Hydro INTERNATIONAL

THE GLOBAL MAGAZINE FOR HYDROGRAPHY
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JULY/AUGUST 2017 | VOLUME 21 NUMBER 4

Trends and New Technology In the ROV Industry

COASTAL MONITORING OF WATER QUALITY

Surveying a Hell Hole

Mapping a Hyper-acid Crater Lake with a USV

July-August Volume 21 #4

Carrying the affordable and portable USV into the 'Hell Hole' to survey the Laguna Caliente in the Poás Volcano crater in Costa Rica. The water is 55°C and has a pH of 0.5. Knowing the volume and bathymetry of the lake is crucial in monitoring and predicting the behaviour of this active volcano. See the article from page 19.

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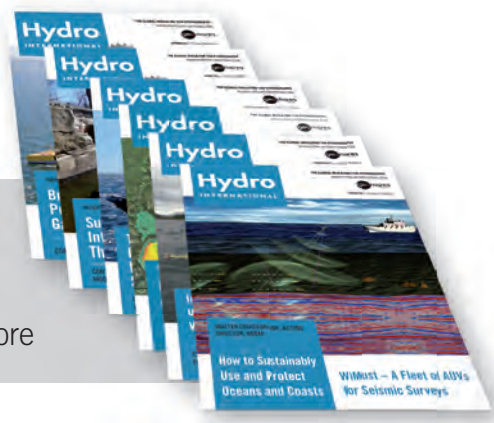

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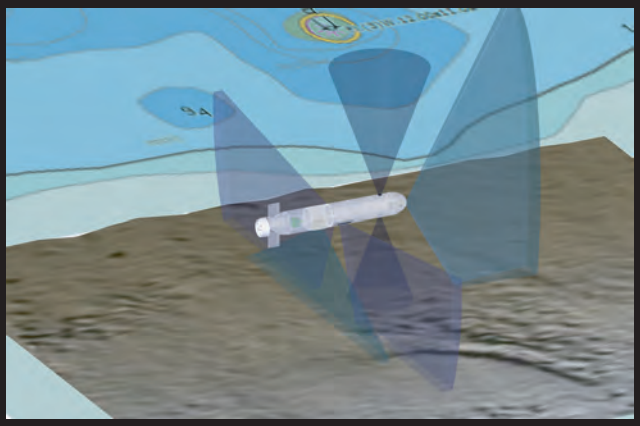

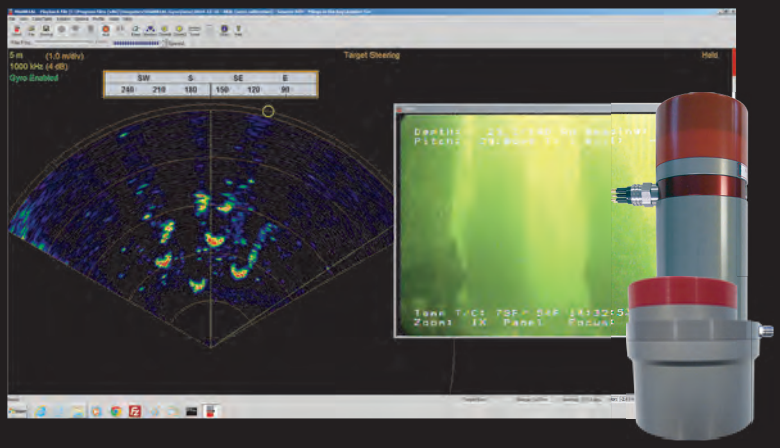

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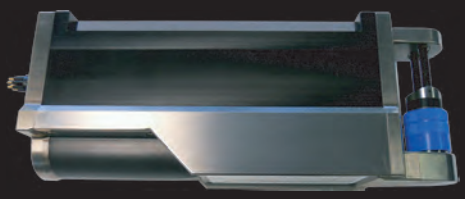

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Hydro INTERNATIONAL

Hydro International is an independent international magazine published 6 times a year by Geomares Publishing. The magazine and related e-newsletter inform worldwide professional, industrial and governmental readers of the latest news and developments in the hydrographic, surveying, marine cartographic and geomatics world. Hydro International encompasses all aspects, activities and equipment related to the acquisition, processing, presentation, control and management of hydrographic and surveying-related activities.

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 ISSN 1385-4569

PHOTOGRAPHY: ARIE BRUINSMA (WWW.ARIEBRUINSMA.NL)

Going to Depths

Even though it is the middle of summer, at least here in the northern hemisphere, we are diving deep into the coldest and farthest depths of the ocean in this issue of *Hydro International*. In the season where most of the activity is on and beside the water, we look at those initiatives that find solutions to mapping those vast areas of seafloor that have not been mapped before. The mapping will be done mainly through the fast developing technology of unmanned systems, of many different types. Why should we want to map all those immense pieces of underwater land, at times as large as entire nations? So far we've managed safely without the knowledge of what is down there at the bottom of sea. The chairman of the Nippon Foundation, Mr Yohei Sasakawa, said recently at the UN Oceans conference in New York that 'understanding the bathymetry of the global ocean is imperative, not only for improving maritime navigation, but also for enhancing our ability to project climate change and monitor maritime biodiversity and resources.' As chairman of the Nippon Foundation he launched the NF-GEBCO Seabed 2030 as a joint project of the Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO). It was announced In New York that the Nippon Foundation is willing to contribute USD 18.5 million for the first ten years of the project. That money will be used to compile a high-quality, high-resolution digital model of the ocean floor combing all available and newly collected bathymetric data.

In the meantime, the GEBCO Alumni team is entering the semi-final stage of the Shell Ocean Discovery XPRIZE. During this competition that runs over the course of 36 months, ending in December 2018, teams from all over the spectrum are developing and testing technology that will be able to help towards the same goal of Seabed 2030. The team consists of GEBCO fellows from all parts of the world. Kongsberg Maritime offers technological support to the GEBCO team while they pursue their goal of winning the Shell Ocean Discovery XPRIZE.

In this issue of *Hydro International* on Unmanned Systems we interviewed Richard Mills, of the section Marine Robotics of Kongsberg Maritime and Arne Kjorsvik, CEO Eelume AS (see page 12). Eelume is a start-up company and Kongsberg Maritime one of the giants in underwater technology. The two companies are working together on the Eelume, a snake-like underwater robot that can live permanently on the seafloor and because of its shape and flexibility will be ready to go to those places that are difficult to reach. Not specifically aimed at the depths that the technology developed in the XPRIZE is going to, it is still a strong sign that this trend of building more versatile, flexible and robust technology to map the underwater world is only growing stronger. Not just because it is possible, but moreover because it is necessary to go to all depths to save the planet, its oceans and the life in and around it!

Durk Haarsma durk.haarsma@geomares.nl

The Unmanned System: A New Menace to the Hydrographic Surveyor Profession?

The evolution of hydrographic surveying technology has been moving in a very fast pace over the last decade. The introduction of the unmanned systems such as Autonomous Underwater Vehicles (AUVs), Unmanned Surface Vehicles (USVs), Remotely Operated Underwater Vehicles (ROVs), Maritime Autonomous Systems (MAS) and Marine Drones have tremendously changed the landscape of the bathymetry surveying industry. Recently, most of these systems have been accepted and widely used in hydrographic fields. Apparently, the tendency of industry players to choose this unmanned system as acquisition tool was not only driven by the capability of the unmanned system to achieve high – precision and accuracy standards but this system offers high-resolution data with a much lower operational cost.

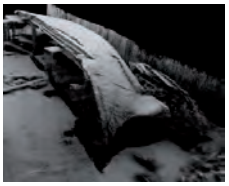
Whether we like it or not, technological advances cannot be prevented. However, this new system can also become a significant threat to the hydrographic surveying profession. Recently, the popular discussion topic over coffee and in office corridors is whether a career as a hydrographic surveyor is still relevant after almost all levels of data collection have been taken over by the unmanned systems. The death of a profession is not a new thing. In the field of surveying itself, some professions have been taken over by technology. During the old days, we had survey recorders and calligraphers. Where are these professions now? Their job is no longer relevant in modern surveys. Thus, the advancement of electronic and robotic technology is likely to take away some of the fieldworkers' tasks. So it is possible that in a decade or two, a profession such as that of a hydrographic surveyor will slowly become irrelevant and maybe even extinct.

Nevertheless, it is important for hydrographic surveyors to keep abreast of the principle theory of these systems especially when applying them to specific hydrographic survey projects. It is now common for a hydrographic survey team to be comprised of relevant personnel from different fields, such as geomatics and geospatial experts, geophysicists, civil and computer engineers, in order to complement the different tools onboard a hydrographic survey vessel including the various unmanned systems available to execute the task in hand. The execution of unmanned systems in hydrographic survey projects depends on understanding the principle of the systems and therefore requires experts with a relevant background. The existence of unmanned systems supplements existing systems that the hydrographic surveyors are very familiar with and provides a choice to the hydrographic surveyors depending on the requirement of the projects.

As an academician, I believe that the profession of hydrographic surveyors is still relevant and has a great potential to keep growing. Nevertheless, the skills and expertise in the field of

surveying needs to be more diverse. With the current trend of unmanned systems, hydrographic surveyors need to develop their knowledge in other areas, mainly electronic and computer programming. The knowledge in electronic and computer programming will be critical in the new era of surveying technology. Academic institutions must also embrace efforts to update their course modules following the surveying technology evolution, particularly the unmanned system technology.

Wrecks Discovered in Beirut Harbour



▲ *Lighthouse Geo survey of wrecks in the Port of Beirut.*

Lighthouse Geo has made a video using QPS Fledermaus interactive 4D geospatial processing and analysis software. The video portrays three wrecks and a part of the Beirut harbour structure, previously unknown and now charted for the first time. One of the surveys carried out involved a wreck survey. QINSy, used for data acquisition and online QC/QA, mapped a 80m long wreck.

▶ ***bit.ly/2uLTiW4***

Caution Required When Using Nautical Charts of Arctic Waters

As members or associate members of the Arctic Regional Hydrographic Commission (ARHC) and as Member States of the International Hydrographic Organization (IHO), the government Hydrographic Offices of Canada, Denmark, Finland, Iceland, Norway, the Russian Federation and the United States of America wish to highlight the significant limitations and risks associated with marine navigation in the Arctic.

▶ ***bit.ly/2tJ0Hid***

Canadian Hydrographer Certification Scheme

The Association of Canada Lands Surveyors (ACLS) has developed a certification model for hydrographers and offshore surveyors which has been officially recognised by the IHO/FIG/ICA International Board of Standards and Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) in April 2016 and is ready to receive applications. For information on the scheme, please visit the ACLS website, contact the ACLS Registrar Jean-Claude Tétreault or call +1-6137239200.

▶ ***bit.ly/2tKbASB***

Most Shared

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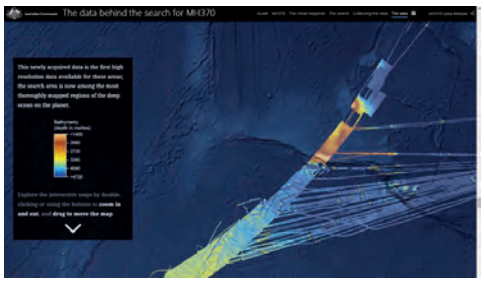
Hydro International's website www.hydro-international.com has a new feature: a listing of authors. Authors of feature articles are listed here with their biography and ways to contact or link with them. In addition, the articles that they have contributed to are on the author´s page. The number of authors and linked articles will expand in the course of time. If the listing needs updating, please contact content manager Joost Boers, joost.boers@geomares.nl.

▶ ***bit.ly/hyd-authors***

Data Behind MH370 Search: Phase One Released



▲ *Geoscience Australia Data Mapstory MH370 Phase One.*

Geoscience Australia has released the seafloor mapping data collected during the first phase of the search for missing Malaysia Airlines flight MH370. The search for MH370 involved collecting large volumes of data in a remote part of the southern Indian Ocean. The search was conducted in two phases - the first phase was a survey to collect bathymetry data, or data of the seafloor topography, to develop maps of the seafloor in the search area. These maps were used to safely guide the second phase of the search, the underwater search.

▶ ***bit.ly/2tJWooU***

Rear Adm. Shepard M. Smith to Chair IHO Council

▲ *RADM Shepard Smith.*

Rear Adm. Shepard M. Smith, director of NOAA's Office of Coast Survey and the US national representative to the International Hydrographic Organization (IHO), was elected as the chair of the IHO Council.

▶ ***bit.ly/2tJCs5e***

MMT Expands Business with New Survey Vessel

During the past year MMT have gained a good market position and in order to keep developing have taken important steps to continue to grow their business, including chartering a new vessel, M/V *Olympic Delta*, and investing in the Surveyor Interceptor no 2. Both initiatives are set to expand the company's possibility to meet increased demand for their services.

▸ *bit.ly/2tJCLgo*

▲ *M/V* Olympic Delta.

Italian Hydrographic Institute Joins Italian Hydrographic Society

The Italian Hydrographic Society (IHS) is pleased to announce that the Italian Hydrographic Institute is now a member. With its acceptance, IHS will be able to count on their expertise on hydrographic subjects, and in this way the association will be able to widespread the hydrographic culture all over the country.

▸ *bit.ly/2tMxPQ*

JALBTCX 532 Award for Yves Pastol

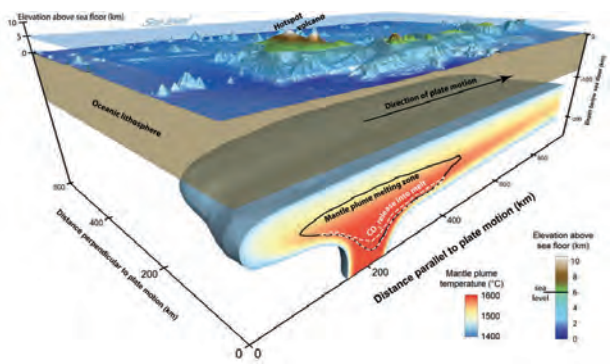
During the recent Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) Conference, which took place from 6-8 June 2017 in Savannah, USA, SHOM hydrographic surveyor Yves Pastol received the 532 Award for his life-long dedication to airborne Lidar bathymetry.

▸ *bit.ly/2tKhvHk*

Reduced Sea Level Caused Volcanos to Overflow

Throughout the last 800,000 years, Antarctic temperatures and atmospheric carbon dioxide concentrations showed a similar evolution. However, this was different during the transition to the last ice age: approximately 80,000 years ago, temperatures declined, while the carbon dioxide content of the atmosphere remained relatively stable. An international research team led by the GEOMAR Helmholtz Centre for Ocean Research Kiel and the Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research has discovered that a decreasing sea level may have caused enhanced volcanic activity in the ocean, which can explain the anomaly. The results are published in the journal Nature Communications.

▸ *bit.ly/2tNCH9*



▲ *Model of an island volcano. During the last transition to glacial conditions the decreasing pressure at the seafloor could have induced increased lava and carbon dioxide emissions. Image courtesy: Jörg Hasenclever.*

EdgeTech Provides 6205 to UNH CCOM

The University of New Hampshire's Center for Coastal and Ocean Mapping/ Joint Hydrographic Center (CCOM/JHC, USA), was recently provided with an EdgeTech 6205 MPES system. The 6205 will be utilised in the Fundamentals of Ocean Mapping course this fall and deployed in other research activities at the centre throughout the year.

▸ *bit.ly/2tK9mmt*

Coastal Acoustic Release Technology

Teledyne Benthos has announced the introduction of its coastal release technology. New products include the value-priced Releaseit Deck Unit and dunking transducer, as well as the R-500 Coastal Acoustic Release.

▸ *bit.ly/2tKi0WY*

▲ *Teledyne Benthos Releaseit Coastal Acoustic Release technology.*

Australian River Flow Compares ADCPs

The Australian Bureau of Meteorology collates and shares a wealth of river flow data from monitoring organisations across Australia, and the quality of the data starts with the hydrographers that collect it. In March 2017, 50 hydrographers from Australia and New Zealand converged at Thredbo River in New South Wales, armed with an assortment of acoustic doppler instrumentation used to measure river flows. Participants tested their equipment, skills and procedures. They took measurements at fixed locations along the river to allow comparisons.

▸ *bit.ly/2tKk10l*

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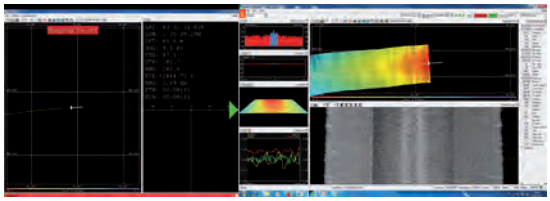
Teledyne Marine Benthos SeaROVER	bit.ly/2uP8NMX

French Bathymetric Survey Vessel Renovated and Refurbished

Located on the western border between Basque Country and Gascony, the harbour of Bayonne belongs to the region Nouvelle-Aquitaine, which is under obligation to provide information to the various harbour operators about the depths in the areas of the harbour. MacArtney France supplied the multibeam solution for the bathymetric survey vessel *Ingénieurs Lesbordes* and is the integrator of the various steps of modification that were imperative to the successful adaptation of the vessel to the prevailing IHO survey standards.

▸ *bit.ly/2tK9Fh7*



◂ *Speed test renovated survey vessel in the harbour of Bayonne, France.*

60th OCEANS Conference in Aberdeen

The Marine Technology Society (MTS) and the IEEE Oceanic Engineering Society (OES), co-sponsored the 'OCEANS '17 MTS/IEEE Aberdeen', from 19–22 June 2017, at the AECC in Aberdeen, Scotland. OCEANS Aberdeen was the 60th edition of this premier global ocean engineering and marine technology forum.

▸ *bit.ly/2vRcMW1*

▲ *The MTS/IEEE OCEANS'17 Aberdeen Student Poster Competition (SPC) award winners, from left to right: Ms. Faye Campbell (Conference LOC SPC Chair), Bilal Wehbe (Second Place), Klemen Istenic (First Place), Habib Mirhedayati Rouds (Third Place), and Dr. Philippe Courmontagne (IEEE OES SPC Chair).*

SSDM Showcase 2017

In conjunction with the release of Seabed Survey Data Model (SSDM) version 2 earlier this year, PETRONAS took the initiative to organise the SSDM Showcase 2017. The main objective of this half-day event was to inculcate awareness and to promote the utilisation of SSDM for all seabed survey data deliverables in Malaysian waters.

▸ *bit.ly/2uOGUVm*

▲ *Participants of the SSDM Showcase.*

First Year of the IC-ENC Latin America Office

The regional IC-ENC Office in Brazil became fully operational on 21 June 2016. It has been a year of learning, hard work and dedication to keep IC-ENC's validation high levels on time. The main reason for the existence of the regional office is to provide personalised support to the Latin-American Hydrographic Services in order to better serve their needs in terms of the production and validation of electronic nautical charts. The office has performed this task with mastery because of the easy communication thanks to the language and time zone, helping the countries to improve the quality of the ENCs available in the market, which is increasing every day.

▲ *Participants of the first IC-ENC Technical Conference in Taunton.*

The first cell validated was the New Cell BR501712. During this first year, more than 862 Updates, 382 New Editions and 173 New Cells were validated by Lieutenant Ana Mileze and Corporal Bruna Pinheiro. The report gives an insight on the actions in the first year.

▸ *bit.ly/2uOTVhM*

Career Talk at Universiti Teknologi MARA Perlis, Malaysia

Sea-to-Space Advanced Mapping (S2SAM) Research Group from the Center of Studies for Surveying Sciences and Geomatics (CSSSG) at Universiti Teknologi MARA Perlis, Malaysia organised 2 days of career talks, on 13 and 14 May 2017, with the theme 'Geomatics Profession in Oil and Gas Industry'. The event was attended by 50 undergraduate students.

S2SAM was represented by one of the hydrographic surveying lecturers, Mohd Zainee Zainal, and was jointly organised with his CSSSG final year undergraduate students who have hydrographic surveying as their final year project thesis.

Three alumni of the university were invited as speakers. Two of the former students are currently working at PETRONAS and the third speaker is a hydrographic surveying business consultant. He is also the chairman of the newly founded Malaysian Hydrographic Society (MyHS).

▸ *bit.ly/2uOBPwl*

▲ *The delegates of the career event.*

Hydro International interviews Richard Mills, Marine Robotics, Kongsberg Martime and Arne Kjørsvik, CEO Eelume AS

"We Are Limited by **Imagination** Rather Than **Technology**"

Now that the spotlights are on unmanned vehicles for various tasks in subsea survey, inspection and maintenance, it's interesting to see how two businesses are looking at the technology. In 2016, Kongsberg and the start-up Eelume started their cooperation to develop an innovative type of underwater robot that can live permanently on the seafloor and because of its snake-like shape and flexibility will be prepared to access areas that are difficult to get to with traditional technology. *Hydro International* interviewed Richard Mills, Sales Director Marine Robotics, Kongsberg Martime and Arne Kjørsvik, CEO of Eelume AS.

▲ *Richard Mills*

After a long time of relative stability in the design and tasks of AUVs and ROVs, there seem to be a movement over the past years. What do you see as the most important recent developments related to survey and mapping?

The most important recent developments with regard to mapping and survey vehicles has been in how the data is handled. Until very recently, the vast majority of data collected by AUVs, such as side-scan imagery or bathymetry, has been processed either on the mother ship, or on shore. These processes have been heavily reliant on human input. However, in the last few months we have seen the introduction of in-mission processing, and cloud-based data handling services. Now some of the manual data processing can be completed automatically, thereby reducing the time from data collection to reporting.

How was the Eelume snake-like operational concept invented?

The idea behind snake robotics surfaced early in 2000 due to discussions between the firefighting department in Trondheim city and the Norwegian University of Science and Technology (NTNU). NTNU had started to develop a controllable firefighting hose that could spray water in confined spaces. The next step was to put the snake into water to see if it would also swim like a snake. That's when the

concept for a swimming snake-like robot was born.

What kind of operations were intially anticipated for the device, and how is this developing?

We are working on two main operational capabilities: inspection and light intervention. The inspection task is an obvious step, with a flexible vehicle that can access tight spaces and places that larger vehicles cannot access. The intervention capability is being driven by the oil and gas industry, with the requirement to reduce costs. Obviously there are some challenges to operating a valve with a small vehicle, so we are collaborating with established suppliers in the industry to deliver a redesigned electric torque tool.

What was the biggest challenge faced by the developers during the research and design?

As for most development projects, time and resources are challenging, however, Eelume has strong supporters that are key elements for success. The Eelume solution will be able to work tethered, much like an ROV, or untethered like an AUV. Furthermore, Eelume will connect to a high-bandwidth communications network for direct control when untethered. This mode is essential for interacting with structures. Ensuring correct system architecture and software protocols to enable all of these control methods while retaining the compact, flexible and modular hardware is perhaps one of the greatest challenges.

Will this be a principal choice for the future users or will the device be hybrid so the user can choose easily?

With a new concept like Eelume, we are limited by imagination rather than technology. The final solution will have hybrid capabilities, working like a tethered or untethered ROV, and autonomously like a survey class AUV, following a mission plan. Today, intervention tasks demand an operator in the loop, but we see that may change as autonomous operations become culturally acceptable.

Will an Eelume robot be capable of accomplishing just one task or can a user retool a device – even underwater?

The plan is to enable Eelume to attach swappable tools and battery modules. These will be located on a rack or carousel located subsea along with the vehicle dock. The vehicle can then select which tool it needs, whether that is a torque tool, cleaning brush, or extra battery for longer endurance missions.

▲ *Arne Kjørsvik*

Will the robot have an impact on payload design in general?

At present, the majority of ROV tools are quite heavy and hydraulically operated. We have started to work with tool designers and suppliers to create custom, light weight electric tools specifically tailored for the Eelume vehicle.

Eelume is not affected by weather, ship endurance or crew fatigue

As the Eelume vehicles can stay underwater for a longer time, how will operators keep track of the device, also for aspects such as position keeping and maintenance?

Most underwater vehicles have a combination of sensors for navigation and positioning. Eelume is no different. The vehicle has an inertial measurement unit, coupled with other sensors like a depth sensor or Doppler Velocity Log for navigation. We will also use relative positioning in and around templates and structures.

How was the concept received during the introduction at Ocean Business in Southampton? What were the most

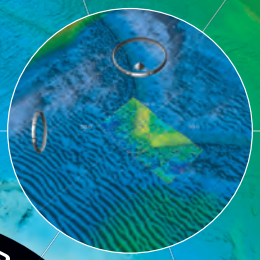
SPECIALISTS IN SOFTWARE FOR MARINE GEOSPATIAL DATA

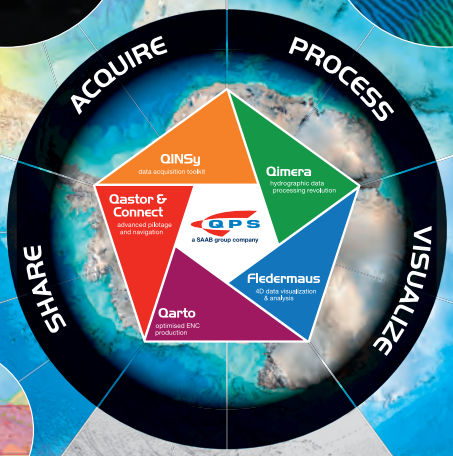
QINSy

QPS QINSy is navigation / positioning and reporting software used on board offshore construction vessels, pipe-lay barges, drilling rigs, seismic research vessels and all manner of hydrographic survey vessels (Surface and sub-surface). QPS is a market leader in the offshore renewable energy industry, the dredging industry and port communities.

Qimera

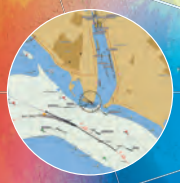
QPS Qimera is probably the simplest yet most powerful post processing application available. Built on the strengths of QINSy and Fledermaus and optimized for the latest computing technology, Qimera is feature rich and extremely easy to use. Able to work with QINSy data files, plus many other raw sonar file formats, the Qimera Dynamic Workflow revolutionizes the efficiency with which post processing can be completed.





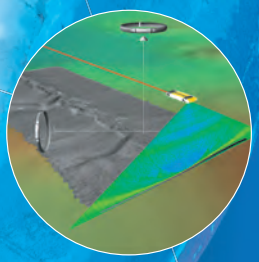
Qastor/ Connect Server

Precise navigation - Using wired or wireless methods, QPS Qastor interfaces to most devices outputting NMEA data strings to AIS transponders/receivers and to the QPS Connect Server. Connect typically supplies ENC updates and meteorological data feeds to Qastor users, but is also capable of distributing other types of information (like VTS feeds or Qastor common files).



Fledermaus

QPS Fledermaus is an industry leading interactive 4D geospatial visualization and analysis tool. Commercial, academic and government clients use Fledermaus to interact with massive geographical datasets of numerous data types for ocean mapping and land-based projects. The intuitive 4D display allows clients to rapidly gain insight and extract more information from their underlying data. This provides our clients with added value in data interpretation efficiency, quality control accuracy, data analysis completeness and project integration. All of which promotes clear communication.



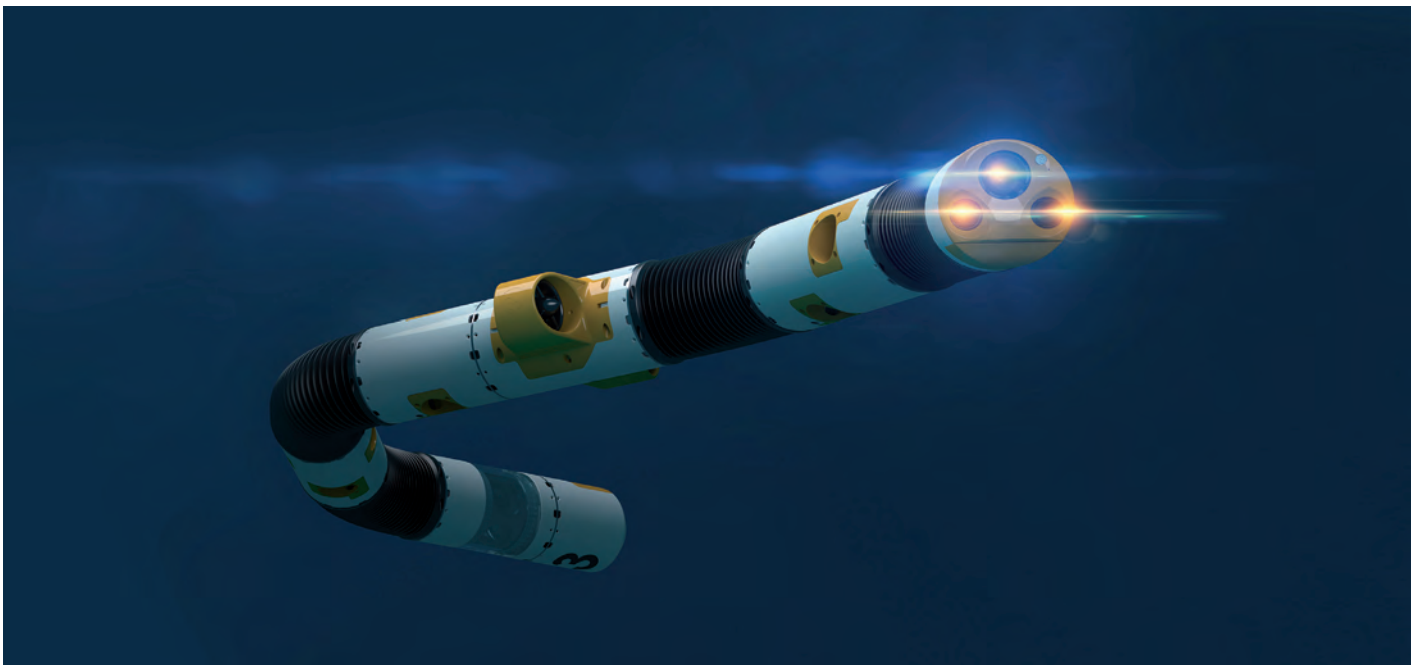
Qarto

The strength of Qarto is the very fast and automated ENC production. Qarto makes possible the short turn-around times from survey to chart that are necessary for the safe operation of the busy waterways. Qarto vn3 distinguishes itself by its efficient way of data storage and by its principle based on semi-static base cells that are updated with highly dynamic hydrographic data. Completely updated ENC base cells are ready for distribution avery shortly after the survey being completed.

www.qps.nl (sales@qps.nl)
www.qps-us.com (sales@qps-us.com)

QPS is focused on the system integration of survey sensors, the development of software used for maritime geomatic surveys, Portable Pilot Units and Electronic Navigation Charts (ENC) production. QPS is seen as market leader in these fields.

QPS
a SAAB group company



▲ *Eelume*

remarkable 'new' uses for unmanned underwater work suggested or anticipated by users?

The project has been very well received, not only at Ocean Business, but also at the Australasian Oil and Gas show, AUVSI in the USA and most recently Oceans 17 in Aberdeen. We have sought feedback specifically on the capabilities and requirements for the vehicle, to ensure we develop a solution that works, and not just a cool vehicle. So far we have had interest from within the oil and gas industry, but also nuclear power stations, defence organisations, water suppliers and more.

There are a number of projects that look at nature-derived technologies for propulsion and operating (unmanned) underwater vehicles. Are you looking into more options in this area?

The field of biomimetic robot development has grown over recent years. Not least due to the videos presented by DARPA and Boston Dynamics of the walking style robots that might one day find their way into military use. In the commercial world, we are always interested in new developments and keep a watchful eye on many different styles of robots.

Will the tasks and operations of current ROVs and AUVs change once the Eelume robot becomes more common? How do you imagine their designs to change?

The IMR industry is changing. Not only are manufacturers developing new tools like Eelume, but also the oil companies are demanding more capability with ever growing pressure on costs. As a result, we see the opportunities for Eelume increasing. Having it located on the seafloor in a docking station right next to its area of operations provides 24/7 access to a capability that was only available when an ROV ship was present. Eelume is not affected by weather, ship endurance or crew fatigue and can be operated from almost anywhere around the world. This will make it easier for asset owners to conduct inspection on demand and scheduled inspections, and in addition utilise the necessary tool when needed. ◀

The field of biomimetic robot development has grown over recent years

Richard Mills is the director of sales for Marine Robotics at Kongsberg Maritime. He leads the sales team for HUGIN, MUNIN, Eelume and USV product lines. Richard specialises in the commercial application of marine robotics. He is currently a board member of Eelume, a Norwegian company developing a subsea resident robot for IMR operations in collaboration with Kongsberg Maritime, Statoil and the Norwegian technical university (NTNU). Richard joined Kongsberg in 2012 from International Submarine Engineering Ltd. (ISE) based in Vancouver, Canada. He held a similar position with ISE. Prior to joining the subsea industry Richard was an officer in the UK's Royal Air Force.
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Arne Kjørsvik has an MSc in Engineering Cybernetics from NTNU (Norwegian University of Science and Technology) and started his career as system developer at Novotek, and later at Kongsberg Defence and Aerospace working on underwater vehicles for mine counter measures. He then moved on to MARINTEK as a research engineer and worked on various control systems for vessels including simulator development. In 2006, he started at Marine Cybernetics, and became the chief market officer in 2008 and continued in that position until the company was sold to DNV-GL. He began at Eelume as CEO in September 2016. Eelume is a start-up company creating cost-saving disruptive underwater technology to the offshore industry.
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New Technology Bringing Science and Industry Together

Snow Crab Tracking using Wave Gliders

Coastal communities around the globe are seeking better ways to understand and manage regional ecosystems. They depend on the ocean to sustain economic opportunities, ensure food security, and safeguard fragile environments and species. For harvesters, scientists and government organisations in Nova Scotia, Canada, timely, accurate, comprehensive data on movements of valued species is essential for designing effective fishery management regimes.

Ocean Tracking Network (OTN), the Canadian government and local harvesters have been tagging and monitoring aquatic animals for years. But not all tracking methods are practical or cost-effective for highly mobile, yet slow moving animals like snow crab and lobster. Electronic tagging systems and traditional bottom-moored acoustic receivers have limitations on detection range, and have to be periodically retrieved or interrogated via acoustic modems to get the data stored on them. The challenge for scientists is to seek new ways of developing 'mobile receivers' that can patrol an area and generate the same data that an extensive moored array would deliver.

To tackle this challenge, a powerful collaboration was formed under the leadership of OTN, working with local fishermen, Canada's Department of Fisheries and Oceans (DFO) and Emera Inc. scientists. These stakeholders have joined forces to explore new technologies and new ways to monitor snow crab migration in eastern Nova Scotia.

Ocean Tracking Network: A Research Initiative Grows

Since 2008, OTN (oceantrackingnetwork.org), headquartered at Dalhousie University in Halifax, Nova Scotia, Canada, has been deploying acoustic receivers and oceanographic monitoring equipment in key ocean locations and inland waters around the world. In numerous projects they document the movements and survival of aquatic animals carrying a variety of electronic tags (acoustic, satellite, radio, data archival), with a special focus on acoustic technologies.

Maritime Link Power Line Initiative

OTN's expertise in tracking marine animals was called upon to assist in evaluating potential environmental impacts on crabs and lobsters from the proposed undersea Maritime Link power line that would span the Cabot Strait exit of the Gulf of St. Lawrence. Multiple stakeholder groups needed a better understanding of crab migration patterns, to determine whether the project would impact the animals, and if yes how to mitigate any issues.

OTN joined forces with stakeholders to monitor snow crab migration in eastern Nova Scotia. The joint effort involved OTN, local fishermen, Canada's Department of Fisheries and Oceans (DFO) and Emera scientists (the project's proponents).

Each group has its own information needs about the crabs' movements, behaviour, and

▲ *Figure 1: Canadian snow crab.*

▲ *Figure 2: Emera Maritime Link (left bottom box)– Area with snow crab monitoring (image courtesy: Emera).*

population abundance.

- Emera focused on meeting the impact assessment directives for monitoring and documenting the habits and behaviour of snow crab before and after cable installation.
- OTN sought the best possible data for the scientific community to provide a foundation for sustainable oceans management.
- Commercial harvesters were working with government agencies to adjust fishing quotas so that they more accurately tracked the spatial distribution of the resource.
- DFO required further data to support its conservation and sustainable fisheries mandates.

Fishermen Gain Visibility, Strengthen Dialogue

Commercial harvesters in Nova Scotia depend on a healthy ecosystem for their livelihood. Snow crab fishing is a major industry in the community, with annual revenues of more than CAD111 million (2014). Harvesters need to balance production as well as sustainability, bringing in the largest possible harvest without impacting the long-term health of the crab population.

Fishing quotas are a critical mechanism for balancing the long-term environmental and commercial needs of the fishery. With so much at stake, local harvesters are doing all they can to ensure that quotas will maintain sustainable fisheries.

Fishing in the Canadian waters of the North Atlantic is regulated by zones, and each zone is assigned a specific quota every year by the DFO. The agency sets these quotas based on data from an annual biomass survey, and statistical modelling which factors in things like environmental variables.

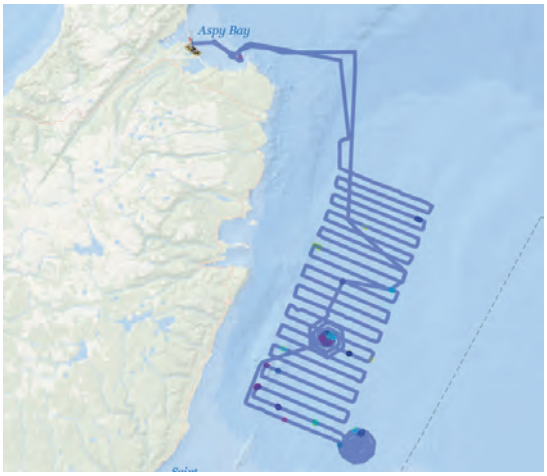
Quotas can vary dramatically between adjacent zones. One zone might allow an annual harvest of 8,000lbs., while its neighbour might permit 160,000lbs. It is not surprising that local harvesters whose activities are limited to specified zones are not always in full agreement with their assigned quota—especially if it differs with their perception of the potential catch. An annual snapshot of a specific population cannot always reflect migration and other behaviour that is difficult to model.

Local fishermen note that scientists at the DFO have been going out year after year to perform biomass estimates, and if they cannot find crab in their annual surveys, the quota remains low. This is despite the fishermen's observations of phenomenal catches. Their theory is that the crabs were moving from one zone to another which was missed in the annual survey (the survey also includes data collected from boats that report catching a tagged crab).

Emera Maritime Link and Snow Crabs Monitoring Mission

To monitor and accurately track the movement of the Snow Crabs, VEMCO Positioning System (VPS) arrays were deployed for fine scale movements (shown as red lines). The Wave Glider surveys (blue) provided valuable data on medium and long-range movements of snow crabs. Findings showed:

- At least 15 of 48 animals were detected in 2015
- Snow crab movement is extensive with documented travel as far as 600km+.



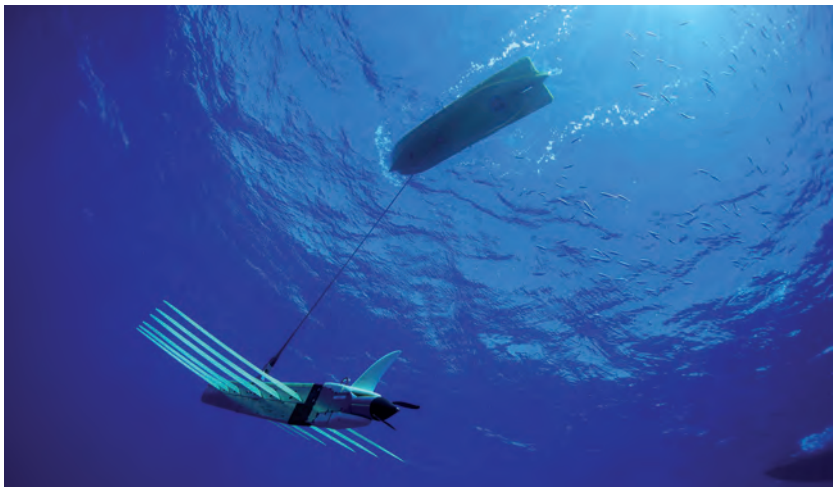
▲ *Figure 3: OTN Mission #46 (DL) to track tagged crab (image courtesy: OTN).*

A New Partnership Yields Results

To help strengthen their case and verify their own informal observations, these fishing groups took the initiative to develop an acoustic tracking programme to see if the crabs were moving among zones. The harvesters built partnerships with government and OTN, paid to tag approximately 100 snow crab at their own expense, and provided their vessels and time to deploy undersea receivers along the fishing zone boundary line.

Dr. Whoriskey of OTN suggested using the Wave Glider to better monitor the movement of the snow crabs. The fishermen thought this was a great idea as they believed the Wave Gliders would provide more accurate monitoring of the mobile snow crabs. The fishermen questioned both stationary receivers used by OTN, as snow crabs may not always pass near the lines, and the annual stock surveys performed by DFO. By

▲ *Figure 4: OTN employee applying a tag to a crab before returning it to water (image courtesy: OTN).*



▲ *Figure 5: Liquid Robotics – subsea view of the Wave Glider, a long-duration, unmanned ocean robot (image courtesy: Liquid Robotics).*

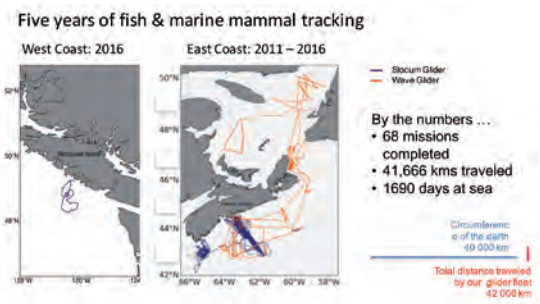
Manufacturer	Model	Measurements
Airmar	200WX	Lat/lon, air temperature, barometric pressure, wind speed, wind direction
Datawell	MOSE-G	wave height and direction
SeaBird	GPCTD + DO	conductivity, temperature, dissolved oxygen concentration
Turner	C3	chlorophyll a fluorescence, CDOM fluorescence, turbidity @ 850nm
Vemco	VR2C	acoustic receiver @ 69kHz

▲ *Table 1: Wave Glider with the following instrumentation.*

using the Wave Glider they could travel directly into where fishing is concentrated, and move back and forth across the area. This data could indicate if a crab had moved into an area. By combining both mobile (the Wave Glider) and stationary receiver lines, OTN got a more continuous survey of snow crab migration instead of a point in time snapshot.

OTN's Experience with Mobile Autonomous Platforms

OTN has been using Wave Gliders® (of Liquid Robotics) for years in support of national and international research programmes. The Wave Glider is an autonomous, long-duration ocean robot powered by waves and sun. It can be instructed to patrol specific target areas continuously, 24x7, and deliver data on movements of marine life within these areas. It carries a broad array of scientific sensors and can communicate data in real-time from the seabed to space.



▲ *Figure 6: Five years of fish and marine mammal tracking 2011-2016 (image courtesy: OTN).*

OTN has realised results:

- Offloaded 500+ stations to date
- 97% success rate
- Saved ship days previously used to manually harvest data from receiver lines.

The Wave Glider has proved its worth for supporting the operations and maintenance of acoustic telemetry arrays. Previously, researchers had to spend up to a week at sea retrieving data from fixed receivers. The Wave Glider initiative reduced the average cost of these voyages by 66 percent. Funds once used to harvest data could be redirected to more undersea receivers, expanding research, or other programmes. The development of the Wave Glider as a mobile receiver flowed naturally from this initial use.

This successful initiative not only provides new information about the behaviour of the crabs, it also sets the stage for continued dialogue and partnerships with all the stakeholders. Plans are already underway to tag additional crab in 2017, and DFO, as well as the OTN and harvesters, are committed to teaming up on the next phase of the project, which will involve how the crabs respond to a new marine protected area in the study region.

Department of Fisheries and Oceans (DFO) Gains Data for Better Science and Resource Management

Canada's DFO plays the central science role in the snow crab tracking project. This government agency strives for sustainable fishery management based on robust science. Since its ultimate mandate is sustainability of the fisheries, the organisation must be conservation-oriented. When evaluating new data and methodologies, the DFO is cautious, but also open to new information and approaches.

When the DFO and harvesters came together to work on the Wave Glider tracking project, the DFO saw the project as an opportunity to add an important new set of data to its understanding of the local ecosystems. They were interested in using the acoustic tags to understand previously inaccessible segments of population, where there was very little information. Dr. Jae Choi, DFO Science Maritimes, finds the use of the Wave Glider very fascinating as they are able to observe a segment of the snow crab population for which previously they had almost no movement (data).

Revealing the Big Picture with More Data

With Wave Glider data provided by OTN, DFO can access new sources of data about species that had been unavailable using previous methods. The Wave Glider can also provide near continuous data upload and mobile tracking over longer periods of time—a capability that simply was not possible with boat catches or fixed undersea receivers. The Wave Gliders can cost-effectively patrol an area for weeks or months to provide an extended view into the behaviour and migration patterns of these mobile animals. DFO can also tag other species such as crab predators that are associated with the crab ecosystem, to gain a better understanding about the relationships between different species in the area.

A Springboard for Collaboration and Future Opportunities

The community-driven research programme is an important partnership model for helping Canada's coastal communities sustain economic opportunities, ensure food security and safeguard ecosystems. Local fishermen are gaining access to data that could potentially impact their industry through a mobile platform that can share data on tagged animals instantly. Scientists and academics at DFO and OTN are expanding their studies and tapping into data that can help them do their jobs better and more cost-effectively.

But among the most exciting developments is the close collaboration between all parties, which culminates in a yearly Snow Crab Summit. The project has brought together a diverse set of groups, all working toward a common goal: gaining the best available science on the health and behaviour of a species that is vital to the region.

Nova Scotia's fishermen, government agencies, scientists, and other stakeholders are looking forward to continued collaboration to enhance their knowledge in the years to come. ◀

Peter Elliman serves as director of product marketing at Liquid Robotics where he helps customers and partners understand the value and potential of the Wave Glider. Prior to joining Liquid Robotics, Peter spent over 12 years in various marketing roles for emerging and established companies that include Tintri, Symantec, IBM, and others. Peter holds two degrees from the University of Virginia including a Bachelor's degree in English Literature and an MBA from its Darden Business School.

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Mapping a Hyper-acid Crater Lake with a USV

Surveying a **Hell Hole**

The 2,708 metre high Poás volcano is one of the most active volcanoes in Costa Rica, located 35km northwest from the capital San José. This stratovolcano contains a 300m wide crater lake filled with natural, very acidic, hot concentrated chloride-sulfate brine, the Laguna Caliente ('hot lagoon'). Knowing the volume and bathymetry of the lake is crucial in monitoring and predicting the behaviour of this active volcano, but there is no recent bathymetric data available. To map the lake bathymetry of this very hostile environment we developed a cheap and portable, sonar equipped Unmanned Surface Vehicle (USV) and surveyed the lake with it.

The Laguna Caliente Challenge

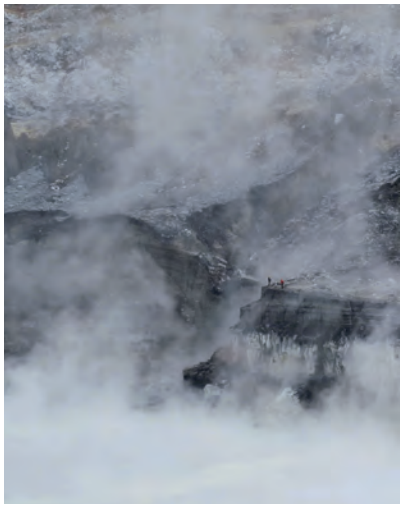
The pH of the Laguna Caliente is as low as 0.5 and the temperature is 55 °C and higher. The lake's surface is frequently disturbed by small but impressive phreatic explosions. These extreme conditions are caused by the discharge of magmatic gases into the bottom of the lake. Energy and mass balance calculations are based on survey data taken during the year 1994 when the lake had completely dried out. Meanwhile, the lake has filled up again and the geometry has probably changed considerably since that time, both by sedimentation and due to big phreatic explosions, like the one on 25 February 2014 that ejected water, sediment and rocks 400 metres into the air. Collecting bathymetric data in these extreme conditions is a daunting task. The lake is too hazardous for human access so a USV is the only option. However, no one wants to risk valuable equipment in this hell hole.

After a visit to the lake in 2015, we took on the challenge to design and build a cheap and easily transportable sonar boat with readily available and inexpensive components. It had to be cheap because the risk of losing the prototype was extremely high. And the boat had to be light and small enough so it could fit into airline baggage as well as being easy to carry in a backpack across challenging terrain.

Designing the USV

A radio controlled boat seems to be a logical choice, but visibility is often very poor over the steaming crater lake, therefore the boat had to

▲ *Figure 1: Overview of the Poas crater with Laguna Caliente in the middle.*



▲ *Figure 2: At the border of Laguna Caliente.*

▲ *Figure 3: Carrying the USV.*

be autonomous. This also created the opportunity to design a set of preprogrammed missions making repeated measurements over time possible. The choice of autopilot was easy because we had experience constructing different multicopters based on the ArduPilot autopilot suite. The controller of choice was the affordable Pixhawk controller with an external U-Blox GPS module (2.5m horizontal accuracy), running open source ArduRover firmware. For our ground control station we used the Windows-based Mission Planner developed by Michael Oborne.

The hull of the boat was a very cheap second-hand bait boat found on a flea market. This boat had the perfect dimensions and was made from ABS. This type of plastic has good qualities for the extreme environment in which it had to function. The catamaran design of the bait boat was an extra advantage favouring the stability of the sonar platform. The two hulls of the catamaran where filled with PU foam making the boat unsinkable.

▲ *Figure 4: The USV in action.*

We didn't want to use a conventional propulsion system with a water propeller and a shaft piercing the hull. The metal shaft would be too vulnerable and therefore unreliable in the hot acid. In fact, during the construction of the boat great attention was given to using as many plastic parts as possible, which are more resistant to acid than metal. Instead of an underwater propeller, a 12 inch carbon fibre air propeller driven by a 350W brushless motor mounted on a servo-controlled rotatable vertical mast was built. The carbon fibre guaranteed form stability in the hot atmosphere above the lake. The end result was a USV weighing less than 10kg and measuring just 540 x 380 x 220mm.

The choice of the cruise speed was important. Different factors played a role. First of all, the geometry of the boat and the position of the propulsion pushed the bow into the water when gaining speed. So the bulk of the weight was put in the stern. The second consideration was the sampling time of the sonar versus the distance travelled during that time. The speed had to be low enough to get a satisfying resolution. The last factor was temperature; the boat had to operate in water of 55°C. So it became important to minimise the current drawn from the batteries which would otherwise produce too much extra heat in an already overstressed system. All these considerations resulted in a cruise speed of 0.8m/s or 3km/h. Operating at this speed and powered from two parallel 5 Ah 12.6V lithium-ion polymer batteries, the USV runs autonomously for nearly three hours.

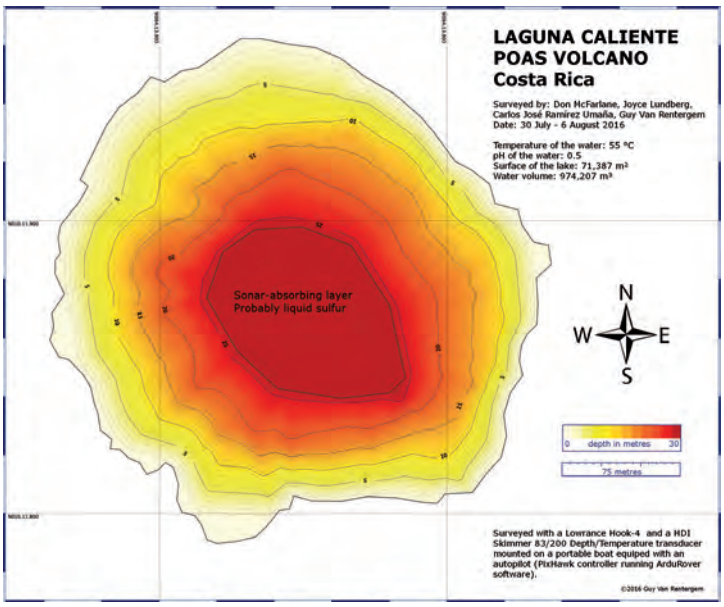
The sonar was an inexpensive Lowrance Hook4 with a HDI Skimmer 83kHz-200khz single beam transducer with 22° beam angle (200kHz), good enough for a first prototype USV. The data was saved on an SD card and after finishing the mission the data was processed with the very affordable ReefMaster software from Australia. ReefMaster is a Windows application combining graphical track and waypoint management with underwater mapping.

Survey

In the summer of 2016, the authors, together with Joyce Lundberg and Carlos José Ramírez Umaña performed the actual survey. The USV had survived the transcontinental flight from Europe to Costa Rica and was deployed in 20 minutes upon arrival at the lake. For the deployment we were equipped with gas masks, helmets, raincoats and the warning to drop everything and run in case of a big phreatic explosion. The gas masks were necessary because the air can become unbreathable due to toxic sulphurous fumes.

A survey plan had been designed in advance with the Mission Planner. The software uses satellite images provided by Bing Maps. However, this service does not provide a creation date, so we had no idea if the lake still had the same dimensions. We took care while designing the survey track to stay more than 25m from the 'Bing-border' of the lake to avoid grounding the USV. We also avoided the dangerous centre of the lake with its frequent phreatic explosions. A circle with a radius of 50m was declared a no-go zone. The track crossed this zone only twice and in a straight line in order to collect sufficient data to create the map. The total length of the track was 1.44km requiring about 30 minutes to survey. Knowing this time was important because no visual confirmation of the position was possible as a result of the dense fog over the

▲ *Figure 5: The track as designed with Mission Planner.*



▲ *Figure 6: Generated map of Laguna Caliente.*

water. In fact, the first time we deployed the USV the Return-To-Launch command was given soon after the start of the survey because we had no clue at all if the boat was still functioning. After intense minutes of waiting the boat emerged from the fog in full working condition, notwithstanding the extreme conditions.

The Map

During processing the bathymetric data with the ReefMaster software we discovered a big hole in the centre of the lake at a depth of 26 metres where the sonar did not collect any bathymetric data. At the other side of the hole the sonar started to collect data again. So this was not a malfunctioning of the sonar, but the sound waves being absorbed by a layer at 26m depth. The scientific literature about Poás does mention a molten sulphur layer at the bottom of the lake. This layer originates from sulphur-rich magmatic gases condensing in the water. At a depth of 26 metres water boils at 140°C. This is way above the melting point of sulphur which is 115°C. Also the density of sulphur is about twice as much as water, so it collects and stays at the bottom.

An error analysis was done on the acquired data considering that both horizontal positioning as well as the echo sounder are not professional instruments from a hydrographic perspective. Considering the slope of the lake (20°) the effect of the transducer is limited on the final depth readings. The main issue is the speed of sound in this specific environment. As there was no speed data in the literature for this type of environment we did an error analysis. Considering that the Lowrance transducer has temperature compensation we assumed that actual surface temperatures (up to around 55° C) were taken into account. We considered the temperature distribution which is generally uniform up to the bottom. The main influence that is not considered is that of salinity with a measured salinity of 77.6 PSU giving a potential increase of around 60m/s and a potential depth error of around 4% of actual depth.

With an add-on ReefMaster module we calculated the surface and volume from the sonar data. Based on the data collected in the summer of 2016 and without correction, Laguna Caliente measures 71,387m² and has a volume of 974,207m³.

Conclusion

With a small budget we were able to build a USV which collected bathymetric data of an active acidic crater lake and delivered convincing results. This can open new opportunities to monitor the 30 or so volcanoes worldwide with similar lakes.

For follow on projects a narrower beam transducer as well as a fast reacting temperature sensor would increase overall accuracy of the measurements. Also a simple method for taking a temperature profile would be helpful in order to confirm the assumed temperature profile in the lake. An option would be to build a radio controlled reel with an sensor pod measuring density and temperature.

Note

Widespread volcanic activity has meant that Laguna Caliente disappeared mid-2017, and that the national park, museum and visitor's centre will be closed until further notice. ◀

More Infomation:
(These videos are integrated in the online version of the article: http://bit.ly/2u14RFR)

- Video 1: Phreatic explosions https://www.youtube.com/watch?v=hj0nh_QRd0A
- Video 2: Early prototype of the boat https://www.youtube.com/watch?v=LcM_Vo4cAZA
- Video 3: Designing the USV and fieldwork at Laguna Caliente: https://youtu.be/s4qaEjSPRcU

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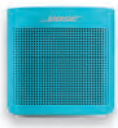

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Autonomous Surveying of Shallow Coastal Waters for Clean Seas and Shorelines

Coastal Monitoring of Water Quality

The wave-propelled AutoNaut unmanned surface vessel (USV) completed a short trial off the south-west coast of England to monitor the water quality by a sewage outfall. AutoNaut demonstrated its ability to reliably operate in shallow waters whilst also recording and transmitting data. A suite of sensors aboard the USV worked in conjunction with satellite data from synthetic aperture radar (SAR). Analysis indicated that the seawater close to the outflow was not negatively affected. The combination of technologies is pioneering for the application and the trial highlights the potential of this innovative approach to conduct long-term marine monitoring – including the reduction of costs and risks relative to conventional methods.

▲ *Figure 1: AutoNaut USV.*

In the trial, commissioned by a UK water utility, sensors measuring water quality were installed in a 5-metre AutoNaut USV. The mission aims were to detect the plume from a coastal sewage outfall and establish its characteristics. Contemporaneous satellite-based synthetic aperture radar (SAR) data was analysed to establish whether the same plume could be detected from space.

Surveying in rugged coastal waters presents additional challenges for any boat. For a USV, completion of a survey so close to land requires both the autonomous technology to be 100% reliable and the craft itself to have proven sea-worthiness. The AutoNaut USV uses patented Wave Foil Technology to propel itself forward solely by the motion of the waves. It maintains an average of 3 knots and can operate in all sea conditions - with an auxiliary propeller in case of flat-calm conditions. The craft is highly manoeuvrable and can confidently keep station within a 50-metre radius. Additionally, the boat has very little draft, having no sub-sea tethered mechanism, and is therefore able to work safely in shallow waters. Solar panels and a battery bank power a suite of sensors for the project objectives. This use of renewable energy enables very long-term missions to be completed – with no requirement for fuel. Autonomy at sea, albeit with oversight from onshore operators, also removes the safety risks of personnel working offshore.

Method

The mission was completed over a 24-hour period in January 2017. The AutoNaut track passed over the diffuser and maintained a search pattern approximately 0.25 nautical miles from the diffuser, 2 miles out from land. The AutoNaut was fitted with a YSI EX02 Sonde unit with sensor nodes for water chemistry, including: Conductivity, Temperature and pH. Additionally, a Gill Windsonic weather station was fitted on the mast to measure wind speed and direction.

Operating close inshore presented challenges. The site had limited sea room and the USV was always in close proximity to the rocky shoreline, often as near as 2 miles from land. Strong local tides and the UK winter weather were watched carefully, as were the potential hazards of lobster pots and flotsam. In line with guidelines set out by the Maritime Coastguard Agency, the presence of a support boat was deemed to be a necessary precaution. For the duration of the trial, the support boat was at sea and on standby for safety assurance but did not otherwise take a direct role in the autonomous operation

Local communication wireless links enabled the on-site team to issue control commands whilst in line of sight. However, satellite link via Iridium means remote operations can be overseen from anywhere in the world. In this instance, from AutoNaut's headquarters in Chichester, UK.

The simplicity of the AutoNaut design allowed it to be transported in the back of a van to the launch site. The team assembled the USV on the quayside in a matter of hours and, after procedural checks, it was put to sea to begin surveying. The AutoNaut was deployed manually by a small team from a local slipway.

The intention to complete the AutoNaut mission contemporaneously with the availability of the satellite SAR data meant a narrow window of opportunity. Two days in January were the only viable trial days when tide times allowed entry/exit from the harbour base during the restricted daylight hours. In order to deliver a comprehensive dataset over a tidal cycle, a 24-hour continuous mission was completed with the AutoNaut over dates which included the time slot for the Sentinel 1B satellite overpass.

Weather and sea conditions were worse than forecast and a patrol line was set up in a safe operating area to the south and west of the diffuser for the duration of the mission from where the outflow plume from the diffuser could be monitored through approximately 50% of the tidal cycle.

Satellite-based Synthetic Apperture Radar (SAR) Data

The SAR imagery captured clearly shows the Atlantic swell and the white water around the rocks and Island on the vertical polarisation image, but gives no definitive indication of any fresh water plume from or around the diffuser. It has been proven that such images are able to clearly show evidence of oil or sewage effluent on the water surface in low sea states due to the smoothing effect of the contamination on the sea/wave surface. It has not been demonstrated that SAR imagery can define a fresh (i.e. clean) water plume as the small change in water density is unlikely to cause the same effect.

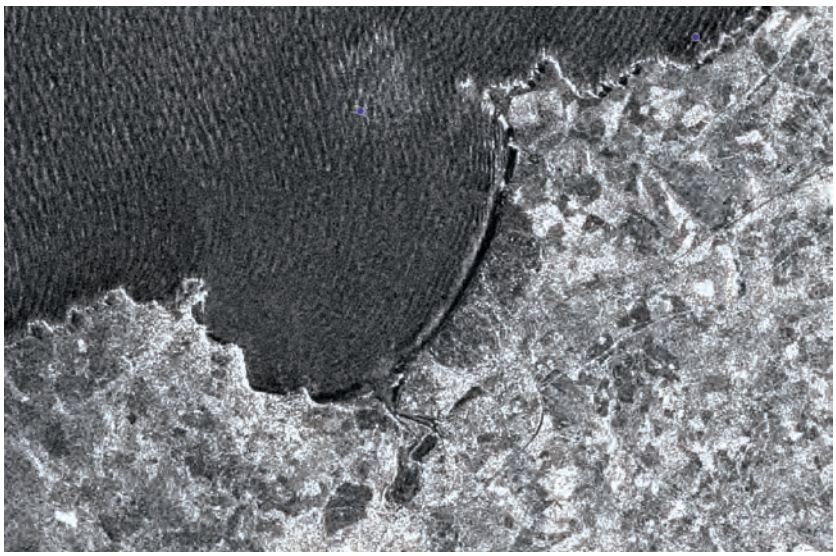
Uses patented Wave Foil Technology to propel itself forward solely by the motion of the waves

▲ *Figure 2: The YSI EX02 Sonde multiparameter water chemistry sensor.*

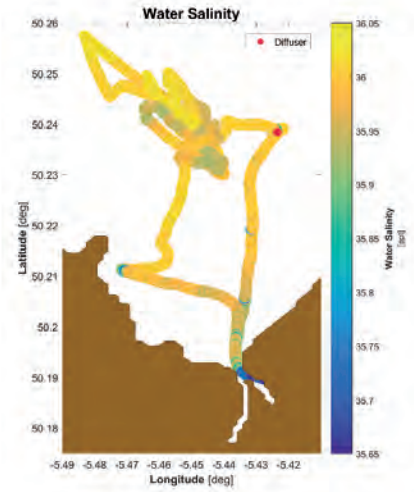
However, salinity and temperature will be particularly relevant markers for a fresh water plume on the surface as long as the mixing effect of the wave/swell action is not vigorous enough to dilute the fresh water through the water column. Given the prevailing weather conditions, it would be unlikely that any normal fresh water flow from the diffuser would remain unmixed at the surface for a sensor mounted in the AutoNaut to be able to detect it.

Autonaut Data

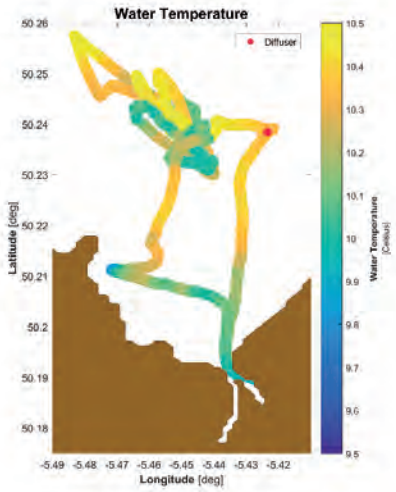
As figure 4 illustrates, the salinity of the water throughout the mission remained stable, and the temperature only fluctuated by 0.5°C (Figure 5). There was no change to the readings over the 2 tidal cycles of the mission; the tidal



▲ *Figure 3: Sentinel-1B SAR image 25 January 2017 (Vertical Polarisation). (Blue pin shows position of diffuser).*



▲ *Figure 4: Water salinity measured.*



▲ *Figure 5: Water temperature as measured.*

flow in the bay changes direction from ENE to WSW approximately 90 minutes after the times of HW and LW. Any change to the data would be visible when the ebb tide was flowing WSW but there is no change to either the salinity during those periods and the small changes to the water temperature do not provide any direct evidence of the presence of fresh water during those periods.

Conclusions

During this particular survey, no plume was detected by either the USV sensors or by the satellite SAR imagery. It is not known what volume of outfall discharge there was to detect at this time but it is thought that mixing in the turbulent sea conditions prevailing during the demonstration will have obliterated outfall traces. The trial successfully demonstrated that data on sewage outfall plumes can be gathered contemporaneously from space-based SAR imagery and the AutoNaut USV at sea. The combination enables SAR satellite imagery to cover a potential pollution incident with persistent ground-truthing of such an incident by the AutoNaut USV. Such flexibility makes it possible to deliver an accurate definition of the extent of a marine pollution incident. Satellite coverage is extending and the availability of SAR imagery is increasing. Similarly, USV technology, such as AutoNaut, is constantly maturing and proving its capabilities. For the future, distinct potential is emerging for a space-based autonomous system to provide early warning and prompt real-time response – and significantly reduce the impact of marine pollution.

Future Projects

Lessons from these coastal water deployments are about to be brought together in a highly ambitious mission in south east Asia. Two new 5-metre AutoNauts are being prepared to monitor pollution from oil spills where a busy shipping lane passes close to vulnerable mangrove swamps and valuable tourist resorts. AutoNaut will ground-truth space-based SAR observations enabling the local authorities to both tackle pollution and eventually to prosecute offending ships.

Other coastal monitoring roles for AutoNaut are being developed with partners in the United Arab Emirates where the 10m deep coastal water extends 20 kilometres from the coast. With some 11 artificial islands being built as oil and gas productions platforms, and new nuclear facilities coming on stream, there is a significant need to automate the long-term monitoring of this shallow-water habitat, a task for which AutoNaut is uniquely suited. ◀

Mike Poole developed the original ideas and design iterations for the AutoNaut over a number of years. He has a wealth of practical marine operations experience including 10 years as a professional sailboat skipper with the French shipping company OSCOSA and a DoT Yachtmaster Ocean qualification. He is a founding executive director of AutoNaut Ltd.

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Phil Johnston Phil has a background working at sea as an offshore environmental consultant. He specialised in the effects of underwater noise and passive acoustic monitoring for marine mammals. Phil now leads business development for AutoNaut Ltd.

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New IMCA ROV Classifications and Applications Moving Towards Renewables

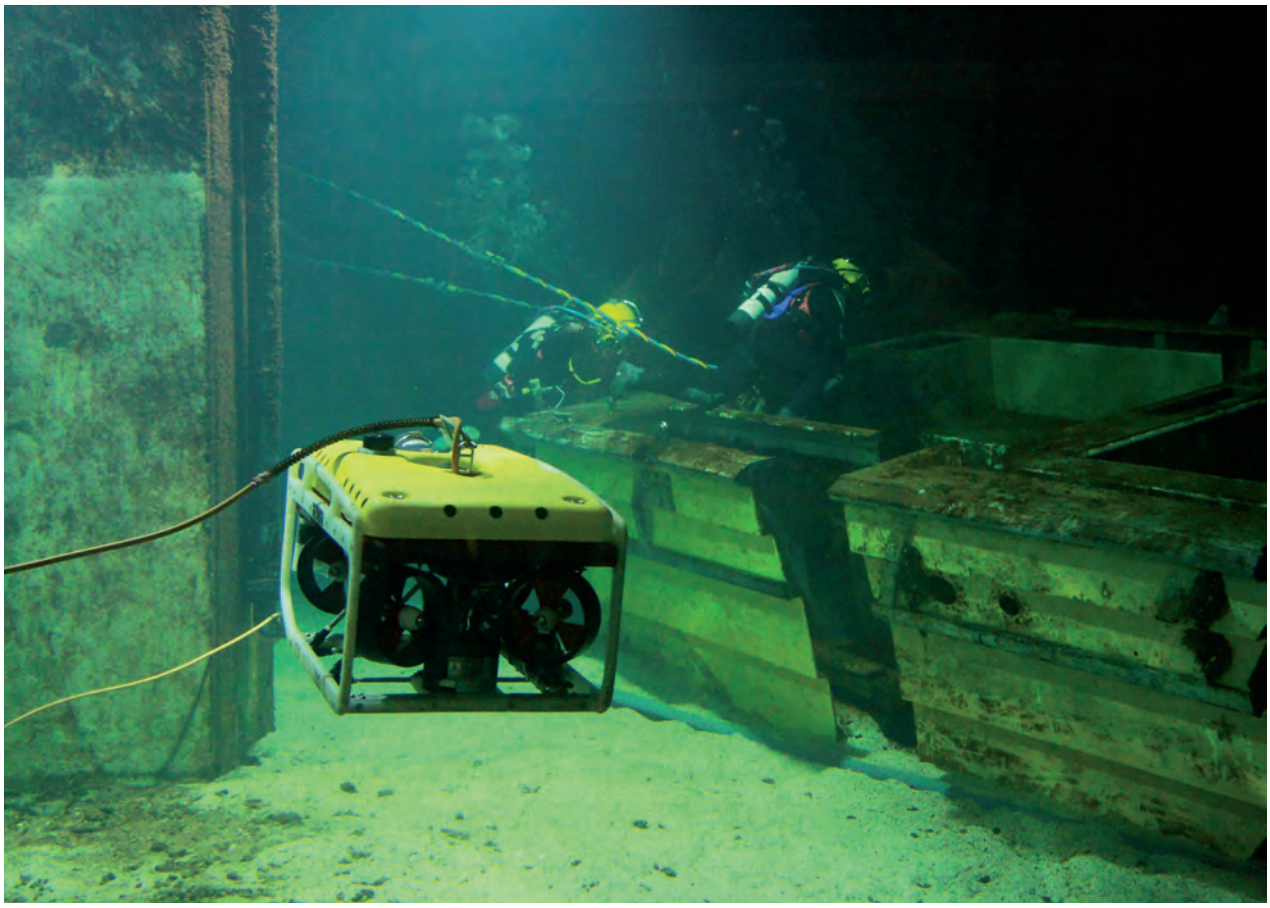
Trends and New Technology in the ROV Industry

Over the past few years, the requirements for ROV support in the oil & gas sector has been hampered by the downturn in the sector. However, the continued investment in renewable energy has provided opportunities for manufacturers to continue their R&D projects to create the next generation of ROV systems.

In view of this, the IMCA guidelines for the Safe and Efficient Operation of Remotely Operated Vehicles (IMCA R 004 Rev4) has been updated. The guidelines now include an expanded list of ROV classifications based upon the increased diversification of tasks performed by ROV systems around the globe.

The revised classifications are as follows:

- Class I – Pure observation ROVs.
- Class IIA – Observation class vehicles with a payload option.
- Class IIB – Observation class vehicles with light intervention/survey and construction capability.
- Class IIIA – Standard work class vehicles with a payload of <200kg and through frame lift of approx. 1000kg.
- Class IIIB – Advanced work class vehicles with a payload of >200kg and through frame lift of up to 3000kg.
- Class IVA – Towed vehicles, typically ploughs



▲ *Figure 1: Class IIA ROV, suitable for survey jobs. Image courtesy: The Underwater Centre, Fort William and Tasmania.*

used in subsea cable burial operations.

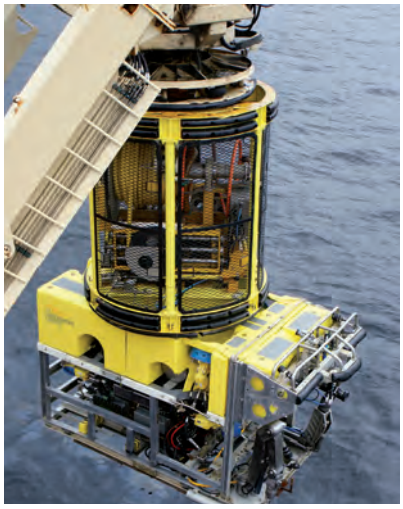
- Class IVB – Tracked vehicles utilising HP water jetting and specialised rock cutting tools, again used in the burial of subsea cables and pipelines.
- Class V – Prototype or development vehicles.
- Class VIA – Autonomous Underwater Vehicles (AUV) weighing <100kg.
- Class VIB – Autonomous Underwater Vehicles weighing > 100kg.

Class I vehicles are used in a purely observation role, providing the client with a relatively inexpensive and highly portable method of performing general visual inspection or close visual inspection of various subsea assets. Their generally compact size limits the vehicles' capabilities to operate in areas of high currents; however they have been successfully used in operations in which these vehicles have been deployed from a work class vehicle, acting as a mothership.

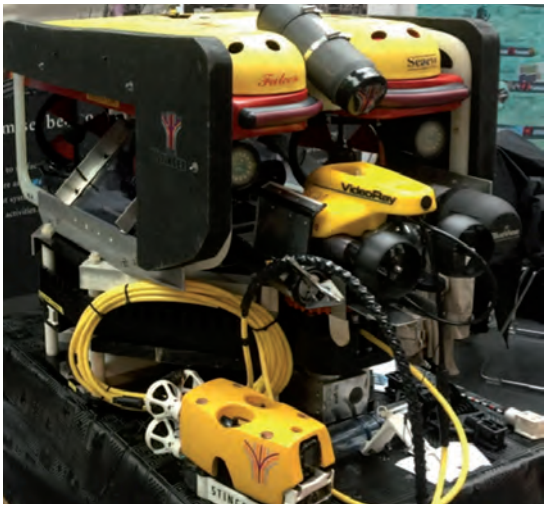
Class IIA systems typically have a suitable payload that allows the fitment of additional camera systems and subsea sensors providing a basic survey/NDT (non-destructive testing) capability. They also have a higher thrust-to-weight ratio than the Class I vehicles allowing them to operate in conditions similar to the larger ROV systems. These systems are still highly portable and generally do not require a dedicated launch and recovery system (LARS) for operation.

Class IIB systems are still predominantly observation class but with a significant payload allowing the use of lightweight manipulator systems thus providing a light intervention capability. Even though these ROV systems require a dedicated LARS (launch and recovery system) and control van, they require a much smaller footprint area on a vessel compared to the Class III vehicles and therefore can be deployed from a much wider range of support vessels.

Class IIIA systems are the general work horses of the industry and can successfully perform the vast majority of tasks required in a typical field construction role including survey, metrology, construction and intervention. These systems typically require significant deck space on a vessel in order to accommodate the LARS, control van, and workshop van, etc. and are therefore more suited to the current DP (dynamic positioning) class of support vessels.



▲ *Figure 2: Launch of a Class IIIA ROV. Image courtesy: The Underwater Centre, Fort William and Tasmania.*



▲ *Figure 3: An ROV (SAAB SeaEye Falcon) serving as a base station to launch smaller ones (Videoray ROV – middle - and a fly-out Stinger Nano - below).*

Class IIIB systems are the heavy weights of the oil & gas sectors and were developed to provide a high capacity hydraulic capability in order to remotely override the blow out preventer (BOP) used during the drilling and work over phases.

Class IVA towed systems are technically the simplest in design and operation and are loosely based on a typical agricultural plough, being towed along by a vessel. The simplicity in design and operation provides an economic method of cable burial over a large distance and as such are used primarily in trans-ocean projects.

Class IVB tracked vehicles provide a significantly more accurate method of burying cable and pipeline, although this process is considerably more time consuming than using the plough method. The benefits however are a controlled depth of burial and accurate positional data along with the capability of burial through areas of seabed rock formations.

Class V prototype or development vehicles allow the manufacturers to create one off designs in order to facilitate a particular task. A typical design that has been developed is the current range of Rock Grabbers that are being used to clear pathways in subsea boulder fields around Western Europe in order to facilitate burial of the various subsea cables.

Class VIA AUV systems come in many guises, from the typical survey data gathering type used by many oceanographic institutes, to the more complex military applications such as counter mine operations.

Class VIB AUV systems provide a significantly larger platform that enables a much wider range of survey equipment to be fitted. These systems are potentially capable of performing survey and intervention tasks, however much of this is still under development and therefore limited to commercial applications at present.

Requirement for long-term installation, repair and maintenance

Trends in ROV Applications

As the technology utilised in remotely operated vehicles continues to mature there are some significant increases in the types of operations now being performed 'remotely'.

The current trend in the renewable sector involving the installation of offshore windfarm sites has created a requirement for long-term installation, repair and maintenance (IRM) tasks that will require diver-less intervention due to the environmental conditions such as high current and low visibility encountered at these locations. Similarly many of the various deepwater operational tasks previously carried out by semi-submersibles can now be performed from an ROV support vessel utilising remote technology, thereby significantly reducing the operational costs.

▲ *Figure 4: Launch of a Saab SeaEye Falcon. Image courtesy: The Underwater Centre, Fort William and Tasmania.*

The continued development of subsea sensor technology will no doubt expand the role of ROV/AUVs over the next decade, utilising the advances in acoustic positioning and laser technologies to accurately map both the seabed and subsea structures and create very accurate real-time 3D models from point cloud data streamed to the surface. The continued advances in subsea acoustic data transmission will allow the ROV/AUV to communicate directly with subsea asset control systems in the event of a topside communications failure thus providing an additional override facility.

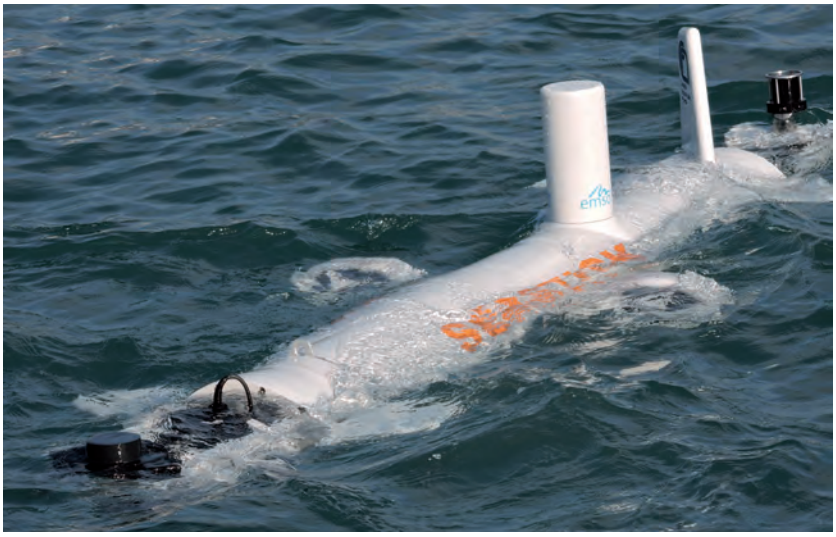
Advancements in electrical motor technology has also seen an increase in the number of 'electrical' propulsion ROV systems, however these are typically being used in regions that may be environmentally sensitive to hydrocarbon releases. Large electric vehicles generally consume significant amounts of power, and that power has to be transmitted to the vehicle along the main umbilical/tether and thus is the limiting factor for a purely electric system. The use of hydraulics as a power source is therefore a more efficient method of providing both a work capability along with propulsion and will no doubt continue for the foreseeable future utilising more environmentally appropriate fluids.

The latest developments in hybrid ROV/AUV technology appear to offer some major benefits for the subsea industry mainly relating to operational costs. The idea of having AUV systems permanently docked in subsea 'stations' ready for deployment at a moment's notice is definitely possible with current technology; however long-term reliability and maintenance may be the key factors that prevent this becoming a feasible option.

The requirement for accurate seabed/pipeline survey is certainly one area where the hybrid systems can seriously challenge the current method of utilising work class ROVs. Although the sensors utilised on both systems are comparable in technical performance, the control system onboard the AUV can react significantly quicker than a human pilot to the dynamic conditions experienced subsea and, therefore, provide a much more stable platform from which to gather the data.

In this case what does the future hold? Entirely autonomous vehicles cruising the world's oceans or, indeed, hybrid technology whereby a skilled technician constantly monitors operations whilst the control system performs the auto-pilot function? Either way, there will always be a requirement for skilled personnel to provide the necessary back-up when things do not go according to plan. ◀

There will always be a requirement for skilled personnel



▲ *Figure 5: SEASTICK, an example of a hybrid ROV/AUV.*

The Underwater Centre has been providing Remotely Operated Vehicle (ROV) pilot technician training for over 15 years. Their ROV courses give graduates experience of flying work class and observation class ROVs in an open-water, tidal environment, as well as taking their technical understanding and know-how and applying it to the repair and maintenance of ROVs. The operational experience gained on their range of ROV courses means that, as well as being developed and run in accordance with guidelines set out by the International Marine Contractors Association (IMCA), these courses go beyond those guidelines. The Centre works closely with key industry stakeholders, such as IMCA, Technip, Fugro and Kongsberg and is continuing to work with accrediting organisations who monitor and verify the course content externally.
✉ http://www.theunderwatercentre.com/

The Arctic Field Party

It seems ironic that in the early stages of the Cold War, the United States Government sent surveyors and hydrographic engineers to the coldest reaches of the North American continent. For these men, it was truly a Cold War. From 1945 through 1953 field parties of the United States Coast and Geodetic Survey were sent to survey sea routes through the Bering, Chukchi, and Beaufort Sea as well as to conduct geodetic surveys to help position Distant Early Warning system radars and help delineate the vast resources of the Alaskan Arctic. These men toiled in obscurity beneath the midnight sun in summer and in the Arctic night of winter. This was dangerous difficult work in the interest of national security.

The roots of this endeavour lay in a project titled Pet 4, referring to Naval Petroleum Reserve No. 4 by the United States Navy Office of Naval Petroleum and Oil Shale Reserves. This project involved the Navy and the United States Geological Survey (USGS), but the Coast and Geodetic Survey, Air Force, and numerous contractors were involved in related tasks although not directly under Pet 4 supervision. Pet 4 was meant to discover additional petroleum reserves in the 180,000 square kilometre area between the Brooks Range and the Arctic Ocean. However, this area was also important for defence purposes as it is strategically located relative to global politics. It is also crossed by many great-circle air routes. Thus the C&GS was called in to survey sea routes for supply ships, provide geodetic control for both mapping purposes and the siting of various facilities, and determine magnetic declination for navigation purposes at selected points.

Because of the remote location, long distances between operational units, and extreme environmental conditions, logistics were a major factor in planning operations. The vast majority of supplies were brought to Point Barrow, the northernmost point of Alaska, by Navy convoy in the late summer in an operation known as Barex. The second Barex convoy, in 1945, was expedited by providing naval operating units with a hydrographic survey produced under the direction of Commander Ralph Woodworth, USC&GS, the first chief of what became known as the Arctic Field Party. The Navy ships unloaded all manner of heavy equipment including caterpillar tractors, wanigans mounted on runners for supply storerooms and living quarters, food supplies, and even LCMs to be used for transportation and hydrographic surveys during periods of open water.

▲ *Figure 1: Using a caterpillar tractor to launch a survey boat.*

▲ *Figure 2: Rear Admiral Harley Nygren, NOAA Corps (ret.).*

The following year combined operations were begun in the vicinity of Point Barrow with geodetic surveys followed by hydrographic surveys. By early 1948, geodetic control surveys and some hydrographic surveys had extended from Dease Inlet to the east of Barrow and west to Wainwright, over 300km. Apparently little topographic work was done by the Arctic Field Party as in 1948, the C&GS flew aerial photographic missions of the Arctic coast from Barrow to Demarcation Point at the Canadian Border. By this time, sufficient experience had been gained in Arctic operations to commence the survey from Demarcation Point to Dease Inlet.

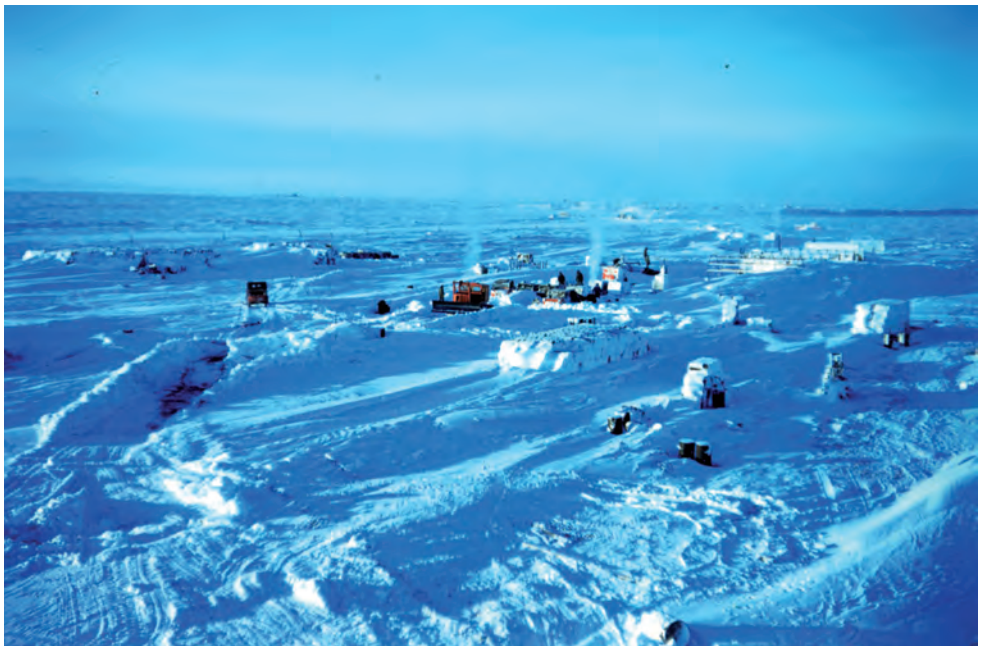
The C&GS learned from the experience of the Navy and USGS and used caterpillar tractors, weasels (small tracked vehicles), and wanigans (sheds mounted on skids used for both sleeping quarters and storage of supplies) for long distance travel. Two or three wanigans would be connected to each caterpillar tractor and all tractors, wanigans

and weasels would make up a cat-train. The 1948 cat-train made its trek to Barter Island, 560km to the east, in mid-March where a camp was established. Travel in this area was complicated by the weather and terrain. Although helicopters could be used in the vicinity of Barrow to transport men and light equipment, they could not be used far from a maintenance facility. Caterpillar tractors pulling wanigans on skids could only be used in the winter months when ice on the ocean and inland lakes was sufficiently thick to support them. Airplanes on skis were used in the winter and early spring until the ice was too thin to support them and float planes from late June to early September when there was sufficient open water for take-off and landing. Some areas, such as on the barrier islands of the Arctic coast, could support wheeled aircraft during the months of melting. Geodetic work ceased during the period when ice was melting as the weasels, although amphibious, used for ground transportation could, and sometimes did, break through thin ice. The downtime from mid-May to mid-July was used to prepare four launches (Navy Landing Craft Mechanised - LCMs) for hydrographic work.

After establishing the Barter Island camp, geodetic work was completed from Demarcation Point to about 80 miles west of Barter Island. Starting in September, transportation again became difficult with the beginning of the freeze-up. Survey crews were evacuated and flown to Fairbanks for return to homes in Seattle, Washington and elsewhere. Wanigans, supplies and fuel were left behind for use the following year. In 1949, Commander Robert Earle, USC&GS, took over as chief of the Barter Island survey crew. He got his baptism of fire (or one might say ice) in mid-February as he and crew members were flown to the Barter Island camp in order to begin preparations for a move 240km to the west to Tigvariak Island. In his words: "it was pitch black dark when we let down on the small airfield on the north of the coast. We hadn't realized the meaning of the word cold until we stepped out of the plane, where the wind was blowing over 32km an hour and the temperature was 39 degrees below zero. When we faced the wind it seemed that our faces would become paralyzed…."

In preparation for the move, he sent a reconnaissance team ahead to mark the trail, and then hitched up the wanigans and sleds to the tractors and set out. Although the trail had been marked, blowing snow often reduced visibility and the trail was lost. When things went well, 40 to 50km was considered a good days run. After eight days, the cat-train arrived at Tigvariak. Because all was covered with ice and snow, it was very difficult to find the designated camp site and the equipment and supplies that had been cached there. Five trips by cat-train were required to remove all supplies from Barter Island including the four LCMs that had been placed on cradles at the end of summer. An interesting but sometimes dangerous phenomena of the polar regions is the occurrence of white-outs, a situation occurring when sky, snow, and ice all take on the same hue causing a human observer to lose his sense of direction as well as sense of up and down. Roy Sylar, a civilian geodesist, described such a situation that occurred while crossing a stretch of sea ice: "… the motor of our vehicle started to labour, then went into a stall and we started rolling backwards, finally coming to rest. To say the least, this all came as a surprise since there was no visible indication we were on anything except level sea ice. Harley stepped out and proceeded ahead to see if we could identify what we had

▲ *Figure 3: Cruising through an ice field. From l to r: Ted Shanahan, Stan Jeffers, Jerry Gray and Simon Tagarook.*



▲ *Figure 4: The Barter Island Camp starts taking shape after a few days of digging.*

come upon. As he went forward he rose up towards the sky until he lost his footing and came sliding down to end up near where Gene and I sat. As it proved out we had started to mount an invisible iceberg standing some twenty or twenty-five feet above the surrounding surface. Even after circling the area, depending on motor speed to tell us whether or not we were on the level, we were not able to make out the berg…."

After building the camp at Tigvariak Island, the field party commenced geodetic work using an assumed geodetic position and an observed azimuth for a start point. Thence a four-mile baseline was measured across the ice of a frozen bay. From that base the triangulation network was extended east and west from the island. Primary transportation for the geodetic parties was by weasel. This work came to a halt in mid-May with the melting of sea and lake ice making travel nearly impossible. Work began on readying the LCMs and establishing Shoran electronic navigation stations for controlling the hydrography. Besides installing a fathometer and navigation equipment, the boats were painted bright orange in order to help find them in the event of breakdown or other emergency. By mid-July the hydrography was begun. Hydrography was carried to the edge of the ice barrier, a few km offshore.

For the next five years the basic routine of the field parties was to fly into the work area in mid- to late-winter, move camp if necessary, conduct geodetic operations and then hydrographic operations prior to evacuation in the late summer and early fall. The surveyors faced multiple hazards including intense cold ranging to -45 degrees Celsius, the occasional polar bear, rotten ice, near zero visibility both during white-outs and fogs, shifting ice fields, and the shear isolation of their working area in the event of medical emergencies.

Roy Sylar, as noted above, was an astute observer of other natural phenomena. Among the things he noted that ultimately had great importance were oil seeps: "A curiosity of the Arctic plain is to see oil bubbling from the ground in sub-zero weather. A place this can be witnessed is at Simpson Seep near Smith Bay. Another is on the banks of the Kuparuk River near Prudhoe Bay. While camped at MacIntyre Point at the entrance of Prudhoe Bay, in 1949, we had to travel many miles to find clean ice to melt for domestic use because the frozen ponds and streams in the immediate vicinity were contaminated with seeping oil." He was seeing manifestations of North America's largest oil field, the Prudhoe Bay Field which has produced over 12 billion barrels of oil since 1977. He also observed the migrations of the great caribou herds with the accompanying packs of wolves harrying the stragglers, be they calves or the old and weak. Sylar also noted atmospheric phenomena such as mirages, sun dogs, and multiple rainbows.

▲ *Figure 5: Cat-train on the move.*

The geodetic and hydrographic surveying of the Alaskan Arctic was a difficult endeavour. In spite of the hardships, Robert Earle wrote: "While this was the most rugged assignment I ever had, it was also the most interesting in that many types of problems arose to challenge one's attention and ingenuity. In spite of working under extremely adverse conditions, most of the men … would volunteer year after year to return to the Arctic for duty."

Editor's Note: This article could not have been written without reference to Roy Sylar's "Reminiscences of Four Years in Arctic Alaska" at http://www.history.noaa.gov/stories_tales/sylar.html, Robert Earle's speech "Arctic Field Party Work" at http://www.history.noaa.gov/stories_tales/earle.html, and conversations with and photos taken by Rear Admiral Harley Nygren, NOAA Corps (ret.). See: http://www.photolib.noaa.gov/corps/arctic.html and http://www.photolib.noaa.gov/meet_hn.html ◀

▲ *Figure 6: Increasing expanses of melted snow and ice during the spring melt. Weasel checking sea ice landing strip at Oliktok Point.*

Glomar Offshore

Navigating through the **Offshore Shipping Storm**

Glomar Offshore is a diversified ship management company based in Den Helder, the Netherlands, that operates in the Global Offshore Support Vessel field, with a focus on the North Sea and Baltic Oil & Gas and Renewables markets. Deployment is focused on the Survey, Subsea (Diving & ROV), Offshore Accommodation and Access, and Standby markets.

Glomar is a family owned, family-equity company. It was launched 10 years ago with 5 vessels and is still majority owned by its founder. During this decade, the company quadrupled in size, thanks to proactive planning, an aggressive pricing strategy and a general boom in the offshore market. The company now has a fleet of 19 modern units, and clearly wants to add more vessels to the fleet.

Klaas Weij, founder and CEO, says "the company's expansion has been based on long-term partnerships, involving the design, construction and operation of vessels explicitly built for specific clients". This illustrates the company's management philosophy, i.e. to be pragmatic, modest and involved, and hands–on. Critical to this has been the parallel ownership of

▲ *Figure 1:* Glomar Vantage.

a shipyard in Gdynia, Poland, where Glomar can build, rebuild, retrofit, upgrade and maintain all its vessels.

QHSE Superiority

Glomar currently employs approximately 35 people at the Den Helder head office, with half a dozen more based in Poland and Belgium. Having a full management setup, all technical, crewing, commercial, purchasing and QHSE activities are performed in-house.
QHSE superiority and competence, being one of the most important elements sought after by clients, is the cornerstone of the whole organisation and is highlighted in the company's mission statement:

- To always meet our customer's requirements.
- To be their first choice supplier for our range of services.
- To establish and maintain ourselves as one of the leading companies in Europe.
- To provide efficient and cost-effective services.
- To enhance our reputation for quality service through continuous improvement.
- To conduct incident free operations.

▲ *Figure 2:* Glomar Wave.

Expansion

In addition to serving the O&G, Seismic and Offshore Wind industries with standby and guard vessels in the Dutch, German and UK continental shelves, Glomar is currently expanding into the Survey (both Geotechnical and Geolophysical) and Subsea inspection, maintenance and construction markets, with approximately 15% of the fleet dedicated to such activities. Either independently or together with joint venture partners that can provide specialised equipment, such as side-scan sonar, multibeams, CPTs, (WC) ROVs or more specialised tools, Glomar can bid on virtually any new survey tender or project in the market.

More specifically, the company purchased the DP1/4-point mooring *Glomar Vantage* (previously the *Fugro Commander*) last year, which has been mobilised with a drilling tower and large moon pool to allow for such activities. Adding to that, the purpose-built DP2 *Glomar Wave* can undertake both subsea activities, including light construction, as well as above water inspection, repair and maintenance, as she has the ability to be mobilised with a heave compensated offshore access gangway.

Glomar's vessels are currently busy in campaigns in France, Belgium and Germany, with projects lined up in Scotland and the German & Danish Baltic during the summer of 2017.

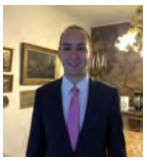
In general, current and previous clients have included Oil & Gas and Offshore Wind operators directly, as well as local and international construction and engineering companies, surveyors, academic institutions and government organisations.

What the Future Holds

In a market that has been hard hit by the severe drop in oil prices since 2015, it is difficult to predict what the future holds. 2017 has shown some signs of stabilisation, both economically and politically, with government and corporate decision makers continuing, restarting or sanctioning new projects, especially in the Renewables industry. One contributor to this has been Energy companies that are now able to venture into new offshore windfarm projects without requiring any subsidies. Whilst a positive development, this has neither been sufficient to absorb idle tonnage, nor boost charter rates yet.

On the other hand, O&G companies have been more conservative. Although Seismic and Drilling campaigns are currently much more economical, majors have been sceptical of OPEC's production decrease, of election and referendum outcomes in Europe and the US, and of tensions in the Middle East. Together with a brain drain in offshore clusters such as Aberdeen or Stavanger, a halt in R&D and a decreased appetite for new, untested technologies is evident. Smaller, 'second tier' operators, however, have been more aggressive in buying assets in the North Sea as this offers them a stable, mature and 'bullet proof' area of operations.

It is unlikely that a soar in offshore activity will happen before 2019. Yet, it is generally acknowledged that the market has seen the 'bottom of the barrel' and that increased activity can be expected in the Northern European survey market, with a potential regional focus in France, the UK and the Baltic states. Outside of mainland Europe, there is high anticipation of survey campaigns in the Eastern Mediterranean (especially Egypt) and Central/South America. ◀



Panos Komninos, MSc, MICS is chartering manager at Glomar Offshore BV in the Netherlands. He is responsible for all commercial, business development and marketing activities for the utilisation of the fleet of 20 offshore support vessels. He has been in the maritime business since 2008. His previous position was charterer at an offshore service provider.
✉ P.Komninos@glomaroffshore.com

New Technology to Assist in **Mapping the Ocean Floor**

The GEBCO-NF Alumni team, which together with other teams has now advanced to the semi-finals of the USD7 million Shell Ocean Discovery XPRIZE competition, is developing technology that can be used directly for mapping the ocean floor by the year 2030.

The aspirational objective of mapping the entire ocean floor by 2030 was announced by the chairman of the Nippon Foundation, Mr Yohei Sasakawa, in his acceptance speech at the 'Oceans 8' awards ceremony during the UN Ocean conference in New York, when he launched NF-GEBCO Seabed 2030, as a joint project of the Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO). As he said "understanding the bathymetry of the global ocean is imperative, not only for improving maritime navigation, but also for enhancing our ability to project climate change and monitor maritime biodiversity and resources". He pointed out that less than 15% of the bathymetry of the world's ocean floor is currently accurately mapped.

To this end, the Nippon Foundation plans to contribute USD18.5 million for the first ten years of the project. The plan is for Seabed 2030 to compile all available and newly collected bathymetric data into a high-quality, high-resolution digital model of the ocean floor and to promote international efforts to collect new data.

The work will be done through the establishment of four Regional Data Assembly and Coordination Centres (RDACCs) and a Global Data Assembly and Coordination Centre (GDACC) based at the British Oceanographic Data Centre, National Oceanography Centre. The RDACCs will be based at the Alfred Wegener Institute, Germany, covering the Southern Ocean, at the National Institute of Water and Atmospheric Research, Wellington, New Zealand, covering the South and West Pacific Ocean, at the Lamont Doherty Earth Observatory, Columbia University, USA, covering the Atlantic and Indian Oceans, and at Stockholm University, Sweden, for the North Pacific and Arctic Ocean.

Seabed 2030 will take responsibility for bringing collected depth data together, finding and highlighting the unmapped gaps, and helping to coordinate mapping by working with the established ocean mapping community within academia, offshore industry and government. A particular initiative will be to work with the fishing industry to increase the amount of data from fishing vessels that operate worldwide. Recreational and merchant vessels will also be approached. A working group with industry is planned through the World Ocean Council. An initiative of the International Hydrographic Organisation (IHO) on Crowd Source Bathymetry will also contribute.

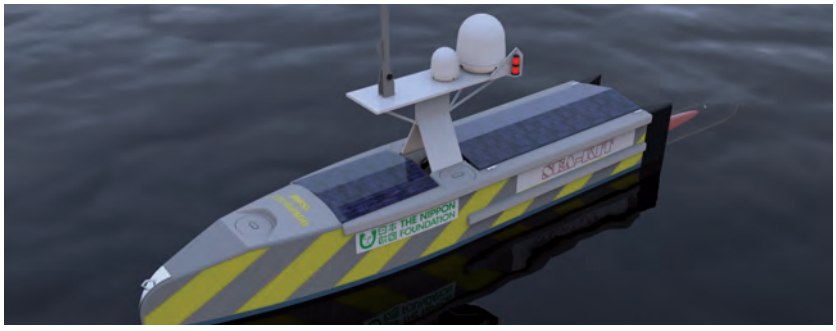
The GEBCO-NF Alumni team in the XPRIZE competition, funded by the Nippon Foundation and the Sasakawa Peace Foundation, is made up of graduate fellows from the Nippon Foundation's GEBCO Postgraduate Certificate in Ocean Bathymetry Training Programme, run at the Centre for Coastal and Ocean Mapping at the University of New Hampshire. The team is led by graduate fellows from Israel, Poland, Russia, the USA, South Africa, Japan, Philippines and Malaysia, as well as technical advisers from Norway, Canada, the USA, the UK, and New Zealand. All hold positions in their own country's maritime industries, including within government, research organisations and hydrographic offices, and bring a variety of professional backgrounds to the team – ranging from engineering, software development, physics and offshore project management.

Among the goals of the team is to develop SEA-KIT, a groundbreaking unmanned multipurpose transoceanic survey vessel capable of deploying and recovering an AUV. The surface vessel will also serve as a data repeater station facilitating autonomous and remote operations in the maritime environment.

SEA-KIT, currently being built by Hush Craft Ltd, based in Essex, UK, has been designed to match competition goals but also to have the longer term Seabed 2030 goals in mind. Kongsberg Maritime, one of the world's leading sonar and AUV manufacturers is working with Hushcraft on the SEA-KIT control systems. A Kongsberg HUGIN AUV, mounted with proprietary synthetic aperture sonar systems, will be used to collect bathymetric and imagery data. The AUV is being provided by Ocean Floor Geophysics, based in Vancouver, Canada.

The semi-final of the competition will held in October and November off Puerto Rico and will significantly advance ocean mapping technology.

Information on Seabed 2030 can be found at seabed2030.gebco.net and on GEBCO-NF Alumni at gebco-nf.com ◂



▲ *Designed to match XPRIZE competition goals – an image of SEA-KIT, currently under construction by Hush Craft, based in Essex UK. Images and information courtesy: Hush Craft Ltd.*

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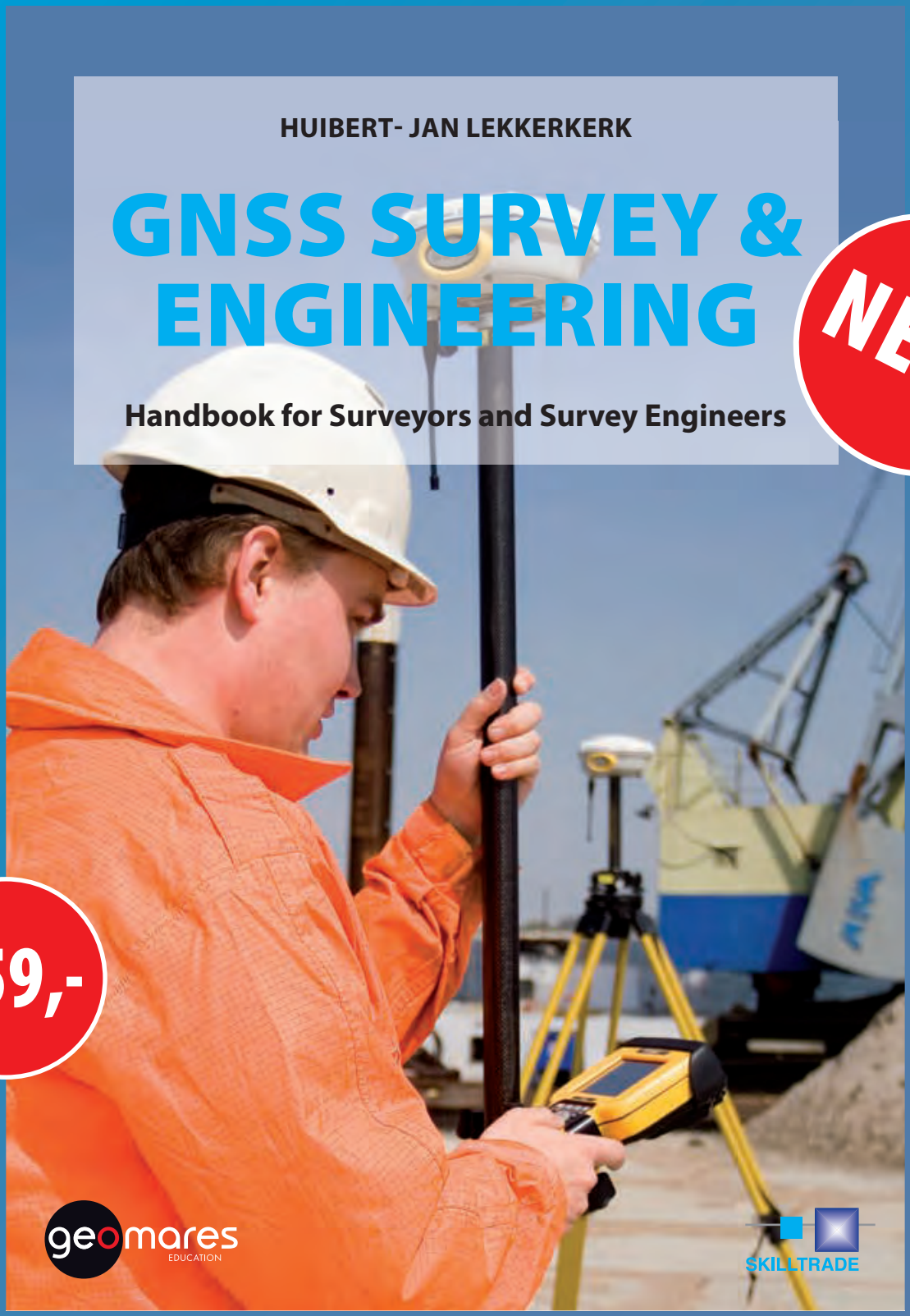

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Hydrographic Society Benelux

World Hydrography Day 2017: Have a Look Behind the Dikes

Hydrography is important to visualise the water floor. This can be done in various ways, from using a sounding stick to a remotely controlled single beam echo sounder or a survey vessel manned 24/7. On Tuesday 20 June, the worlds of dredging and hydrography were united at the offices of Waternet in Amsterdam, most importantly to learn from each other. World Hydrography Day was also celebrated during a social event at the RIC Rowing Club.

When do you apply which technique? How can you best map the depth and structure of the floor?

Paul Spaan (Platform Baggernet) opened the gathering and interviewed host Peter de Haan (Waternet / Waterschap Amstel, Gooi & Vecht) and chairman Leeke van der Poel (Hydrographic Society Benelux). This was followed by two presentations by Hans Hussem on various offshore and inshore survey techniques, which was expanded on by Marc van der Donck (Hydrographic Service of the Netherlands) who showed the impact and need for surveys in the Netherlands. Edwin ten Hennepe (Waternet) gave a presentation on 'Laser altimetry looks promising for measuring bathymetry in ditches', followed by a presentation by Elmert de Boer of Hoogheemraadschap van Rijnland on 'Sediment out of balance - sediment maintenance in the Netherlands'.

After the presentations, several survey vessels and a USV were moored alongside the Amstel River and participants were given the opportunity to gather information. World Hydrography Day was celebrated in the bar and on the sunny terrace outside.

▲ *On-water demonstrations and viewing of several survey vessels was an appreciated part of the programme.*

Australasian Hydrographic Society

World Hydrography Day in Australasia

21 June is World Hydrography Day, which was promulgated by the United Nations on 29 November 2005. World Hydrography Day also marks the 96th anniversary of the establishment of the International Hydrographic Organization (IHO).

Hydrography has been essential in the exploration and development of the South West (SW) Pacific region. Apart from using the stars for navigation, the early spread of people through the SW Pacific has also been dependent upon Hydrography and the knowledge that was passed down to those behind the early explorers either by word of mouth or through the use of nautical charts and other hydrographic knowledge. While 'Moana' may just be an animated movie to some, it also depicted the use of some hydrographic information to navigate. Explorers such as Cook, Flinders, Janszoon, La Perouse, and even the First Australians, were both navigators and hydrographers at the same time, opening up new worlds and opportunities.

Hydrography is the charting of the Oceans and Seas and navigable waterways of the planet. The IHO has stated: "It remains a fact that the depth of barely 10% of the world's oceans and about 50% of the world's coastal waters has been measured directly. The depth of the remainder is either estimated from such things as satellite-based gravity measurements or no depth is available at all. The result is that there are higher resolution maps of the Moon, Mars and Venus than for most of the world's maritime areas. Survey coverage is particularly poor in the Caribbean, Indian and Pacific Oceans and the Polar regions, but all areas of the world are affected to some extent, including the waters of many developed coastal States."

Contrary to popular belief, and despite it being the largest country in the SW Pacific region, there are still parts of the Australian coast that have not been completely charted today.

A product of Hydrography is nautical charts. This allows nation states to trade by providing routes for safe shipping. With our near neighbours in the PNG and the South West Pacific, safe passage allows their economies to benefit from tourism, fishing, exporting of their goods and commodities and importing their daily needs. Further, Hydrography allows for the planning for the effects of climate change.

The science of Hydrography is used for exploration and oil & gas infrastructure, including drilling platforms and pipelines. It is used to lay subsea cables (power and telecommunications) between countries and continents. It is used in developing renewable energy sources (wind, waves and tides).

There are changes coming within the profession, with the use of satellite derived bathymetry, autonomous vehicles (surface and subsea) and crowdsourced bathymetry, and outsourcing of Hydrography from the public sector to the private sector.

As island nations, Australia and its neighbours in the SW Pacific region depend on Hydrography for the safe and productive export of resources and for the import of many of its needs. As such, the work of hydrographers is significant and important to the development of the region's economies, the support of safety of navigation, the protection of the marine environment, coastal zone management, marine spatial data infrastructures, defence and security, resource exploration, and all other components of the blue economy - whether from the public or the private sector.

SEPTEMBER

INSPIRE Conference 2017
Kehl, GE; Strasbourg, FR
→ 4-8 September
inspire.ec.europa.eu/conference2017

MTS/IEEE OCEANS 2017 Anchorage
Anchorage, US
→ 18-21 September
www.oceans17mtsieeeanchorage.org

OCTOBER

Offshore Energy
Amsterdam, NL
→ 9-11 October
offshore-energy.biz

9th Advisory Board on the Law of the Sea (ABLOS) Conference
Monaco
→ 10-11 October
www.ablosconference.com

Sea Tech Week
Brest, FR
→ 8-12 October
www.seatechweek.eu

Teledyne Marine Technology Workshop
Dan Diego, US
→ 15-18 October
www.teledynemarine.com/events/teledyne-marine-technology-workshop-2017

Underwater Vehicles Conference
Aberdeen, GB
→ 24 October
www.subseauk.com/8328/underwater-vehicles-conference

BIT's 6th Annual World Congress of Ocean-2017
Shenzhen, CN
→ 30 October-1 November
www.bitcongress.com/WCo2017/default.asp

NOVEMBER

Oceanology International China
Qingdao, CN
→ 1-3 November
www.oichina.com.cn

PLOCAN Glider School
Telde, ES
→ 6-11 November
gliderschool.eu

CEDA Dredging Days
Rotterdam, NL
→ 9-10 November
www.cedaconferences.org/dredgingdays2017

Marine Autonomy and Technology Showcase
Southampton, GB
→ 13-17 November
conference.noc.ac.uk/matshowcase

GEBCO Symposium: Map the Gaps
Busan, KR
→ 15 November
www.mapthegaps.org

Hydro17
Rotterdam, NL
→ 14-16 November
hydro17.com

Asia-Pacific Deep Sea Mining Summit
Singapore, SG
→ 21-22 November
www.asia.deepsea-mining-summit.com

Sustainable Ocean Summit
Halifax, CA
→ 29 November – 1 December
www.sustainableoceansummit.org

Calendar Notices
For more events and additional information on the shows mentioned on this page, see www.hydro-international.com. Please send notices at least 3 months before the event date to: Trea Fledderus, marketing assistant, email: trea.fledderus@geomares.nl.

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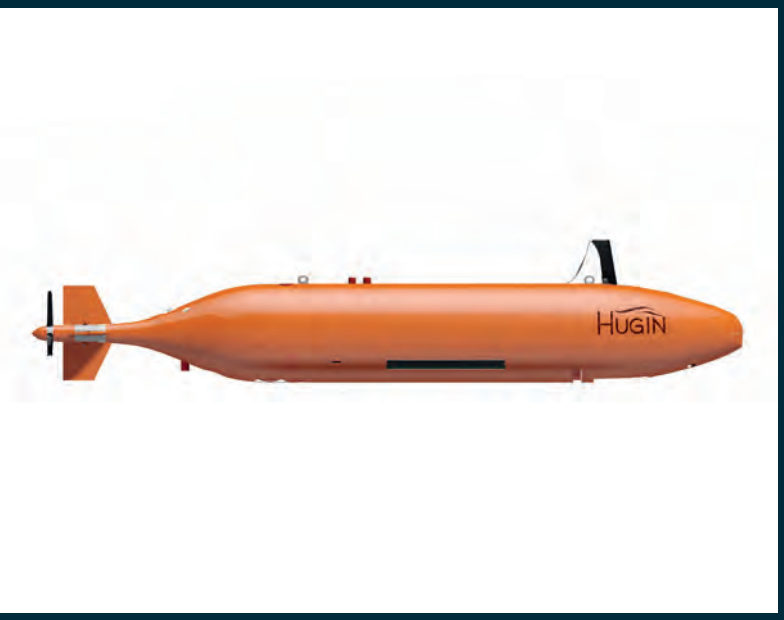

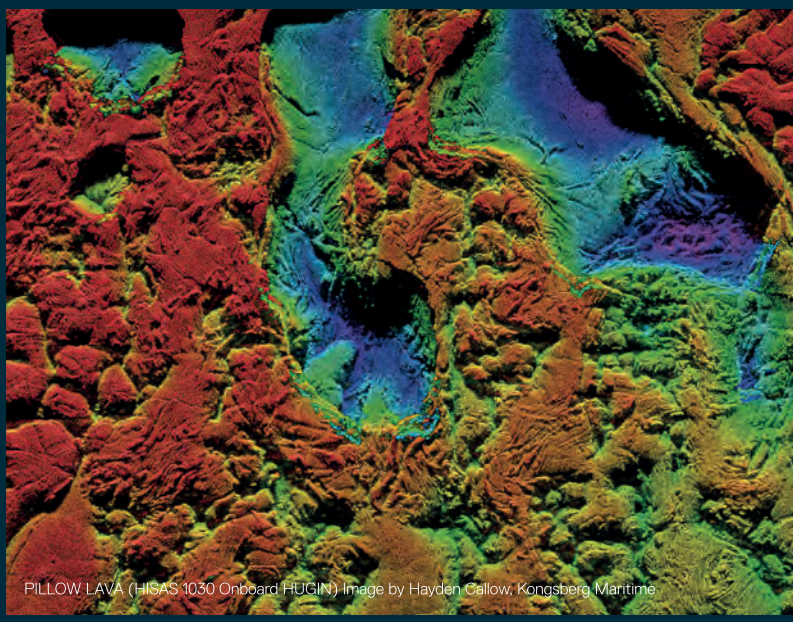

PILLOW LAVA (HISAS 1030 Onboard HUGIN) Image by Hayden Callow, Kongsberg Maritime

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