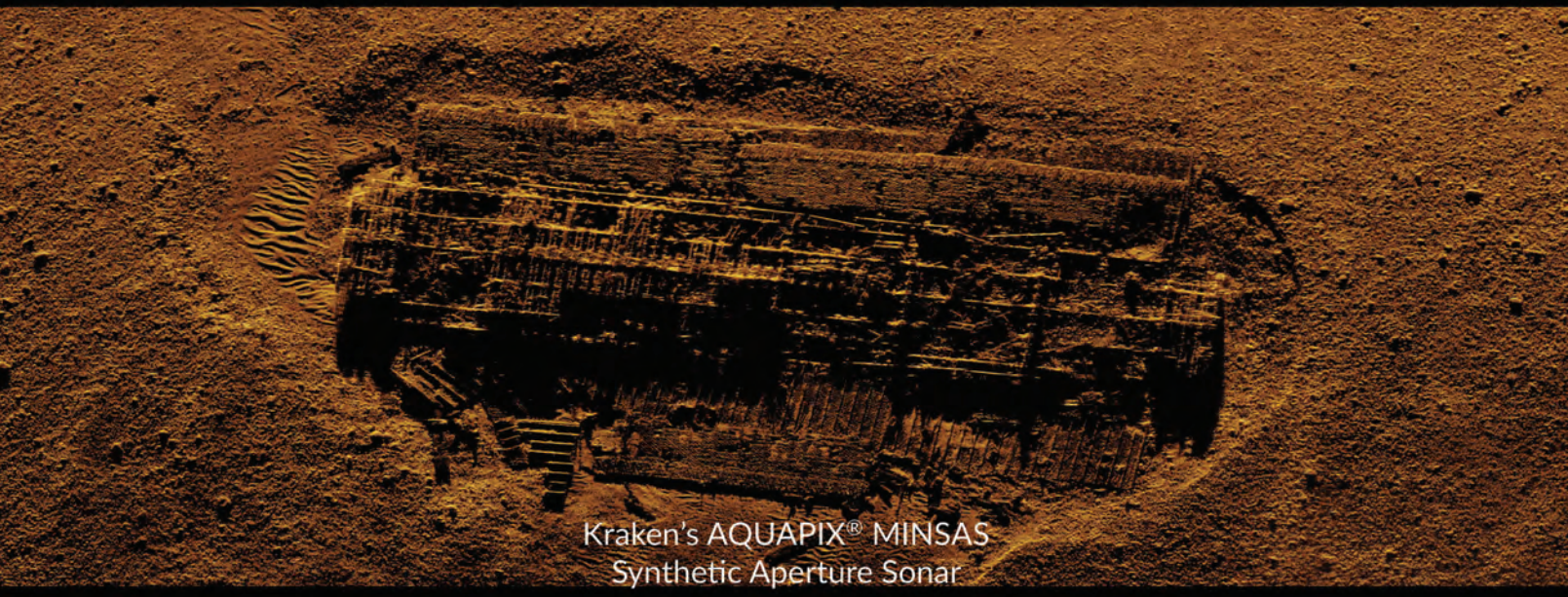

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Maritime Blue-Light Laser Discovered

An EU maritime study has identified a record-breaking 'blue-light' laser for the maritime industry.

Scientists working on the $1 million KETmaritime project have released a detailed report on the potential of 'Photonic Marine Applications'.

The latest report, which has been produced by Spanish research center AIMEN, reveals new boundaries broken in marine laser development – enhancing the detection of underwater objects including submarines and archaeological sites.

Project coordinator Ana Vila from the International Iberian Nanotechnology Laboratory (INL) said: "In recent months, France-based multidisciplinary research laboratory CIMAP has been actively developing blue-light lasers in constant wave and pulsed regimes," she said. "It recently achieved a record 7.5W constant wave output at 452nm wavelength. This is understood to be by far the highest constant wave 'pure blue' power generated from a frequency-doubled fiber laser.

"The absorption of light in pure water is lowest in the 400-450nm spectral range. Laser light set in this range can penetrate long distances with minimal reduction in strength. These light sources can be used to determine distances, or by means of Lidar techniques record underwater objects, like submarines and archaeological sites. Conventional methods to detect underwater targets have employed acoustic waves. However, laser-based systems have clear advantages in high directionality and high range resolution. They also allow new methods of wide-band and interception-proofed communication."

The study of 'photonics' seeks to generate, control and detect photons – an elementary particle of light carrying energy. It can be used to concentrate beams for cutting and welding as well as 3D scanning and surgical applications, through to more 'ordinary' applications, such as presence detection for door control, bar code scanning and printers.

The global photonics market is expected to surpass $688 billion in 2020. Between 2005 and 2015, it showed a real annual growth rate of 7pc, which is twice as fast as global GDP growth and higher than many other sectors including food (2pc) and automotive (3-5pc).

Ms Vila said the new report identifies photonics as one of the most important technologies for the 21st century. "Through recently acquired knowledge and technological breakthroughs we are ready to profit from the 'photonic revolution' achieving greater advances and control in the application of light across many high-tech markets," she said. "In the coming years, the maritime sector will greatly benefit from a broad variety of applications of photonic devices.

"It has become an increasingly accessible technology with particular relevance to Structural Health Monitoring of marine assets, as well as Virtual and Augmented Reality across shipbuilding. It will also play a particularly important role in the development of detection and recognition systems applicable to areas including navigation, tracking of objects and masses at sea and maritime rescue."

The KETmaritime project is funded by the Interreg Atlantic Area Program, via the European Regional Development Fund and is delivered by a consortium of seven partners across Europe.

The consortium includes French multidisciplinary research laboratory CIMAP (CEA group), Portuguese maritime economic cluster Fórum Oceano and Spanish industrial design center IDONIAL. Ireland's national center for marine and renewable energy MaREI and UK marine cluster organization Marine South East are delivering further support, alongside Spanish non-profit research association AIMEN.

The KETmaritime consortium delivering a major pan-European project showcasing 'next-generation' technology.

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SMD is thinking Outside the Box

All electric systems are starting to free companies from the traditional strict form factors that ROVs traditionally take. With a more flexible modular harness, vehicles can be built from standardized building blocks. Saab Seaeye, a firm well versed in all-electric vehicles, has been making noises in this direction, using the smarts it's been developing for the Sabertooth for new electric vehicles. Another firm looking to enter the resident vehicle space is UK-based subsea machinery firm SMD. During Offshore Europe, it launched its Quantum EV ROV. While the Quantum EV ROV made the headlines, what SMD launched was a technology suite, rather than a single ROV, based on an open-electric framework for whatever shape vehicle is required and that can be adapted for a variety of tethered or untethered operations.

Mark Collins, SMD's Director for Remote and Autonomous Technologies, says four years' work has gone into the design, which will be available as a product this year [2020] – but will also to be used as a harness for other form factor systems, such as AUVs because of its modularity. Key was going all-electric, using an in-house designed 25kW DC electric propulsion system, to make it more environmentally friendly but also more energy efficient, compared with hydraulically powered systems, says Collins. This includes a new thruster, based on an enclosed magnetic gear box with only two moving parts, and a new HV DC transmission system. That means smaller diameter umbilicals can be used and down to 6,000 m, providing power to a 680v ring main DC system, that allows plug and play systems.

It's been designed to operate tethered or untethered with a battery as a resident system or deployed from manned or unmanned vessels. And, the design aims to allow easy build-in of future technologies, such as developments in artificial intelligence.

Collins says the EV will have 20% more thrust and 50% fewer moving parts, compared to hydraulic systems. It's also 20% more compact and 20% lighter, so it can be operated from smaller vessels. A hydraulic power unit has been developed for using hydraulic tools – until all-electric tooling is developed – using the new DC thruster motors and new hydraulic control units. When electric tools do come, they will be able to be stored on the vehicle in the space freed up by removing hydraulics, instead of having to add skids.

"The technology is a family of industrialized building blocks for subsea machines," said Collins. "These are scalable and can be brought together to form different machines. We created a Work Class ROV using the technology for the initial launch, but that is because it is familiar. We could have easily created a underwater intervention drone or another type of vehicle. Starting at the foundation level and working up means we can ensure every component and sub-system is the best it can be. Clients can then customize from a solid base and layer on their own control methods."

New MD of Resolve Alaska

Resolve Alaska, the northwest operating arm of the Resolve Marine Group, appointed A.W. McAfee as its new Managing Director.

FET ROV: Arctic Research

Forum Energy Technologies has secured an order from Amundsen Science (Université Laval, Canada) to supply a light work-class remotely operated vehicle (ROV) to support its Arctic scientific research activities.

The vehicle will be installed on board the Canadian research icebreaker CCGS Amundsen and will support the exploration of Arctic and Sub-arctic seafloor ecosystems.

Sonardyne Acquires 2G

Sonardyne International has acquired underwater imaging and inspection specialist 2G Robotics Inc.

2G Robotics will join the Sonardyne group of companies, while remaining an independent business and brand. 2G Robotics' founder Jason Gillham will continue to lead the company as CEO.

CGG, Fairfield Collaborate

CGG and Fairfield Geotechnologies have signed a second cooperation agreement to acquire a series of large-scale, high-density, multi-client surveys in the Central Basin Platform (CBP) of the Permian Basin located in West Texas. The new wide-azimuth datasets will provide a better understanding of the structural complexity of the transition between the CBP and surrounding basins to enhance industry drilling.

Scantrol Hires Gaupaas

Scantrol, a supplier of monitoring and control systems to the marine and offshore industries, has hired Frode Gaupaas as Business Development Manager for Subsea.

Diver Health the Focus of Research Project

Ten subsea companies have pledged $84,000 towards a medical research project which aims to determine the best procedure for resuscitation of divers in a diving bell.

Led by Philip Bryson, medical director of diving services of Iqarus, the joint industry project (JIP) will find out how resuscitation techniques should be delivered to a casualty in a diving bell at depth.

To date the JIP is being funded by Boskalis, DFS Diving, KD Marine, Kreuz Subsea, Rever, Shelf Subsea, Statoil, Technip and Total.

For the full story visit:
https://www.marinetechnologynews.com/news/diver-health-focus-research-598647

OceansAdvance

OceansAdvance Pilot Project: *Young Women in Ocean Tech*

The Ocean Technology Sector has been identified as a growth area for Atlantic Canada. The 2017 Atlantic Canada OT Sector Export and FDI Strategy clearly identified potential growth opportunities for this sector.

OceansAdvance is committed to fulfilling the vision of the Atlantic Growth Strategy by helping firms in the Region increase their export value into international markets as well as to help build a talent pipeline for the future with supporting the development and retention of HQP. As well we are anxious to support the research and academic community and to help grow the sector by supporting future entrepreneurs.

In addition to the traditional trade show support for IEEE MTS OCEANS shows this year, OceansAdvance added two additional components to the program: *Women in Ocean Technology* and *Start-Ups in the Ocean Sector*.

The Government of Canada, in particular the Atlantic Canada Opportunities Agency (ACOA) recognizes the fact that we need to increase the number of women in the ocean technology sector and OCEANS'19 was identified as a means to engage and entice young women currently involved in oceans studies to stay in the sector.

With this commitment by the Canadian Government in mind OceansAdvance applied for funding to bring a contingent of 13 young female ocean tech students from Memorial University's Marine Institute (M.I.) in St. John's Newfoundland as well as the Nova Scotia Community College (NSCC) of Halifax, Nova Scotia. ACOA's mandate is to support Pan Atlantic projects in the Region.

The student's areas of study included a one year Ocean Technology program at NSCC and both ocean mapping and underwater technology programs from M.I. For this pilot project and in partnership with MUN-MI-NSCC and supported by ACOA Halifax, OceansAdvance worked with the Technical Chair from OCEANS'19 Liz Crout, to develop a program which would allow these young females an opportunity to fully experience what an international technical conference and exhibit has to offer.

OceansAdvance believed that the combination of technical paper presentations, and plenaries coupled with the vast array of international firms exhibiting would give these students a better understanding of the exciting opportunities this sector has to offer.

In addition to the busy schedule while at OCEANS'19 it was recognized that the students had little or no prior experience in attending such a large, multifaceted event and OceansAdvance felt they would likely feel overwhelmed and at a loss in such a setting. Therefore, an online training course was held for them, tailored specifically to tradeshow and conference new attendees to prepare them for this event.

A consultant/trainer was brought in to deliver a two hour online tutorial online program which gave these students and start-ups a solid background on how best to "work" a tradeshow and conference.

"Women in Engineering Breakfast was amazing & such an eye opener, where I start doesn't mean this is where I'll land but the sector is exciting and there are tremendous opportunities."

Feedback from one of the students on the pilot project

OceansAdvance

Image: © currahee_shutter

Subsea Expo '20
AsiaPac Opportunities Abound

Decommissioning in Southeast Asia and Australia offers a $100 billion opportunity out to 2040 with a million tonnes of steel to be removed and thousands of wells to be sealed, a business breakfast in Aberdeen at Subsea Expo.

Blair Miller, who works for Scottish Development International (SDI) in Singapore, covering Southeast Asia and Australia, told the Global Opportunities Business Breakfast, on the first day of Subsea Expo, that decommissioning, followed by renewable energy and then conventional oil and gas, are the top three opportunities in the region for the subsea industry.

"It's the equivalent of the North Sea by expenditure and greater by volume," he told the event. Some $3.5B every year over the next decade is expended to be spent on decommissioning in Southeast Asia and Australia, he said. According to Wood Mackenzie, there's almost $100B of spending expected out to 2040, with hundreds of fields, thousands of wells and a million tonnes of steel and lots of waste to remove, he added.

"The prime markets are going to be Malaysia, Thailand and Indonesia, then to a lesser extent Australia and New Zealand," said Miller. "The reason is, there's been almost no decommissioning work done to date, despite the size of the market. There's be a handful done and some as rigs to reefs. [more broadly] It's a process that has to take place and the local supply chain has no experience in these areas." Part of the reason for this is the process being held up by legal and liability issues, which are still being ironed out. For those wanting to work in this area, it will mean working with local incumbents, he adds.

Another area of opportunity is in renewables. The first offshore wind farm in Australia – the Star of The South – is going ahead and will be 2GW offshore Victoria, run by a company started by Scottish people, says Miller. While there have been issues around permitting, the operators will be looking for expertise around front end engineering and design and installation of wind turbines. "A big challenge is bringing vessels into Australia, so anything you can do to mitigate vessel time will be well received," says Miller.

Also, within renewables, marine energy is an opportunity. While not at the scale of the large offshore wind farms, there could be many of them across the island nations, says Miller. With experience developed in building marine energy systems at the European Marine Energy Centre (EMEC) in Orkney, Scotland, some firms are already starting to supply systems into Asia. The region will be looking for experience in vessel support, cabling, trenching and Environmental Impact Assessments.

Finally, there are also opportunities in conventional oil and gas, he says, in Indonesia and Australia. The latter is more of a greenfield province where operators are doing far from shore ultra-long subsea tiebacks at record breaking scales and distance, says Miller, with comparable standards and costs to the UK. Meanwhile in Indonesia, the focus is more on brownfield asset management and maintenance work predominantly.

$4.2b Indian Spending Spree Ahead

Projects worth $4.2 billion in capex are expected to get underwater offshore India this year and next, an event in Aberdeen was told.

The projects, across India's Krishna Godavari (KG) Basin in the Bay of Bengal, northeast India, range from shallow water to ultra-deep water and are set to come onstream between 2022 and 2024.

Ketan Pednekar, senior trade specialist at Scottish Development International (SDI), was highlighting opportunities open to the subsea industry during a February 11, 2020, *Global Opportunities Business Breakfast* at Subsea Expo in Aberdeen.

He said that India's offshore oil and gas production and exploration is focused on the east coast of India, mostly owned by either ONGC (Oil and Natural Gas Corp.) or Reliance Industries, with some also to the west. While there're also some opportunities in decommissioning activity, the big money is being spent on ongoing projects led by ONGC in the KG Basin, totalling 34 wells, for which some of the subsea trees are already being built in Montrose, Scotland.

In the KG basin there are three clusters of developments coming up: KG-DWN 98/2 Clusters 1 and 3. Cluster 3 is the biggest, involving nine gas wells in ultra-deep waters at 2400-2900m, 140km offshore, tied to a floating production system, with estimated capex totalling $3.2 billion. Awards are expected to be made in 2021 with first production in 2023-24.

Cluster 1, which also includes the GS-29 development, involves six oil wells and two gas wells, tied to a platform and floating production facility, in 80-700m water depth, according to Pednekar's slides. This project is pegged at US$665 million capex, with award of contracts expected in 2021, with production in 2022.

The two are distinct from Cluster 2, a 34 well (15 oil, eight gas and 11 water injection developments), which is due onstream this year in 280-1300m water depth at a cost estimated by the UK's Department for International Trade (DIT) at $5 billion.

Reporting by Elaine Maslin

For the full story, please visit: **www.oedigital.com/news/475536-4-2-billion-indian-spending-spree-ahead**

Electric Motor Selection

for Underwater Vehicles: *Considerations of partial load efficiency*

By Donald MacPherson, Technical Director, HydroComp, Inc.

It is easy to appreciate why permanent magnet synchronous motors (PMSMs) are popular for use in underwater vehicles (UVs). They are compact and efficient with a high power density. More importantly, perhaps, they allow for effective operation across a broad RPM range which is beneficial for vehicles with multiple operating conditions. That said, we find vehicle product developers are often uncertain about a motor's "efficiency". This article offers a few comments from the perspective of a propeller designer, developing the components that puts the load on a UV's motor.

We first must start with a description of the "system", which is composed of the Vehicle (that establishes the thrust requirement), a Propulsor (typically an open or ducted propeller that creates the needed thrust), and the Drive (that prime mover whose only job is to spin the Propulsor at its necessary RPM). If we wrap the system into a conceptual unit, the system benefit is vehicle speed (or thrust, in the case of a towpull application) while the system cost is the "fuel consumption". For systems driven by internal combustion engines, the cost is the consumption of fuel oil, say, in units of liters-per-hour. Engine manufacturers typically provide enough information about fuel consumption across the engine's RPM and power range so that we can reliably predict fuel use for any application. A plot of this distribution is often called a "fuel map", but let me have you think of it as an output-to-input energy "efficiency map".

Unfortunately, we have a completely different circumstance when using PMSM drives. Confusion can arise because the generated benefit of the motor and the fuel used by the motor share the term "power" – one being the output mechanical shaft power (that drives the propulsor) and the other its input electrical power (a function of the voltage and current supplied by the controller). The ratio of the two is "motor efficiency". Knowing the correct motor efficiency at all RPMs and loadings is critical to successful system design and analysis. While most developer testing records electrical power, we need to know shaft power for an understanding of the system's overall performance.

While a manufacturer's published motor curve indicates the limit of torque (and thus power) across the RPM range, they frequently only indicate the mechanical-to-electrical efficiency at a single design point or upon the torque limit. Unlike what is available from engine suppliers, we rarely have a full mechanical-to-electrical power "efficiency map" across the useful range of both RPM and shaft power loading for PMSMs. To obtain this data, some of our clients have their motors tested on small dynamometers to generate an efficiency map. However, this can be costly and time-consuming – and a potentially wasted exercise during early-stage design where there is a question if the motor will even be selected.

What are the sources of lost efficiency for PMSMs? The explanation is a complicated mix of terms like winding resistance, mechanical friction, even magnetic flux effects. So let's simplify it a bit with some generalizations using broad terms of: mechanical load shaft power (PS), efficiency (EFF), RPM, and power losses (LOSS).

- Motor efficiency is defined as EFF = PS / (PS+LOSS).
- To simplify things, we can say that losses are of two types: dependent on power loading or dependent on RPM.
- The losses (not the efficiency, but the losses) tend to be proportional a) to RPM and b) to the square of power.

A generic representative efficiency map is shown in the plots below for a "constant-torque, constant-power" PMSM. It is our practice to always convert a "torque-based" plot to one that is "power-based", as we feel that power is a better way to communicate energy generation and transmission for vehicles and propulsors. The solid black line represents the motor's limit curve, the dashed line is a generic propulsor demand curve, and the colored lines are sample efficiency map figures.

From this plot, we can see how operating at partial load influences motor efficiency. There is a broad range of RPM that maintains high efficiency, as nearly half of the upper range of RPM is within a couple percent of the motor's maximum efficiency – so long as the motor is generating 80% or so of its rated power. In terms of vehicle operation, at top speed efficiency is maximum, pushing 95%. At 75% speed, power demand is 40%-45% and efficiency drops to 85%-90%. At 50% speed, little power is needed and motor efficiency can drop to less than 75%.

(Graphic: remember, these are generic figures used here to represent a concept. Actual efficiencies will vary from model to model.)

So, let me leave you with a few basic observations:

- The maximum potential efficiency of a PMSM varies with motor size – with larger power motors offering potential for higher efficiencies. For example, a 20 kW PMSM can have maxi-

mum motor efficiencies exceeding 95% at full load, where a motor less than 1 kW typically reaches only 90%.

- As noted above, while efficiency varies with RPM, there should be a fairly broad range of RPM that maintains high efficiency for most applications requiring full or nearly full load.
- Partial power loading is the big issue for most applications, as running a motor at low power can cause a significant drop in motor efficiency. For example, motor efficiency can drop to less than 70% for fractional shaft power.

Electric motors – particularly PMSMs – are an important focus of our development work for NavCad in 2020. We are working on simplifying the definition of these drives in NavCad with electrical power as the "fuel" and generic motor curve shapes (such as "constant-torque, constant-power") for early-stage design. And, of course, we are deep into a prediction model for off-design partial load efficiency maps!

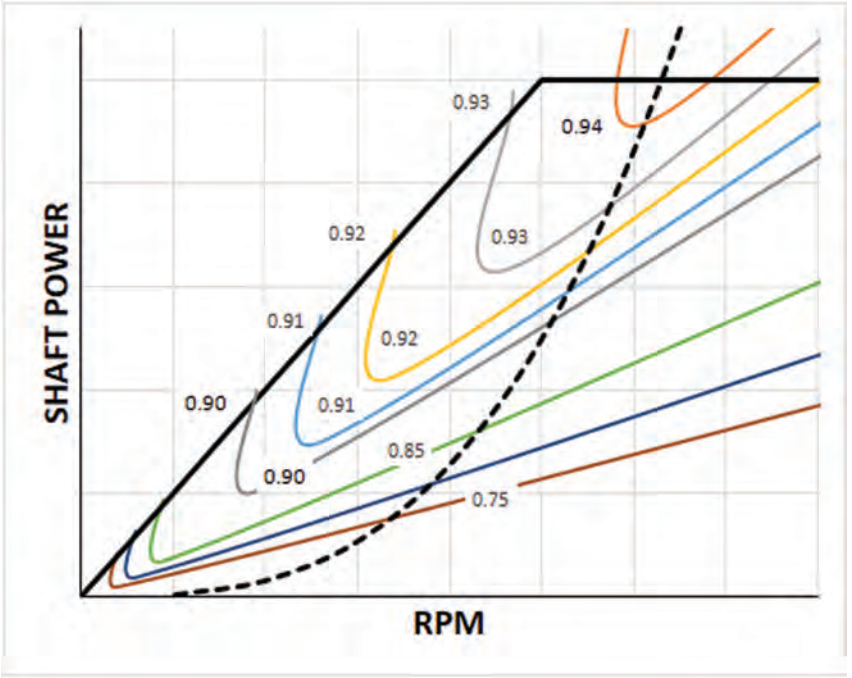


Image: Hydrocomp

eDNA Emerging

By Justin Manley

There is a new buzzword in the ocean science/sensing community. The word is eDNA, an abbreviation for environmental DNA. This refers to DNA that can be extracted from environmental samples without first isolating any target organisms. In the maritime community such samples are taken from water. All living organisms leave traces of DNA in their environments which is an indicator of their presence over time. This DNA is released into the environment through the biological process of living animals or by the decomposition of dead organisms. eDNA is a complex mixture of traces that enables the detection of a species regardless of its life stage or gender. This is a powerful tool for understanding the complex biological web of an ocean or coastal ecosystem.

While eDNA is potent, it is also ephemeral. Once released in the environment, the constituent DNA can be degraded by environmental factors. Generally, cold and dry conditions result in slow eDNA degradation. For example, in permafrost, eDNA can endure for hundreds or thousands of years. But in aquatic environments, the DNA released by an organism can be detected for only a few days. Despite this, the ocean science community is eager to employ this relatively new tool. In late November 2018 approximately 100 ocean scientists and stakeholders interested in marine eDNA assembled at The Rockefeller University in New York City for a conference sponsored by the Monmouth University-Rockefeller University (MURU) Marine Science and Policy Initiative. The executive summary of this gathering made it clear: "eDNA works. Get going."

But what does that mean for technologists? How does this scientific method translate into operational ocean observing? Two research labs, The Monterey Bay Aquarium Research Institute (MBARI) in California and the Sieben Lab at Dalhousie University in Nova Scotia. among others, have been working to address the question.

MBARI has been working in this domain for decades. Starting about 25 years ago, it conceived of "ecogenomic

A field-deployed microfluidic sensor.

(credit: Dartmouth Ocean Technologies Inc. and Sieben Laboratory Dalhousie University)

A microfluidic sensor from Dalhousie.

(credit: Dartmouth Ocean Technologies Inc. and Sieben Laboratory Dalhousie University)

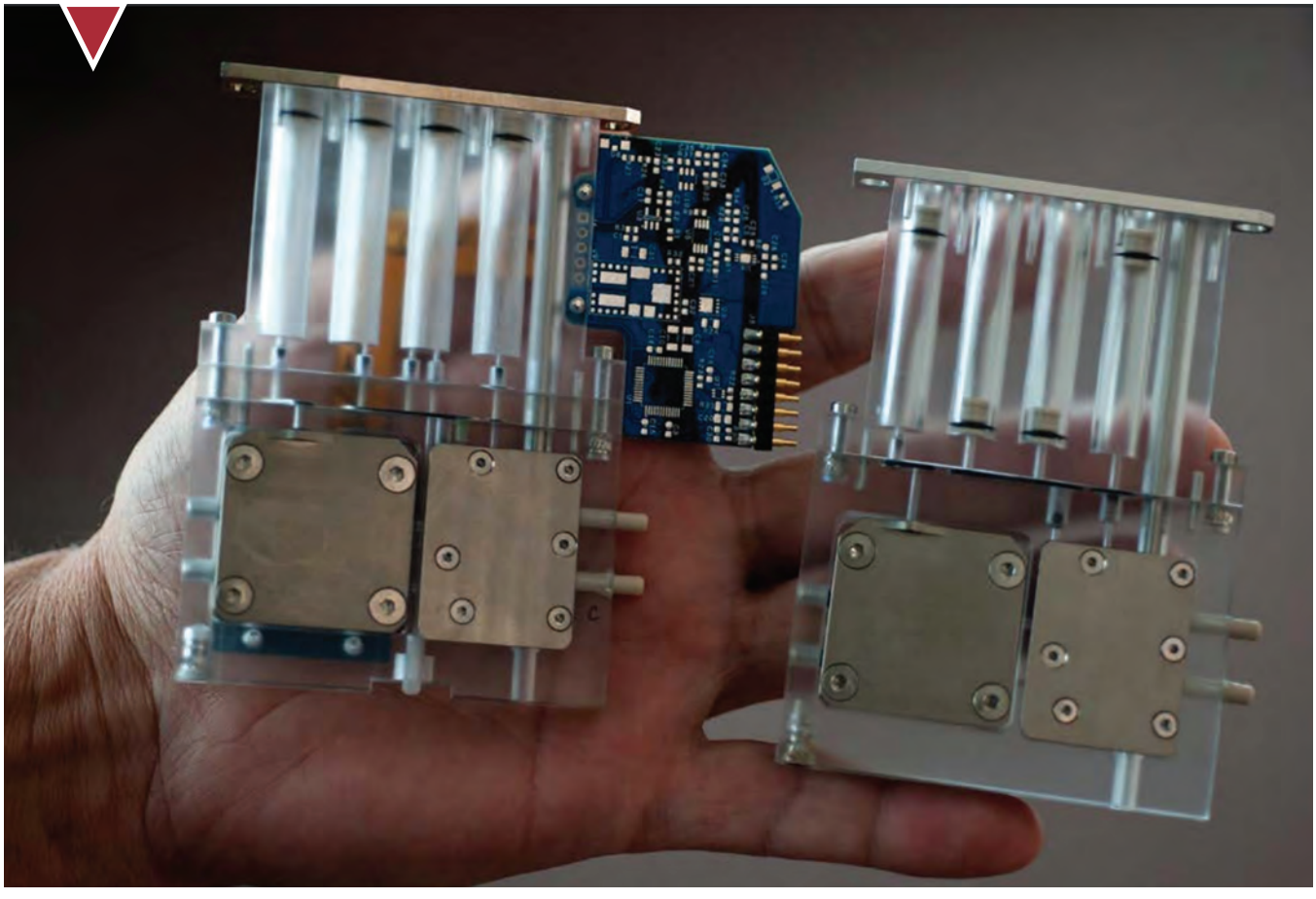
sensors," devices to apply molecular analytical techniques subsea. The Environmental Sample Processor (ESP) was conceived as an instrument to address the technological and operational concepts of ecogenomic sensors. Over time, the ESP emerged as a working instrument, enabling the use of DNA probes and protein arrays and the quantitative polymerase chain reaction (qPCR) technique to assess the presence and abundance of a range of organisms. The ESP is also used to preserve samples for a variety of laboratory tests not yet possible to carry out in situ. The instrument has been deployed on a variety of platforms, including coastal moorings, piers, an open ocean drifter, research vessels, a shallow water benthic lander, and a 4,000 m rated "elevator" designed for use on deep-sea cabled observatories.

The initial motivation for developing the ESP was harmful algal blooms (HABs). Traditionally, understanding HABs required the transportation of physical field samples to a laboratory to identify the relevant organisms. This could take days or longer prompting the development of rapid methods for identifying and quantifying HABs of public health concern. Distinguishing toxic and nontoxic HAB species required species-specific molecular probes. But at the time it still took orders of magnitude longer to process samples using molecular probes as compared to physical, chemical, or optical measurements with commercially available sensors.

Creating a portable "molecular biology laboratory in a can" was seen as a solution to more rapid HAB warnings following sample collection. After years of traditional lab techniques this was a nontrivial undertaking. By way of example, molecular analysis relies on use of perishable biochemical reagents, which are typically maintained in very precise conditions. Laboratory approaches can employ a clean, or even sterile, environment, have significant physical space, and are not power-limited. But the ESP overcomes these challenges. The ESP can perform qPCR unattended, while submerged. The instrument was commercialized and is now available from McLane Research Laboratories. This instrument, while functional, is larger and challenging to deploy.

More recently, a new version of the ESP has been developed for use aboard an autonomous underwater vehicle (AUV). In 2009 MBARI initiated an effort to re-engineer the ESP to fit on the long-range AUV, a novel AUV developed there. The new instrument, like its predecessor, was designed for both

Cartridges for the third-generation Environmental Sample Processor.

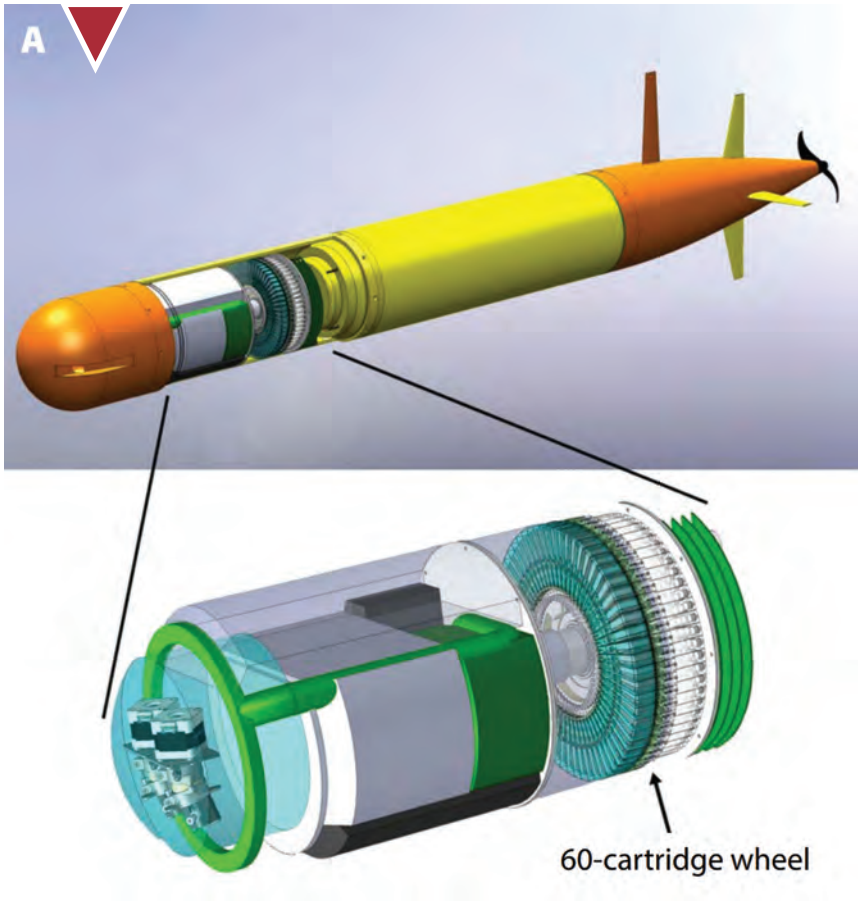


(Credit: MBARI)

select sample analysis and sample preservation. Unlike its predecessors, however, the new ESP design concept is inherently more modular, with sample collection and handling distinct from sensors needed for real-time analytical work. This new ESP employs single-use cartridges containing both media for concentrating particles and reagents for processing that material. The interface between the cartridges and the sampler has a fixed design. Cartridges can evolve to meet new needs so long as they meet the interface specification. Two types of ESP cartridges have been devised. One is meant for sample preservation only, while the other is designed for homogenizing collected material and passage to downstream analytical modules. This cartridge based design has been tested at sea on the MBARI LRAUV.

The use of microfluidics for in situ nutrient sensing has gained a great deal of traction in recent years. Microfluidic systems require less power, reagent, time, and human involvement than conventional instruments, making them ideal for long term deployments. These concepts are being employed to eDNA by the Sieben Lab at Dalhousie University in Nova Scotia. Their "Inlaid Optical Celltm" technology is a patent-pending approach that enables miniaturized optical spectroscopy on ultra-small amounts of fluid, less than a few microliters. Conserving reagent usage per measurement minimizes the volume of onboard chemicals and waste storage leading to smaller sensors. These inlaid cells are used to perform absorbance and fluorescence measurements. In these systems, on-chip valving and pump-

Illustration showing how the third-generation Environmental Sample Processor mounts inside MBARI's long-range AUV



(Credit: MBARI)

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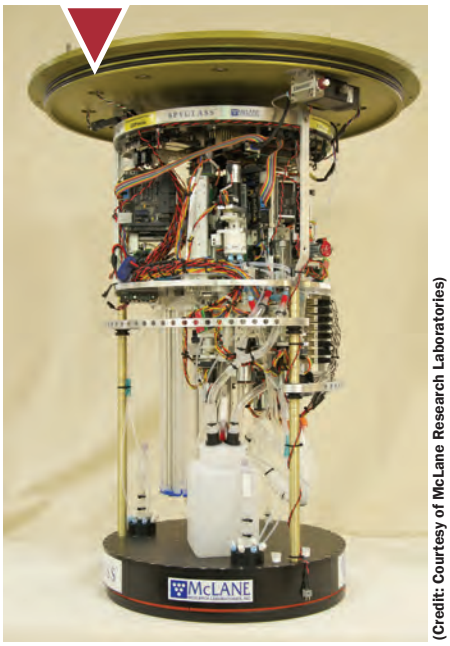
ing permit sophisticated fluid handling on the device, removing the need for expensive off-chip connectors and off-the-shelf solenoid valves and pumps. The on-chip valves also minimize dead or swept volume. The lab has developed an approach that uses magnetically tunable check valves for low-power and low-cost fluid routing solutions. By combining microfluidic valving, pumping, thermal control, and optical systems they can create lab-on-chip systems that automate long and complicated protocols to perform diverse chemistry and biomolecular assays. Examples of wet-chemistry methods include those for nutrients (nitrate, phosphate, silicate, etc.) and for genomics (integrated sample preparation, DNA capture/extraction, qPCR, etc.)

The team is collaborating with Dartmouth Ocean Technologies to make these sensors and instruments for deployment in remote environments. They have successfully demonstrated them on towed bodies and are commercializing new robust tools built on their microfluidic approach.

The field of eDNA monitoring is an emerging trend in ocean observing. As new instruments are refined and fielded the community will derive new insights about the behavior and distribution of marine life. This will be of utility to government agencies, such as fisheries regulators, and commercial operators such as fishers and aquaculture. There are also potential applications in defense and law enforcement. It is likely that by the end of this decade eDNA data will be as ubiquitous as the conductivity, temperature, and depth information that dominates physical oceanography today.

The second-generation environmental sample processor showing internal components.



(Credit: Courtesy of McLane Research Laboratories)

An All-Seeing Eye

There are surveys, and then there are surveys. For survey-tech outfit, Ecotone, the business model is offering a faster, digital way to monitor the health of seabed environments and offshore infrastructure. There's enough to do with Norway set to invest $4.89 billion in pipelines in 2020 to add to thousands of kilometers of pipe worldwide. The Trondheim company's Underwater Hyperspectral Imager, or UHI camera, uses the unseen colors of the spectrum to ID and archive pipeline anomalies, moving biology or rare coral — no x-rays or acoustic pings.

By William Stoichevski

Photos: Ecotone

Armed and ready: An Ecotone Underwater Hyperspectral Imager, or UHI, attached to an ROV and stand-alone.

Equinor was so impressed with Ecotone's UHI sensing, or hyperspectral camera tech, its investment arm … invested. Aquaculture giant, SalMar, bought a version of the tech to monitor biological conditions, a job normally done by humans. What both companies see is the UHI's ability to count and define trouble spots while automatically codifying and archiving innumerable digital images for speedy analysis. In fact, digitally notating and analysing the unseen could offer the fastest way to environmental compliance and maintenance assessments over large areas.

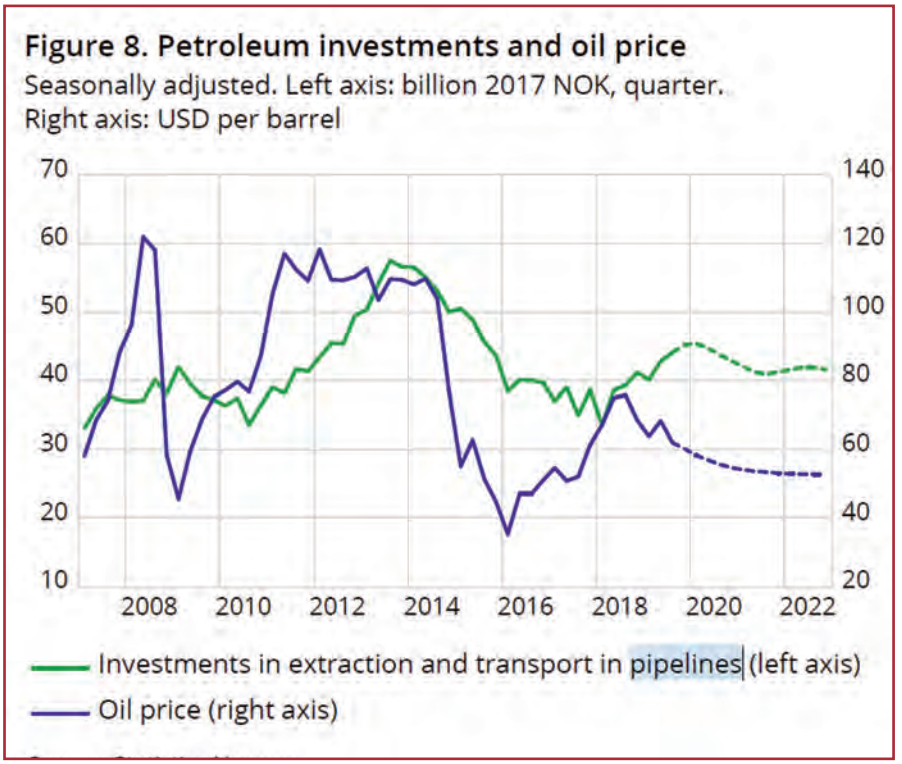
Speed is essential, for an environmental impact assessment survey — for an oilfield, a pipeline or a salmon farm — is only the start of site work. These early steps could entail photographing marine biology over an area that could comprise hundreds of kilometers (for a pipeline survey) or just a square mile for a salmon farm. For inspections of existing pipelines or other subsea infrastructure by ROV or UAV, the market offers no all-in-one survey tool of biology and pipeline health: bathymetric surveys are just that, and pipeline surveys today require a pooling of expert minds.

While Ecotone's equipment promises speed, the development path to efficient surveying by UHI attached to ROV or UAV began slowly. The camera itself was a 2009 NTNU university spin-off that followed successful optical fingerprinting tests. Its hyperspectral imager — which sees 400 colors versus the HD camera's red, green and blue — quickly showed it could do inspections of vast, sprawling, subsea infrastructure and of seabed life.

It excelled at pipelines, where anomalies could range from torn seals to worn welds, corrosion and leaks. The UHI could find

"It's all automated based on machine-learning principles. There has been development on the data analysis side with a higher degree of automation to cut down on the time and work involved in data processing and analysis, and it allows us to deliver an effective and accurate service for mapping and inspection."

Oddbjoern Roedsten
CEO, Ecotone



flaws on silt-covered pipes that would remain invisible to an ROV using regular cameras and lights or UAVs with available sensor arrays. By 2016, the UHI had evolved for pipeline IMR into SpectraPipe with analysis and archiving software understood to be faster and safer than x-ray or acoustic methods of pipeline maintenance surveying.

"It's all automated based on machine-learning principles," says Ecotone CEO, Oddbjoern Roedsten, adding that tweaks to the equipment to 2016 have led to today's first commercial uses. "There has been development on the data analysis side with a higher degree of automation to cut down on the time and work involved in data processing and analysis, and it allows us to deliver an effective and accurate service for mapping and inspection."

Vital speed

While pipeline inspection continues to see the introduction of new UAVs and ROVs that move down the survey track faster, they're nothing without their sensors. That's where Ecotone comes in: working with surveyors to compile the IMR and seabed survey data in a manner that allows speedy analysis and decision-making.

A UDI-equipped ROV affords the ability to effect a stand-alone study that provides the deciding data needed to compile an environmental or pipeline report. A 2017 survey of starfish below a salmon net-pen, for one, discovered they moved away from fish waste deposits before new species moved in. "We tell the system, "This is a starfish." Then we build a spectral library of the species we observe," says Roedsten.

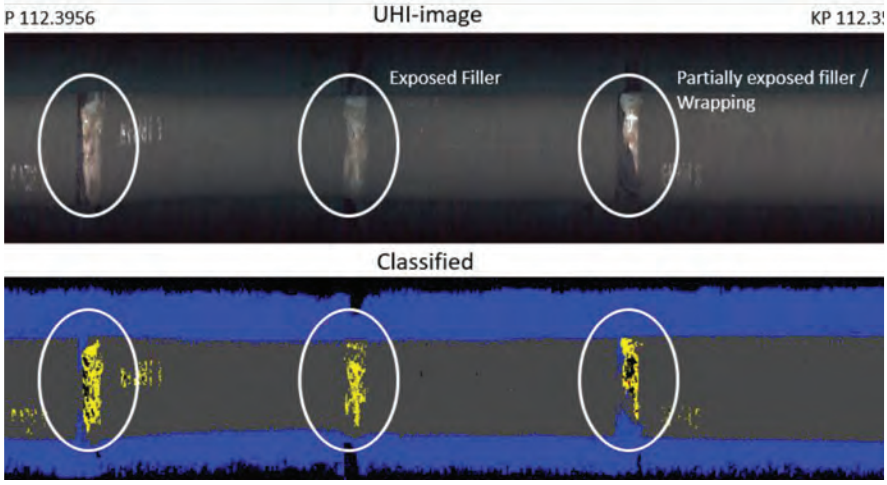
SpectraPipe inspections

While SpectraPipe doesn't use the same camera for pipeline inspections as another UHI uses to count salmon parasites, "It's the same principle. Different light reflectance, the same tech … but different light."

Having written before about hyperspectral cameras on UAVs before, we note this is the first mention of money-making tech. The UHI has been tested on UAVs, Roedsten says, but not in commercial settings yet. "Our current method of operation is with ROVs, and there are no specific requirements for the ROV (or UAV) except a size that accepts the payload and depth ratings for the specific surveys. We have no underwater vehicles (at) Ecotone, but use the vehicles available from the different survey companies."

No, hyperspectral imaging sensors or cameras that ID objects or chemicals aren't new. It's the tech used in remote sensing satellites and airplanes, where reflected light of all wavelengths is converted to digital information. Spectral signatures vary by color and chemistry, hence the designation: optical fingerprinting technology.

The SpectraPipe UHI has a depth rating of between 500 and 6,000 meters (or between shallow water by offshore oil and gas standards and a medium-deep oceanic trench). Attached to an ROV or AUV, the system brings lights, altimeter and a pressure sensor to bear while performing its online and offline recording. A medium or large ROV or AUV is needed, one with a 12-72 VDC power supply and an ethernet link to a topside vessel.



Credit: RBB vs hyperspectral pipeline study snapshot

Efficient: part of the mass digital compilation of pipeline flaws made possible by hyperspectral imaging.

Algorithmic appeal

A topside control system — Ecotone's trademark Immersion SW for UHI control — provides a live view from the camera and real-time configuration of the data being captured and stored.

The processing of survey results is a major Ecotone strength and key to event detection, description and codification. Apart from the resulting library of known materials, algorithms automate the notation that happens before an online report is generated automatically.

The alternative is pipeline inspection as it's largely done today: by visual inspection using HD cameras mounted on ROVs, with the results gone over by a team of experts. "This is both time consuming and exposed to human error and subjectivity," Ecotone marketing materials insist. By using the UHI, anomalies invisible to the human eye are detected and defined automatically. No need for a team of pipeline experts every time. Fill fail is fill fail.

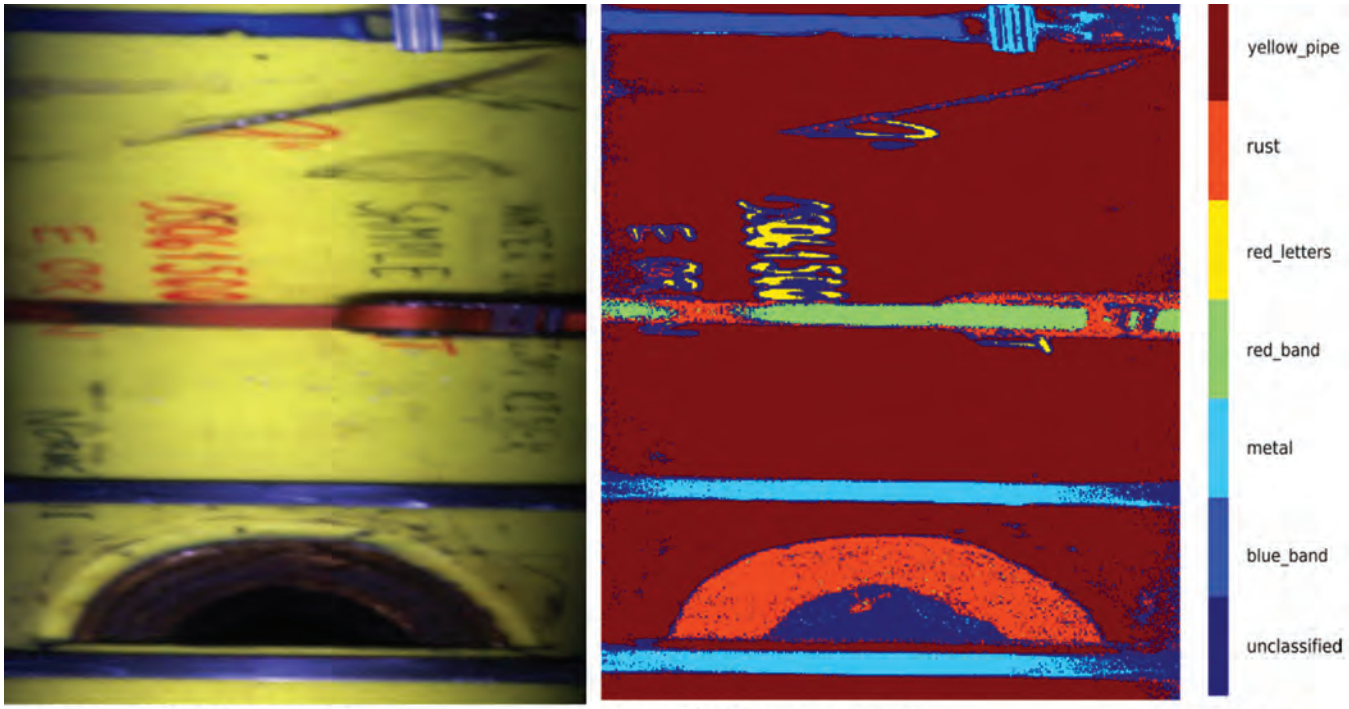
Back onshore, the client is handed a detailed report based on a post-processing of UHI visual data that yields high-quality analysis.

A best practice

One way to satisfy all stakeholders on pipeline safety is to generate reports quickly, and they are needed regularly: by pipeline operators and owners; by classification societies; by suppliers and by regulatory enforcement.

One common area of concern is pipeline joint failures that could lead to hydrocarbon leaks or prevent such op-

RGB versus spectral: the trained image on the right is codified and archived and forms the basis of report-generation.



Credit: Ecotone

erations as hot taps (cutting into "live" pipe) or fittings attachment. Field joint damage is the jargon, but it appears to be a survey area SpectraPipe excels at. We're shown how the SpectraPipe classifies exposed polyurethane filler by producing an instant IMR code. Generated codes for field joints are FJFD for filler damaged; FJFE (filler exposed or loose wrapping) and FJCC (corrosion coating exposed). The coded "events" accrue and help form a readable, accurate pipeline report.

It isn't just Ecotone generating pipeline repair codes. Class flag bearer, DNV GL, has for years been pushing its RP-FF11e recommended practice code for subsea pipeline repair. It covers fittings like clamps, couplings, T-branch connections and isolation plugs, including the welded connections of these.

That's where Ecotone can help: by scanning miles of connections, en masse, and then storing the descriptive data with GPS positions. DNV GL standards, service specifications and recommended practices might then be used to quickly assess the overall bill. Hence the writer's assertion that this UHI system looks like it'll be capable of speeding compliance on best practices for subsea pipelines.

Just the start

The Ecotone method is expected to develop into a way to inspect other subsea installations — from submerged jackets to stands of subsea trees and their manifolds — so, there's a giant worldwide market at hand.

While, there are other pipeline inspection tech companies out there, bathymetric and pipeline-positioning data seems a biproduct of Ecotone's core activity. SpectraPipe condition and environmental imagery is key, and it also generates mapping info.

"Our goal is to continue delivering mapping and inspection services for both oil and gas and aquaculture applications," he says. "During 2019 we have performed several seabed mapping surveys for (both industries), looking at environmental impact from drilling operations and salmon farming operations."

For now, Ecotone will "actively seek" IMR pipeline and subsea inspection work in the pipeline integrity market. They'll talk to "operators and survey companies to identify projects where our solutions are a good fit".

That ought to go well, as Equinor Tech Ventures is an owner — as are local investors, the company founders and its employees. For 10 full time employees, this IMR story is just the beginning.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The San Juan, before she was lost.

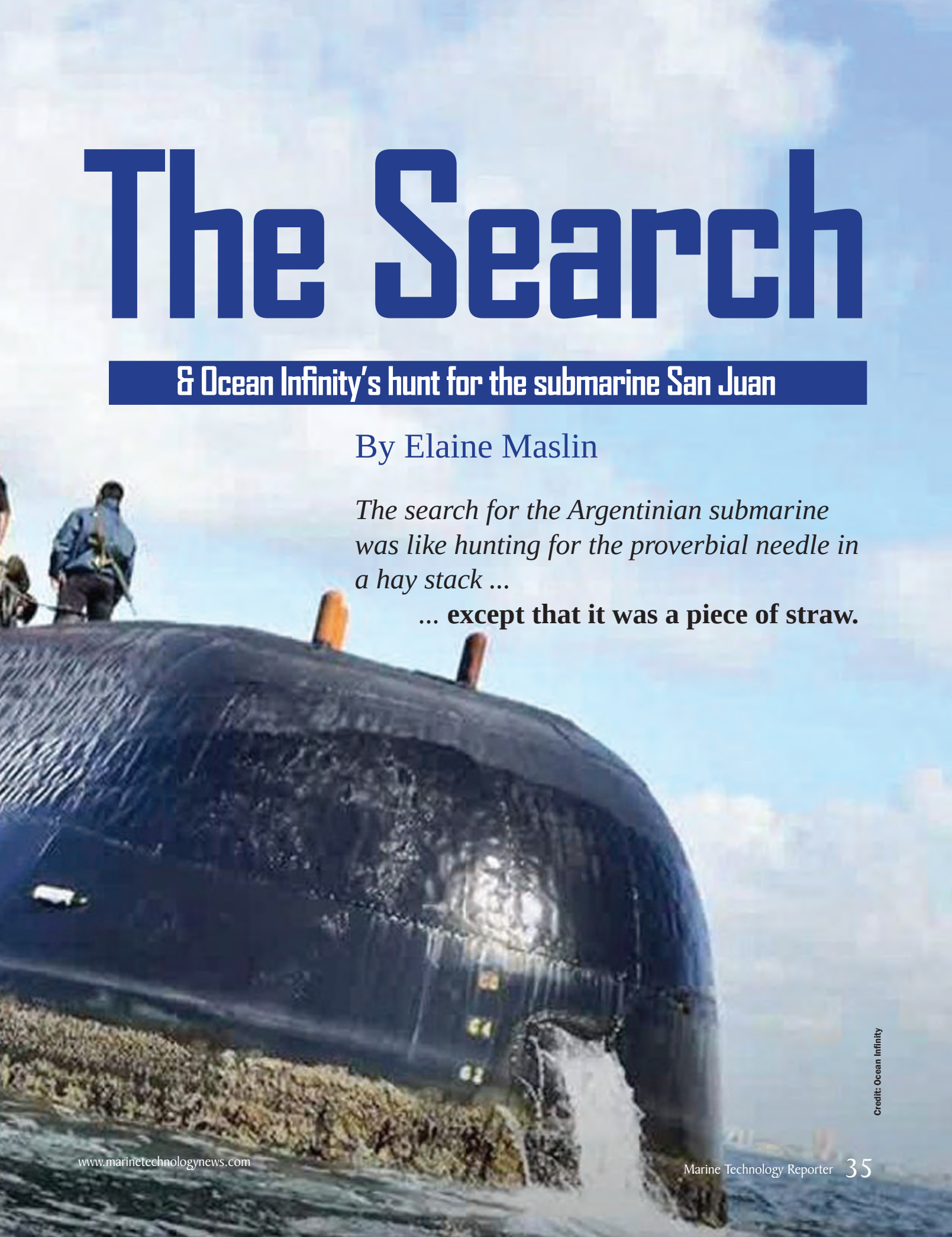
The Search

& Ocean Infinity's hunt for the submarine San Juan

By Elaine Maslin

The search for the Argentinian submarine was like hunting for the proverbial needle in a hay stack ...

... except that it was a piece of straw.



Credit: Ocean Infinity

At 7:19 a.m., local time, on November 15, 2017, the last message was received from the San Juan submarine. She belonged to the Argentinian navy and was on a routine mission from Ushuaia in the Patagonia region to Mar del Plata in Buenos Aires province when she lost contact with the military.

Fifteen days later, neither the submarine nor any debris had been found and the crew of 44 sailors were presumed dead. The loss made international headlines, as did the ongoing search, as the families of those presumed dead wanted to know what had happened. It was thought the submarine had encountered a problem with the forward batteries, but little information was available.

An initial search proved futile. There was little to go on, except an unusual signal detected by two of 11 Comprehensive Nuclear-Test-Ban Treaty (CTBTO) hydroacoustic stations that are dotted about the world. They were hydroacoustic stations HA10 (Ascension Island) and HA04 (Crozet), which detected a signal from an underwater "impulsive event" at 13:51 GMT on 15 November. Despite this clue, it would turn into one of the most challenging searches.

Reducing the ellipse

"The challenge for the searchers was that the acoustic anomaly had a large ellipse," Rear Admiral Nick Lambert, Ocean Infinity's project manager on the project told the Marine Autonomy and Technology Showcase event in Southampton late last year. To narrow it down, a defined charge was dropped at a known time, which would help to refine the understanding of the acoustic signal and reduce the ellipse. It showed the

The Seach is on: The search for the San Juan was one of Ocean Infinity's most challenging.

Credit: Ocean Infinity

submarine had dropped in water deeper than 100m, which meant it was beyond the recoverable water depth.

The search, however, continued and Ocean Infinity was brought in. Since the firm started operating in 2016, disrupting the autonomous underwater vehicle (AUV) space by deploying multiple AUVs from one vessel on search or survey missions, the company has made a name for itself in a number of international search efforts.

Ocean Infinity committed to conduct the search operation for up to 60 days and to covers its cost, unless the subma-

rine was found. It deployed its Seabed Constructor vessel with five Hugins. The initial 10-12 days covered three, what were thought key, search areas. But the submarine wasn't found. "We went back and brought in more experts to think about what happened and expanded and expanded the search."

Ocean Infinity's setup is geared to find things on the seabed, quickly. Its Hugins are capable of operating in water depths from 5- 6,000 m and cover vast areas of the seabed quickly. They are equipped with a variety of tools including side scan sonar, a multi-beam echo-sounder HD camera, and synthetic aperture sonar.

However, the search for the San Juan had to deal with challenging underwater terrain, "full of an astonishing number of submarine sized and shaped rocks, trenches and a steep drop-off the continental shelf, which complicated the search," says Oliver Plunkett, Ocean Infinity's CEO. The ship had a host of experts to help in the hunt, including members of the Argentinian Navy, the UK's Royal Navy, via the UK Ambassador in Buenos Aires, and the US Navy's Supervisor of Salvage and Diving. Three officers of the Argentine Navy and four family members of the crew of the San Juan also joined Seabed Constructor to observe the search operation. The pressure was on.

After the initial search, the AUVs were re-programmed to fly riverbed formations on the seafloor to detect anomalies. "When look at them [anomalies detected in the sonar data] they all look like spooky sub shapes," said Lambert. Submariners who had been consulted had thought it would end up in a canyon. It was also predicted that submarines tend to break into three, and the implosion creates a small debris field.

Finally, data from the five Hugins led the team to position to a spot where there was a shape described as nearly 200 feet long – roughly the size of San Juan. It had already identified and inspected 23 possible detections – each one of which had led to false hope for the crew, Argentinian navy members and not least the San Juan crew family members onboard. This one was in the area which had had the highest possibility of finding it. But it wasn't in an expected position, the shape was perched on top of a geological feature and "it

The Seabed Constructor was used in the search for the San Juan.

Credit: Ocean Infinity

was hard to determine if it was geology or manmade."

At 11 pm, local time, on November 2018, a remotely operated underwater vehicle (ROV) was launched from the Seabed Constructor to take a closer look at get better images. Near to midnight, the images captured by the ROV confirmed that it was indeed the missing San Juan. It was found in 920 m water depth, about 600 km east of Comodoro Rivadavia in the Atlantic Ocean; a year and two days after her loss.

The search had seen Ocean Infinity cover an area the size of south east England to find an object the size of two buses, says Plunkett. Even with the benefit of knowing where it was and its condition, "it was one of the most challenging targets we have ever attempted," he said. "It was found sitting on the downslope of a geological ridge at a 10-degree angle with parts of the submarine falling further down the slope. The large hull section was nearly perfectly aligned with the ridge line, which in itself was at the end of an area of clear rockfall. The hull was twisted and deformed into a non-linear feature. The thruster propeller had wholly fallen away from the shaft and the torpedo tubes were exposed. The chances of it being in that location aligned in that way are nearly nil. It is also important to remember it was an object approximately 60 metres long designed not to be detected by sonar. It was the proverbial needle in a haystack – except it looked like a piece of straw."

As part of its search, Ocean Infinity looked at what happened to other submarines, such as the Thresher and USS Scorpion, but kept an open mind, planning around finding the smallest likely intact piece. This could have been, for example, the submarine's sail. "When a submarine goes beyond the crush depth (in the ARA San Juan's case around 596m) it first implodes and then explodes. Hence the destruction field of the imploded submarine remains small," he adds. This explains why wreckage on the surface was never found.

It's not just a technical project. Plunket says that the importance of the families

of those that were lost with the vessel was central to the mission, which was why a team of family representatives as well as Armada Argentina crew were onboard the Seabed Constructor during the search. “The additional pressure to succeed for the families who were onboard with our team 24/7 and the pain of failure as each of those first 23 targets was revealed to be a miss was a massive challenge that I was extremely proud that our team rose to,” he says.

Last year, an Argentine legislative commission released its findings on the cause of the sinking of the San Juan. It said that, on the night before the ARA San Juan disappeared, water had entered its ventilation system and caused a fire in one of its battery tanks. The vessel surfaced and continued sailing. The captain reported that he was ready to descend to 40 m to assess the damage and reconnect the batteries the next day, but nothing more was heard from the submarine. Budget limitations and naval inefficiencies were cited as contributing factors. Ocean Infinity, meanwhile, continues to grow. It now has three multipurpose support vessels, the latest being the Normand Frontier. Each is equipped with five AUVs, three unmanned surface vessels (USVs), two ROVs and a full ocean depth hull mounted multi-beam echo-sounder, deep water 45-tonne fibre rope winch and construction class crane. The Normand Frontier was mobilised in November 2019 on a three-year charter from Solstad Offshore. It was recently the host vessel for a seabed data project in Angola for Total. The Hugins now also have new 6000 m depth tolerant batteries from Kraken Robotics subsidiary, Kraken Power, that extend battery life from 60 to 100 hours. This allows for missions to be conducted across

Credit: Ocean Infinity

a period of more than four days without a battery change. Ocean Infinity says that the technology, when partnered with its multi-AUV approach, increases the possible survey range to nearly 700 line km per AUV.

It's not all smooth sailing. Last year one of its Hugins was lost in the Weddell Sea in pack ice. Another was also lost during the MH70 search. "It's not a failure," says Lambert. "It's not being afraid to go and push boundaries." Ocean Infinity has been doing just that. In fact, just last month [February] it launched a new company, Armada, with plans to build a fleet of 15, 21-37m long unmanned surface vessels, or robotic ships, as they were named. Construction has started and some will be operational this year, Dan Hook, the firm's managing director (formerly in the same role as ASV Global, now owned by L3Harris) told the launch event.

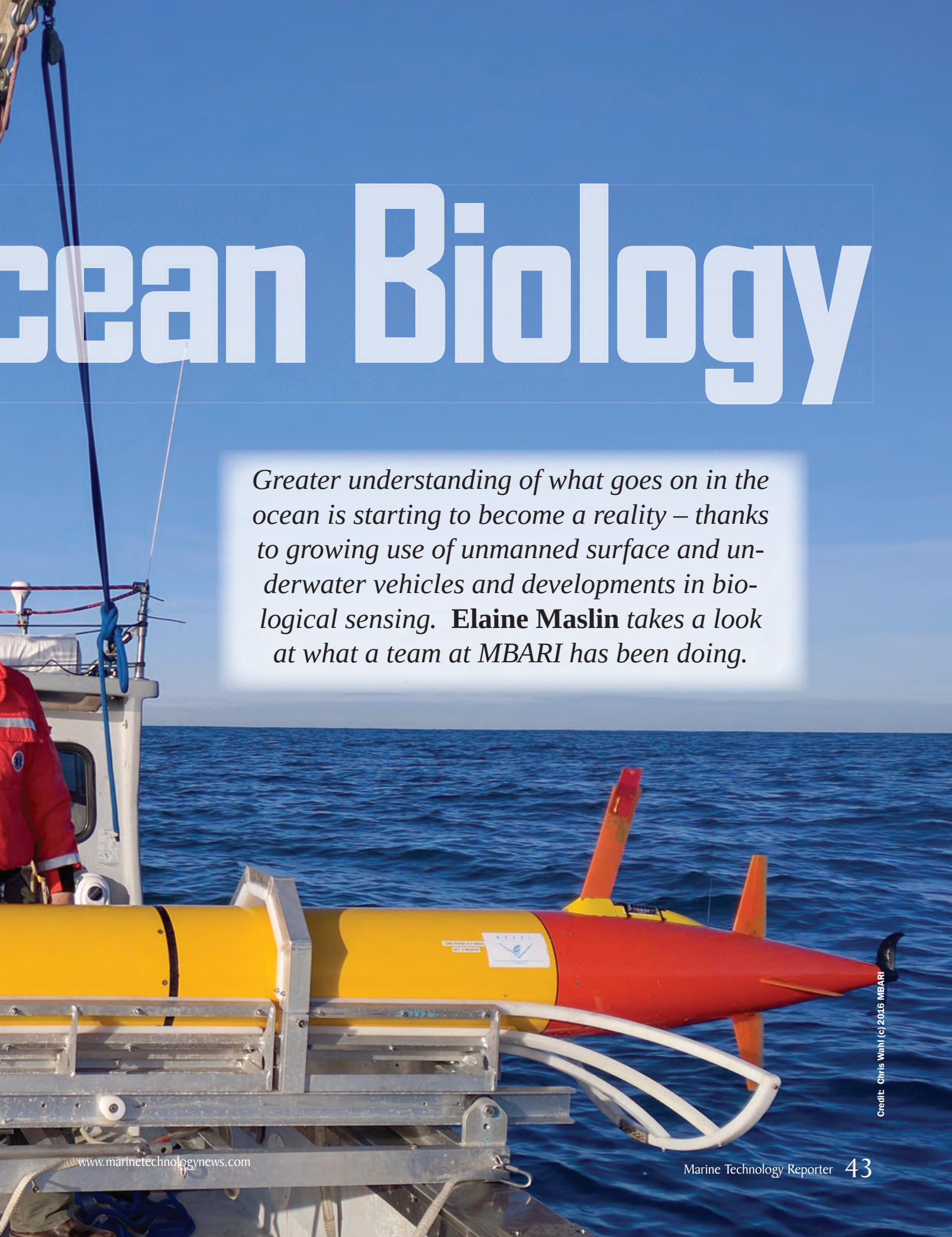
Ocean Infinity's Hugin's now have longer batteries.

Unlocking

MBARI engineer Brent Jones on a test deployment of MBARI's long-range AUV "Makai" in Monterey Bay. Makai is designed to carry a third-generation Environmental Sample Processor (ESP).

cean Biology

Greater understanding of what goes on in the ocean is starting to become a reality – thanks to growing use of unmanned surface and underwater vehicles and developments in biological sensing. **Elaine Maslin** *takes a look at what a team at MBARI has been doing.*



Credit: Chris Wahl (c) 2016 MBARI

Gathering biological data from the oceans remains a significant challenge for oceanographers. Now, an increasing range of unmanned vehicles that are able to work together is becoming available, as is an ability to collect biological data using them.

It sounds straight forward, but traditionally the collection and processing of biological samples has involved collecting samples, usually from a research ship, which are then gathered and taken for processing in a laboratory. The result can be patchy or miss significant events.

It's also been difficult and impractical for underwater vehicles to do, because they're not big enough to store the number of samples that would be needed or carry the laboratory equipment that could do onboard analysis – until now.

A team at Monterey Bay Aquarium Research Institute (MBARI), based at Moss Landing, California, has been working on a so-called "ecogenomic" sensor solution for over the last 25 years and it's now been getting results, as part of multi-vehicle missions on and beneath the surface.

Dr. Jim Birch, director of MBARI's SURF center, says it started with a group interest in microbial oceanography – the study of the smallest organisms in the ocean, including understanding how and why harmful algae blooms form. Dr Birch spoke about the work and its results at the National Oceanography Centre's Marine Autonomy and Technology Showcase (MATS) event in Southampton, late last year. The result is an Environmental Sample Processor (ESP), a compact robotic system that filters a water sample and then processes the biomass to create analysable samples.

The ESP program was started by current MBARI CEO, Chris Scholin when he was a post-doc at MBARI. The goal was to be able to detect harmful algae blooms (HABs) in situ, without having to take samples back to a lab. The first 10 years focused on developing detection chemistries that could identify the harmful algae. But, from the start, "Chris's idea was to forget the samples and put the lab in the ocean, sending only the data back," says Dr. Birch. "A 'first generation' ESP was a

A long-range autonomous underwater vehicle carrying an ESP is recovered to the R/V Falkor after a mission.

beta-type robot that was deployed once in the Gulf of Maine to show that it would work, which it did."

Then came a Second Generation (2G) ESP, which fits into the size of a 50-gallon drum. One was deployed in about 2006 in Monterey Bay and the design has since been licensed for commercialization to McLane Research Laboratories in Falmouth, Mass. It's been a "workhorse" for the past 14 years, says Dr Birch. Both the 1G and 2G ESPs were static robots, moored in the water they are sampling, or installed in areas where water can be automatically pumped to them.

"The 'sample' that the ESP collects is actually material left behind when you filter a known volume of water," he explains. Samples can either be preserved for later analysis, or processed by the ESP in-field. Processing requires some molecular biology, and to do that, microorganisms in the samples must be lysed to release their cellular contents. "The ESP uses enzymatic lysis, breaking cells open with heat and a special enzyme and creating a homogenate or lysate that can then be analyzed in a number of ways," says Dr Birch.

"We saw early-on that mobility could expand the ESP's potential and began to ask, could we put what was in a 50 gallon drum into the size of two basketballs as an AUV payload?", says Dr Birch. It just so happened that, at the time, 5-6 years ago, MBARI was developing a long range AUV (LRAUV) based on a Tethys-class AUV. The result is the 'third' generation ESP (3G ESP), with a new ring cartridge design and magnetic push rod plungers. It contains two types of sample cartridges, archival, to preserve and store samples, and the "Lyse-n-go" for infield processing and analysis.

The LRAUV is a propeller driven, 30cm diameter, 2.3 m long (3.2 m with 3G-ESP), 120 kg (160 kg with 3G-ESP) vehicle depth-rated to 300 m. By honing many of the systems related to propulsion, the LRAUV can run 7-14 day missions before needing to be recovered and recharged. An internal buoyancy engine also permits fine-level depth control, important behaviour when trying to sample the biologically rich thin-layers found throughout the oceans.

This technology was put to the test during a project with

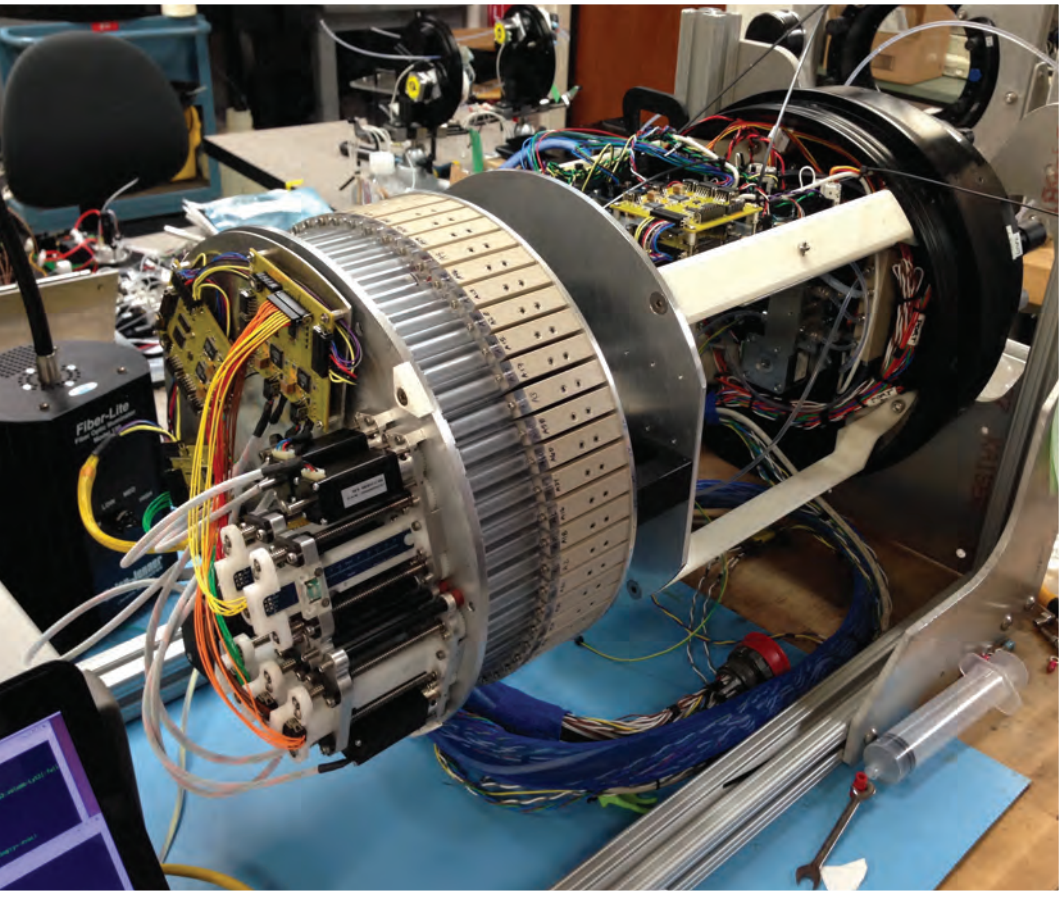
Credit: Photo by Thom Hoffman / Courtesy of Schmidt Ocean Institute.

"Chris's idea was to forget the samples and put the lab in the ocean, sending only the data back. A 'first generation' ESP was a beta-type robot that was deployed once in the Gulf of Maine to show that it would work, which it did."

Dr. Jim Birch,
Director MBARI's SURF Center

MBARI researchers head out into Monterey Bay to deploy a long-range autonomous underwater vehicle (LR-AUV), an underwater robot that is programmed at the surface and then travels underwater for hundreds of miles, measuring water chemistry and collecting water samples as it goes.

An ESP



Credit: Jim Birch

Credit: Brian Kieft (c) 2015 MBARI

the University of Hawaii, who acquired three LRAUVs with ESPs. The goal was to allow greater access to the sea than their ship schedule allowed in order to study the microbial populations that inhabit a Deep Chlorophyll Maximum (DCM – a region ~120m deep with maximum concentrations of chlorophyll).

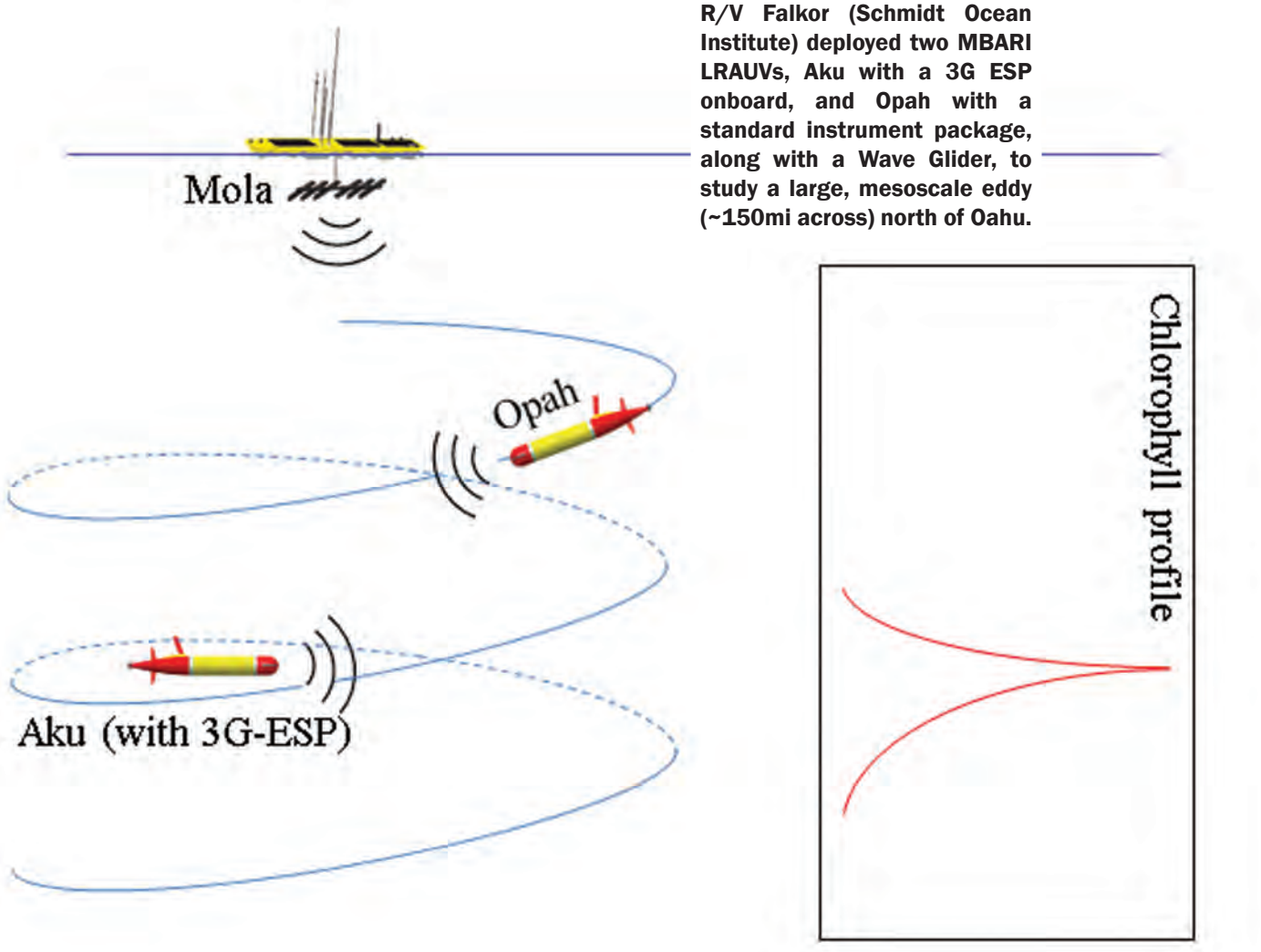
The culmination of this project was in 2018, when the R/V Falkor (Schmidt Ocean Institute) deployed two MBARI LRAUVs, Aku with a 3G ESP onboard, and Opah with a standard instrument package, along with a Wave Glider, to study a large, mesoscale eddy (~150mi across) north of Oahu. Aku descended to locate the DCM and identify the temperature at the depth of highest chlorophyll fluorescence. By controlling its depth as a function of temperature, Aku was able to stay in the DCM for four days without surfacing. While drifting, Aku pumped ~1 liter of seawater through each filter stack and then preserve the filtrate with RNA-Later, for future analysis ashore.

Meanwhile, Opah tracked Aku using USBL positioning, keeping Aku at the center of an 800m radius circle, collecting contextual data. Above them a Wave Glider also tracked Aku, and provided position and communications to the R/V Falkor. A drogue with a surface buoy was also launched to track the centre of the eddy.

In total, 82 samples were collected, preserved and archived in one-liter increments at three-hour intervals over nine day-night cycles, from within, above or below the DCM.

"The deployment turned out to be wildly successful, with Ed Delong, who is interested in the timing of microbial responses to the environment, able to collect water samples from a drifting, submerged vehicle (i.e., in the same

The culmination of this project was in 2018, when the R/V Falkor (Schmidt Ocean Institute) deployed two MBARI LRAUVs, Aku with a 3G ESP onboard, and Opah with a standard instrument package, along with a Wave Glider, to study a large, mesoscale eddy (~150mi across) north of Oahu.



water mass) every four hours over four days," says Dr Birch. "It produced a remarkable dataset, that he is still in the midst of analyzing."

In June 2019, MBARI carried out another ESP-vehicle project, this time closer to home in Monterey Bay. This was a large, multi-asset experiment that combined traditional off-the-ship water-sampling methods with a fleet of MBARI LRAUVs, two with ESPs, as well as an i2MAP imaging AUV, one with a bioluminescence sensor, alongside Wave Gliders, a Sail Drone with an echosounder, and two other research vessels, one with an ROV onboard which was able to gather video data. All these were deployed over a week in May-June 2019, 37km offshore Moss Landing, around the 900m deep Monterey Accelerated Research System (MARS) cabled observatory, which also has an upward looking sonar system, the Deep Echo-Integrating Marine Observatory System (DEIMOS), to detect marine life and which was able to track the AUVs. The goal was to look at the diurnal (day-night) zooplankton migration in the bay. Using multiple vehicles meant different layers of the water column at different scales could be studied at the same time. "On this cruise, we were able to collect acoustic, genetic, and bioluminescence data autonomously and video data through ROV Ventana to match with our shipboard CTD and net sampling," says Postdoctoral Fellow Katie Pitz, who was on the cruise. "It will be exciting to uncover what we've learned through these different methods."

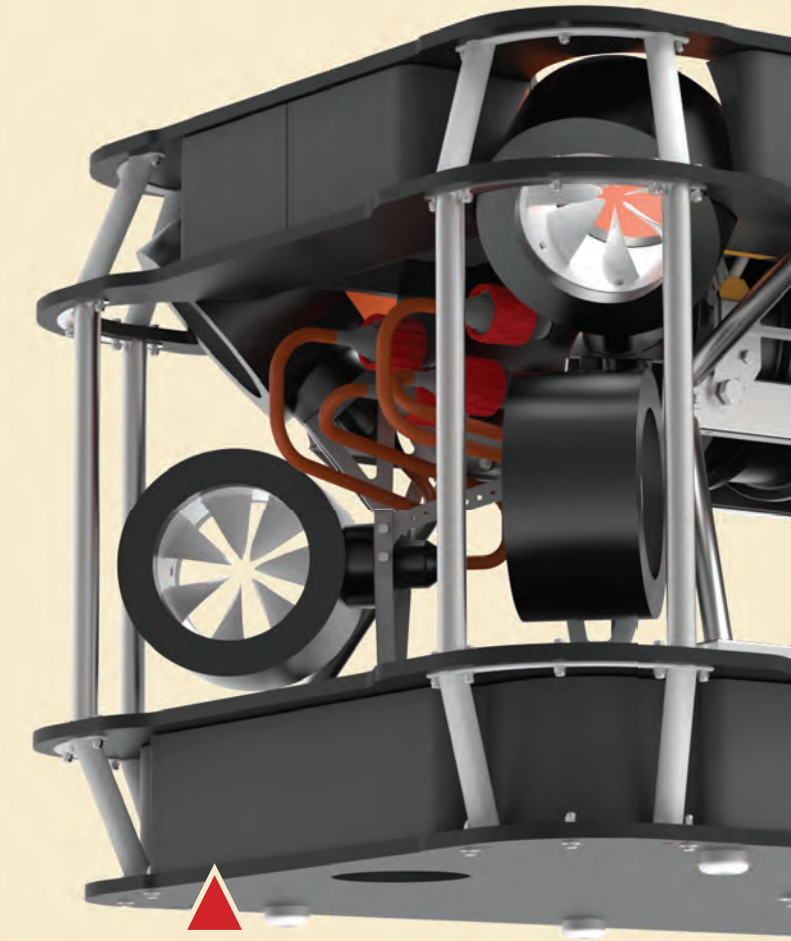
This project has opened exciting possibilities for future research. For instance, because of the ability of DEIMOS to detect layers where sealife congregates, real-time processing of the acoustograms could direct vehicles to areas of interest in near real-time. "Ultimately, we are working toward moving the processing onto the vehicle itself, to completely remove a human from the process, and get the vehicles to actively search out areas of interest on their own, given parameters humans have provided them at the start of the experiment," says Dr Birch. "This is the future."

There's also more work to be done on the ESP. In-situ sample processing (lysis and analysis) can be done, but the cartridges that perform these processes could be easier to use, says Dr Birch. "We are pushing forward a serious redesign with reliability and usability at the fore-front. Our current efforts are focused on simplicity, reliability, and manufacturability." Mass producing parts would also help reduce costs and therefore get more people to use this technology. But there's more to come. "We are developing a remote, autonomous qPCR capability, and exploring the possibility of in situ gene sequencing," says Birch. That would push the ESP's capability even further.

These moves would both make the equipment easier to use by other researchers across the world and further increase how much we understand about the ocean.

Gorilla ROV

Built to be robust, reliable in the demanding offshore sector



The Gorilla ROV is based on Copenhagen Subsea's Rim-driven thruster, technology which, combined with industrial electronics from Japan's OMRON, gives a high level of reliability. The use of eight thrusters gives the Gorilla ROV the ability to keep its position in strong currents.

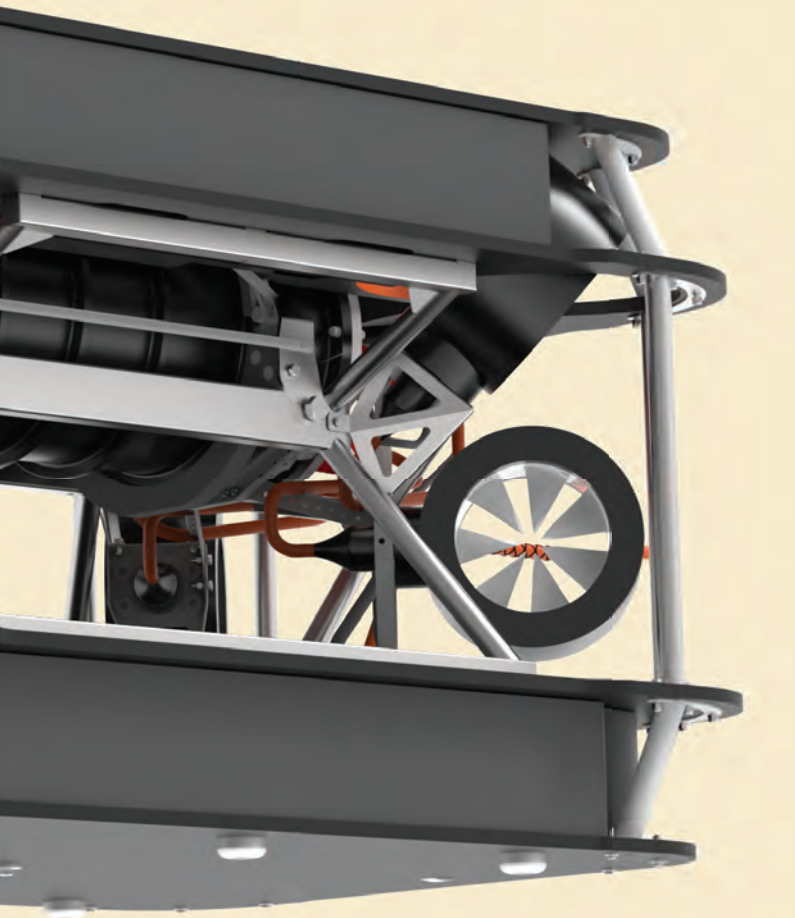
Copenhagen Subsea launched a new powerful Remotely Operated Vehicle (ROV), specifically developed for the offshore industry. The ROV is based on Copenhagen Subsea's rim-driven thruster technology and is designed to be robust and reliable in challenging environments – qualities which inspired us to name it the Gorilla.

In fact, reliability has been first and foremost throughout the design and development of the Gorilla. By basing the ROV on industrial components, Copenhagen Subsea was seeking to ensure the utmost operational reliability.

The Gorilla is equipped as standard with an intelligent Dynamic Positioning (DP) system, enabling automatic control of position, depth, altitude, heading, pitch and roll. A lack of thrusters can be a problem in ROV design, which makes it impossible to control the pitch and roll of the vehicle and thus hard for the operator to keep it stable during operations. Even weak currents can cause some ROVs to tilt and the operator to lose control of the vehicle, potentially leading even to the abandonment of the mission and recovery of the ROV. By contrast, the Gorilla's DP system makes it easy to operate the vehicle even in low visibility and strong currents. This is based on an advanced sensor system, which delivers input to the DP system to constantly adjust output of the ROV's eight thrusters in a fly-by-wire system to keep it stable in the water.

The Gorilla can sense the seafloor from up to 70 meters above, enabling the DP system to keep it in the required position, even should the operator take hands off the controls.

This solves another common problem during launch of conventional ROVs, when the current can quickly push it away from the vessel, leaving the operator disoriented and without knowledge of its exact location or where to steer to reach its destination. This can often lead to an abandoned mission, necessitating a second attempt or a wait for conditions to improve. Instead, the Gorilla will use its DP system to instantly adjust the output of its eight thrusters to maintain position relative to the seabed, meaning the operator can easily steer to the designated destination. Copenhagen Subsea said the ROV can carry up to 70 kg and it has an easy to understand payload interface with a power supply and separate fiber cable connection, dedicated to the customer specific requirement.



Reliability **has been first and foremost throughout the design and development of the Gorilla.**

Allan Nygaard Bertelsen
CEO, Copenhagen Subsea

The electrical system of the Gorilla ROV is based on industrial hardware from Japanese industrial electronics company OMRON, meaning that top to bottom Gorilla uses only industrial standard hardware components which are available commercially, a key differentiating factor in the reliability of the Gorilla. Industrial hardware components are cheaper, more reliable and easier to maintain as they are produced in series of hundreds of thousands and deployed worldwide across multiple industries. Such standard components are readily available off-the-shelf anywhere in the world and with significantly shorter delivery times for spare parts, compared to regular waits of 12 weeks or more for proprietary parts from conventional ROV manufacturers. Customers will have access to all electric documentation in the form of wiring diagrams, meaning they can service and maintain the vehicle on their own, as well as a full component list so they can source all parts directly. It means an operating company can simply change the Gorilla's standard spare parts itself.

These robust industrial components are generally larger, but this means they have the required dimensions to perform reliably in extreme offshore conditions with extended temperature range. These parts also have the capacity to handle overload currents during acceleration and deacceleration and fast shifts of rotational direction. These elements are crucial to keep an ROV stable in challenging offshore conditions. Ideally suited for any task in short, the Gorilla is tough and strong, works reliably in challenging conditions, is simple to maintain with easy access spare parts and is easily controlled thanks to Copenhagen Subsea's thruster technology.

www.copenhagensubsea.com

Helping ocean researchers obtain critical, high-resolution measurements at a lower cost

Understanding the three-dimensional nature of the ocean is becoming a critical focal point of ocean research, but it can be a costly affair.

Paired with Nortek current profilers, Del Mar Oceanographic's Wirewalker is giving researchers from around the globe a cost-effective way to answer vital questions surrounding the functioning of ocean processes. This information helps improve environmental monitoring and climate forecasting, which in turn assists in developing measures to adapt to our changing climate.

Information on the three-dimensional structure of the ocean is proving increasingly vital for multiple research projects. These include characterizing the ocean mixed layers in order to improve weather and climate forecasting, monitoring environmental conditions, and exploring co-located measurements of physical and biological variability to unravel the links between physical processes and biological productivity.

Combating escalating costs of ocean measurements

In coastal waters, physical and biological measurements are often taken from a single instrument attached to a permanent structure such as a pier, or from a series of instruments distributed along the length of a mooring. "A single instrument attached to a permanent structure doesn't provide information regarding the vertical ocean structure, which is all-important. A series of instruments along a mooring is expensive, especially if many types of measurements are to be collected," explains Dr. Andrew J. Lucas. He is Assistant Professor at Scripps Institution of Oceanography and Department of Mechanical and Aerospace Engineering at UC San Diego, and co-founder of Del Mar Oceanographic.

Further offshore, costs continue to mount. Here, instruments are lowered down and pulled up through the water column by diesel-powered winches on a ship.

Together with Dr. Robert Pinkel, Distinguished Professor (Emeritus) at the Scripps Institution of Oceanography and co-founder of Del Mar Oceanographic, Lucas has developed a cost-effective and easy-to-use mechanism for gathering such two-dimensional data – the Wirewalker, a platform that can safely move instruments throughout the water column to collect data. "The challenge is to see enough of the ocean in a single experiment that we can figure out how it works," Pinkel says.

More Ocean Info

Powered solely by wave energy captured by a bobbing float at the surface and a weight suspended in the water column on a suspension wire, the Wirewalker propels itself down the wire to the desired maximum profiling depth. At this point, the Wirewalker loosens its grip on the wire and begins to record data from the attached instruments as it slowly returns up the wire to the surface – powered entirely by the platform's own buoyancy. Once back at the surface, the Wirewalker re-establishes its grip on the wire, ready for another downward cycle.

"Typical instruments record a signal as a function of time at whatever position they are located," Pinkel explains. "The

Nortek and Del Mar Oceanographic are collaborating to give researchers a cost-effective way to answer questions surrounding the functioning of ocean processes.

The Wirewalker is a platform that can safely move instruments throughout the water column to collect data on the vertical ocean structure.

Wirewalker can turn these one-dimensional signals into two-dimensional depth-time images, enabling much more ocean information to be collected and insight to be gained from experiments."

With no need for electronics, motors or computers to control the Wirewalker's movement, there are fewer moving parts to break down. On-board batteries are only used to power the attached instruments.

Crucially, the Wirewalker does not require a suite of specially designed instruments to capture data. For the most part, researchers can mount their existing instruments on the Wirewalker. "It is a force multiplier," Pinkel states. "Almost any internally recording instrument can be mounted on a Wirewalker and used without extensive modification."

The Wirewalker, which costs less than most of the instruments that it can carry, can be deployed as a single fixed mooring or as an array of moorings, or can act as a drifter. This flexibility makes it suitable for a range of different research programs.

Since development began in 1998, researchers at Scripps Institution of Oceanography have paired the Wirewalker with several different instruments, including Nortek's Aquadopp and Signature current profilers, which Lucas says have provided critical, high-resolution measurements of current velocity.

"Nortek has been very helpful in adapting the Aquadopp and Signature products to the Wirewalker platform," Lucas reports, noting that the vertical movement of the platform presented a unique set of challenges that needed to be overcome during the Wirewalker's development phase.

The Wirewalker/Nortek combination has been used in several locations around the globe, including by the USA's Office of Naval Research funded projects in the Bay of Bengal, the North Atlantic and North Pacific, as well as by the Scripps Institution of Oceanography off the coast of southern California, USA. The projects have covered two broad areas of research: 1) characterizing ocean mixed layer velocities free from the influence of surface waves, and 2) obtaining vertical resolution of velocity fluctuations on small scales over large depth ranges.

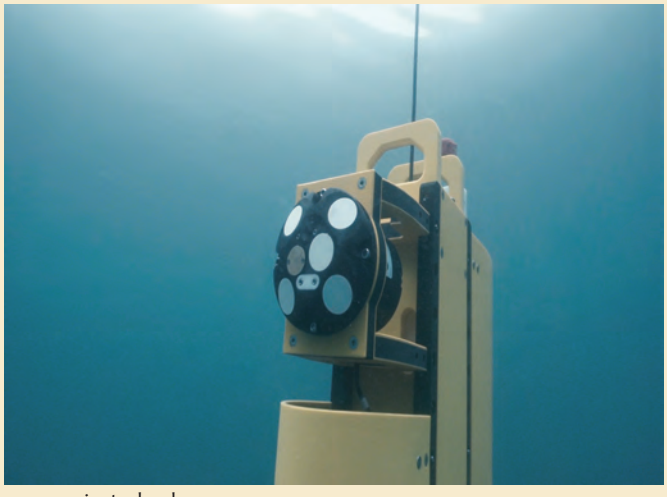
One particular research project where the Wirewalker/Nortek combination has been particularly useful focuses on understanding how internal waves and other small-scale physical dynamics drive air–sea exchange. As Lucas explains, "The aim is to improve how the influence of the ocean on the atmosphere, and vice versa, are included in weather and climate forecasts."

Another research project has successfully demonstrated the critical (and somewhat under-appreciated) role internal waves play on processes that control carbon fixation and productivity.

Improving accessibility

Commercial production of the Wirewalker started in 2015, though Del Mar Oceanographic is continually improving its usability for researchers, including accessibility to the data captured by any instruments mounted on it. "In many experiments, the data very quickly become more valuable than the Wirewalker and its instruments," Pinkel says. The company is currently upgrading the Wirewalker's ability to transmit data to shore via GSM, VHS and the Iridium satellite constellation. In the future, they will also harness wave energy to power the instruments that the Wirewalker carries, further extending the potential duration of deployments.

The Wirewalker can turn one-dimensional signals into 2D depth-time images, enabling more ocean information to be collected and insight to be gained from experiments.



The Signature1000 is a versatile ADCP capable of measuring mean currents and turbulence, as well as wave height and direction.

All images: NORTEK

New Products

Innovative new products, technologies and concepts

MacArntney to Launch eLARS

Photo: MacArtney

MacArtney is ready to launch an all-new, all-electric launch and recovery system for the ocean space market. The all-new, all-electric eLARS can be delivered as a complete system or as a stand-alone A-frame and will support a wide range of inspection and observation class, as well as work class ROVs. The eLARS features include zero pressurized oil over water, reducing the risk of oil spillages; and improved power efficiency. Thus requiring less vessel power and improving overall energy efficiency, and enabling vessels with smaller generator sets to operate the system. Going electric also increases usable deck space in the absence of the traditional HPU (Hydraulic Power Unit). The new eLARS provides an intelligent and versatile control system. A range of real-time condition metrics displays information that empowers the operator to make operational and maintenance decisions in the moment. Full automation capability is also considerably easier with a control system design equipped for semi and fully automated operational sequences.

Coda Octopus Debuts Echoscope AIR

The Echoscope AIR initially focuses on the above water, short range construction market applications where imaging and placing objects above the waterline can be as critical as underwater, adding to placement accuracy and efficiency for operators and project construction teams. It gives users an extra level of scene awareness to ensure inspection and monitoring tasks are completed safely and efficiently with the same real-time 3D data and multi-aspect imaging as enjoyed uniquely by Echoscope users. Providing the same real-time volumetric 3D data as the Echoscope allows use of real-time and post-processing software applications (Underwater Survey Explorer and CMS). The initial focus for Echoscope AIR is:

- **Breakwater Construction:** The Echoscope AIR can visualize the movement and track blocks above waterline for the first time. The Echoscope AIR fully integrated within the CodaOctopus Construction Monitoring Software (CMS) and is directly interchangeable for the Echoscope.
- **Port, Harbor, and Bridge Inspection:** The Echoscope AIR is also supported in our Underwater Survey Explorer (USE) software allowing short range above water inspection tasks to be executed with the same ease as currently performed with Echoscope underwater.

Meller Optics

Maritime Sapphire Optics for Subsea Apps

Meller Optics introduced a range of custom manufactured sapphire lenses, windows, and domes for use in submersibles and deep water applications. Meller Marine Sapphire Optics feature Mohs 9 hardness and can withstand fast moving sand, particles, and deep water pressure to 10,000 psi, depending upon application. Custom manufactured to OEM specifications, they can be supplied as lenses, windows, and domes in sizes from 0.25- to 10-in. O.D. with varying wall thicknesses and treatments. Featuring surface finishes that can be held to 10-5 scratch-dig, roughness to less than or equal to 0.3 nm RA, and flatness to 0.5 fringes HeNe, Meller Marine Sapphire Optics can incorporate elliptical edge shaping and steps, holes, and slots for mounting. Suitable for use in submersibles, probes, and sensors, their smooth flat surfaces help prevent algae growth.

Hydroid

Hydroid Delivers to USN

Hydroid delivered the first REMUS 300 Unmanned Underwater Vehicle (UUV) prototype to the U.S. Navy through the Defense Innovation Unit (DIU), a new, modular UUV will be assessed over the next year as a potential solution for the Next Generation Small-Class UUV (SUUV) program for the Navy.

The REMUS 300 maintains the 7.5-inch diameter of the REMUS 100, increases the depth rating to 305 meters, and remains two-man portable. Built around the REMUS Technology Platform, the design also allows for reconfigurable payloads, sensors and energy modules to meet mission requirements.

New AI Tool for Sonaar Noise Clean-up

Teledyne CARIS has announced the released of HIPS and SIPS 11.3. This new software upgrade will introduce the first-ever COTS (commercial-off-the-shelf) release of an artificial intelligence (AI) solution for classifying and cleaning sonar noise.

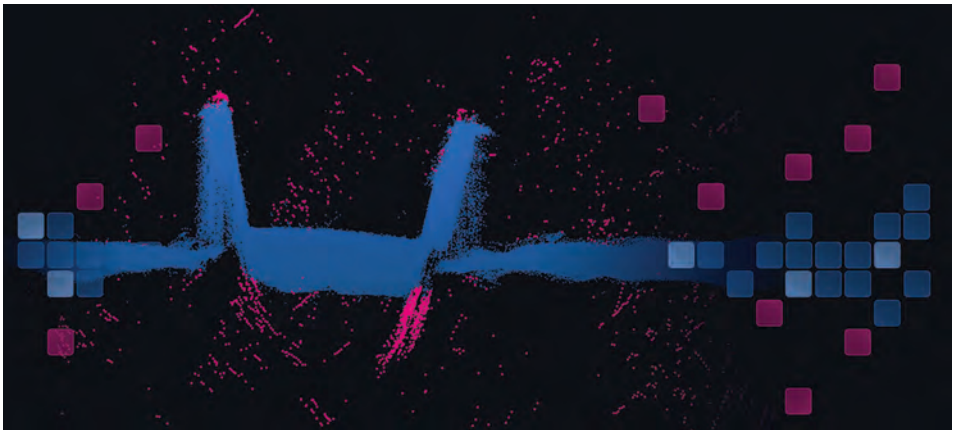
Teledyne CARIS said it seeks to reduce the need for manual cleaning and to move data swiftly from acquisition to review. The Sonar Noise Classifier automatically identifies the vast majority of sonar noise, resulting in a reduction of manual cleaning effort by a factor of up to 10x at an accuracy of 95%.

This allows the hydrographer to focus more time on other important aspects of the survey and processing workflow.

This new approach to clean sonar noise is powered by the CARIS Mira AI engine, a new cloud-based platform to host current and future AI solutions. CARIS Mira AI also provides a flexible package capable of scaling with data processing needs. All data directed to the CARIS Mira AI platform is anonymized, randomized and encrypted before transmission. For additional security, no data remains stored on the cloud following the AI classification process.

"By leveraging deep learning techniques, Teledyne CARIS is poised to bring fundamental change to how sonar data is processed.

The use of AI opens exciting opportunities for the future of hydrographic survey, from automated processing pipelines for crowd sourced bathymetry, to feature detection for charting," said Karen Cove, Senior Product Manager.



Teledyne CARIS

Arctic Rays

New 30K Lumen LED

Arctic Rays announced Dragonfish II, a dual-channel LED torch light for professional imaging applications. The Dragonfish II features dual-channel, independently dimmable LED arrays allowing for white or color blending and independent bi-color operation. Initial eight production units are going to launch customer OceanX for use on manned submersibles and an ROV.

User-settable PWM dimming frequency over RS232 or analog control, allows for flicker-free operation for various frame rates. Input voltage range is 200-420 Vdc or 90-260 Vac. The 6,000 meter rated, hard-anodized 6061-T6 aluminum housing is extremely compact with an overall diameter of 111mm (4.38 in.) and length of 177mm (7.0 in.) long (DC version) or 249mm (9.6 in.) long (AC version) including connector.

Photo Credit: Oceanology International

Oi 2020

The Conference Program

Oceanology International's upcoming three-day event, Oi London 2020 (ExCel London, March 17-19), marks the 50th anniversary of the renowned exhibition and conference series. Between its hopeful, speculative beginnings in Brighton on the eve of the 1970s and the present day, Oi has consistently grown in stature, prestige and impact. Its global profile as a marketplace, networking hub and sounding board for new technologies has been boosted significantly by the addition of sister events in China (since 2013) and the US (since 2017), while the Oi portfolio is due for further expansion with the forthcoming launch in Abu Dhabi of a new exhibition and conference series with a Middle East and Indian Ocean focus.

Organizers Reed Exhibitions have worked to provide value for attendees in what is expected to be the biggest event in Oi's half-century history. "We have secured more exhibition floorspace in ExCel London than ever before," says David Ince, Event Director, Reed Exhibitions, "approximately 17,000 sq. m., to make room for over 500 exhibitors from 90 countries, and are enabling twice as many companies to stage on-water product demonstrations in the Royal Victoria Dock than at previous shows. With more than 8,000 visitors coming through the doors, we're endeavoring to make this golden anniversary expo a standout experience for every single one of them."

It's a matter of record that the conference element in Oi events has always proved as influential as the exhibition, and the recently unveiled conference program for Oi London 2020 represents a typically exhaustive mine of information for attendees. The backbone of the conference agenda is a series of free-to-attend technical tracks, presented by an agglomeration of thought leaders and industry experts, on the following topics:

Offshore Energy Development, Asset Integrity and Monitoring, Hydrography, Geophysics & Geotechnics, Coastal Zone & Shallow Water, Navigation & Positioning, Imaging & Metrology, Ocean Observation & Sensing, Marine Pollution & Environmental Stressors, Data Interpretation & Al, Unmanned Vehicles & Vessels, and Ocean ICT.

Each topic is broken down into dedicated sessions, concluding with audience Q&As, in which the most innovative developments in specific fields are examined in gratifying detail. Taking the Unmanned Vehicles & Vessels track as an example of this principle demonstrates how sessions pan out over the three days of the event. The track itself, sponsored by marine technology and environmental service solutions company Seiche, is subdivided into four subject threads – ICT for Unmanned Systems and Operations (South Gallery, Room 9, Tuesday, March 17, 11.45-16.00), Unmanned Vehicle Concepts of Operations (South Gallery Rooms 3 & 4, Wednesday, March 18, 10.00-11.30), New Unmanned Vehicle Developments (South Gallery Rooms 3 & 4, Wednesday, March 18, 11.45-13.15) and Use of Autonomous Systems (Thursday, March 19, South Gallery Rooms 3 & 4, 11:45-13:15).

Within these, key aspects will be covered in concise, focused 20-minute presentations. So, for instance, the New Unmanned Vehicle Developments thread will encompass brief seminars on Roving Bat: A New-Generation Solution For Uwild Applications, Enabling Technologies for Next-Generation Smart Robotics and Unmanned Underwater Vehicles (UUVS): Area Coverage Rate (ACR), Sustained Area Coverage Rate (ACR-S) and Expeditionary Operations. Chairpersons for these sessions over the three days of Oi London 2020 will include Richard Mills, Vice President Marine Robotics Sales, Kongsberg, and Ahmed Abousabea, ROV Specialist, Total; while fellow industry professionals ranging from Kate Larkin, Deputy Head of Secretariat, EMODnet and Matthew Kingsland, Senior Robotics Systems Engineer, NOC to Dr. Gordon Clark, Chief Engineer, General Dynamics and scientist Johannes Oeffner of Fraunhofer CML will number among the speakers.

As regards other technical tracks, the new Marine Pollution & Environmental Stressors strand is destined to be a particularly timely and cogent enterprise, outlining the latest methodologies for tackling marine pollution and confronting issues such as ocean acidification which are being brought about by climate change. The inherent doctrine of advancing responsible practices for studying, safeguarding and improving the ocean environment is understandably at the root of every theme in the Oi conference schedule. The Ocean Observation & Sensing track, for example, will look at the most encouraging measurement and analysis developments in the sphere of ocean and atmospheric physics, chemistry, biology and genomics, while Imaging & Metrology (sponsored by international subsea operating company DOF Subsea) will pursue the application of the newest imaging and measurement technologies as a means of optimising on-water and subsea operating capabilities.

Delegates can also book tickets now for two one-day events, both mainstays of the Oi 2020 calendar. The first of these, the Ocean Futures Forum (Tuesday, March 17, 10:00-16:00) will gather together business leaders and senior strategists for in-depth discussions on the evolving scientific and technological requirements of the Blue Economy, and their environmental implications, from both European and US perspectives. Speakers will include Chris Williams, Managing Director, UK Seabed Resources; Olive Heffernan, marine biologist and freelance science writer; and Ralph Rayner, Chairman, Sonardyne International.

Catch the Next Wave, meanwhile, on Thursday, March 19, 09:40-17:00, will find paired speakers envisaging ways in which cross-discipline, cross-sector connections can drive crucial ocean science and technology innovations over the next 50 years. Speaker pairings will include Don Walsh of The Explorer's Club and Patrick Lahey, President, Triton Submarines.

"The conference schedule will also be complemented by a range of business-focused content programmes in our Spotlight Theatre on the exhibition floor," adds David Ince, "so the prospect for delegates to glean invaluable information while forging new connections is more pronounced than ever, as befits this special anniversary event. The technological innovations, scientific breakthroughs and collaborative initiatives spotlighted by Oi events over the last half-century have done so much to put the building blocks in place for the stewardship of our oceans in the future; and Oi London 2020 heralds an inspirational new chapter in the conscientious progression of the ocean science community."

www.oceanologyinternational.com

Oi '20: The Show Floor

New technologies to be seen at the Oceanology International Exhibition, March 17-19, 2020, EXCEL, London, England.

AIRMAR
Oi Booth B250

The ultrasonic 200WX-IPX7 WeatherStation Instrument meets this growing demand for real-time, site-specific weather information collected offshore by integrating numerous sensors within its rugged, compact housing. In addition to its ultrasonic WeatherStation Instruments, Airmar offers a full line of ultrasonic transducers for hydrographic survey and scientific applications, including models suitable for shallow and deep water survey, sub-bottom profiling and aquatic habitat assessment.

Dynautics
Oi Booth P301

Dynautics will exhibit a complete range of vessel automation products that provide the "Brains Behind Unmanned Missions" at Oi2020. Scientific research vessels, such as the climate monitoring undertaken by East Anglia University and AutoNaut ASV, uses Dynautics SPECTRE 2 navigation and control electronics. Survey applications, used for mapping the seabed, such as EIVA, Hydromagic, Hypack and QPS are easily integrated with the Dynautics E-Boat SPECTRE which makes the collection of data faster, simpler and more cost-effective. Helping scientists understand the changing shape of the seabed. Dynautics also have extensive 'on and below water' experience.

Falmouth Scientific, Inc.
Oi Booth N10

Falmouth Scientific, Inc. (FSI) provides Sensors, Systems and Transducers for survey solutions and applications in salt and fresh water environments. FSI's standard product areas include the Hegg Marine Solutions (HMS) Bubble Gun seismic systems, sub-bottom, and side scan sonar imaging systems; ACM-PLUS current, wave, and tide monitoring systems; advanced electro-acoustic transducers; and acoustic relocation systems. Services include custom design, development, integration, and production of marine Sensors, Systems and Transducer technology, as well as value-added services such as prototyping, product assembly, potting, calibration, and pressure testing.

GRi Simulations
Oi Booth E400

Since 1998 GRi Simulations Inc. (GRi) has been focused on delivering high-fidelity training, planning and real-time 3D Interactive solutions for critical marine operations. From augmented reality to integrated engineering technologies, GRi has the experience to enhance the safety, security and productivity of integrated marine systems and operations through its Virtual Remotely Operated Vehicle and Interactive Design and Engineering Analysis Field Development Kit Digital Twin platforms. GRi meets the high-fidelity simulation demands of complex multi-platform systems and operations including ROVs, AUVs and USVs, Ship's Bridge, Winches and LARS.

Innerspace Corporation
Oi Booth R395

The Innerspace Electric Thrusters are now offered with a matching integrated or standalone controller option, oil filled and pressure balanced, eliminating the need for a motor controller housed in a separate one atmosphere bottle. Where space allows the Integrated Motor Controller (IMC) option is a two-connection solution to the thruster. The separate HV DC power feed and low voltage digital control connection provide a simple interconnect to vehicle systems, and very low radiated emissions. Where space does not allow, the Stand-alone Motor Controller (SMC) is offered in a separate bottle with resolver and phase power connections to the motor. Specially designed to match the 1002 Series Electric Thruster range from Innerspace, the motor controller operates in torque or velocity mode.

Kraken
Oi Booth E400

Kraken Robotics Inc. is a marine technology company engaged in the design, development and marketing of advanced sensors, software, pressure tolerant batteries and underwater robotics for Unmanned Maritime Vehicles used in military and commercial applications. It is recognized as leading innovators of synthetic aperture sonar (SAS), an underwater imaging technology that improves seabed surveys by providing ultra-high resolution imagery at superior coverage rates. Kraken has evolved from building world class SAS sensors to building world class underwater vehicles including tethered (KATFISH) and autonomous (THUNDERFISH) versions.

NKE Instrumentation
Oi Booth C401

The new generation of multiparameter sonde is officially out: the WiMo sonde. Two versions of the sonde will be available: the WiMo with four locations and the WiMo Plus with seven locations. The WiMo sonde allows you to measure up to 20 parameters thanks to its smart sensors suite that benefit from real plug and play and automatic recognition as you can connect and disconnect the smart

AIRMAR
Oi Booth B250

NKE Instrumentation
Oi Booth C401

and digital sensors even with functioning sonde. One of the main advantages of this WiMo sonde is its ease of use and user-friendly web embedded interface compatible with all kinds of devices. The key feature of the WiMo sonde is its easiness as you can connect, disconnect and also calibrate the sensors whenever and wherever you need. Transmission of data won't have any secrets for you as it has a wide range of autonomous communication modules. As there are two embedded sensors – temperature and water pressure – you can use the sonde as a data logger without any sensors as a wave and tide underwater logger.

Novacavi
Oi Booth N250

NOVACAVI will highlight its experience in addressing aquaculture ROV systems challenges at Oi 2020.

NOVACAVI offers a wide range of custom cables, robust cables for the harsh environment they are working in and the most flexible ones perfectly suiting diver less ROV multiple tasks (mooring inspection, net maintenance, cleaning, water and sediment sampling, mort removal). Designed and manufactured to be watertight and long-lasting, custom tethers and umbilicals can be negative, positive or neutral buoyant as required.

PanGeo Subsea
Oi Booth E400

PanGeo Subsea is a marine geophysical-geotechnical service delivery company specializing in high resolution true 3D volumetric acoustic imaging solutions to mitigate risk in offshore installations. PanGeo offers:

- accurate positioning and continuous visualization of cables and pipelines during depth of burial surveys;
- identification of buried anomalies threatening integrity of pipe/cable in parallel with depth of burial survey;
- true 3D volumetric imaging and accurate positioning of buried infrastructure for efficient site decommissioning;
- true 3D volumetric imaging and accurate positioning of buried Unexploded Ordnances (UXO) including non-ferrous UXO; and
- true 3D volumetric imaging of buried geohazards (boulders) enabling de-risking and micro-siting of offshore wind farms piles.

QPS
Oi Booth F601

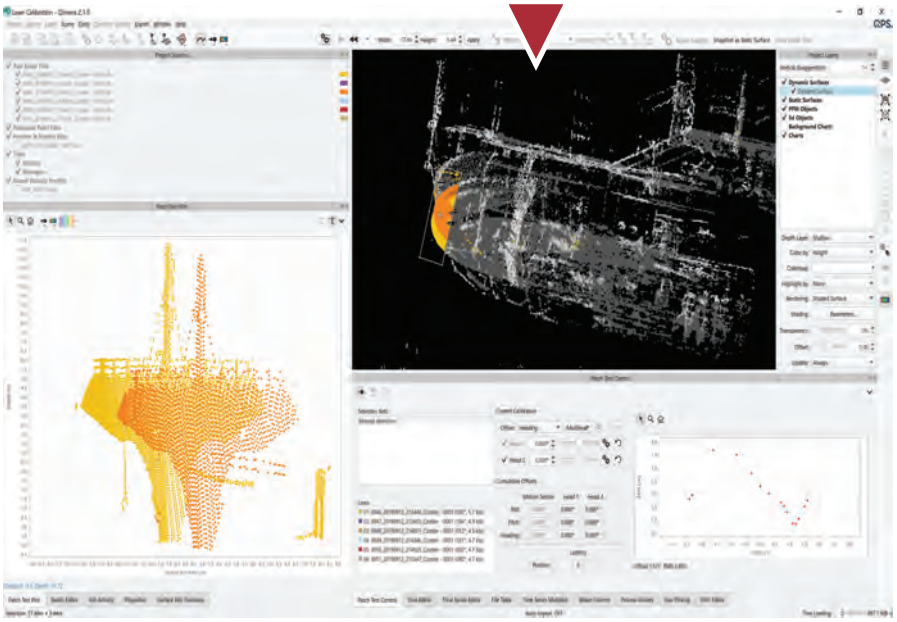
QPS launched new software versions of Qinsy, Qimera, and Fledermaus, with the primary focus on cross-product features through the product line. At Oi 2020, QPS will present the latest features integrated through the product line, which include a new dynamic surface file format, new project dialogs, and a new geodetic configuration interface. Also presented will be the new look and feel of Qinsy 9, along with SVP folder monitoring and an online line log. Qimera 2 features laser calibration, classification and RGB support for LiDAR data, support for refraction corrections for Structure from Motion (SfM) bathymetry, the addition of the Isolated Cluster Removal filter, an SVP "crossfade" to help smooth out transitions between SVP casts, and much more. New features in Fledermaus 8 include enhanced presentation capabilities, as well as the exciting new 3D Mesh technology that has inherent advantages over gridded bathymetry.

RS Aqua
Oi Booth G501

Following the 20 year success of the WaveRadar REX, RS Aqua is introducing its successor, the WaveRadar REX 2, at Oceanology International 2020. The REX 2 is considerably smaller, weighing a mere 8.5 kg, with power consumption of ~1 W. This is a 63% reduction in weight and 90% reduction in power consumption over the original REX. The REX 2 also includes im-

Novacavi
Oi Booth N250

QPS
Oi Booth F601



proved sampling algorithms to increase wave measurement accuracy, and is constructed almost entirely from stainless steel to improve longevity. These improvements were undertaken after consultations with experienced REX users, and at RS Aqua we are confident the REX 2 will continue to lead the way in offshore wave measurement for many years to come.

Rutter Inc.
Oi Booth F200

Rutter's sigma S6 systems integrate with either navigational or dedicated-purpose marine x-band radars and include: sigma S6 Oil Spill Detection; sigma S6 Ice Navigator; sigma S6 Small Target Surveillance; sigma S6 WaMoS II, wave and surface current measurement; and sigma S6 WaveVision, real-time visibility of large waves up to 60 seconds before impact.

Seamor Marine
Oi Booth P351

SEAMOR Marine researches, designsn, builds and sells ROVs. Its three flagship vehicles are handcrafted in Nanaimo, on Canada's West Coast, and are found working on every continent and every major body of water globally. At Oi 2020 Seamor will exhibit its newest ROV, the Mako. The Mako carries a payload of up to 22.5kg (14kg standard) on its large open frame, allowing users to easily install heavy instrumentation, including multi-beam imaging sonars. The Mako comes standard with eight SEAMOR designed thrusters, four of which are vertical, providing a more stable flight. Depth rated to 300 metres (or a 600 metre deep-water model), the Mako is easy to fly and has proven reliability under heavy industrial use.

SeaTrac
Oi Booth N551

Learn more about SeaTrac's new 4.8 meter solar-powered autonomous surface vessel, the SP-48, an open multi-purpose platform for surface to underwater applications based on customizable instrumentation packages. Founded by MIT naval architects, SeaTrac makes, sells and leases its ASVs for a wide variety of military, commercial and research missions. Sensor agnostic, with a handy moonpool and ability to make tight radius turns, the SeaTrac SP-48 is versatile and persistent for real-time ocean observation, data collection, intelligence, surveillance and reconnaissance missions. Built to operate in all marine environments—from near shore to open ocean—the SP-48 has an efficient self-righting hull and electric motor that frees it from reliance on wind or waves for propulsion.

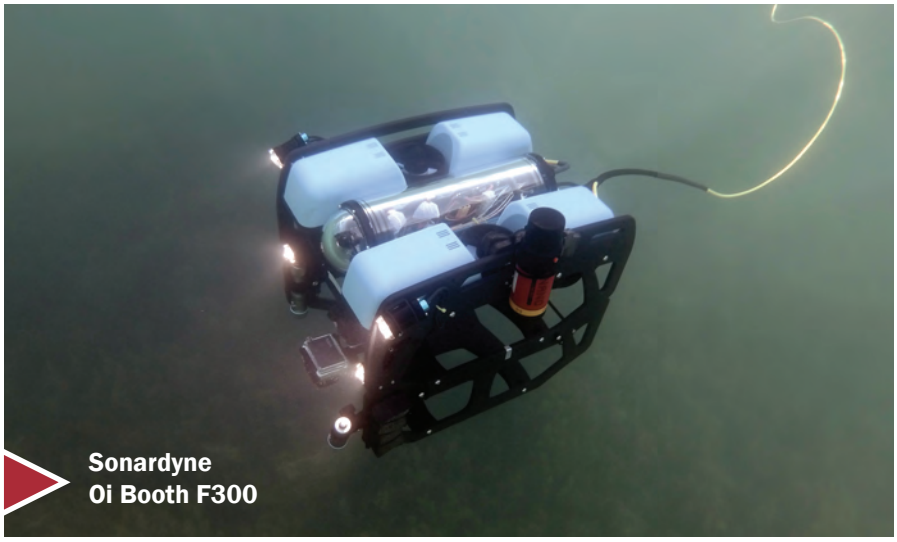
Seiche
Oi Booth Q100

Seiche is launching a digital hydrophone developed in partnership with QinetiQ. Due to be unveiled at Oi2020 Hydraq QQ1000, is a combination of acoustic and auxiliary sensors suitable for seabed, rising cable, or suspended cable deployment. The Hydraq QQ1000 sensor meets the challenges of accurately measuring radiated noise and man-made noise pollution in the marine environment. The acoustic measurement bandwidth is compatible with current noise standards, including ISO, DNV and STANAG.

Silicon Sensing
Oi Booth A307

Silicon Sensing Systems will showcase its new AMU30 inertial measurement

Silicon Sensing
Oi Booth A307



Sonardyne
Oi Booth F300

unit (IMU) at Oceanology International. This device responds to growing demand for a tactical grade, non-ITAR (International Traffic in Arms Regulations) IMU that also outputs pitch, roll and heading data. Two AMU30s will sit at the heart of the Mayflower Autonomous Ship (MAS400) autopilot as it voyages, unmanned, across the Atlantic this autumn – celebrating the original Mayflower journey from the UK to America 400 years ago. AMU30 is a micro electro-mechanical system (MEMS) product that delivers impressive inertial performance, including exceptional bias stability and low noise characteristics, whilst incorporating an embedded Kalman Filter based AHRS algorithm. AMU30 offers a real alternative to heavier, larger and more costly fibre optic gyro-based devices.

Seafloor Systems Inc.
Oi Booth P300

Seafloor Systems plans to introduce its next generation EchoBoat USV at OI '20 in London. The EchoBoat 240, a 2.4m Monohull USV was designed from the ground up to feature such innovations not available before in a portable platform including a semi-displacement hull with the ability to plane at lower speeds, an oversize sea chest capable of fitting a full size multibeam sonar transducer, an integrated SVP/CTD deployment system, and Seafloors proprietary integrated USV Dashboard system for monitoring critical system information and components.

RS Aqua
Oi Booth G501

Sonardyne
Oi Booth F300

Sonardyne International will use Oceanology to announce additions to its 2020 product line-up. It will launch SPRINT-Nav Mini, its newest hybrid acoustic-inertial solution, ADCP functionality for its Syrinx DVL and its second-generation Gyro USBL.

SPRINT-Nav Mini offers an all-in-one turn-key solution, comprised of an AHRS, DVL and depth sensor, all-in-one, for medium-sized vehicle platforms that would normally not be able to host high-end navigation systems. This includes observation-class and drill support ROVs, low-logistic AUVs, manned submersibles and USVs. SPRINT-Nav Mini comes in a 215 mm-high and 149 mm-diameter housing and takes advantage of the unique, tight integration between an inertial measurement unit, pressure sensor and the company's own-design Syrinx 500 kHz DVL.

A 300 m-rated SPRINT-Nav Mini weighs just 3.6 kg in air; it is also available in a 4,000 m-rated unit of the same size.

Sonardyne is also introducing the replacement for its popular Gyro USBL. The first generation combined the vessel heading, pitch and roll data that is critical to Ultra-Short BaseLine (USBL) system performance, with an acoustic transceiver, all packaged in one housing. The new Gyro USBL is 30% shorter and 40% lighter than the one it replaces.

On the water, Sonardyne will be demonstrate the increased functionality that's available to users of its Syrinx 600

Seamor Marine
Oi Booth P351

Teledyne Marine
Oi Booth G100

kHz Doppler velocity log (DVL), specifically, the ability to provide acoustic current Doppler profiling (ADCP), as well as dual DVL/ADCP operations, without compromising bottom track.

When using SPRINT-Nav, which has a tightly coupled Syrinx DVL built-in, ADCP functionality really comes into its own. Users get absolute profile velocities in the most challenging conditions while maintaining SPRINT-Nav's class leading navigation performance. When bottom track is not available, inertial velocities from SPRINT are used by Syrinx to compensate the ADCP water column velocities for vehicle motion. That means users get absolute water velocities through the local water column, even when they have no DVL bottom track.

SubC Imaging
Oi Booth E401

SubC Imaging is a supplier of state-of-the-art underwater vision systems. SubC works with clients throughout the marine industry, including, but not exclusive to: oceanographic research institutions, offshore energy companies, hydrographic surveyors, environmental monitoring organizations, and ROV/AUV manufacturers. Since inception, SubC has provided products, solutions and services to more than 140 organizations in over 30 countries around the world and has earned a reputation as a go-to supplier for innovative solutions that provide the reliability and quality demanded throughout the marine industry.

SULIS Subsea Corp.
Oi Booth E401

From filming newly-discovered shipwrecks with the Black Sea Maritime Archaeology Project, to capturing imagery of hydrothermal vents with the Schmidt Ocean Institute, SULIS's underwater camera technology is fast becoming the choice for deep-sea scientists, explorers, and film-makers.

Teledyne Marine
Oi Booth G100

To help customers navigate its many solutions, the Teledyne Marine has designated one booth as a Discovery Zone, which will detail how and where Teledyne Marine products are being used alone, and in combination, to solve the difficult challenges our customers face in our key markets, including oceanographic, energy, infrastructure and civil engineering, defense and security, and marine life.

A second booth will serve as a Collaboration Zone, with ample meeting space for customers to relax, collaborate and brainstorm in a comfortable and engaging setting with Teledyne Marine's 50+ OneTeam members throughout the conference.

Visitors are also invited to experience products first-hand via a series of dockside and on-water demonstrations. Daily dockside demos will showcase the SeaBotix remotely operated underwater vehicle (ROV) equipped with Benthos brand new Ultra Compact Transponder (UCT) and new ruggedized BlueView M-series MK2.

On-water demos will highlight a full suite of our technologies, including ultra-high-resolution mid-water RESON SeaBat T50-R Extended Range with a built in INS multibeam echosounder, Odom's new compact single beam echo-

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sounder, RD Instruments TASMAN DVL and Teledyne TSS Saturn high accuracy fiber optic INS, Optech TLS-M3 high-resolution laser scanner, PDS and CARIS On-board software, and Benthos new GNSS Survey Feature for easy recovery of acoustic release deployments.

Unmanned Survey Solutions (USS)
Oi Booth G702

Unmanned Survey Solutions (USS) design, build and operate Unmanned Surface Vessel's (USV's) for use in marine, scientific and environmental industries worldwide. Built by surveyors, for surveyors these USV's offer an innovative modular design with specialist payload capabilities for hydrographic and environmental surveys for data acquisition in challenging marine environments. The Inception Class MKII USV is designed to produce high-end, accurate hydrographic surveys in challenging shallow-water zones. Ideal for bathymetric surveying in areas where access for a manned survey vessel is difficult. It can be operated by remote control or autonomously depending on the location and application.

The Accession Class USV is a modular USV, adaptable for either nearshore or offshore operations. Used by a wide range of operators from Port Authorities to offshore survey companies.

Unmanned Survey Solutions (USS)
Oi Booth G702

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