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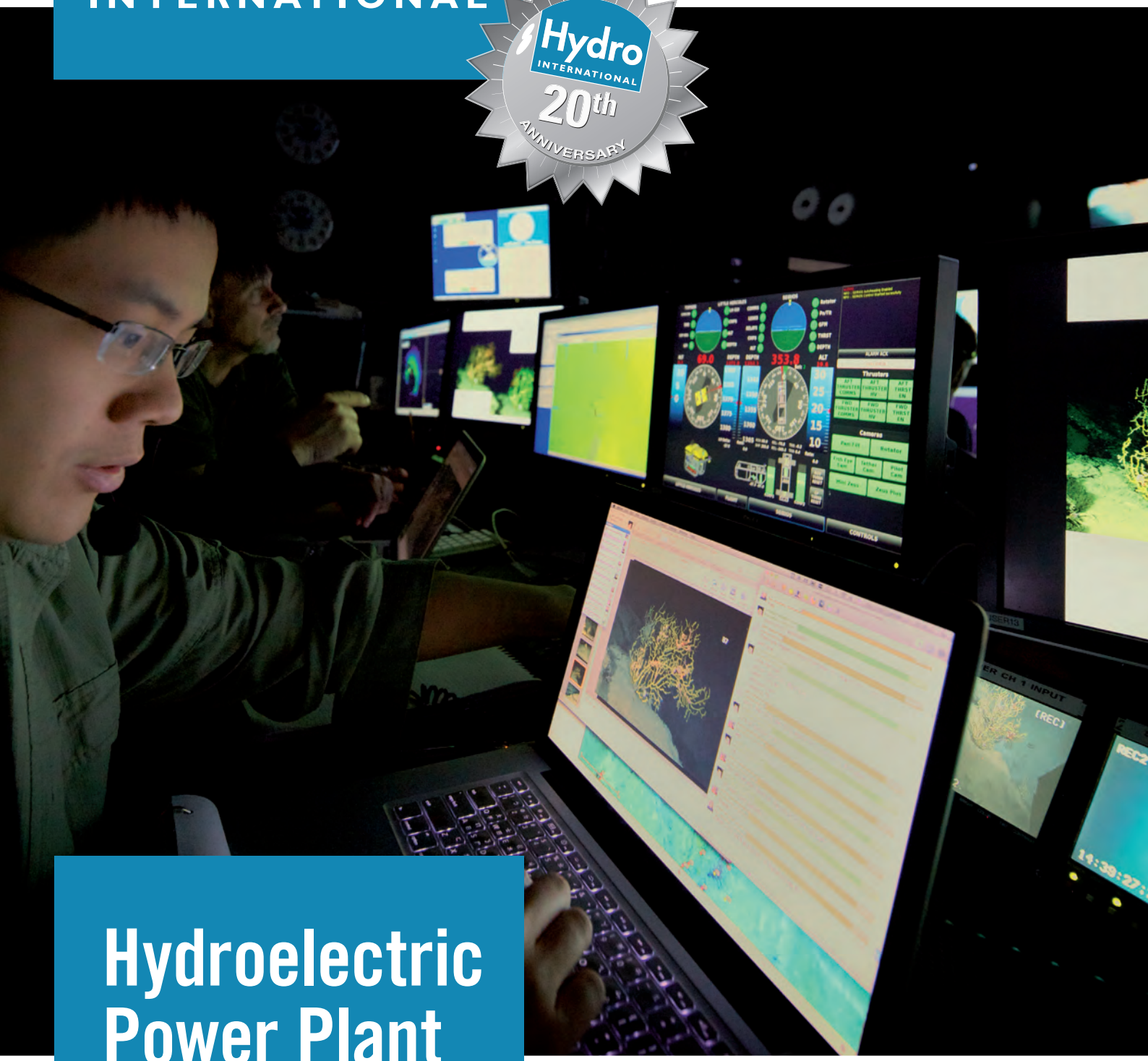

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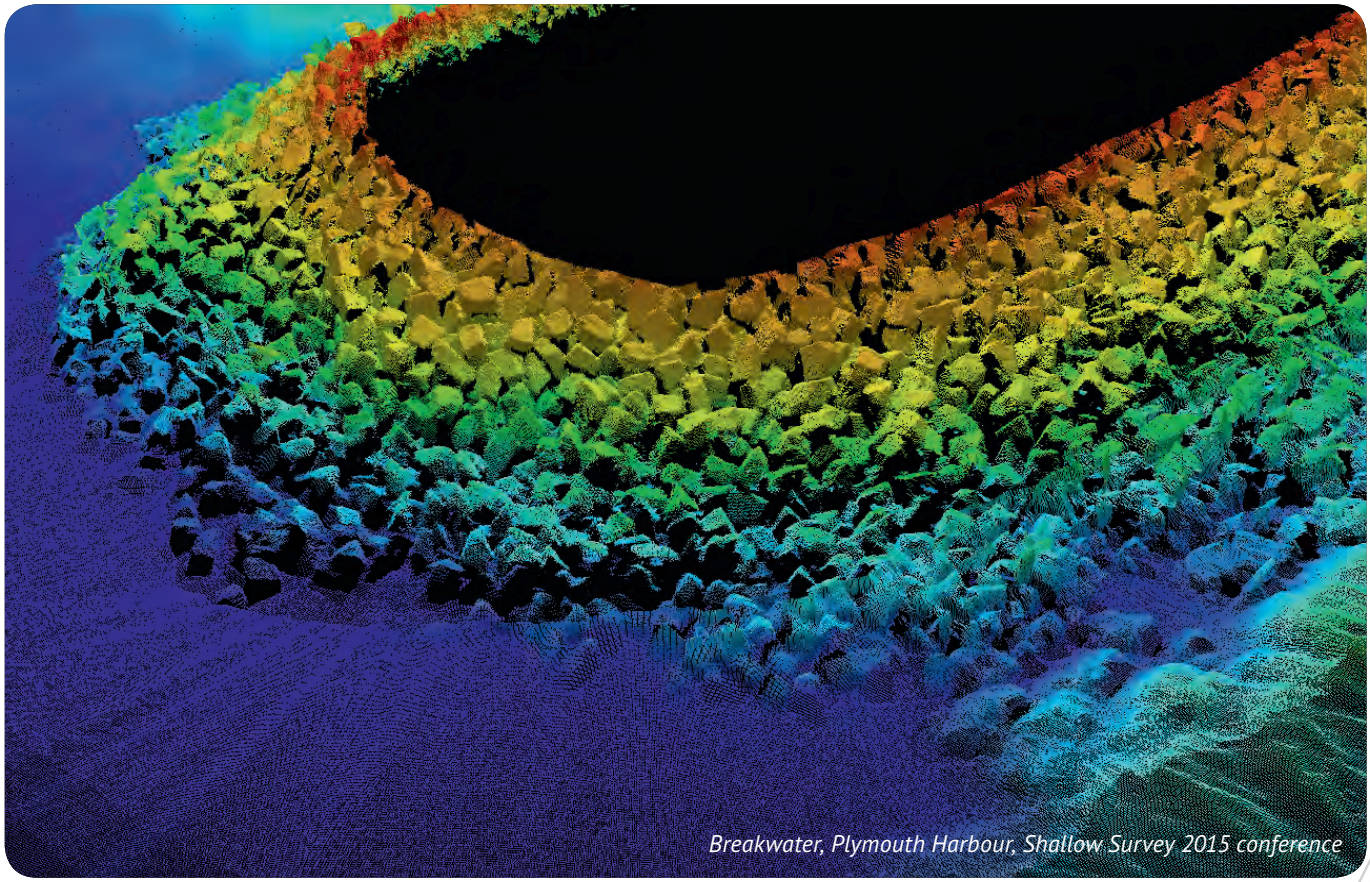

Breakwater, Plymouth Harbour, Shallow Survey 2015 conference

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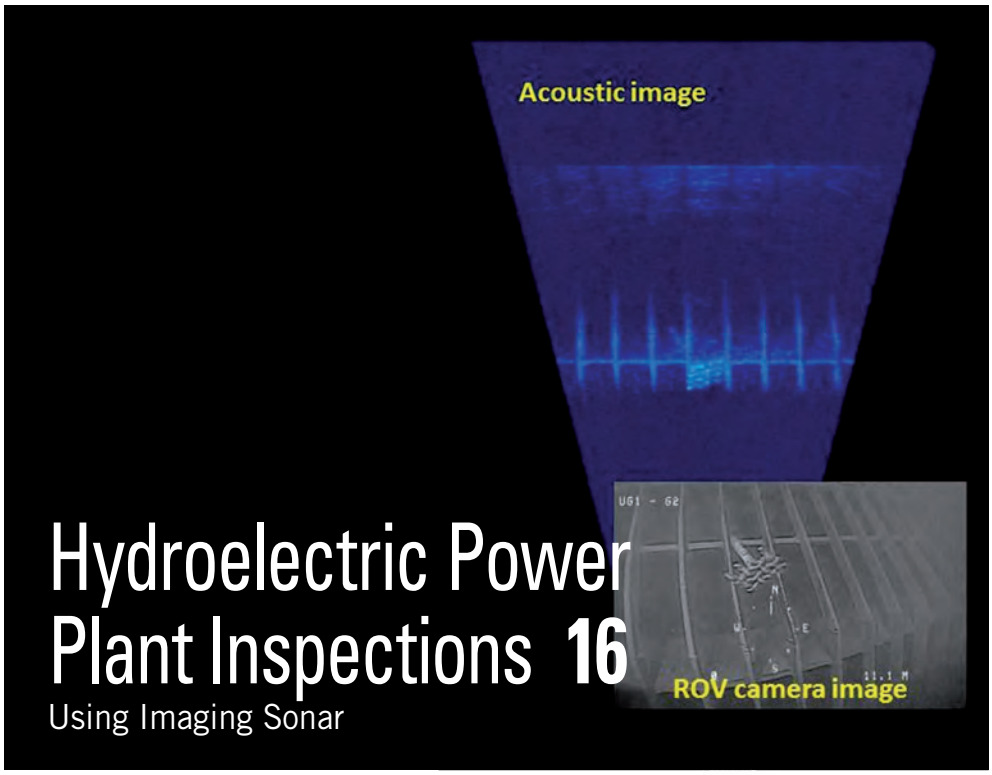

July/August 2016
Volume 20 #5

Pen-Yuan Hsing works in the ROV Control Room to maximise the scientific benefits of the dives. Image courtesy: NOAA Okeanos Explorer Programme.

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Hydro INTERNATIONAL

Hydro International is an independent international magazine published 8 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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Forum

"More than 1,500 people have climbed Mt. Everest, upwards of 300 have journeyed into space, and 12 have walked on the moon, but only three have descended and returned from the deepest part of the ocean". It's this quote by Dawn Wright, chief scientist at Esri, in their publication *The ArcGIS Imagery Book* that definitely hits the nail on the head. We don't know anything about most of our oceans and much about very limited parts of them. This is exactly why the Forum for Future Ocean Floor Mapping was held in Monaco from 15 to 17 June. More than 200 delegates from academia, NGOs and the private sector gathered to discuss and draw a road map to full coverage data of the ocean floor by 2030. The Forum was organised by the Nippon Foundation and the GEBCO Guiding Committee. Not coincidentally, the General Bathymetric Chart of the Oceans (GEBCO) was initiated more than a hundred years ago, also in Monaco, by Prince Albert I of the principality and professor Julien Thoulet of the University of Nancy. Since then a group of scientists from all over the globe have worked hard, voluntarily and effortlessly, to produce charts of the ocean, with bathymetric contour lines and coastlines. The charts have been used primarily by the scientific community. But nowadays societal needs and a focus on the ocean has become far more prominent. GEBCO therefore decided, with support of Nippon Foundation, to organise the Forum to answer to this societal need, scientific curiosity and technological developments. In this issue of *Hydro International* we carry an interview with Shin Tani, chairman of the GEBCO Guiding Committee (see page 12). He explains that the increase in marine protected areas (MPAs), coastal management, fishing resources, site selection for platforms, pipelines and cables, have made it necessary for GEBCO to reset its focus. He invites the ocean community – industry, NGOs and academia not yet involved to join the discussions that will take place within GEBCO. This will result in a GEBCO that is far more visible on the stage of ocean policy. He has one message for our readers: share data! If everybody shares the data available the goal of a fully mapped ocean floor will come within reach much sooner than if everybody keeps guarding their own data. Shin Tani is also convinced that data should not be kept secret, also because technically it's impossible to do so. There's only one real reason to share data and use it to make the most accurate maps: for the sake and safety of the users of the sea, and in the end the fate of the ocean, the ecosystem, the earth. Hopefully, in a few years' time, we'll conclude that the first step towards all of this was the Forum for Future of Ocean Mapping in the summer of 2016 and that in the years ahead the complete misbalance of people who climbed the highest top of the earth has shifted for the better towards those who have visited, or at least mapped, the deepest places on that same earth.

Durk Haarsma durk.haarsma@geomares.nl

Hydrographic Charting Data Management Challenges

Three years ago we discussed the global proliferation of large coastal hydrographic charting-based projects. More recently the topic was large, multi-month MBES applications on a variety of regional seabed mapping programmes ranging from oil exploration applications to multi-year seabed searches for accident investigations. MBES and associated hydrographic charting programmes on the scale of multiple ships, multiple months and long distances from home-base have placed extreme pressures on data volumes management and moving that data to the client in an efficient, cost effective and timely manner. Added challenges include breakthroughs in the collection of water column and high density backscatter imagery, which can increase the data volumes by an order of magnitude. With recent breakthroughs in data management and data transfer, the industry is poised for significant changes on managing, moving and manipulating data between active collection offshore and near real-time results onshore.

Today, a typical regional seafloor geochem seeps study is based on the collection and processing of upwards of >500km^2/day of terrain, backscatter and water column anomalies over 30+ days of continuous uninterrupted operations. This collection routine yields > 400 gigabytes of data per month that is desperately anticipated by clients and analysts onshore. This rapid delivery, turnaround and integrated interpretation is essential to meeting the goals of identifying, prioritising and collecting the geochemical phase of the programme, without any significant delays or vessel swaps. This ability to move the full dataset between the vessel and shore, or vessel to vessel, also allows for real-time interaction between the client/analysts and the field teams. This in turn allows for scope or target area modifications, ensuring the best utilisation of the expensive vessel asset and focus on the most important areas of interest. Gone are the days of isolated data collection over several weeks of field ops, followed by additional weeks of cleaning and tuning the data ashore, before eventually providing the results to the clients.

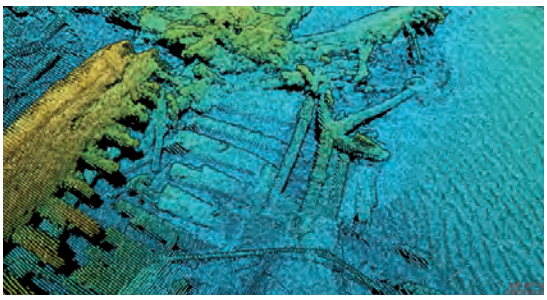
Another example of the advantages of large-scale data transfer can be applied to seabed search programmes in remote locations that can last for many months. In this case, the client and analysts are eager to locate and identify the target of interest as rapidly as possible. The data transfer capability of large-scale MBES derived terrain data and side-scan sonar imagery, allows multiple shore-based teams of experts to immediately begin the process of combing through the gigabytes of information. As with the previous example, this brings the ultimate decision makers directly into the strategy discussion for any required changes in approach, areas of interest or rapid decision making. This is a critical advantage over just a few years ago when the entire dataset could not be reviewed by the interested parties until days or weeks after the last instrument was stowed and the vessel was heading to port.

From these recent examples of successful applications of the technologies, it is easy to see that the near future will include this application for nearly any type of offshore data collection based programme. Combining these capabilities with hydrographic charting requirements that traditionally relied on intensive staffing coupled with the decrease of satellite bandwidth cost and cloud-based processing technologies maturing, it is feasible to see how the large labour force can begin to be shared from a shore-based team of hydrographers that can easily process data from multiple platforms. Add to this the near term expected usage of multiple ASVs for multiple data collection applications and even more data volumes, then large-scale data transfers and the associated shore-based shore support services are likely to be the norm very soon.

Historical American Shipwrecks Documented

2G Robotics and NOAA, with the assistance of Offshore Analysis & Research Solutions (OARS), recently used 2G Robotics' underwater laser scanning technology to create 3D models of some of America's most nationally significant shipwrecks. They were scanned in the Thunder Bay National Marine Sanctuary, USA.

▸ *bit.ly/2aOu9h9*



Underwater Laser Scan of historical wreck Ogarita *made with 2G Robotics ULS-500 Pro*

Greenland Melting Ice Contributes More to Sea-level Rise

Information from ESA's CryoSat satellite reveals how melting ice in Greenland has recently contributed twice as much to sea-level rise as the prior two decades. Between 2011 and 2014, Greenland lost around one trillion tonnes of ice. This corresponds to a 0.75mm contribution to global sea-level rise each year – about twice the average of the preceding two decades.

▸ *bit.ly/2aOuC2D*

ESA CryoSat ice mission.

Annual Review of the Marine Science and Technology Sector

The eighth survey, focused on UK companies operating primarily in Marine Science and Technology (MST) activities, aims to provide an insight into current business activity in terms of market sectors, market size and business confidence both current and forecast. The majority of companies reported limited growth during 2016, with some consolidation taking place as the depressed oil price affects their markets.

▸ *bit.ly/2aOulqY*

Most Shared

Most shared during the last month from www.hydro-international.com

EIVA and UNH/CCOM Enter into Partnership - bit.ly/2a0v9S9
Integrating UAS and Multibeam Echosounder Data - bit.ly/2arcP57
Conference on New Oceanographic Survey Vessels - bit.ly/2a3Rxah
ENC Bathymetry Plotter Narrows Contour Lines - bit.ly/2a0uP5R
Historical American Shipwrecks Documented in Collaboration - bit.ly/2a0u9h9

EIVA and UNH/CCOM Partnership

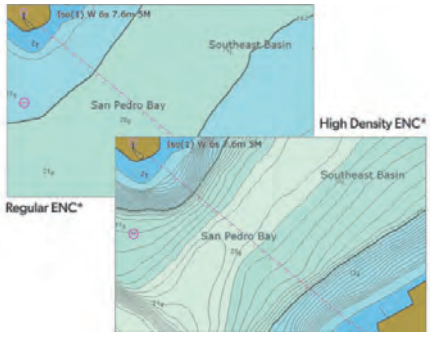
The University of New Hampshire (UNH) Center for Coastal and Ocean Mapping (CCOM, USA) and EIVA (Denmark) are pleased to announce that EIVA is now an official industrial partner of CCOM. With this partnership, EIVA is able to implement CCOM's tools in the new generations of the NaviSuite software products, and UNH students, researchers and staff get free use of NaviSuite.

▸ *bit.ly/2a0v9S9*

ENC Bathymetry Plotter Narrows Contour Lines

Germany-based SevenCs has released a brand new member of the ENC Tools family. ENC Bathymetry Plotter assists the producer of nautical charts in contour generation and helps to reduce the manual work. The contouring process is based on a shoal-biased Nautical Elevation Model and creates contour lines that have a smooth appearance and do not require any further generalisation.

▸ *bit.ly/2a0uP5R*

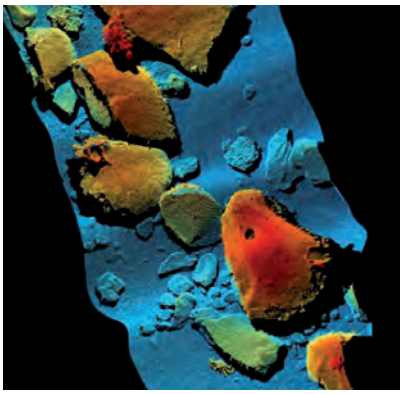


Regular vs high-density ENC7.

3D Mobile Seabed Mapping Using Underwater Laser Technology

Sonardyne has used 2G Robotics' underwater laser scanning technology to dynamically scan and map the seabed in Monterey Bay, California, USA. The high-resolution deepwater mapping of Sur Ridge was performed using 2G Robotics' ULS-500 underwater laser scanner mounted on an ROV.

▸ *bit.ly/2a0x6hx*



3D Laser mapping of Sur Ridge Monterey Bay, California.

Wave Monitoring Buoy Deployed off Mauritius

Wave energy developer Carnegie Wave Energy Limited has successfully deployed and commissioned a wave monitoring buoy off the south coast of Mauritius. The project was carried out in conjunction with its Mauritian Project partners: The Mauritian Research Council (MRC), Australia's High Commissioner to Mauritius and the University of Western Australia.

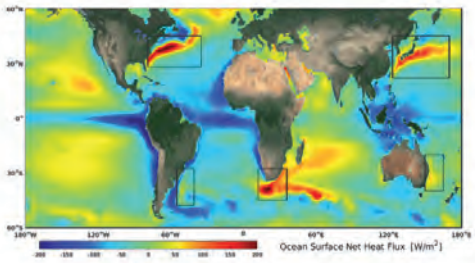
▸ *bit.ly/2a0vtAt*

Australia's High Commissioner to Mauritius, Ms. Susan Coles (left) with Mauritian Research Council representatives, Carnegie's Project Manager Neil De Tisi (second from right) and analysis engineer Jess Kolbusz (right) in front of the Wave Measuring Buoy in Mauritius.

Intensification and Poleward Shift of Oceanic Boundary Currents

As scientists from the Alfred-Wegener-Institute, Germany, have shown in a new study, wind-driven subtropical boundary currents in the northern and southern hemispheres are going to increase in strength by the end of this century. The Kuroshio Current, the Agulhas Current and other oceanic currents are shifting their paths towards the pole and thus carry higher temperatures and the risk of storms to temperate latitudes.

▸ *bit.ly/2a0vQei*

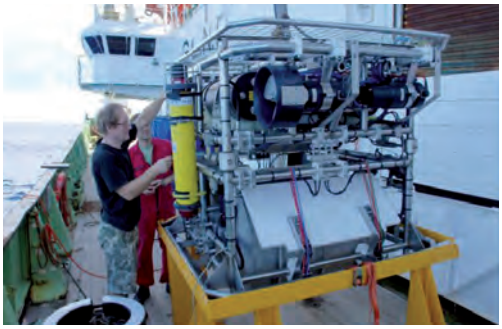


Heat flux of ocean currents. Image courtesy: AWI.

Expedition to Test New Technologies for Exploring Deep-sea Deposits

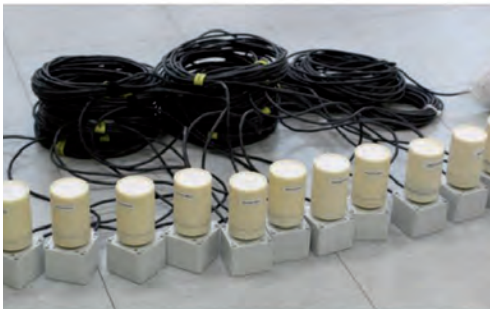
A research cruise this summer, led by the National Oceanography Centre (NOC, UK), will address the massive technical challenges in exploring for seafloor mineral deposits. The expedition will take place on board the RRS *James Cook*. In its decade of service, this ship has travelled 218,972 miles in pursuit of science – the equivalent of circumnavigating the globe ten times.

▸ *bit.ly/2a0w0lT*



HyBis Underwater Vehicle being prepared for a dive by Bramley Morton. Image courtesy: Steve McPhail.

Echologgers for KIOST



Echologger Air50 for KIOST ready for distribution.

Air-borne precision echo sounder Echologger Air50 was launched and supplied to the institute KIOST (Korea Institute of Ocean Science & Technology). 12 units of the device were initially installed to study sediment move and tide speed in a swash zone. KIOST intends to deploy more devices to cover a wider area.

▸ *bit.ly/2a0x09s*

Launch of UK Marine Science Centre

A UK marine science centre launched on Tuesday 5 July 2016 aims to provide solutions to challenges facing the world's seas and society, from climate change to energy and food security. The Collaborative Centre for Sustainable Use of the Seas (CCSUS) brings together more than 40 scientists from the University of East Anglia (UEA) and the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

▸ *bit.ly/2a0vGna*

Hydrographic Academy Students Experience SeaBat T50-P

As part of the Postgraduate Diploma in Hydrography course, students at The Hydrographic Academy, UK, participated in field activities to gain practical experience and understanding. Teledyne RESON joined these students in their marine station on the historic waterside for a week in order to train them in working with the SeaBat T50-P multibeam echo sounder and Teledyne PDS software.

▸ *bit.ly/2a0x1uh*

Seabat P50 survey by Hydrographic Academy participants.

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EchoLogger – RS900 High Resolution Scanning Sonar	bit.ly/EchoLoggerRS900
Coda Octopus - Echoscope® C500 Real-Time 3D Sonar	bit.ly/EchoscopeC500
EchoLogger - MRS900 Mini Imaging Sonar	bit.ly/EchoLoggerMRS900
Teledyne Marine – SeaBat 7128	bit.ly/SeaBat7128

Survey Vessel *FeliX* Operational

iXblue has christened its new survey vessel *FeliX*, a 25m catamaran developed for hydrographic, biological and oceanographic surveys. Her composite construction houses innovative techniques, responding to scientific and economical requirements. *FeliX* is described as agile in her movements, while at the same time being respectful towards the environment.

▸ *bit.ly/2a0x217*

Survey vessel FeliX.

World Hydrography Day **2016** Celebrated in **Adelaide**

This year marks the 95th anniversary of World Hydrography Day on 21 June and the SSSI Hydrography Commission, SSSI SA and the Australasian Hydrographic Society were pleased to host an Adelaide event at 'The Beachouse', Glenelg to celebrate the occasion. The event received extraordinary support from local hydrographic industry partners, resulting in HydroSurvey Australia, Precision Hydrographic Services and Fugro LADS Corporation sponsoring the day.

With breathtaking views of Glenelg Beach, over 30 delegates were witness to a broad range of presentations, many drawn from local South Australian case studies. Topics included the WHD 2016 theme 'Hydrography, the key to well-managed seas and waterways', as well as, the evolution of Airborne Lidar Bathymetry for shallow coastal waters, estuary and rivers; a case study of a local South Australian hydrographic survey project near Kangaroo Island; the future implementation of the GDA2020; an update on the South Australian Tidal Network; a case study of an Airborne Lidar Bathymetry project in French Polynesia; as well as a graduate's first-hand account of starting a career as a hydrographic surveyor.

▸ ***http://bit.ly/29t5EZt***

▲ *The theme of World Hydrography Day was subject of one presentation.*

Streaming Into ADCP Knowledge

European surveyors working with ADCP met in Utrecht in the Netherlands on 15 and 16 June 2016 for the ADCP Workshop organised by AquaVision. As this event had already been organised several times in the past, the recipe was known: the first day included technical updates and presentations, the second day was dedicated to a good hands-on workshop for the delegates on the programme.

The organisers can look back on a successful and well-attended conference. And the delegates returned home with improved skills, ideas for further applications and more hands-on experience.

▸ ***bit.ly/29t4Cgd***

▲ *Figure 1: The delegates listening to the presentation in the plenary sessions on Wednesday 15 June.*

▲ *Figure 2: Networking at the trade show during the breaks.*

BY **YOUSUF MALIK**, DEFENCE IQ, UNITED KINGDOM

Sailing Back from **Mars**

I was amazed to learn that the topography of planet Mars is better known than the topography of our own seabed. This fact was echoed by Admiral Bruno Frachon, the chief of the French naval hydrographic office, SHOM, at the recent OSV 2016 conference in London this June organised by Defence IQ. But that is not the principal reason navies are investing anew in fleets of hydrographic and oceanographic survey vessels to help build a better picture of the vast breadths and depths of our oceans.

If only there had been a few operational naval commanders present at the OSV 2016 conference, they would have gained an understanding of how the arcane and under-appreciated science of hydrography is so critically important to the success of their missions and would be lobbying their governments for more cash to let them acquire more ocean survey capability. There seemed a real sense of urgency in the dialogue and discussions; an urgency to learn how to go about procuring a survey capability that many navies realise they so desperately need. Alongside discussions on what is essential; what can you do without when building the requirement for a survey vessel, the message was clear: regardless of whether we are talking about Mine Countermeasures, Anti-Access, Area Denial (A2/AD) strategies, submarine operations, anti-submarine warfare, naval patrol—a thorough understanding of the undersea 'lay of the land' and the undersea mission environment is the ultimate game changer.

▸ ***bit.ly/2a3Rxah***

▲ *Figure 1: Fabrice Weinbach, Director Maritime Safety & Security, OCEA SA.*

▲ *Figure 2: There was a huge interest for multi-role, multi mission vessels as presented by, for example, Damen Shipyards.*

Hundreds Attend UKHO's World Hydrography Day Event

As part of the events to mark the 2016 World Hydrography Day (WHD) this month, the United Kingdom Hydrographic Office (UKHO) recently hosted an interactive family day around the theme of 'Getting to know the UKHO' in partnership with the Museum of Somerset. The event was free of charge and open to all. Interactive sessions ran during the day to give hundreds of parents and children the opportunity to participate in family-fun hydrographic activities as well as meet expert mariners and representatives from the UKHO.

▸ ***bit.ly/29US3r6***

▲ *A child interested in a digital and paper chart display at UKHO.*

Hydro International interviews Shin Tani, chair of GEBCO Guiding Committee

Ocean Floor to be Mapped by 2030

The first Forum for Future of the Ocean Floor Mapping was held in Monaco from 15 to 17 June 2016. Some 200 delegates gathered, under the flag of General Bathymetric Chart of the Oceans (GEBCO), to discuss the future of the mapping of the ocean floor, aiming to come up with a roadmap towards 100% coverage of a mapped ocean floor. GEBCO was established 113 years ago, also in Monaco. *Hydro International* talked with the chair of GEBCO Guiding Committee, former Chief Hydrographer of Japan, Shin Tani. Shin Tani is adamant about the need of sharing data to reach the goal of a completely mapped ocean floor. He is less sure about a time-frame in which the international ocean community will achieve that full coverage.

Could you please explain to me why it is such an urgent matter to have this Forum right now?

'There are many, many reasons. Let me name a few. First of all, GEBCO has focused on the use by scientists. Maybe a small group outside of the scientific community looked at GEBCO products as well; some keen about protecting the ocean, others interested in biodiversity or fisheries and recently ocean energy and tsunami modelling , but it is time now to broaden our scope. GEBCO historically worked in areas deeper than 200 metres. This was also even included in our guidelines, but that's almost obsolete. We are looking at shallower water now as well. We no longer have a hard boundary. Inclusion of shallower-than-200m bathymetry was started around 1990, when gridding of digitised contour lines started, in order to restrict the funny reaction of gridding algorithm. At around the same time the demand for new and bigger datasets arose, a demand that has grown ever since, in part also because of the focus on Marine Protected Areas (MPAs), wind turbines and the other areas of interest.

There is a clear demand for higher resolution data on shallower water. We realise and recognise that we need to answer to that demand and therefore also have to consult on the exact demands. Another factor that made clear that the boundary of 200 m depth is not a sustainable one, are the devastating tsunamis that have occurred over the last decades. Scientists working on the prediction of tsunami's propagation and inundation are also looking at us for answers on how the seafloor is shaped. In general, one could say that there is a societal need, but also scientific curiosity and technological developments and GEBCO wants to respond to that. A Forum such as this is the perfect way to discuss with stakeholders.'

Will this result in a bigger role and more visibility for GEBCO?

'Oh, yes. By its nature, activities for GEBCO are of course voluntary and have been carried out in scientific environments. The scientific researchers donate their time, in the office or maybe out of the office to contribute to GEBCO. In addition, all data that we collect are basically data voluntarily donated from scientific vessels. That also means that the data we obtain were limited to scientifically interesting areas, except for a few exceptions, for instance in Japan, where data was donated on the entire Exclusive Economic Zone around the island to GEBCO. A very detailed bathymetric survey was conducted for the Extended Continental Shelf programme. North American and European stakeholders have arranged the so called Galway Statement, which will end up in a lot of new data from the North Atlantic. Similar projects can be arranged between South Africa and Argentina and Chile and New Zealand, where bathymetric data are still really sparse. I would like to improve the situation. So there are already major developments that could make more data available for GEBCO to incorporate in its products and therefore its role will become more important.'

If Hydrographic Offices stick to nothing else than publishing nautical charts, that would be a disaster

The year 2030 is a year that is buzzing around at the Forum as the turning point. Where will we stand 15 years from now?

'Maybe I'm just dreaming, but I think that at a certain point a dramatic change will take place.

Hydro International is collaborating to keep you fully updated on the outcomes of the Forum for Future Ocean Floor Mapping. Check our magazine regularly to stay in the know on all the efforts being undertaken by GEBCO, together with the international ocean community, to map the ocean floor up to the full 100%.

One day, when people realise the importance of detailed bathymetry and start to hand over data, people may compete or donate data and the amount of data becoming available will dramatically increase. Many factors play a role in this: for example, internet and the smartphone, which will help us in a positive way. When the turning point is reached, the situation will change drastically. I expect this to happen to us.'

What about crowdsourced bathymetry as a major source for new data?

'Crowdsourced bathymetry will become the major source of data for GEBCO, from any kind of ship sailing the world's oceans. I would like to remind you that the very first GEBCO relied largely on cable laying companies' sounding data. They were truly the crowdsourced bathymetry.'

And do you dare to give an estimate of how much of the ocean floor will be mapped by 2030, in percentage terms?

'Having a 100 percent coverage of bathymetry of the ocean is not that easy and simple. It may not be impossible, but it is certainly very difficult. In 10 years? I don't think so. Can I replace 10 by 15 years or 20 years? Still hesitating...but 50 years, that maybe a yes. But it depends on the size of the grid, in question, of course. For example, bathymetry under ice cover needs dramatic development of surveying technology. Otherwise 100 percent coverage will not be very easy.'

▲ *Shin Tani. Image taken during the Forum for Future of the Ocean Floor Mapping.*

There are more than 12,000 hydrographers and oceanographers all over the globe reading Hydro International. What would you like to tell them?

'Share data! Keeping data to yourself is, in my view, a crime. It should be shared. Once everybody shares, 15%, the percentage of the ocean floor that has now been mapped, will easily become 40%. I remember that I talked with a Russian guy who told me that a city called Obnisk, an academic city, but also a city where nuclear facilities were located, was not mapped correctly for intelligence reasons. Once Google Maps became available, the correct details of this city became known to the world. What I am saying is that what governments try to keep a secret, will no longer be secrets in the future. And this goes for ocean depths as well.

Once everybody shares, 15%, the percentage of the ocean floor that has now been mapped, will easily become 40%

There is no use in keeping data classified, because there is no way you can keep it secret. Do you agree?

Indeed, and I would like to extend this especially to the Hydrographic Offices. If you do not serve as a source of bathymetric information for more than just navigational charts, somebody else will do it for you. If the Hydrographic Offices stick to nothing else than publishing nautical charts, that would be a disaster for the Hydrographic Offices and for the ocean community. There are so many people who require shallow-water bathymetry, again for purposes of monitoring MPAs or predicting tsunamis. The Hydrographic Offices have to serve them as well.

Do you have one last message to the industry in our field?

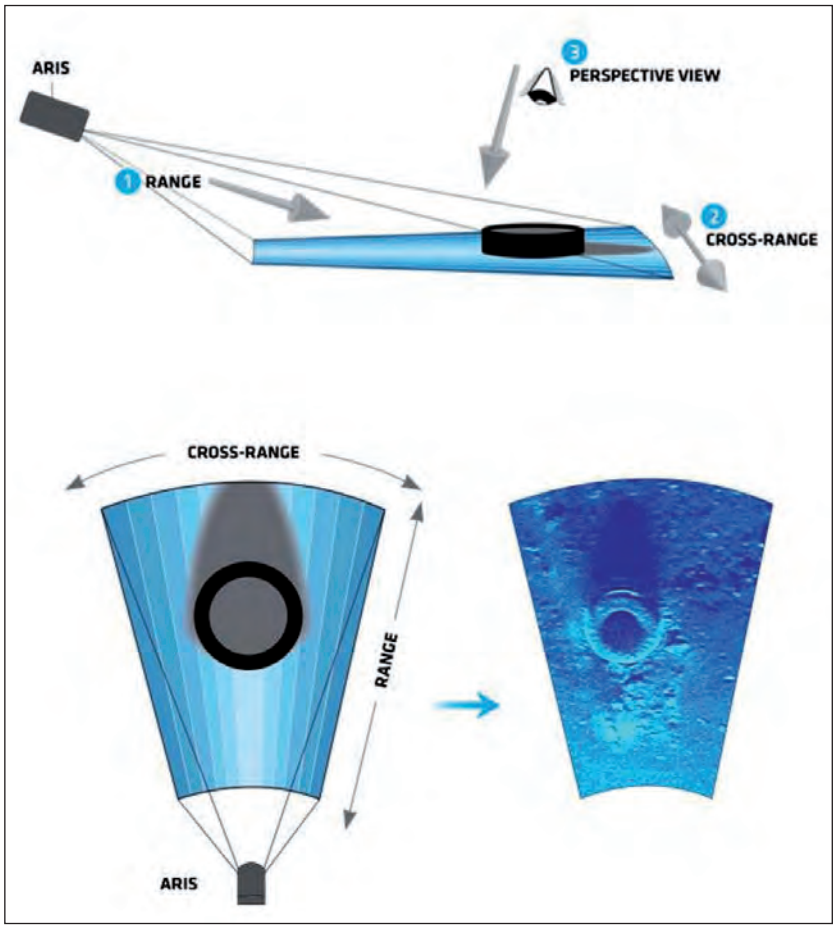
I would like to invite them all to become part of GEBCO. They are stakeholders and we would like to include them, not just in this Forum but also in the future. All stakeholders in bathymetric data should join our discussions. In addition, I would like to extend my message of sharing data. Data should not be kept for just a few while it could be useful for the needs and safety of the public and in the end the fate of the ocean, the ecosystem, the earth. ◂

Shin Tani has been chairman of the GEBCO Guiding Committee since October 2013. Before that he had been active within GEBCO for 24 years. Shin Tani was Chief Hydrographer of Japan and Vice Admiral with the Japan Coast Guard. He holds an MSc in Geophysics from the Post Graduate School of Kyoto University. Shin Tani is a member of the IHO-IAG ABLOS (Advisory Board on the Law of the Sea) as well as a member of the UJNR Sea Bottom Surveys Panel. He has been Cabinet Counsellor for the Secretariat of the Japanese Government in charge of ocean policy, renewable energy, ocean survey and monitoring, data management, marine cadastral and UNCLOS Extended Continental Shelf.

Using Imaging Sonar

Hydroelectric Power **Plant Inspections**

In Brazil there is a legal requirement to inspect all hydroelectric dams and power plants (HPP) every five to ten years, but the methods to be employed for such inspections are not well-defined. Most of the work is currently done by autonomous scuba divers using visual and conventional direct methods. However, there is considerable pressure to reduce the use of diver deployment in such a dangerous work environment. Due to very low visibility the confidence in these surveys is relatively low with much time required to accomplish an inspection. In cases where extended monitoring of the presence of fish near turbines in turbid water is necessary an acoustic technique such as imaging sonar is needed to accomplish the desired objectives.



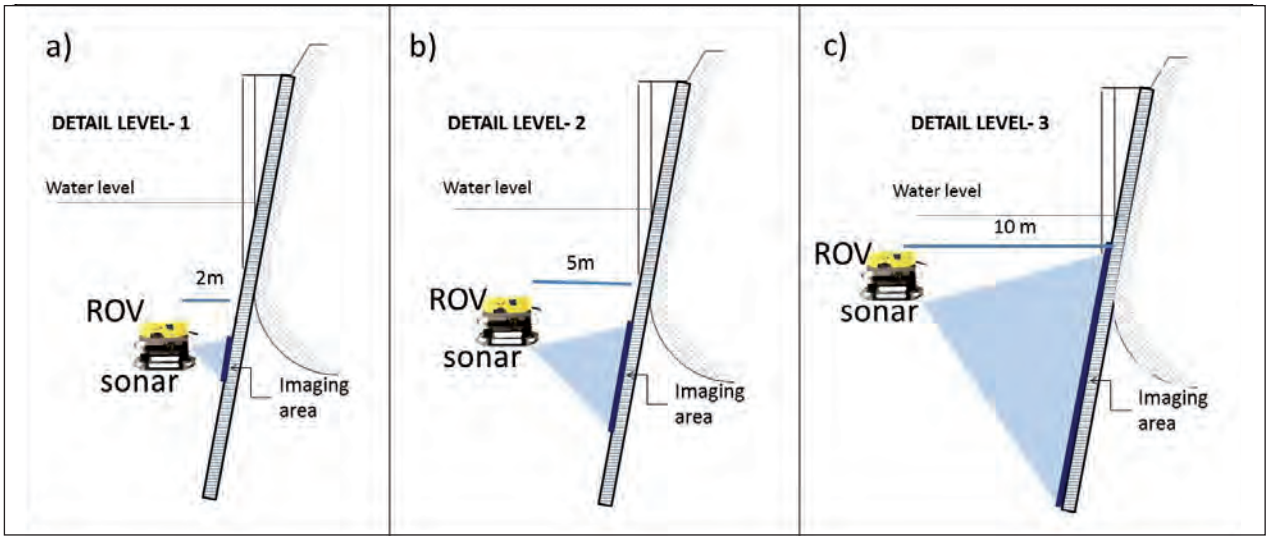
▲ *Figure 1: Definition of Sonar range and grazing angle (image courtesy: SoundMetrics Co.).*

The objectives for an HPP inspection can be summarised as follows:

1. Identification and location of specific targets, such as lost tools or parts that could inhibit or degrade the operation of any component of the HPP.
2. Inspection of broad areas for maintenance, usually related to the civil structure (concrete) in spillways and runoff channels with the objective of identifying structural problems indicated by cracking, exposure of reinforcing bars, areas of concrete spalling (flaking), misalignment at joints, and undermining and settlement of these structures.
3. General inspection and monitoring normally associated with critical operational issues such as debris accumulation on water intake screens which may cause flow restriction.
4. Assessing environmental issues around inventory and monitoring biota and its relationship with the generating process (i.e. assess the effectiveness of fish ladders or quantify fish injury/survival rates in the hydro turbine passage).

ARIS Explorer 3000

Imaging sonar for the implementation of HPP services must satisfy certain



▲ *Figure 2: Definition of Detail Level – DL.*

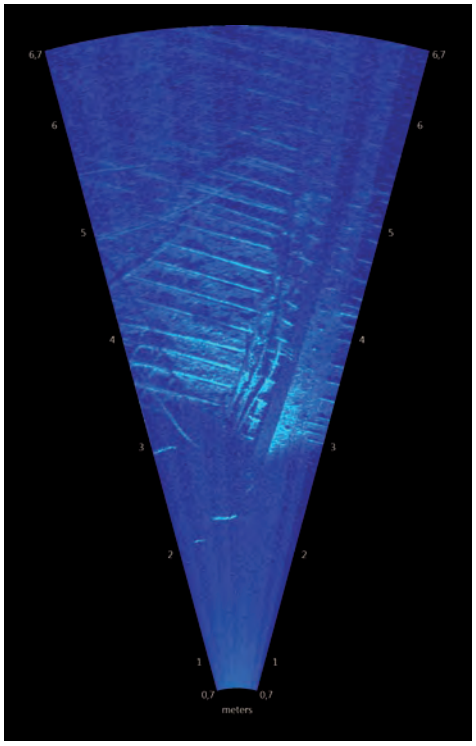
requirements: it must operate at high frequencies to enable discrimination of small features in the target image, it must also have a high image refresh rate to allow a reasonable time to survey the desired area and the software must allow review and post-processing. The acoustic camera, based on multi-beam imaging sonar systems, fulfils these requirements. For this study, several inspections were performed in sites in Brazil, Latin America and Africa using Sound Metrix's' ARIS (Adaptive Resolution Imaging Sonar) Explorer 3000 imagery.

The ARIS is the second generation of Identification Sonar and records the intensity of the returned acoustic energy using colour mapping. It can operate on one of two frequencies (LF: 1.8 and HF: 3.0MHz) and has acoustic lenses that form 128 very narrow beams of nominally 0.25. The acoustic lens introduces some non-linearity in beam spacing such that the beams are spaced slightly farther apart at the centre of the image, and slightly closer together at the edges of the image. The maximum down-range resolution is 3mm for both frequencies. The maximum frame rate is about 6fps at LF with a range up to 15m, and about 14fps at HF with a range up to 5m when using all 128 beams or double that when in 64 beam mode.

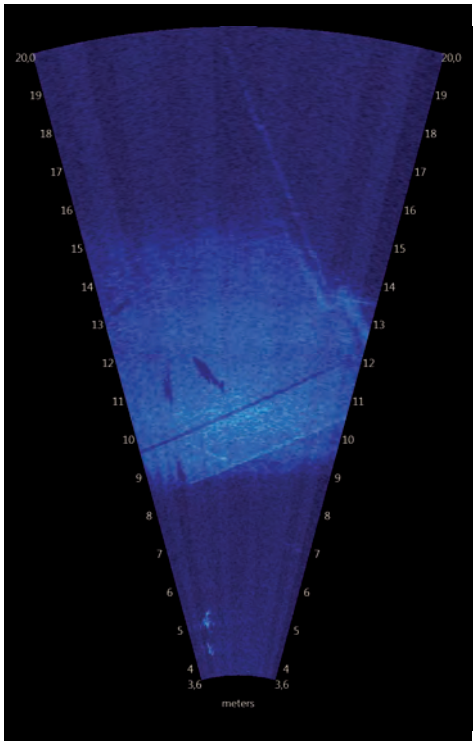
The survey conditions surrounding trash racks can be quite challenging

DL - Detail Level

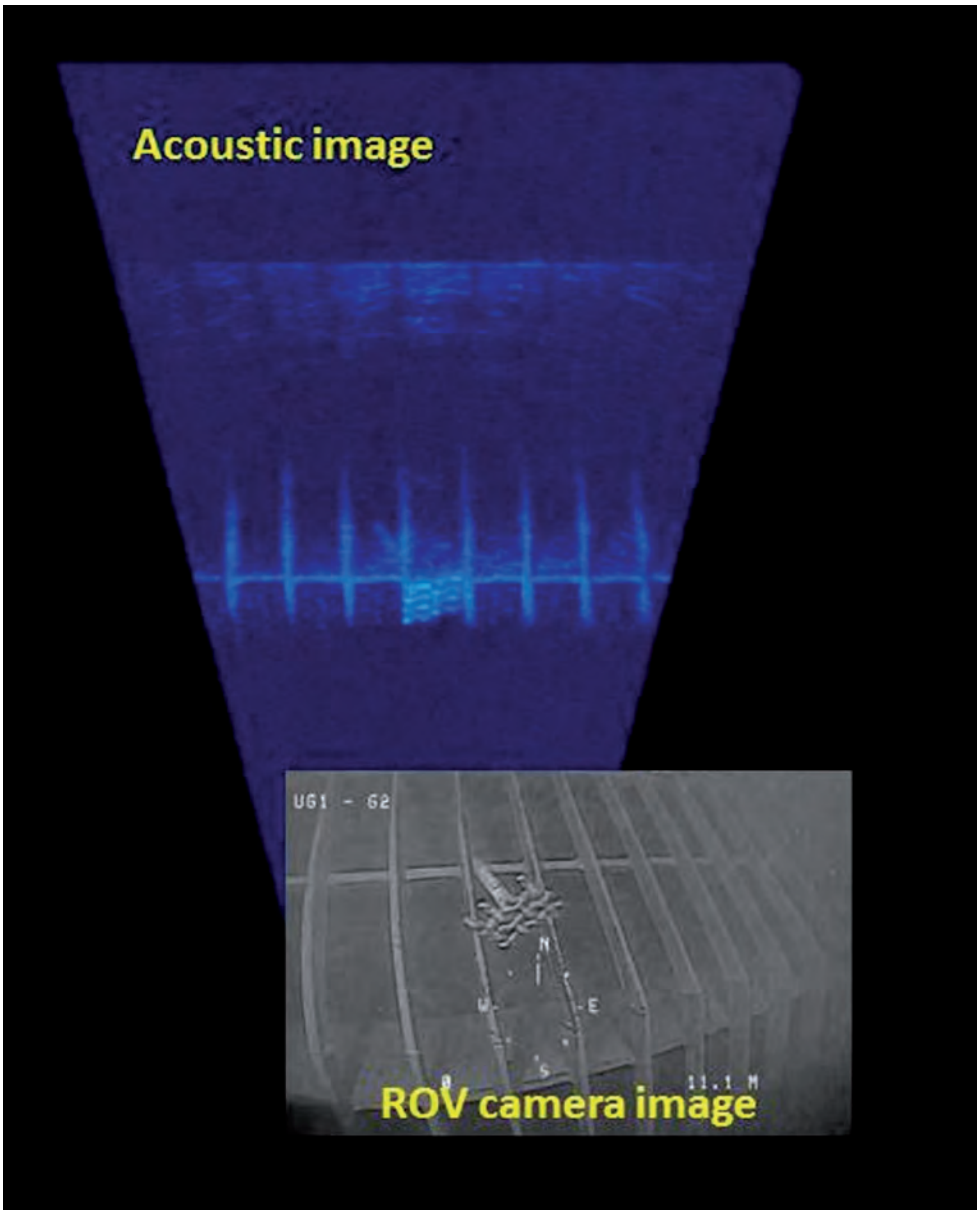
The sonar must be oriented to project beams with a small grazing angle to the surface of interest. The resulting image appears as viewed from angles between the projected beams and the surface (Figure 1). Since the majority of dams have not been designed with fixed structures from which to deploy underwater equipment, a major part of an inspection project must include designing a deployment scheme. A supporting frame can be used in conjunction with a remotely controlled rotator device or the sonar can be deployed from a boat or ROV. The position of the deployed sonar in relation to the target and the used frequency lead to what we describe as the three 'Detail levels (DLs)' (Figure 2):



▲ *Figure 3: Close inspection of concrete wear and exposed steel bars in a stilling basin of an HPP caused by the impact of rocks and debris.*



▲ *Figure 4: Concrete ramp at the stilling basin discharger with the sonar deployed from a motorboat.*



▲ *Figure 5: Trash rack with a small metal object caught up in it. Inset: ROV-acquired optical image taken simultaneously.*

- DL1 for resolution of one centimetre or less using HF. In this case the sonar should not be farther than 1 or 2m from the target and the deployment platform must be quite stable. If the visibility conditions are favourable, it is possible to use an optical camera simultaneously. The image window coverage area is typically 1m² or less.
- DL2 provides nominal resolution of a few centimetres (typically 5cm or less) at a distance of 3 to 4m. Both frequencies can be used depending on acoustic conditions. This configuration strikes a good balance between resolution and covered area. With an image window in the order of 5m².
- DL3 is recommended when it is necessary for overall imaging of larger areas with reduced resolution (up to 20m² per image window) using LF at distances of 10 to 15m from the target. It may be possible to mount the sonar near the water surface depending on the total water depth.

Imaging sonar surveys could have considerable advantages in terms of safety, accuracy and costs

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Mode of Operation

In the inspections we did DL1 was used extensively for concrete assessment where cracks and faults serve as an early warning of structural problems (Figure 3). For monitoring purposes or other inspection requirements where long-term imaging is necessary, the sonar can be attached to a fixed structure such as a telescopic extension arm and operated as visual support for technical manoeuvres or periodic maintenance. Concrete inspections can also be performed at DL3 from a boat when looking for larger scale features such as fracturing or erosion in spillway floors, downstream channels or tailraces. When using a boat, the survey needs to be done in the short periods when the turbines are idle or the spillway closed. If the sonar is not fixed on a structure a motion reduction filter should be applied to stabilise the image and improve data quality.

The most frequent type of survey is the assessment of trash rack and intake conditions in detail level 1 and 2. The survey conditions surrounding trash racks can be quite challenging due to high current flow, extensive structural areas and low to no optical visibility. In these scenarios we used the ARIS integrated on an ROV and fixed on a telescoping extension arm. In the latter case it was possible to visualise the water intake

process in real-time during operation, allowing the observation of debris accumulation that was obstructing the trash racks. This validated numerical models of head loss related to percentage blockage.

Conclusion

Hydroelectric power plant environments, normally associated with turbid waters, have complex inspection needs and frequent requests for underwater inspection and maintenance services. Imaging sonar has proven to be effective with the performance of the sonar depending on the proper combination of deployment (fixed mount, boat mount, ROV integration, and optional rotator), orientation of the sonar (grazing angle, distance) and the settings of the sonar (frequency). When properly conducted, imaging sonar surveys could bring considerable advantages in terms of safety, accuracy and costs in comparison with current methods of visual/scuba diving inspections bringing innovative and cost-effective solutions for such strategic and complex areas as Hydro power planning, construction and management. ◂

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Forward Looking Sonar and Polar Navigation by Cruise Ships

The **Pull** of the **Poles**

The April 2015 issue of *Hydro International* considered the contribution of Forward Looking Sonar (FLS) to safer navigation in inadequately charted waters. Certain polar waters fall in this category; in recognition, some expedition cruise vessels have FLS. The extent of FLS provision in the current expedition fleet will be examined in this article as well as the trend for larger traditional cruise ships to extend their itineraries into higher latitudes. Two groundings in Arctic waters are also analysed. The implementation of the Polar Code will do nothing to prevent similar accidents.

Lindblad Explorer (73m), a purpose-built expedition vessel, took 104 passengers to Antarctica in 1970 initiating sea-based tourism in that region. Changes in climate patterns and sea-ice cover have since made it possible for cruise ships to visit previously quite inaccessible Arctic destinations such as the Northwest Passage (NWP) and the Northern Sea Route (NSR). The need for better charting of these areas is recognised, but the magnitude of the task challenges available surveying capacity. Degraded performance of navigation systems in

▲ *Figure 1:* Ocean Nova *(73m), a typical Expedition Cruise Ship, with capacity for 68/78 passengers. Image courtesy: QuarkExpeditions.com.*

high latitudes compounds this situation. FLS can reduce the resulting risks.

Growth of Polar Cruising Tourism

Lindblad Explorer was the prototype for much of the present expedition fleet of some 35 vessels, each carrying 50 to 250 passengers (an example is the *Ocean Nova*, Figure 1). Antarctica now has a well-established and well-regulated pattern of expedition cruising, with some 40,000 passengers visiting the region annually. Landing is not permitted from ships carrying more than 200 passengers.

There are no formal landing restrictions in the Arctic, which now attracts 70,000 cruise ship visitors each year, a fifth on expedition vessels. Svalbard and Greenland being the most popular destinations. Cruise ship tourism now represents a significant proportion of the reported vessel activity in the Arctic. In 2012, *The World* (196m) transited the NWP and in 2016, *Crystal Serenity* (250m), with an ice breaking capable escort, will make a similar voyage.

Larger traditional cruise ships, each with 500 to 3000 passengers regularly visit both Arctic and Antarctic waters. Although ageing converted expedition vessels are being, or will be, replaced during the current decade by purpose-built vessels carrying 200 to 300 passengers, no significant increase in the total number of voyages is currently anticipated.

Status of Nautical Charting in Polar Waters

Destinations in the High Arctic Canadian territories and routes through the NWP invite ever more adventurous cruising. Given that ice retreat here is less predictable year on year both the survey task and voyage planning are much more challenging. Resources currently available to improve navigation in the region are limited. Charting efforts in Canada are now being focused on providing safe corridors. Some inshore areas and fjords on the west coast of Greenland are also being surveyed by Denmark for the benefit of cruise ships. The office of US Coast Survey, concerned about the rise in vessel traffic in the Arctic and the inadequacy of the charts, is increasing its survey efforts off Alaska (Figure 2).

▲ *Figure 2: NOAA Ship* Fairweather*, one of 4 vessels engaged in 2015 survey programme for the Arctic Nautical Charting Plan to Support Sustainable Marine Transportation in Alaska and the Arctic. Image courtesy: NOAA.*

The anticipated measures to improve hydrographic surveying and charting in Antarctica recommended in 2008 and again at the 2014 Antarctic Treaty Consultative Meetings have yet to be successfully implemented. One exception was the French Hydrographer's mobilisation of MBES in the expedition yacht *Xplore* for surveys of anchorages and safe havens. This use of the vessel is being extended to the Arctic. The arrival of ever larger cruise ships in the region (Figure 3), is a concern. This has in part led to calls for vessel routing and limiting access to unsurveyed or inadequately charted areas.

Degraded performance of navigation systems in high latitudes

Initiatives to develop and systemise the collection and dissemination of Crowd Sourced Bathymetry (CSB) in critical polar waters are gaining momentum. However, prudent cruise operators are advocating the complementary use of FLS. Despite the increased survey efforts indicated above, these self-help measures will remain necessary for the foreseeable future.

Hazards of Polar Cruising

Expedition polar cruising has not been without incident. Following her 1970 pioneering cruise, the *Lindblad Explorer* experienced serious groundings in Antarctica in 1972 and 1979. She eventually sank in the Bransfield Strait in 2007, while attempting to force her way through thick ice. Other less spectacular but equally disturbing incidents have been recorded in both Antarctica and the Arctic, the latter may have led to the fitting of FLS in some ships from 2006 onwards. Even so, since that time at least two Expedition ships fitted with FLS have still run aground. *Clipper Adventurer* (101m) was severely damaged in the Canadian Arctic in 2010 and *Le Soléal* (142m) suffered minor damage in eastern Siberian waters in 2013.

The most likely causes of major damage to ships in polar waters stem from encountering severe ice conditions or submerged rocks.

▲ *Figure 3: The bigger they are … (the harder they fall)* Celebrity Infinity *GRT 91,000, 294m regularly takes 2,000 passengers on a cruise-by voyage past the Antarctic Peninsula. Image courtesy: Benson Kua via Flickr.com.*

More Information

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These factors might fatally combine when vessels are forced to depart from a charted corridor or previously determined safe track. The danger is increased by the degradation in performance of satellite (GNSS) navigation and communication systems in higher latitudes. This has potentially adverse consequences when attempting to follow a previously sounded track.

However, the successful completion of several hundred polar cruises each year suggests that the associated risks are generally being managed. A number of cruise operators have also recognised that they can be mitigated by FLS in combination with prudent navigation and access to CSB. At the same time, bridge teams remain at risk by providing their passengers with a unique polar experience by venturing too close inshore or into poorly charted areas. Such ventures cannot be justified without the wider adoption of FLS. The investigation report into the grounding of *Le Soléal* commented: *Le Soléal* operated for cruises, which led her to take unusual routes and passages as expected by the passengers, sailing as close as possible to coasts.

Analysis of Groundings

At the time of her grounding the FLS on the *Clipper Adventurer* was defective. The carriage of forward looking sonar is not mandatory by Canadian Regulations, nor was it a recommended requirement in the IMO Guidelines for Ships Operating in Polar Waters. However, accident investigators commented that: "The unserviceable condition of the forward looking sonar deprived the bridge team of an additional source of valuable information. Forward looking sonars are designed to provide safety critical information regarding underwater obstructions ahead of ships and provide automatic navigation alerts to bridge teams".

Cruise ship tourism now represents a significant proportion of the reported vessel activity in the Arctic

An enquiry into the *Le Soléal* grounding revealed that although her FLS was operational at the time it was not being actively

▲ *Figure 4 The Pull Factor: A polar bear as can be sighted from the deck of an expedition ship. Image courtesy: Sheilapic76 via Flickr.com.*

monitored. Because the use of FLS is not an IMO recommendation the investigation made no comment about its use, other than that the sonar had a range of 300m. In fact, the system as installed had range options of 330m and 440m. Had the longer range been in use and the sonar properly monitored, the grounding might have been avoided. *Le Soléal*'s operators are now upgrading the sonar software in their ships to provide a range of 500m.

There is a compelling argument for the installation of FLS in all expedition cruise vessels

Forward Looking Sonar

The Polar Code enjoins masters to take account of any limitations in the hydrographic data when considering a route through polar waters, but overlooks the potential of FLS. Regardless of this, FLS is installed in several expedition vessels, where it is used mainly when exploring a new anchorage or closing the shore for photo opportunities. The master of *Ocean Nova* makes extensive use of FLS when anchoring and repeating earlier tracks in unsurveyed waters. Significantly, the benefits of FLS are being cited in the advertising literature of some expedition cruise operators.

The short-range systems that now predominate require constant monitoring and are unsuitable for use at normal passage speeds. However, longer range sonars are starting to be specified, and these are certainly needed in larger vessels. Significantly, *The World* had sonar with 930m range for her NWP transit and *Crystal Serenity* will also reportedly have FLS. Unfortunately, as mandating the installation of FLS would require an amendment to the Polar Code and an addition to the SOLAS carriage requirements, provision will remain voluntary for the foreseeable future.

Conclusions

An increase in cruise tourism is likely following the improved access to Arctic waters with all their scenic and wildlife attractions (Figure 4). This may encourage some cruise ship companies to let their ships venture farther north, while also extending their cruising itineraries into Antarctic waters to fully exploit the rising demand for polar voyaging.

Given the unsatisfactory state of nautical charting in many polar cruise destinations these trends give cause for concern, with a grounding being the most likely major marine incident. The provisions of the Polar Code may mitigate the consequences of such an incident, but will not prevent one. Some of its provisions will not apply immediately to vessels currently in service. There is therefore a compelling argument for the installation of FLS in all expedition cruise vessels and for restrictions to be placed on the routing of traditional cruise ships unless also fitted with appropriate sonar.

Any prudent mariner will be aware that the 'nearest land is usually underneath the keel'. A view that the informed use of FLS can only serve to reinforce.

Acknowledgements

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Using Multibeam Bathymetry, Topographic Laser Scanning & UAS Photogrammetry

Marine **Asset Integrity** Mapping

Advances in marine & terrestrial scanning survey techniques together with precise inertial navigation sensors, multi-sensor acquisition system and cost-effective UAS photogrammetry allow hydrographic surveyors to undertake high-precision marine asset integrity mapping. The benefit of this approach is that it produces a very accurate three dimensional digital elevation model that could be used as a baseline comparative survey to determine the long-term stability of sea walls and breakwater structures for engineering purposes.

Marine GeoSolutions have extensive experience in acquiring combined multibeam bathymetry & topographic laser scanning datasets and partnered with Land Surveys to demonstrate the viability of this technology over a test area along the Hillarys Boat Harbour breakwater in Perth, Western Australia.

Survey Methods

A Reson SeaBat 7101ER-SV multibeam echo sounder, Riegl VZ-1000 topographic laser scanner, POS MV 320 inertial navigation system and ASCTEC Falcon 8 UAV were used to acquire the datasets. A RTK GNSS base station was installed on a local survey monument within 500 metres of the survey area. The survey instrumentation was installed on the inshore survey vessel and the lever arm offsets accurately measured. Separate patch tests were conducted to determine misalignments between the multibeam sonar and inertial RTK-aided inertial navigation system and between the topographic laser scanner and the RTK-aided inertial navigation system. The Hillarys light tower was used to conduct a patch test on the topographic laser scanning data (Figure 2). The laser patch test line plan involved imaging the light tower from three different sides with the lines being equidistant from the structure. For the patch test, the flat paving area around the light tower was used for the Roll Test and the vertical light tower itself was used for the Pitch & Yaw Tests.

The modular design of the system means that surveys can be conducted simultaneously

Any pitch offset in the data shows the vertical alignment of the light tower in all three patch test lines radiating from the ground like a bunch of flowers whereas any yaw offset shows the position of the light tower as a series of parallel vertical structures that are separated horizontally from each other. The multibeam sonar beam-forming was modified in the processor to ensure that the 511 equiangular-beams (EA) generated and were able to extend to the water surface when the sonar transducer was rotated by up to 40°. Two sets of survey lines were run 5m off the breakwater to simultaneously acquire multibeam bathymetry and topographic laser scanning datasets. The multibeam echo sounder was set to a ping rate of 18Hz at a 20m range scale generating 511 beams per ping whilst the topographic laser scanner acquired 5,000 samples per pulse. To ensure excellent data quality, particular attention was paid to data time-stamping, offset measurements and patch test bias determinations. All inertial positioning, laser scanner & multibeam echo sounder data acquisition, processing, system calibrations, dataset merging & most of the data

▲ *Figure 1: Locality map showing the breakwater at Hillarys Boat Harbour demarcated by the yellow polygon.*

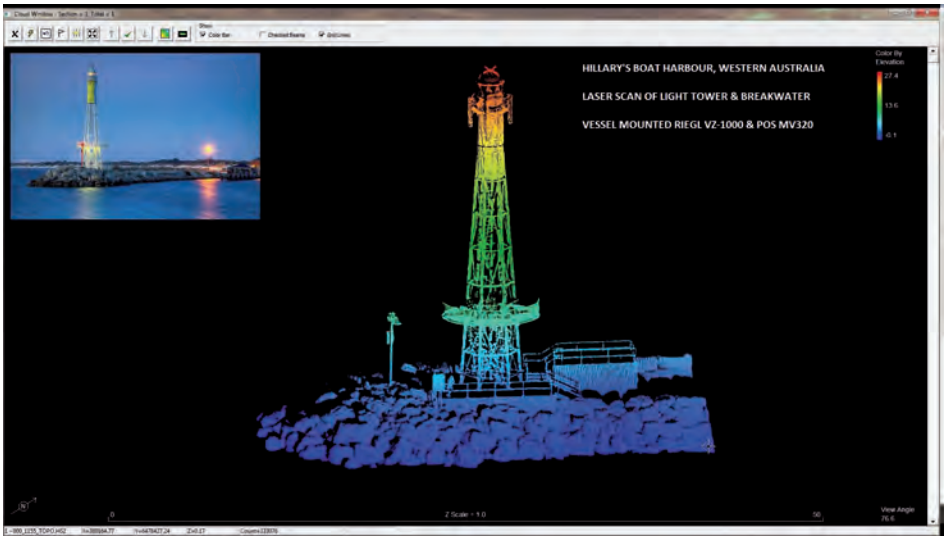


Figure 2: A 3D point cloud image of the Hillarys light tower and breakwater collected with the RIEGL VZ-1000 topographic laser scanner.

visualisation were undertaken using HYPACK hydrographic software. Additional visualisation was performed in QPS Fledermaus. Only a minimum amount of data editing in both the multibeam bathymetry and topographic laser scanner datasets were necessary as the datasets were generally noise-free. The editing involved removing some spurious bathymetry and laser point data at the water/air interface.

A series of fifteen ground control points for the UAS photogrammetry were established on the breakwater using RTK GNSS positioning to enable the precise rectification of the photogrammetry imagery. A total of two 12-minute UAS flights over the breakwater produced forty-three photographs covering 100% of the breakwater.

Results

The primary aims of this survey were to test the repeatability and accuracy of the acquired data on separate survey runs and to investigate the size of the data gap that exists between the topographic laser scanner data (above the water line) and multibeam bathymetry data below the water line on a single survey run. Initially, the survey was run in a standard configuration with the multibeam transducer centre-beam projecting vertically down and the laser oriented to acquire data off the starboard side of the survey vessel.

In order to minimise the data gap between the laser scanner data and the bathymetry data, the multibeam transducer was rotated by 40° to physically steer the 'sweet spot' of the curved transducer array midway between horizontal and vertical to achieve increased data coverage across the flanks of the submerged breakwater (Figures 3 & 4).

In order to test the accuracy & repeatability of the topographic laser scanning and the positioning system, two small objects were placed along the skyline of the Hillarys breakwater to investigate if these items could be mapped with the laser system. One of the items (a Crown beer bottle) was left stationary on the breakwater for two separate survey runs, and a second item (a Blackberry phone) was moved a small distance (0.070m) between the two survey runs. Comparisons of the skyline laser data between the two survey runs revealed an agreement of ± 0.01m for the centre-point of the stationary Crown beer bottle position, while the two recorded positions of the Blackberry phone confirmed that the phone had been moved one phone width (0.075m) between the two survey runs; the actual phone width is 0.070m. The results of this test are shown in Figure 5.

A second test was performed to simulate a rock displacement on the breakwater, which could affect the structural integrity of the structure. A 0.5m^3 box was used to model the rock displacement and was repositioned on a subsequent survey run. The results indicate that the displacement of a small rock could be easily detected using this technology.

GCP Station ID	RTK Survey Control Elevation (m)	Laser Elevation (m)	Position Difference		Elevation Difference (m)
			dE (m)	dN (m)	
9001	4.479	4.470	0.025	0.022	**0.009**
9004	3.931	3.940	0.021	0.303	**-0.009**
9005	1.736	1.730	0.036	0.023	**0.006**
9006	2.806	2.820	0.090	0.134	**-0.014**
9007	1.209	1.210	0.020	0.111	**-0.001**
9010	0.689	0.700	0.051	0.018	**-0.011**
9014	0.724	0.740	0.012	0.100	**-0.016**
9015	1.013	1.020	0.000	0.070	**-0.007**
Mean Elevation Difference					**0.009**

Table 1: Tabulated differences between the GCPs and the topographic scanning laser point cloud data.

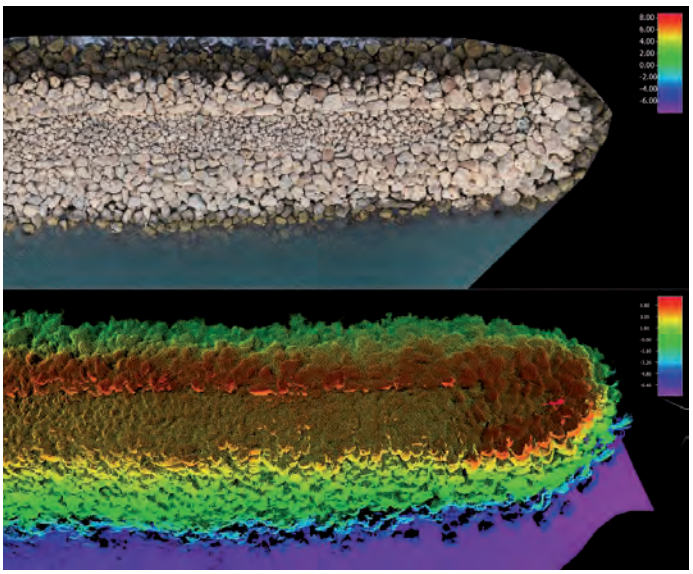


Figure 3: UAV aerial image (top image) of the end of the breakwater and corresponding UAV photogrammetry, topographic laser scanning and multibeam bathymetry merged point clouds (lower image).

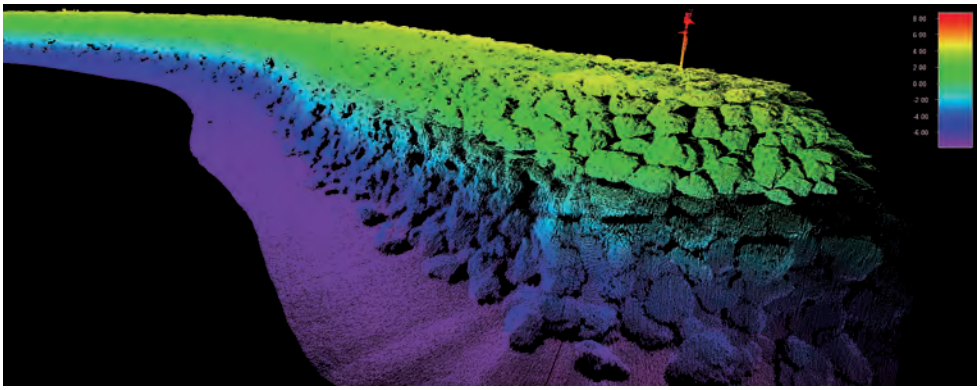


Figure 4: A low angle 3D point cloud showing the seamless merged topographic laser scanning data (red, yellow & green hues) and the multibeam bathymetry data (blue & purple hues). Note there is no data gap between the topographic laser scanner data and the multibeam bathymetry data.

To quantify the expected levels of accuracy achievable using the combined multibeam bathymetry and topographic laser scanning, the positions and elevation of the ground control points (GCP) where compared to the laser point cloud data. In general, the XYZ positions were within a centimetric accuracy. (Table 1).

The photogrammetric reprojection error for the UAV aerial imagery was less than 0.008m when processed using the ground control points.

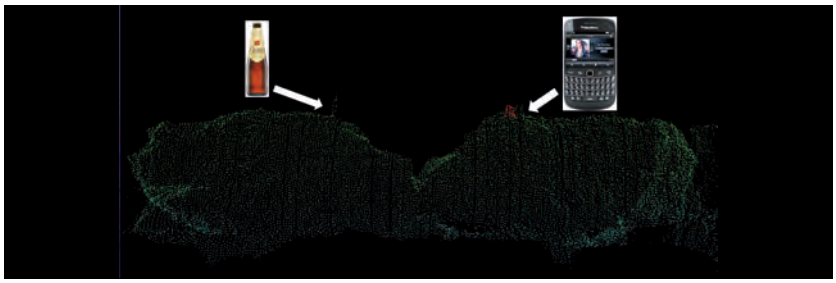
Conclusions

This paper demonstrates that the combined use of a topographic laser scanner, multibeam echo sounder and UAV photogrammetry together with precise inertial navigation and robust calibrations yield centrimetric accuracy for high-precision marine asset integrity mapping. As these datasets are acquired from various different incident angles, this produces a seamless digital elevation model (DEM) with very few, if any, areas which have not been insonified or imaged. The precision and repeatability of this technique is high, with multiple runs of the same survey line showing overall errors of less than 0.010m between all sensors. The modular design of the system means that surveys can be conducted simultaneously and on the same day for small areas, without the need for waiting on tidal level variations.

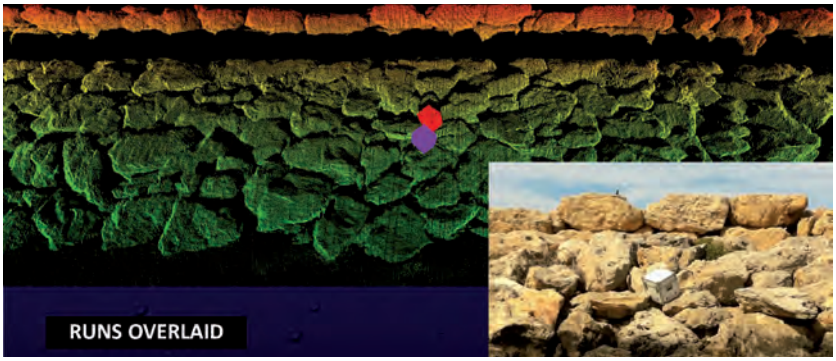
The benefit of this approach produces a very accurate three dimensional digital elevation model which could be used as a baseline comparative survey to determine the long-term stability of sea walls and breakwater structures for engineering purposes. It is postulated that marine structure subsidence can be monitored to better than 0.020m.

Any structural instability in a seawall or breakwater will cause the construction 'rock' blocks, rubble or concrete armour units to move, slide or be buried in the underlying marine sediments. By undertaking a surface difference comparison of the XYZ gridded datasets between the high-precision baseline survey and a subsequent follow-up survey, the surveyor or engineer can ascertain which areas of the marine structure have remained stable and which show any displacement. Once the areas showing displacement have been identified, one can investigate the XYZ point cloud data carefully in these selected areas to determine the exact nature and severity of the displacement and how this will affect the structural integrity of the installation. These data can also be utilised to plan any remedial engineering intervention.

The displacement of a small rock could be easily detected using this technology



▲ *Figure 5: Topographic laser point cloud showing the beer bottle and Blackberry phone along the skyline of the Hillarys Breakwater imaged from a distance of 30m.*



▲ *Figure 6: Topographic laser scanner point cloud showing the 0.5 m³ box on the first survey run (red box) and after being moved (purple box) for second run. The inset photograph shows the white box used to simulate rock displacement.*

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Darren Wilkinson is employed by Land Surveys in Business Development for Geospatial Services and has been in the geospatial industry for 32 years. He holds qualifications in Cartography, Photogrammetry and Business.

Mountains in the Sea II

As noted in the previous issue of *Hydro International*, at least 200 seamounts had been discovered prior to the Second World War. The advent of acoustic sounding systems and the efforts of a few expeditions and organisations accounted for the majority of these discoveries. However, because of an increasing number of vessels equipped with sounding instruments and the far-ranging fleet operations of the United States Navy, discovery in the oceans did not stop with the coming of the Second World War. Warships equipped with echo sounders crisscrossed the world's oceans. In particular, the Pacific ocean was fertile ground for the discovery of new features. A number of seamounts were sounded on and named by United States warships traversing the Pacific from the Aleutians to the South Pacific during this era. Detroit Seamount, Miami Guyot, Pensacola Seamount, and Cape Johnson Guyot are examples of features discovered during the course of various ship transits during the war.

The most remarkable effort associated with serendipitous bathymetric discovery during the war was that of Harry Hess, a Princeton University geology professor who was also a naval reserve officer. During the war he was initially navigation officer and then commanding officer of the *USS Cape Johnson*, a troop transport that made landings at both Leyte Gulf in the Philippine Islands and Iwo Jima, the latter being the scene of some of the fiercest fighting of the Pacific war. Hess operated a fathometer and maintained a record of the *Cape Johnson*'s track. As a result, he discovered twenty previously unknown flat-topped seamounts. In a review of sounding records acquired by other naval vessels (Hess gave credit to the *USS Massachusetts* as having acquired the most soundings and also noted the cruisers *New Orleans* and *Chester*, the hospital ships *Solace, Bountiful, and Relief,* and the survey ships *Sumner, Pathfinder and Hydrographer* as being quite active in acquiring soundings) and pre-war sounding tracks, Hess identified another 140 flat-topped seamounts – features that he termed guyots, named for the Princeton University geology hall which was a flat-topped building. Although Hess is often credited with the first discoveries of these flat-topped mountains, in a 1946 paper, he noted that others had discovered and mapped similar features. Ironically, Hess felt that the guyots he observed were of Pre-Cambrian age (600 million years old and earlier), implying a static seafloor. Ironically, a few years later, he became known as a founding father of the theory of plate tectonics.

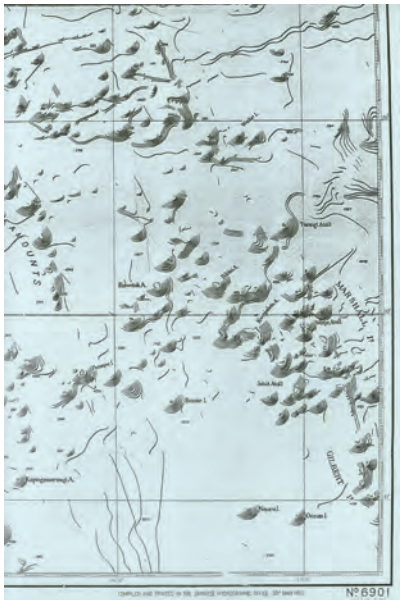
▲ *Figure 1: Albert Theberge standing on the* Surveyor *after 63,000 miles of SEAMAP and a similar defence related survey.*

In the fifteen years following World War II, the Coast and Geodetic Survey resumed its normal operations and continued running transects across the Gulf of Alaska and discovered a number of additional seamounts in this area and off the west coast of North America. Other government agencies and other nations were involved as well in somewhat sporadic mapping efforts. However, academic institutions, funded primarily by the

United States Navy Office of Naval Research, traversed much of the world ocean and firmly established the ubiquitous nature of seamounts. Three academic institutions in particular were heavily involved in this effort - the Scripps Institution of Oceanography in the Pacific Ocean and the Lamont Geological Observatory (today the Lamont-Doherty Earth Observatory) and Woods Hole Oceanographic Institution in the Atlantic. These institutions, besides having their own vessels, oftentimes cooperated with other elements of the government such as the Naval Electronics Laboratory and the United States Geological Survey.

Initial explorations involved the Mid-Atlantic Ridge and the area off the east coast of the United States in the Atlantic by the Woods Hole vessel *Atlantis*. Its 1947 cruise netted a few seamounts and verified the existence of a seamount discovered by the *USS Muir* in 1945 on a cruise from Philadelphia to Dakar. In 1949, Maurice Ewing and Ivan Tolstoy surveyed Muir Seamount on the Woods Hole vessel *Caryn* in detail, perhaps the first peak so investigated by an academic institution. That same year they also discovered the Caryn Seamount and a number of seamounts associated with what is now known as the New England Seamount Chain. Over the next two decades, discoveries continued. Additional seamounts were discovered in the New England Seamount Chain and named for vessels of WHOI including Balanus, Asterias, Mytilus, Panulirus, and Bear Seamounts.

No academic exploration of the Pacific was made until 1950 when Scripps embarked on its Midpac Expedition to the Mid-Pacific Mountains. Scripps scientists working with Naval Electronics Laboratory personnel visited this area on the Scripps vessel *Horizon* and a navy vessel *EPCE (R) – 857* southwest of the Hawaiian Islands and studied the great guyots found there. As opposed to Hess's interpretation of these mountains as Pre-Cambrian, Edward Hamilton of the Naval Electronics Laboratory studied dredge samples from the guyots and discovered them to be of Cretaceous age and thus approximately 100 million years old, another clue on the road to plate tectonics. However, the Midpac Expedition and subsequent Scripps expeditions such as Capricorn, Shellback, Nova, Monsoon, Northern Holiday, and Downwind. netted seamount discoveries with Scripps Guyot, Capricorn Seamount, Horizon Guyot, Nova Bank, Baird Seamount, and even



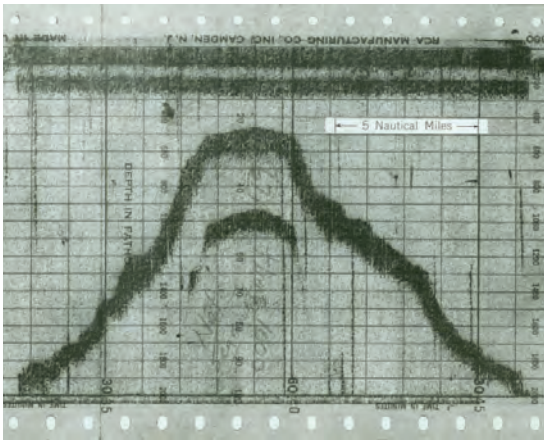
▲ *Figure 2: Section of anglicised version of Japanese Chart 6901, showing seamounts with unique shaded contour method.*

▲ *Figure 3: One of 90 tracks between Aleutians and Kodiak Island between 1925 and 1960 and Seattle conducted by the Coast and Geodetic Survey.*

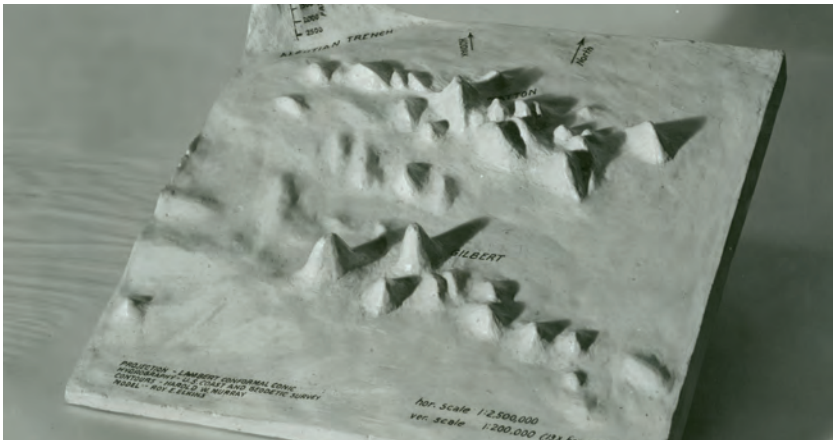
seamounts named for the wives of various Scripps scientists such as Gifford Guyot, Gifford Seamount, Valerie Seamount, Helen Seamount, and Betty Guyot dotting the charts. Not all of these names survived though as the name Helen Seamount and Gifford Seamount (southeast Pacific) do not seem to have survived although Gifford Guyot (southwest Pacific) did.

Academic seamount discovery was not always by ship though. In 1953, Robert Dietz of SIO was awarded a Fullbright scholarship to study underwater sound transmission at the University of Tokyo. While there he also became familiar with Japanese bathymetric chart 6901, which covered the northwest Pacific from the Asian mainland to 175 E longitude and from the Aleutians to 5 S Latitude. The first edition of this chart was published in 1939 and demonstrates how far ahead of western nation mapping efforts the Japanese Hydrographic Office was at that time. The Japanese had obviously mounted a systematic mapping effort over a multi-year period. The 1953 anglicised version of this map shows literally hundreds of seamounts. Study of this map led Dietz to naming the Emperor Seamount chain, Magellan Seamounts, Marcus-Wake Seamounts, and seamounts of the Marshall and Gilbert Islands. Dietz observed that, "The most striking aspect of the chart is the extensive groups of seamounts, some of which pierce the surface but others of which are deeply submerged. Many of the seamounts are truly enormous as can be realised by comparing them to the highest mountain in Japan, Mt. Fuji…." This one chart added dozens of seamounts to those known to western investigators.

After a number of years of exploration that tended to be targeted and somewhat random versus systematic mapping of the seafloor, the National Academy of Sciences commissioned a report concerning the future of oceanography. Chaired by Harrison Brown of the University of California, its title was *Oceanography 1960-1970*. One of its recommendations, championed by Chief Oceanographer Harris B. Stewart of the Coast and Geodetic Survey, was to systematically collect oceanographic data and map the ocean floor. Initially envisioned as a cooperative venture between governments and institutions, the C&GS was the only institution to embrace the concept. Subsequently, starting in 1960, the C&GS ships *Pioneer* and *Surveyor*, began systematic surveys of the west coast of the United States and north central Pacific Ocean. The programme was called Scientific Exploration and Mapping Program (SEAMAP). Prior to termination of the program in 1973, these ships logged hundreds of thousands of miles of bathymetry, gravity and magnetics. This author logged 63,000 miles of North Pacific Ocean on the *Surveyor* in 1970 on SEAMAP and a defence-related project. During SEAMAP cruises well over 100 additional seamounts (as



▲ *Figure 4: Fathogram trace of Pathfinder Seamount observed at point 67 on accompanying trackline graphic.*

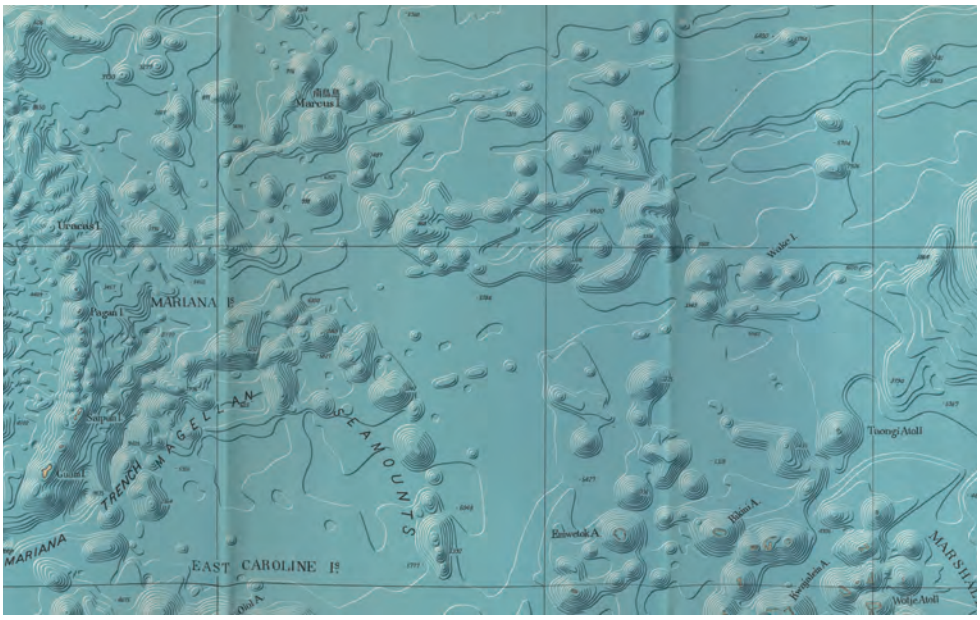


▲ *Figure 5: Pre-computer hand-made three-dimensional model of seamounts in the Gulf of Alaska. This model was made prior to 1948 (year of Harold Murray's death) and is perhaps the first attempt to model the configuration of a seamount chain.*

well as further delineating fracture zones, ridges, sea channels, and other features) were added to the inventory of known seamounts including many of those in the Musician Seamounts north of Hawaii and those of the Coast and Geodetic Survey Seamount Province south of the Alaska Peninsula.

One of the last surveys conducted under the auspices of this project was of the Juan de Fuca Ridge area off the coast of Washington. In a graceful gesture, numerous seamounts in this area were named for academic and government investigators who had contributed to the mapping of the Pacific Ocean including Menard, Chase, Revelle, Shor, Raitt, Raff, and Vacquier Seamounts for Scripps scientists, McManus, Schaefer, and Thompson for those from other institutions, and various additional seamounts named for C&GS personnel and visiting international scientists including Srivastava, Macnab, Iwabuchi, and Kagami.

By the early 1970s, well over 2,000 seamounts were known (not counting those discovered in the course of classified United States and Russian surveys) and the impetus began shifting from geographic discovery and mapping of these features to understanding the geology, physical oceanography and ecology of seamounts. Much of this was initially driven by the economic incentives of the fishing industry. In 1957, a tuna clipper, the *Hurricane*, discovered a bank far offshore from the tip of Baja California that was a locus of tuna concentration. Initially called Hurricane Bank, the tragic death of tuna researcher Bell Shimada in a plane crash in 1958 led to officially naming it Shimada Seamount. Subsequent exploration of seamounts has led to understanding that they occupy unique and fragile ecological niches in the world ocean causing perturbations in ocean currents, concentrating nutrients, providing stepping-stones for species migration, and serving as habitat for rare species of corals, sponges, and other creatures of the deep. Fortunately or unfortunately, they also are the site of seemingly economically viable, but sometimes unsustainable, fisheries resources such as orange roughy and other slow growing and slow to propagate species. In spite of the integration of disciplines to understand seamounts, the role of the bathymetrist and hydrographer remains. Although numerous discoveries of seamounts were made with old single beam sounding instruments on widely spaced tracklines, modern study requires resurveying with full bottom coverage in order to understand the bottom configuration prior to deploying high-value near-bottom instruments such as tethered robotic vehicles. Although satellite-altimetry has helped reveal additional seamounts, there are still discoveries made by the method of the old sailing ships discovering reefs and banks. In 2005, the United States nuclear submarine *San Francisco* discovered an undersea mountain the old-fashioned way, by running into it. Hopefully nothing of this sort will occur again, but it underscores the fact that we still know woefully little of the 70% of our planet covered by water and are a long way from fulfilling Harris Stewart's dream of a systematic mapping of the world's oceans. Perhaps it is time to revive the dream. ◀



▲ *Figure 6: Magellan Seamounts off the Mariana Islands, Magellan's landing place after crossing the Pacific.*

Recognition of New Training and Education Programmes

Revised Standards of Competence for Hydrographic Surveyors and Nautical Cartographers

The FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) was jointly established in 1977 by the International Federation of Surveyors (FIG) and the International Hydrographic Organization (IHO) to promote, develop and maintain international standards of competence for hydrographic surveyors. In 2001, the International Cartographic Association (ICA) joined the Board so that standards of competence could also be provided for nautical cartographers. The IBSC also reviews training and education programmes against its standards and currently provides international recognition to 61 programmes and schemes.

▲ *Figure 1: IBSC39 cover (draft).*

The IBSC held its annual meeting in April this year and reviewed a record number of 18 programmes. The Board was able to grant recognition to 11 programmes for Hydrographic Surveyors (four at Category 'A' level and seven at Category 'B' level), including one new programme. The Board also recognised the ninth programme for nautical cartographers and a second national scheme for individual recognition. The other seven submissions were recognised conditionally. Worth noting is the increasing number of institutions successfully using e-learning and blended-learning tools to deliver elements of their programme.

Progress on Separating Cat A and Cat B Standards

The Board reviewed the progress made in its revision of the Standards of Competence, following the decision to separate standards for category 'A' and category 'B' programmes and to update their content to comply with the latest scientific and technological developments. The new set of standards describe competencies in terms of Intended Learning Outcomes (ILOs) that provide levels of understanding for associated content. Four publications, namely S-5A, S-5B, S-8A and S-8B, and accompanying guidelines provide the framework under which submitting institutions can constructively arrange their resources to provide courses that will meet the standards. The standards are being separated with learning outcomes defined in accordance with expectations at the category 'A' and the category 'B' levels. They are not prescriptive in terms of time allocation and method of delivery, allowing each institution to build an educational programme that adopts a teaching and learning process in accordance with the Standards.

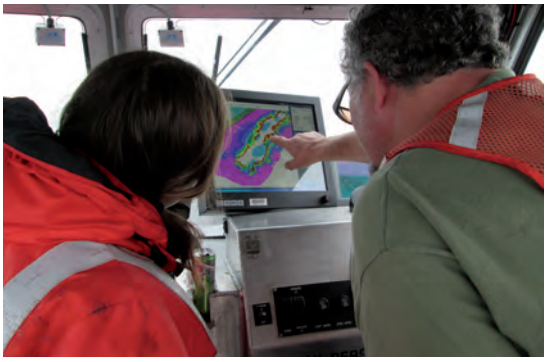
Progress

The Board completed its work on the Standards of Competence for Hydrographic Surveyors Category 'A' (S-5A), by incorporating a significant number of suggestions and recommendations received from the broad hydrographic community during the consultation phase. The draft S-5A is being submitted to the 8th session of the IHO Inter-Regional Coordination Committee (IRCC8) for endorsement. Subject to this endorsement and subsequent approval, the new publication will be in force from September 2016 to complement the new publication S-5B that has already been approved. The two documents will supersede the existing publication S-5 Edition 11.1.0.

The Board completed its first draft of S-8B – the Category 'B' Standard of Competence for Nautical Cartographers. Draft versions of S-8B and the category 'A' level S-8A will be available for circulation and comment by the end of the year. Both will follow the approval process in 2017 and will eventually replace the current Edition 3.1.0 of S-8.

Next Meeting

The next meeting of the IBSC will take place in March 2017 in Wellington, New Zealand when more than 20 programmes and schemes are expected to be reviewed. Work that is undertaken on the standards throughout the year will also be reviewed.
The composition of the Board and details of its work are available on the IHO website at: www.iho.int → Committees & WG → IBSC ◂



▲ *Figure 2: Working with electronic charts. Image courtesy: NOAA.*

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Australasian Hydrographic Society

AHS West Australia Region Technical Meeting

The West Australian Region of the Australasian Hydrographic Society organised a Technical Presentation on 9 May 2016 at the Curtin University's HIVE.

The HIVE (Hub for Immersive Visualisation and eResearch) at Curtin University offers state of the art visualisation systems for displaying data more effectively and imaginatively. Four presenters from the Centre for Marine Science & Technology (CMST) presented their important research work. Dr Iain Parnum presented impressive recent research work showing how to use multibeam systems for mapping marine ecosystems. Following that Dr Tim Gourlay demonstrated his research about recent developments in ship hydrodynamics modelling and measurement at CMST.

The role of multibeams and echo sounders in the fishing industry was highlighted by Dr Miles Parsons in his presentation called 'Fishing and pinging: what role can echo sounders play in fisheries management?'

The HIVE 3D visualisation screen impressed all the attendees with a 3D Imaging Survey of HMAS *Sydney* (II) and HSK *Kormoran* displayed and presented by Dr Andrew Woods.

▲ *Figure 1: The HIVE (Hub for Immersive Visualisation and eResearch) at Curtin University*

▲ *Figure 2: From left to right: Cory Brooks, Dr Andrew Woods, Dr Miles Parsons, Dr Iain Parnum, Dr Tim Gourlay, Kam Austine.*

Tides Workshop 2016

The Permanent Committee on Tides & Mean Sea Level (PCTMSL) Bureau in Australia has sponsored a tides workshop aimed at raising the level of tidal knowledge of those people involved in marine operations, hydrographic surveying and data collection.

The workshop was conducted at the Tidal Unit, Bureau of Meteorology, Adelaide, and consisted of a mixture of theory and hands-on sessions over three days, from 16 to 18 May 2016 with a field trip on the 19 May 2016. The topics that were covered included tidal theory, storm surges and extreme events, mean sea level and climate variability, climate change and sea level rise, instrumentation, real-time systems and meteorological sensors, benchmark levelling and datums, tidal models, data analysis and quality control, and archiving and quality assurance.

▲ *Participants of the Tides Workshop 2016.*

AUGUST

CARIS World Tour 2016
Kuala Lumpur, Malaysia
→ 23-25 August
www.caris.com/worldtour

SEPTEMBER

Offshore Site Investigation & Geotechnics (OSIG)
London, UK
→ 12-14 September
www.sut.org/event/osig2017

Echoview Training Course
Halifax. Canada
→ 12-16 September
www.echoview.com/products-services/training-and-events

European Dredging Summit
Hamburg, Germany
→ 14-15 September
www.wplgroup.com/aci/event/dredging-summit-europe

EIVA Days Denmark
Skanderborg, Denmark
→ 14-15 September
www.eiva.com/about/events/eiva-days-denmark-2016

MTS/IEEE Oceans '16
Monterey, USA
→ 19-23 September
www.oceans16mtsieeemonterey.org

India Cleanseas 2016
Goa, India
→ 22-24 September
www.cleanseas.in

EWEA Annual Conference/ WindEnergy Hamburg
Hamburg, Germany
→ 27-30 September
www.windenergyhamburg.com

OCTOBER

SaferSeas/Sea Tech Week
Brest, France
→ 10-14 October
www.saferseas-brest.org/Accueil-257-0-0-0.html

International conference on Marine Data and Information Systems (IMDIS)
Gdansk, Poland
→ 11-13 October
imdis2016.seadatanet.org

Flood Expo
London, UK
→ 12-13 October
www.thefloodexpo.co.uk

Euro Naval
Paris, France
→ 17-21 October
bit.ly/10anvm1

Iranimex
Kish, Iran
→ 18-21 October
www.europort.nl/about-europort/europort-exports/iranimex

Offshore Energy
Amsterdam, The Netherlands
→ 25-26 October
www.offshoreenergy.biz

NOVEMBER

Trimble Dimensions
Las Vegas, USA
→ 7-9 November
www.trimbledimensions.com

North Sea Open Science Conference
Ostend, Belgium
→ 7-10 November
www.northseaconference.be

Ocean Energy Europe 2016
Brussels, Belgium
→ 8-9 November
http://www.oceanenergy-europe.eu/oee-2016

Hydro '16
Rostock-Warnemünde, Germany
→ 8-10 November
hydro2016.com

Oceanology International China
Shanghai, China
→ 9-11 November
www.oichina.com.cn/en/home

European Autumn Gas Conference
→ 14-16 November
The Hague, The Netherlands
www.theeagc.com

Asia-Pacific Dredging Summit
Singapore
→ 23-24 November
bit.ly/10aoD9n

GSDI World Conference
Taipei, Taiwan
→ 28 November-2 December
bit.ly/gsdi2015

Sustainable Ocean Summit
Rotterdam, The Netherlands
→ 30 November – 2 December
www.oceancouncil.org

JANUARY 2017

HYPACK 2017 Training Event
New Orleans, USA
→ 9-12 January
hypack.com

FEBRUARY

Oceanology International North America 2017
San Diego, USA
→ 14-16 February
www.oceanologyinternational-northamerica.com

MARCH

US Hydro 2017
Galveston, USA
→ 20-23 March
www.ushydro2017.com

APRIL

Ocean Business
Southampton, UK
→ 4-6 April
www.oceanbusiness.com

Gastech
Chiba-City, Japan
→ 4-7 April
www.gastechevent.com

XIXth International Hydrographic Conference
Monaco
→ 24-28 April
For more information:
www.iho.int

JUNE

EWEA Offshore
London, UK
→ 6-8 June
www.ewea.org/events/ewea-offshore

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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- accuracy: up to 0.04 degrees

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- reliable data transmissions
- range: up to 8000 m
- accuracy: better than 0.01 m

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- depth: up to 6000 m
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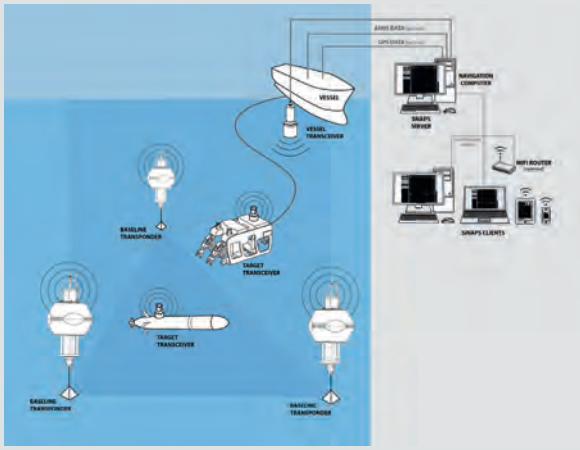

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