UT TWO

UNDERWATER TECHNOLOGY

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NemoSens AUV

SUBSEA NEWS

VICTORY

Shell has taken a final investment decision on the Victory gas field in the UK North Sea, approximately 47km north-west of Shetland.

It will feature a single subsea well tied back to existing infrastructure of the Greater Laggan Area system, using a new 16km pipeline.

It is anticipated the Victory field will come online in the middle of the decade and at its peak, produce enough gas to heat almost 900,000 homes per year.

This represents around 150 million standard cubic feet per day of gas (approximately 25,000 barrels of oil equivalent per day). Most of the field's recoverable gas is expected to be extracted by the end of the decade.

- TechnipFMC has been awarded a significant contract by bp for its Argos Southwest Extension project in the Mad Dog field.

TechnipFMC will install pipe and an umbilical, tying back three new wells to the Argos platform in the Gulf of Mexico.

- Subsea7 has announced the award of a sizeable extension of an existing frame agreement by bp, for subsea construction, inspection, repair and maintenance services (IRM), across bp's North Sea assets.

Under the terms of this two-year extension to the end of 2025, Subsea7 will provide an IRM, survey and a light construction vessel, complete with work class and observation ROVs.

MACARTNEY LAUNCHES NEW TRUSTLINK HYBRID CONNECTOR WITH MINIMAL FOOTPRINT

MacArtney has introduced the Hybrid connector, a compact addition to its TrustLink Metal Shell series. Designed to meet customer demands, the Hybrid seamlessly delivers power, data and communication in one.

TrustLink Metal Shell

The TrustLink Metal Shell (MS) design prioritises reliability in a high-density connector, addressing the challenges of harsh marine environments with limited space.

Paul Anthony, Global Business Manager Connectivity, emphasises the Hybrid's innovation: "With the Hybrid connector, MacArtney has taken this a step further. The single-footprint Hybrid is ideal for tight spots. With two optical passes and four electrical contacts, it enhances versatility while reducing the number of connectors required."

"Building on the success of the TrustLink MS connectors, the Hybrid naturally extends the series. It is developed in response to customer demands for a small, all-in-one connectivity solution supporting numerous applications, including efficient and reliable data transmission with minimal attenuation and interference."

Leveraging MacArtney's proven OptoLink technology, initially designed to deliver dependable fibre optic connections in a compact connector, the Hybrid excels in high-speed data and video transmission.

This is achieved through minimal insertion loss and low back reflection.

Expanded optical beam technology ensures robust and secure connections, positioning it as the ideal connectivity solution where the accuracy and integrity of transferred data are paramount.

Furthermore, its easy-to-clean connector design ensures seamless maintenance.

Acknowledging the need for accessibility and ensuring a quick turnaround for our customers, the Hybrid will be available from stock.

TrustLink Metal with two optical passes and four electrical contacts

BAYONET AUGV

Greensea IQ will use the Oceanology show in London to address the challenges of working in the surf zone by using its Bayonet AUGV.

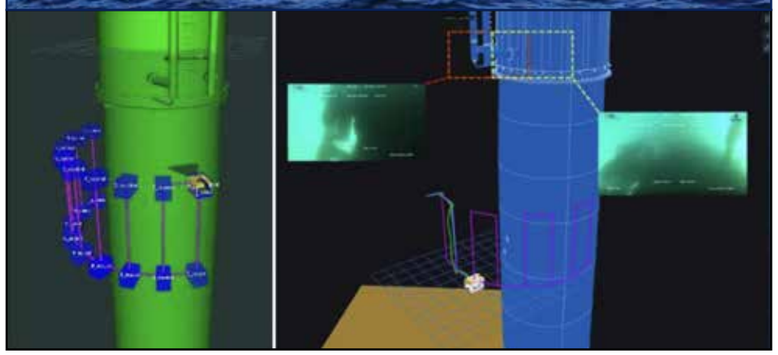
Designed to navigate accurately and steadfastly through dynamic surf zone conditions, Bayonet AUGVs provide real-time, actionable data, enhancing situational awareness for operators in near-shore operations.

The Bayonet AUGV product line, including Bayonet 150, 250, and 350, caters to diverse operational needs. From smaller size and lightweight, to larger two-person portable crawlers capable of handling heavier and larger payloads, Bayonet vehicles offer access to challenging and previously inaccessible environments.

Bayonet AUGV

Through Greensea IQ's Robot as a Service (RaaS) offering, the Bayonet platform is very accessible without the burden of large capital expenditures to acquire and maintain it, making it ideal for both short- and long-term projects.

Providing the only cost-effective solution capable of working within the complexities of surf zone conditions, it can accomplish a range of applications including coastal zone management, RTK survey to support beach renourishment projects and UXO identification.



MONOPILES

Recently, Forssea's ARGOS was mobilised onboard *Louis Dreyfus Armateurs* (LDA) crew transfer vessel to execute subsea monopile inspection on the Saint-Nazaire offshore wind farm.

This project was sponsored to validate the capability of diving directly from the field asset to avoid external vessel mobilisation expenses.

The CTV was moored on the monopile to cut gas/oil consumption during the ROV dive. The method statement showed that the ARGOS compact ROV spread facilitated metocean window selection while reducing maintenance cost and associated CO_2 emissions, even in the harsh Atlantic coastal environment with its significant tide amplitude.

OWF

Forssea Robotics also completed first OWF autonomous inspection during the Saint-Nazaire intervention. This demonstration followed several steps:

- Mission preparation based on client digital asset
- ROV initialisation on the first point of interest
- Autonomous foundation survey (path following) with no need for USBL sensor (subsea acoustic positioning)

Overall, autonomous flight proved to effective for inspecting standardised structures like monopiles, with up to 50% faster survey maintaining very stable video feed and making each trajectory predictable. Forssea is planning to commercialise this solution early 2024 in addition with real-time remote supervision and video annotation capability, to reduce offshore personnel requirements and optimise dives during low tides, making CTV planning more flexible.

Moreover, a new cutting-edge visual odometry system will soon be deployed and interfaced with the ROV to improve navigation accuracy in shallow water.

AUV SERVICE

Gdynia- based Enamor is a research and production company with a strong focus on cutting-edge technology projects in navigation, communication, hydrography, and automation.

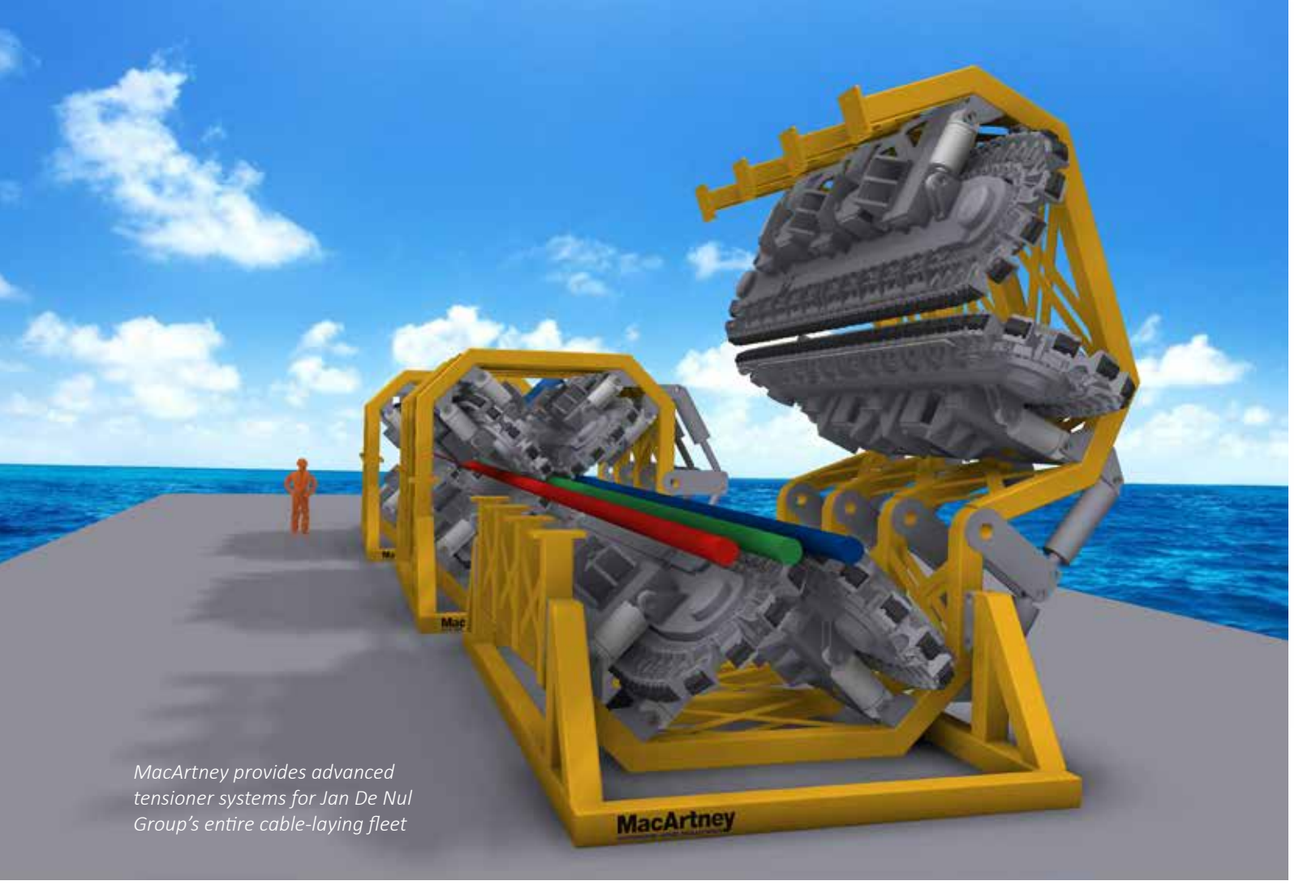
Their collaboration with Teledyne Gavia spans over a decade since the initial delivery of Gavia AUVs for the Polish Navy EOD divers in 2012 and subsequent Gavia deliveries including for the Kormoran class MCMVs.

In the first half of 2023, Enamor's engineers and technicians underwent rigorous training at Teledyne Gavia to perform AUV maintenance routines in Poland.

As a result, Enamor has now been officially appointed as a regional Service Center for AUVs in Europe,

a testament to their dedication to quality service and support.

This development highlights Teledyne's commitment to ensuring AUVs' operational readiness and efficiency in Europe. Teledyne Gavia's AUVs, known for their low logistics modular design, can be rapidly transported and maintained, increasing operational availability and reliability. This versatility allows AUVs to be configured for various missions, including mine countermeasures (MCM), search & salvage, hydrographic survey, and critical underwater infrastructure inspections.



MacArtney provides advanced tensioner systems for Jan De Nul Group's entire cable-laying fleet

CEMAC TENSIONER SYSTEMS FOR COMPLETE CLV FLEET

MacArtney Offshore Wind Solutions,specialising in offshore mission equipment, has announced an expansion of its partnership with Jan De Nul Group.

The company has been entrusted with designing and supplying custom CEMAC tensioner systems for Jan De Nul Group's entire cable-laying vessel (CLV) fleet, including the world's largest, the *Fleeming Jenkin.*

MacArtney's comprehensive scope involves designing, constructing, and delivering advanced tensioner systems for Jan De Nul Group's entire cable-laying fleet, including the *Connector*, *Willem de Vlamingh* and the new *Fleeming Jenkin*. The scope also encompasses upgrading tensioner systems previously delivered for the *Isaac Newton*.

"Our involvement extends to the recently announced XL CLV - the *Fleeming Jenkin*- boasting a cable carrying capacity of 28,000 tonnes and engineered for ultra-deep laying in waters up to 3,000 meters, as well as bundled lay operations,"

For the XL CLV, MacArtney will supply three high-capacity CEMAC fourtrack main deck tensioners designed to facilitate bundled lay operations with minimised cable distance and combined lay operations up to 150t, two CEMAC loading arm tensioners and associated fully electrical 1-tonne cable engines.

Recognising the technology expertise following previous collaborations with MacArtney Group on a 50t all electric Launch and Recovery System (eLARS), Jan De Nul Group engaged MacArtney to develop a largescale, leading-edge solution for their CLV fleet.

"MacArtney's mission-critical equipment solutions are known for their exceptional versatility and seamless integration with clients' existing systems," said a source.

"The electrically driven tensioners ensure safe and controlled cable handling, with real-time monitoring of cable integrity.

"All equipment is fully integrated with the vessel's central control system. The solution is futureproof and designed to handle Jan De Nul Group's advanced export and interconnect cable installations."

BREAKWATER POSITIONING

Breakwaters play a critical role in protecting coastal structures and ensuring the safety of ports and harbours.

Ensuring their stability is paramount, as any failure can lead to costly repairs, operational disruptions, and potential hazards.

Correct block placement is a fundamental aspect of breakwater stability, governed by various factors such as contact, orientation, and density. Teledyne's SeaBat T51 and SEABIM software have joined forces to offer a comprehensive solution in pursuit of accurate and efficient block placement analysis.

The primary challenge lies in precisely placing concrete blocks within the breakwater. Incorrect placemen can compromise stability, leading to block movement, interlocking issues, and structural damage.

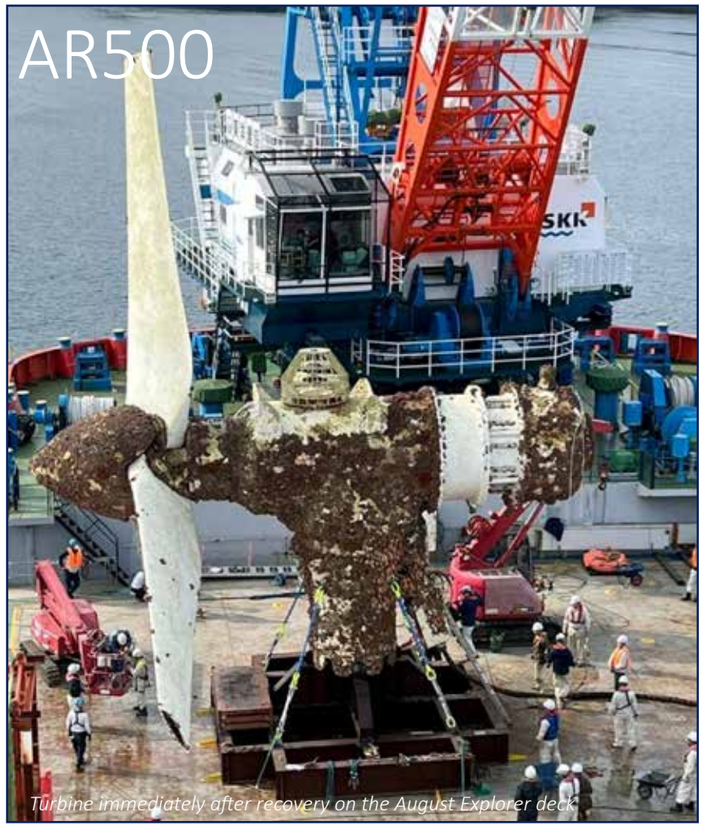
Traditionally, diver-assisted surveys have been used for analysis, but these pose risks to human safety, lack reliability, and may not provide the necessary parameters for accurate assessments. Furthermore, identifying incorrect placement early in construction is crucial to prevent expensive rework.

"By leveraging the high-resolution data provided by the SeaBat T51, SEABIM ensures accurate and detailed analysis of block placement, interlocking quality, and block condition," said a spokesman.

"This synergy enables preventive maintenance operations to be planned efficiently, reduces the risk of structural failures, and minimises costly rework during construction."

Breakwater

AR500



Turbine immediately after recovery on the August Explorer deck

The AR500 tidal turbine has successfully completed Phase 1 of the Goto Islands pilot project and was recovered from the Naru Strait in December 2023.

This phase concluded 12-months of generation with an impressive 97% availability. Built upon the success of the pilot project, the turbine is now ready to be locally upgraded and redeployed in Q1 2025.

The Proteus Marine Renewables Operations team, coupled with local support from Toyo Construction, Goto Transportation and Shibuya Diving, executed the successful recovery in 2 days. The recovery operations included the retrieval of the export cable dry mate connector, followed by the AR500 turbine itself using Proteus bespoke in-house subsea handling equipment.

Our small offshore team executed the works with their usual high standards of safety, planning, contingency and efficiency in a very challenging environment. Anyone that has worked in strong tidal flows will the know the challenges it brings.

The successful recovery also marked a significant milestone as the first retrieval of a tidal turbine using a Japanese DP vessel.

The *August Explorer* was the subject of much scrutiny and analysis prior to the operations and she proved to be a versatile and capable vessel when it came to the operations.

The operations were also completed without the use of a work-class ROV. This was made possible with the use of Proteus bespoke in-house subsea handling equipment.

ISLAND OCEAN

DeepOcean will charter a converted, battery-powered multi-purpose support vessel *Island Condor* – to be re-named *Island Ocean*) – following conversion and upgrade. Equipped with a 150t crane, it will provide subsea inspection, maintenance, and repair (IMR), light construction and recycling services.

As part of the conversion process, the vessel will undergo an extension of approximately 11. Additionally, dual ROV hangars will be installed, the superstructure will be extended, the DP system will be upgraded, and a large battery pack will be installed. Furthermore, a state-of-the-art launch and recovery system for the ROVs will be installed.

HYDROWING BARGE

HydroWing has designed an innovative new barge which will help drive down the cost of installation and maintenance for its patented tidal stream array technology.

HydroWing is designed to be a cost-effective and scalable solution to tidal stream energy generation and was the largest tidal stream project in Wales to be successful in the UK government's latest 'Contracts for Difference' round, having been awarded a 10MW project at the Morlais tidal energy site in Anglesey.

Commercialisation of the tidal energy sector has so far been held back by high operations and maintenance costs. HydroWing's next generation technology addresses that challenge head on. Its HydroWing technology offers a modular, reliable solution, based on its unique patented design. The wing system streamlines operations and maintenance by allowing for removal of sets of tidal energy turbines without the need to remove or work on the foundations.

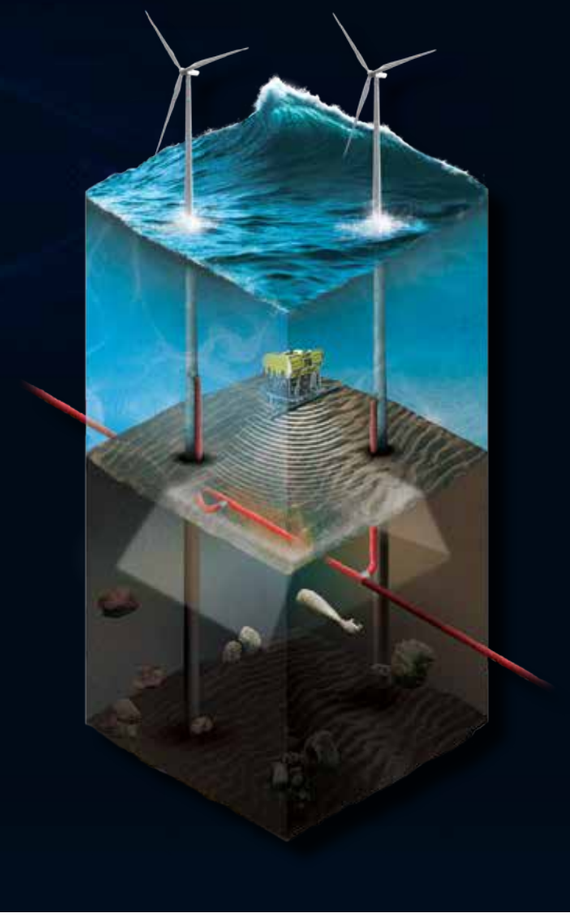
The new Quad Hull Barge is the latest innovation to the HydroWing system, which further increases productivity and drives down costs.

Richard Parkinson, MD of Inyanga Marine Energy Group, which is the parent company for HydroWing, said: "Deployment, recovery, and operations and maintenance are large factors in determining the levelised cost of electricity.

However, offshore construction vessel availability is very weak with expensive day rates. This means that the cost of planned and unplanned offshore operations is very high. HydroWing's new Quad Hull Barge has been specifically designed to tackle this issue, driving down costs and ensuring the turbines can be effectively maintained at low cost and with reduced downtime.

"By using four hulls connected by crossbeams and arch support beams, the limit to load width is dramatically increased. Where commercial vessels would typically need to place the load onto the deck with little to no overhang of the load, the Quad Hull Barge locks the load after lifting to the arch.

This reduces offshore handling and makes the operation much safer. It means that the width of the load can be independent of the vessel width.



LIFT BAG LOBSTER TRAPS

Teledyne Benthos has entered into a partnership with Sea Mammal Education Learning Technology Society (SMELTS) that brings forth a game-changing solution for sustainable ropeless lobster fishing.

Through the integration of Teledyne's industry-standard acoustic modem technology and the new Acoustic Trigger feature, these advancements are set to revolutionise the lobster and crab fishing industries.

Teledyne Benthos and SMELTS have worked together and leveraged Teledyne's proven acoustic modern technology with SMELTS' ropeless lobster traps.

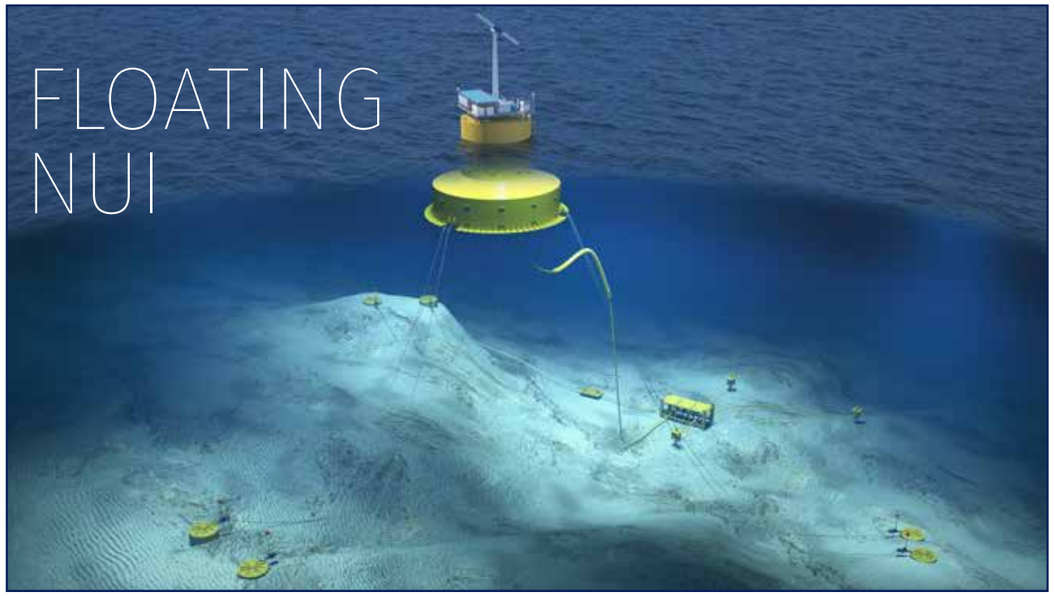
Along with this partnership, Teledyne is also excited to introduce the Acoustic Trigger feature, which will enable a safer and more efficient fishing experience.

Extensively tested through a series of sea trials over the past several years, this technology has proven its potential to positively impact the lobster and crab fishing industries.

Teledyne Benthos, renowned for its underwater communication technology, introduces the innovative Acoustic Trigger feature, which enhances the capabilities of Teledyne Benthos acoustic modems, allowing for seamless integration with external devices.

This enhancement provides users with reliable and high-performance subsea wireless control by leveraging the robustness of Benthos technology and the redundant security features associated with Teledyne Benthos modems.

Ropeless lobster traps



BUOYANT PRODUCTION TECHNOLOGIES AND PETRONAS TO JOINTLY DEVELOP NEW TECHNOLOGY TO UNLOCK CHALLENGING SUBSEA TIEBACKS

Buoyant Production Technologies (BPT), a subsidiary of Crondall Energy and Petronas Research have together embarked on a Joint Industry Project (JIP) to qualify new Floating NUI (Normally Unattended Installation) technology for deployment on offshore projects.

The technology qualification process will allow unmanned floaters to be deployed offshore to both power and control subsea developments without the requirement for a long-distance static umbilical. This will transform the feasibility of longer distance oil and gas tieback projects and has the potential to significantly improve project economics and reduce overall project emissions.

BPT and Petronas have jointly developed the specification and qualification objectives for the demonstrator project. The engineering phase commenced in the summer of 2023 and the parties expect to commence fabrication in Q1 2024.

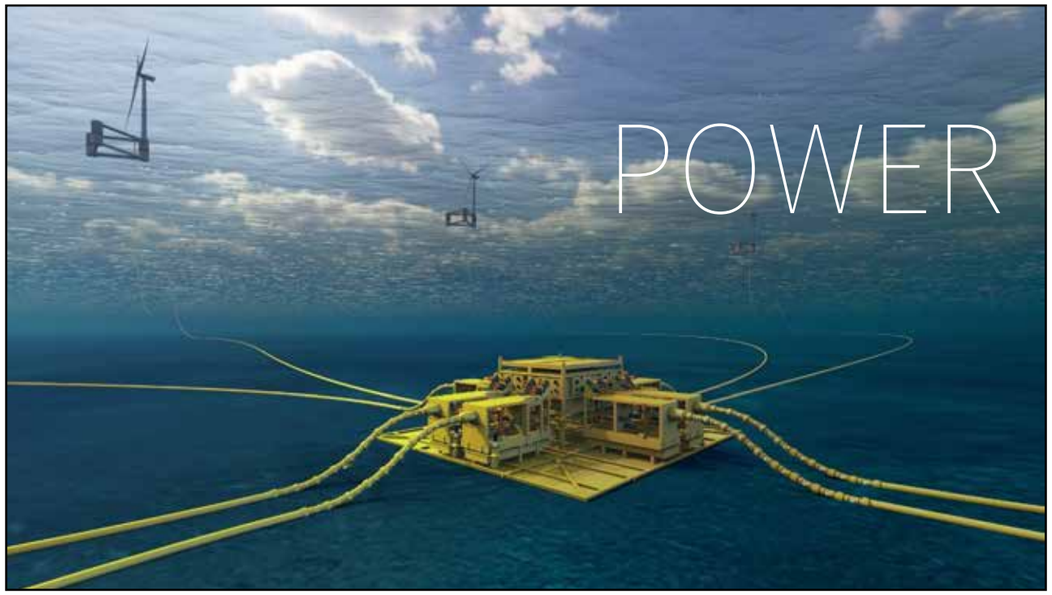
The small payload demonstrator unit will be installed at the FABTEST site offshore Falmouth harbour in the UK, in Q4 2024, followed by a comprehensive 12-month testing programme.

The testing phase will demonstrate the performance of the floater and ability to remotely monitor and control this uncrewed floating facility in a representative ocean environment.

The project and technology qualification programme will be independently verified by a leading Classification Society.

Small payload demonstrator

SUBSEA NEWS



Aker Solutions has signed a front-end engineering and design (FEED) contract with the Marine Energy Test Centre (METCentre) in Norway to pilot new subsea power system Subsea Collector.

This presently consists of two floating offshore wind turbines located 10 kilometers off the southwestern coast of Karmøy. The test area will expand to seven floating offshore wind turbines from 2026.

Subsea Collector provides an alternative solution to connect multiple wind turbines electrically in a star configuration instead of the traditional daisy chain pattern, allowing for more flexibility in offshore wind farm architecture and construction.

The design also allows for reduced cable length per turbine and park, as well as less vessel time and installation costs. Initial findings support total cost savings on a 1GW floating wind farm of up to 10 percent.

The main component parts of the Subsea Collector comprise a 66kV wet mate connection system provided by Benestad and subsea switchgear with supervisory control and data acquisition by subsea power and automation alliance partner, ABB. Installation will be carried out by Windstaller Alliance, an alliance between Aker Solutions, DeepOcean and Solstad Offshore. Aker Solutions will also provide the static export cable to shore.

The METCentre evaluated several alternative configurations for its new cable infrastructure and concluded by moving forward with a pilot installation of Aker Solutions' Subsea Collector to enable the expansion of the test site.

OFFSHORE CHARGING

EnBW and bp, developers of the Morgan and Mona Offshore Wind Farm Projects and Stillstrom, a pioneer of innovative offshore charging solutions, have initiated a comprehensive feasibility study to assesses the operational, technical, and economic viability of integrating offshore charging solutions for Service Operation Vessels (SOVs) and Crew Transfer Vessels (CTVs).

The study specifically focuses on offshore charging solutions connecting and integrating to the wind farms' offshore substations.

Offshore charging solutions for Service Operation Vessels (SOVs) and Crew Transfer Vessels (CTVs)

EdgeTech, a leader in high resolution sonar imaging systems and underwater technology, has increased the standard depth rating to 3,000 meters on all new 2050 combined tri-frequency side scan sonar and high resolution sub-bottom profiling sonar systems.

The 2050-DSS is a tri-frequency side scan sonar system, where any two, operator selectable, frequencies can be operated simultaneously.

The system can be provided with either a 120, 410 & 850 kHz towfish, or a 230, 540 & 850 kHz towfish. Additionally, both towfish options are equipped with a 2-16 kHz sub-bottom profiler, that utilizes a PVDF panel receive hydrophone.

The 2050-DSS comes complete with a combined towfish, digital telemetry that runs over a single coaxial cable, a 19-inch rack mount topside interface, and EdgeTech's DISCOVER acquisition software.

The 2050-DSS can be integrated with several auxiliary sensors such as magnetometer and USBL responder. Additionally, an interface is fitted to the electronics so that the electronics and sensors can be mounted onto an ROV. The 2050-DSS is ideal for applications such as cable and pipeline surveys, marine construction surveys, pre and post dredging surveys and more. The new increased depth rating enables an even larger scope of applications particularly in relation to the use of the systems on ROVs.

MICRO AUV

NEMOSENS: HOW MODULARITY TAKES THE LEAD OF MICRO AUV MARKET

Micro AUVs were designed to revolutionise ocean exploration and research by offering compact platforms, very affordable and easy to use. They proved especially among the civilian sector users to be an invaluable tool for a better understanding of our oceans.

Equipped with different configurations of sensors, sonars, cameras, and other intelligence gathering instrumentation, micro AUVs offer the most efficient way to quickly collect data.

But after some years of curiosity, the growing interest in these new compact and competitive systems made users very quickly raising their level of requirements, drifting from acceptable single configuration platforms to strong needs for multiple solutions on one single asset, going far beyond the limits of platforms too compact to integrate more than two or three sensors.

This is how NemoSens, designed by French company RTsys in 2018, changed the way of thinking the needs of underwater survey by micro AUVs, starting with a fairly simple question: how to better understand oceans in order to mitigate climate change and protect marine life? To this question a direct and simple answer keeps coming up: the use of micro AUVs to replace larger vehicles that are too expensive for inspection's needs over limited areas.

Fair enough but if the micro AUV is only dedicated to one or two scope of actions, then the need of several vehicles increases the cost package as well as the logistic on site and the maintenance constraints during systems' lifetime.

The success of RTsys micro vehicle lies in the customization of the vehicle based on specific mission requirements. Different modules can be easily swapped or added, enabling the AUV to adapt to various tasks, environments, or research goals.

As technology advances, individual modules can be upgraded without having to replace the entire AUV, this makes it easier to stay current with the latest sensors, communication systems, or other technologies. Different missions may require specific sensors or equipment.

A modular AUV like NemoSens answers to this constraint as the only micro AUV of the market with modular architecture and swappable dedicated modules. Operators can easily switch between different sensor payloads, to collect diverse data without the need of several dedicated AUVs for each type of missions. In addition to the ease of operations, this new technological approach also results in costs saving, not only by using one unique modular vehicle but also if a specific module fails or needs maintenance, it can be replaced quickly without affecting the entire AUV's operational status. In some cases, users may be able to perform field repairs by replacing or repairing specific modules without specialized tools or extensive technical knowledge.

A single NemoSens can be configured with various payloads such as camera, lights, DVL, CTD sensor, SSS

In practice, NemoSens can be equipped with many types of equipment such as multiparameter probes (eg, CTDs), side-scan sonar, video cameras, magnetometers, altimeters, ADCPs and many more... When outfitting the NemoSens with new sensors, RTsys engineers are looking for compact devices (in size and weight), easily integrable, with high quality data acquisition, and affordable enough so that the AUV remains accessible to a wide range of consumers.

The team at RTsys is constantly trying to improve their designs and functionality to be even more adaptable and accessible. "We are always looking for new functions to offer to our users," comments Cyrille Lohier, RTsys AUV Product Manager. "So this could typically come from smaller probes or new sensors offering the possibility to monitor more parameters, always with the target of using one single platform!

OPEN ARCHITECTURE

The modularity of NemoSens comes from its internal processor: an open architecture operated under LINUX.

Researchers can use NemoSens as a platform for experimentation and testing, this enabling users to rapidly prototype and evaluate new technologies without redesigning an entire AUV for each new sensor or item to be tested underwater. New DVL, upgraded multi parameter sensors, new technology of sonar: nothing is better than NemoSens to test new prototypes in real conditions underwater.

With a 300m depth rating and an extreme portability (less than 1m and less than 10 kg), its open LINUX architecture also allows users to develop their own navigation algorithm for greater flexibility and maximal use. Engineered for the precise identification and localization of underwater target across large search areas,

NemoSens delivers ultra-high accuracy positioning thanks to its acoustic communication system. This bundle of features makes NemoSens the only micro AUV of the market to provide a modular and multi features platform with high positioning accuracy.

OCEAN EXPLORATION AND RESEARCH

Designed in a collaboration between NOAA's National Centers for Coastal Ocean Science (NCCOS) and RTsys, NemoSens was specifically designed to fill a technological gap and a growing need to provide sufficient images cost-effectively, to gather crucial baseline data about the seafloor, and track changes to these ecosystems over time in order to characterize ecosystems and inform decisions about offshore energy development, sustainable fisheries and protecting special places in the ocean.

NCCOS will use several vehicles to collect high-resolution digital images of the seabed as deep as 300m inside the United States Exclusive Economic Zone and will therefore play a vital role in NOAA's ongoing mission to protect and preserve oceans and support a vibrant blue economy.

This new state-of-the-art configuration has been equipped with SwordFish: an imaging payload developed by US manufacturer Arctic Rays and made of a fully integrated camera + lighting solution to provide turnkey imaging acquisition for seafloor survey. This swappable imaging payload features geo-referenced digital capture of

High-res photo captured with Arctic Rays SwordFish imaging payload © NOAA

4K UHD video and still images with high-output dual-mode lighting and an onboard CPU and SSD storage.

Like every modular section of NemoSens, this payload is integrated while utilizing sustainable energy sources and thus minimizing its environmental footprint for extended mission durations. This plan is part of the collaborators' commitment to fostering a sustainable future for our planet.

Three primary units are in process for delivery to NOAA's lab in Beaufort, North Carolina, early 2024. Pierre-Alexandre Caux, RTsys Business Director, said "we are truly honoured to have been chosen by NOAA's National Centers for Coastal Ocean Science to elevate the research in marine biology, oceanography, and environmental science. Upgrading NemoSens for studying marine life, mapping ocean floors, and collecting data on underwater ecosystems widens once again the capability of this unique and versatile micro AUV.

The democratisation of our combined expertise and shared technology will definitely lead to a more comprehensive understanding of oceans and marine environments with a single micro AUV unit, fully modular and versatile to answer to tens of different mission with only one single platform."

With more than 50 configurations already delivered across the world, NemoSens is leading the sector of micro AUVs while offering the most flexible underwater survey solution to scientific, industrial and defence users.

SPILL DETECTION

NORWEGIAN COMPANY VISSIM RECENTLY WON A CONTRACT FROM AKER BP TO EQUIP THE VALHALL, ULA, EDVARD GRIEG, IVAR AASEN, ALVHEIM AND SKARV INSTALLATIONS WITH ITS ADVANCED OIL SPILL DETECTION SOLUTION.

Vissim was founded in 1988 as a navigation and simulation technology company. Since then, it has been innovating and developing systems for the marine industry. In 1997, the first coastal surveillance and the first VTS was released, followed by several new technologies. In 2009, the first oil spill detection system was made available.

"The service is based on the fact that when oil floats on water, the two materials behave very differently due to their relative densities and it is these dissimilarities that we look to quantify," said Håvard Odden, director of the company's North Sea operations.

"Radar is routinely used in offshore Installations, so effectively, the physical hardware is already available. Our system simply takes the output from the radar and runs the data through our software.

"The system is compatible with all

Screen image

analogue magnetron-type radars and even the new generation of digital radars as long as the software is fed with the raw signal. If it is processed too much before we receive the input, it becomes more difficult

“In fact, we are not even restricted to radar from offshore installations – we can also apply the algorithms to aeroplane radar or even satellite output. Satellites are very powerful and able to scan a much bigger area but their downside is that as they only pass once or twice a day and so do not gather information in real time. It may be 24 hours before a leak is detected or confirmed and thus a large amount of oil can be released between each satellite passing over.

"Conversely, our system is physically closer to the leak. This minimises the response time, allowing operators to act quickly and reduce the consequences of the oil spill.

"In addition to offshore installations, the system can also be used to monitor coastlines and ports. We had an incident a year ago in the port of Sockna in Egypt, where the port was accused of illegally dispatching oil. We used our software to prove that the port was not the polluter and the culprit was actually a vessel some way outside the town."

There are a number of factors that go into the eventual detection. The weather plays a part – it is harder to detect if there is no wind at all as this reduced relative movement.

"If a leak comes from a pipeline, say, 1000m below on the seabed, it is likely to result in a spill over quite a large area and so the size may be an important factor in quantification. Another variable is the API gravity of the oil. The software can detect quite small amounts of heavy oil.

SOFTWARE

The early versions of the oil spill detection are still operational in many parts of world, both on vessels and on fixed installations.

More recently, however, Vissim has developed a new and upgraded radar detection solution will become an integrated part of Aker BP’s digital platform for oil spill monitoring and detection.

"The upgraded oil spill detection system uses better image processing technology and achieves much higher sensitivity," said Odden. "This allows it to detect even smaller oil spills.

"While the radar is good at detecting oil, it is also good at recognising different types of phenomenon such as the wake of ships or even rain clouds. The historical problem is that these aberrations potentially create false alarms.

"The software system therefore capitalises on machine learning to classify the detected response, thus reducing these false alarms. This in turn reduces stress on operators

"As it processes the data and learns more about the application, it gets smarter and smarter in the way it classifies the data.

"Depending on the circumstances, it can typically recognise a pool of oil up to six nautical miles away. "

HOLISTIC DETECTION

Radar does not penetrate into water, so to provide a more holistic response, it may be best to combine it with other methods of leak detection.

Last year, Vissim expanded its oil spill monitoring and detection services by integrating input from several detection sources including radars, satellites, sensors on subsea production equipment, combining them into one, complete and easy-to-understand visual overview.

There are a number of types of oil detection.

CAPACITIVE SENSORS

A capacitive sensor for oil spill detection is a device that uses the principle of capacitance to detect the presence of oil spills and monitor oil pipelines for leaks.

ACOUSTIC SENSORS:

Acoustic sensors use sound waves to detect the presence of oil spills. Sound waves are reflected off objects in the water, and the reflected waves can be analyzed to determine the presence and location of an oil spill.

IMAGE SENSORS

A camera, possibly one able to detect ultraviolet images, can also be input into the model.

POLLUTION CONTROL

NOISE

MANY CLAIM THAT UNDERWATER NOISE POLLUTION IS RESPONSIBLE FOR SEA MAMMAL BEACHING BUT THERE IS NO REAL UNDERSTANDING OF THE ISSUES DUE TO LACK OF DATA. RS AQUA HOPES TO CORRECT THIS WITH A BACKGROUND STUDY

RS Aqua is a leading supplier of cutting-edge technology for ocean exploration in sectors such as marine robotics, aquaculture, offshore energy, and ecological applications. The latest project from the company, MARLIN, introduces an innovative approach to monitoring underwater noise.

“We have previously developed a range of passive acoustic recorders” said Ocean Scientist Eleanor Stanton, “including our flagship Orca. This acoustic recorder accommodates up to five hydrophone channel inputs. We also have a smaller, single-channel acoustic recorder called the Porpoise- this is perfect for ambient noise monitoring/characterisation, construction monitoring, and marine mammal research.”

Having recently securing funding from Innovate UK, and in collaboration with the University of Southampton, RS Aqua’s project MARLIN will develop an underwater sensor that uses machine learning to identify harmful environmental activities and transmit information in real-time to a web app. For the first time, this will allow stakeholders to remotely monitor the underwater environment and make decisions in real-time.

This will mean developing new machine-learning techniques to distinguish between ambient and unusual environmental noise, such as marine mammals. There are three main aspects to MARLIN:

•The Internet of Things (IOT) at sea: we will harness the new broadband communication networks offered by Low Earth Orbit (LEO) satellites to allow users to specify and receive data analytics, real time alerts and big data chunks from their system as required. This will bring IOT to underwater ocean sensors in a way not previously possible.

•Machine Learning: MARLIN will learn the ambient noise of its environment over time and identify when something unusual occurs. “This could be the detection and identification of marine mammals, noise pollution levels, illegal fishing activity or different vessel types”, said Eleanor Stanton. “The idea is that deep neural networks will be used to unravel subtle signatures, and neuroplasticity type algorithms will dynamically self-learn."

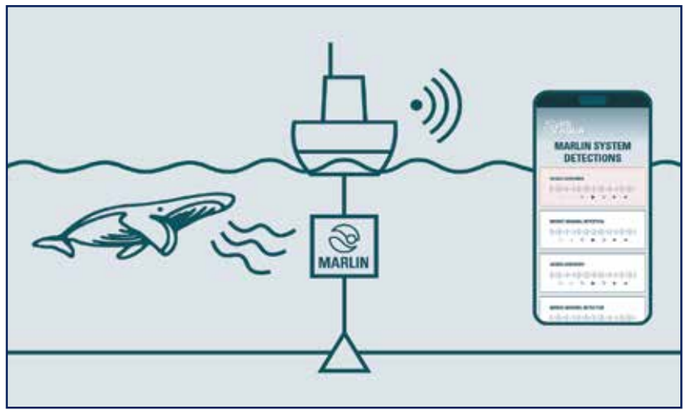
•In the smartphone and web graphical user interface, users will be able to view their data in real-time. As MARLIN’s control panel, the app will allow users to focus on specific acoustic events and request more broadband data as required.

“We believe MARLIN will revolutionise how we collect and analyse environmental noise in remote ocean locations, as well as revolutionising how we use broadband internet in the remote ocean.

“It’s still early days for project MARLIN and one of our first steps has been to deploy a lander off the coast of the UK. "

This lander is equipped with a Porpoise passive acoustic recorder that has been collecting baseline acoustic data that we can then use for the machine-learning aspect of the project to help train the algorithm.

“Currently large marine vessels often need to be used for ocean monitoring missions, whereas remote real-time monitoring systems like MARLIN will reduce the need for ship time at sea, reducing vessel CO2 emissions massively which is a huge step forward.”



Project MARLIN - an illustration demonstrating the real-time monitoring of ambient and unusual environmental noise

SURVEY

UNDERWATER DATA COLLECTION

In the dynamic realm of unmanned underwater vehicles (UUVs), the shift towards smaller, more numerous and highly capable vehicles is reshaping the industry's approach to underwater data collection. This is being underpinned by advancements in technology, integration of artificial intelligence (AI) and machine learning (ML), and the projected growth of the global UUV market.

At the forefront of this transformative wave is Neil Brown Ocean Sensors, Inc. (NBOSI), a US-based manufacturer specialising in research-quality conductivity-temperature sensors for mobile marine platforms since 2004. NBOSI's latest integrated CTD is not only setting new standards in underwater data collection, but is also addressing critical challenges faced by UUV operators.

"The trend towards smaller, more numerous underwater vehicles is evident across various sectors, from environmental monitoring to commercial, defence, and research," said Dr Dave Fratantoni, NBOSI's CEO. " Over the past decade, advancements in critical technologies such as processors and battery storage has led to these subsea vehicles becoming more effective.

"The integration of AI and ML technology is propelling UUVs into a new era. Enhanced bandwidth connections, on-board edge processing, improved object recognition and sophisticated interconnectivity among vehicles deployed in a fleet indicate a fast-moving evolution in the industry. Subsea robotic fleets collaborating intelligently and executing swarm deployments are no longer confined to the realm of fiction but are becoming a reality.

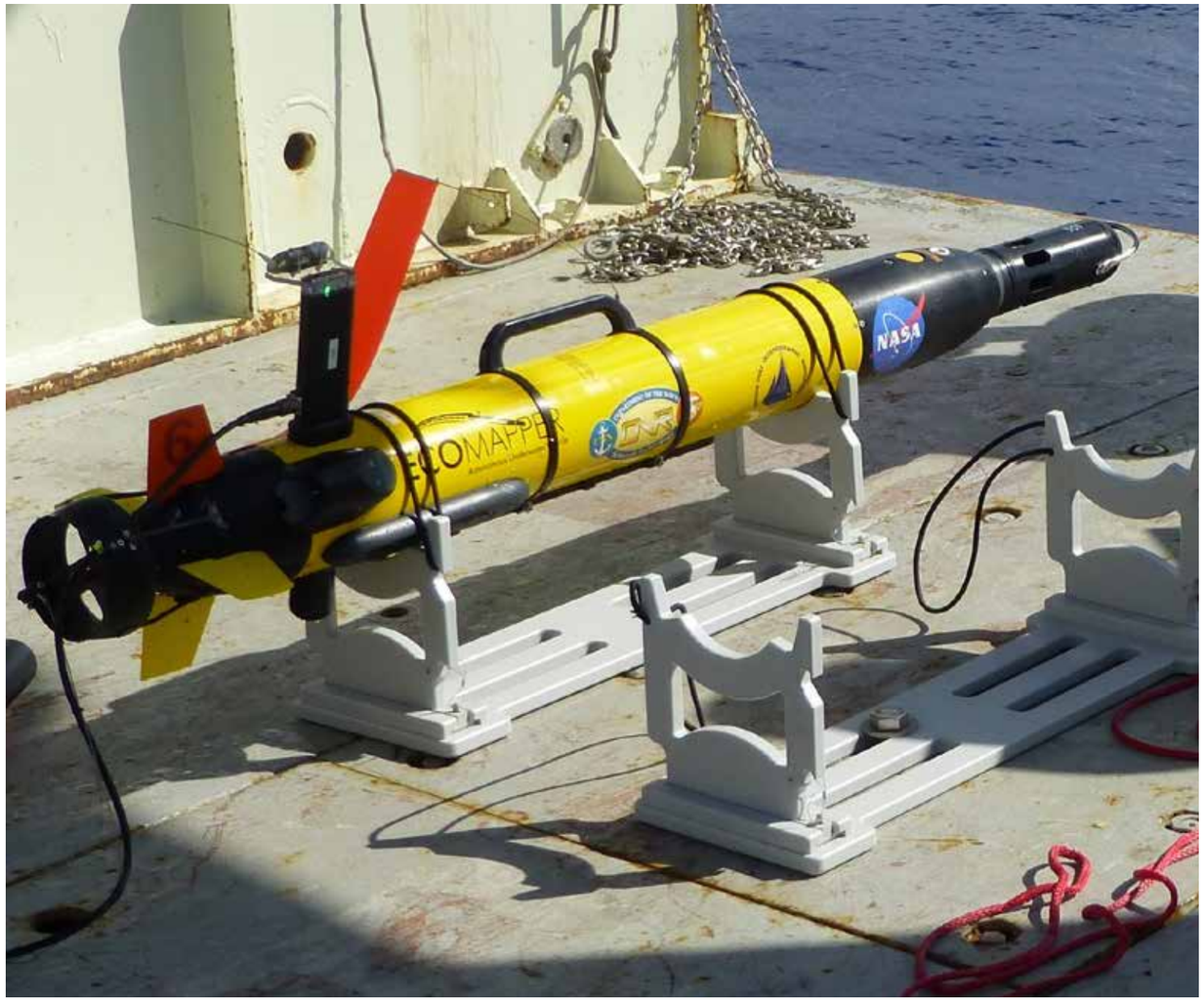
"Market research forecasts a substantial growth in the global uncrewed underwater vehicles market, projecting an increase from US$3.34 billion in 2023 to US$8.14 billion by 2030, reflecting a compound annual growth rate of 13.5%. This growth signals a clear envisioning by subsea industries of a need for considerably more of these small yet capable vehicles, despite rapid improvements in efficiency and capability."

Straits Research emphasises the significant growth expected in the demand for electrically-driven small and medium underwater drones, and the increasing need for battery-powered vehicles.

The surge in demand has been attributed to sectors such as offshore wind, oil and gas, scientific research, and defence, where accurate underwater data is crucial for tasks like surveying deep-water seabed and monitoring vital infrastructure.

Fratantoni, anticipates a three-fold increase in demand for the company's sensors, soon reaching a significant milestone with the sale of the 1000th sensor in the first half of 2024.

"The push towards smaller, more numerous, and vastly more capable vehicles in the industry aligns with NBOSI's expertise. The sensors enable achieving more with a smaller



hull, addressing the industry's increasing need to map and collect data across extensive ocean beds for environmental reasons and responding to geopolitical instability driving defence procurements."

CTD SENSOR

NBOSI is set to introduce its latest product – a compact, UUV-optimised integrated CTD sensor in 2024. This palm-sized, sturdy, easy-to-integrate sensor yields research-quality temperature, salinity, depth and sound speed measurements. A key innovation is the elimination of the requirement for the installation of control electronics within the vehicle's pressure hull, streamlining installation, calibration, and field maintenance.

The integrated CTD combines a highly accurate and fast-responding temperature probe and a uniquely robust conductivity cell with a precision pressure sensor, enabling real-time output of temperature, salinity, ocean density and sound speed.

This not only reduces payload and data processing burdens on small platforms, but also enhances the overall efficiency of data collection. The benefits of this new integrated sensor approach are numerous, with a significant focus on ease of maintenance, calibration, and freeing up valuable in-vehicle real estate.

“For smaller vehicles and extensive fleets, the key benefit lies in simplified maintenance," said Dr. Fratantoni. "Unlike traditional methods requiring hull access and internal electronics removal, our integrated sensor allows for straightforward external servicing.

"Whether sending back to us for rapid, low-cost calibration, or swapping with a standby spare, the result is faster recalibration and superior data quality.

"Integrating the electronics and sensing elements into a more ‘plug and play’ externally mounted single unit will significantly streamline servicing and calibration, whilst also freeing up valuable in-vehicle space. In the era of shrinking vehicle sizes, preserving in-hull volume is crucial.

"Even in larger vehicles, where an internal board is optional, the new board is a quarter of the size of its predecessor.

"The elimination of the need for an

internal electronics board simplifies installation, routine calibration, spares inventory, and field replacement. This streamlining not only enhances operational processes but also reduces the complexity of maintaining growing UUV fleets.

- The integration of a precision pressure sensor enables real-time direct output of accurate sound speed, ensuring optimal data quality without requiring computation by the vehicle's CPU.

This advancement provides immediate and accurate insights into underwater environments, enhancing the efficiency of data collection.

- Certain sensor variants of the integrated CTD feature a bulkhead connector on the cell, replacing the existing molded cable connection. This innovation decouples cable and sensor acquisition, providing end-users with greater design freedom and operational flexibility, making UUV deployments more efficient.

- Maintaining continuity with existing NBOSI CTD sensors, the form factor and dimensions of the new integrated CTD sensor remain intentionally identical. This ensures backward-compatible data output, allowing for quick integration without necessitating vehicle firmware changes.

The simple 4-wire power and data integration facilitate fast and easy implementation, suitable for both new builds and upgrades of existing systems.

CONTRACTS

Over the past year, NBOSI has played a pivotal role in supplying custom sensors for diverse applications.

From an innovative mine-hunting vehicle by Mitsubishi Heavy Industries in Japan, to a collaboration with Cornell University for the remote study of a deep brine pool in the Gulf of Mexico, NBOSI's technology is making waves in cutting-edge projects.

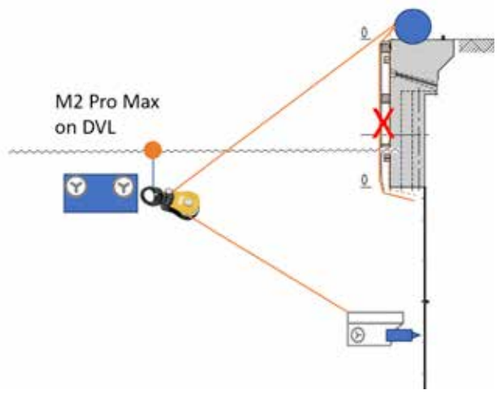
Notably, the NBOSI technology is a part of the HII REMUS 300, the foundational vehicle for the US Navy's extensive Lionfish SUUV programme.

DRONE Q ROBOTICS UMBILICAL SUPPORT

Small ROVs are ideally suited for conducting underwater inspection surveys on vertical structures. The vehicles can be quickly and easily deployed by being lowered down from the surface and scan the upright walls or supports for corrosion or damage. In many applications, they are used to look for damage from barnacles or other hard shell marine growth. When looking at piers,however, they can easily become entangled while the sharp growth can cause physical damage if the vehicle or umbilical comes into contact and pulled vertically up to the surface.

One solution employed by Dutch ROV survey group Drone Q Robotics includes a novel arrangement involving a second ROV stationed nearby but clear of the wall or structure being examined. It has a DVL and small anchor buoy to keep it floating just 50cms under the water surface.

The ROV holds a special designed block pulley from a 3D printed handle. The Inspection ROV;s tether is attached



to the pulley, keeping it out of harms way. This arrangement is especially useful in high current waters, to reduce the drag of the current on the Inspection ROVs tether, thus enhancing the operability of the Inspection ROV.

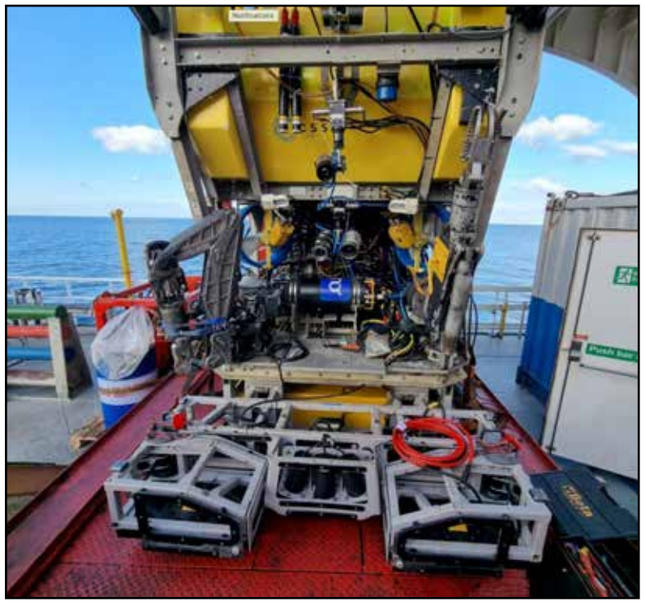
KRAKEN SURVEY FOR CSS SUBSEA

Kraken Robotics have recently completed a burial assessment survey on behalf of CSS Subsea along the Cassiopeia umbilical.

Mobilised onboard the *Go Supporter* vessel, a Schilling HD WROV and Kraken's Sub-Bottom Imager (SBI) 3D acoustic system were utilised to image the buried umbilical to ensure it was sufficiently protected from other sea users.

Running from August 2023 to January 2024, the project's goal was the safe and efficient installation of an unarmoured umbilical. The SBI was used during trenching operations to ensure the umbilical was buried to the correct depth.

Following SBI survey operations, if any shallow sections were identified, remedial trenching and survey passes were undertaken.



ROVINS 9-DVL ALL-IN-ONE INS/DVL

UNPRECEDENTED NAVIGATION ACCURACY WITH NEW SENSOR

Benefitting from Exail's proven Fibre-Optic Gyroscope (FOG) technology, which has revolutionized navigation in the last decades, and the latest DVL advancements from Nortek, Exail's new Rovins 9-DVL innovative solution merges the top navigation technologies available today.

With its unique design and compactness, it is the ultimate tool for subsea companies looking to maximize efficiency and success.

THE ULTIMATE TECHNOLOGY FUSION IN AN ALL-IN-ONE COMPACT DEVICE

Rovins 9-DVL is a flexible and plug-and-play system that combines an Exail INS based on UmiX Inertial Measurement Unit (IMU) and a Nortek Compact 500 DVL in a single compact housing. It is designed to be easily integrated in a variety of subsea vehicles such as ROV, AUV, and tow fishes and is suitable for operations from shallow to deep water depths down to 6000 m.

Embedding Exail's UmiX, the most compact high-performance IMU, Rovins 9-DVL delivers unparalleled navigation performance in the smallest design available on the market. Compared to equivalent FOG systems, the Rovins 9-DVL IMU is half the size, half the power consumption, and twice the performance.

Integrating miniaturized in-house accelerometers, it also features new FOG gyroscopes custom-built for this system. With its cutting-edge performance and ultra-compact form factor, this new gyroscope expands the boundaries of what is possible in subsea navigation.

Exail's UmiX is tightly coupled with Nortek DVL500-Compact, a universal DVL that combines a compact design with unprecedented functionality.

With a bottom range detection capability of up to 175 m and a DVL frequency of 500 kHz, this DVL can fly higher in the water column and closer to the seabed (up to 0.3 m) than similar equipment. This makes it an ideal solution for small vehicles to conduct operations in challenging subsea environments.

POWERING UNMATCHED NAVIGATION PERFORMANCE AND ACCURACY

Tightly integrating raw sensor data from the IMU and DVL allows for higher levels of accuracy and reliability. Indeed, by combining the DVL measurements of the vehicle's velocity relative to the seafloor with the INS acceleration and rotation rate measurements, the system can estimate the vehicle's position more accurately, even in areas with complex or irregular seafloor conditions.

The DVL can also help reduce the INS drift over time, while the INS compensates for external disturbances such as waves that can affect the DVL's velocity measurements. For further accuracy, the data collected can be processed with Exail Delph INS Subsea software, which enables users to access both DVL and IMU interfaces through a single user MMI.

"By merging the complementary measurements of the INS and DVL, the resulting navigation data becomes much more precise and accurate than either system used alone.

And the ability to connect external sensors such as pressure sensors, through the satellite connectors available on the system, will provide even greater accuracy" says Maxime Le Roy, Product Manager at Exail.

Rovins 9-DVL

"Overall, this results in a more accurate and robust navigation solution that enables subsea vehicles to navigate and operate more efficiently in any sea conditions, even in areas where GNSS signals are weak or unavailable".

EASY-TO-USE FLEXIBLE SOLUTION, TAILORED TO THE CHALLENGES OF THE UNDERWATER ENVIRONMENT

Compact, lightweight, and versatile, Rovins 9-DVL has been specifically designed to greatly simplify the work of subsea operators in the field. Its unique horizontal design allows for easy integration into all types of subsea platforms, from observation-class to work-class Underwater Unmanned Vehicles (UUV).

The integration process is further simplified as fewer cables are required within the vehicle frame. Additionally, Rovins 9-DVL boasts an open architecture that enables connection to third-party sensors via standard straight or right-angled connectors- both of which are supplied with the system- allowing for maximum integration flexibility.

Rovins 9-DVL comes pre-calibrated and plug-and-play, making on-the-field calibration unnecessary and integration into vehicles fast and easy. It also features new electronic control units that enable self-alignment in motion, eliminating the static alignment time required by previous generations of Exail INS. This makes the system ready for immediate deployment, saving significant time and money in offshore operations, which is crucial for operational efficiency.

A cost-effective and hassle-free solution, Rovins 9-DVL relies on Exail's expertise and robust technology, requiring no maintenance. Thanks to its titanium housing, it is highly resistant to high pressure and harsh environments, enabling operations at water depths down to 6000m.

It operates on low power consumption (< 18 W), making it an ideal choice for ROV and AUV manufacturers and latest h-ROVs operators seeking to save watts without compromising on data processing power.

"With decades of expertise in the underwater domain, Exail has leveraged its knowledge to create a unique and efficient solution that effectively addresses the operational challenges faced by subsea vehicle operators" outlines Stéphane Meyer, Subsea positioning and navigation division Director.

"With its powerful technology integration, compact design, user-friendliness, and cost-effectiveness, the Rovins 9-DVL all-in-one system provides an exceptional size/performance ratio that has never been equaled in the market. This game-changing navigation system is set to revolutionize the subsea vehicle operations landscape, enabling our customers to significantly improve their operational efficiency in all marine applications, ranging from offshore energy to seabed exploration."

ADVANCED MBARI TECHNOLOGY AIDS EFFORTS TO RESEARCH FRAGILE DEEP-SEA ANIMALS

New technologies are transforming how scientists study delicate ocean animals to document deep-sea biodiversity. Image: Joost Daniels Schmidt Institute

An estimated 30–60% of marine life has yet to be described by scientists, often because of the difficult process of collecting specimens for study.

A multidisciplinary team of roboticists, ocean engineers, bioengineers and marine and molecular biologists have successfully demonstrated how new technologies can rapidly obtain high-resolution 3D images and preserved tissue to accelerate the discovery of new life in the deep sea.

MBARI Principal Engineer Kakani Katija recently joined a team of roboticists, engineers, and biologists led by the University of Rhode Island to demonstrate how technology can accelerate research on delicate deep-sea animals.

"Revolutionary advancements in underwater imaging, robotics, and genomic sequencing are transforming ocean exploration," said Katija. "By leveraging these new tools, within minutes of an encounter with a deep-sea animal, scientists can capture detailed measurements and motion of the animal, obtain its entire genome, and generate a comprehensive list of genes being expressed to assess its physiological status.

The Bioinspiration Lab has developed innovative imaging systems that can visualise deep-sea animals in their natural environment.

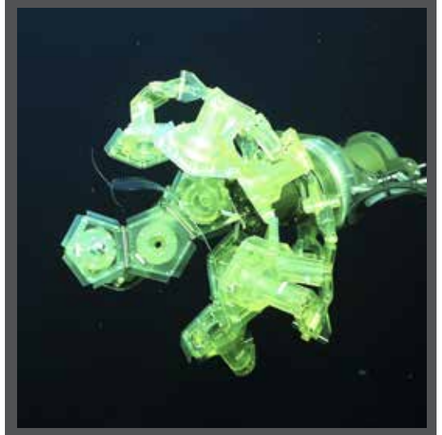
The team envisions using these advanced technologies to build a comprehensive picture of the biology and behaviour of deep-sea animals. For example, they observed a gossamer worm (Tomopteris sp.)—a worm that lives in the water column instead of along the seafloor—while it was swimming back and forth exploring its surroundings.

Rapid collection and preservation of the worm's tissues revealed high levels of gene expression in the whisker-like cirri, suggesting these organs serve a neurosensory function for following chemical trails.

Further development of these technologies could eventually allow researchers to collect complete scans and inventories of life in the deep sea within a catch-and-release framework.

"By combining a suite of emerging technologies, we're transforming our ability to explore the ocean. " said Katija.

RAD



The rotary-actuated dodecahedron (RAD-2): © Schmidt Ocean Institute

Developed by engineers in the School of Engineering and Applied Sciences at Harvard University, the RAD-2 folds around an animal like origami to collect the specimen and sample its tissues.

This sampler preserves a snapshot of the organism's genetic activity at the time of collection, allowing scientists to identify which genes were active and being expressed at that time, known to scientists as the transcriptome.

SEABED 2030

IN DECEMBER 2023, THE MIDDLE EAST BRANCH OF THE SUT DISCUSSED THE GEBCO SEABED 2030 PROJECT AS PART OF THREE PRESENTATIONS DELIVERED AROUND THE TIME OF THE COP 28 SUMMIT IN DUBAI. *VICKI FERRINI* SENIOR SCIENTIST, COLUMBIA UNIVERSITY, EXPLAINS THE PROJECT FUNDAMENTALS.

Around 70% of the planet is covered by water and only 25% of *that* has been mapped to modern standards. This reflects the lack of information at a time when many are just starting to understand the vast importance of the oceans to the future of the planet and life upon it.

This was the reason for the original launch of Seabed 2030. The Nippon Foundation GEBCO Seabed 2030 project is a collaborative project to inspire the complete mapping of the world's ocean floor by 2030.

GEBCO is the General Bathymetric Chart of the Oceans. It can be seen as both a data product and a project that operates under the joint auspices of the International Hydrographic Organisation and the Intergovernmental Oceanographic Commission of UNESCO.

For close to 20 years, GEBCO has been working with the Japanese philanthropic organisation Nippon Foundation to grow the next generation of ocean cartographers.

Prior to Seabed 2030, the GEBCO Global Grid was made available at a resolution of 30 arc seconds, however, the group has released its annual compilation at a resolution of 15 arc seconds. It provides grid viewing software, printable maps and web services to help people around the world produce the bathymetric grids and maps and products that they might need. The data can be downloaded from GEBCO.NET

"Bathymetric data is an essential ocean observation," said Vicki Ferrini. "Maps are fundamental to work in the marine environment and so it makes sense for the global community to generate such products together in order to gain a better understanding of the ocean. The reality is, however, that mapping the entire ocean can only be achieved through cooperation and coordination because it is simply so big a project and there is too much to do.

"Seabed 2030 can be viewed as an accelerator for GEBCO. When we started the project, only 6% of the world was mapped. We have been moving rapidly, but we still have 75% of the ocean to cover in less than 10 years."

A very important question is, what does 100% map coverage mean?

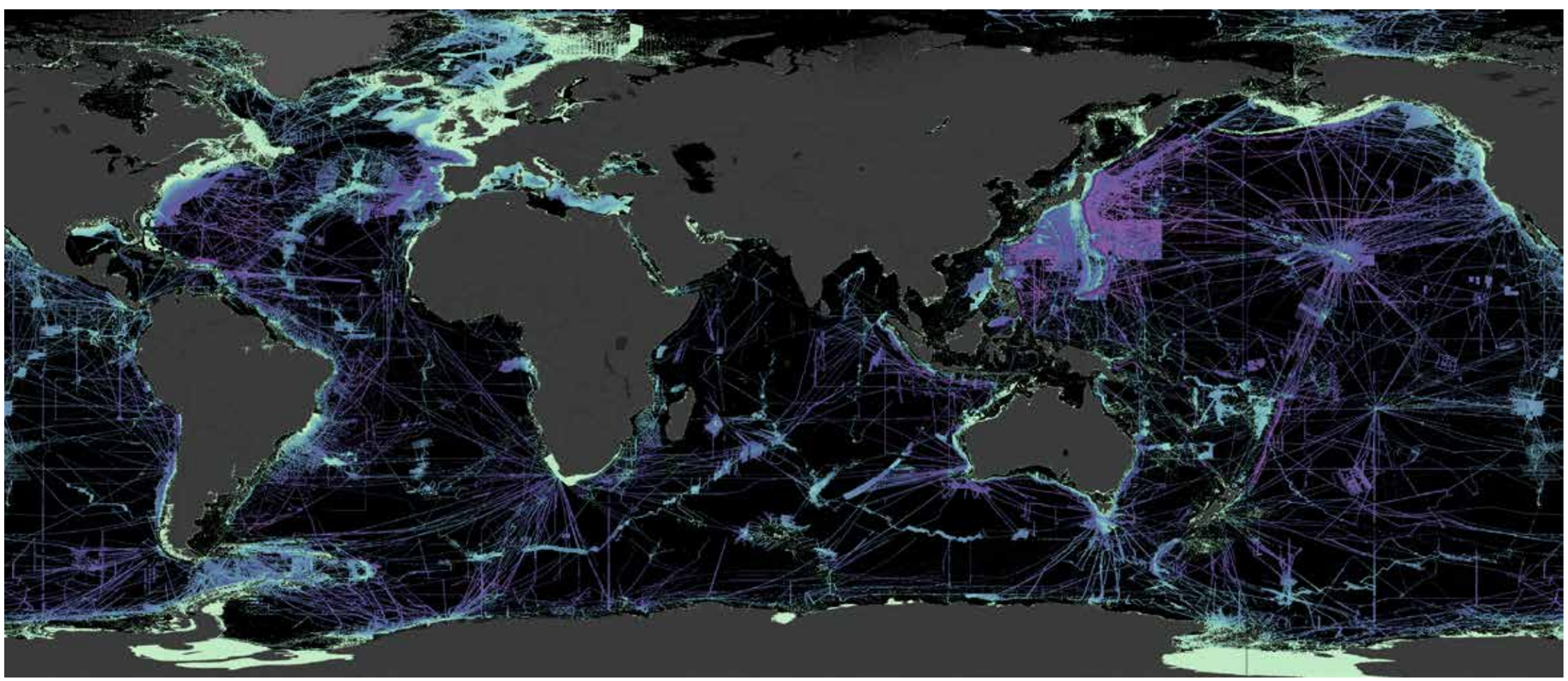
"We can map in the deep sea at resolutions of sub-meter if we use the right kind of technology, but that would take us a very, very long time to do globally," explained Ferrini. "For water shallower than 1500m, we're aspiring for one measurement every 100m, to give a 100m resolution grid.

"The vast majority of the ocean, however, falls in the three kilometres to the 5700m depth zone, and our resolution target there is 400m – roughly 15 arc second. The depth band between 1500 and 3000m is a 200m resolution goal, and then in the deepest water, is 800m data points would be acceptable.

"We have integrated all the data that exists, however, in some places, we know more data exists but just not in the public domain. It also includes tiny track lines of data with more being filled in every year, but this leaves a lot of seafloor yet to be mapped.

"Importantly, the objective is not just to create the GEBCO grid" explained Ferrini. "After 2030 when hopefully, the seabed is 100% mapped, we also want to ensure that all the work that we've done over this decade is future proofed.

"Agorithms improve over time.With different ways of integrating data, we'll be able to produce new products, hopefully even faster, with fewer humans in the loop to generate the products of tomorrow."



This GEBCO visualisation shows how much or how little of the ocean is mapped. As of GEBCO 2023, the mapped part is 24.9%.

ORGANISATION

The project artificially divides the ocean into four regions, each being overseen by different organisations. The Atlantic and Indian Oceans is managed from Columbia University in New York City at while the Arctic and the North Pacific is jointly stewarded by Stockholm University and the University of New Hampshire's Center for Coastal and Ocean Mapping. The South and West Pacific stewarded by three groups in New Zealand including Geological and Nuclear Sciences Limited (GNS) and Land Information New Zealand (LINZ), led by the National Institutes of Water and Atmosphere (NEWA) .
The Alfred Wegener Institute in Germany looks after the Southern Ocean,

Those regional products are fed to the British Oceanographic Data Centre, which builds and distributes the global products

SURVEY

Many different types of data are input into the models from different sensors, multi beam, single beam, sub bottom and derived seismic.

"We get digitized contours and soundings from old nautical charts as well as LiDAR data, satellite derived bathymetry, ENC soundings," said Ferrini. "We, therefore, get many different formats for commercial software, legacy formats and old open source software as well as SWAF and ASCII files. Our job is to make sense of them and bring them together."

"Our ability as data integrators to address problems as data are processed. If a sound speed profile isnt applied, we can fix that in post processing. If we receive point clouds or a grid and there's a sound speed problem, we have to remove the data.

"If people give data but the quality isn't great, we can try to make it better. But if they can make the process SWAF files available, we can pick up where they left off and we can build upon what they've done efficiently and get the products moved faster. We prioritize grids based on the data quality and stack them together to create the regional products.

"Partnerships are the key to success for Seabed 2030. We have over 50 partners so far from different sectors. Academia and the government have traditionally been the strongest voluntary donors of data but industry is starting to really come into the fold while the public is also starting to participate.

The strong relationships we have with IHO and IOC are helping us get more governments involved. But there's a huge role to be played by groups all around the world who are working with ocean data to get more data in to this globally sourced map that we're building.

Some emerging solutions that are accelerating our progress such as transit data acquisition. Fugro, one of our partners has provided over 2.3 million km^2 of transit data that they collect when the ships are moving from job to job.

"There's a lot of transit data acquired in the US and a lot of effort to make tools available to help process that data more efficiently. There's some other examples in France and New Zealand.

"Another emerging solution is crowdsource bathymetry data. If any vessel with a navigational sonar could install a small data logger, they can collect data that can fold into the maps.

One example is a crowdsource bathymetry effort from the Great Barrier Reef which has been extremely successful because of the frequency and the number of ships, the frequency of visiting. And in fact, the IHO has a crowdsource bathymetry working group.

Another emerging solution is robots, both surface and subsurface drones and other uncrewed systems that can go to hard to reach places at lower cost and collect data that can be delivered.

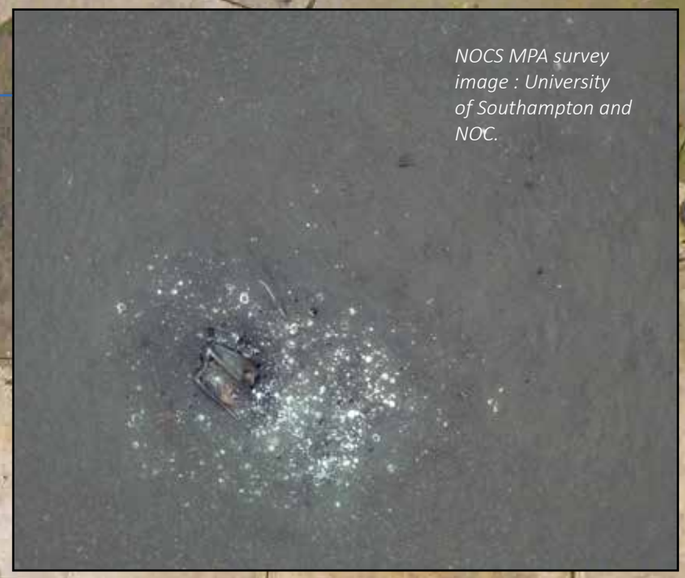
Other emerging solutions include remote sensing techniques, both satellite-derived bathymetry looking through shallow water and wave kinematic-derived bathymetry, which is also being prototyped with us. LiDAR represents a more traditional approach used over the past.

How to get involved. Go to the website and find some information there or sign up for our mailing list. The team is really eager to help work with whatever people are able to contribute.

BENEFITS OF A BETTER UNDERSTANDING OF THE OCEANS

- Nautical charts
- Oil and gas exploration
- Safety and storm surge/tsunami inundation models
- Ecosystem identification and management
- Emergency response
- Satellite verification models
- Offshore infrastructure
- Ocean Models
- Coastal/Marine Spatial Planning
- Coastal Hazard Assessment
- Ocean Exploration
- Coastal Change Analysis
- Sea Level Rise Mitigation
- New Energy Siting
- Marine Heritage
- Blue Economy

AUTOSUB SEAFLOOR IMAGERY



NOCS MPA survey image : University of Southampton and NOC.

FULLY AUTONOMOUS SURVEY OF MARINE PROTECTED AREA COLLECTS HIGH RESOLUTION SEAFLOOR IMAGERY

The National Oceanography Centre (NOC), working with the University of Southampton and the Department for Environment, Food and Rural Affairs (Defra), recently completed a Fully Autonomous Marine Protected Area Seafloor Survey.

This survey will help us understand the suitability of using autonomous underwater vehicles for UK offshore marine monitoring, and establish to what extent such systems can help the UK Government meet its increasing marine monitoring ambitions.

NOC conducted the fully autonomous seafloor survey of the Central Fladen Nature Conservation Marine Protected Area, which is located some 140 km south-southeast of Lerwick (Shetland), using an Autosub Long Range (ALR), famously known as 'Boaty McBoatface' launched from shore.

The ALR carried the University of Southampton's 'BioCam' instrument, a three-dimensional seafloor imaging system that comprises a stereo pair of cameras, dual LED strobes, and dual line lasers. Operated together, these instruments generate georeferenced, colour corrected conventional still images, as well as texture maps and corresponding microtopographic maps of the seafloor.

The data gathered will enable subsequent assessment of seafloor type and condition, the abundance and identity of seafloor related fish and larger invertebrate animals, and provide evidence of human impacts on the seabed environment (physical disturbance of seabed by trawling and presence of litter for example).

The survey is therefore providing natural capital and conservation relevant information on asset extent, condition, and human pressures.

This project is part of Defra's Marine Natural Capital and Ecosystem Assessment (mNCEA) programme, which is supporting the adoption of innovative marine monitoring technologies. These technologies will help to deliver the 'Big Data' needed in advanced data-driven machine learning for mapping and assessment of our marine natural capital and the benefits it provides.

NOC scientists have been using autonomous underwater vehicles as key tools for gathering ocean data for over 20 years, and this mission demonstrates one of the many potential commercial applications of the ALR's cutting-edge technology. The fully autonomous approach

made possible by using a shore launched ALR enables offshore marine environmental surveys to be completed without requiring a survey ship, significantly reducing costs whilst supporting Net Zero initiatives. Additionally, the use of ALRs has the potential to generate higher quality seafloor mapping data and seafloor photography than comparable systems deployed by wire from a survey ship.

Project lead and National Oceanography Centre scientist Dr Brian Bett explained: "The UK has around a quarter of a million square kilometres of offshore marine protected areas, which is equal to the total land surface of the UK. Finding an effective and efficient method of monitoring these areas is challenging, with autonomous vehicles likely to play a key role".

This survey builds on the success and learnings of the previous AT-SEA missions, which demonstrated ALRs capability to undertake ecological surveys in end-of-life oil fields. The ability to use ALRs for high-tech, low impact marine surveying and monitoring projects negates the need for a traditional survey ship and crew, generating improved quality and quantity of information at a significantly reduced cost.

Following the successful recovery of the raw data gathered during the survey, work now continues to produce data products informing users about the current conditions of the MPA.

BIOMIMETICS

APPLIED BIOMIMETICS

Marine Biomimetics describes the practice of designing structures, systems and technologies that take inspiration from marine organisms and ecosystems to enhance marine operations.

The Applied Biomimetics Marine Hydrodynamics Group (ABMHydro), part of the Mechanical Engineering and Marine Technology at the Newcastle University, aims to use its expertise in marine hydrodynamics to develop effective and feasible biomimetic solutions.

The group has a number of the projects, completed or ongoing, that have successfully used functional or structural inspiration to improve traditional engineering designs.

HUMPBACK WHALE

Humpback whales are giant marine mammals around 12–16m long. They have a distinctive body shape due to unusually long fins. These whales contribute two areas of interest to the group.

Schools of whales are known to hunt by swimming circularly to concentrate fish into a small central zone. They then produce a net of bubbles to prevent the enclosed shoal from escaping. They can then feed on the shoal.

The practice of securing offshore structures to the seabed often involves hammering piles into the ground. This produces significant intensities of sound which may be stressful to marine animals and possibly disrupt their natural means of navigating, potentially causing the larger mammals to beach. The offshore industry has looked for ways to minimise acoustic leakage. One strategy that appears successful is, like whales, to enclose the area in a bubble curtain, to prevent the sound pulses from escaping.

Humpback Whale Image: Todd Cravens

It is the Humpback Whale's unusually long pictorial fins, however, that provide some of the most interesting research. This is because their leading edges have evolved tubercles and it is believed that these bumps aid in the humpback's ability to perform agile manoeuvres to catch prey.

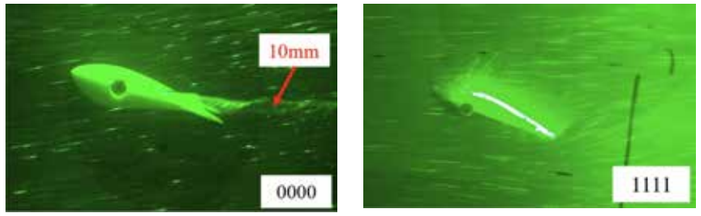
It is ventured that they improve the swimming ability by reducing cavitation.
“Cavitation is a particularly undesirable phenomena that is caused due to the drop in local static pressure below the threshold vapour pressure," said group leader Dr. Weichao Shi at the Newcastle University in the Mechanical Engineering and Marine Technology.
"This effectively turns the liquid into vapour.”
"This cavitation is known to cause propeller damage and performance degradation as well as producing a subsequent increase in underwater radiated noise.

"As such, it is generally accepted that mitigating propeller cavitation is extremely important .
"The main benefits of modifying the shape of the fin has been shown through the research to be an increased lift to drag ratio, a delay of stall, noise mitigation and also cavitation containment capabilities. This is possibly due to rotating vortex pairs that are induced by the leading edge sinusoidal waveform.
"Considerable research has already been carried out on the influence of tubercles and cavitation on hydrofoils

APPLYING TUBERCLES TO A HYDROFOIL

Research carried out at Newcastle University in applying tubercle technology to a hydrofoil commenced by developing a number of CNC-machined 3-D models with different leading edge sections. Experimentation showed that performance of the hydrofoil can be dramatically enhanced by the tubercles and that lift coefficients were increased greatly. The foil with the shortest tubercle application length (1/4 of the span) at tip region overall displayed the best performance.

A strong tip vortex cavitation was produced by 0000 whereas no cavitation was observed under the same condition of 1111. This concept is currently being applied to tidal turbines open propellers, control surfaces (eg,rudders) and propeller ducts.



Flow change with the addition of tubercles

and also on rudders, while tubercles on tidal turbines showed a reduction cavitation and a reduction underwater radiated noise."

More recently, the group has been looking to apply the tubercles to a marine propeller to investigate the influence of leading edge tubercles on the sheet cavitation development and hydrodynamic performance

In total, four propellers were used in the analysis

Propeller designs

A B series propeller was used as a baseline with three tubercle propellers designed a geometrical configuration.

Experimentation showed in heavy cavitating conditions, the tubercles can reduce the sheet cavitation volume by over 50% This is due to the redistribution of the surface pressure along the leading edge of the blade and also the induced streamwise current rotating vortex pairs. They found the most successful configuration at reducing the cavitation was the long wavelength large height.

Where cavitation reduction was significant, it is likely that the tubercles could improve the propulsion efficiency but this would come at a cost of thrust reduction. It is therefore believed that for this particular propeller design, the influence of tubercles would likely not lead to a performance improvement hydrodynamically.

Looking to the future the group plan to carry experimental model scale tests in a cavitation tunnel as this would allow for further understanding of the other cavitation mechanisms that weren't considered in the study, such as the tip vortex cavitation. They can also to look at the influence on the underwater radiant noise of the tubercles as applied to the main propeller.

SWIMMING IN THE BOUNDARY LAYER

Remora, sometimes called the 'suckerfish' often form a natural symbiotic relationships with larger fish, particularly sharks. Rather than swimming on their own, they attach themselves onto the host with the help of a sucking plate-shaped disc on their head. The remora then ceases motion while the host is swimming to naturally glide through the water.

The location of this is not random. Three favourable attachment locations are
1. Belly- 39.7%
2. Back- 27.2%
3. Pectoral fins- 20.6%

The ABMHydro performed an analysis using STAR-CCM+ CFD software to investigate the hydrodynamic merits of the remora's attachment behaviour.

The research has primarily focused on the investigations of the effect of the developed boundary layer flow and particularly, the effect of the different attachment locations on the shark body.

Regarding the effect of boundary layer flow, the drag reduction rate is related to the boundary layer thickness. Measurement showed that drag reduction increased from 27% to 36% with the increased boundary layer thickness (based on the length of the flat plate). From a drag reduction point of view, the remora tends to attach to regions covered a developed boundary layer

In the belly and back attachment case, there is a low-velocity area coupled with an adverse pressure gradient area that builds up due to the blockage of the shark body. The pressure force provides a forward thrust to the remora.

In the pectoral fin attachment case, the shark's fin blocks a part of incoming flow, however, most of the remora body is still exposed. In the high-velocity and high-pressure regions, drag reduction rate is the lowest.

SPERM WHALES

The sperm whale is the largest of the toothed whales and able to dive to 2250m.Sperm whaling was a major industry in the 19th century mainly targeting spermaceti (sperm oil), which was used for illumination making oil lamps, lubricants, and candles.

Interestingly, spermaceti is also a Phase Changing Material (PCM) that melts at high temperatures and solidifies in low temperatures. During the phase changing process, the volume changes, which is suspected to help adjust the whale's buoyancy. ABMH is aiming to use this properto to develop a self-sustainable underwater glider, converting thermal energy in the ocean to drive the buoyancy engine.

The working cycle of this thermal buoyancy engine can be divided into six steps. Floating at the surface, (buoyancy exceeds gravity). the heat of the of the warm sea water, causes phase changing material(PCM) in the heat transfer cylinder to melt and expand.

The first stage starts with the expanding PCM squeezing the an hydraulic oil-filled rubber tube. The pressure the PCM can generate is very high. The oil is pushed into the hydraulic pressure transfer cylinder. It function is to transfer the hydraulic pressure to lower working hydraulic pressure and increase the oil volume change.

The magnetic valve A and B opens, and the piston in the cylinder is pushed by the oil. Oil in the upper part of the cylinder flows into the accumulator and the mechanical

Sperm whales

energy is restored in the high pressure.

Meanwhile, oil in the outer bladder at the base of the engine is sucked into the cylinder and the buoyancy becomes smaller. When buoyancy drops to near gravity, valve B closes to stop further change.

In Step 2, the PCM continues to melt and expand and the vacuum in the cylinder pushes the piston upwards.

Step 3. After all the PCM has melted, magnetic valve A closes. The oil in the outer bladder is pushed into the vacuum in the cylinder by atmospheric pressure.

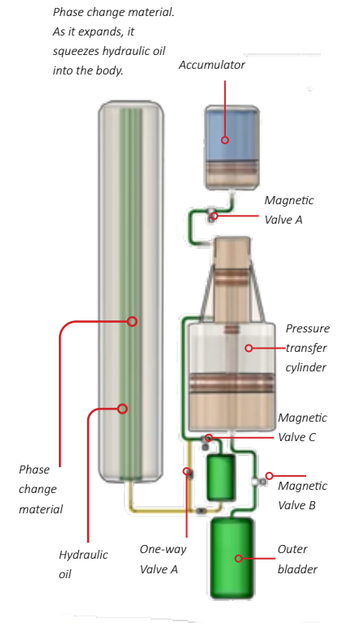
Step 4. This causes the buoyancy to become less than gravity and the vehicle starts to descend. As the water temperature goes down, the PCM starts to re-solidify and the one-way valve opens automatically.

The oil in the inner oil bladder is pushed into the heat transfer cylinder by the inner air pressure of the watertight hull.

Step 5. Upon reaching working depth, where the buoyancy is less than gravity, magnetic valves A B and C open. The oil in the accumulator is pushed into the pressure transfer cylinder which changes the high pressure of the oil to water pressure outside. The increased volume of oil flows into the outer bladder and increases the total buoyancy.

At this moment the buoyancy becomes bigger than gravity and the AUV starts to ascend.

Step 6. After arriving in the warm sea surface the next cycle begins.



THE FLIGHT OF THE PINGUIN

IN 2020 EVOLOGICS LAUNCHED PINGUIN, A NOVEL AUV PROTOTYPE RESEMBLING THE SHAPE OF A PENGUIN. SINCE THEN, THE DESIGN HAS UNDERGONE A RIGOROUS DEVELOPMENT PROGRAMME INCORPORATING THE LATEST SENSORS AND AI. THE AUV COULD REACH A COMMERCIAL STAGE THIS YEAR.

As an Antarctic biologist, Dr Rudolf Bannasch often marvelled at the underwater flying ability of Adele, Chinstrap, Gentoo and other Antarctic penguins, and particularly, their speed and agility that allowed them to escape from predators.

He went on to form Evologics, an underwater electronics company with a design philosophy of recognising how nature evolved systems such as underwater positioning, communications and networking etc, and looking for ways of emulating these using in engineering. Importantly, they also built vehicles that could deploy these instruments.

After 20 years, he began to think back to the fast and manoeuvrable penguins, and realised that these same properties could be very useful in AUVs.

"One of the most beneficial characteristics in AUVs is long duration," said Bannasch. "Duration is governed by available power and energy efficiency.

"Penguins can travel long distances by expending very low levels of energy. The stomach of a penguin is around 1L. It feeds upon krill. It has been estimated that if same mechanism burned energy rich fuel rather than krill, one litre would drive the penguin for 1500km "

The energy efficiency is owed in part, to their very low drag coefficient. Many engineers assume that the most hydrodynamically

efficient body is a classic torpedo shape, but this is untrue.

"In our engineering laboratory, we cast models of frozen penguins in plastics and tested them in wind tunnels, water tanks and towing tanks," said Bannasch "We calculated that the drag of the penguin shape was 20 to 30% lower than any typical AUV hull body.

"We developed a design called the PinGuin, a streamlined penguin-shaped hull powered by four rear thrusters that would allow manoeuvring by differential control of the motors.

"We believe that it is a good solution to arrange the propulsion system at the rear in line with the body. All the fluid passing around outside the body will be picked up by the propellers and accelerated again. This means minimum energy losses to the water.

"Furthermore, by using the propulsion system as a thrust vector steering device, we can control the direction at high speed. The

STABILITY

Fish and dolphins swim by firing muscles rhythmically causing the body to flex in sinusoidal movement, and the tail fin to push against the water to propel the body forward.

Underpinned by 40 million years of evolution, t he hydrodynamic movement of the penguin, however, uses locomotion apparatus derived from flying ancestors.

The power comes from the webbed feet coupled with side flippers which are used for to make agile turns. The result is that the body remains in the same posture during the entire flight. In the PinGuin, this inherent stability is ideal when pointing sensors at a target.

body shape has very low energy demands and just require relatively small motors to achieve a good performance. We see the vehicle being used for underwater mapping and searching for objects

"Important in the design is the vehicle has no external devices protruding out of the body and generating extra drag. All the equipment and sensors are integrated in the hull. We don't have a pressure hull. The inside is pressure and the electronic parts are sealed internally and acoustically transparent. The body is also non-magnetic.

"Since the prototype launch, we have been through many iterations. We have carried out a considerable amount of work to increase reliability and introduced a range of equipment.

"There are have been many challenges to solve such as material compatibility, manufacturing optimisation and the arrangement of the sensors.

"We have just completed the first series of vehicles. Three are operational and another five are now in preparation. The model we are currently building it is approximately the same size as an Adele Penguin and that has a speed up to 10 knots underwater.

SWARMS AND ARTIFICIAL INTELLIGENCE

Most large AUVs are designed to go on a mission and return a day or several days later with the data it has collected. It may be, however, that the data arrives too late for the operator to react to what the vehicle has discovered.

PinGuins are designed to be used in another way. With their low energy consumption their batteries give an endurance of 8 –10 hours operation in the sea so they can also be run singly, Evologics', is to run a number of together in swarms. The advantage of numerous AUVs communicating with each other, is that they can react considerably quicker and when searching, cover a greater range than a lone larger AUV. For vehicles to move in swarms, however, they require considerable onboard intelligence.

MUM

One application for the PinGuin is as part of the Modifiable underwater Mothership (MUM) project.

MUM is a new class of extra-large modular uncrewed underwater vehicle designed for various applications in the civil maritime industry such as transport and deployment of payloads and exploration of remote areas.
It consists of compartments as large shipping containers mounted together within a streamlined hull.

Such a large vehicle is likely to benefit from a symbiotic swarm of Pinguins that can swarm out to explore the environment while also serving communication and navigation.

If the MUM vehicle goes underneath the North Pole, for example, it will be effectively blind. Without access to GPS or external aids, it will have to rely on inertial navigation.

Placing a chain of penguins every few kilometers however, allows data hopping and positioning. It can also assist in the open sea by one Pinguin at the surface taking GPS measurements and sending the information down via acoustic link.

"Animals depend on the situational awareness – not only looking what is in front of them but understanding the greater surrounding environment. As such, we not only want to control the vehicle remotely or have a simple autopilot, but also automatically react to the external situation.

"Vehicles in a swarm will not only need to navigate in three dimensions, but also be aware of the others in the area. To retain situational awareness means integrating a range of different sensors, possibly combining equipment on different vehicles. We have cameras and environmental sensors on board this also generates a lot of a data

"To enable processing the large amounts of data that this may generate, and particularly providing the capability of object recognition, we have invested a lot of time and money to implement artificial intelligence and edge processing directly on each vehicle.

Instead, of sending large video files, etc, we use onboard processing to carry out semantic information compression and turn the data into information which is easier to send.

"We are very interested in object recognition, not only other vehicles, but things like pipelines or underwater mines. We are looking to apply AI techniques to train the vehicle using onboard neural networks. With the onboard processing, the only information that needs to be transmitted to the operator are what the objects are, the probability of the interpretation and the coordinates.

BOUNDARY EFFECTS

Historically, it was often accepted that a smooth hard shiny vehicle surface was the most hydrodynamically efficient because it afforded minimal resistance.

It was only when researchers began to look at things like sharkskin- rough to the touch- that they recognised that the characteristic microstructure gives a measurable improvement in performance at the boundary layers when moving from laminar to turbulent flow. It reduces or delays the transition.

Is this the same with Penguins?

"We carried out research in a special 21m long swimming tank in the Antarctic, performing an analysis on the dolphin skins and penguin feathers," said Bannasch.

"Several penguins have a compliant flexible skin. When dry, the feathers are soft like a pillow but as soon as the penguin enters the water, their strong subcutaneous muscle system and behaves like a like a diving suit.

"We carried out parallel studies using a range of materials such as neoprene and then compared the behaviour to both Antarctic dolphins and the penguins.

"We have some interaction with colleagues in Russia who use compliant walls in torpedo design. They have recorded a direct reduction of resistance of up to 20% using a specially prepared wrapper able to adjust to the to the fluid dynamic

"Despite the advantages of a biomimetic skin, we, did not use this because we wanted to have an acoustically transparent vehicle. We have front-looking and side scan sonars as well as an advanced comms system that would not have been compatible with a plastic skin covering.

We believe we have designed the optimal body shape that reduces the pressure drag and conclude that this is more important than friction drag

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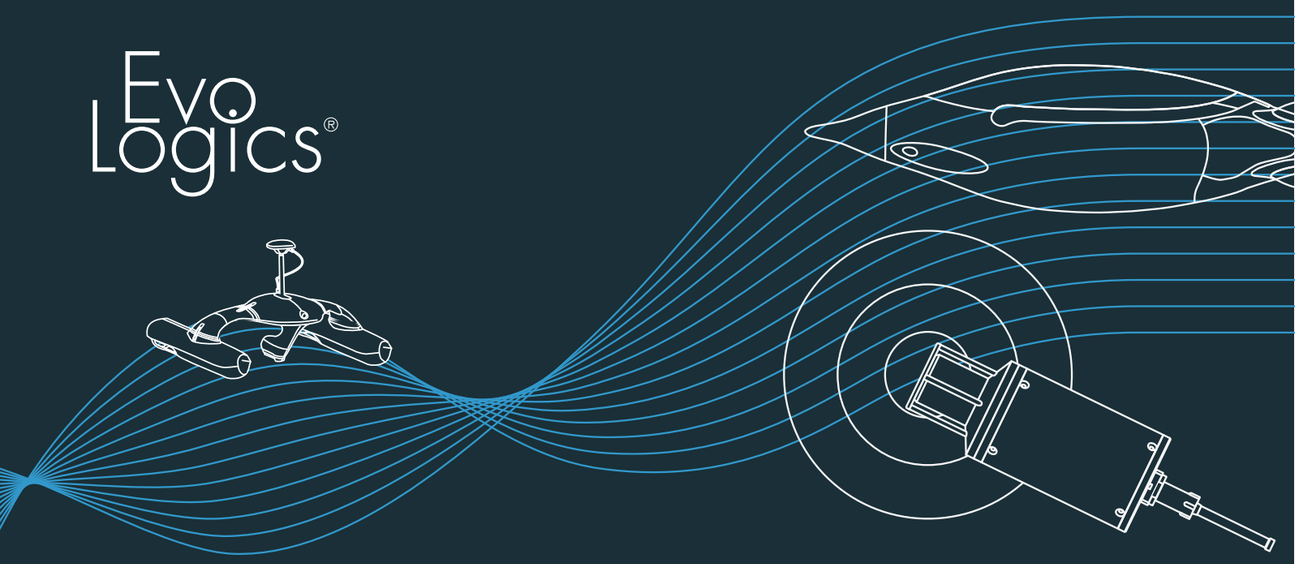

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