MARINE TECHNOLOGY REPORTER

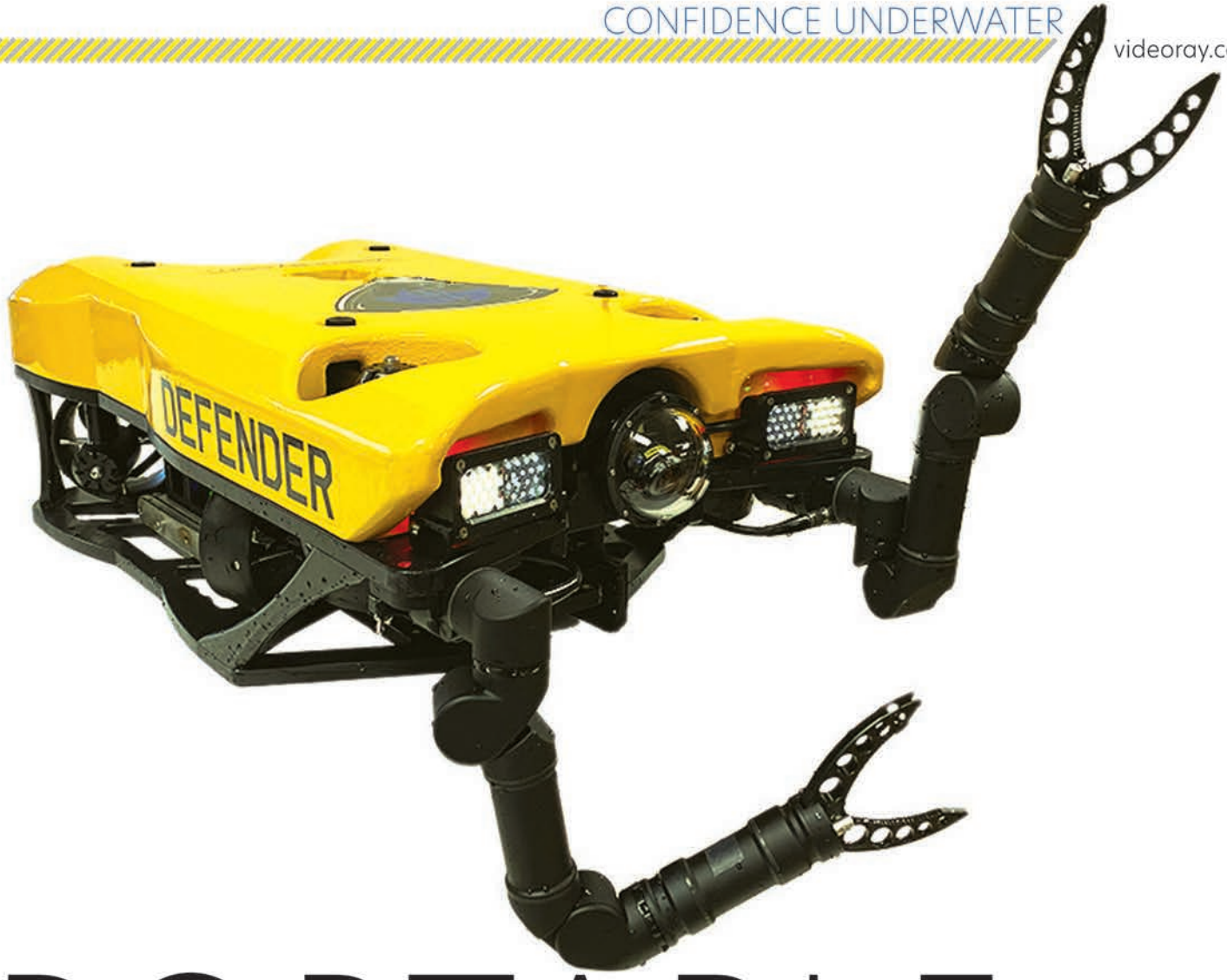
July/August 2020

www.marinetechnologynews.com

MTR 100

The People, the Technology & the Trends Driving Subsea Science, Commerce & Defense

Volume 63 Number 6



PORTABLE and POWERFUL

VideoRay is the global leader in underwater Remotely Operated Vehicles. We back our quality-driven solutions with exceptional service and support. We also offer accessories and tools that power you through inspection and light intervention challenges. Discover the "VideoRay Difference" and experience *Confidence Underwater*.

VideoRay

sales@videoray.com +1 610 458-3000

MacArtney
UNDERWATER TECHNOLOGY

PRESENTS

All-electric eLARS

Electric Launch and Recovery Systems

- Technology solution for tomorrow
- Intelligent control system
- Eco-friendly
- Low cost of ownership
- High degree of integrity

WHO DO YOU TRUST?

macartney.com

MTR 100

July/August 2020
Volume 63 • Number 6

THE MTR100 2020

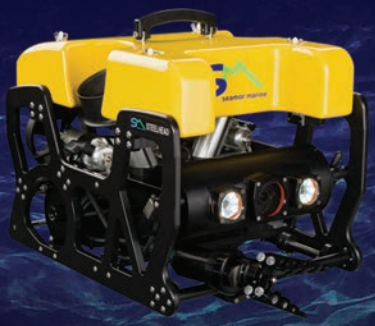
On the Cover: Graham Hawkes tests off-the-shelf dive lights and Paralenz camera for SeaRocket in Penobscot Bay, Maine. SeaRocket dives just over 600-feet deep to old dredging dump sites in the Bay. © **Peter Ralston**

SEAMOR MARINE

SEAMOR ROV

World-class Subsea Remotely Operated Vehicles
Experience the best in power, reliability & versatility.

COME SEE THE DEEP

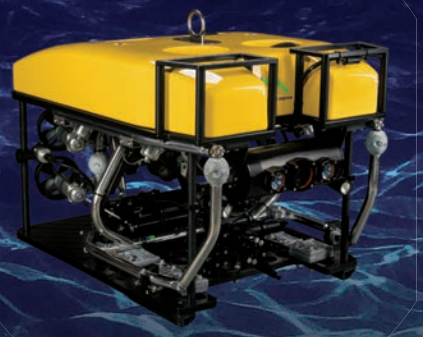


SEAMOR STEELHEAD

This ROV is perfect for inspecting confined spaces. Quickly deploy the Steelhead to get the images you need & get the job done.
Actual Size (L x W x H)
19.8" x 15.1" x 14.7"

SEAMOR CHINOOK

Compact yet powerful, the Chinook ROV can dive to 600 metres & support a large range of navigational & searching aids.
Actual Size (L x W x H)
27" x 15.1" x 16"



SEAMOR MAKO

The Mako has a large open-frame design & capability to carry various accessories up to 22 kg & can run them all at once.
Actual Size (L x W x H)
33" x 25" x 26.5"

1914 Northfield Road
Nanaimo, BC
V9S 3B5 Canada

t 250-729-8899
tf 888-729-8890
e sales@seamor.com

seamor.com

© Peter Ralston

www.marinetechnologynews.com

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
Tel: (561) 732-4368; Fax: (561) 732-6984

PUBLISHER
John C. O'Malley
jomalley@marinelink.com

Associate Publisher & Editor
Gregory R. Trauthwein
trauthwein@marinelink.com

Editorial Intern
Celia Konowe

Contributing Writers
Justin Manley, U.S.
Elaine Maslin, Aberdeen
Tom Mulligan, Ireland
Claudio Paschoa, Brazil
William Stoichevski, Oslo

Production Manager
Irina Vasilets
vasilets@marinelink.com

Production & Graphic Design
Nicole Ventimiglia
nicole@marinelink.com

Corporate Staff
Manager, Marketing
Mark O'Malley
momalley@marinelink.com

Accounting
Esther Rothenberger
rothenberger@marinelink.com

Manager, Information Technology Services
Vladimir Bibik
bibik@marinelink.com

Circulation
Kathleen Hickey
mtrcirc@marinelink.com

Advertising
Vice President, Sales and Marketing
Rob Howard
howard@marinelink.com
Tel: (561) 732-4368 • Fax: (561) 732-6984

Advertising Sales Manager
Mike Kozlowski
kozlowski@marinelink.com
Tel: (561) 733-2477 • Fax: (561) 732-9670

Editor's Note

As this is now the 15th Annual "*MTR100*", I was all set to announce that this year that I had finally gotten a handle on the mammoth task of parsing applications and delivering what we see as a fair representation of some of the most compelling and exciting discoveries and advances in the subsea space for the purposes of science, commerce and defense.

Then COVID-19 hit.

As we enter nearly six months of business upheaval, my common refrain is that today it takes double the effort for half the result. Trust that we know many of our readers are in exactly the same boat, as remote work operations are the norm rather than the exception, and many businesses are still trying to steady the ship and move forward in a safe and reasonable manner. That is precisely the reason that we, as a media company serving the maritime, offshore energy, subsea, ports and logistics markets for more than 80 years, are pleased to continue producing information products in print, online and electronically to serve your business needs.

My professional saving grace this summer was the hard work of **Celia Konowe**, *MTR's* summer intern. Celia was relentless from the start in pursuing the internship opportunity, and I'm happy to say she was equally relentless in delivering insightful editorial for our pages; both the nitty gritty processing MTR100 applications to the delivery of a bevy of insightful feature articles. Out of sheer necessity we threw Celia into the deep end from the outset, and she responded in kind with some outstanding one-on-one interviews. In this edition she profiles three of 2020's "Ocean Influencers" – **Dr. Cleopatra Doumbia-Henry, Graham Hawkes** and **Dr. Jyotika Virmani** – in addition to delivering a thoroughly researched feature on the problem of, and potential solutions for, the microplastics mess in our world's waterways.

Gregory R. Trauthwein
Associate Publisher & Editor

MARINE TECHNOLOGY REPORTER
www.marinetechnologynews.com
Vol. 63 *No. 6*
ISSN 1559-7415
USPS# 023-276
118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

Marine Technology Reporter (ISSN 1559-7415) is published monthly except for February, August, and December by New Wave Media, 118 E. 25th St., New York, NY 10010-1062. Periodicals Postage Paid at New York, NY and additional mailing offices.

POSTMASTER: Send all UAA to CFS. NON-POSTAL AND MILITARY FACILITIES send address corrections to Marine Technology Reporter, 850 Montauk Hwy., #867, Bayport, NY 11705.

The publisher assumes no responsibility for any misprints or claims or actions taken by advertisers. The publisher reserves the right to refuse any advertising. Contents of the publication either in whole or part may not be produced without the express permission of the publisher.

Member
BPA WORLDWIDE BUSINESS

Subscription:
To subscribe please visit
www.marinetechnologynews.com

EvoLogics GmbH

Berlin, Germany – https://evologics.de

EvoLogics GmbH develops underwater information and communication systems based on bionic concepts, combining cutting edge engineering with the best ideas found in nature. Advanced product features include enabling technologies for deepwater exploration and production. EvoLogics' range of products offers highly reliable, flexible and cost-effective solutions for multiple underwater communication, positioning, navigation and monitoring applications.

We strive for innovation and invest our vast experience into developing, manufacturing and supporting products that deliver excellent performance and solve the most challenging tasks. The company was founded in 2000 in Berlin, Germany, by a group of leading international scientists and maritime engineering experts. The company focuses on developing innovative solutions for maritime and offshore industries, as well as smart robotic systems design and bionic research.

The EvoLogics S2C (Sweep-Spread Carrier) spread spectrum technology was developed after eight years of extensive studies into the physics of dolphin communication. It mimics the sound energy patterns of dolphins to deliver acoustic signals even in adverse underwater conditions. Based on S2C technology, the EvoLogics underwater communication and positioning systems provide a fast and reliable full-duplex digital communication link and accurate positioning data. Moreover, EvoLogics S2C devices implement an advanced communication protocol and support multiple data management options along with addressing and networking. S2C devices of the scientific edition line offer a developer platform for network protocol design.

Forssea Robotics

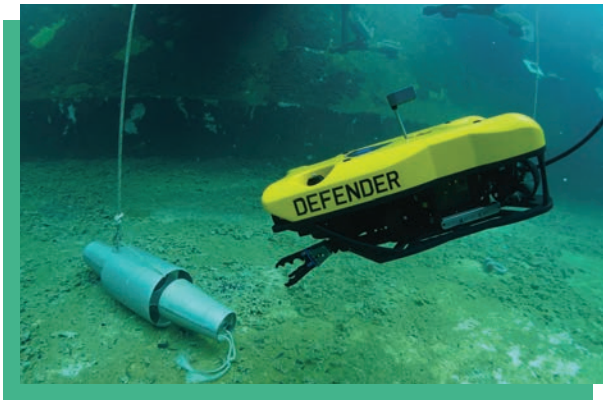
Paris, France – www.forssea-robotics.fr

Forssea Robotics is a subsea robotics and vision company launched in May 2016 to develop innovative technology to reduce subsea operating costs in the offshore niche markets. After three years of R&D, FORSSEA started the qualification of its technologies in 2019 and formed a commercial partnership with Subsea Technology and Rentals.

Forssea innovations include:

ATOLL: Smart lifting autonomous docking ROV, designed to deploy and recover light assets on the seabed (such as LBL transponders). The ROV can perform a supervised autonomous dive, approach and docking based on embedded control algorithms. ATOLL can mechanically engage a subsea structure for recovery back to surface.

ARGOS: Smart light intervention class smart ROV designed for autonomous or supervised inspections with a key focus on renewable markets and USV integration for unmanned operations and remote piloting from an onshore control center. The standard vehicle platform includes the latest advances in ROV technology that the industry has come to demand and expect from modern ROV design. ARGOS is compact in design and the vehicle is powerful enough to perform IRM operations with use of the optional electric five function manipulator arm and various tooling and survey skid interfaces.



VideoRay

Pottstown, PA – www.videoray.com

VideoRay is a leader in man-portable ROVs, and with both the largest R&D staff and the most demanding customers, it continues to produce solutions to unique problems. Mission Specialist technology is based on modular components providing unrivaled flexibility. The largest and most powerful Mission Specialist configuration, the Defender, is optimized for precise control, heavier payloads, lifting, and specialized operations. The Pro 5 trades off larger payload, massive thrust, and more precise autonomous control for more portability and lower cost. Mission Specialist technology is unique in the ability to add new sensors and accessories from a broad range of manufacturers, as it supports a wide range of power and communications options. Both the Defender and Pro 5 are engineered to evolve as they tackle more advanced and complicated assignments. The core components of each ROV are continually being evaluated to ensure the vessels are operating at peak performance. And the subs are frequently being adapted to handle a greater array of accessories based on the needs and demands of customers such as the U.S. Navy.

ECS Special Projects Ltd., which is based in the United Kingdom, has developed the Viper Mine Disposal System exclusively for the Defender. The setup employs twin shot Viper disposal systems with the capability of attaching to multiple targets. They can be initiated using a shock tube link to the surface or by using acoustic initiation. The Defender is also outfitted with Micro-Ranger 2 Ultra-Short BaseLine (USBL) technology from Sonardyne, another UK-based company. The Micro-Ranger 2 USBL system is designed for shallow water tracking of divers and small ROVs as well as autonomous underwater vehicles (AUVs). In recent EOD trials for the Navy, the Defender performed flawlessly with the addition of the Viper and Micro-Ranger 2 systems.

Airmar Technology Corporation

Milford, New Hampshire – www.airmar.com

Working with subsidiaries who develop products for different markets has provided Airmar with access to technologies that have opened new avenues of innovation and product development. One example is Airmar's DX900+, which was originally developed by subsidiary, Marport, for use on commercial fishing nets. Airmar recognized the value the product's electromagnetic technology could have for the sailing industry, and introduced the DX900+ as a thru-hull transducer for accurately measuring speed-through-water and leeway travel without the limitations incurred by a traditional paddlewheel. Now, Airmar is working on converting that same technology for use on ASVs and USVs. Airmar is also currently working to repurpose a material developed by our subsidiary in the defense market, MSI, that will revolutionize transducers as we know them. Airmar's newest product is the 200m Mini Altimeter Kit Smart Sensor, an ultrasonic, ultra-compact altimeter kit optimized for use on USVs, AUVs and ROVs. The 200m Mini Altimeter measures height off the seafloor and underwater structures, and is rated for a depth of up to 1,000 meters. The most significant feature of the 200m Mini Altimeter is that it delivers a full 200-meter range with output resolution to 1 cm, while most altimeter products offer a range of only 100 meters or less. Another crucial feature is its minimal power consumption of just 150 mA at 12 V, so it meets the most demanding power requirements of USVs, AUVs and ROVs. In addition, the 200m Mini Altimeter Kit is available with either a 170 kHz or 200 kHz transducer to provide an option that would lessen the probability of overlap with other nearby acoustic devices. It communicates NMEA 0183 serial data protocol over RS232 or RS422, and can be programmed to operate in manual or fully automatic sounding modes.

Acteon

Norwich, England
www.acteon.com
Dr. Carl Trowell, President/CEO
No. of Employees: 2000

Established in 1989, the Acteon business developed organically through the 1990s, then later through targeted acquisitions and a unique business model. Acteon now brings together a comprehensive suite of branded marine and subsea services that use leading complementary technologies and capabilities from across a range of interconnected disciplines. Acteon solutions simplify the interface between Acteon and customers that need more than one of its operating companies' products or services to address their subsea challenges, whatever their scale and complexity. Each combination is packaged as a customer-specific integrated service and delivered through a single Acteon point of contact under a single contract.

In 2019, Acteon expanded its reach in the renewables field through a collaborative agreement with Ocean Power Technologies. The partnership included the deployment of OPT's PowerBuoy system, and surveillance and monitoring technology and a turnkey mooring and deployment solution provided respectively by Acteon operating companies, Pulse Structural Monitoring and InterMoor. Last year, Acteon also expanded the global reach of its survey business through the acquisition of TerraSond, a multidisciplinary geospatial and geophysical business, and with offshore marine geotechnical and geophysical survey company Benthic.

Headquartered in Houston, Benthic adds deepwater and ultra-deepwater surveying capabilities to Acteon through its proprietary portable remotely operated drill (PROD) technology.

Work has recently been executed in South America in water depths exceeding 2100 m, and the latest equipment upgrades enable operations in depths up to 4000 m, and there are plans to expand services to include offshore wind and scientific research.

Wholistically, the company focuses on digital technologies, technology implementation and research and development advances, which aim to transform project economics and operational efficiency.

- Acteon company UTEC's Proprietary Virtual Asset Management solution, iSite, provides innovative dimensional control and virtual asset management solutions. It allows clients to remotely manage any assets from their desktop, driving cost out of offshore planning and communication.
- Acteon's own subsea integrity engineering services provider, Clarus Subsea Integrity Inc., who develop solutions by efficiently interpreting data to help operators make better-informed decisions in operating their assets. Clarus offers a unique data management solution in iCUE, a user-friendly web-based integrity management portal that allows structured data organisation and provides visual summaries of integrity information such as risks, anomalies, inspection plans and reports, condition monitoring KPIs, and more.
- Acteon offers a wide range of innovative and robust instruments and systems for offshore asset installation, inspection and monitoring, with the integrity and life-of-field of the offshore structure in mind.

Ohmsett

Leonardo, New Jersey – www.ohmsett.com

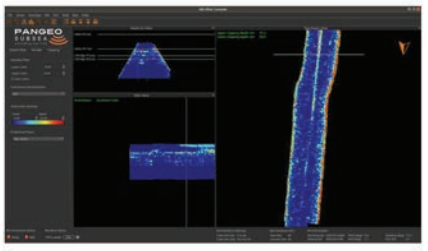
Ohmsett's unique capabilities and realistic marine environment play an essential role in developing new technology for the marine industry. The outdoor wave and tow tank provides controlled repeatable test settings to help validate engineering expectations and evaluate prototype designs under varying flow, position and load conditions. Managed by the Bureau of Safety and Environmental Enforcement (BSEE) under a contract with Applied Research Associates, Inc. (ARA), it is the largest outdoor facility of its type in North America, providing users from around the world with a unique testing environment.

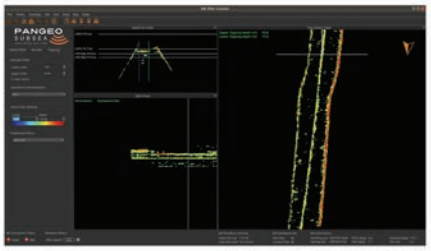
The most notable feature of the Ohmsett facility is the above-ground concrete test tank measuring 667 feet long by 65 feet wide by 8 feet deep filled with 2.6 million gallons of crystal clear salt water. The wave generating capabilities include programmable formations to provide waves suited for research and testing needs.

By providing a unique wave tank and laboratory environment for R&D, we assist researchers and manufacturers in developing and evaluating cutting edge technologies in the marine environment. Ohmsett has the capability to test technology ranging from surface, subsurface vehicles and robotic instrumentation to support oil spill response technologies. In various scenarios, researchers can simulate subsurface release of oil at the wellhead to test subsurface containment and recovery systems, sunken oil detection, non-floating oils, neutrally buoyant oil plumes, and underwater monitoring. The outdoor tank is also well suited for performance testing of wave energy converters, counter terrorism barrier systems, and more.

PanGeo Subsea Inc.

www.pangeosubsea.com





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 sub-seabed solutions to enable accurate positioning and continuous visualization of cables and pipelines and the identification of buried anomalies threatening their integrity during depth of burial surveys and decommissioning; true 3D volumetric imaging and accurate positioning of buried geo-hazards (boulders) and Unexploded Ordnances (UXO), enabling de-risking and micro-siting of offshore wind farms piles.

The PanGeo Subsea Pilot Console is a proprietary software package developed by PanGeo Subsea to provide clear visualization of cables during data acquisition. The newly released Pilot Console provides real-time images of the cable/asset sub-seabed in three views: plan view, cross-track vertical profile and along-track vertical profile. The online PanGeo technician views the live data stream in real-time to ensure the asset is being surveyed as required and that data quality is acceptable.

Upgraded in January 2020, the new Pilot Console provides significant upgrades and benefits including:

- The ability to apply filters to live data, enabling a transparency function to the seabed. The recorded data still contains all acquired data and returns from below the seabed however, the filters are applied to the real-time image used to track assets to produce clearer images below the seabed
- Signal processing within Pilot Console can highlight the image of an asset, enabling easier tracking of buried infrastructure
- Improved asset tracking in challenging soil conditions as transparency filters remove the lithological returns and the requirement to manually slice through the data for location of the top of product.
- Reduction of downtime associated with cease of operations and vessel turn-around to image last known cable location.

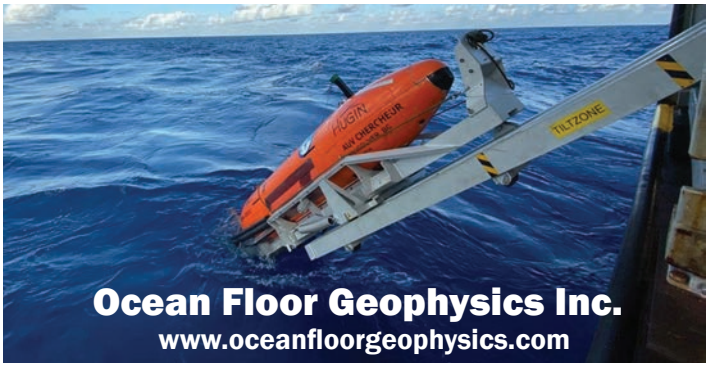
The commercial release of the upgraded Pilot Console has increased overall survey speeds achieved in campaigns to date and it has opened the door to future developments of PanGeo Subsea's technology.

Oceaneering International

Houston, Texas – www.oceaneering.com
President and CEO: Rod Larson
No. of Employees: 10,000

Oceaneering International is a well-known provider of Remotely Operated Vehicles (ROVs) as well as a market leader for innovative life of field products and services for the offshore energy industry. Over the last three years, it has been developing the next generation of subsea vehicles, such as the Freedom Autonomous Vehicle and the Liberty E-ROV Resident Vehicle. In late 2019, it launched the Isurus Work Class ROV to allow operations to be carried out in harsh weather conditions and for a variety of applications including offshore renewables work.

The Oceaneering Isurus Work Class ROV optimizes costly vessel time and reduces idle time with its ability to perform in severe currents and harsh environments. The ROV enables operators to reduce time spent waiting on weather, increasing productivity. The vehicle can achieve 5 knots in forward and reverse, lateral speed of greater than 2 knots, and a vertical speed of 1.3 knots. Isurus is equipped with dual seven-function manipulator arms, advanced vehicle control and navigation, and optional station keeping functionality. It is fully capable of being remotely piloted from a dedicated onshore base. The propulsion system is strategically designed to provide the station keeping and thrust required to complete complex operations and enable the ROV to operate in challenging conditions. Operating at 5 knots enables work to be completed for offshore renewables as well as known harsh weather areas such as the UK North Sea, West of Shetland, India, and Brazil. Isurus can complete both work-class work scopes as well as survey and inspection tasks. The Isurus ROV has the potential to shift the paradigm that dictates how and when work can be completed by delivering a highly capable, robust system that overcomes a common industry challenge.



Ocean Floor Geophysics provides survey and subsea asset inspection services with AUVs, ROVs, USVs, ASVs, active towfish and Hovering AUVs. In 2019 OFG fielded an AUV non-contact integrated Cathodic Protection (iCP) inspection system, allowing for the complete inspection of subsea pipelines and infrastructure without the need to return with an ROV for a traditional "stab" CP. The AUV iCP data integrated with a combination of digital imagery, laser profile data, multibeam, synthetic aperture sonar and high accuracy navigation, and was deployed on AUV pipeline inspection jobs in Asia-Pacific and West Africa in 2019.

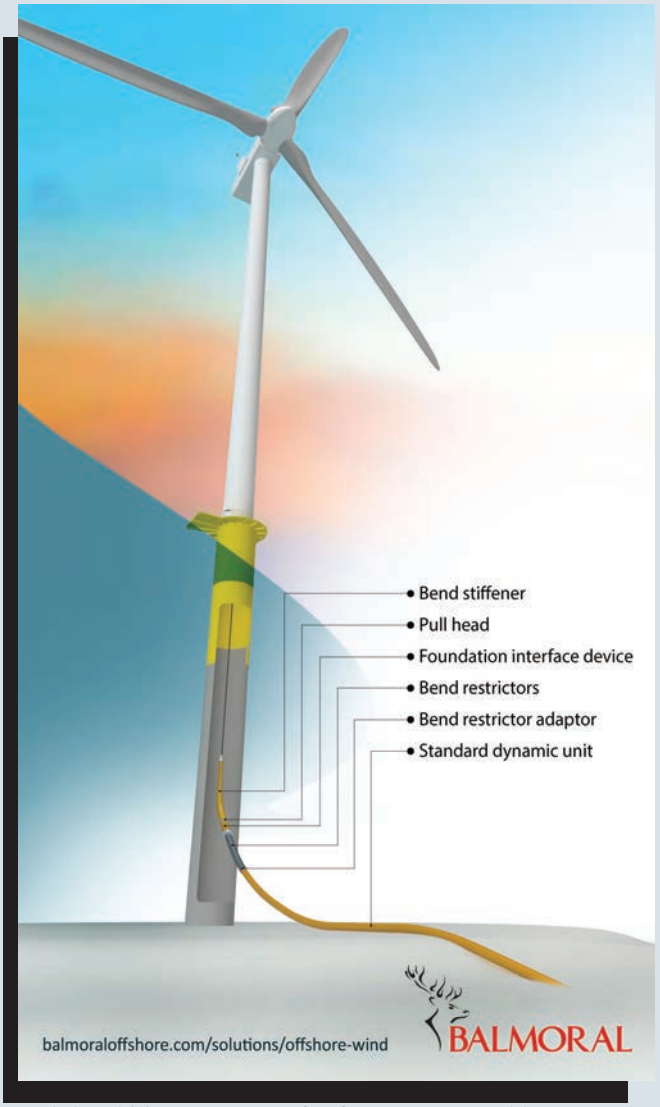
Balmoral Comtec Ltd.

Aberdeen, Scotland – www.balmoraloffshore.com

Serving the offshore oil & gas and renewables sectors, Balmoral is a leader for buoyancy, protection and insulation product solutions. Its product range includes drilling and distributed riser buoyancy, thermal insulation, cable protection, bend restrictors, stiffeners and riser protection guards. The company's purpose-built production facilities, subsea test centre, R&D continuous improvement programme, experienced HSE, engineering and commercial departments all play their part in delivering safe and successful projects on a global basis. Installers and operators are seeking to deploy the latest technology to achieve efficiencies throughout the life of a project. With 40 years' experience Balmoral is positioned to advise clients on their subsea challenges. Providing added value from concept development through detailed design, manufacturing and testing, the team at Balmoral help projects achieve their full potential safely and cost-effectively.

Balmoral is a trusted partner to the offshore energy sector, with enviable technical expertise, a vast project track record, evidence-based buoyancy, protection and insulation product solutions. Proprietary laboratory, hydrostatic and mechanical testing facilities enable it to research, identify and develop cost effective materials across a spectrum of applications. The company continues to make significant investments in comprehensive syntactic, composite and polymer processing facilities.

Balmoral's in-house 'Discovery Unit', a combination of R&D, materials and testing specialists, has created an integrated cable protection system for fixed-base offshore wind farms. The patented system, available in three standard sizes, includes a combination of bend restrictors and stiffener, foundation interface device, standard dynamic unit and a detachable pull head, all of which is designed, manufactured and brought together in-house before being tested on the company's test rig. Solutions for varying apertures on monopile installations are available as well as J-tube and I-tube options for jacket structures. The systems are designed based on the fatigue limit state and offer something different because of their unique diver-less removal feature and the ability to account for free span caused by scour development. The patented fiber reinforced technology adds stiffness to the system controlling the curvature during the project lifespan. This reduces the amount of movement experienced by the cable, improving fatigue performance and greatly reducing the risk of failure through the life of the field.



Applied Acoustics

Great Yarmouth, England – www.appliedacoustics.com

Applied Acoustics long ago identified the shift in business activities of its core customers from offshore oil and gas projects to the growing global offshore wind industry, and has spent time realigning its range of Dura-Spark geophysical sound sources to now offer a complete array of systems in tune with offshore wind operators. As of this year, two lightweight sparkers have been added to the Dura-Spark product line, complementing the existing systems and creating an extended family of negative discharge sparkers. Featuring twin banks of 40 electrode tips, the Dura-Spark L80 can operate in 40 or 80 tip mode, offering energy outputs of either 100 Joules or 200 Joules per shot, which is ideal for very shallow areas. Its small footprint and low power consumption makes it particularly useful on board smaller survey craft with limited deck space and minimal lifting equipment. The Dura-Spark L200 features twin banks of 100 electrode tips that can be fired at up to 500 Joules per shot concurrently, independently, in flip-flop mode, or with a combination of fire delay or split fire delay. Making its first appearance during the second half of 2019, the Dura-Spark UHD 400 + 400 sits at the head of the Dura-Spark family and is the most sophisticated system in the range. Consisting of twin decks of 400 electrode tips, the operator is able to tune the source from the vessel to fit the required function and data requirements. Each deck can be fired independently from the CSP power supply, in flip flop mode, combined with fire delays, or a split fire delay. Using the fire delay functions, the signatures from the two decks can be combined to bubble form the acoustic signature, creating an extremely clean pulse at high energy outputs and resulting in sparker data of the highest quality and resolution.

The Ocean Cleanup founder & CEO Boyen Slat on the Interceptor 002 in Klang River, Malaysia.
© The Ocean Cleanup

Technology & Technique to Identify & Clean Up the

Microplastics Mess

By Celia Konowe

The science and technology surrounding discovery, mitigation and clean-up of microplastics in the world's environment makes this year's "MTR100." Here we offer insights on the organizations, people and technologies taking the lead.

As marine journalists, scientists, technologists, activists and enthusiasts, we are aware of the large-scale impact that consumer macro-plastic products have on aquatic ecosystems. Ranging from plastic bags and straws to bottles and fishing nets, these materials pollute harbors, rivers, lakes and oceans, all while threatening the prosperity of wildlife, natural habitats and human health. To make matters worse, the chemical structure of most plastic materials prevents its complete degradation in nature, instead leaving behind microplastic particles. Measured as smaller than five millimeters in size, microplastics can be difficult to see with the naked eye and even harder to collect and identify. Microplastics are not new to the marine industry; the presence of such tiny particles in our oceans is well accepted and has spurred a cultural and technological race to understand and remove this contaminant. However, as new technologies and techniques are developed to count and identify samples, the number of

microplastics in our waterways seems to be growing. The issue is unravelling itself to be larger and far more widespread than once believed, and one that is inarguably linked to culture. So, what is really going on and what should be done about it?

"A not so micro problem"

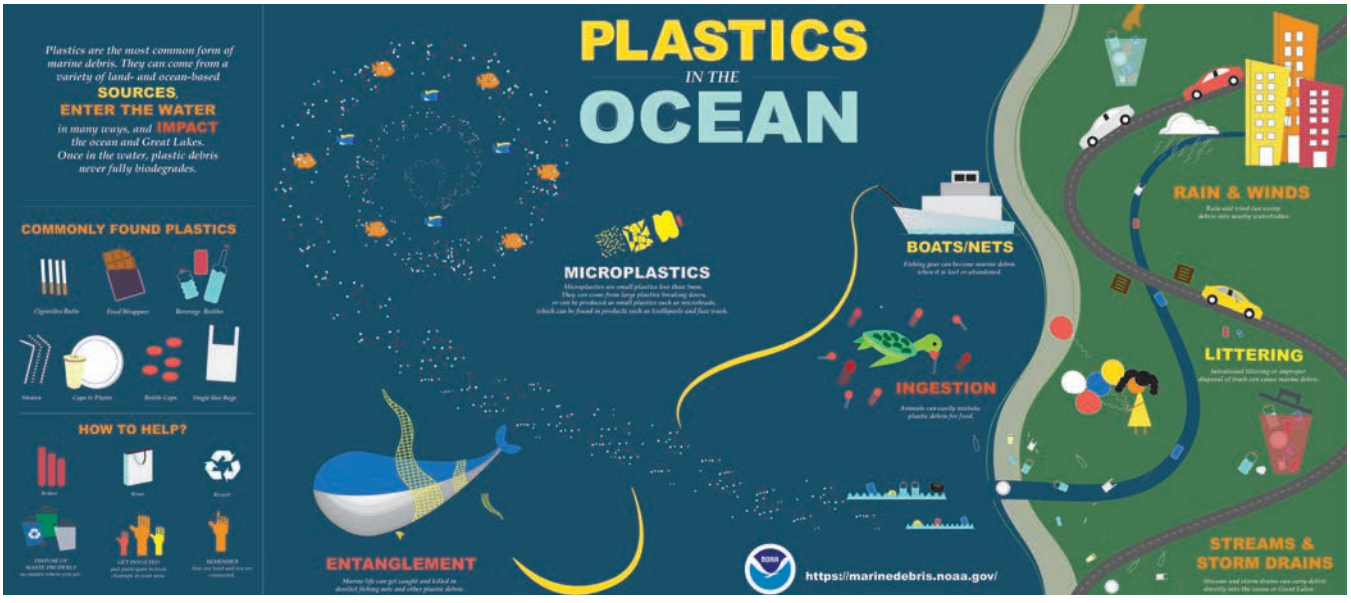
Our connection to plastic goes back centuries, when Mesoamericans used organic materials like natural rubbers to create balls, bands and other objects. Dependency on man-made versions of such products grew in the developed world during the Industrial Revolution and intensified after the end of World War II, since they're cheap, versatile and sanitary. Humans today are practically surrounded by plastics, with waste and microplastics accumulating through repeated daily use.

Presence & impacts of ubiquitous ocean plastics affecting the marine ecosystem in Rabida Island, featuring Black-striped salema (Xenocys jessiae) endemic fish from the Galápagos"
© J.P. Muñoz-Pérez

As defined by the **National Oceanographic and Atmospheric Administration (NOAA)** Marine Debris Program, microplastics can be broken down into two subsections. Primary micros, designed to be small, come in the form of resin pellets and beads, which are subsequently used to make larger items or personal care products (like microbeads in face wash). Secondary microplastics derive from bigger pieces of plastic like bags, bottles and toys, which break down in the environment due to sun, wind and waves. Also, under the secondary umbrella are microfibers, or synthetic fibers like polyester or nylon, that are used to make clothing, furnishings and even fishing lines, that break apart during general wear and washing/drying.

While we have broadly categorized microplastics based on origin material and degradation type, much remains unknown about these particles. Questions and issues often revolve around four topics: the varied composition of microplastic samples, each of which contains thousands of different particles that all react uniquely in nature; the lack of technology needed to properly collect, analyze and identify miniscule pieces; their lengthy lifespan due to an inability to breakdown naturally; and how they're spreading over land, sea and air, and to what distance.

Virginia Institute of Marine Science (VIMS) professor Rob Hale, who is also lead author on a recently published paper titled *"A Global Perspective on Microplastics,"* explained the need to understand these particles. "People often assume that all plastics are the same and behave identically in the environment, but that isn't the case at all. To resolve key questions and mitigate possible impacts, everyone—manufacturers, scientists, health-care specialists, engineers, economists, policymakers, and others—must collaborate to better understand the composition and nature of plastic products and their additives." VIMS doctoral student Meredith Seeley, a co-author of the paper, added, "We have to recognize that microplastic pollution is an international problem



that doesn't respect political boundaries." The microplastic problem is one of macro proportion—and with each new discovery, its influence seems to spread further across our planet.

"Blowing in the Wind"

Evidence is growing to show that plastic pollution is not limited to the world's oceans and probably never has been. Its substantial footprint has expanded; particles are often carried through the wind or evaporate from waterways into the air. Impacted parts of the planet, some just recently discovered, include the deep-sea floor, city air and even arctic snow. Research conducted at the **Alfred Wegener Institute for Polar and Marine Research** has discovered microplastics in the Arctic, particles transported over large distances by the atmosphere and later returned to land through precipitation. The team, led by Dr. Melanie Bergmann and Dr. Gunnar Gerdts, conducted analyses on snow samples from regions in Germany such as Heligoland, Bavaria and Bremen, as well as the Swiss Alps and the Arctic. In each location, the snow contained high concentrations of microplastics, even in the most remote of areas (in the Arctic, samples contained up to 14,400 particles per liter). When analyzing sea ice from the Arctic Ocean, the amount and distribution of microplastics was determined by using a Fourier Transform Infrared Spectrometer (FT-IR), a device that shines a beam of light containing multiple frequencies at once and measures how much light is absorbed. Depending on each particle's unique composition, different wave lengths will be absorbed and reflected, identifying the substance by its "optic fingerprint." Using this approach, as Gerdts explained, "We also discovered plastic particles that were only 11 micrometers across. That's roughly one-sixth the diameter of a human hair and explains why we found concentrations of over 12,000 particles per liter of sea ice — two to three times higher than what we'd found in past measurements."

In the Arctic snow, types of particles found included nitrile rubber, which is often used to make gaskets and hoses, and paints containing plastics, which are used to coat the surface of buildings, ships, cars and offshore oil rigs. In the ice floes, the scientists predominantly found similar paint particles and nylon waste from fishing nets.

The question that remains is how these omnipresent particles impact living organisms.

Scientists from AWI collect arctic sea ice to test for microplastic contamination.
© Mar Fernandez

"Survival of the plastics"

As microplastics break down and float through the air and water, they inevitably invade entire food webs. While the full scope is unknown, the presence is undeniable. On the Galápagos Islands, investigation has already begun to quantify the distribution and impact of marine microplastic pollution on local marine vertebrates. Juan Pablo Muñoz-Pérez, a research scientist at the **Galápagos Science Center** (a joint effort between the Universidad San Francisco de Quito and the University of North Carolina at Chapel Hill), is on the forefront collecting and analyzing samples from the archipelago's most threatened creatures to support the improved management of such contaminants in Ecuador. Between June and September of 2019, he and his team sampled 98 marine iguanas from nine different habitats (these locations covered four subspecies across four islands) to establish current microplastic exposure and investigate potential health risks. "The assessment of the health data indicated that the animals captured and sampled were clinically healthy based on standard vital signs, morphometrics, and blood value data. However, in total, 75 synthetic fibers and fragments were found across the scat samples from 84 animals. Each contaminated scat had between one and four synthetic particles per sample. Only the scats from one of the nine locations tested were plastic-free," Muñoz-Pérez said. These discoveries are only the start though, as other species like the Galápagos sea lion and all four species of sea turtles in the archipelago (green sea, leatherback, hawksbill, and olive ridley) are also in danger. To Muñoz-Pérez, the future of the microplastic crisis looks dire. "Galápagos is a beacon for the entire ocean. If the Galápagos is starting to have worrisome levels of marine microplastic pollution, this represents the ultimate conservation frontier. If we can't do something about it here, I don't know where we can."

Plastic pollution shouldn't be limited to marine ecosystems. It starts early on in our waterways and often near urban areas, contaminating and breaking down in rivers, lakes and harbors. Research conducted by Theresa Talley, a **California Sea Grant** extension specialist and researcher at **Scripps Institution of Oceanography** (UC San Diego), shows that in a sample of fish from Chollas Creek, which flows into the San Diego Bay, nearly a quarter contained microplastics. With the goal of better understanding the movement of plastic through urban watersheds and its impacts on local species, the team collected sediment and fish samples,

the latter to be dissected. Twenty-five categories of plastics were identified in the sediment, including pieces of film, polystyrene, microbeads and synthetic fibers, with fish consuming about half the categories. Knowing why organisms only consume certain types of plastic, and the lasting impacts of these habits, are crucial to understanding the long-term health hazards. "If we want to reduce the risks that plastic pollution poses to sea life and, ultimately humans, we need to better understand the processes underlying the entry of plastics into food webs," Talley explained. "It's no longer enough to document all the places we find plastics. If we want to develop solutions, we need a clearer understanding of how and why the plastics move through ecosystems."

"Tech to the Fore"

As technology advances and new techniques are discovered, available information on microplastic pollution grows. Research strategies change and adapt to fit the unconventional characteristics and spreading ability of these tiny fragments. From computer codes to satellites, the race to solve the plastic question has soared to new heights.

Also flying through the sky is Robert DeLaurentis, known also as the "Zen Pilot," on his journey around the world. Working with Scripps marine biologist Dimitri Deheyn, DeLaurentis places a fresh set of sticky adhesives to his aircraft for each leg to collect particles as he flies. Back at the lab in San Diego, Deheyn analyzes the pieces of tape, observing and identifying stuck-on microfibers (tiny synthetic fibers that drift into the water and air from clothes). The expectation is to find different concentrations of microfibers as the plane traverses the globe, with variations influenced by whether the ground below is inhabited or not. "After finding microfibers in water samples from all over the world, it was clear that one main route of contamination had to be through the atmosphere," said Deheyn.

An expert in ecotoxicology and biomimicry, Deheyn has begun to apply the theory and techniques behind these fields of science to the microplastic dilemma. "Nature has come with more than 3.8 billion years of trials and error through the process of evolution. This accounts for making materials with particular properties that can degrade naturally in ecosystems. But this isn't the case for plastics, since it takes hundreds of years for those to degrade," he said. "The biomimicry process helps you live in better unison and synchrony with nature by finding materials that fully return to the environment. We try to use this idea to raise awareness that alternatives to plastics need to be found and that nature can inspire us to find such material."

eXXpedition founder Emily Penn studying a sample. **© Eleanor Church Lark Rise Pictures**

The technique used in Deheyn's lab to quantify and categorize microfibers was designed by engineering graduate student Jessica Sandoval and works similarly to face recognition software. The Automated Microplastics Identifier (AMI) learns about typical microfiber shapes based on diameter, curviness, length, color and possible fluorescence. Things get a little more challenging, though, when multiple microfibers overlap. "It's like having a few strands of spaghettis on your plate. You can probably count them based on their shape, length, etc., but not when you have a full bowl. In terms of the technique, it all comes down to the computer analyzing the content of individual and contiguous pixels in an image; the continuity of these pixels defines the shape of each fiber," Deheyn said.

Another technique for identifying microplastic particles is using a confocal Raman microspectrophotometer, which can provide the "molecular fingerprint" of a specimen's chemical composition. Professor Gordon Taylor and PhD student Luis Medina Faull from **Stony Brook University** explained how this instrument worked by shining a monochromatic laser through a microscope lens onto a sample. While most of the laser light is reflected or passes through, a tiny fraction of the photons collides with chemicals in the sample and give up their energy, which causes them to vibrate at different frequencies. "The photons released from this interaction are now many different colors. The same microscope lens collects all light scattered back from the sample, which is then directed toward the Raman spectrophotometer. Prior to entering the spectrophotometer, photons having the same color as the laser are filtered out, admitting only the lower energy photons, which are then spatially separated by a prism and imaged on a charge coupled device (CCD) camera chip," Taylor added. The CCD chip measures the number of photons scattered at each color to produce a spectrum of peaks and valleys. The beauty of this spectrophotometer is that it can provide "fingerprints" of objects as small as about 0.3 micrometers (a human hair is about 75 micrometers thick). Also, every plastic polymer has a distinctive

Raman spectrum, so this instrument enables distinguishing plastics from both natural materials and other plastics.

Realizing that one of the many knowledge gaps in microplastic research is the absence of quantitative information, Taylor's lab has also developed an effective technique to collect, analyze and identify samples. As opposed to the common use of a manta trawl, a net made of thin mesh (330-500 micrometers) that allows for sifting through large volumes of water, Taylor plans to collect samples of seawater (0.5-2 liters) that will later be filtered through a metallic filter (0.2 m pore size). "The filters are mounted on a microscope slide and scanned by the microspectrophotometer. From these measurements, we can calculate concentrations, volumes and masses of each plastic polymer in the sample," Taylor explained. This method allows for sampling from any depth (manta trawls are limited to the sea surface) and the data obtained is critical to formulating comprehensive assessments of the ocean's plastic inventory.

Additional techniques explored by Taylor's lab include 3D chemical mapping of the particles, which has revealed that some larger microplastics have multipolymer composition. A new achievement to this field, Taylor sees hope in being able to detect mass contributions of multiple polymers in individual plastic samples: "Such capabilities may improve our abilities to forensically source microplastic particles in natural waters and better understand microplastic contamination pathways."

While identifying microplastic composition, it's also crucial to understand that many of these particles started as something larger. Macro plastics, which break down into increasingly smaller pieces, can be cleaned from waterways early on, which will significantly reduce the quantity and impact of future microplastics. Dr. Lauren Biermann of the **Plymouth Marine Laboratory** (PML), in conjunction with funding from the European Space Agency (ESA), has been working to detect aggregated patches of plastics using the ESA's Sentinel-2 satellites and corresponding data archive. "For our work, this meant scouring the archive to choose very clean and clear examples of 'all things that float on water' and may end up mixed in with plastics. We found our driftwood off Canada, seaweed off Barbados, wind-whipped sea foam near river mouths along the Scottish coastline, pumice that had bubbled up from an underwater volcanic eruption near Tonga, and examples of seawater from each of these locations," Biermann said. With this information, her fellow PML colleague, Dr. Dan Clewley, then trained their Naïve Bayes classifier to automate distinction of driftwood from seaweed from sea foam from pumice, and most importantly, all of these from plastics. The team ran high-resolution, multispectral optical satellite data of coastal waters through an algorithm, subsequently creating the Floating Debris Index (FDI). "The FDI helps us to spot patches of floating material/objects/debris, no matter what these patches are composed of. It's effective at doing so, thanks to the way it leverages the near infra-red band of the Sentinel-2 Multi-Spectral Instrument (MSI) to 'see' things that don't completely fill a 10m x 10m pixel. From this point, spectral signature becomes key for discrimination, and we use that to check each highlighted pixel for similarity to the spectral shape of plastic," Biermann added.

The Ocean Cleanup System 001 deployed in the Great Pacific Garbage Patch, October 2018. © The Ocean Cleanup

The role of satellites and other overhead technology like drones, Biermann acknowledged, is one that is becoming increasingly important in the field of plastic contamination. "The problem of marine plastics is not a mystery—we know how and where plastics are produced, we know at best less than 30% of plastics make it to recycling, and we know which countries produce the most, recycle the least and ship off the rest to developing countries." But, satellites can play a meaningful role in plastic detection through active removal. Even early on in our waterways, like in rivers and lakes, such technology can make a huge difference by detecting floating plastics for removal before they enter the ocean.

As Biermann and fellow scientists at the PML detect macro plastic pollution in our waterways, scientists and activists at The **Ocean Cleanup** are already at work to remove both river and marine macro particles. "Rivers are the main source of ocean plastic pollution; they are the arteries that carry waste from land to the ocean. Our research found that 1000 rivers are responsible for roughly 80% of the pollution. To rid the oceans of plastic, we need to not only clean up what is already out there, but also stop new plastic from entering the ocean: we need to close the tap," the organization explained. The solution: the Interceptor, the company's solar-powered, autonomous answer to catching plastic at the start. Functioning as a barrier and a conveyor belt, the Interceptor concentrates and extracts plastic from rivers: "The barrier concentrates the debris as it floats with the current and directs it to a permeable conveyer belt. At this point, the waste is transferred up the belt to an automated shuttle that distributes the waste between one of six

containers located on a separate barge. Once full, the barge is exchanged, and the waste is transferred to a local waste management facility." Currently functioning Interceptor systems are in Jakarta, Indonesia, and Klang, Malaysia, with more to come in Vietnam and the Dominican Republic.

The Ocean Cleanup is also tackling marine plastic pollution, although the challenges of cleaning the gyres are far from few, as contaminants are spread across millions of square miles and travel in all directions. The organization's system consists of a floater that sits at the surface and provides buoyancy, and a skirt that prevents debris from escaping and leads into the retention system. What makes this solution unique, though, is in its design: "For an area of this size, active cleanup methods would be too energy-intensive; this is why we have chosen a passive design. The cleanup systems rely on natural forces to navigate the patches—a feature that also increases its survivability in the harsh ocean environment. Both the plastic and system are being carried by the wind, waves and current." Better yet, models predict that a full-scale cleanup system roll-out could clean 50% of the Great Pacific Garbage Patch in only five years. While technology and technique are important, getting to the root cause and enacting cultural shift from plastics is the longer term play.

"Kicking the habit"

The "why" can be tied back to that historic dependency, as well as convenience, low costs and a lack of available and equally popular materials. The question of how to change cultural mindset is trickier.

eXXpedition was co-founded in 2014 by Emily Penn to contribute to microplastic research while providing women from all walks of life a chance to sail the world and manage the plastic problem hands on. Penn's inspiration to create such an organization came while hitchhiking to Australia on a bio-fueled boat in 2008. "During that journey, I couldn't believe that I was seeing so much plastic in the remotest areas of our planet. The nearest people to us were in the space station above our heads and I was seeing a toothbrush washing across the deck of the boat." The plastic problem transcends geographic or political boundaries. "A big part of our approach to solving the plastic pollution issue is that there's no silver bullet solution, but there are hundreds of different ways that we can solve it. So, we need experts in every field—it's about saying, great, you're an engineer, let's look at ways we can improve waste management. You're a chemist, let's look at ways we can reinvent plastic or a biodegradable material. You're a teacher, let's talk about it. You're a policy maker, let's legislate it," said Penn.

The guest crews experience the microplastic crisis up close by conducting research and analyzing findings on each leg of the tour. On board, the crews use a manta trawl to sample the surface of the ocean and a Niskin bottle to test subsurface water from a depth of 25 meters. In coastal waters, they also collect sediment samples. For particle analysis, the boat houses a PerkinElmer Spectrum Two FT-IR spectrometer and both sediment and Niskin samples are sent to the lab at the University of Plymouth to be analyzed.

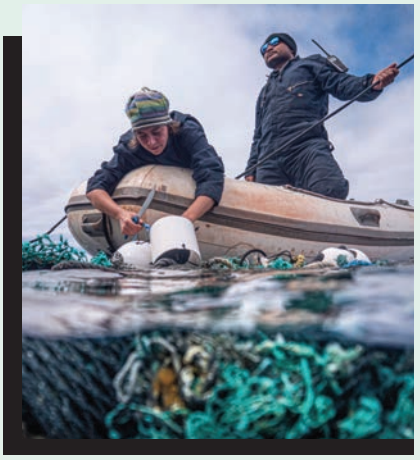
This past June 8, on World Oceans Day, Penn and global technology leader SAP launched the SHiFT Platform, a program that uses innovative technology to help users identify their role in tackling ocean plastic pollution. "A big challenge for many people is knowing where to start. That's why I first developed the SHiFT methodology—a journey of discovery to help people understand the crux of a problem and weigh up where they have the biggest opportunity to make an impact," said Penn. "We're in this amazing position at the moment where there is a lot of awareness compared to a few years ago, but now we find people saying to us 'OK, we get there's a problem and we care about it, now what can we do?'"

Founded in 2005, **The 5 Gyres Institute** takes on similar stance of using science to influence cultural and societal mindsets. Bearing the motto "science to solution," co-founders Marcus Eriksen and his wife were inspired by the unknown reality of marine plastic pollution and spent years conducting research and collecting evidence to prove the danger of microplastic pollution. Eriksen fondly credits a moment in 2015, when President Obama signed a bill banning microplastics from consumer products after 5 Gyres published a paper about microbeads discovered in the Great Lakes. Eriksen and his wife have taken on a more guiding position and shifted to include activism in their work. "There is enough research to act on, so we are now focused more on engaging the leaders of tomorrow in science, policy and entrepreneurship. We are still about 'science to solutions,' but understanding that to build a larger movement you need to provide tools to the next generation." Some of these tools come in the form of education and helping to organize local campaigns. 5 Gyres offers English-Spanish virtual programs, called Trash Academy (Academia de Basura), that chronicle the life cycle of plastic and address potential solutions, offered online for public access.

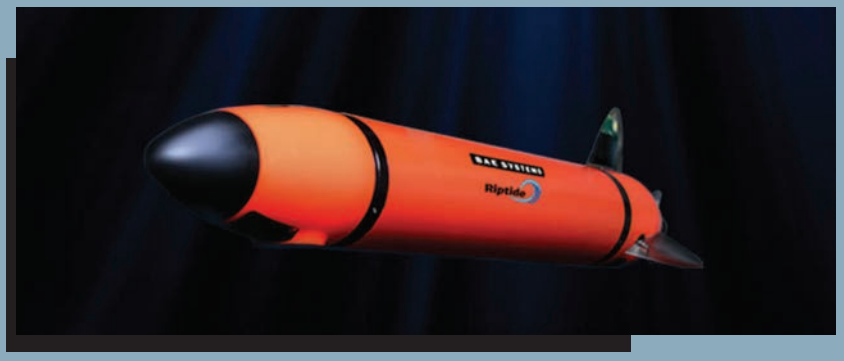
"The clock is ticking"

Microplastic research, while gaining significant traction in recent years, has only scratched the surface of this widespread, invisible contaminant. Drifting through the ocean, frozen in arctic snow, eaten by wildlife, disintegrating from our clothes—these particles are ubiquitous and still their full impact, specifically on humans, remain unknown. There is no single solution, rather a combined effort to reduced production and consumption; emphasizing proper disposal; policy creation to encourage sustainable alternatives; education and awareness campaigns should guide and motivate communities; as well as scientific research and technological advance identify, quantify and mitigate. There's so much we don't know, but this, we do: the menace may be miniscule, the response must be massive.

Ocean Voyages Institute



Ocean Voyages Institute's marine plastic recovery vessel, S/V KWAI, docked at the end of June after a 48-day expedition removing 103 tons of fishing nets and consumer plastics from the North Pacific Subtropical Convergence Zone (more commonly known as the Great Pacific Garbage Patch or Gyre). The expedition sets a record of the largest at sea clean-up in the Gyre to date, and more than doubles Ocean Voyages Institute's own results from last year. During the expedition, the KWAI's crew collected marine plastic pollution with the help of GPS satellite trackers that Ocean Voyages Institute designed with engineer Andy Sybrandy of Pacific Gyre, Inc. The beacons are placed on nets by volunteer yachts and ships. Drones, as well as lookouts up the mast, enable the ship's crew to home in on the debris. They then recover the litter, place it in industrial bags, and store it in the ship's cargo hold for proper recycling and repurposing at the end of the voyage.



BAE Systems/Riptide

By 2019 the success of this product was noted by BAE Systems. The BAE Systems FAST Labs organization acquired Riptide and is now maturing the platform technology and scaling manufacturing. FAST Labs is the R&D arm of BAE Systems, Inc. and is unique in the defense industry as an in-house, customer-funded R&D business designed to collaborate across the company's global enterprise to develop and transition advanced technologies.

The micro AUV originally launched by Riptide is benefitting from this process. Another small AUV that has recently come on scene is the RangerBot. This vehicle takes a different approach to delivering an affordable solution for end users. The RangerBot was designed by engineers at Queensland University of Technology (QUT) in Brisbane, Australia. The team at QUT work in a robotics center focused on machine vision.

They also work to support environmental assessments on the Great Barrier Reef. A key paradigm shift was enabled when the team, recognizing that water conditions in their target environment were very clear, chose to employ exclusively vision-based sensing.

SubSeaSail LLC

San Diego, CA – https://subseasail.com

SubSeaSail LLC (SSS), based in San Diego CA, designs and manufactures unique unmanned semi-submersible sailing vessels (USSVs) that are wind-propelled and solar-powered. The platform is capable of autonomous or manual missions, individually or swarming. The key tenant is "Engineered for Simplicity" with significant, patented and patent-pending technologies. SSS has received a patent for a sailing vessel with the hull below the surface and the wingsail above. This reduces friction (drag) while producing little-to-no wake and a significantly reduced Infrared, radar and visual signature. A second patent is for a Passive Mechanical Wingsail Control Mechanism that sets the wingsail at the optimum angle with respect to the wind direction and the desired direction of travel without the use of electronics, pulleys or lines. This feature significantly reduces complexity and cost while increasing reliability. A servo for the rudder is the only electromechanical component in the platform required for sailing control. An optional thruster can be added for navigation out of harbors, away from hazards, or to augment control in low wind conditions.

A key feature of the SSS platform is that it can take various form factors and is highly scalable. A catamaran version demonstrated that it can sail above or below the water and, while on the surface, can perform missions such as deploying and/or recharging unmanned aerial systems or to deliver cargo without need for a deep-water ports. The Gen6(S) variation is designed to sink to 10m to avoid bad actors, bad weather, or ship traffic. Systems are being developed with various solar panel configurations to maximize power generation or stealth. Applications are broad and include ASW, C4ISR, cargo re-positioning and delivery, communications gateways, mine delivery/counter measures, ocean sensing, protection of exclusive economic zones and marine protected areas (MPAs and EEZs), targets and decoys, UUV delivery/launch/landing/recharging, and UXO detection.

SubSeaSail has delivered a system to the US Army Corps of Engineers for unexploded Ordnance Detection turbidity monitoring. They are currently working with a partner on a patent-pending Reconfigurable Acoustic Array allowing location and identification of targets for various applications including target detection and protection of MPAs and EEZs in a disruptively economical system package.

General Dynamics Mission Systems

Fairfax, Virginia – www.gdmissionsystems.com

General Dynamics Mission Systems is a leading innovator of open architecture and mission integration, providing open architecture solutions to meet demanding operational requirements on any platform in the multi-domain operational arenas — from the outer reaches of space to the sea floor. In 2016 General Dynamics acquired the unmanned underwater vehicle (UUV) provider, Bluefin Robotics, to extend the integration of high consequence solutions to the unmanned undersea space. The integration of Bluefin Robotics transitioned more than 20 years of UUV development and sustainment experience into the larger General Dynamics portfolio. General Dynamics has focused continued investment and development of Bluefin Robotics products, developing leading edge UUV platforms across multiple size-classes, sensor and payload integration, and the delivery of next-generation vehicles that explore, inform, and protect our assets and the environment. The General Dynamics family of Bluefin Robotics products consists of autonomous UUVs and related technologies for defense, commercial and scientific customers worldwide.

General Dynamics Bluefin Robotics uses a "system of systems" approach to expand UUV capabilities from task-oriented to mission-based integrations. Its open-architecture approach uses the best available technology to deliver mission-ready products. Through collaborative efforts with customers, it has been able to focus product development to deliver solutions for stated missions and to design products that are able to adapt to newly identified operational needs.

Advanced, Mission-Ready and Modular Medium-Class UUV The General Dynamics Bluefin-12 is a lightweight medium-class unmanned underwater vehicle (UUV) designed to deliver mission critical data and complete high-consequence and changing missions. The Bluefin-12 base model comes with an open and flexible payload bay, providing more than 4,000 cm3 of payload volume to allow rapid integration of mission specific payloads. This UUV can also be configured as a turnkey system delivering integrated survey capabilities including high-resolution sonar, environmental sensing, powerful on-board data processing and highly accurate navigation. Built with robust core capabilities, increased modularity, embedded intelligence, data processing, and extended operational range, the Bluefin-12 is ready for today's mission and prepared for tomorrow's threats.

Blue Robotics

www.bluerobotics.com

Since its founding in 2014, Blue Robotics has existed to propel marine robotics. Starting with the T100 Thruster, its product line has grown to more than 250 components. Since opening six years ago, it has shipped hundreds of thousands of components and systems, including more than 45,000 thrusters and 2,000 BlueROV2s. In the last 12 months, Blue Robotics added to its product line while building its distributor team globally. It hosted its second Blue Robotics Open House to bring together marine robotics enthusiasts, including a mini trade show featuring six young marine tech companies. It also introduced several new products including the Ping360, a mechanical scanning sonar and a surface power supply in collaboration with Outland Technology.

Blue Robotics' product line spans a wide range of technology areas with a common theme of cost-consciousness, innovative design drawing inspiration from proven technologies, and extensive documentation and information.

Its core technology is its patented thruster design, which is compact and inherently pressure tolerant, with an emphasis on affordability. In addition to thrusters, it offers actuators, watertight enclosures, buoyancy foam, sensors, lights, cables, control system electronics, sonars, and its flagship product, the BlueROV2 subsea vehicle, designed to be the most affordable and capable mini-ROV in the world. In the last year, the company has added new products including the Ping360 mechanical scanning sonar.

Greensea Systems

www.greensea.com

Greensea Systems is a leader in advanced robotic systems for high-level tasking, interoperability, and intervention. Greensea's OPENSEA operating platform provides a fully-distributed, open software framework for highly integrated systems across all brands of sensors, devices, and equipment while cutting-edge technologies for navigation and autonomy elevate system intelligence. One cohesive operator interface, Workspace, fuses system data into a comprehensive command and control center for streamlined workflow and improved productivity. Greensea's commercial products are customizable and all systems are supported with documentation and knowledgeable, field-experienced engineers.

Greensea continues significant growth through the acceptance of its open architecture software platform, OPENSEA, and world-wide adoption of OPENSEA-based products for military applications. Greensea supports manufacturers and software developers through its OPENSEA as a Platform and OEM business segments, providing OPENSEA as an open architecture solution for developing and manufacturing robotics and emerging technologies. Greensea services the defense industry in two primary programs: robotics for maritime Explosive Ordnance Disposal and Special Operations Forces combat swimming. Greensea launched a new business segment for ship hull robotics, based on a novel navigation and autonomy solution for robots crawling on a hull.

Greensea expanded operations in 2019 adding offices in

Plymouth, MA and San Diego, CA.

Greensea's core technology, OPENSEA, is designed to reduce cost, reduce risk, and accelerate technology insertion within the marine industry. Its library-based, open architecture is fully distributed and includes all of the interfaces and utilities essential to robotics and the unmanned systems community including navigation, autonomy, and mission planning.

New vehicles, equipment, and devices are easily integrated, minimizing risk and expense, by leveraging the robust, OPENSEA library which confines new software to small, independent applications that are separate from proven, robust software. Deriving from the OPENSEA library, the OPENSEA application suite provides hundreds of distributed independent applications that work together as building blocks for a complete system. These applications communicate with each other through the OPENSEA network and provide discrete capabilities required to integrate a system that is scalable, flexible, and severable.

Torqeedo, Inc.

Crystal Lake, IL – www.torqeedo.com

Torqeedo supplies integrated electric and hybrid propulsion systems for manned and unmanned surface vessels used in underwater survey operations. Recent deployments include:

• XOCEAN (Ireland) - XO-450 unmanned survey vessel powered by two Torqeedo Cruise 2.0 electric pod drives with a Power 24-lithium ion battery and lightweight micro generator, plus two Ultralight outboards at the bows to enhance station keeping.

• Sea Robotics (US) – Endurance 7.0 autonomous survey vessel powered by Torqeedo high-voltage Deep Blue 80i electric drive with BMWi3 30.5 kW lithium ion propulsion battery, plus a water-cooled DC-DC converter and 24 VDC lithium ion battery for the DC-DC backup and a 25 kW diesel generator.

• Marine Advanced Robotics (US) – WAM-V 16 autonomous survey vessel powered by a fully meshed Torqeedo electric propulsion system consisting of two Torqeedo Cruise 2.0 outboards with high-torque propellers and multiple Power 24-volt lithium-ion batteries.

• Alumarine (France) – Manned hydrographic survey boat with a dual-mode electric/diesel propulsion system. The integrated electric propulsion package consists of two Cruise electric outboards coupled with high-voltage Power 48-5000 lithium ion batteries.

JW Fishers Mfg., Inc.

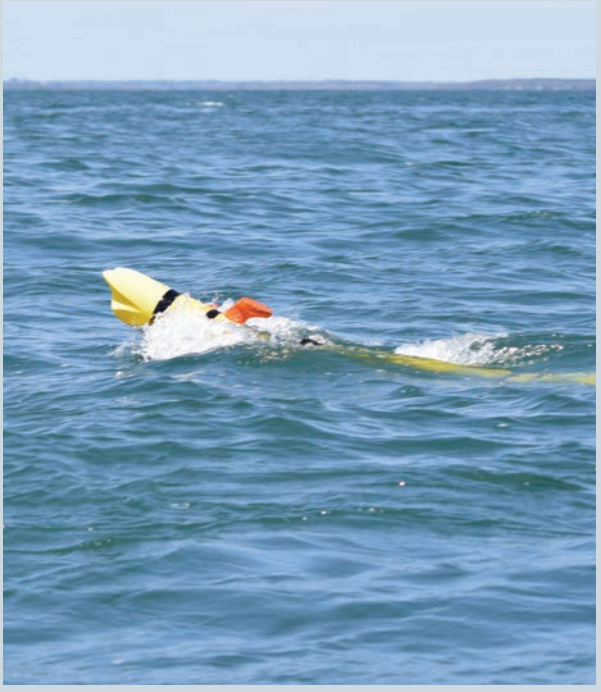
East Taunton, Mass – www.jwfishers.com

JW Fishers was founded in the mid-1960s by Jack Fisher, an avid diver who needed an underwater metal detector to use on a salvage project. Over the next several years he developed and built his own, and as a result of customer requests for more powerful models that could cover larger areas, the company expanded its line to include boat-towed metal detectors and magnetometers. Underwater cameras were a natural follow-on to the product line: customers wanted a tool they could use to look at targets they were finding with their boat-towed detectors or they simply wanted to do a visual search of an area. Next came a family of sonar systems including scanning sonars and side scan sonars (the ultimate underwater search system). Acoustic pingers were added as a way to mark the location of underwater sites and oceanographic instruments. Cable and pipe trackers followed resulting from customer demand for easy to use instruments that could find deeply buried pipelines, electrical lines, and fiber optic cables. JW Fishers both designs and manufactures all of its underwater search systems at its factory in the US. In 2019 JW Fishers upgraded its entire video line to 1080p HD cameras. The upgraded systems range from a boat towed video system (TOV-2 HD), to a dropped video system (DV-2HD), a mini camera system (MC-2 HD) and a Diver Held Camera system (DHC-2 HD). Also available is the Video Recording Monitor (VRM-2 HD) totally redesigned that displays and records video in 1080p HD format, has still picture capability and the ability to add audio to the recorded files.

Klein Marine Systems, Inc.

Salem, New Hampshire
www.KleinMarineSystems.com

Founded in 1968, Klein Marine Systems, a wholly owned subsidiary of Mitcham Industries, Inc., is a leading supplier of side scan sonar equipment, waterside security and surveillance systems. Klein Marine Systems introduced the first Nadir Imaging Sonar for AUV/ROV vehicle manufacturers in an innovative, stand-alone nose cone configuration. The µMA-X is a highly scalable modular component which integrates its custom fit nose cone easily to the current AUV/ROV vehicles. The µMA-X is powered by the Klein BLUE technology providing superior imaging performance with the same interpretation characteristics equal to Side Scan Sonar. The µMA-X can be scaled to accommodate both larger or smaller diameter vehicles. The Klein µMA-X when paired with Side Scan Sonar will provide a 40% increase in survey efficiency, provide complete NADIR coverage and is compatible with ATR systems. The Klein µMA-X delivers efficiencies in survey time, reduced power consumption in a compact, low-power and neutrally buoyant modular system. The µMA-X is easily integrated into any vehicle and includes an Internal Motion Sensor which eliminates the requirement to integrate to the vehicle sensor, providing redundancy. The system uses the vehicle data input via the Ethernet with a simple, non-proprietary NMEA data link with the vehicle.



Kongsberg Maritime

Horten, Norway – km.kongsberg.com

Kongsberg Maritime's (KM) has an extensive and varied subsea product and service portfolio, a subsidiary of the 206-year-old KONGSBERG Group. KM's products, systems and services cover all industry sectors, from subsea, offshore, naval and merchant market segments to fishing, aquaculture, exploration and scientific research categories. A drive to create collaborative, ethical and easily applicable solutions which simultaneously cut costs, increase operational efficiency and enhance personnel safety is matched with a firm corporate commitment to engender and support sustainable, environmentally-responsible technologies and working practices. Key projects and concepts which embody this pledge in a subsurface context include the company's ongoing work in the realms of AUVs, multibeam echo sounders, subsea mapping systems, seabed sensor carriers and fishery research equipment, allied with a substantial investment in green initiatives such as ocean farming for climate-friendly food production. The company's Maritime Broadband Radio (MBR) 'information highway,' meanwhile, can allow shore-based teams to remotely interact with AUVs and USVs in underwater operations such as pipeline surveying, mine hunting or bathymetric surveying, with no loss of real-time package data.

Recent months have seen a number of subsea developments for KM. The new LARS solution transforms launch and recovery of the HUGIN range of AUVs on high-freeboard vessels in high sea states. Sited amidships, LARS releases and captures AUVs below the surface, away from the splash zone. This reduces the risk of damage by weather or the launch vessel, frees up aft deck space and increases crew safety by removing the need to work over the stern. The HUGIN Superior AUV is now equipped with a next-generation HISAS synthetic aperture sonar and can cover up to 4.5 square km per hour. Rated to depths of 6,000m, HUGIN Superior carries up to 10 environmental payload sensors and boasts adaptive in-mission autonomy which reacts to its surroundings. In another recent endorsement, the Finnish Navy has contracted KM to supply its hull-mounted SS2030 and over-the-side SD9500 Anti-Submarine Warfare and diver detection sonars for the new Pohjanmaa-class corvettes. Suited for deployment in shallow waters with minimal reverberation, the sonars' intelligent tracking algorithms enable them to conduct volumetric survey tasks in addition to detecting objects in the water column.

MacArtney Group

Esbjerg, Denmark – www.macartney.com

MacArtney has been carrying on a prosperous business for more than 40 years and is a privately owned corporation with group headquarters in Esbjerg on the west coast of Denmark. From the head office, MacArtney has been providing logistical, technical, financial and marketing support to all of the Group companies since 1978.

The MacArtney Group is a global supplier of underwater technology systems, products and integrated solutions specializing in design, manufacturing, sales and after-sales service of a wide range of systems to offshore oil and gas operators, surveyors, the renewable energy sector, ocean science institutes and defense and navy industries across the world. The company offers an extensive variety of advanced and reliable products and system solutions which are designed and tested to supply high quality, efficiency and dependable performance in challenging underwater environments. MacArtney supplies include SubConn, OptoLink, TrustLink and GreenLink connectivity, cable and termination solutions, advanced NEXUS and EMO fibre optic telemetry

systems, electric CORMAC and MERMAC winches, handling and LARS systems including the all-new, all-electric eLARS. The MacArtney range of fast and precise remotely operated towed vehicles (ROTV) includes the MacArtney FOCUS 2, FOCUS 3 and TRIAXUS vehicles. MacArtney also designs and manufactures CEMAC offshore cable handling equipment intended for pipeline and cable-laying deployment. Moreover, MacArtney supplies a versatile range of LUXUS underwater cameras, lights, media controllers and accessories.

01 Doumbia-Henry

© Christoffer Lomfors

Dr. Cleopatra Doumbia-Henry

President, World Maritime University (WMU)

By Celia Konowe

Dr. Cleopatra Doumbia-Henry, president of the World Maritime University (WMU) in Sweden, is a leader on issues impacting the international shipping industry, maritime law and gender equality in ocean-related fields. A distinguished academic in the field of international law, justice drives her motivation for social and environmental change on a global scale.

Born and raised in the Commonwealth of Dominica, Doumbia-Henry grew up surrounded by maritime culture, where the Caribbean Sea and the shipping industry have a large impact on the economy and daily life. Her professional interests and successes can be credited to both her island upbringing and paternal guidance and support. Cited as a source of inspiration, Doumbia-Henry's father was a farmer, educator, and politician, teaching at a local school and serving as both a member of Parliament and in various ministerial positions. After her mother's death during her teen years, her father single-handily supported the family while raising nine children.

Soon after, Doumbia-Henry left home to attend the Cave Hill Campus of the University of West Indies in Barbados,

where she graduated with an upper second-class degree in law. She later completed a master's in law and earned the opportunity to pursue a PhD in international law at the Graduate Institute of International Studies and the University of Geneva.

Her research examined the law-making role played by international organizations, such as the International Maritime Organization (IMO), and their influence on the law and practice of states and industry: "I was fascinated by the way technical international instruments adopted by IMO had an incredible impact due to the global nature of shipping and the need for uniform standards required to enable shipping to be safe, secure and protect the marine environment."

In 2015, Doumbia-Henry became the president of WMU, an institution that educates future leaders in the maritime and ocean sectors and conducts research in crucial fields. Operating within the framework of the university and furthering sustainable ocean management is the recently inaugurated WMU-Sasakawa Global Ocean Institute. Formally introduced in May 2018, the Institute "acts as an international focal point where policy makers, the scientific community, regulators, industry actors, academics and representatives of civil society meet to discuss how best to manage and use ocean spaces and their resources for the sustainable development of present and future generations," said Doumbia-Henry. Furthermore, the Institute is making unique contributions to human rights and ocean activities with a focus on the needs of developing countries, plus promoting gender equality and empowering women and all girls in ocean-related fields. "To address the challenges faced by the ocean today, we must mobilize all the qualified human resources around the world. During the 37 years of its existence, WMU has educated more than 1,100 female graduates who are working in various government agencies and institutions, some of them holding very senior positions, which is an important indicator of such progress," she added. As such, WMU is partnering with Fisheries and Oceans Canada to deliver a project titled, "Empowering Women of the UN Decade of Ocean Science for Sustainable Development." Additional activities, all which incorporate evidence-driven and interdisciplinary research, features issues such as: marine debris, Sargassum, and marine spatial planning in the eastern Caribbean; a land-to-ocean PhD program for candidates from developing countries; and automation and robotics for ship survey purposes under the European Union's H2020 program.

From her prominent position and with years of maritime industry legal work, Doumbia-Henry is aware of the problems threatening the future of the world's oceans. The biggest risks, she said, were those linked to unsustainable anthropogenic activities, such as "the impacts of human-induced climate change, ocean acidification, land-based sources of marine pollution, the loss of marine biodiversity in the deep ocean, unsustainable fisheries and illegal, unregulated and unreported fishing," to name a few. These issues, among many others, will have human and economic costs that will be felt disproportionately more in the developing world. Global security is also threatened by the possibility of unilateral action by countries in relation to ocean and maritime regulations. "There's the pervasive threat of the failure of multilateralism and respect for diversity, along with the resurgence of national interests taking precedence over community interests within the international legal order," Doumbia-Henry said. The COVID-19 pandemic also remains at the forefront of challenges to a successful maritime future. Doumbia-Henry sees the virus as a chance to highlight the importance of developing and implementing science-based policy and regulations. At the same time, the pandemic has emphasized the "need of developing countries to have their own scientific capacity to plan and implement mitigation measures, including circular economics that aren't dependent on global supply chains."

Another noticeable repercussion for all countries has been the plight of seafarers working on board merchant and cruise ships. "On June 29th, over 400,000 seafarers were still stranded, with 200,000 needing to leave ships and a similar number needing to replace them. They have been experiencing a growing humanitarian crisis since they haven't been able to transit and transfer through ports and airports that would enable them to return home following the end of their contracts," said Doumbia-Henry.

The impending maritime threats are well recognized, though, and Doumbia-Henry shared much that has been done recently on the legal front to create awareness and incite action. Notable international processes that maintain the same impact include biodiversity plans beyond national jurisdiction at the Intergovernmental Conference, the implementation of ocean-related goals in the 2030 Agenda for Sustainable Development, the UN Global Compact, the IMO Strategic Plan 2018-2023, and the "Our Ocean, Our Future: Call for Action" document adopted by the UN Ocean Conference in 2017. And crucially, Doumbia-Henry pointed out, there are changes beyond the maritime industry. In 2017 the UN proclaimed the decade of 2021-2030 a "Decade of Ocean Science for Sustainable Development," providing a unique opportunity to "create a new foundation, across the science-policy interface, to strengthen the management of our oceans and coasts for the benefit of humanity." She added, "We're also seeing the incorporation of ocean-related options into Nationally Determined Contributions (NDCs) under the Paris Agreement, as well as greater convergence between ocean and climate change regulatory regimes."

A member of the maritime community since birth, Doumbia-Henry is intimately familiar with ocean-based practices, marine laws and regulation, and sustainability actions. Her role at WMU is a crucial one, as the coming years may prove to be some of the most important for our planet's future. Doumbia-Henry's impressive legal career, undeniable knowledge, and passion for social and environmental justice will all become ever more significant in the fight to protect our oceans.

All photos courtesy: Don Walsh

02 Walsh

Don Walsh

60th Anniversary of Trieste's Deep Dive

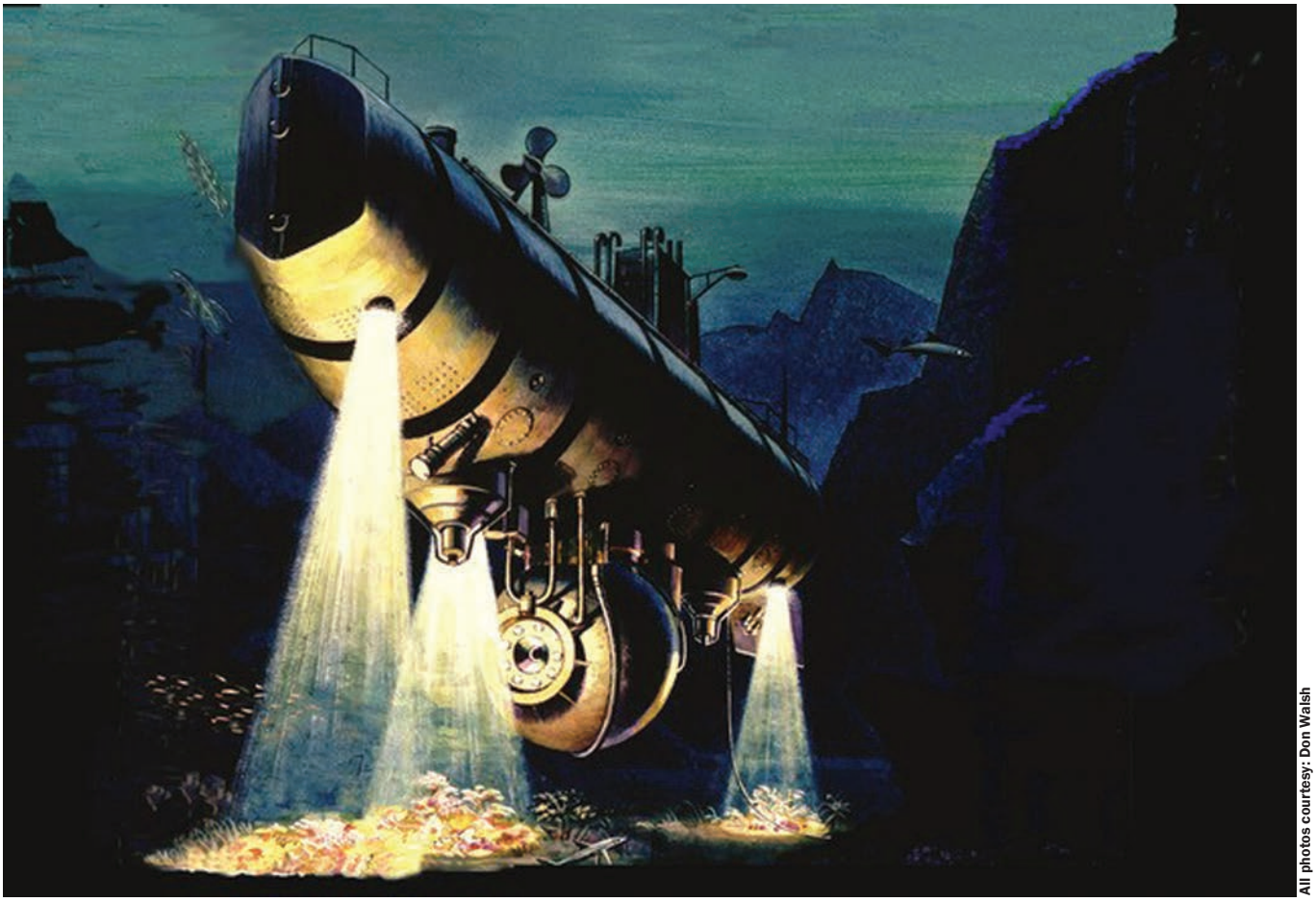
By Regina Ciardiello

Growing up in the San Francisco Bay Area, Capt. Don Walsh decided to join the U.S. Navy at Naval Air Station Oakland in 1948, where he became an aircrewman in torpedo bombers. Two years later, he entered the U.S. Naval Academy, and in 1956, he enrolled in submarine school. Little did he know that four years later — in 1960 — he'd be the first person (with Jacques Piccard) to travel to the furthest ocean depths onboard the submersible Bathyscaph Trieste (Trieste).

During his tenure as Officer-in-Charge of Trieste, Capt. Walsh was designated USN Deep Submersible Pilot #1. In January 1960, he and Piccard dove in Trieste to the deepest place in the ocean: 35,840 feet. For this achievement, Lieutenant Walsh received a medal from U.S. President Eisenhower at the White House.

In the years following the Trieste expedition, Commander Walsh served from 1970-1975 on duty in Washington DC as Special Assistant (Submarines) to the Assistant Secretary of the Navy for Re-

Above Left: At 88 years young, Capt. Walsh still runs the day-to-day operations of International Maritime, a consulting company he established in 1976. Above Right: The Trieste as it appeared in 1960 on the cover of *Popular Mechanics* Magazine. (Captain Walsh owns the original art)



All photos courtesy: Don Walsh

search and Development (ASNR&D) and later as Deputy Director of Navy Laboratories. He retired from military life in 1975 with the rank of Captain.

Aside from his own achievements, Capt. Walsh notes the development of full ocean depth manned and unmanned submersibles as one of the most important industry milestones. He also cites the areas within the evolution of Autonomous Unmanned Vehicles (AUVs) capable of long duration, unattended missions. He says these vessels allow for "oceanographic work not possible with conventional research ships." The last item he notes is the development of Remotely Operated Vehicles (ROVs) designed to perform high-precision tasks. "All three of these technology developments have been developed interdependently," he says. "That is, you will find the 'DNA' of the early pioneering vehicles in all those operating today.

Equinor

Photo: Equinor

"V" is for "Victory" **Pål Eitrheim, Equinor's Executive Vice President, New Energy Solutions, reacts to news of New York award.**

03 Offshore Wind

Offshore Wind

Impacting energy, subsea, maritime and logistics

Ørsted • Equinor • WindServe Marine • Vard • Wärtsilä • Aqueous Corp.

By Barry Parker

Offshore Wind, collectively, comes in at #3, as it single handedly has the power to impact the entire offshore energy, subsea, maritime and logistics markets. In the United States alone, a report from Wood Mackenzie estimates the potential benefit from 28 new gW of wind power and $1.7 billion in U.S. Treasury revenue by 2022, powered by total investment in the U.S. offshore wind industry of $17 billion by 2025, $108 billion by 2030, and $166 billion by 2035. Profiled here are six leaders of the pack.

Ørsted

The Europeans have a generation lead on the world in the offshore wind sector, with the Danish project developer Ørsted bringing experience back to the early 1990s, long before "green energy" was on the radar. Headquartered in Denmark, its footprint extends across continents. The consultants McKinsey, in an article on the company, wrote, "Ørsted invested aggressively in offshore wind and phased out coal. By 2019, it had become the world's largest producer of

offshore-wind energy." By early 2020, it controlled 6.8 gW of installed offshore wind capacity. This includes its project Hornsea One (in the North Sea, owned jointly), 1.2 gW. A follow-on project, Hornsea Two (1.4 gW) is expected to come online in mid-2022. Though these mega projects are in European waters, the U.S. figures prominently in its plans. Ørsted, in conjunction with U.S. partners, has stakes in a trio of pending east coast projects- South Fork (130MW), Revolution Wind (704MW), Sunrise Wind (880MW), and- in the mid-Atlantic, Ocean Wind (1.1 gW) and Skipjack (120MW). Most recently, Coastal Virginia Offshore Wind, a small demonstration project coming online later this year, sees Ørsted teaming up with Dominion Energy, in what is expected to be the precursor to a massive wind farm off the coast from Virginia Beach.

Equinor

The European experience in offshore energy can be seen in Equinor, which has been morphing its dominance in North Sea fossil fuels into a leading presence in wind power. In late 2019, it won a contract to develop what is slated to be the world's largest windfarm, at 3.6 gW, in the Dogger Bank field east of the U.K. Its present portfolio includes Hywind Scotland, a 30 MW array of floating turbines, mirroring oil's pivot from jack-ups to floaters. Equinor's plans also see a movement across the Atlantic to the U.S. A major victory was achieved in 2019 when its bid to develop a windfarm in the New York Bight was accepted, setting the stage for the company's first windfarm outside of Europe. Its 816 MW Empire Wind project, anticipated to come online as soon as late 2024, fits into its "… ambition of building an offshore wind core area on the U.S. East Coast." Equinor is committed to developing the nation's first offshore wind supply chain to support the construction, installation and operation of offshore wind projects, investing more than $60 million in port upgrades in New York that will support future offshore wind projects and further strengthen the state's position as the U.S. hub for offshore wind.

WindServe

An important theme among the companies described here is that of established businesses serving offshore oil, and transportation, transitioning into the newly emerging offshore wind segment. Reinauer Marine, a long-time provider of oil products transport along the U.S. East Coast, made a strategic acquisition of the Senesco shipyard, a builder of

Vard

Wärtsilä

tugs and barges, in Rhode Island back in 2006. Fast forward a dozen years later, the Block Island Wind project (at 30 MW - the first functioning windfarm in U.S. waters, now in the Ørsted portfolio) is now online, and Rhode Island is well positioned to become a hub. WindServe Marine was established by Reinauer to support the burgeoning projects. WindServe's shipyard facility in Quonset Point, on Narragansett Bay, played a role in the construction of Block Island Wind, where parts were transported out to the construction site. Activities included outfitting the feeder barge with dynamic positioning system and cable reel, fabricating and outfitting a jack-up vessel with blade transfer outriggers, and handling various quayside storage and lifting operations.

Vard

European expertise will be vital for the U.S. However, as activity ramps up on the U.S. Outer Continental Shelf, Jones Act compliant service vessels will be needed. Vard, through its engineering and naval architectural arm based in British Columbia (and a part of the Fincantieri Group) won Approval in Principle from the American Bureau of Shipping, in late 2019, for a service vessel that would be compatible with Jones Act requirements. The vessel design is a bespoke version of Vard's 4 07 service operation vessel (SOV), with the standard design described as "a suitable vessel for small wind parks in harsher environment. Despite the cost-effective size, the operability is close to that of most larger SOVs." Vard's Offshore renewables team, based in Norway, explains that it is "offering vessel solutions for the entire offshore renewables value chain, including offshore wind, tidal and wave power.

This includes wind farm support vessels with high focus on efficient logistics, crew and technician comfort, and high operability." Vard designed vessels include platform supply vessels, anchor handlers and subsea construction vessels. Its offshore service vessels include the Bravante series (built at Eastern Shipbuilding, in Florida) and its multi-purpose vessels (built at the same yard) include a pair built for Harvey Marine. Its designs are also found in Hornbeck's OSV fleet.

Wärtsilä

This Helsinki-based solutions provider for the marine and energy segments has been at the forefront of recent developments in optimized vessel performance, and has been taking a long-term view on developments in the burgeoning wind power sector. In April, 2020, Wärtsilä explained in a presentation: "The opportunities for SOV and large installation vessels fall into two categories: retrofitting and new builds. Much of the opportunity for conversions/retrofit projects is in the U.S. market, as strong growth continues there." When it comes to newbuilds, Wärtsilä has a design for SOV's, which it markets in conjunction with its packages which integrate the bridge, engine room and other increasingly complex systems. As projects move into deeper waters, and heavier turbines become the norm, the nature of vessel demand is likely tilted towards newbuilds, with Wärtsilä saying, "In the U.S. offshore wind farm market, the operators are preparing for the possibility of building type-specific SOVs that can accommodate the usually land-based wind turbine technicians while conducting the maintenance of the offshore wind farms," says Blake Jackson, a U.S.-based sales manager for Wärtsilä Marine Business.

Aqueous

Looking further down the coast, as development shifts into the mid-Atlantic states, Aqueos Corporation, with an office in southern Louisiana where it is well known for subsea work in the oil and construction sectors, completed a diving contract for support of the Coastal Virginia Offshore Wind project. While this project (to be operational by late 2020) is starting small, with two Siemens turbines of 6 MW each, the participation of Aqueos provides a tangible example of offshore oil expertise transitioning to offshore wind. Indeed, in its announcement of its work offshore Virginia, a company executive explained, "We capitalized on our years of experience in the oilfields of the Gulf of Mexico."

Photo: Kraken

04

Kenny

Karl Kenny

Kraken Robotics

By Greg Trauthwein

Karl Kenny and Kraken Robotics are on a mission to revolutionize the way business is conducted subsea. It's about high-quality data, collected, delivered and analyzed more regularly, liberally shared among a disparate group of stakeholders, from science to commerce to military. It's about tossing out old norms and embracing different ways of doing business.

Underwater vehicle platforms; advanced sensor technology and components; Robotics as a Service (RaaS); Data Analytics as a Service (DaaS); Digital Twins – Karl Kenny and his Kraken Robotics team are embarked on a plan to grow, but it's a growth trajectory that's bigger than one company, one product, one service; it's a growth trajectory as big as the oceans themselves. But make no mistake, while the product and service platform of Kraken continues to grow diverse, Kraken's focus is laser sharp: build a complete vertical subsea platform, that is scalable, to help bring about meaningful change for all subsea industry stakeholders.

Kenny is pushing hard to ensure that his company continually evolves the technology, particularly the ability to work more efficiently and to 'see' better underwater, as he understands that the quality of data starts with its collection: *"Garbage in, garbage out,"* says Kenny, who worked at Microsoft before it was a public company. Kenny thinks big, beyond the confines of his company and his Canadian home.

The subsea industry is about a genera-

Kraken Robotic Systems Inc.
www.krakenrobotics.com

Since 2012, Kraken Robotics has been on the leading edge of development of sensors, software and underwater robotics for the marine industry. 2019 was a significant year for Kraken with the sale of its ThunderFish AUV prototype to Defense, Research and Development Canada, several sales of its new KATFISH towed SAS platform, and major milestones have been achieved with its SeaPower pressure tolerant subsea batteries. The company's OceanVision Robotics as a Service project became the first project approved under Canada's Ocean Supercluster.

Kraken said its customer Ocean Infinity achieved significant milestones in endurance testing of its Kongsberg Hugin AUVs using the new SeaPower batteries, including several missions to greater than 5000m and an unprecedented mission of more than 100 hours without recharging, while running a full survey payload. As a result, using Kraken batteries, Ocean Infinity can operate increased survey ranges to nearly 700 line-km per deployment. Kraken said it is the first to achieve a practical resolution of 2 cm with a commercial Synthetic Aperture Sonar (SAS). Kraken's Ultra High Definition (UHD) software improves the AquaPix SAS image resolution from 3.0 x 3.3 cm (across along track) to 1.9 x 2.1 cm and maintains constant UHD resolution across the entire swath. Kraken formally signed the Ocean Supercluster contract for the OceanVision, a $19 million project will see the development of new sensor and underwater vehicle technologies as well as services such as Robotics as a Service and Data Analytics as a Service.

Overall, Kraken develops high performance sensors, software, batteries, and underwater robotics for Unmanned Maritime Vehicles. It recently developed SeaVision 3D full-color laser scanning system provides millimetre resolution inspection capabilities on subsea infrastructure. The SeaVision is available in both a dual pod laser scanning system for use on ROVs as well as a profiler mode (using a camera, laser and lights) for use on AUVs and towed systems. Kraken manufactures KATFISH, an intelligent towed SAS system capable of acquiring over 3 billion pixels per 3km2 per hour of area coverage rate. The KATFISH system is comprised of an actively controlled smart towfish, SAS imaging, bathymetry and gap-filler sonars, launch and recovery system, operator console, and visualization software.

tion behind robotics markets on the land and in the air for a fairly simple reason: working under the water in the ocean is an extremely difficult and harsh operating environment, with a lack of effective tools, namely GPS and WiFi, that are key tech enablers and accelerators above the waves. But that's not the full story according to Kenny, as he sees an industry entrenched in silos without effective means, or impetus, to communicate more frequently, to share data, information and insight so that the same plots of subsea turf are not studied again and again by varying groups with different agenda. Kenny and his team are setting a course to change this, creating a true subsea vertical that offers the know-how, the equipment, the services as well as the vision and the strategy to help connect the dots.

Kraken's strategy is premised on delivering both RaaS and Data Analytics as a Service to help organizations work more efficiently, safely and cost effectively in the world's oceans.

"Our subsea industry is so fragmented, everyone works in their own silos," said Kenny. He contends that the industry as a collective must figure the best means to survey a given area once, instead of multiple stakeholders surveying the area time and again to get the specific information needed for their own project. "It's the same patch of land, but there is no collaboration. *Let's stop calling it 'IMR' or 'hydrography,' let's call it 'surveillance.'* Let's go and see what's on the seabed and get that data in extremely high resolution. That's what Kraken is doing with its Synthetic Aperture Sonar – it's a better picture, more detail, it's crisper. We have a new sonar coming that will penetrate into the seabed so we can find buried objects."

While Kraken serves the entire subsea market – from military to commercial to science – globally, Kenny sees the big market potential on the commercial side. "Military will always be important, but in this grand scheme of things, as you discuss robotics, digitalization and digital twinning, with the billions of dollars of critical infrastructure on the seabed, this is going to be a much bigger demand driver than the military driver in the long run."

While Kenny is a big picture thinker, he knows that ultimately success starts with the quality of the data, so the company started in 2012 with the hardware, and today is building its business platform based on the technologies highlighted in the box to the left.

A New 'Vision'

OceanVision is a three-year, $18.8 million project focused on the development of new marine technologies and products to enable an underwater robotics data acquisition and data analytics as a service business. Under the OceanVision project, Canada's Ocean Supercluster will provide an investment up to $6.3 million, with the balance of project funding to be provided by other government agencies, industry partners and Kraken. "If we get OceanVision right, this will be a model that is scalable," said Kenny. In October 2019, Kraken completed its first offshore survey campaign for the OceanVision project, deploying its sensors and unmanned underwater platforms to conduct ultra-high definition seabed imaging and mapping on the Grand Banks of Newfoundland and other areas of Atlantic Canada. Over the next 30 months, this funding will allow Kraken and its partners to develop new technologies and provide high resolution seafloor imaging and mapping covering more than 5,000 sq. km. around Atlantic Canada. "We're going to continue to see things get smarter, smaller, cheaper, lighter and more pervasive across the board." What Kenny is advocating for subsea is a surveillance presence, starting with the highest quality data input through the most complete data analytics, that can monitor the ocean more cost- and time-efficiently. Digital twinning is a term that comes up in this regard, as "this means we can inspect it more often," said Kenny. "It's almost like medical imaging and the comparative analysis you get from a CAT scan," to continually monitor a medical condition; the more often you inspect, the better the data. The holy grail? Data analytics. "Data analytics and predictive analytics is where the big value lies," said Kenny. "The more you scan, the better you can understand the evolution."

05 Virmani

Jyotika Virmani

Schmidt Ocean Institute

By Celia Konowe

Dr. Jyotika Virmani, Schmidt Ocean Institute's (SOI) first executive director, defines what it means to be passionate and motivated in the field of marine science and exploration. Her humble start began in her hometown of Manchester, England, inspired by the nearby Lovell Telescope — which was then the world's largest steerable dish radio telescope. Today, her interests and studies, spanning atmosphere to ocean, have guided her drive to lead and foster scientific advancement in the marine and subsea industry, all while facing adversity including redefining the role of women in science. Growing up in a nation under the rule and guidance of Queen Elizabeth II and Margaret Thatcher and surrounded by a supportive family, Virmani never questioned the possibility of noteworthy and pioneering women. Believing it is important for children to grow up around role models, she remarked how lucky she was to grow up with female figureheads. Virmani's studies led her to the intersection of marine and atmospheric science. While completing her master's degree in atmospheric science at SUNY Stony Brook, Virmani was given the chance to take a few marine science courses and she noted, "That's when it really clicked, that the weather and climate is this interconnected system, which includes atmosphere and ocean." Her subsequent PhD was in physical oceanography at the University of South Florida, where she lived and worked with the Florida Coastal Ocean Observing System Consortium during the notorious 2004-2005 Atlantic hurricane season. It was here her career became one of adversity. Environmental adversity, that is.

Shortly after Virmani moved back to England to take a job with the Met

(Meteorological) Office, the Icelandic volcano Eyjafjallajökull erupted in April 2010. She had a direct role in the ensuing crisis since the Met Office functions as the regional prediction center for global ash production. Later that month, the Deepwater Horizon oil spill occurred in the Gulf of Mexico, near where Virmani had previously lived and worked. She was asked to return to Florida to help with the spill's aftermath and did so later that year. Several years later in 2017, while working as the senior director for the XPRIZE Foundation Plant and Environment team, an entire test bed off the coast of Puerto Rico was destroyed by Hurricane Maria. Despite other setbacks, including having lost crucial data while pursuing her PhD, Virmani emphasized the importance of perseverance. "You can quit at any time—I could've quit my PhD—so I would say if you really want to do it, just keep working at it and work through it."

While discussing the future of marine science and technology, Virmani admitted that it's impossible to ignore the influence of COVID-19, both near and long term. Marine research and education have been largely impacted for the foreseeable future, with degree programs being delayed or moved online and research missions put on hold. How the world deals with the crisis, though, is a clue to changes in numerous fields of science. "What this pandemic has done, and it's not just in the field of marine science—it's across the board—is brought forward a lot of those technology changes that we thought would take much longer to achieve." For Virmani, the marine industry's future is rooted in rapid technological advancement and COVID-19 is simply demonstrating its capabilities. "We're on the cusp of a lot of streams coming together—not just in the ocean, but the infrastructure, too—so I think we're going to see this fantastic, rapid increase as technology changes at an exponentially fast rate. We're also looking at, increasingly more and more, the intersections of different kinds of science and different kinds of technology. For example, merging new material science and capabilities with the robots, or using artificial intelligence to analyze the data." SOI already has begun adapting its technology to pandemic-related restrictions, continuing the year-long research mission aboard the R/V Falkor that began in Australian waters in early 2020. Despite the lockdown, numerous deepwater expeditions have been completed with the help of a telepresence crew. New discoveries have already been made, proving to Virmani that despite COVID-19, there's still much more to achieve in the coming years. "I think we're in a new golden era of ocean exploration because this technology will allow us to scale out a lot more. The ocean is so massive—we've only really explored 5% of it, so we have such a vast area to cover and we're going to need this technology to help us do that."

The future for SOI looks promising, with numerous achievements expected in the coming months. A partnership with the Seabed 2030 Project (a collaboration between the Nippon Foundation of Japan and the General Bathymetric Chart of the Oceans) has been announced, featuring a signed memorandum of understanding, as well as confirming SOI's participation in sharing seafloor mapping data. Even more recently, the National Oceanic and Atmospheric Administration announced its intention to strengthen a longstanding relationship with SOI, with the goal of further exploring, mapping, and protecting the ocean. SOI staff also look forward to technological advancements, including a process for ROVs to collect deep-water samples sustainably and safely.

With so much already overcome and accomplished, Virmani sees a limitless future. Her mission, laughingly quoting Star Trek, is "to boldly go." She hopes to continue SOI's work and further "push and expand the field of science and research, as well as technology development opportunities at sea." With her experience and passion, perhaps she'll also embrace the words of Captain Jean-Luc Picard, "Things are only impossible until they're not."

06

Hawkes

© Julie Silverman

© Pinewood Studios

Graham Hawkes

HAWX Open Ocean

By Celia Konowe

Graham Hawkes is a subsea innovator, explorer, inventor and pusher of boundaries. A pioneer in the realm of ocean engineering, he's designed and built more than 60 manned submersibles—everything from atmospheric dive suits to flying subs. As a test pilot, he's maintained the deepest solo dive record for more than 20 years. He's also the founder of HAWX Open Ocean LLC, created to design and build revolutionary marine technologies that enable undersea access to all.

Inspired by the people he's encountered throughout his career, Hawkes' passion of and dedication towards marine exploration has evolved over the years. Meeting marine biologist Sylvia Early "challenged me to achieve the goal of reaching full ocean depth and helped me develop an appreciation of all 'critters' and a sense of needing to care for this planet," he said. Later on, upon talking with environmental leader and communicator Julie Silverman, he understood "the need for everyone to have access to the ocean to better inform the stewardship of the planet." This, coupled with his desire to make a better place for his grandkids, gave birth to HAWX Open Ocean with the focus of working from the bottom-up, or with the next generation of ocean innovators—kids.

Hawkes' drive is also influenced by witnessing the evolution of the subsea industry. In the early days of submersible designing, amidst competition, Phil Nuytten, Canadian entrepreneur and inventor of the Newtsuit atmospheric diving suit, told Hawkes, "They can copy where I've been but they don't know where I'm going." Hawkes reflected, "That has stuck with me through all of the ups and downs of the submersible industry. It keeps pushing me forward knowing that innovation is what comes from your imagination not from someone else's expectations."

He is also motivated to make a difference because of a lack of change in the industry, as ocean discovery is still driven by a few wealthy organizations and individuals and

Above Left: Graham Hawkes, pioneering marine engineer, owner of HAWX Open Ocean, LLC, inventor of SeaRocket. Left: Graham Hawkes, designer of the Mantis one-man submersible, on set with Roger Moore, 1981. Hawkes piloted the Mantis sub used against James Bond in the film For Your Eyes Only.

Top to Bottom:
Graham explains to Islesboro, ME students how the **Sea Rocket** works; Hawkes with diver Oliver Hawkes, in 2015 piloting the **Dragon**; Hawkes and **Richard Branson** 'flying' Graham's favorite sub, **Super Falcon** looking for a great white shark, Guadalupe Island, Mexico 2010.


© Isleboro Central School


© Hawkes


© Amos Nachoum

the majority of marine environments remain unknown to humanity. As a result, Hawkes hopes to encourage more collaboration and new innovators in the field, as well as evolving subsea technology to provide access to the public. "There is a natural progression of human access and technology innovation. The first forays into new spaces are typically enabled by the government because of the high cost of these early-stage efforts, but there is constant pressure to lower costs and expand access," he explained. "Hence, the mission of HAWX is to introduce both unmanned and manned solutions, giving the general public access and the choice of going themselves or sending a probe."

To enable local communities to conduct ocean ground truthing and data collections, Hawkes believes there needs to be a major shift to affordable observation and data gathering technologies. "I can make anything complicated, heavy and big — I've proven that — but what's needed is a way to quickly, easily and affordably spot-sample to collect visualization of the water column and bottom, thus giving them access to observe, understand and manage their own ocean backyards," he said. As a result, the SeaRocket, a "touch-and-go" untethered lander that uses a consumer HD video camera (like a GoPro), was born. The SeaRocket SR3000 Pro series is designed for research and commercial use and can carry various sensor payloads, such as conductivity, temperature and depth (CTD). SR3000s, as Hawkes pointed out, "weigh under 20 pounds, have a depth rating up to 30,000 feet, and have a long high-visibility mast above the surface for visual location." Additionally, the product is fully automatic, does not require batteries and uses a small biodegradable descent weight to dive and surface. Later this summer will see the SeaRocket STEM Kit, a smaller, lighter family-friendly probe for exploring bodies of water less than 130 feet deep.

Despite the presence of COVID-19, collaborations are essential for HAWX Open Ocean to reach more people around the world and to build a global capacity for ocean exploration and observation. "We collaborate with companies and organizations that produce robust, off-the-shelf and DIY low-cost solutions that the ocean accessible for all," said Hawkes. Future partnerships, to name a few, include Paralenz (compact dive cameras with built-in data collection sensors such as CTD), Hohonu Inc. (low-cost water level sensor and data loggers), and Oceanography for Everyone (DIY CTD data collector).

Hawkes' future projects well align with his mission of innovation and accessibility for all. Citing the Deepflight Super Falcon as a favorite past project and a personal engineering challenge, but not fit for the market at the time, Hawkes sees the key for the next generation of manned submersible to be "focusing on what is wanted, rather than what I or the deep submergence community expects." He added, "I am now building prototypes that have little in common with traditional submersibles and are more like a hybrid of an exoskeleton that assists a human to dive more naturally." On top of his new designs, Hawkes has begun working with students, inspired by their ability to listen, the questions they ask, and their desire to world real world problems. "I'm impressed by their enthusiasm and passion for making the world a better place. It makes me feel very optimistic about the future," he said.

For Hawkes, with experience comes perspective. Exploring what is possible, especially when unconventional, does not always equal popularity. "I accept this and now consider one of my proudest achievements as being called 'the lunatic fringe' by Dave Gallo, then Woods Hole Oceanographic Institution's director of special projects," said Hawkes. "Perhaps I can help see the future, but it's different from what is expected." With HAWX Open Ocean and Hawkes' revolutionary innovation and passion, a future of heightened and accessible subsea exploration is ahead.

Teledyne Marine

07 Read

Mike Read

Teledyne Marine

By Greg Trauthwein

Teledyne Marine is no stranger to the *MTR* reader, a group of leading-edge marine and subsea technology companies that are part of Teledyne Technologies Inc. and a driver of consolidation in the subsea sector for more than a decade. At the helm sits Mike Read, President, who has held a steady hand over the evolution of Teledyne Marine, through market cycles up and down.

Through acquisitions and collaboration over the past 10 years, Teledyne Marine has evolved into an industry powerhouse, bringing imaging, instruments, interconnect, seismic and vehicle technology together, today encompassing 23 brands grouped in three integrated verticals run by 1,500 employees globally.

2020 is significant for the evolution of Teledyne Marine, as it marks the culmination of its five-year effort to create 'one' Teledyne Marine with a one common ERP system, one global sales and service team, and one common software platform – Teledyne Marine Software (TMS) – across its 23 brands. Read said "TMS is particularly strategic, enabling the Instruments and Imaging products to communicate seamlessly. You can imagine all of the different software packages; it was all over the map, which is understandable. Now we're working towards all of these products communicating seamlessly, producing better data, and delivering a better user experience."

The integration of Teledyne Marine into three verticals – the large interconnect business; instruments and imaging; and vehicles – is particularly timely as one of its largest customer segments, the offshore energy business, is enduring another slump, magnified by the

COVID-19 pandemic, and oil majors and large engineering firms alike are streamlining operations and technologies to be profitable with a $40 price per barrel of oil. "All operational excellence metrics are now centralized," said Read. "We've made Teledyne Marine stronger, focused on global service levels, with a robust development strategy on the product side. We've stopped a lot of small developments, instead focusing on 'Top 10 New projects.' We're looking forward to the remainder of this year, and the next five years where hopefully pandemics are not on the menu."

People to People

While companies like Teledyne Marine are geared toward the creation of products and systems that help make the 'dull, dirty, dangerous' jobs safer and more efficient, ultimately it is a people business. "As effective as Zoom and Webex can been, there's no doubt that this is a people to people business," said Read. "We like to have our customers come in to brainstorm with our people, and our customers like to come here with their problems. In addition, we manufacture a large amount of hardware every year, so our production people have to come to work. But it's always safety first; and (with the advent of COVID-19) we've been able to make our facilities even safer."

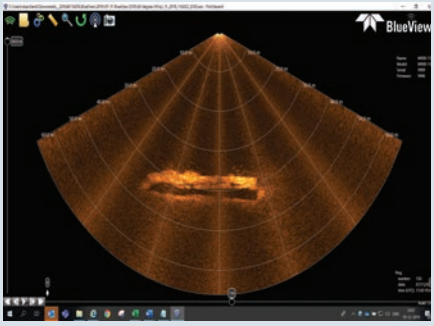
Looking ahead, Read sees ample opportunity; "In each of the markets we serve there's a little bit of good news."

In Read's estimation, the first bit of good news for Teledyne Marine is that it's part of Teledyne Technologies, "a diverse company that has acquired more than 65 companies over the last 20 years. Our parent company is very diverse; we are strong as a company," said Read. "At the marine level, we have a strong offshore energy business (providing) the majority of the electrical & optical interconnect to the sector. We are the market leaders."

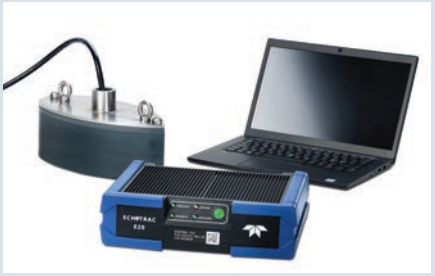
On the military side, Read said the company is fortunate that there are a lot of subsea defense applications, led by the U.S. Navy, whether it's building nuclear submarines, whether it's building mine countermeasure vessels, whether for the U.S. Coast Guard or for foreign

Z-Boat 1800T

M-Series Mk2 2D Multibeam Imaging



ECHOTRAC E20 Hydrographic Echosounder



Teledyne Marine Continues to Innovate

Teledyne Marine is a group of leading-edge subsea technology companies that are part of Teledyne Technologies Inc. Through acquisitions and collaboration, it has evolved into a powerhouse, with a large breadth of technology, including: vehicles, instruments, imaging, interconnect and seismic solutions. Here are some latest technology advances:

Z-Boat 1800T, Trimble Edition (Teledyne Oceanscience)

The Z-BOATTM 1800-T is a high-resolution shallow water hydrographic unmanned survey vehicle with an Odom Echotrac E20 Singlebeam Echosounder and dual antenna Trimble BX992 GNSS heading receiver. Each sensor is integrated into a compact, portable, and cost-effective package. The combination of Trimble's precise heading and positioning/guidance paired with Teledyne's accurate/precise sonars and rugged autonomous vehicle design, allow for best in class data collection under harsh conditions and is ideally suited for marine construction, dredging, and civil engineering tasks.

M-Series Mk2 2D Multibeam Imaging (Teledyne Blueview)

The M Series 2D multibeam imaging sonars deliver a compact form factor with low power requirements and unparalleled sonar image quality over a wide field of view. The new open nose cone design delivers optimal acoustic performance for increased image quality and improved range performance. All M Series sonars operate while in motion or from a stationary position, delivering real-time imagery and data. This product is ideally suited for diver platforms for search and recovery or ROVs for object detection and obstacle avoidance, as well as near field high-resolution object identification.

ECHOTRAC E20 Hydrographic Echosounder (Teledyne Odom Hydrographic)

The ECHOTRAC E20 is a portable, compact and robust echosounder designed to survey in all environments. The E20's versatility allows customers to maximize system utilization, resulting in reduced hardware investment. Easy to use and fast to mobilize.

navies. "That market today is more active than it ever has been." He said the advantage of the integration of Teledyne Marine into 'one' is particularly clear on the military side, as it is able to offer bundled packages – from Gavia AUV's, to Seabotix ROVs, to multibeam sonar on the ship itself, for example. "We do that now with one Teledyne Marine, and we could not have done that five years ago as a wholistic opportunity."

Looking for new opportunities, the company recently entered the marine construction sector. Business opportunities in dredging, as harbors deepen for ever larger ships; and in the business of clearing harbors for the decommissioning of old and construction of new bridges is vibrant and growing.

Read adds, "We continue to package and align our technologies for new and exciting emerging markets. As experts in real-time underwater vision, we're combining our technologies and partnering with organizations such as Trimble and DSC Dredge to provide operators of heavy machinery on barges and dredges with tools to improve their efficiency and effectiveness."

Challenges Ahead

Challenges abound for any leader in any industry, and when Read surveys the landscape of the markets his company serves, he still sees the need for the implementation of technology solutions to remove the human element from particularly dangerous situations previously the province of divers. In addition, he personally has been leading the charge to push for increased standardization throughout the product sectors, believing that a pervasive $40 per barrel oil price will help in this regard. He gives an example: "Instead of 800 variants of four-way electrical flying leads, you can get it down to 10, and that will help to take cost out," he said. Summarize, Read said "we love challenges, for example the challenge to make materials last 30 years underwater; that is our sweet spot, that's our niche. We have a materials database in Teledyne Scientific for the last 10 years which proves the reliability of the materials chosen. It's unique, no one else has this. It's important because the cost of failure is enormous."

Tasman DVL

Tasman DVL (RD Instruments)

The Tasman DVL, with its array of features, reduced size and increased range, is becoming the new standard in Doppler navigation technology. With bottom-tracking ranges from 0.15 m to 400 m in up to 6,000 m water depths, the Tasman is versatile enough to navigate small ROVs to large diameter AUVs. Key advancements include field-swappable phased array transducers, system health monitoring/leak detection, ethernet compatibility, and the ability to upgrade to collect ADCP data.

HydroPACT 660E

HydroPACT 660E (Teledyne TSS)

The HydroPACT 660E brings pipe tracking and UXO detection capabilities to small inspection and observation class ROVs, for applications that were previously only available on larger vehicles such as work class ROVs and trenchers. The single smaller pod reduces the installed footprint and payload of the system while maintaining an operating range of greater than 85% of that of the larger HydroPACT 440 system. The coil array features an integrated cable for even greater reliability and is very well-suited to smaller ROVs, offering users the opportunity to reduce their operating costs on future projects.

APEX EM

Photo: University of Miami Rosenstiel School of Marine and Atmospheric Science

APEX EM (Teledyne Webb Research)

The APEX Electro-Magnetic (EM) float helps researchers gather greater details on motion within the water column. APEX EM floats are being used increasingly by researchers to better understand and predict major weather events and climate events, such as hurricanes. The autonomous drifting 'Electromagnetic Profiling' float (APEX-EM) can precisely measure water column current velocity by using motionally-induced electric fields, which are themselves generated by ocean currents moving through the Earth's magnetic field. Other sensors to measure properties such as pressure, temperature & salinity are also included on an APEX-EM.

www.teledynemarine.com

The Hydrone-R
© Saipem

Send in The Robots

Robotics have been on the development fast track, driven to remove humans from dull, dirty and dangerous jobs; to remove ships for economic reasons; and to 'live' where they work. Here we review some of the most compelling advances in the past year.

ROVs: New Approaches

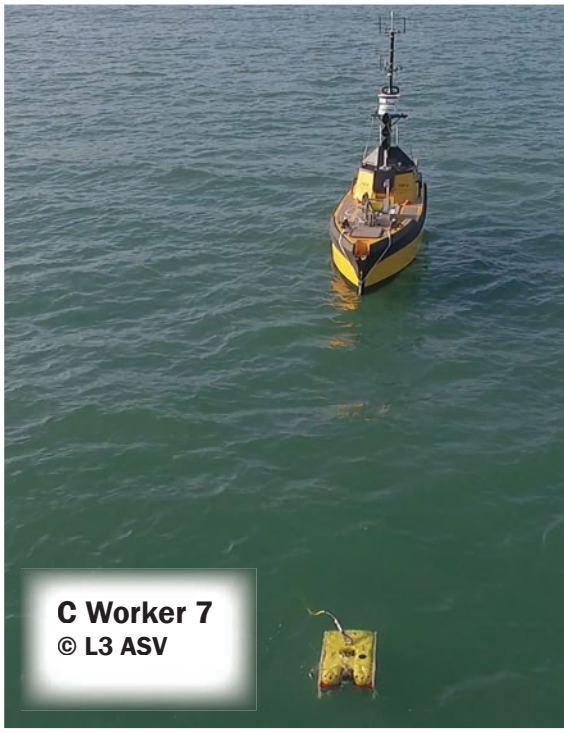
For years the mantra has been to 'remove the ship' from the offshore work equation, as it is far more CapEx and OpEx intensive than unmanned brethren. In a defense-focused demonstration Teledyne Seabotix ROVs were operated from Marine Advanced Research WAM-V USVs. In commercial practice, SAABSeaeye ROVs have been supported by **L3 ASV** C-worker USVs. In these configurations the objective is primarily inspection. An operator ashore, connected via radio or satellite telemetry, can use the combined systems to examine structures or the seafloor. Light intervention is feasible but typically the ROVs involved lack the physical power to engage core offshore maintenance tasks. Another concept is to install an ROV in a fixed location. This might be attached to a large installation providing power and data connectivity back to shore. It could also be connected via a buoy, for telemetry, and rely upon batteries for power. In either case the ROV is now a fixture on the site and does not depend upon an expensive vessel for support. **Oceaneering** has developed its e-ROV, and seen positive results in early trials. **Saipem** has likewise invested significantly in this area. Its Hydrone-R vehicle is the result of nearly two-years of development.

Seafloor Residency

The natural evolution of ROVs trusted to operate for hours or days without ships is vehicles resident on the seafloor

without tethers. **SAABSeaeye's** Sabertooth has been a leader in this area starting with a widely referenced demonstration in Houston's Neutral Buoyancy Lab in late 2016. Since then others have entered this space. **Oceaneering** unveiled its Freedom vehicle. This system is designed to be multi-role with the ability to execute survey and inspection tasks. It is intended to be housed in a docking station installed on the seafloor site where it will return for recharging. The vision for such systems is to be installed and left on the seafloor for months. It combines the mechanical engineering challenges of making ROVs reliable with software necessary for long-term operability. These technology concepts are slowly being developed and Oceaneering's solution had advanced rapidly to offer a market choice.

The vision of wireless seafloor resident vehicles is powerful. But it remains a future vision. Today long-duration deployments of tethered seafloor resident vehicles are imminent, notably with **Eelume**, an undersea vehicle blurring the lines between AUV and ROV while employing a distinctive architecture that supports modularity and maneuverability. Looking something like its eel namesake, this technology has begun offshore proving trials for subsea-residence operations. Eelume subsea-resident systems were deployed at a Norwegian Science & Technology University underwater test site in 360 m. water offshore Trondheim during May 2019. The Eelume robots were deployed to the sea-bed with a docking garage and used to perform a number of inspection and light intervention tasks on the underwater test site. These first subsea-resident Eelume systems will operate in battery-powered,



C Worker 7
© L3 ASV

tethered control mode, but before the end of the year are expected to demonstrate tetherless operations.

Meet Aquanaut

Expanding on the vision of untethered undersea robots for IMR is **Houston Mechatronic's Aquanaut**, a transforming system designed to operate in both an AUV mode for survey and transit and an ROV mode for closer inspection and manipulation. The intention for Aquanaut is for the system to arrive on a job site and execute tasks, such as valve manipulations, using its own onboard intelligence. Operators will use only high-level supervisory control to check system status and issue mission commands. This concept challenges both technology and business conventions.

Aquanaut's transforming capabilities are impressive mechanical developments. But the sensing and software engineering developments are equally important. Training a robotic system to perceive, understand, and engage a complex undersea environment is a significant challenge. Aquanaut is envisioned as an IMR on-call service, providing the necessary activity when and where needed, sans (more expensive) support ship and crew.

MIT's' "Roboats"

The "Roboat" project from the **Massachusetts Institute of Technology (MIT)** and the **Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute)** envisions a shape-shifting fleet of vessels that can by autonomously disconnect and reassemble, changing configurations to form pop-up bridges, stages, and other structures.

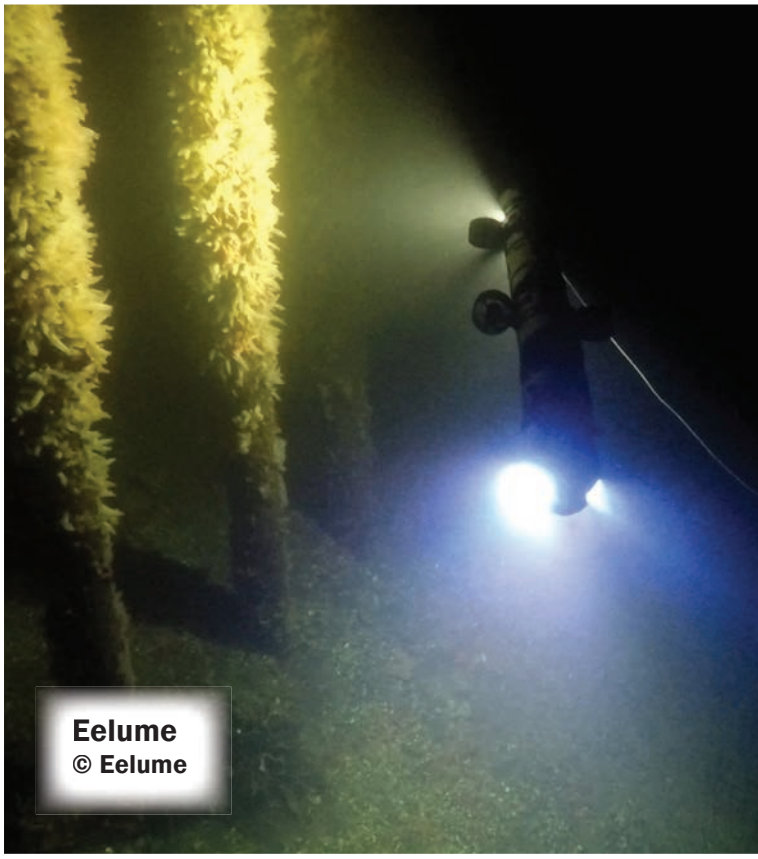
The autonomous boats as currently envisioned are rectangular hulls equipped with sensors, thrusters, microcontrollers, GPS modules, cameras, and other hardware. The project is led by MIT professors Carlo Ratti, Daniela Rus, Dennis Frenchman, and Andrew Whittle. In the future, Amsterdam wants the roboats to cruise its 165 winding canals, transporting goods and people, collecting trash, or self-assembling into "pop-up" platforms — such as bridges and stages — to help relieve congestion on the city's busy streets.

For their work, the researchers had to tackle challenges with autonomous planning, tracking, and connecting groups of roboat units. Giving each unit unique capabilities to, for instance, locate each other, agree on how to break apart and reform, and then move around freely, would require complex communication and control techniques that could make movement inefficient and slow.

Experiments were conducted on quarter-sized roboat units, which measure about 1 meter long and half a meter wide. But the researchers believe their trajectory-planning algorithm will scale well in controlling full-sized units, which will measure about 4 meters long and 2 meters wide.

The next step: researchers plan to use the roboats to form into a dynamic "bridge" across a 60-meter canal between the NEMO Science Museum in Amsterdam's city center and an area that's under development. The project, called RoundAround, will employ roboats to sail in a continuous circle across the canal, picking up and dropping off passengers at docks and stopping or rerouting when they detect anything in the way.

"Roboats"
© MIT



Eelume
© Eelume

NORBIT Subsea

Trondheim, Norway
www.norbit.com

NORBIT Subsea disrupted the coastal hydrographic market with its WBMS platform. The key to success of WBMS is the idea of designing a state-of-the-art, super-compact, highly integrated multibeam echo sounding platform while, at the same time, making the hydrographic experience as easy, productive and worry-free as possible for the hydrographers. Capitalizing on this philosophy, in June 2020, NORBIT Subsea raised the bar of innovation by launching WINGHEAD, the latest addition to the NORBIT family. WINGHEAD is a true 1024 beams multibeam echo sounder, with frequency agility from 200kHz to 700kHz, with a resolution of 0.5 x 0.9 degrees (at the center frequency of 400kHz) and with the iconic NORBIT curved arrays. We made no compromise on miniaturization: with a low hydrodynamic impact and a weight in air of less than 7kg (including the mounting brackets and the GNSS/INS) WINGHEAD is positioned to be the preferred platform for the most demanding applications also for unmanned surveys. The first WINGHEAD production batch has already been sold in the first two weeks after its launch, a demonstration of the solid reputation of success that NORBIT enjoys in this industry when it comes to new product introduction. WINGHEAD is the multibeam echo sounder that will become, for many years, the benchmark sonar in the hydrographic industry.

Xsens Technologies BV

Enschede, Netherlands – www.xsens.com

Founded in 2000 in Enschede, Netherlands, Xsens Technology BV is a supplier of Inertial Sensor Modules and 3D motion capture technology. Xsens inertial sensor modules produce real-time, accurate and reliable outputs that make them perfect for integration into collision avoidance systems, autonomous surveying equipment and geolocation services. Particularly well suited to marine applications, the Xsens motion tracking sensors are electrically and mechanically robust; they are highly resistant to interference from common marine phenomena such as strong magnetic fields and continuous vibration. They are also supplied in robust packages which are rated for use in harsh and wet environments and extreme temperatures.

Xsens' MTi-30 Attitude and Heading Referencing System (AHRS) recently played a huge role in one company's missions of carrying out data-rich surveys of the sea floor. Planblue, a spin off company from the Max Planck Institute of Microbiology in Bremen, Germany, uses Xsens' MTi-30 AHRS to measure their sub-sea camera's acceleration and rate of turn in three dimensions up to 400 times per second. The stability of these outputs is maintained by Xsens' proprietary calibration and compensation software, so that Planblue's post-processing AI software can cancel out the effect of vibration to produce detailed maps of the sea floor. These maps open up a whole range of possibilities in the areas of conservation, renewable energy generation and the development of marine infrastructure.

Another piece of Xsens technology that is already enabling the future of maritime transport is autonomous ships. CaptainAI, a Dutch start-up developing marine autopilot technology, aims to supplement or even replace the ship's captain with an AI-based system which will help to lower the cost of shipping, while providing higher levels of performance and reliability. Integral to CaptainAI's technology is the Xsens MTi-G710, a high-performance inertial navigation module that provides real-time, accurate and consistent outputs for attitude, heading, position, velocity and acceleration.

BIRNS, Inc.

www.birns.com
Eric Birns, President/CEO

Today, BIRNS is an ISO 9001:2015 certified leader in the design and manufacturing of high performance connector, cable assembly, penetrator and lighting systems. BIRNS deep submergence connectivity solutions are designed, engineered and built to deliver superior performance—faster data transfer for better telemetry and communications, and safer, more reliable power distribution for severely demanding environments. The company a broad array of customers' needs with the BIRNS Millennium and Primum 6km-rated connecter series, as well as its ranges of electrical and optical penetrators. The company's lighting systems have been blazing new trails on the ocean floor since Sea Lab, and continue to provide trusted illumination for some of the toughest jobs on the planet.

BIRNS inspects, tests and qualifies its engineered products. Serving as an independent testing resource for the industry, as well as developing and conducting in-house testing procedures for all of its products, BIRNS offers state-of-the-art protocols including advanced hydrostatic pressure testing, extreme cold/extreme depth pressure and hot and cold thermal shock testing.

9+ Gbits/Sec Ethernet: Recently BIRNS introduced several new connectivity capabilities in its Millennium connector series to further support the requirements of today's evolving subsea systems. In 2020, the company launched a Ethernet cable assembly capability, transmitting data at 9.4+/- 0.1 Gigabits per second. BIRNS developed exclusive deep submergence cable constructed for Cat 8.2 use, and performance testing proved that data consistently transmitted at this rate over the entire range of pressures from 0 to 8700 PSI/600 bar (6000m equivalent depth).

RF Advancements and Extreme Depth/Cold: BIRNS introduced advances in RF cable assemblies to the market, as well, with unique coax contacts capable of open face pressure rating, and cable assemblies with losses of 0.4-0.7 dB at 1.5-3.0GHz. The team also launched a new precision testing capability for deep submergence connectors and cable assemblies—an extreme low temperature, extreme depth testing system. This test system successfully allows 48 hour+ continuous testing of connectors and cable assemblies at 6km in a controlled 2°C (±1°C) environment. It was initially developed to meet customer requirements for a new BIRNS Millennium 6km-rated hybrid electro-optical pin configuration, the 3O-1F3, which features the company's new miniature 1.25mm optical ferrule.

QinetiQ Inc.

Waltham, Massachusetts – www.qinetiq-na.com

QinetiQ Inc. is a leading defense and security company in the US providing mission-led innovation at pace. QinetiQ Inc. is part of QinetiQ (QQ.L)—a leading integrated global defense and security company. QinetiQ employs over 6,000 people globally, with 750 based in the U.S.

A part of its maritime robotics offerings is SEAScout, an unmanned undersea vehicle (UUV) portfolio consisting of a series of modular and expandable hand portable vehicles and provide to the user an unrivaled capability in expandability, reconfigurability, and greater range of missions than other UUV's in the class. The SEAScout family of vehicles enable the accomplishment of multiple maritime mission sets from a single baseline platform incorporating reconfigurable payloads.

The SEAScout family of vehicles is based upon a 4-7/8" diameter by 36" long baseline system dubbed MkII. QinetiQ have operated variants to accommodate payloads expanding to 48" long. Operating speed is 2kn with maximum speed in excess of 16kn. The vehicle depth is 800 ft. and weight at 22 lb. dry. The battery may be customer specified. All SEAScout vehicles maintain the ability to offload data or re-task while deployed. They are also able to trail an array for sensing and data collection within the vehicle. New to the family for 2019 is the development of the MkIII vehicle. The MkIII vehicle maintains the baseline diameter but is 62" long to accommodate a wide range of sensors to enable a forward deployed robust IPOE, ISR, or marine survey missions. The operational speed range is 2kn to 12kn, and is still hand portable at 40 lbs. dry.

RBR

Ottawa, Canada – www.rbr-global.com

RBR customers are actively using Generation³ products from the ocean abyss to the polar ice caps to make great discoveries. RBR has expanded product offerings to sensors, loggers, systems and OEM components. The past year has been busy with new engineering, sensor design, and ocean deployments in collaboration with global commercial partners to enable innovations in Argo floats and autonomous vehicles such as AUVs and gliders.

RBR is always striving for innovation and has expanded its instrument product line to include the RBRquartz³ BPR|zero, a special version of the RBRquartz³ BPR (bottom pressure recorder) implementing an internal barometer and switching valve. The novel AzeroA technique is used to provide in-situ reference measurements to correct for long term drift in the Paroscientific Digiquartz® pressure gauge. The RBRquartz³ BPR is intended for deep-water, long-term deployments where high stability and resolution of absolute pressure measurements are critical. Combined with the RBRfermata external battery canister, the RBRquartz³ BPR|zero can sample continuously at 1Hz for 600 days or every 10s for more than eight years.

RBR makes high-precision instruments used for measuring the blue planet. Designed with the user experience and flexibility in mind, RBR's instruments measure up to ten parameters. Communication is available with USB-C as the standardized connector on every instrument, and Wi-Fi connectivity is available on every standard logger. All Generation³ instruments run on AA batteries. By having one cable that fits all, with widely available batteries, preparing for deployments has never been easier. The Wi-Fi connectivity allows the user to control, download, and view data via Ruskin Mobile. Other Generation³ features include reduced power consumption and faster sampling. The lower power platform also enables vertical profiling floats, such as Argo, and autonomous underwater vehicles, such as ocean gliders, to sample more frequently or extend their mission duration, greatly reducing costs or enabling extended missions. By increasing the sampling rate up to 32Hz, RBR instruments can be used for mixing studies and to resolve thin layers in the ocean. For system integrators, the RBR loggers act as a 'sensor hub' to control and communicate with a suite of sensors.

RBR

Remote Ocean Systems

San Diego, CA – www.rosys.com

For more than 40 years Remote Ocean Systems has been a leader in the development and manufacture of camera, lighting and positioning systems for the most extreme oceanographic, industrial, commercial and military applications and environments. ROS is ISO-9001-2008 certified company with a 28,000 square foot research and manufacturing facility. Its product line includes underwater video cameras, lights, rugged pan and tilt positioning systems, video inspection systems and control systems manufactured primarily for the oceanographic, nuclear and defense industries.

For 2020, ROS has developed two new technology products designed for deep ocean applications. The SeaStar is a high-powered, lightweight compact LED light that delivers 10,000 lumens output with full-range dimming capability. The SeaStar is completely Field Serviceable and available with flood or spot reflector options.

It is depth rated to 6,000 meters.

The Accu-positioner is a new ROS technology Pan & Tilt Positioner that features a reliable and rugged deep ocean design and computer-controlled accuracy to +/-0.1°. The Accu-positioneris controlled with COTS controllers, devices and ROS GUI. It operates with zero backlash and is depth rated to 6000 meters.

Saab Seaeye

Saab Seaeye Delivers Electric Manipulator Arm Breakthrough

What is reported to be the world's first seven-function all-electric work-class manipulator has been developed by Saab Seaeye. According to the manufacturer, this breakthrough heralds a significant advance in underwater robotic technology in the growing electric tooling and vehicle market.

The all-electric work-class seven-function manipulator is designed to have equal power and more precision, delivering a 'more intelligent' in comparison to the hydraulic equivalent.

Its control system enables both manual and automated control, with the potential for full autonomy in the future.

Millimeter precision comes from each of the seven joint modules having its own self-contained smart distributed microprocessor designed to deliver intelligent, intuitive and precise arm control. According to SaabSeaeye this delivers exacting, repeatable, precision which can predict limb motion paths for self-collision avoidance, adjusts movement requests to meet available power and collates joint data for unified control.

Included in the design is an adaptable power input system with advanced power management to limit peaks in power demand and manage regenerative loads. Tested through many million cycles, the titanium built eManip's planned reliability is aimed at reducing operating costs.

Reduced maintenance and reliability improvements through electrification has created a system that, in addition to conventional ROV deployment, is suited to onshore control with USV deployment or long term immersion with resident systems.

The eManip's intuitive control simplifies use of the manipulator by mimicking the movement of the master arm. Algorithms also predict and manage movement at each joint.

Designed to be future friendly - including the potential for interchanging the jaws with other tools - eManip's advanced technology will enable the transition from manual control to supervised autonomy with advanced perception systems, towards full autonomy.

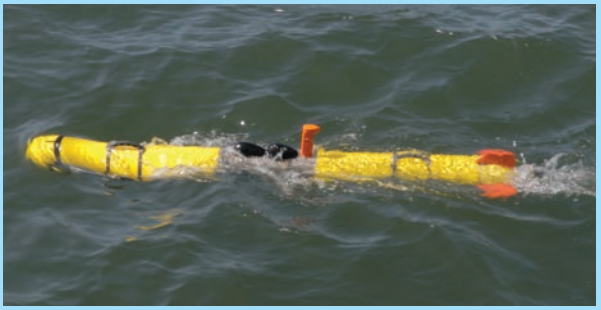
Blueprint Subsea

www.blueprintsubsea.com

Ultra High Resolution Imaging Sonar

Blueprint extended its sonar product range with the introduction of the M3000d dual frequency multibeam imaging sonar. For general purpose navigation and target detection the sonar is operated at 1.2MHz. This provides a maximum range capability of 30m and an acoustic aperture of 20 by 130 degrees. While the image quality at this frequency is impressive, it may be further improved by switching the sonar to 3MHz for target identification. At this frequency the sonar provides an exceptional acoustic angular resolution of 0.25 degrees and a beam spacing of better than 0.1 degrees. Near field focusing is performed digitally within the sonar and offers a minimum range capability of better than 10cm.

All of this is done using the standard Oculus form factor, with a small space envelope and a weight in water of under 400g making it an ideal solution for small ROVs and diver handheld systems.



L3Harris/Oceanserver

https://ocean-server.com

L3Harris Technologies is an agile global aerospace and defense technology innovator, delivering end-to-end solutions that meet customers' mission-critical needs. The company provides advanced defense and commercial technologies across air, land, sea, space and cyber domains. L3Harris has approximately $18 billion in annual revenue and 50,000 employees, with customers in 130 coun-tries. As part of our unmanned maritime system offerings to the subsea defense community, we are proud to offer the Iver family of UUVs. The Iver4 is a next-generation small diameter UUV featur-ing ultra-low logistics, extended mission duration, highest quality sensor data, and swappable pay-load and battery sections.

Digital Edge Subsea

www.digitaledgesubsea.com

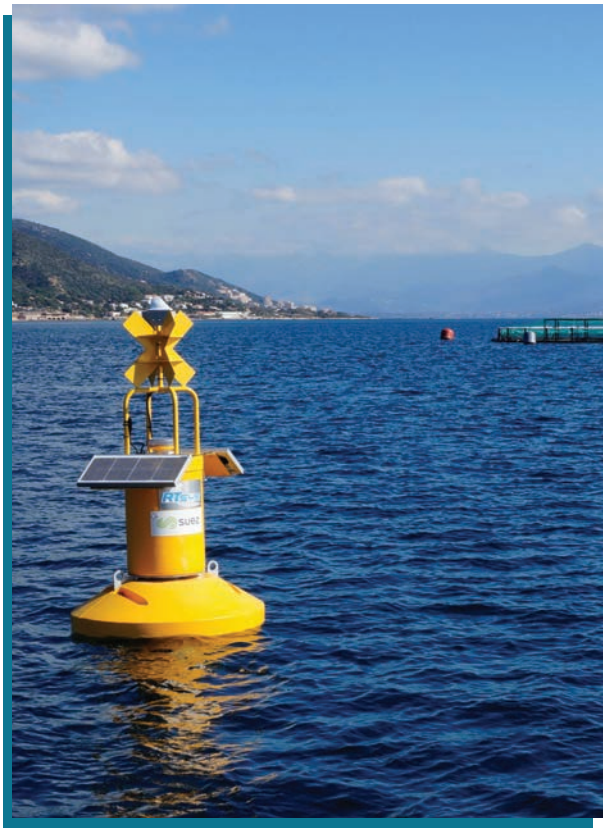
Digital Edge Subsea supplies the digital video recording inspection system, the EdgeDVR. Continuous improvement is the mantra at Digital Edge, and latest developments include the new Version 5 software and hardware, keeping the original mandate of being easy, simple to use and reliable. The software will now have three levels: EdgeLite, Edge and EdgePro. With regards to the hardware, the company will also have three main types, Standard Definition, High Definition and our first 4K system. The addition of a 4K(UHD) model is a reflection of the latest technology that is now being used on some of the latest ROV and diving systems.

Deep Ocean Engineering

https://www.deepocean.com

Last year Deep Ocean Engineering (DOE) has unveiled a new electric, light work-class remotely operat-ed underwater vehicle (ROV), the Phantom X8, designed for deep sea exploration and light interven-tion work.

The vehicle is the largest and most heavy-duty ROV manufactured by DOE and packs a robust design for deep sea maneuverability and power. Configured with six vectored horizontal and two vertical 2.2 kW Tecnadyne brushless thrusters, the Phantom X8 has complete control and authority in any given direction, even in the toughest currents. For clarity underwater, the Phantom X8 boasts high definition (1080p) front (+/-90°) (pan optional) and rear (low light) cameras with 3 LED lights emitting 30,000 total Lumens with adjustable brightness controlled by the pilot control box or GUI.



RTSYS

Caudan, France – www.rtsys.eu/en

RTSYS shows solid skills and expertise in underwater acoustics and robotics with proven success addressing both civil and defense sectors. Marine biologists and offshore companies trust RTSYS for Passive Acoustic Monitoring solutions and AUVs while many Navies around the globe use its products for MCM and ASW. Underwater acoustics embedded in AUV and diverheld systems now offer outstanding communication features displaying in real-time position, navigation data, or text messages. While in operations, divers can thus interact with AUVs, beacons, and the surface allowing maximum efficiency and safety.

Every RTSYS product relies on SDA (Synchronous Data Acquisition) technology allowing high-computing capacities and low-energy consumption. Twenty high-level engineers gather their skills in the company following four areas of expertise: acoustic signal processing, embedded electronics, softwares and underwater robotics and mechanics.

SBG Systems

Carrières sur Seine, France – www.sbg-systems.com

SBG Systems has been designing solutions for marine applications dedicated to surveyors for the motion of their echosounders and for georeferencing for years. For even more performance, the company also completes its offer to surveyors with its in-house post-processing software, Qinertia.

This year, SBG Systems renewed its line of miniature inertial sensors with high-end functionalities and RTK called the Ellipse Series. The third generation of this product line benefits from a 64-bit architecture allowing high precision signal processing. All the INS/GNSS now embed a dual-frequency, quad constellations GNSS receiver for centimetric position, and higher orientation accuracy. The Ellipse Series fits all kinds of marine applications from enhanced subsea applications to hydrography with single beam or side-scan echo sounder. It is also a solution for ship motion and autopilots.

Ellipse is the smallest heave sensor at this level of performance, and the OEM version allows the tightest or deepest integrations. All these features are made possible either in the 17-gram OEM version or the IP68 box version.

The Ellipse-D embeds a dual-antenna RTK GNSS, allowing heading in a few seconds, in all dynamic conditions, and even in challenging GNSS conditions. This inertial sensor provides unmatched precise performance in attitude (0.05°) and heading (0.2°). It is also compatible with SBG Systems' in-house Post-processing software, Qinertia. Post-processing allows even higher accuracy for delivering more precise maps after data collection.

Qinertia is full-featured software that gives access to offline RTK corrections and processes inertial and GNSS raw data to further enhance accuracy and secure the survey, thus enhancing SBG Inertial Navigation Systems' performance.Qinertia now covers all surveyors' projects by offering a license dedicated to GNSS post-processing. This allows surveyors to post-process both static and kinematic GNSS data. Open to the world, Qinertia supports all major GNSS receivers and is now compatible with third-party IMUs.

Copenhagen Subsea A/S

Hellerup, Denmark – www.copenhagensubsea.com

Copenhagen Subsea A/S is a leader in thruster and Remotely Operated Vehicle (ROV) technology.

Headquartered and inspired by its namesake city, Copenhagen Subsea melds the technical with the aesthetic, creating products designed to be reliable, powerful and attractive. Copenhagen Subsea uses the latest manufacturing technology for its thruster and ROV technology; for example, they make diligent use of 3D printing for the propellers.

Copenhagen Subsea has launched this year a new powerful ROV, specifically developed for tough offshore conditions.

The ROV uses eight Copenhagen Subsea thrusters, designed to make it reliable and robust while keeping its position in strong currents and allowing for operation in harsh and demanding environments—qualities which inspired the name "Gorilla."

The Gorilla ROV is equipped as standard with an intelligent Dynamic Positioning (DP) system, enabling automatic control of position, depth, altitude, heading, pitch and roll.

The Gorilla ROV is based on industrial hardware from the Japanese industrial electronics company OMRON. Industrial hardware components are more reliable and are built to handle extreme conditions such as high current inrush from the thruster during deceleration and current overload at fast shifting of the thruster direction. Both of these are critical for the ROV to be able to keep its position in strong currents.

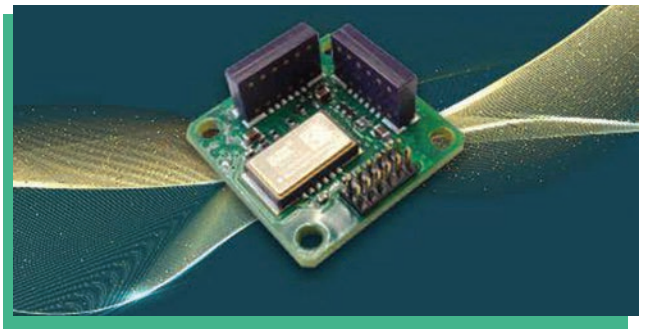
In short, the Gorilla is tough and strong, works reliably in challenging conditions, is simple to maintain with easy access to spare parts and is easily controlled thanks to Copenhagen Subsea's innovative thruster technology, making it suited for completing any task in tough offshore conditions.

EdgeTech

West Wareham, MA – www.edgetech.com

EdgeTech is known for its side scan sonars, sub-bottom profilers, bathymetry systems, AUV, USV and ROV-based sonar systems, combined and customized solutions.

In 2012 ORE Offshore, a provider of acoustic releases, transponders and USBL systems, adopted the EdgeTech name after more than 10 years of operating as an affiliate. This year EdgeTech has continued to develop new products and enhancements to existing solutions. New systems include USV-optimized side scan sonar/ bathymetry systems, new pole-mounted sub-bottom profiling configurations, enhanced 6205s bathymetry systems and expanded ropeless fishing. Over the past year EdgeTech has enhanced its sonar and acoustic release product offerings with a number of new solutions. The EdgeTech 2205 USV-based sonar systems provide combined side scan sonar, bathymetry and optional sub-bottom profiling capabilities that have been optimized for shallow water USV operations. Using the popular 2205 platform, the USV-optimized solutions can operate at lower power settings while optimizing heat dissipation and power consumption, both critical factors for shallow water, small unmanned surface vessels operating in challenging conditions. The system produces real time, high resolution, side scan imagery and 3D maps of the seafloor. Building on the 3400 Sub-bottom profiler solution EdgeTech has developed a new group of unique over-the-side (OTS) pole-mounted sub-bottom profiling systems. The new EdgeTech 3400 OTS offers multiple transducer configurations and PVDF receivers. The EdgeTech 6205s is the only shallow water wide swath bathymetry system to now offer EdgeTech's motion tolerant side scan sonar feature for operation in more adverse weather conditions. The EdgeTech 6205s is a fully integrated boat/pole-mounted Swath Bathymetry and Dual Frequency Side Scan Sonar System that produces real time, high resolution, side scan imagery and 3D maps of the seafloor. EdgeTech's Ropeless Fishing System with embedded acoustic release technology was developed to eliminate vertical lines connecting a surface buoy to bottom fishing gear. Over the past year, the system has expanded to include different trap configurations for various types and depths of fishing.



Silicon Sensing Systems Ltd

Plymouth, England – www.siliconsensing.com

Silicon Sensing Systems is a gyroscope and inertial systems engineering development company, jointly owned by Collins Aerospace and Sumitomo Precision Products. The company was formed in 1999 and is a market leader in silicon micro electro-mechanical systems (MEMS)-based navigation and stabilization technology. Approaching 40 million MEMS gyroscopes and accelerometers have been supplied to customers around the world since the company's formation. Silicon Sensing Systems Ltd celebrated its 20th anniversary in 2019. This JV, between Sumitomo Precision Products and Collins Aerospace, has experienced over 40% business growth since 2016 with interest in it inertial sensing technologies growing as precision motion sensing has become a key issue across an ever-broadening range of markets. Silicon Sensing Systems has already supplied its unique MEMS technology for use in navigation and stabilization systems operating in areas as diverse as ship in-port navigation, subsea mapping, terrain surveying, autonomous vehicle navigation and robotics. Silicon Sensing is currently moving its Japan-based foundry to a new site, which will increase capacity to manufacture its all-silicon sensors, and has already transferred to new, larger premises in the UK.

SEAMOR Marine

Nanaimo, BC, Canada – www.seamor.com

CanPac Marine Services ranks as one of the major commercial diving contractors in Canada. SEAMOR Marine's Mako class ROV works intensively for CanPac in a wide range of commercial applications, the most recent of which was at the pictured lake 1,350 meters above sea level to inspect a low level intake for a dam. Consistent reports such as the one below confirm the extraordinary reliability and performance of the SEAMOR Mako. The Mako helped replace damaged diffusers on a stormwater outfall in a high current area offshore of Victoria, BC, at a depth of 60m (200 ft.).

"The depth and current created challenging conditions for the CanPac team, but the Mako ROV allowed the diving supervisor to survey the site beforehand then closely monitor the divers during the repair operation," said Mr. Robin Li, President of SEA-MOR Marine. "The Mako can cover lots of ground, ascending and descending without issue even in current, to look at different angles."

CanPac's diving supervisor used the Mako to check the condition of the work site and scan for any potential hazards before deploying the dive team.

During the operation, the Mako served as a second set of eyes enabling the supervisor to monitor the divers and work-site in real time to safely manage any developing haz-ardous situations. In an emergency, the supervisor could have used the Mako to over-see the rescue of a diver.

"Our Mako ROV once again proved to be an extremely valuable asset enhancing our productivity and safety during this project." said Ryan Anderson, Director of Operations at CanPac Marine Services. "We chose the Mako for this project mainly because of its proven efficiency in high current."

High current can jeopardize safety in a commercial diving situation, but the Mako ROV was designed to mitigate the risk.

"The Mako runs on DC power supplied from the surface," says Li. "Other vehicles of the same size run AC power directly to the vehicle, which could pose a significant risk to the divers if they come in contact with stray current."

CanPac, with a spotless safety record over its 40+ years of operations, has used the Mako ROV for dozens of inspections over the last months. "It's a versatile, reliable workhorse that can handle a heavy payload and operate in challenging conditions," said Anderson. "It does the job that we've had to use much larger work class ROVs for in the past, and it has resulted in a considerable cost sav-ings for us and our clients."

The Mako ROV is the company's largest ROV and can support a payload of up to 22.5 kilograms (50 pounds), working in depths up to 600 meters (2,000 feet).

Based in Nanaimo, British Columbia on Vancouver Island on Canada's west coast, SEAMOR Marine Ltd. designs and manufactures underwater observation and inspec-tion-class remotely operated vehicles (ROVs) and modular accessories. SEAMOR sells worldwide and has ROVs operating on every continent and in every major body of wa-ter around the globe.

Motive Offshore

www.motive-offshore.com

Motive Offshore developed a renewable hybrid power pack harnessing the power of the sun and the wind to help keep operations running, replacing traditional diesel generators. The integrated power containers are custom-built to suit customers' needs dependant on working environment, kW load demand and location specific needs. Fully marinized and engineered to withstand the rigors of working offshore, the company claims a 96% reduction in OpEx costs through fuel efficiency, examples of which have already been achieved in the North Sea. In addition to power supply, the boxes have the option to provide storage of goods, spare parts and tooling.

Vesper Marine

www.vespermarine.com

Vesper Marine provides marine safety products for commercial and recreational vessels, aids to navigation and marine asset owners. Guardian Asset Protection uses AIS in an innovative way to significantly reduce the risk of damage to submarine cables and pipes, directly warning vessel operators before a potential incident occurs. First, it makes invisible assets visible. Owners of marine infrastructure can create a Virtual Aid to Navigation (AtoN). This is created when a signal sent from a transmitter in an accessible location is used to mark a remote point. The onboard equipment of any ship in the area then automatically alerts crews if they are on a collision course with the marked subsea asset. Second, based on customized rules, Guardian will look for vessel activity that presents a possible threat and proactively send an automatic message.

Picotech Ltd

www.picotech-ltd.com

Picotech is a developer and manufacturer of one-person-portable, autonomous hydrographic survey solutions. In June 2020, Picotech launched what it touts as the world's smallest integrated multibeam echosounder, the PicoMB130 Surf. The PicoMB130 was launched alongside Picotech's brand new USV, the PicoCAT. PicoCAT features an open-source autopilot and uses COTS RC with telemetry and audible alerts for RSSI, vehicle and payload battery consumption and switch warnings to make surveying easier.

Seafloor Systems, Inc.

www.seafloorsystems.com

Seafloor Systems is known for its innovative application of hydro acoustic sonar and unmanned marine surface vehicle technology to the survey industry. Seafloor developed the original Hydrolite echosounder system in 2005 to meet the needs of the US Army Dive Teams. It continues to innovate in the survey grade echo sounder and unmanned surface vehicle sectors. Seafloor introduced the first hot-swappable transducer well technology for the EchoBoat in 2017, which enables the user to quickly swap sonar modules without removing the vehicle from the water. Modules include a multibeam echosounder with integrated IMU, side scan sonar, single beam echosounder, ADCP, and sub bottom profiler.

Sonardyne

Yateley, England – www.sonardyne.com

Sonardyne works with national and international research institutions, as well as governments and commercial establishments, across the energy, oceanographic and defense sectors. The company is supporting and providing swarm control of underwater drones, autonomous vehicle navigation, vessel-based obstacle avoidance, remote data harvesting using unmanned surface vehicles, subsea resident system technologies, seabed imaging and more. From hybrid underwater navigation to high data-rate wireless communications, Sonardyne's core technologies enable users to access to the world's inland waters, coastlines, seas and oceans, where they want, when they want and from any platform – manned or unmanned – for data harvesting, long-endurance surveillance or highly precise survey operations.

Sonardyne has been supporting remote operations, from data harvesting to underwater positioning, via unmanned surface vessels (USVs) and autonomous underwater vehicles AUVs), for more than a decade. It's now also providing USV services for over-the-horizon data gathering, reducing environmental footprints, risk and cost for operators including Shell and BP. Most recently, Sonardyne provided end-to-end data gathering services using an XOCEAN USV to collect data from long-endurance seafloor monitoring instruments, also from Sonardyne, for Shell; completely remotely, without any staff – operator or contractor – having to travel. The vessel was 'posted' to Norway, launched by a local marine service company and the data delivered, in near-real time, to analysts. Sonardyne is also enabling increased confidence in USV navigation using its hybrid inertial-acoustic navigation technology, SPRINT-Nav, which is already established as the high-performance instrument of choice for underwater vehicles. On a USV, SPRINT-Nav provides reliable positioning able to ride out vessel GPS interference, as proven in a recent UK Defence and Security Accelerator (DASA) project. The same family of instruments is also guiding a next-generation subsea vehicles, under-ice AUVs and long-endurance underwater surveillance vehicles, such as the Solus-R. Sonardyne's acoustic, inertial, optical and sonar systems are used for navigation, positioning, imaging, control, monitoring and communications, across the entire marine space. The company's latest offerings include the world's smallest hybrid navigator SPRINT-Nav Mini. It's a new addition to Sonardyne's hybrid inertial-acoustic family of navigation instruments. SPRINT-Nav replaces the separate AHRS, DVL and depth sensors otherwise required for underwater vehicle navigation in a single instrument.

Sonardyne also recently launched its Vigilant Forward Looking Sonar (FLS), providing mariners with long-range awareness and automated alarms of any underwater obstacles on their route ahead, out to 1.5 km. It's suitable for smaller vessels, as well as expedition cruise ships, research vessels or commercial shipping. In addition, Sonardyne is supporting new, more efficient ways of working in the survey and construction market, enabling real-time SLAM calibration of Sparse LBL arrays, reducing operational overheads and paving the way for more to be done remotely, from onshore, with its advanced Fusion 2 LBL and INS software supported by its Wideband 3 embedded acoustic ranging and telemetry communications and 6+ hardware.

SubC Imaging

Clarenville, Canada – www.subcimaging.com

SubC Imaging builds custom subsea cameras and complete imaging solutions. Thanks to the advanced technology and hands-on approach to service, SubC has helped its customers publish ground-breaking research time and time again. SubC provides purpose-built products to assist researchers around the world in gaining new marine insights. These products and solutions help reduce project complexity and provide enhanced return on investment in terms of both time and cost.

In February of 2020, SubC celebrated its 10-year anniversary in the subsea business. Not only has SubC continued to enhance its current subsea imaging solutions that include cameras, LEDs, lasers, and DVRO, it has also expanded its product line.

The Remote Streaming Service is a cloud-based, secure, low-latency streaming service that offers real-time HD video to shoreside offices anywhere in the world for immediate review and monitoring without requiring personnel on board a vessel.

The new Sixgill MK2 Ethernet 20x Optical Zoom camera is a high-sensitivity image processor with ONVIF Profile S and Sony VISCA camera control over IP and web UI.

The low-cost, high-performance Rayfin PowerLine Ethernet (PLE) camera is the latest addition to the Rayfin family and is designed for coastal waters, working over long distances of twisted pair cable. SubC's distributor list continues to grow, expanding to a total of 14 distributors worldwide after four new additions this past year: SUBSEA 20/20, Neotek France, HuiOcean, SeaTech.

Solutions include:

• Digital Stills & 4K (for anomaly identification, clip generation and photogrammetry)

• Observatory (reliable multi-purpose Ethernet camera, mux and data-logger for long duration use)

• Drop/Tow (for smaller vessels working in coastal water of under 500 meters. Powerline Ethernet (PLE) enables low-cost simplification of cables and deployment setup for transmission of video and data)

• Autonomous Camera (timelapse digital stills and 4K video for deployments where live video is not possible or required)

• Multi-camera Survey (includes all of the software and hardware required for an effective inspection without all the cost. Available in HD, SD, IP Ethernet, and 4K configurations)

SubCtech

Kiel, Germany – www.subctech.com

SubCtech offers underwater power solutions and ocean monitoring systems, providing solutions in close collaboration with its clients in science and in industry such as offshore Oil+Gas. Li-Ion batteries PowerPacks, pCO2 analyzers OceanPack and system solutions are our core products and a one-stop service. Its "Made in Germany" products are designed to be easy to handle and efficient. The company has a global focus. SubCtech is certified as a "proved vendor" in the offshore industry according to ISO 13628-6 and API17f for design and operation of subsea production systems and is also certified by ISO 9001:2015. Its qualified engineers are educated and certified for highest-quality IPC-A-600/610 class 3 production and functional safety according to IEC 61508 up to SIL-2 (first SIL-3 product expected in 2020).

SubCtech GmbH, "Subsea Technologies for the Marine Environment," is the producer of Li-Ion PowerPacks and OceanPack measurement systems used for scientific research and industrial monitoring of water quality and oceanographic parameters. Its unique technology, easy maintenance, and construction built for the ocean's roughest conditions make SubCtech products perfect for any type of vessels and platforms. The company reaches all targeted markets with the product family of subsea Li-Ion batteries in the division "Ocean Power." In particular, the Oil + Gas Offshore industry requires increasingly autonomous systems for greater and greater depths. Complete systems are projected together with data loggers and the implementation of sensors.

A Constant level of high quality is ensured thanks to certification and periodic audits by the Oil + Gas Industry. Projects in depths of up to 6000m are realized in the division of "Ocean Monitoring" with the adaptation of sensors for pCO2. The pCO2 analyzers are used for maritime surveillance and research on buoys and ships.

Sunfish Inc.

Austin, Texas – www.sunfishinc.com

Sunfish Inc. is a leader in development of hovering autonomous underwater vehicles for exploration and inspection. Sunfish is a person-portable, 6DOF machine that moves in any direction, assumes any orientation, and independently rotates about any axis. This maneuverability allows Sunfish to sense the environment, acquire data, and build full 3D maps in ways previously unattainable to improve navigation and location accuracy using feature recognition. This capability enables onboard behavioral autonomy, allowing Sunfish to undertake unguided missions. The system is optimized for low-logistics operations, enabled by its light weight (<50 kg) and compact size. Sunfish deployed alongside the 2015 NASA ARTEMIS AUV under ice in Antarctica, conducted the first fully autonomous exploration of a flooded subterranean labyrinth in 2017 at Peacock Springs, Florida, and in 2019 explored the largest subterranean lake on the planet, Dragon's Breath in Namibia.

In August 2019, Sunfish embarked on a National Geographic Society expedition to explore Dragon's Breath. Faced with depths and ranges that exceeded the capabilities of diving technology, divers ultimately abandoned their efforts to survey the cavern and its full extent remained a mystery.

Sunfish currently offers two classes of vehicle: Sunfish Explorer and Sunfish Imager. Sunfish Explorer is an all-acoustic geometric mapping vehicle. Sunfish Imager is a mapping and imaging vehicle using laser mapping technology with optical overlay. All Sunfish vehicles are offered in either 200m or 1,000m depth rating. Standard range is 5 km and 10 km with an upgraded battery. Sunfish carries as standard equipment a 480 beam, 240 kHz multi-beam sonar and an HD forward-looking, bow-mounted camera. Sunfish is designed to operate in four distinct modes: fully autonomy, supervised autonomy, actionscript, and ROV mode.

Teledyne CARIS

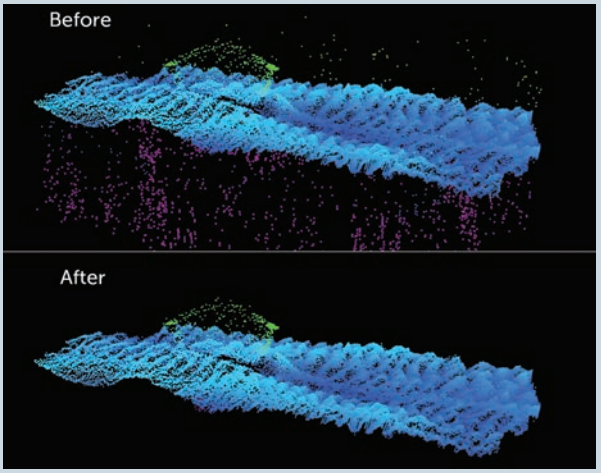
www.teledynecaris.com

Teledyne CARIS has been an innovator in the marine GIS community for more than 40 years. The CARIS toolset provides optimization and realizes true operational advantages. Teledyne CARIS' Ping-to-Chart portfolio features a comprehensive suite of products for processing of raw survey data through to the production and distribution of hydrographic data through new Cloud services. Teledyne CARIS has ventured into efficiency-realizing artificial intelligence with its new CARIS Mira AI platform.

Research on Artificial Intelligence (AI) has seen exponential growth due to breakthroughs in a subdomain called Deep Learning. Deep Learning algorithms allow us to teach a computer to achieve tasks that only humans were previously able to do. Taking advantage of access to large repositories of digital data, powerful computing infrastructure including Graphical Processing Units (GPUs) and domain expertise, CARIS is training Deep Learning algorithms to tackle key challenges in hydrographic data processing. CARIS Mira AI brings these advancements directly to workflows while retaining a seamless user experience across our product line.

The CARIS Mira AI initial offering is the Sonar Noise Classifier, which applies its AI algorithm to identify and clean up to 90% of sonar noise speeding up delivery time on data processing. Backed by Amazon Web Services (AWS), offering a robust, scalable cloud platform means no additional desktop hardware is required to move users into the future of processing.

With these evolving technologies, the AWS-certified team is focused on the safety and security of customer data while it is in our care: all data directed to the CARIS Mira AI platform is anonymized, randomized and encrypted before transmission.



International Submarine Engineering

www.ise.bc.ca

ISE has consistently pushed what is possible for the last 45 years in the subsea and countless other industries. It has created robust and modular AUVs with many firsts (first to have AUVs successfully complete missions in both polar regions, for example). ISE is currently manufacturing its first autonomous AUV docking system which will allow the AUV to find and dock with a capture mechanism for data download, charging and recovery.

Hydromea

https://www.hydromea.com/

Hydromea's LUMA wireless optical systems for high-bandwidth through-water data transfer are compact (size of a deck of cards), lightweight (50g), extremely power-efficient (consumption in mW) and affordable (all units are priced below $10'000 range). Better yet, LUMA is the only optical wireless system on the market certified to be deployed down to 6,000m. In 2019, LUMAs were deployed at 4,200m depth in the South Pacific Ocean to transfer real-time data from instruments placed on the ocean floor. Hydromea scaled manufacturing of its thrusters and as of January 2020, the thrusters are available on its webshop with 48-hour delivery window.

McLane Research Labs. Inc

https://mclanelabs.com

McLane Research Laboratories, Inc. was founded in 1983 to manufacture and develop advanced time-series instrumentation for the oceanographic community. McLane is a leader in time-series in-situ oceanographic profilers, samplers, and flotation. The company produces three main product lines: Profilers, Samplers, and Flotation. In 2019, McLane expanded its Profiler line with the Prawler which collects and transmits sensor data from the surface to 500m of the water column. The instrument travels the mooring wire using wave actuated motion. The Prawler is a field-proven instrument originally developed by NOAA's Pacific Marine Environmental Lab with support from NOAA's Office of Oceanic and Atmospheric Research Climate Program.

NOVACAVI

https://www.novacavi.it/

NOVACAVI, specialist cable designer and manufacturer, is technically supporting the increasing demand of purpose-built cables for drones and robotic vehicles. Specific applications include: aquatic exploration, environmental monitoring, hazardous environments inspection and maintenance, protection and surveillance activities, and search and rescue operations. All cables are entirely tailored to customer's requirements with engineering expertise, comprehensive knowledge of materials and a high degree of manufacturing. Key features include: high strength, optimized dimensions and weight, extreme dynamic and torsion capability, excellent resistance to any external agents, weather-proof proven materials, and custom design and in-house manufacturing.

Turner Designs

San Jose, CA – www.turnerdesigns.com

Turner Designs remains one of the few independently-owned companies focused on providing fluorometers and other optical sensors to the environmental water quality market. Providing solutions to customers around the world for over 48 years. 2020 has been a big year for changes at Turner Designs. Stacey Duff joined as President, replacing Jim Crawford, who is now focused on managing the engineering development. Duff arrives with a strong background in operations and process improvement, introducing Lean Six Sigma to the team. The entire company is now focused on identifying "weaknesses" within the organization and having great fun seeing them get addressed. Turner Designs retired its 10AU Field Fluorometer early in 2020, a product which was introduced in ~1992 with many of those initial units still in use around the world. Its predecessor, the Model 10 introduced in ~1974 was, in many ways, the instrument that established fluorometry as an integral part of environmental research.

Harmful Algal Blooms (HABs) have become a major problem around the world and a major product focus for Turner Designs with products spanning customers' budgets and desired deployments. PhytoFind is at the high end, offering real time in situ algal classification. Real-time abundance estimates are calculated for PE-containing algae (mixed group), PC-containing algae (Cyanobacterial groups), and total algae (green/brown groups). Estimates are reported as chlorophyll µg/L concentrations as well as percent contribution per group relative to the whole phytoplankton population sampled. Cyclops-7 and low power C-FLUOR submersible sensors are available with optics for chlorophyll and blue green algae for simple determination of chlorophyll or PC/PE levels. The C-FLUOR ships pre-calibrated and is now available with a digital output enabling output as a direct concentration estimate. CyanoFluor is a handheld field fluorometer which can quickly estimate the abundance of cyanobacteria in a mixed algal population using phycocyanin to chlorophyll ratios. Monitoring these ratios over time enables users to predict the onset of HABs.

Valeport Ltd

Totnes, England – www.valeport.co.uk

Valeport is one of the foremost manufacturers of oceanographic, hydrographic and hydrometric instrumentation for more than 50 years. Based in the UK, the privately owned, independent family business has a £9.1m turnover and designs, manufactures and services underwater measuring equipment. Today, Valeport has a comprehensive portfolio of underwater measuring equipment and supplies a worldwide customer base that includes: environmental, research, defense, oil and gas, renewable energy, construction, port/harbor, dredging, civil engineering and scientific research sectors. Valeport also pledged its support to a campaign to protect seagrass. Partnering with a UK coastal zoo and aquarium, Valeport's support for the #SaveOurSeagrass research project will help to secure the project's future and provide instruments and expertise to the program. The aim is to protect the seagrass meadows under threat off Tor Bay, on the UK SW coast and use research to begin trialing seagrass cultivation.

Valeport developed the Digital Time of Flight Sound Velocity measurement—which made Valeport the world leader in Sound Velocity technology. Valeport continues to evolve the technology to ensure that SV sensors offer levels of performance that are demonstrably far in excess of competitors. Valeport recently upgraded its most popular sound speed profiler, the SWiFT SVP, to provide enhanced versatility and deployment. An improved depth rating and increased pressure accuracy have now become standard on the SWiFT profiler. Valeport introduced this evolution of the SWiFT profiler in response to customer feedback. The SWiFT is designed with the intention of a seamless workflow at its core, and delivers high accuracy sound velocity, pressure, temperature, salinity and density measurement, with the convenience of Bluetooth connectivity, rechargeable battery and an integral GPS module. The improved SWiFT will now operate down to 500m as standard (previously 200m), whilst retaining all its popular switching on/off.

Cellula Robotics Ltd.

Burnaby, Canada – www.cellula.com

Cellula Robotics is an engineering solutions company based in Vancouver, Canada, that specializes in the turn-key design and production of seafloor intervention and subsea autonomous vehicle systems. In 2019, Cellula built and started sea trials of Solus-LR, a fuel cell powered with 250kWh usable energy, 3000msw long range unmanned underwater vehicle (UUV) for Defence Research Development Canada. It also contributed to many significant projects worldwide, such as creating a CO2 Injection Skid for National Oceanography Centre's STEMM-CCS research expedition, and completing two projects for Canada's Innovation for Defence Excellence and Security program.

Impact Subsea

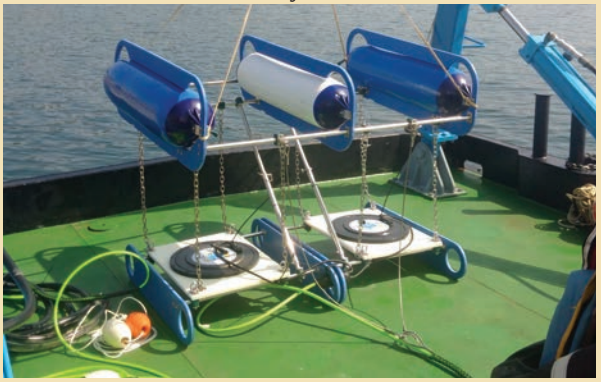
www.impactsubsea.co.uk

Founded in 2015, Impact Subsea aims to set a new standard for underwater sensor solutions, specializing in underwater sensors including: underwater altimeters, depth sensors, AHRS and sonars. It launched its ISS360 Sonar, touted by the company the world's smallest imaging sonar. Available with optional integrated AHRS and two depth ratings; 1500m and 4000m. Impact Subsea also launched a new version of its software, seaView V2. While currently only compatible with the sonar, further features will be added in order to operate with all Impact Subsea sensors. Also launched this year is a full ocean depth Altimeter – the ISA500-11K.

Falmouth Scientific Inc.

www.falmouth.com

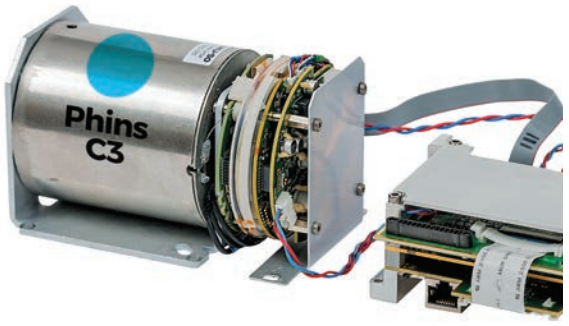
Falmouth Scientific, Inc. (FSI), founded in 1989 based on Woods Hole Oceanographic Institution technology licenses, provides sensors, systems and transducers for survey solutions and applications in salt and freshwater environments. FSI's standard product areas include seismic sources, sub-bottom profilers, side scan sonar imaging systems; current, wave, and tide monitoring systems; advanced electro-acoustic transducers; and acoustic relocation systems. FSI will soon be moving into a new modern facility just a short distance away from the current location by late summer 2020.



HYDROCOMP INC

www.hydrocompinc.com

HydroComp is a leader in providing hydrodynamic software and services for resistance and propulsion prediction, propeller sizing and design and forensic performance analysis. Through its unique array of software packages and services, HydroComp serves more than 1200 naval architectural design firms, shipyards, yacht owners, ship operators, propeller designers, universities and militaries. Underwater vehicle designers require unique analytical capabilities to provide effective and efficient solutions to challenging subsea problems. HydroComp's tools – NavCad, PropElements, PropCad, and PropExpert – provide the critical capabilities necessary for vehicle designers and researchers to better understand and simulate vessel hydrodynamics, propulsion performance, power requirements, vehicle range, energy budgets and silencing of propeller noise.



iXblue

www.ixblue.com

iXblue has been developing better performing navigation and positioning solutions that bring critical operation capabilities to surface and subsea assets (inertial navigation systems, USBL and LBL acoustic positioning systems, forward-looking sonars, etc.). iXblue brings more robust autonomy and more safety to those platforms. This in-house mastering of all technologies relating to navigation and autonomy has led iXblue to develop its own USV (Unmanned Surface Vessel), DriX, which gathered the interest of companies operating in the offshore and geosciences industry and is now considered a game changing tech in those markets.

OceanAlpha

www.oceanalpha.com

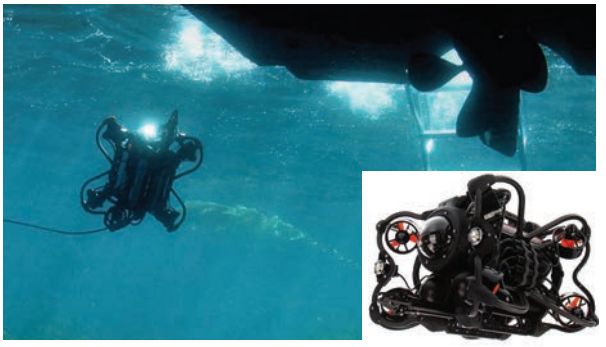
Headquartered in Hong Kong, OceanAlpha Group manufactures unmanned surface vehicles (USV), growing from a small office in 2010 to a workforce of more than 300 today, including 110 R&D engineers. OceanAlpha's Dolphin 1 Smart Lifebuoy, an Unmanned Remote Surface Vehicle, is dedicated to improve response times and make the water a safer place. Dolphin 1 has the ability to both cut through waves and, more importantly, has the lift and buoyancy to carry victims back to safety. Five hundred meters of communication range ensures efficient rescue within visible eyesight.

Moog Focal

www.moog.com/focal

Moog Focal specializes in electrical slip rings, fiber optic rotary joints, hydraulic utility swivels and fiber optic multiplexer solutions for the worldwide marine industry including ROV, seismic, FPSO turret and oceanographic applications. Product features include hybrid packages that combine fiber, electrical, and fluid rotary joints for harsh environments, explosion proof/flameproof for hazardous locations and adaptation to customers' size and mounting constraints. Moog Focal has continued to develop new tech and enhance product offerings, including the release of additional 914-DX expansion card into the 914 X series product line. The 914-DX offers a significant reduction in size for isolated serial channels, and features a software configurable TTL option for the first time from a Moog Focal multiplexer.

MOOG
FOCAL™



RJE Oceanbotics

www.oceanbotics.com

During the COVID-19 lock down, RJE instituted a remote demonstration for the SRV-8 so that customers and prospects could pilot the ROV from anywhere in the world. In March it fulfilled one of its biggest single orders to date—15 ROVs. Another significant development is the addition of Shawn Devlin as Sales Executive. RJE Oceanbotics is a technology based company. The driving force behind Engineer Ryan Engle's SRV-8 design, is the SRV-8's SubNav Software. SubNav is designed to allow the pilot to take full advantage of the SRV-8 design of 8 vectored thrusters that allow for dynamic vectored control and 6 degrees of freedom.

Aleron Subsea

www.aleron-group.com

Aleron Subsea was founded in 2009, becoming fully operational in 2014. ROVQUIP joined the group in 2014 and is now a key ROV tooling supplier. Aleron has a range of in-house and third-party tooling and have been awarded several scopes for manufacturing skid packages and supplying tooling spreads. Aleron Subsea has built specialist ROV's that have assisted in unique renewable projects globally, like its TRACKROV and AUXROV, and in 2020, it launched a new 300HP MultiROV system.

Blue Trail Engineering

www.bluetrailengineering.com

Blue Trail Engineering was founded over a year ago, and in that short time has become a key player in the marine robotics industry. Its Cobalt Series miniature waterproof connectors and cables are designed to offer high reliability at a fraction of the size and cost. In addition, it produces thrusters for small ASVs and AUVs. In December 2019, Blue Trail Engineering introduced the Cobalt Series of connectors and cables, beginning with 3-pin and 6-pin versions. In May of 2020, it expanded the Cobalt Series with a 4-pin high-current version. In June of 2020, it added an 8-pin version and started providing cables with twisted-pair wiring for USB and Ethernet applications.

BeeX Autonomous Systems

www.beex.sg

BeeX is reportedly the first in Asia to manufacture its own hoover-capable AUVs and deploy them off USVs, all controlled with proprietary distributed software. Its vehicles are designed with an autonomy-first concepts, and it has evolved from humble beginnings as an undergraduate robotics team from the National University of Singapore (NUS). Established as a ground-up initiative in 2012, the team, named BumbleBee, participated in competitions funded by the US Office of Naval Research. Six months ago, it was awarded a grant by the Singapore government to provide capital to design and build a two-man portable and hoover-capable AUV. Named A.IKANBILIS, the vehicle will be released for pilots in August 2020.

Dynautics Ltd

www.dynautics.com

Dynautics has operated in the marine sector for more than 20 years, most recently focused on UUV and USV's. When customers demand a product in double quick time, you have to step up and take the challenge. That is what happened when the U.S. Navy wanted a specific UUV. USN had a tight specification and Dynautics had the simulation software (AUV SIM) and control and guidance technology with the Underwater Spectre firmware and hardware to make it a fair fight. Combining these tools, tech and rapid prototyping techniques, the products were delivered, tested and accepted within 100 days, start to finish.

MTR Marketplace

PRODUCT, PROFESSIONAL, VESSELS, BARGES & REAL ESTATE FOR SALE

Advertiser Index

Page	Company	Website	Phone#
31	Balmoral Comtec Ltd.	www.balmorloffshore.com/renewables	011-44-1224-859180
19	Blueprint Subsea	www.blueprintsubsea.com	+44 (0) 1539 531536
9	Deep Ocean Engineering, Inc.	www.deepocean.com	(408) 436-1102
23	Digital Edge Subsea Ltd	www.digitaledgesubsea.com	+44 (1229) 206456
C3	EvoLogics GmbH	www.evologics.de	49 30 4679 862 0
43	HAWX Open Ocean, LLC, SeaRocket	www.HawxOpenOcean.com	Please visit us online
17	JW Fishers Mfg Inc.	www.jwfishers.com	(508) 822-7330
29	L3Harris / Oceanserver	www.L3harris.com	(508) 678-0550
1	MacArtney	www.macartney.com	Please visit us online
45	Ocean Sensor Systems, Inc.	www.oceansensorsystems.com	(954) 796-6583
C4	PanGeo Subsea	www.pangeosubsea.com	Please visit us online
11	Remote Ocean Systems	www.rosys.com	(858) 565-8500
17	SBG Systems	www.sbg-systems.com	Please visit us online
3	Seamor Marine Ltd.	www.seamor.com	(250) 729-8899
21	Silicon Sensing Systems Limited	www.siliconsensing.com	+44 (0) 1752 723330
47	SubC Imaging	www.subcimaging.com/clients	(709) 702-0395
43	SubCtech GmbH	www.subctech.com	+49 (0) 431-22039 884
C2	VideoRay LLC	www.videoray.com	(610) 458-3000

The listings above are an editorial service provided for the convenience of our readers.
If you are an advertiser and would like to update or modify any of the above information, please contact: productionmanager@marinelink.com

Evo Logics®

SMART SUBSEA SOLUTIONS

Delivering data in most adverse conditions: underwater acoustic modems with advanced communication technology and networking

Accurate USBL and LBL positioning of underwater assets

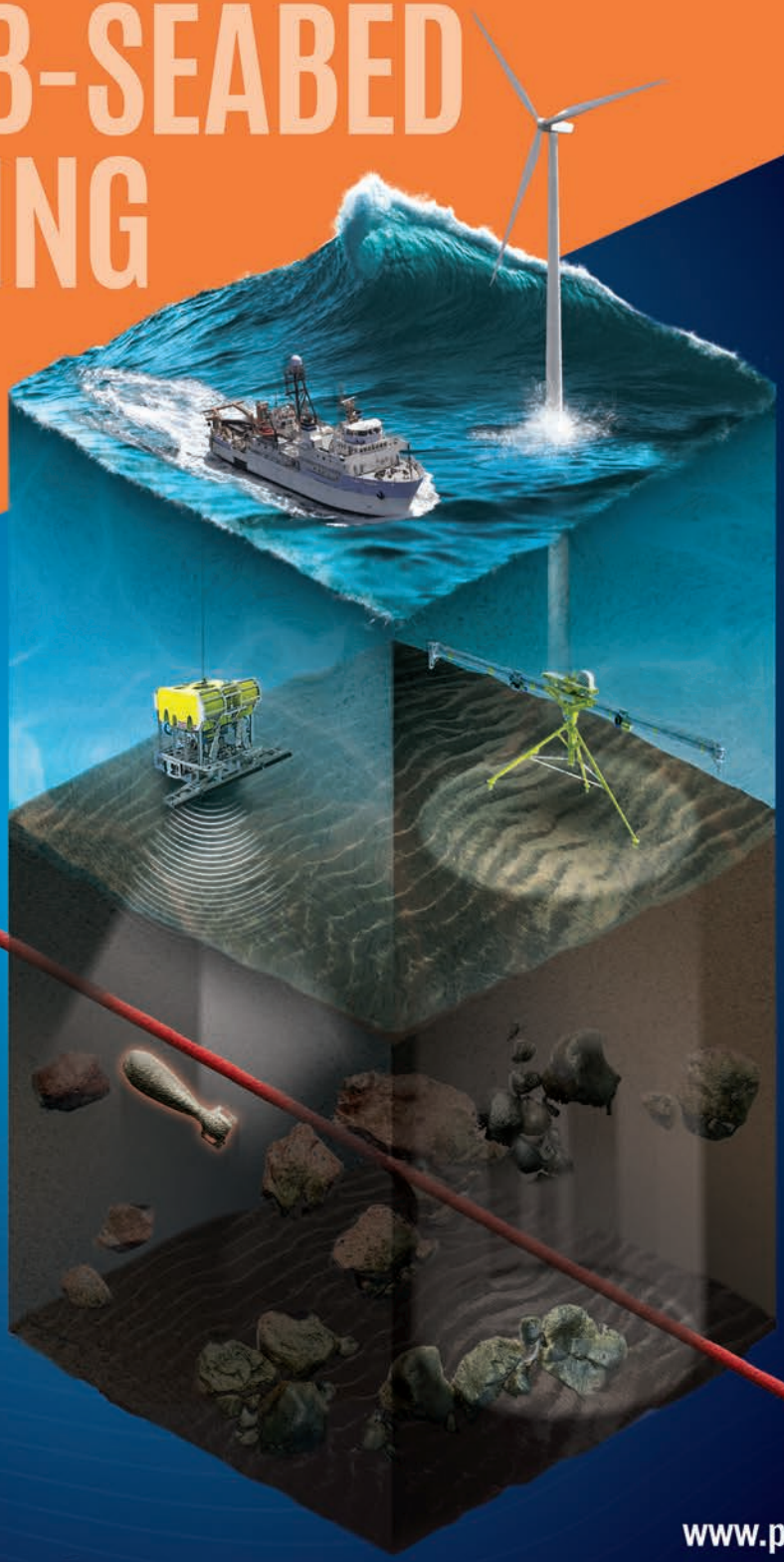
Modem emulator and other cost-saving developer tools

Autonomous surface vehicle for bathymetry, monitoring and AUV support

sales@evologics.de

EvoLogics.de

THE GLOBAL LEADER IN SUB-SEABED IMAGING



SUB BOTTOM IMAGER™

Real time 3D volumetric Synthetic Aperture Sonar (SAS) provides high resolution for:

- Pre-route survey;
- Depth of burial;
- Out of straightness;
- Decommissioning;
- Unexploded ordnance detection;
- Marine archeology

ACOUSTIC CORER™

3D volumetric Synthetic Aperture Sonar (SAS) images hazards up to 30-40 m deep in complex sub-seabeds for:

- Offshore wind farm foundations;
- Subsea installations;
- Drill rig positioning;
- Borehole replacement;
- Excavated drilling centers

www.pangeosubsea.com

PANGEO SUBSEA
sounding out risk

St. John's, NL, Canada Tel +1 709 739 8032
Dartmouth, NS, Canada Tel +1 902 943 5223
Alexandria, VA, USA Tel +1 401 439 8738
Aberdeen, UK Tel +44 1224 766180