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ON THE COVER

This photo of a nudibranch (*Cyerce nigra*) was taken in Romblon, Philippines. This species can also be found in the Western Pacific Ocean and grows up to 15mm in size. Because of the way they move, they are called butterfly nudibranchs. The *Cyerce nigra* is one of three butterfly nudibranchs found in the region.

By: Brook Peterson, waterdogphotography.com









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Editor's Letter



By Kira Coley, Senior Editor

On the Road to Sustainable

F or many industries, the road to sustainability is long and challenging. This is especially true for the shipping industry: several new and upcoming regulations will drastically change ship designs and daily operations. This will bring about numerous technical and financial challenges which will necessitate, in many respects, new levels of collaboration and knowledge sharing within a highly competitive market. Even so, today's shipping industry is resolute as it strives towards a sustainable future.

Many of the stories in this issue of ECO show great examples of collaboration and open dialogue in practice. It's the kind that Henry Ford once described: "If everyone is moving forward together, then success takes care of itself."

Katharine Palmer, Lloyd's Register, kicks off this issue's editorial theme, Sustainable Shipping, with her thoughts on what is needed within the industry to achieve the new sustainability goals.

While there are many challenges ahead, with the support of science and policy-makers, a collaborative industry will be able to cut emissions, slow the spread of invasive species, and reduce impacts on pristine environments – especially with the opening of the Northwest Passage through the Arctic.

It's hard to imagine that communities of people can thrive in the harsh conditions encountered in the Arctic. The Inuit have endured the centuries by working with nature, understanding their environment and benefiting from the pristine marine ecosystem that surrounds the island territories of Nunavut – the base of **Jackie Dawson**'s research and this issue's main story. In Canada, researchers and nonprofit organizations are working together with several government departments, industry, and 14 Canadian Arctic communities to design low-impact shipping corridors that will also consider Inuit culture and preserve their unique heritage.

Kim Lundgreen, University of Southern Denmark, spoke to ECO about the threat of invasive species and the steps being taken to reduce the spread. He shares some breathtaking facts that reveal the extent of this international problem, and tells us about his work with industry collaborators that aims to improve ballast water treatment systems.

From tiny organisms hiding in a ship's ballast to colliding with the largest mammals on the planet: whales. In Australia, we hear about the challenging work led by **CSIRO** to reduce ship collisions with whales by mapping and quantifying risk. After centuries of whaling, the healthy population recovery of some species could mean that reports of ship strikes become more common, therefore "understanding and quantifying risks is an important tool to develop pragmatic solutions," write the authors.

With the help of industry experts, **Wärtsilä** and **Ocean Optics**, we take a closer look at the regulations catalyzing innovation in the sector, novel solutions to help monitor unchecked atmospheric emissions, and we explore what the industry will look like as it emerges in a new, more sustainable form.

Finally, we finish the theme with photographer **Brook Peterson** as she takes us on a underwater visual journey exploring the shipwrecks of Chuuk Lagoon – a ship graveyard that is now thriving with marine life.

I hope you enjoy the latest issue of ECO. I'd also love to hear from you, our readers, with thoughts or comments about this month's magazine. Email me directly at editor@ ecomagazine.com.







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A Year on Ice: Plans for Groundbreaking International MOSAiC Expedition Revealed

It could be the largest scale Arctic research expedition of all time: In September 2019, the German research icebreaker *Polarstern* will depart from Tromsø, Norway and spend the next year drifting through the Arctic Ocean.

M OSAiC will take a modern research icebreaker vessel, brimming with cutting-edge scientific instrumentation, near the North Pole in winter. A total of 600 people from 17 countries will participate in the expedition – and several times that number of researchers will use the data gathered to take climate and ecosystem research to the next level. The mission will be spearheaded by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI).

Four additional icebreakers will provide logistical support, and a dedicated landing strip will be created for resupply flights and two research aircraft. Helicopters, snowcats and snowmobiles will also be used. This elaborate polar mission is necessary in order to gather data on the region – which is virtually inaccessible in winter – that is urgently needed for climate research. Though the Arctic regions have a tremendous influence on our climate, that influence remains poorly understood.

"The outcomes of the MOSAiC expedition will take our understanding of the Arctic to a new level. We desperately need this data in order to better grasp the impacts of global climate change and refine our prognoses," says Federal Minister of Education and Research, Anja Karliczek.

Expedition head and coordinator of MOSAiC, Professor Markus Rex, Head of Atmospheric Research at AWI said, "What happens in the Arctic doesn't stay in the Arctic. The climate development in our latitudes greatly depends on what weather the Arctic 'cooks up.' We now need to take a closer look, and explore the interactions between the atmosphere, ice and ocean there. The polar night in the Arctic plays a pivotal role for the adaptation of life forms; as such, we also expect to gain wholly new biological insights."

The expedition has five focus areas: the physics of sea ice and snow cover, atmospheric processes, ocean processes, biogeochemical cycles, and the ecosystem of the Arctic. The budget for the expedition is more than 120 million euros, contributed by all of the international partners involved, but chiefly by the Helmholtz Association, which means 90 percent came from Germany's Federal Ministry of Education and Research (BMBF). Though the expedition launch is still more than a year away, planning began in 2011. Now the preparations are entering their final, hot phase - and the countdown to the most spectacular Arctic expedition of our time has begun.



Snow drift during an expedition. Photo credit: Stefan Hendricks

Marine Reserves are Vital but Under Pressure

An international team led by ARC Center of Excellence for Coral Reef Studies accessed nearly 1,800 tropical coral reefs around the world and found that only marine reserves in areas of low human impact were effective at sustaining top predators.

In the study, published in *PNAS*, the authors noted that fish stocks were extremely depleted on reefs that were accessible to large human populations. On reefs subject to high human pressure, however, marine reserves had five times more fish than openly fished reefs – a benefit that can spillover into nearby fisheries.

Professor Josh Cinner said the study makes clear the benefits and limitations of implementing key coral reef conservation strategies in different types of locations.

Discovery of Key Proteins for Young Coral Skeleton Formation

For the first time, a study published in *Nature* has identified the biological process of mineralization that occurs in a young coral shifting from the plankton stage to the "settled" stage, in which it forms the skeleton from minerals that protect its colony.

Previous studies have focused on the production of minerals in adult corals to build the skeleton, but the exact stage at which corals initiate the process has remained a mystery until now. The discovery is important for understanding the process of coral reef formation and protecting marine creatures from the ecological damage associated with global warming. It also carries implications for new biotechnological developments using coral extractions to regenerate and reconstruct human bones.

Narwhals' Acoustic Behavior Described Using Audio Tagging

The clicking, buzzing, and calling behavioral patterns of elusive East Greenland narwhals have been described thanks to in-depth recordings in a paper published in *PLOS ONE*. The author of the study captured six narwhals in East Greenland and tagged them with acoustic and satellite instruments.

The researchers were able to record 533 hours of audio and analyzed their recordings to describe how the whales' acoustic behavior varied by location and time.

The researchers found that the narwhals produced three types of sounds: clicks, buzzes and calls. Clicks and buzzes were produced during echolocation for feeding, while the authors presume that calls served communication purposes.

Increase in Storms Could Have 'Catastrophic Impact' on Fishing Industry

Potential changes in the frequency and intensity of storms off the coast of the U.K. and around the world could have a "catastrophic impact" on the livelihood of fishermen and sustainability of fishing industries, research led by the University of Exeter has shown.

T he research, published in the journal *Nature Climate Change*, is based on a review of past studies and examination of future projections. It warns that the increase in storms could make fishing more dangerous, displace fish from their natural habitats, and interfere with the ability of fish to breed.

Storms off the coast of the U.K. are projected to become more frequent and intense over the next two centuries. More dramatic storms are expected in the North Sea and North Atlantic to the west of the U.K., Ireland, and France threatening the future of fishermen and the fish they catch. The paper says detailed projections and simulations are urgently required to predict more precisely where storms are likely to hit in the future and to support fishing communities to adapt to this element of climate change.

The team of experts from the University of Exeter, Met Office, University of Bristol and Willis Research Network, urges climate change research to focus sharply on the increase in frequency and intensity of storms as a priority.

Lead author Nigel Sainsbury, University of Exeter, said, "Storms are a threat to fishermens' safety, productivity, assets and jobs, and to the health of billions of people around the world who rely on fish for their daily nutrition.

Changing storminess could have serious consequences for vulnerable coastal communities around the world. Conducting research in this area is critical to support the adaptation of fisheries to climate change."

Extreme Sea Levels Predicted to Increase Along Global Coastlines

A new study has predicted that future global warming will lead to an increase in 'extreme sea levels,' with consequent flood risks to coastal infrastructure and human populations.

E xtreme sea levels occur through a combination of high tides and extreme weather events, which can generate storm surges and high wind waves. These phenomena are exacerbated by gradual rises in mean sea level and predicted increases in tropical cyclone activity. For the first time, researchers have taken account of all these processes to assess future risk of extreme sea levels out to the year 2100.

The National Oceanography Centre (NOC) was part of the international research team, from Italy, Greece, the Netherlands, and the U.K., that published this new research in the leading scientific journal *Nature Communications*. The most startling result was that extreme sea level events, which occur once every 100 years on average at the present day, would happen almost annually along most global coastlines by the end of the century.

The research team also calculated that the impacts of extreme sea level were significantly reduced in scenarios where CO2 emissions were mitigated compared to a 'business-as-usual' scenario. This is largely due to reduced thermal expansion of the oceans and lower rates of glacier and ice sheet melting.



The new results will be of particular value to coastal planners and indicate that upgrades to existing coastal defenses would require an average increased height of at least 50 centimeters by 2100, although locally this may need to be in the order of one to two meters.

New U.K. Strategy to Protect World's Oceans Announced

On June 22, an ambitious plan was unveiled to bring together all of the U.K. Government's international oceans work under a single strategy.

Several government departments will work to agree and implement a new international oceans strategy that will be developed over the coming months.

The new plan will provide a blueprint for international action towards the oceans that support the long-term prosperity of the U.K. and the longterm health of the marine environment.

Scientists Use Hydrophone to Listen in on Methane Seeps in Ocean

Research published in the journal *Deep-Sea Research II*, has successfully recorded the sound of methane bubbles from the seafloor off the Oregon coast using a hydrophone.

This opens the door to using acoustics to identify – and perhaps quantify – this important greenhouse gas in the ocean.

The next step, researchers say, is to fine-tune their ability to detect the acoustic signature of the bubbles so they can use the sounds to estimate the volume of methane in the offshore reservoirs.

Sticklebacks Infected with Parasites Influence Behavior of Healthy Fish

Evolutionary biologists at the University of Münster have demonstrated for the first time that the tapeworm not only influences the behavior of an infected fish but that indirectly, it can also induce equally risky behavior in other healthy fish.

The study is published in *Proceed-ings of the Royal Society B*. In laboratory experiments, researchers observed schools of stickleback in which the number of infected fish exceeds that of healthy fish, this healthy minority imitates the changed behavior of the infected members of their group.

Major Study Reveals Great Barrier Reef's 30,000-year Fight for Survival

A landmark international study, recently published in *Nature Geoscience*, shows that the Great Barrier Reef has suffered five death events in the last 30,000 years.

The groundbreaking study of the world's largest reef system, reveals that these events were driven mostly by variations in sea level and associated environmental changes.

The importance of the study cannot be overstated, as the project is the first of its kind to reconstruct the evolution of



the reef over the last 30 millennia in response to large-scale, abrupt environmental changes. The research findings indicate that the reef adapted to these dramatic changes by migrating up and down the sea floor as the sea level rose and fell.

To obtain comprehensive geomorphic, sedimentological, biological and dating information, scientists deployed underwater sonar to map the seafloor and extracted fossil reef cores at 16 locations. Overall, the research demonstrates that the reef adapted to major environmental changes such as sea level and water temperature rise more effectively than previously thought. However, the study also sheds light on the reef's high sensitivity to sediment input and poor water quality. The researchers suggest that while the reef has been able to turn the corner after all five death events, mainly due to its remarkable ability to move across the seafloor at a rate of between 0.2 and 1.5 meters a year, they are doubtful about its ability to survive the current trend of global reef decline.

Underwater Robots Give Unique Arctic Insight

Underwater robots have uncovered new evidence about life in the Arctic and, for the first time, revealed the moment the region's marine ecosystem springs into life after the dark winter season.

R esearchers from the Scottish Association for Marine Science (SAMS) in Oban have been able to observe seasonal changes as they happen in the Arctic, thanks to a continuous glider presence in the Barents Sea between January and July this year.

The unique data was gathered by autonomous ocean-going 'gliders' and will help marine scientists understand more about the so-called 'Arctic spring bloom,' which kick-starts the ecosystem and is crucial in providing food for animals in the region.

Gliders took measurements such as ocean temperature, oxygen levels, salinity, and chlorophyll - an indication of the biological content of the water. A rapid increase in the chlorophyll levels in mid-April this year showed the moment the spring bloom began.

SAMS marine scientist Professor Finlo Cottier, who leads Arctic PRIZE, said, "We have seen the change from 24hour darkness in winter to the arrival of spring when the combination of light and warming water allows an explosion of algae. This is food for tiny zooplankton, which provides energy through the food chain for all sorts of life. However, the life cycle of the zooplankton and the spring bloom have to align for the Arctic food chain to be a success. With Arctic sea ice retreating earlier each year, the water is more exposed to the light and mixing. Is there going to be a mismatch between food availability and zooplankton life cycles in years to come? It's a bit like waking up at the same hour each morning, only to find that breakfast time has changed."

With warmer winters across the polar region, the Arctic Ocean is now experiencing year-on-year reductions in the extent of sea ice. These changes are having an unprecedented impact on how the Arctic ecosystem operates. It is important to understand how climate change is altering these properties and to quantify their impacts on the Arctic ecosystem if computer models that predict future change are to be improved.

Research Identifies Benefits of Dredging the Lower Mississippi River

A study released on July 9, 2018, says that making strategic investments in dredging the lower Mississippi River is one of the most effective ways to promote and elevate America's farmers.

T o cost-effectively and reliably access domestic and international markets, U.S. soybean farmers rely on a multi-modal transportation system comprised of rural roads and bridges, highways and interstates, freight railroads, inland waterways, and ports. Each link in this supply chain is essential for farmers to remain profitable. While sufficient levels of investment must be directed to each of these essential modes, a recent analysis by the Soy Transportation Coalition (STC) highlights that one particular infrastructure enhancement offers the potential to significantly enhance the competitiveness of the U.S. soybean industry and individual farmer profitability.

The 256-mile stretch of the Mississippi River from Baton Rouge, Louisiana to the Gulf of Mexico accounts for 60 percent of U.S. soybean exports, along with 59 percent of corn exports – by far the leading export region for both commodities. There is a growing effort among Mississippi River stakeholders, including agriculture, to promote the dredging of the lower river shipping channel from 45 feet to 50 feet in depth. The STC report – performed by Informa Economics IEG – was designed to increase understanding and awareness of the benefit to the U.S. soybean industry of this potential project.

The STC research highlights that shipping costs for soybeans from Mississippi Gulf export terminals would decline 13 cents per bushel (\$5 per metric ton) if the lower Mississippi River is dredged to 50 feet. A deeper river will allow both larger ships to be utilized and current ships being used to be loaded with more revenue-producing freight.

The research also highlights the impact on interior basis – the difference between the local price a farmer receives and the market value established by the Chicago Board of Trade – for soybeans in 31 states if the lower Mississippi River shipping channel is dredged. It is well established that farmers located in closer proximity to the nation's inland waterways and barge transportation enjoy a positive or less negative basis vs. soybeans grown in areas further removed. As a rule, the less costly and more efficient the supply chain, subsequent to farmers delivering their soybeans, the higher the value received by the farmer for the bushels of soybeans produced. The STC directed the researchers to produce basis maps for



soybean-producing states located adjacent to navigable inland waterways – highlighting the current situation and how basis could improve for soybean farmers if the lower Mississippi River shipping channel is dredged.

Areas of the state of Illinois enjoying positive or slightly negative basis will expand if the lower Mississippi River is dredged. The areas with more pronounced negative basis will be crowded out by more favorable basis territory. It is estimated that this development will result in Illinois soybean farmers annually receiving over \$77 million more for their soybean crop. This dynamic will be replicated in other soybean producing states along the inland waterway system.

While the research projects in Illinois receive the largest benefit from dredging the lower Mississippi River, the STC research estimates farmers in the 31 evaluated states would annually receive an additional \$461 million for their soybeans. While those states located in close proximity to the inland waterway system will realize the most benefit, states further removed will also benefit from the increased modal competition between rail and barge. When modal competition increases, a downward pressure on shipping rates will often occur.

With barge transportation becoming more viable for a larger percentage of the soybean-producing areas of the country, there will be a greater degree of overlap between areas served by railroads and barge. Soybean shippers will benefit from this modal competition. The full study can be accessed via the STC's website at www.soytransportation.org.

Trump Issues Executive Order on National Ocean Policy

On June 19, President Trump signed the Executive Order Regarding Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States.

The executive order is intended to advance the economic, security, and environmental interests of the United States through improved public access to marine data and information; efficient federal agency coordination on ocean related matters; and engagement with marine industries, the science and technology community, and other ocean stakeholders, including Regional Ocean Partnerships.

President Trump's executive order revokes and replaces Executive Or-

der 13547, issued by former President Obama, a.k.a. "The National Ocean Policy," which focused on marine conservation and established the National Ocean Council, consisting of 27 federal agencies, departments, and offices. The council released the National Ocean Policy Implementation Plan in 2013 and helped create ocean.data.gov, which provides data in support of ocean planning efforts. The full Executive Order is available for review on the White House website.



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New Oceanographic Insight Pinpoints Marine 'Hotspots of Risk'

Increased computing power has given fisheries researchers new tools to identify 'hotspots of risk,' where ocean fronts and eddies bring together masses of fish, fishermen, and predators, raising the risk of entangling non-target fish and protected species such marine mammals, sea turtles, and sharks.

U sing a novel, high-resolution "Lagrangian coherent structures" mapping technique, scientists are able to model dynamic features in ocean surface currents. The capacity for improved, near real-time mapping of ocean fronts and eddies may now help alert fishermen and fisheries managers to the increased risk so they can try to avoid those protected species and better target the species they are after, explains the authors of an article published June 25 in *Proceedings of the National Academy of Sciences*.

Lagrangian coherent structures, known in the field of fluid dynamics, represent areas of mixing, where different water masses meet and tend to concentrate marine life and, in turn, fishermen. The new approach uses high-resolution ocean modeling to help detect and predict the areas as they form and move through the ocean and to highlight the elevated risk they may present.

"Understanding where bycatch risk is greatest can help fishermen avoid it, and can help us manage fisheries sustainably," said Elliott Hazen, a research ecologist at NOAA Fisheries' Southwest Fisheries Science Center and co-author of the new research. "By identifying which oceanographic features are most likely to result in bycatch, we can improve existing dynamic ocean management tools such as EcoCast to provide novel solutions to address the challenges of fisheries management."

EcoCast is a mapping tool NOAA Fisheries scientists recently developed to help fishermen identify productive fishing areas while avoiding areas with high risk of catching other, unintended species.

In the new study, scientists used the models of ocean dynamics to assess the probability of capturing commercial fish species such as swordfish, opah, and tuna against the risk of catching other species fishermen want to avoid such as some species of sharks, sea turtles, and whales. They found that drift gillnets set in conjunction with such zones were more likely to catch the swordfish they target, but also greatly raise the risk of catching certain non-target species.

Fishermen likely target the zones because they tend to attract swordfish, but scientists suggested that shifting fisheries closures in specific areas at certain times, or fishing at particular depth ranges, might help preserve the swordfish catch while minimizing the risk of catching other species by accident. NOAA Fisheries is increasingly considering options for such "dynamic ocean management," where managers adjust fishing rules in real-time based on ocean data.

Mako shark at Cape Point, South Africa [left] and Steller sea lions [right] sometimes become entangled in fishing nets set for other species. Credit: Steve Woods



Boring Barnacles Prefer the Shallow Life on Coral Reefs

Some species can reduce reef frameworks and influence the net gain or loss of calcium carbonate over time. But the relative importance of barnacles in this process has been unclear. A study published in *PLoS One* found barnacle density decreases both with depth and by how extensively living coral covers the reef framework.

The density of barnacles also decreased with greater availability of coral cover, suggesting barnacle populations prefer to spread out. Scientists suggest that a better understanding of boring barnacles as well as reef conditions over time will reveal whether this bioeroder can serve as a long-term indicator of such reef conditions as temperature or nutrient dynamics.

Study Finds Cleaner Shrimp Follow A Dependable Script

The cleaner shrimp live on coral reefs in the Caribbean Sea. Shrimp wait at a "cleaning station" where they pick parasites and dead skin off the mouth, gills, and scales of passing fish such as blue tangs, parrotfish, and snappers. Many of these fish would normally eat crustaceans such as shrimp.

A new study published in the *Royal Society Journal Proceedings B* suggests that the cleaner shrimp may use a special signal which involves waving their long white antennae to convince fish predators not to eat them. In 80 percent of the observations when shrimp wave, it would result in cleaning. The fish also turn dark, suggesting color change conveys to the shrimp that it's a friend, not a foe.

Zebrafish Beat Google Street View with Near 360-degree UV-Vision

A zebrafish view of the world has been forensically analyzed by researchers to reveal that how they see their surroundings changes hugely depending on what direction they are looking. The study, published in *Current Biology*, found they use near 360-degree view of their world to detect threatening silhouettes above them in blackand-white but can seek out the almost transparent single-cell organisms they feed on by detecting the scattering of light in UV.

The study is the first in-depth physiological description of any vertebrate's retinal setup for color vision that uses "four input colors". By comparison, humans only use three and mice, dogs and horses only two.

Researchers Discover Volcanic Heat Source Under Glacier

Scientists have discovered an active volcanic heat source beneath the Pine Island Glacier in Antarctica.

The discovery and other findings of the study, published in *Nature Communications*, are critical to understanding the stability of the West Antarctic Ice Sheet (WAIS), of which the Pine Island Glacier is a part. The paper is based on research conducted during a major expedition in 2014 to Antarctica led by scientists from the U.K. They worked aboard an icebreaker, the RRS *James Clark Ross*, from January to March, Antarctica's summer.

The WAIS lies atop a major volcanic rift system, but there had been no evidence of current magmatic activity. The last such activity was 2,200 years ago and while volcanic heat can be traced to dormant volcanoes, what scientists found at Pine Island was new. The volcanic rift system makes it difficult to measure heat flow to the WAIS. But as the team conducted its research, it found high quantities of an isotope of helium, which comes almost exclusively from the mantle.

The study authors note that, "Helium isotope and noble gas measurements provide geochemical evidence of sub-glacial meltwater production that is subsequently transported to the cavity of the Pine Island Ice Shelf." They add that heat energy released by the volcances and hydrothermal vents suggests that the heat source beneath Pine Island is about 25 times greater than the bulk of heat flux from an individual dormant volcano.

Professor Karen Heywood, from the University of East Anglia and chief scientist for the expedition, said, "The discovery of volcanoes beneath the Antarctic ice sheet means that there is an additional source of heat to melt the ice, lubricate its passage toward the sea, and add to the melting from warm ocean waters. It will be important to include this in our efforts to estimate whether the Antarctic ice sheet might become unstable and further increase sea level rise."



View from icebreaker RRS James Clark Ross on a 2014 expedition. Credit Brice Loose (URI)



Photo credit: G.P Schmahi / FGBNMS

Discovery of World's First Known Manta Ray Nursery

A research team led by Ph.D. candidate Joshua Stewart has identified a manta ray nursery in the Gulf of Mexico.

R esearchers from Scripps Institution of Oceanography and NOAA's Office of National Marine Sanctuaries have discovered the world's first known manta ray nursery. Oceanic mantas are typically found in subtropical and tropical waters around the globe with aggregation sites commonly found far from coastal areas, making their populations hard to access and study. For this reason, major knowledge gaps remain in their basic biology, ecology, and life history. Baby mantas are virtually absent from nearly all manta populations around the world, so even less is known about the juvenile life stage.

Joshua Stewart, a marine biology Ph.D. candidate at Scripps, and lead author of the study published in *Marine Biology*, observed the juvenile mantas while conducting research on manta population structure at Flower Garden Banks, one of 15 federally designated underwater areas protected by the Office of National Marine Sanctuaries.

"The juvenile life stage for oceanic mantas has been a bit of a black box for us since we're so rarely able to observe them," said Stewart, who also serves as executive director of the Manta Trust, a global manta conservation program. "Identifying this area as a nursery highlights its importance for conservation and management, but it also gives us the opportunity to focus on the juveniles and learn about them. This discovery is a major advancement in our understanding of the species and the importance of different habitats throughout their lives."

Seven-Year Study Reveals Data to Protect Oceans Against Future Oil Spills

A seven-year study published in the *Marine and Coastal Fisheries* records the most comprehensive data available of marine life throughout the entire Gulf of Mexico after *Deepwater Horizon*.

The most notable population declines since the disaster are those of the red snapper and southern hake in the northern Gulf, the location of the *Deepwater Horizon* oil spill. Overall, fish were most abundant in the northern and north western Gulf. Scientists suggest this is because of increased fishery protections and more phytoplankton in the area. The average sizes of fish were larger there compared to the West Florida Shelf, Yucatan Peninsula and Cuba where fewer large predators exist.

The species' compositions and size data provide a basis for evaluating resiliency to overfishing, climate change, pollution, habitat loss, invasive species and other stressors on fish populations. Specimens from the surveys continue to be tested for oil residues, other organic pollutants and heavy metals. Overall the degree of oil contamination of fish from the northern Gulf continues to decline, although no areas assessed so far are oil free.

The goal of this research is to establish where the oil contamination baseline is in the aftermath of *Deepwater Horizon*.

Oil Toxicity in Deep-Sea Crustaceans

A study, published in *Environmental Toxicology and Chemistry*, conducted 48-hour toxicity experiments on deep-ocean crustaceans to determine the impact threshold levels for polycyclic aromatic hydrocarbon, 1-methylnaphthalene, under various environmental conditions. Compared to other organisms for which similar data is available, the concentrations inside the tested crustaceans at time of death suggest higher sensitivity than previously studied organisms, including other crustaceans. Temperature changes had a larger impact on the partitioning coefficient (used for estimating contaminant adsorption) of 1-methylnaphthalene than salinity changes.

MEPSEAS Project Launched to Protect South-East Asia Marine Environment

Seven ASEAN countries have formally launched an ambitious initiative aimed at improving the environmental health of the seas in the region, through the implementation of key International Maritime Organization (IMO) marine environment protection treaties.

S enior decision-makers at maritime administrations of the beneficiary ASEAN countries (Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam) met for their first high-level regional meeting in Bali, Indonesia (June 25-27), to kick-start the "Marine Environment Protection for Southeast Asia Seas (MEPSEAS) Project".

IMO is implementing the project, with funding from the Norwegian Agency for Development Cooperation (Norad). The ASEAN Maritime Transport Working Group (ASEAN MTWG), the highest regional policy-making body dealing with maritime matters in the region, will act as the advisory body for the MEPSEAS project.

The four-year MEPSEAS project (2018-2021) will focus on enhancing the countries' capacity to implement a number of high-priority treaties, including the International Convention for the Prevention of Pollution from Ships (MARPOL); the Anti-Fouling Systems Convention; the London dumping of wastes at sea convention and protocol; and the Ballast Water Management Convention.

The high-level meeting was also attended by project strategic partners Partnerships in Environmental Management for the Seas of East Asia (PEMSEA); Women in Maritime Asia (WIMA ASIA); and the Tokyo MOU regional port State control (PSC) organization); non-beneficiary partner countries, including Singapore; and shipping industry representatives.

Opening the meeting, Mr. R. Agus H. Purnomo, Director General for Sea Transportation under Ministry of Transportation, Government of the Republic of Indonesia, said that the MEPSEAS project provided an opportunity for the countries to tackle the risks the marine environment faced in the region and support sustainable growth in the maritime sector.

"We should work together to ensure a continued and strengthened contribution towards a green economy, growth, and to protect our marine environment in a sustainable manner. Our active involvement through the MEPSEAS project will prove that we have the same commitment to protecting our marine environment," said Purnomo.

The meeting plans to agree to a project work plan and regional coordination and information sharing arrangements.

The MEPSEAS project will promote na-

tional legal and policy developments and related capacity building in port and flag state inspections to support enforcement of the selected Conventions. The project is also expected to support specific port biological baseline survey training, the Green Shipping-Green Port-Green Shipyards (GGG) initiative of the Philippines, and the holding of a regional maritime technology conference, among other activities.

The MEPSEAS project will build on a previous IMO-Norad foundation project which directly led to the six countries concerned making substantial progress in implementing or acceding to IMO environmental treaties. The latest country to join the project is Myanmar, which aims to initiate actions to accede to and implement two marine environmental Conventions in the near future. For countries which have acceded to the relevant treaties, the new MEPSEAS project will allow them to focus on effective implementation.

"The MEPSEAS project is a clear demonstration of the continued commitment of the ASEAN countries to move towards a sustainable maritime transport system and to address significant marine environmental issues," said Jose Matheickal, Deputy Director (Major Projects) of IMO.



Launch of MEPSEAS IMO initiative. Source: International Maritime Organization (IMO)





Sustainable Shipping

Opinion by Katharine Palmer, Global Sustainability Manager, Lloyd's Register

Katharine Palmer has over 17 years' experience in the marine environment and the shipping industry. She is now the global head of sustainability for Lloyd's Register Marine & Offshore business, providing advice and insight to a wide range of maritime stakeholders including regulators, ship owners and operators, and trade associations on sustainability and environmental-leading practice and future strategies. Katharine is an established shipping industry influencer and thought leader in climate change, the environment, and sustainability, and has held a number of positions on external industry bodies. Currently, Katharine is an Elected Trustee for the Sustainable Shipping Initiative and co-chairs the IMarEST technical leadership Board.

T he shipping industry is characterized by supply and demand market cycles and long lifespan assets - an economic model that means the industry is generally reactive, dealing with immediate cost and supply pressures, and makes forward-thinking difficult and risky. This constrains actions the industry takes towards sustainability, and the industry itself is left fragile. Therefore, policy 'levers' play an important role in maintaining a level playing field for a global industry, and in providing certainty in investment and financing decisions surrounding shipping.

Over the last few years many policy and regulatory frameworks have been introduced. Reducing air emissions, minimizing the impact of invasive species through ballast water management, the Polar Code, combating maritime crime, and strengthening seafarers' rights are significant examples of how policy is helping to move shipping towards a more sustainable future.

There is no doubt that the current drive towards a more sustainable society is something that the shipping industry makes a positive contribution towards, both in terms of the global economy and by contributing to achieving UN sustainable development goals. This also offers business opportunities, which may be underexplored, in securing its own sustainability.

Technology and innovation are key to this. New technology is emerging in many areas such as fuel and energy use, automation and vessel management, and materials and construction. As part of this, the industry has learnt a lot about the enablers and barriers of change in today's world. But to unlock more progress, there are two important areas that require more focus:

Market mechanisms and incentives – for new technologies to be deployed we need to find ways to de-risk these investments. Better sharing of performance data, access to capital, and strong market incentives are essential to minimizing risk. This especially applies to split incentives and understanding who really benefits. Consumer pull is both increasing and driving higher sustainability standards but finding ways to make the rewards greater than the risks will accelerate this change.

Better access to data and greater transparency – digitalization and automation will help with this. Port incentive schemes have a great role to play, but adoption needs to be wider and standardized. Transparency is not just about technology either; social conditions in ship recycling are just as important. The lack of transparency across ship recycling policies can lead to bad practices and related health, safety, and environmental hazards. As such, the Ship Recycling Transparency Initiative was launched on March 7 this year to help raise transparency standards across the industry.

As a founding member of the Sustainable Shipping Initiative, Lloyd's Register shares a vision where sustainability equals success. By exploring the role of shipping in a broader sustainable trade future, bringing in wider perspectives, and backing practical steps to get there, we support the industry in being more transparent, more active on the global stage, and more incentivized to take sustainability action beyond compliance.

Successful Voyages Sustainable Planet

Conference review by Dr Michele Fiorini, IALA's Industrial Member.

Established in 1957, IALA is a non-profit, international technical association, gathering together marine aids to navigation authorities, manufacturers, consultants, and scientific and training institutes from all parts of the world. The work of the committees is aimed at developing common best practice standards through publication of IALA Recommendations and Guidelines.

T his year's International Association of Lighthouse Authorities (IALA) conference - "Successful voyages, Sustainable planet: A New Era for Marine Aids to Navigation in a Connected World" - was the 19th edition of the four-yearly event. Taking place May 27 to June 2 in the magnificent Songdo ConvensiA Convention Center of Incheon, Republic of Korea, more than 500 delegates attended from 70 countries making this year the most participated ever. From day one, the atmosphere was vibrant, exciting, and well attended by remarkable people representing maritime stakeholders from across the globe. The conference had a strong focus on the development and exchange of maritime transport.

At his keynote speech, Mr. Kitack Lim, Secretary-General of the International Maritime Organization (IMO) remarked on the importance of human-element awareness and safety training as a priority when introducing new technologies such as autonomous or unmanned ships. Lim also spoke of the use of Maritime Resource Names (.mrn) - a naming scheme that can uniquely identify any maritime resource in the world – which will be needed for the development of globally-harmonized data models. This will enable the implementation of digital maritime services under the IMO e-Navigation Strategic Implementation Plan.

European shore authorities spoke about how they share Automatic Identification System (AIS) data (used on ships and by vessel traffic services) to support maritime domain awareness. They are currently developing traffic management concepts to improve the efficiency of the full port-to-port transport chain including port entrance and exiting (with engagement of pilots, etc.) and the logistics inside the port itself. Nowadays, it is quite common to observe cargo ships waiting to enter port in busy areas – sometimes for days. Improving efficiency means they must modulate the voyage route in order to arrive *just-in-time* to enter the port when logistics are available such as facilities to load/unload the cargo.

The evolution of the existing AIS into a VHF Data Exchange System (VDES) to build on current capabilities was highlighted as an important step for securing reliable digital communi-



cations, together with other commercial satellite and terrestrial communications services. The practical use of existing public terrestrial systems, such as the mobile phone networks, for providing safety information to fishing vessels and leisure craft was also a hot topic, as well as cybersecurity risks in data transfers which will continue to grow in the future as the industry moves into an even more digitalized age and adopts more data-sharing practices.

In the sessions on Positioning, Navigation and Timing (PNT) the importance of resilience was underscored. Resilient PNT is vital for electronic navigation and underpins a variety of safety-related services. For example, autonomous vessels entering the maritime industry today and in the future will need assured positioning and automatic compensation for Global Navigation Satellite System (GNSS) outages or disruption. Satellite-Based Augmentation System (SBAS), Ranging Mode (R-Mode), Radar positioning and enhanced Loran (eLoran) are electronic systems likely to be used to help achieve the necessary resilience, but there is still no global consensus on a coordinated approach for the maritime world.

Traditional visual navigational aids (known as AtoN signaling) remain essential in waterways but are increasingly being supplemented by virtual electronic AtoN for navigation and for emergencies or disasters. Moving to digital is generally beneficial because it allows more services and less maintenance. But as the entire maritime world moves to digital, traditional installation and maintenance procedures will quickly become out-of-date. In light of this, changes to IALA recommendations where announced at the conference for visual AtoN, including technical developments for practical installation, operation, and maintenance.

An important legacy of the conference was the Incheon Declaration on lighthouses as a Cultural Heritage building - an initiative of the Korean Ministry of Oceans and Fisheries and supported by the IALA motto "Safe voyages, Sustainable planet." The first-ever World Lighthouse Heritage Exhibition was successfully staged alongside the conference and the Industrial Members Exhibition. Furthermore, the first ever female President of IALA, Ms. Youngshin Kim, was also elected. Kim has worked at the Korea Ministry of Oceans and Fisheries for 18 years and is now Director of Aids to Navigation.

It's clear that "The IALA family" is fully determined to bring the maritime sector into the digital era by means of sustainable and successful voyages driven by an e-Navigation paradigm. Brazil will host the next conference in 2022, the bi-centenary anniversary year of independence. I look forward to seeing then how the maritime industry has adapted to a digital and sustainable-focused age.



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Northern Voices

By Kira Coley

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For hundreds of years, the Inuit have survived the world's harshest conditions by living in balance with nature and thriving off the region's pristine coastal waters. Many explorers talk of a unique 'spirit' within the Arctic, born from a vibrant culture and rich history unseen on the shores of its southern polar kin. Since 2005, shipping traffic has risen by more than 75 percent in the region as climate change opens the Northwest Passage.

But concerns from Inuit communities in Nunavut – the island-based territory that frames the notorious sea route – has resulted in the launch of a one-ofa-kind initiative that acts as a platform for northern voices while the Canadian government sets forth proposals for low-impact shipping corridors. By infusing local knowledge and cultural practices into the framework, a more sustainable Arctic shipping policy can be created; one that benefits the industry and preserves Inuit heritage for generations to come.



Photo Credit: Nunavut Tourism

The story of Nunavut begins in 1976 when a national Inuit organization, now known as Inuit Tapirisat Kanatami (ITK), proposed the creation of a new territory in Northern Canada as part of the Inuit land claim settlement. The new territory called Nunavut, meaning 'our land', was the largest to be added to three other regions: Inuvialuit (Northwest Territories and Yukon), Nunavik (Northern Quebec) and Nunatsiavut (Labrador). Together, the regions form Inuit Nunangat, or 'Inuit homeland'.

The Inuit have had an unsettled history over the centuries, explained Jackie Dawson, Associate Professor at the University of Ottawa. "It is a bit of a dark story involving relocation, colonization and more, and yet, considering all of this, Inuit are incredible people. Their greatest quality is their resilience and their strong connection to the land." Now, the surge of shipping traffic in the region has made them apprehensive about the future.

Nunavut is a predominately island-based territory and highly dependent upon marine transportation. Ships support community re-supply, construction, local economic activities such as tourism, mining and fishing, and cultural livelihoods. But over the past decade, shipping in these parts has increased substantially as exploration and extraction of natural resources expands, cargo trade and transport increases, and fishing and adventure tourism rapidly grow in popularity.



Climate change has enabled this increase in shipping in the Arctic, said Dawson. "In the Canadian Arctic, this is happening slower because the ice is a little different than in the European or Russian Arctic. But we've still seen a tripling of activity in the Northwest Passage over the last 10 years. This is quickly becoming a very important topic. Not everyone realizes these are areas where people hunt, fish and thrive off the ocean environment in a sustainable way, and they have done so for hundreds and hundreds of years."

Transport Canada, the Canadian Coast Guard, and Canadian Hydrographic Service, are the Government of Canada agencies developing a network of low-impact marine transportation corridors in the Arctic. These corridors will encourage marine traffic to use routes that pose less risk and minimize the impact on communities and the environment. The low-impact shipping corridors will also be a framework to guide future federal investments to support marine navigation safety in the North, including prioritized improvements to charting and increased hydrography.

Photo Credit: Nunavut Tourism

Until now, however, these low-impact corridors have been mostly based on historical traffic trends and may not be well positioned when considering how Inuit use the marine environment.

In Canada, researchers have created maps of ecologically and biologically significant areas across the Arctic, on which important flora and fauna have been marked, including key calving and breeding grounds for marine wildlife. "But what we have not done - and what the Arctic Council has repeatedly recommended doing - is to also identify culturally significant marine areas," said Dawson. "Our research sought to fill this gap by gathering local perspectives on





the potential impact of marine vessels on marine areas used for cultural and livelihood activities."

In partnership with the Canadian government and with 14 Canadian Arctic communities, the information collected will be infused into the policy framework. The end goal is to influence the allocation and management of the shipping corridors so that any impacts on local activities are reduced or, when possible, avoided entirely.

"It is really quite dangerous. Especially when the ship goes through and breaks up huge areas of the ice that are used as winter ice travel roads. We recently heard a story about an Inuit hunting party. A smaller ship went by and broke up the ice sheet they were using as a crossing, forcing them to travel more than 150 kilometers north to a different area to hunt beluga. They got hit by the harsh weather, and the situation became very dangerous."

Many ship operators working in the Arctic are very experienced and respectful, adds Dawson. "But the Inuit see the potential future implications, especially with the introduction of new, less experienced operators. This is why it's critical that they are involved in and are also leading the science that influences their future."

Mapping Inuit Routes Across the Canadian Arctic

Collecting the data, however, was no small feat. "You can't just 'visit' Arctic communities and engage in science like you would in London or New York," Dawson explains. "We had to be invited, and only then could we begin the mapping exercise that shows where Inuit and northerners hunt, fish and journey across the Arctic. Lucky for us, communities were really excited about this project in that they felt it would make a big difference to them. Especially as they face a future living alongside a growing shipping industry."

Dawson and the project team - which included community research director Dr. Natalie Carter, Inuit researcher Natasha Simomee, more than 12 graduate and undergraduate students, and people from partner organizations such Oceans North and World Wildlife Fund – navigated between each of the 14 remote communities of Nunavut, the Inuvialuit Settlement Region (Northwest Territories), and Nunavik (Quebec). During the summertime, people are often out on the land and using the ocean for traditional and family activities. This meant community trips were done in the wintertime when





local people were in town. "Because it's winter, it's usually dark and cold when we visit. We traveled to communities by plane and it is very expensive. You can go around the world or you can go visit one Inuit community at about \$4-5K per person per flight. When we got there the atmosphere was really positive, but only because we never visited without first speaking to experts and leaders in the communities."

The first few days at each location was spent training Inuit youth on shipping issues and how to facilitate mapping workshops so that they could be hired to conduct the research within their community. "I think the approach we take in terms of training young Inuit and hiring them as research associates is important, and soon we will be at the point where the youth and the local researchers will be doing the mapping and ship monitoring themselves." This is already happening in some locations across the Arctic.

These communities can be as small as 150 people, so the team worked with the youth to gather together a representative group size from each community which includes local users of the real environment, from hunters to fishers, and other people who use the land or the ocean.

For Pond Inlet, the community experiencing the largest increase of shipping activity in Nunavut, nine locals took part in the mapping workshop including Jake Awa, Jayko Alooloo and community elder, Mary Muckpa. Jake Awa is very familiar with the hunting grounds in the area. He also experienced the transition of Inuit first moving into settlements in the 1970s. Mary Muckpa grew up on the land around Pond Inlet. Now retired, Mary is a very knowledgeable elder and regularly shares stories about the ways of life before Inuit settled in communities.

Jayko Alooloo has served on several wildlife-related boards in the area. In the community report composed for Pond Inlet, Jayko said, "Such opportunities embrace my knowledge and allows us [Inuit] to share comparable knowledge in a context in which it's benefiting both parties. It has encouraged me to take part more inclusively, understanding that our knowledge is valuable."

During each workshop, community members mark on a map the areas they use and the routes they travel. "This includes hunting areas as well as areas important for wildlife, but also the time of year this is happening," explains Dawson. If a ship is going through the region during a breeding season, it will make a bigger impact than outside of that time period. This means authorities will need to think about these shipping corridors both temporally and spatially.

"For Inuit the terms of 'fall, winter, spring and summer' are not relevant. Instead, they use locally relevant seasonal terms like 'freeze up,' 'ice' and 'break up.' The months do not matter because they aren't always reliable and the time of year the ice melts can change. But what does matter to these communities is when the ice freezes, when you can go on the ice, and when the ice is breaking up," she said.

Community members outlined a range of potential impacts from ships. The most common included contamination of Arctic waters, animals and people; disruption of sea ice formation and ship induced behavioral changes in wildlife; destruction of animal habitat leading to increased food insecurity; and limiting lnuit and northerners' ability to use local travel routes safely, and hunt successfully. Opportunities were also highlighted related to improved tourism opportunities, community economic development options and increased employment, and increased science and program funding for partnered and locally led initiatives. "The low-impact corridors are seen as an important tool by Inuit to try to mitigate potential risks and optimize opportunities for local communities, and for Canada," added Dawson.

Once they have drawn all of these activities and time frames on the maps, the team returns to the lab to digitize the data into a digital map using a geographic information system (GIS) program. A report is then produced outlining the potential impacts of shipping routes, and recommendations specific to each community that might include seasonal speed limits, no-go zones, no-anchoring zones and no ice-breaking zones.

"It is about being proactive. Some communities are more impacted than others because of where they are located. But I would say without a doubt that all communities are concerned because their livelihood is based on a pristine natural environment. And they are acutely aware of what is going on in the world. I think that everybody, including myself, would like to use the Canadian Arctic and northwest passage as an opportunity to do this right. It is not like around Alaska or Svalbard - we have a little bit of time to make sure that sustainable policies are in place that consider cultural aspects."

Moving Forward in Partnership

Dawson led the drafting team of the statement on the Arctic Ocean, which included Inuit authors and other Canadian experts, that was signed by the G7 Nations at the summit conference



Photo Credit: Meet the North

this June. In the statement, the authors pressed for the need of including local and traditional voices and knowledge in scientific efforts. G7 Nations have signed onto this approach as well as the need to improve satellite imaging and remote sensing in the region.

The next steps will be to finish the individual community reports and compile one big report outlining recommendations to the Canadian government, the Canadian Coast Guard, Transport Canada and Canadian Hydrographic Service. The Inuit maps will be reviewed, along with other information such as ice and hydrography, and recommendations for shipping corridors will be made to mariners.

The ultimate goal, Dawson explained, is to transmit real-time information to mariners with slow or no-go zones and suggest no-anchoring areas which correspond with Inuit activity. This would mean when groups are preparing to engage in an activity such as a bowhead whale hunt, the location and time-frame can be relayed to ships so they know to avoid the area. "It's a little difficult now because we don't exactly have great internet in the Arctic," she adds. "But it is fantastic to see it get this far. It started as this really small idea out of the mouth of an Inuit youth, and now international governments are listening and implementing what they are saying."

Dawson and the team will continue to work with their Inuit partners who have just started the Inuit marine monitoring program where locals are hired to do science in the Arctic Ocean and also monitor for ships. "We will also continue to do a lot of remote sensing work where we will identify risk areas, invasive species, and noise impacts - so there is a lot of work to be done still. For me, partnerships are really important. It is only through working in true collaboration with Inuit organizations, government organizations and the shipping industry that, as scientists, we can make the strong fact-based discoveries needed to ensure the low-impact shipping corridors are effective in mitigating environmental and cultural risks, while capitalizing on opportunities related to increased Arctic shipping. Hopefully this project will demonstrate to the world that a sustainable and successful shipping industry is possible in Arctic Canada if done in partnership."



Fighting the Invasion

Today, invasive species are one of the most serious threats to aquatic ecosystems worldwide. ECO speaks with Kim Lundgreen, Ph.D. Student at the University of Southern Denmark, as he reveals the extent of this international problem as well as the steps being taken to reduce the spread and restore the balance in favor of native communities.

ECO: The spread of aquatic invasive species is a well-known issue impacting coastal ecosystems around the world. But how serious is the problem?

I would say it is very serious, and I don't think many people are truly aware of the extent of the problem, or the huge economic costs when combining both aquatic and land-based invasive species. It was estimated some years ago, that the negative impact of all invasive species put together was equivalent to five percent of the annual world economy – something in the order of \$1,400,000,000,000. This is a number that is hard to grasp; even if the costs are overestimated and it is only perhaps half this value, it is still an astonishing number. Todays' economic burden of land-based invasive species is estimated to be much higher than for aquatic but the continuous introduction of new invasive species in aquatic environments means this will likely increase. A 2012 report from the United Nations Environment Programme estimated annual global costs to be in the order of \$100 billion for controlling and preventing the spread of aquatic invasive species. I find this number to be frighteningly high.

I don't think people had foreseen that "just" moving some organisms around a bit would have such severe consequences, not only economically but also regarding harmful effects on ecosystems and human health.



ECO: What are the main ways organisms are being transported?

Organisms can be transported via hull fouling, where they attach themselves on the outside of the ship's hull, but the major transport occurs in the ships' ballast water. Not many people know what ballast water actually is or what it's used for, and that it is the most important player in the spreading of aquatic invasive species.

Ballast water is a necessity for all large ships for safety and economic reasons. It is used for reinforcement of the hull and for adjusting and trimming the position of the ship during voyage in relation to cargo load for better stability and fuel consumption. Some of the biggest ships out there can carry up to 100,000 m³ of ballast water. That's the same as 40 Olympic sized swimming pools.

In theory, there can be thousands of different species and billions of planktonic cells inside ships' ballast water tanks during voyages.

ECO: Are there species that are more likely to spread than others?

To be acknowledged as an 'invasive species,' an organism must first survive the treatment process during intake. The ballast water is cleaned by treatment systems which are very efficient in removing the larger aquatic animals, but also costly for the ship-owners: the price for some of the treatment systems that can handle large volumes of water are within the range \$1-3 million.

Some of the smaller and tougher species can potentially survive if treatment is not optimal, and they are therefore more likely to spread. This especially includes organisms with egg or larval stages such as crustaceans and mollusks, but some algal species have also shown to be robust towards treatment procedures.

Next, they must survive the potentially long passage in the dark ballast water tanks, and eventually a second treatment that happens before the water is discharged into a new environment.

Organisms must also be able to survive and overcome the new conditions where different ecological factors might dominate in relation to the area they originally came from. Finally, it must be able to adapt to a degree where it succeeds in reproducing and establish a population. Once an invasive species has established a reproductive population it can out-compete local species and multiply into pest proportions.

The damage invasive species exert on the environment and biodiversity is considered one of the most serious threats to aquatic ecosystems worldwide. These damages are often irreversible as it is almost impossible to eliminate an invasive species once a population has been established.

One of the most "successful" – and thereby least wanted – invasive species is the zebra mussel in the Great Lakes. It is native in Eastern Europe where the population is controlled by natural predators. Consequently, the absence of these predators in the Great Lakes and the perfect ecological conditions led to a population explosion after it was introduced via the discharge of ballast water. This caused the near extinction of some local species and, as the mussels consume large quantities of phytoplankton, there was a decrease in the food availability for commercial and game fish in the area. It is estimated that zebra mussels will outcompete 50 percent of the native mussels, eventually causing extinction of more than 100 species. The major economic impacts include clogging the pipes of water treatment facilities and power plants, resulting in huge expenses and mobilization of resources in cleaning operations, as well as costly damages on boats and harbor areas.

Other successful invasive species that have caused major ecological and economic damages include the North American comb jellyfish, the European crab, and the North Pacific sea star which have all had devastating impacts on the fishing industry. The parasitic salmon flukes that infect salmon can cause catastrophic losses in aquaculture productions. And finally, toxic algal blooms can kill or harm other organisms – including humans and blooms also cause huge economic losses for areas reliant on tourism due to the periodic damage and closing of beaches.

ECO: How has this issue evolved with the growth of the shipping industry?

Until the 19th century, ships' ballasts were solid, typically rocks, but with the introduction of steel ships the solid ballast was replaced by water which was more flexible and could be adjusted according to cargo load.

The use of water as ballast introduced the transportation of unwanted organisms to different corners of the world where some were able to establish stable populations and became the first harmful invasive species.

Shipping is the most cost-efficient way of moving goods and, for that reason, shipping accounts for about 80 percent of the global transportation of goods today. It has been estimated that between four and ten billion tons of ballast water is moved around the world annually. With the growing maritime trade caused by globalization, the demand for more and larger ships will, in my opinion, also increase the risk of transporting potential invasive species in ships' ballast water.

One of the most recent concerns today in terms of invasive species is focused on the opening of Arctic Ocean shipping routes. The Arctic has, until now, been isolated from potential invasions due to its harsh climate but with the opening of shipping routes, the pristine Arctic ecosystems now also become vulnerable.

ECO: What is being done to reduce the spread?

I think it is fair to say that the impact of aquatic invasive species was underestimated, and our efforts to implement controls to encircle and contain the problems were initiated too late and too slow.

The "International Convention for the Control and Management of Ships' Ballast Water and Sediments" was adopted by the International Maritime Organization (IMO) in 2004 – many years after it was globally accepted that this was a huge environmental and economic issue. It wasn't until September 2017 that the convention was ratified. All ships are now required to have a ballast water treatment system on board that has been thoroughly verified by testing facilities approved by the IMO.

But many invasions have already occurred, and it seems like there is no saturation tendency in the accumulation of aquatic invasive species. However, it is important to keep complying with current regulations regarding ballast water treatment systems. The regulations are constantly being evaluated and work done by initiatives such as Global TestNet and GloBallast Partnership Programme are central in optimizing current regulations for better protection. Both initiatives aim to increase levels of standardization. support development of new technologies, as well as uphold transparency and openness in testing of ballast water management systems.

ECO: What challenges does the industry face in stemming this issue and meeting new regulation requirements?

Implementing new technologies for treatment systems onboard existing ships is always a challenge, both regarding space limitations and economy. The socalled retrofitting is necessary in thousands of ships, so dry dock capacity is also a challenge.





When a treatment system is installed and running onboard a ship, there isn't currently enough technology to help verify the efficiency of the system, and thereby whether ships comply with the regulations set by the IMO and U.S. Coast Guard.

It's my impression that research communities and the industry are working closely together to find solutions. And it's important we that collaborate closely to uncover the most relevant and pressing technical and biological issues that science needs to address to keep improving treatment systems and testing procedures, and help limit any further spreading of aquatic invasive species.

For example, my Ph.D. project at University of Southern Denmark is a collaboration with DHI Water & Environment, which is an IMO approved testing facility. Together, we are addressing the question: Does the use of laboratory cultured standard test organisms mixed with natural algal populations reduce the sensitivity of the testing procedures for organisms in the size class 10-50 μ m?

The use of a standard test organisms is necessary for most testing facilities because natural algal population concentrations are not always high enough to fulfil the concentration requirements for testing ballast water treatment systems. Because of this, it is common practice to add standard test organisms to reach the requirements for testing. But it has also been asked if these organisms are "weaker" than natural algal species and whether the use of them lowers test water quality.

If that is the case, the result will be less conservative testing conditions and there is a risk of approving treatment systems that are too weak. On the other hand, if standard test organisms turn out to be as or even more robust than natural species, the practice of mixing can be considered safer. Our research has shown that standard test organisms are promising candidates to use together with natural algal populations for sounder validation of treatment systems. All treatment systems need to fulfil some discharge standards set by the IMO and U.S. Coast Guard. This means that after the treatment process water samples must be collected and quantified for number of living organisms in different size classes. The current method for quantification of the size group 10-50 µm, which mainly consists of phytoplankton, requires labor intensive microscope counting, is relatively slow, requires specialized personnel, and is challenged by subjectivity.

In my research, we are currently developing an automated, faster and more objective method by using a high content screening platform and image analysis software and have produced some promising results for an alternative quantification assessment method for validation of treatment systems.

ECO: Do you think with continued collaboration between science and industry, we can one day stop the spread of invasive species?

Overall, I think the scientific community is very interested and motivated in helping the industry as the shared goal is protection of the environment, human health, and the conservation of pristine ecosystems. And the industry can benefit a lot from collaborations with researchers: often in a highly competitive industries they lack the resources to explore the technical and biological challenges they face. In the scientific community, that resource can be mobilized if the outcome of the collaborations results in publications. But for these mutual collaborations to bloom it is essential that there is effective communication between the two communities.

Still, I do not think we will ever be able to stop the spread of aquatic invasive species. With the right attitude and the combined use of expert knowledge from the IMO, U.S. Coast Guard, initiatives such as the GloBallast Project and Global Test-Net, the industry, politicians and the science community, I am optimistic about at least reducing the flow. Hopefully this will result in partial recovery of some affected habitats and improve conditions for sensitive native species worldwide.

Avoiding the Collision Course

Words by: David Peel (CSIRO), Joshua N. Smith (Murdoch University) and Simon Childerhouse (Blue Planet Marine)

"A novel and exciting incident occurred on a recent voyage of the steamer Titus, she suddenly ran into a large whale with such force that the Titus was nearly thrown on her beam ends. ... Captain Turnbull would have endeavoured to secure the monster, but the steamer had too much way on, and a southerly gale was blowing at the time. The whale was watched for some time as it whirled and lashed the waves in its dying struggles..."

Richmond River Herald and Northern Districts Advertiser, December 4, 1891

A titudes about collisions between whales and vessels have changed drastically since this account from a newspaper in 1891. Rather than sensational, we now view such incidents as tragic, and internationally, vessel strikes are recognized as a potential threat to whale populations.

Worldwide, the main species affected by vessel collisions are fin whales, followed by humpback, northern right, gray, minke, sperm, southern right and blue whales. During the last two centuries of whaling almost all of these species were brought to the brink of extinction.

The recovery of these species and their local populations has varied considerably from place to place. Many populations of these whales are still dangerously small (e.g., northern right, western grey, blue whales). For these small populations, vessel collision is primarily an issue of conservation. But, it is also an animal welfare and ethical issue. This is particularly relevant for populations such as the Australian humpback whale which, while showing strong recovery from commercial whaling, is still impacted by vessel strike. Ironically, their healthy return towards pre-whaling numbers is likely to make vessel strikes more common in the future due to more whales being in the ocean.

In addition to the immense changes experienced by whale populations over the last 100 years, worldwide shipping has also seen extensive change over this same period. Shipping is the life blood of modern economies, connecting and providing the mass transportation for over 80 percent of global goods and resources. Consequently, there has been a massive increase in the overall volume of global shipping traffic. For example, the number of vessels in the worldwide merchant fleet has increased by 13 percent in the last seven years (UNCTAD 2018) and future projections show this growth will continue. There have also been considerable changes in the size, type, and speed of vessels. This is relevant to vessel strike as different vessels have different risk profiles.

This change is reflected in our collated data of vessel strikes in Australian waters which showed a steady increase in the average length of vessels colliding with whales between 1890 and 1950. Interestingly, fewer reports of large vessel collisions were made after the 1950s. This is possibly because there are fewer crew on-board the newer vessels, raising the important question of how many collisions are going unnoticed.

Revealing the True Numbers

Quantifying vessel collisions with whales is an enormous challenge. The International Whaling Commission (IWC) maintains a worldwide database of whale collisions to which nations voluntarily contribute data. But many incidents go undetected or unreported, and reporting rates can differ by location, species, and vessel type and size. For example, passenger vessels may be more prevalent in the data than cargo vessels simply because passengers are more likely to notice and report a collision. This inconsistent reporting rate can obscure the actual rate of collisions and make analysis difficult.

Despite these challenges, reported vessel strike data can provide useful insights and, at the least, give a minimum number of collisions that are occurring. In the worldwide database, the majority of records before the 1990s were from the Northern Hemisphere with little data from the Southern Hemisphere, and with only 61 reported collisions in Australia. To address this, we searched historical national and international print media archives for reports of vessel strikes globally, although with a focus on Australian waters. This search found 76 Australian records, providing new insights to historic rates of vessel collisions and more than doubling the number of known vessel strikes in Australia.

Quantifying and Mapping Risk

How can we minimize the risk and impact of collisions with whales? Several agencies and organizations around the world are actively considering the issue. This includes the IWC and the International Maritime Organization. In high risk areas, there are mitigation options available (e.g., education and targeted warnings when animals are seasonally present, speed limits, and re-routing in specific whale high-use areas).

In Australia, the National Environmental Science Programme (NESP) Marine Biodiversity Hub has funded a project to quantify the relative risk of vessel strike. This project is not only focused on collisions between larger vessels and whales, but the more general issue of collisions between all types of vessels (e.g., smaller commercial and recreational vessels) and also other marine fauna (e.g., dugong, turtles).

The aim of the NESP research project is to firstly identify and help prioritize which areas and species within Australian waters should be investigated. Secondly, it is to quantify relative risk of vessel strike and thirdly, to provide tools for the future to inform and compare mitigation options. One of the key outputs of the NESP project is to produce national-scale maps of the relative risk of vessel strike occurring with marine life. This risk is estimated in relative rather than absolute terms primarily because, while it is possible to robustly estimate relative risk (e.g., how much higher is the risk in one area compared with another), we lack much of the information required to estimate absolute risk (e.g., exactly how many whales are being struck). This missing information includes the proportion of animals that notice and avoid the vessels, and the time animals spend near the surface.

The use of relative risk and the associated data layers and maps can still provide powerful insights into the issue. For example, it is possible to compare:

The effect on relative risk due to management changes. For example, Smith et al. (2018) looks at the effect of changes to shipping routes in the Southern Great Barrier Reef on the risk of vessel strike with humpback whales;

Relative risk between sub-groups of the whale population. For example, Peel et al. (2015) found that based on the different areas the animals use, the relative risk to humpback mother-calf groups in the Great Barrier Reef from large vessels (≥80 meters length) was around 3 percent more than the risk for adult-only groups, and, for smaller vessels (<80 meters length), it was 64 percent more for mother-calf groups compared to adults; and

The difference in relative risk between locations and over time. For example, Peel et al. (2018b) examined a range of species around Australia and identified areas of higher relative risk compared to the whole coastline.



These relative risk maps and findings will not tell you if action is required, but they will tell you which locations and species should be looked at more closely. If action is needed, map-

An example of the changes seen in Australian humpback whale numbers (from Jackson et al. 2015) and worldwide commercial ship numbers (based on Lloyd's Register of Ships from Endresen, Sørgård et al. 2007). Source: Peel et al (2018a).



An example of the information used to get a final relative risk map for humpback whales and large vessels (>80m in length) in the Great Barrier Reef Area, Australia.

ping risk can then also be a powerful tool to help compare management options and help target mitigation to provide the most benefit.

The two key pieces of information we need to produce these risk maps are the density of both vessel traffic and whales. The vessel traffic density can be calculated from vessel's Automated Information System (AIS) data. Although originally designed for safety, AIS data provides an exceptional tool to understand and quantify shipping impacts. Calculating animal density is more difficult, especially covering the large areas of concern. Often the data available is patchy and collected using disparate methods, so it is difficult to combine the different sources into a single, integrated map. The obvious solution of course is to collect more data. However, the areas we are talking about are vast (e.g., Australia wide) and for rarer whale species, the task is akin to finding needles in a haystack.

"Why don't the whales just get out of the way?"

A common question we get asked is why don't the whales just get out of the way of vessels? The limited studies of whale behavior near vessels have reported a mixed response; some found strong avoidance of vessels whereas other showed no avoidance response, even to very close approaches. There are also differences between how individual whales react. For example, mother-calf groups may show different avoidance than single adults, feeding whales may show less avoidance than travelling whales, or there may be other external influences that effect the ability of whales to detect and/or avoid vessels. Ultimately, given the 137 reports of whales in Australia alone that have been hit by vessels, it is obvious some whales do not get out of the way.

Interestingly, looking at the witness statements from these events, there are a number of references to animals being motionless and "asleep" before being hit and then moving after being struck. Otherwise, many of the accounts simply describe the unlucky circumstance of the paths of the vessel and the whale crossing, and the whale being struck.

What does the Future Hold?

With current predictions for steady increases in global shipping, the future may seem foreboding for whales. At one end of the spectrum, there are species that are showing little or no signs of recovering from past commercial whaling which, in conjunction with other pressures, may be pushing them even closer to extinction (i.e., North Atlantic right whales). At the other extreme, species that have shown a healthy recovery since whaling ceased could become a victim of their own success, given that as whale numbers increase, so does the likelihood vessels and whales will meet. Therefore, the sight of injured or dying whales could become much more common place for these recovering species in future.

> In a worldwide context, do we rise to the challenge of reducing vessel strikes, or do we just accept the negative conservation, animal welfare and ethical issues? We believe that understanding and quantifying the risks is an important tool to develop pragmatic solutions to help shipping and whales to coexist and share the ocean.

Striving for Sustainable

Today's shipping industry has found itself within a cocoon of new and upcoming regulations stimulating an industry-wide transformation unlike any seen before. With the help of industry experts Wärtsilä, we take a look at the regulations (and challenges in meeting those regulations) catalyzing innovation in the sector and explore what the industry will look like as it emerges in a new, more sustainable form.

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Words by: Sebastiaan Bleuanus, General Manager in Technology Strategy & Innovation, Wärtsilä Marine Solutions



The global shipping industry transports some 80 to 90 percent of the world's goods. Although it is the least polluting form of transportation it is under growing pressure, now more than ever, to reduce its environmental footprint. In the near future, emissions legislations affecting those who operate on the oceans will continue to become ever more stringent, both locally and worldwide.

For the past 50 years, the United Nation's International Maritime Organization (IMO) has been responsible for regulating shipping and pollution issues. In that time, the agency has introduced many measures to prevent and control pollution from ships, and to mitigate the effects and damage from marine operations.

IMO ship pollution rules are contained in the "International Convention on the Prevention of Pollution from Ships," known as MARPOL 73/78. The MARPOL sets limits on emissions of nitrogen and sulfur oxides (NOx and SOx) from ship exhausts and bans deliberate emissions of ozone-depleting substances. These measures are meant to beneficially impact not just the atmospheric environment, but also the health of people living in or near port cities and coastal communities. It also outlines requirements for emissions and fuel quality around the globe and provides even more stringent rules for ships sailing in Emission Control Areas (ECA).

The ECAs are special ocean and coastal zones highlighted as areas in need of reduced nitrogen and/or sulfur oxide emissions. Today's ECAs include the Baltic Sea, the North Sea and the North American ECA, including most of the U.S. and Canadian coast, and the U.S. Caribbean ECA, including Puerto Rico and the U.S. Virgin Islands.

Greenhouse Gas Emissions

Under the 1997 Kyoto Protocol, the IMO was given responsibility for the handling of greenhouse gas (GHG) emissions from marine fuels. This was further addressed in April this year when strict targets were announced with a goal to reduce GHG emissions by at least 50 percent by 2050 compared to 2008 levels and with a view to phase them out completely in the second half of the century.

This agreement was welcomed by Wärtsilä, a Finland-based leading provider of products, systems, and integrated solutions for the marine industry. Jaakko Eskola, CEO of Wärtsilä, commented, "It is critical that we have an industry-wide framework for reducing emissions, and this sends a clear signal that we should all join forces in promoting carbon-free shipping."

Wärtsilä has long focused its development work on introducing technologies that reduce the environmental impact of shipping. As Eskola points out, "A clean shipping future must be based on the combining of different technologies and various solutions, including cleaner fuels, efficient vessel designs, hybrid propulsion technologies, and intelligent vessels."

There is no 'silver bullet' in the case of emissions, nor a one-size-fits-all solution. For instance, Wärtsilä offers a broad range of solutions for limiting GHG emissions including the development of gas and dual-fuel engine technologies, its industry-leading hybrid/electric propulsion solutions, and a portfolio of exhaust gas cleaning systems for vessels running on conventional marine fuels.

Designing for Efficiency

The IMO has established a series of baselines for the amount of fuel each



ship burns depending on how much cargo the vessel is carrying. It periodically sets progressively tougher targets so that by 2025, all new ships will need to be 30 percent more energy efficient than those built in 2014. To achieve this goal the design of the ship itself is very important.

The Energy Efficiency Design Index (EEDI) provides a specific figure for individual ship designs (expressed in grams of CO2 per vessel capacity mile): the smaller the EEDI, the more energy efficient the ship. It represents a combination of various parameters, including the ship's installed power, its size and speed, and the amount of cargo capacity.

Specialists, such as Wärtsilä Ship Design, are now incorporating these EEDI considerations into all new designs so that owners can achieve compliance with both known and the likely future rules and regulations. By focusing on fuel efficiency and enhanced environmental performance, harmful emissions can be minimized or entirely eliminated in line with the IMO guidelines.

Controlling Sulfur Oxide Emissions

The IMO's cap for sulfur emissions in sulfur-specific ECAs is 0.10 percent mass/ mass (m/m). Outside these areas, the global sulfur limit will be cut to 0.50 percent as from January 1, 2020. Today, it stands at 3.50 percent – a significant restriction that will call for rapid action on the part of ship owners and operators.

There are essentially three solutions for meeting this limit: switch to a fuel with low sulfur content, continue to operate on conventional fuel but with an exhaust cleaning 'scrubber system' installed, or switch to liquified natural gas (LNG) fuel.

To produce fuel with low sulfur content, further refining of heavy fuel oil and blending with gasoil will be essential, but this will also be very expensive. At the same time, there isn't a copious amount of low-sulfur fuel available today and it will likely remain limited for some time. This presents a major challenge for the industry since large ocean-going vessels have thus far only had to use low-sulfur fuel when sailing within ECAs. At other times they have normally operated on conventional 3.5 percent sulfur fuel, and having to permanently comply with the IMO's sulfur legislation will lead to changes in the marine sector far more reaching than previously ever seen.

The second alternative for meeting the global 0.50 percent limit is to clean the exhaust gases of SOx using a scrubber system. Given the high price of low-sulfur fuel, many owners have already opted for SOx scrubbers in their new ships. The anticipation is that the additional investment will pay itself back within a reasonable time-frame since it allows the ship to operate on conventional heavy fuel oil.

The third, and perhaps most promising, alternative is to switch to LNG fuel. Of all the fossil fuels, natural gas is the cleanest. It contains no sulfur and reduces GHG emissions by 13 to 30 percent. The bottleneck holding back greater use of LNG as a marine fuel has traditionally been the ability to refuel. The LNG infrastructure, however, is being developed, and here again, Wärtsilä is playing an important role with its competences in designing and building small to mid-size LNG storage terminals and regasification and liquefaction facilities.

Consequently, an increasing number of new ship orders specify an LNG fuel capability, and there are many good arguments to support this trend. While retrofitting existing vessels to operate on LNG requires a considerable investment, this too is increasing in popularity.

Generally speaking, sailing on LNG fuel seems to be a very attractive long-term solution, while using conventional fuel with after treatment systems such as scrubbers, might be the better short-term option due to the lower investment cost.

Controlling Nitrogen Oxide Emissions

Switching to LNG fuel is also a viable option for meeting the IMO's NOx emission regulations since dual-fuel engines running on gas emit 85 percent fewer NOx emissions than a diesel-fueled engine.

New ships will have to comply with the IMO's Tier III regulations when operating within ECAs. This means that the NOx emissions will have to be 80 percent lower than limits outlined in 2000.

Diesel engines can only meet the Tier III restrictions by using catalysts, i.e., Selective Catalytic Reduction units. An alternative might also be to use Exhaust Gas Recirculation, although this technology has drawbacks in fuel consumption and is currently incompatible with fuels containing more than 0.1 percent sulfur.

Hybrid and All-Electric Propulsion

Ships sailing shorter distances, such as ferries, are already using all-electric, battery-operated propulsion. Properly designed, it's the most environmentally sustainable means for ship propulsion today, and even for greater distances, partial electrification with hybrid diesel engine/battery systems will allow emission-free sailing when cruising in ECAs or close to shore.

As energy storage systems become more efficient with greater capacities and lower costs, hybrid systems are being featured more and more on a variety of vessel types. They are particularly relevant to ferries since they are more likely to be operating within areas covered by strict environmental regulations such as coastal towns or areas of natural beauty.

A Vision for Future Shipping

The combined driving forces of stricter environmental legislation and the need to remain competitive by lowering operational costs are forcing a transitional change in the maritime industry. Consequently, a new era of even higher efficiency, environmental sustainability, and increased safety is emerging.

This is impacting all aspects of shipping, from ship design to daily operations, including sailing at the lowest possible speeds, ensuring the highest "fill rates," optimal route selection, adjusting the ships angle in the water to reach the least resistance, and many more.

At the same time, technical measures are rapidly being developed to improve vessel performance with the main goal of using the least amount of energy to propel the vessel by enhancing hull design, optimizing the propulsion system, and creating the most efficient onboard power generation. All of these measures reduce fuel consumption, which in turn lowers the exhaust emission levels.

One of the most critical megatrends that will impact the future of shipping, however, is the ongoing transformation towards digital. Digitalization is benefitting society at large and will undoubtedly have a positive impact on the shipping industry in the near future. Wärtsilä's 'Smart Marine Ecosystem' vision foresees smart vessels sailing between smart ports in an environment of optimal efficiency and minimized emissions.

The industry is moving towards a time when autonomous shipping will change from concept to operational reality. Digitalization is critical to this trend, and to many other initiatives that will make shipping cleaner, more efficient, and environmentally sustainable in the future.

Stemming the Flow: Monitoring Emissions at Sea

Figure 1. By some estimates, shipping accounts for 2% of global emissions. Real-time monitoring of exhaust gases helps operators manage emission output more effectively.

From fenceline and volcanic gas monitoring to collecting remote measurements of coastal erosion, the evolution of portable spectral sensing tools has enabled scientists to gain invaluable insights for a growing number of environmental applications. Spectroscopy experts, Ocean Optics, reveal how optical sensing methods can provide a much-needed solution for monitoring the harmful emissions from ships that are entering our atmosphere.

Words by: Rob Morris, Knowledge Manager, Ocean Optics

A lthough catastrophic environmental events like the *Deepwater Horizon* oil spill typically capture the headlines, ongoing issues like pollution from plastics and exhaust emissions from ships play a more significant role in future sustainability of ocean environments.

For example, 2 percent of global emissions are estimated to come from shipping, even with ongoing efforts to improve ship operation and growing awareness of factors affecting climate change.

The issue is important enough to inspire action by members of the United Nations International Maritime Organization (IMO), which, in early 2018, pledged to cut shipping industry carbon emissions in half by 2050. Technological tools are helping to stem the tide of unchecked atmospheric emissions. Consider optical sensing methods such as spectroscopy, which are helping to provide both marine sensor developers and ship operators with solutions for monitoring exhaust emission gases including nitrogen oxides (NOx), sulfur dioxide (SO2) and ammonia (NH3).

Spectroscopy is well suited to emission monitoring, providing non-destructive, real-time measurements. As spectral devices have become faster, more powerful and easier to integrate into other devices, applications once considered impractical are now achievable. Bringing the spectrometer to the sample is critical for applications where real-time, in situ measurements help to analyze environmental conditions and to monitor important trends (Figure 1).

The Evolution of Miniature CCD-array Spectrometers

In recent years, the trend among developers of spectrometers of all types has been to make the instruments more compact, simpler to use and with more options for managing the data the spectrometer captures. Our focus here is on silicon CCD array-based spectrometers and their relevance to environmental technology.

When miniature CCD array-based spectrometers were introduced in the 1990s, they benefited from a perfect storm of technological circumstances: the development of detectors for mass-volume markets, which lowered system costs dramatically and allowed designers to make the instrument footprint much smaller and more portable than with traditional instruments; the evolution of computing technologies, which allowed spectrometers to process high-speed, high-resolution spectral data; and the growth of fiber optics, which made it much easier to bring the spectrometer to the sample.

Today's CCD-array miniature spectrometers are as powerful and adaptable as ever, with great flexibility in how they can be configured to be a complete solution or integrated into other instrumentation as a component or subassembly (Figure 2).



Figure 2. Modern miniature spectrometers are powerful and adaptable, making their measurement capabilities attractive for integrating into other sensing devices.

Perhaps even more important, microprocessors can replace laptop PCs for data collection and processing, making handheld operation possible and opening the door for the addition of wireless and similar capabilities. This adds another dimension of portability, as spectrometers have been attached to drones and ATVs, used in floating labs and even used by scuba divers to take measurements of corals and other underwater specimens.

Silicon CCD-arrays are limited by the inherent response of the detector, which starts at about 200 nanometers and cuts off at 1100 nanometers. Different detectors can be used for re-

sponse at near-infrared wavelengths. But for those measuring exhaust emissions, the most meaningful exhaust gases have at least some response in the UV, an area of the spectral region where certain types of CCD detectors have strong native response.

Exhaust Emission Instrumentation for Ship Operators

The maritime industry faces various challenges related to exhaust emission from ships: monitoring requirements driven by evolving regional and international regulatory requirements; commercial needs that put a premium on timely, cost-effective and scalable technical solutions; and practical considerations related to sensing instrumentation built for simple operation and demanding marine environments.

Regulatory concerns alone can be daunting, with rules varying by gas type, ship engine speed and emission control area (different ocean regions). Also, there is no agreed upon set of regulations, as both the IMO (via its International Convention for the Prevention of Pollution from Ships) and regional factions devise their own gas-specific protocols.

Fiber optic spectrometers are among the optical sensing tools that sensor developers and ship operators are using to address exhaust emission measurements. In addition to the immediacy of the measurements they provide, these spectrometers can be integrated into marine sensors to monitor exhaust parameters more cost-effectively and with greater flexibility.

For instance, Danfoss IXA (Vejle, Denmark), which provides sensors for the maritime industry, has developed an emission sensor that uses spectroscopy to provide continuous measurements of NOx, SO2 and NH3. This system takes advantage of the benefits of optical spectroscopy but has been adapted to withstand harsh marine conditions and ensure minimal maintenance during lengthy voyages.

Danfoss IXA is part of the Danfoss Group, a global company focused on delivering products and services that promote energy efficiency, safety and reliability. Danfoss IXA provides sensors and systems for the maritime industry, with its focus on optimizing energy consumption and monitoring emission gases from ships.

"We identified an opportunity to provide the maritime industry with a solution for emission measurement that would help ship operators overcome many of the challenges related to existing solutions," said Finn Haugaard, Supply Chain Manager for Danfoss IXA, which recently introduced a marine emission sensor for continuous measurement of emission gases. "To choose spectroscopy was a rather easy choice, as the technology had already proven to be effective in measuring, for example, sulfur, ammonia and various NOx gases." Although the use of spectroscopic methods for exhaust emission analysis is not new, at least some of the techniques traditionally employed are complex. For example, mass spectroscopy can be a slow technique to carry out and may not respond as quickly as changes that occur in the exhaust emission spectral output. With today's modern optical spectroscopy devices, the monitoring system can be mounted directly onto the stack to measure the gases in situ, versus an extractive technique that involves removing the gas sample from the stack for analysis. Even small savings in time and improvements in efficiency can make the total cost of ownership of in situ emission monitoring systems quite reasonable.

Differential Optical Absorption Spectroscopy for Gas Analysis

Differential Optical Absorption Spectroscopy (DOAS) is a method used to determine trace gas concentrations, by transmitting UV or visible light through an open path or fiber probe and measuring the unique absorption characteristics of each gas.

DOAS is a reliable technique for measuring gases that absorb in the UV. In addition to measuring exhaust emissions from ships, DOAS is used for environmental applications such as fenceline monitoring and volcanic gas monitoring. Fenceline monitoring involves deploying portable spectroscopic instrumentation to measure gas emissions that leak from industrial sites, creating potentially unsafe conditions. Volcanologists use DOAS to measure gases emitted from volcanoes including sulfur dioxide (SO2) (Figure 3), which is a major air pollutant associated with respiratory diseases and breathing problems.

Different applications of DOAS for ship exhaust emission monitoring may be employed. In some instances, land-based set-



Figure 3. Gases like NOx and SO2 are found in volcano and ship exhaust emissions. Similar measurement techniques are used for both applications.

ups comparable to fenceline monitoring stations have been used for ambient air sampling at the harbor. Remote sensing from both helicopter and ship-based instruments also have been used, although these options have limitations including an inability to monitor conditions associated with ship operation at sea.

Other devices (like the Danfoss sensor) take advantage of how effectively the sensor can be integrated into the stack aboard the ship. "Our sensor is based on UV absorption spectroscopy," said Haugaard. "UV light is emitted into the gas and a detector – the spectrometer, in this case – measures the amount of light absorbed by the gas. The sensor's computer contains a digital library with the 'fingerprints' of the supported gases and by comparing what we see with [data from] a reference library, we can calculate the exact concentration of each gas."

Armed with accurate, up-to-date emissions data, ship operators can better control their exhaust gas treatment systems by adjusting NOx-reduction systems, switching fuels or taking steps to improve fuel consumption. Also, if the ship's GPS is connected to the sensor, the stored data provides detailed continuous emission monitoring results from throughout the entire shipping route. This is valuable data to prove regulatory compliance and to analyze gas emission trends related to ship size, speed and engine operation.

Developing real-time marine sensors based on DOAS techniques is not without its challenges. Although proving measurement feasibility can be accomplished relatively quickly with a modular spectrometer system, making it seaworthy is a bit more involved. For example, Danfoss and Ocean Optics worked closely for nearly three years to optimize the spectrometer for DOAS measurement of ship emissions. Indeed, the system must be ruggedized to withstand the high temperature and vibration conditions at sea, for trips lasting up to six months at a time – an engineering task requiring a careful combination of mechanical and optical design expertise (Figure 4).

Fortunately, there's a long history of miniature modular spectrometers being customized for use for demanding conditions, from setups deployed inside active volcanoes to systems used aboard spacecraft. Without any moving parts to account for, today's generation of miniature spectrometers are inherently rugged. Combined with more robust optical designs – components that mitigate the effects of temperature changes and the like – these spectrometers become a compelling option for applications like exhaust emission monitoring.

Making the most effective use of the exhaust emission measurements is another challenge. As Haugaard explains, achieving high quality measurements from exhaust gas, which contains significant amounts of hot steam and particles, was



Figure 4. A spectrometer assembly, shown here inside the Danfoss sensor housing, has been ruggedized for challenging conditions at sea.

probably the most complex issue Danfoss faced in developing its marine sensor. Additional factors involve accounting for exhaust gas pressure and temperature, and employing calibration protocols to ensure reliable results.

Environmental Applications Beyond the Exhaust Stack

Optical sensing technologies such as spectroscopy have remarkable potential to provide better insight into environmental monitoring applications, from open-path air quality monitoring in smog-choked cities to remote sensing measurements of coastal erosion. This insight – a type of applied spectral knowledge – can help researchers, government regulators and manufacturers make precisely informed decisions. "As in most other industries, the need for timely and reliable data is growing in the maritime industry," explained Haugaard. "This is driven by a desire to facilitate and accelerate continual improvement of safety and efficiency.

"Optical sensing technologies have already made their way into many different industrial applications onshore, proving that the technology is both commercially relevant as well as technologically stable and mature. The maritime industry can easily become the next big playfield for future marketers offering solutions based on optical sensing."



By: Brook Peterson, Waterdog Photography

On the morning of February 17, 1944 American forces launched Operation Hailstone, a three-day attack on the most formidable Japanese stronghold in the Pacific Ocean. Then known as Truk Lagoon, this bay held a large portion of the Japanese fleet. In just three days, more than 50 ships, including submarines and airplanes were sunk in the waters of the lagoon.

Today, divers delight in the exploration of these sunken treasures. The ships are heavily encrusted with new growth and have become artificial reefs for the natural inhabitants of the lagoon. Many of the ships are covered with anemones. Soft corals in reds, yellows, and purples can be found in abundant clusters along with sponges and other growth along masts and railings. Fish, manta rays, sharks and even turtles inhabit the wrecks. The graveyard now thrives with marine life.





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Coral Reefs will Struggle to Keep Up with Rising Sea Levels

By Jessica Fairbrother, Institute of Marine Sciences, University of Portsmouth (UK)

Sea levels have risen by up to eight inches over the past century due to climate change and show no signs of slowing down. Now, research led by scientists at the University of Exeter have found that already vulnerable coral reefs could be 'drowning' in seawater by the end of the century.

A study, published in *Nature*, has found that coral reefs won't be able to grow fast enough to keep up with the predicted increase in sea levels by 2100.

"These findings highlight a major consequence of ecological decline on these very iconic marine ecosystems. Namely that they are losing their potential to keep pace with accelerating rates of sea level rise," explains lead author Professor Chris Perry.

Coral reefs are home to 25 percent of all marine life, and rivals that of the tropical forest of the Amazon or New Guinea. In recent years, coral reefs have been on the decline due to a range of anthropogenic and environmental factors. It is thought that one-quarter of coral reefs worldwide are considered damaged beyond repair, and two-thirds are under serious threat.

In the study, researchers calculated growth rates from more than 200 tropical western Atlantic and Indian Ocean reefs. They found that even under the most modest climate change predictions, only 3 percent of Indian Ocean reefs will be able to keep up with the rising sea level projections.

If current high emissions continue at today's rate, then most reefs will experience an increase in sea level rise of over half a meter. Reefs also play a key role in shoreline protection by acting as a natural sea defense and limit coastal wave energy exposure. Professor Perry says "[with rising sea levels] their role as coastal protective structures will be diminished and this will have major consequences for many low-lying coastlines and reef islands."

"Now more than ever, we must limit global greenhouse gas emissions. Our predictions, even under the best-case scenarios, suggest that by 2100 the inundation of reefs will expose coastal communities to significant threats of shoreline change," said co-author Professor Peter Mumby of Coral CoE at the University of Queensland. "Healthier coral reefs will reduce the rate of seawater inundation."

Other major factors that also threaten coral reefs include destructive fishing practices, overfishing, careless tourism, and pollution. The combination of all these factors may lock reefs into permanent low growth rates and lead to a higher level of submergence in future sea level rise scenarios.



Illegal Trade of the Angelshark Identified using DNA Barcoding

By Alice Walsh, Institute of Marine Sciences, University of Portsmouth (UK)

The angelshark (genus Squatina) was once common throughout the coastal and outer continental shelf in the Northeast Atlantic. Mediterranean and Black Seas. Today, due to intense fisheries and bycatch, this species is now labeled as critically endangered in the IUCN Red List of Threatened Species. Increasing fishing pressures along with the slow life history of angelsharks makes them susceptible to overexploitation, and characteristics such as late development and low reproductive levels impact the rate of population recovery.

T he coastal waters of Brazil are rich in biodiversity and offers favorable fishing sites. In Southeast Brazil and Patagonian central Argentina, four species are found and overexploited in coastal waters: the spiny angelshark (S. *guggenheim*), the Argentine angelshark (S. *argentina*), the hidden angelshark (S. *occulta*) and the Atlantic angelshark (S. *dumeril*).

Fishing has been very loosely monitored in the past until The Federal Constitution was amended in 1988 to conform with the 1972 UN Stockholm conference on international environmental problems this was a turning point in the expansion of international environmental politics. Although there are rules and regulations around the conservation of these species, the local fisheries regularly catch and market these animals, and monitoring is complicated due to a lack of in-



Angelshark in clear waters of Japan

formation about catches and commercial sales.

Physical features such as size and shape (known as morphological information) has historically been the main method scientists use to identify fish, but this approach requires extensive training and experience. Identifying fish to the correct species level using this approach alone can also be extremely difficult, especially when species are closely related and share physical traits.

In a recent paper, published in *Fisheries Research*, scientists have found that new molecular genetic tools can be used to identify animals at a taxonomic level using techniques involving genetic DNA markers to identify specific genes, also known as DNA barcoding.

Ingrid Vasconcellos Bunholi, a student at the Federal University of Sao Paulo, Brazil, and a team of researchers have obtained breakthrough results which allow future conservation of these marine organisms. DNA extraction of 85 carcass samples were retrieved from Brazilian industrial fishing bottom trawlers between 2015-2016. Scientists used morphological traits to initially identify samples. Sequencing techniques were then used to compare similarity using a 'similarity threshold' of 99 percent to qualify for their results database.

Overall, the scientists found that all 85 individuals were genetically identified as

shark with similarities between 99.73 percent and 100 percent. The majority of which were found to be the spiny angelshark (88.23 percent) as well as finding some specimens of the hidden angelshark (5.88 percent) and Brazilian guitar fish (5.88 percent). All three were on the Brazilian list of 'Endangered Species – Fish and Aquatic Invertebrate.'

Over 90 percent of elasmobranch species (which include sharks, skates, and rays) are listed on the IUCN Red List with around 16.5 percent in the threatened categories and more than 40 percent listed as "Data Deficient" (IUCN, 2017).

Researchers have now started to use molecular markers to identify elasmobranch species to help reduce the risk of fraudulent labeling.

In the paper, the authors noted that this method "should be proposed as a standard procedure for identification of species in Brazilian fish landings and in the surveillance of commercial products along the production chain through the final delivery of fish products to consumers."

Effective marine policy planning will have huge benefits for the conservation and biodiversity of the angelsharks. Implementing stricter regulations for fish identification will help to make long term conservation effects more effective, and DNA barcoding has proven to be a powerful tool in monitoring and conservation.

Presenting Science to a General Audience

Words by: Laura Michie, Project Manager at The Chatty Scientist

Giving presentations is an important part of disseminating research and there is a growing necessity for scientists to present to audiences outside of the academic community. Presenting can be difficult, especially in an era when funding, research impact, and public perception rely so heavily on communicating effectively with a broad audience. The impassive way that scientists are expected to communicate in journals is usually not appropriate when communicating with the public, which often requires scientists to step out of their comfort zone and connect people to the research on an emotional level.

It is possible to engage with the public and clearly communicate your research without compromising the ideas and scientific rigour. Here are five tips for presenting science to a general audience:



Know your Audience and Start Strong

As you prepare the presentation remember: it's not about you or how much you know about this topic. Only share what the audience needs and wants to know. To successfully communicate, it is crucial to understand your audience and to be aware of their background, knowledge base, and interests so that you can adapt your content to them. Look for opportunities where you can create connections to their everyday lives, whether it's by referencing the local football team or mentioning items they regularly use to explain complex concepts.

The beginning of your presentation is crucial. You only have a few moments to grab their attention and hold it before they decide if you're worth listening to, so start strong. A short story about yourself helps to build trust and rapport between you and the audience and an eye-catching image can help grab their attention before you begin.

Answer the 'So What?' and Define your Message

The most important thing is to present ideas clearly: it's easy to lose the attention of an audience if you use too much scientific jargon and overload them with details they're not prepared to understand. Write down no more than three points you want your audience to remember and build the presentation around this. If what you are about to say doesn't relate to that core message, then don't say it. You should also be able to communicate that information in a brief and concise manner. Try writing a 30-second 'elevator summary' before you start on your presentation.

One of the most important questions your audience will ask is 'so what?'. Make sure you explain how it impacts them and why they should care within the first few minutes of your presentation.

Tell a Story

Stories, analogies, and real-life examples enable an audience to engage with scientific content and help technical information come alive. Your audience is more likely to connect with and remember your points if you use these communication tools in your presentation. Think about what story you can tell your audience that will help them engage with your work, then design your presentation to tell it.

Don't Overload Slides

The main purpose of a presentation is to help you explain a topic in as few words as possible, without losing the core message. When you use text-heavy slides, it can lead to cognitive overload and your audience will likely switch off. Embrace the white space as it will help draw the audience's eye to the most important information while you explain with complimentary and compelling narrative. Remember, a picture is worth a thousand words.

Be Dynamic

While content is an important factor in any scientific presentation, don't underestimate the impact of delivery. No matter how compelling your subject, the audience only embraces the message to the degree you present it. Audiences engage with passionate speakers, so allow that to come through when you present. Enthusiasm is contagious. It is important that your delivery feels natural for you, which will take practice. Finally, remember to pause from time to time to allow your listeners to understand what you have said and prepare for what you are about to say.

For more resources and advice about communicating science, head over to www.chattyscientist.com

Share your science with audiences around the world.

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Product and Service Focus: Three Steps to Increase Port Efficiency in the Planning Stage

Words by: Stefan Leschka, DHI Water & Environment Inc.

New dynamic mooring analysis tool allows even better planning of port layout.

Understanding how moored vessels respond to dynamic wind, wave, and current conditions is essential to port authorities, terminal operators, as well as master planners and designers. A port planner knows the efficiency of a terminal could already be decided during early port planning stages – just by looking at predicted vessel motions. There's a way to do so even more efficiently. In the initial planning process, all kinds of dynamic impacts should be included in the picture. Here are three steps to ensure optimal port efficiency:

Consider the Boundary Conditions

A port planner needs to take into account many boundary conditions, such as space for the pier operator for cargo handling, transport, facilities, as well as space needed by the vessels for bypassing and turning. Environmental aspects such as aiming for a calm harbor basin should be considered as well as breakwaters. Try to reduce currents and if possible, have the quay lying in such a direction that the wind will often push the moored vessel into the fenders. These considerations will reduce vessel motions. Smaller vessel motions mean higher terminal efficiency.

Apply Extreme Value Analyses and Numerical Modeling

Predictions for wind conditions and different kinds of waves and currents in a port can be made by using long-term measurements and numerical modeling, which affect berthing conditions. For example, long period waves (swell, long fetch lengths, passing vessels) can reduce the operability of terminals. Combined with extreme value analyses, a port planner would know how often each condition is likely to occur.

Conduct Dynamic Mooring Analyses

The data above should be used directly in dynamic mooring analyses, which provides vessel motions, line, and fender forces. With such a tool, meteorological and hydrodynamic data in a test matrix can be combined freely. The impact

of passing vessels can be incorporated, taking into account that waves and currents can be very different over the entire vessel length.

So how can mooring analysis be done even more quickly and accurately?

The answer lies in a quick tool that allows the testing of an entire matrix in a batch, enabling precise insight into the vessel motions that need to be expected in the port design. This tool helps pre-



Dynamic impacts to be considered during port planning

dict port downtimes and has the ability to test different designs. It allows you to improve the efficiency of your port by selecting the design that gives the lowest downtimes.

The dynamic mooring analysis software MIKE 21 MA features a straightforward and user-friendly interface that anyone can learn to use.

What can be achieved with MIKE 21 Mooring Analysis (MA):

Safe and efficient cargo handling operations - Check mooring configurations under extreme conditions to ensure the safety of a berthed vessel.

A flexible tool for ongoing planning and operation - Marine pilots and operators can quickly check on the safety of the applied the mooring system under present conditions.

Reduced downtime and operational costs - Save costs by identifying adverse conditions for operations in open seas and ports in advance.

Optimization of mooring and fender arrangements - Test and improve mooring arrangements and simply select the solution that works best.

600-Mile Cycle Challenge Raises Over £10,000

A team of seven riders from the Energy Industries Council (EIC) have completed a cycle challenge which took them the length of the U.K., raising over £10,000 for Cancer Research UK and The Ocean Cleanup. The 600-mile bike ride, started from the EIC's Aberdeen office on June 7, stopped in at its Teesside location, and ended at the trade association's London HQ on June 12, with the team travelling over 130 miles on some days. The challenge forms part of the EIC's 75th anniversary celebrations, with proceeds from all anniversary events being divided equally between the two charities selected by EIC staff.

New Platform Promotes Research in Polar Sciences

Springer has launched a unique platform dedicated to research in polar sciences. The platform aims to develop a comprehensive collection of books, open access publications, journal articles and reference works published as part of Springer's polar sciences program. It also features interviews with leading researchers in the field and provides an overview of publication options. In the continuing scenario of climate change, interest in polar sciences is rapidly expanding. To meet the changing needs of the research community, Springer has significantly expanded its polar sciences program in the recent years.

Wave Gliders Collect Live Ocean Data from Hawaii's Kilauea Volcano Lava Flow

Liquid Robotics announces the deployment of two *Wave Gliders* to capture live ocean data close to where lava is flowing into the ocean from Hawaii's Kilauea Volcano.

Over three weeks, the *Wave Gliders* will operate a precise zig zag course, approximately 300 meters from the lava flow plume collecting rare subsurface, surface and atmospheric data. Working with top researchers from the University of Hawai'i at Hilo, Massachusetts Institute of Technology (MIT), and the U.S. Geological Survey's Hawaiian Volcano Observatory (USGS-HVO), the *Wave Gliders* host a wide assortment of sophisticated sensors to measure: water temperatures, oxygen levels, pH levels, salinity, turbidity, conductivity and underwater acoustics. The *Wave Gliders* will stay on station, continuously capturing sustained, high-resolution measurements and imagery throughout the mission.

"The effect of this massive lava flow entering the ocean is dramatic and amazing, but at the same time somewhat mys-

terious," said Roger Hine, CTO and co-founder of Liquid Robotics. "Detailed measurements of the ocean plume and the ecosystems it impacts are now possible and safe to obtain with unmanned systems like our *Wave Gliders*. This is an opportunity of a lifetime to deploy our ocean robots to help advance science." By using an unmanned ocean robot vs. sending a research ship, researchers can collect scientific data on this rare volcanic event without risk to humans.

"The plume of hot, sediment-laden water generated by the lava flowing into the ocean spreads out, impacting surrounding ecosystems and permitted boaters operating in the area," said Dr. Steve Colbert, University of Hawai'i at Hilo. "We don't know how far and how deep that plume extends, or how it changes with oceanographic conditions or changes in the flow of lava. The *Wave Gliders* provide us the opportunity to answer these important questions."

Data collected by the *Wave Gliders* will also help scientists observe in real time the impact of volcanic eruptions and lava flows on marine life (coral reefs and fish populations) and air quality affecting the Hawaiian Islands. As a company with roots on Hawaii island and a dedication to care for the environment and Hawaii's communities, understanding the quality of the lava haze generated by Kilauea is of great importance.

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Keeping Fisheries Sustainable with New Acoustic Technology

Words by: Nortek

With fish and other marine life becoming increasingly important for feeding our growing human population, science-based fisheries management is crucial to keep stocks sustainable. How can acoustic-based scientific instruments contribute in this respect, while also opening up opportunities for interdisciplinary scientific research?

• o keep stocks sustainable, fishery scientists and managers need to understand the dynamics and structure of fish stocks, as well as the resources those fish depend on. What scientific instrumentation can be used in this respect? Echosounders can help us quantify the biomass and behavior of fish, as well as the plankton and/or krill that many fish species eat. Acoustic Doppler Current Profilers (ADCPs), on the other hand, provide information about currents, which can shape the availability of plankton. "It used to be that the biological oceanographers could work in one place, while the physical oceanographers worked separately somewhere else," says David Velasco, lead author of a paper on a combined ADCP and biological echosounder system called Signature100 presented at the Oceans'18 MTS/IEEE Kobe/Techno-Ocean 2018 conference. With fisheries management beginning to take on a more holistic ecosystem approach and funding becoming more limited, collaborations between physical and biological scientists are coming to fruition more and more. Scientific instrumentation therefore needs to follow suit to match these changing needs.

Providing the Tools for Collaborations between Physical and Biological Scientists

The Signature100 lends itself well to collaborations between physical and biological scientists, since it uniquely combines the capabilities of an ADCP and a biological echosounder in one. It is currently the only instrument in the world providing this combined capacity. "The biggest advantage of combining an ADCP and a single-beam, wide-band echosounder as on the Signature100 comes down to costs and logistics," says Velasco. "Currently, scientists wanting to study both physical and biological aspects need to purchase two separate pieces of equipment, each deployed separately. With the Signature100, however, instead of having to deal with two moorings and two separate installations, you just have one," he adds. Since the samples from the ADCP and echosounder are already accurately synchronized with each other in the one instrument, processing the data afterwards also becomes much more efficient.



Providing Information on the Movement of Marine Life

As reported in the IEEE paper, sea trials of the Signature100 in the Mediterranean Sea have demonstrated the high performance of this novel instrument. Focusing on the echosounder performance, a 70 kHz pulse (one of the three frequencies available in the system) was able to provide information on the movement of marine life. Acoustically, a single fish can look very similar to a school of plankton of the same volume. For users to determine whether they are looking at one fish or a mass of plankton, and assess how big the individuals are, it is important they calibrate their echosounder for absolute backscatter. For the purposes of this initial field test, the Signature100's echosounder was not calibrated for absolute backscatter, but from the movement patterns seen in the echograms the team is confident they detected the migration of plankton up and down the water column. Nortek is currently developing a way for users to calibrate the echosounders to enhance the instrument's identification potential.

Identifying Internal Waves in the Ocean

For those more interested in physical oceanography, the Signature100's echosounder beam used in the field validation in the Mediterranean Sea also identified internal waves towards the bottom half of the water column. Meanwhile, setting the ADCP to transmit 60 pings at 0.25 Hz on a 5-minute repeating sequence, and with a profile of sixty 10 meter depth cells, the tested instrument was able to profile currents through a maximum usable range of up to 420 meters.

Enabling Long-Term Deployments for Deeper Scientific Understanding

Although the field test lasted only five days, thanks to the remarkably low power consumption of the unit, in other deployments the Signature100 can collect data for up to a year. The data retrieved from such a long-term deployment can help scientists understand the seasonal dynamics of an area and play a role in understanding the longer-term impact.



The Central Florida chapter of the Florida Association of Environmental Professionals (FAEP) has been selected to host the 2018 annual conference in Orlando, Florida!

September 19th-21st, 2018 Doubletree by Hilton, at Universal Orlando

Book your hotel room, sponsor, and learn more at: www.cfaep.org/faep-conference

CFAEP will be hosting the conference, in collaboration with the Transportation Research Board of the National Academies.





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TRANSPORTATION RESEARCH BOARD

Acoustic Zooplankton Fish Profiler Food Web Study of Keystone Arctic Marine Species

The Central and Arctic Division of Fisheries and Oceans Canada has plans to deploy an array of three multi-frequency Acoustic Zooplankton Fish Profilers (AZFPs-manufactured by ASL Environmental Sciences) in the Amundsen Gulf in 2018. Data retrieved from the array will be used in conjunction with winter and summer net sampling programs to better understand the early life history of Arctic cod and zooplankton copepod, which are keystone species in the Arctic marine food web.

First Textbook on Ocean Renewable Energy has been Published

A textbook has been published on the fundamentals of ocean renewable energy by Bangor University ocean energy expert Dr Simon Neill, in collaboration with Dr Reza Hashemi at the University of Rhode Island. It is the first book on this new topic. Published by Elsevier, it covers a range of marine renewable energy topics, including the fundamentals of energy conversion, the physics of wave and tidal energy, and how to measure, model and optimize the ocean energy resource.

Aqua-Tools' B-QUA Nominated for Seatrade Clean Shipping Award

Aqua-tools' B-QUA ballast water monitoring technique has been nominated in the Clean Shipping category of this year's Seatrade Awards. Marc Raymond, Aqua-tools' founder and CEO, said: "To be nominated for a Seatrade Award so early on is indicative of the important commercial and technical role the industry believes effective, rapid water sampling and testing will have to play in meeting the Ballast Water Management Convention's requirements."

The Ocean Cleanup Announces Official Technology Partner

The Ocean Cleanup announces Seiche Water Technology Group (SWTG) with AutoNaut as its Official Partner for Environmental Mitigation Technologies. SWTG confirms it will be providing an AutoNaut unmanned surface vessel and a suite of mitigation technologies to monitor and help ensure the protection of marine-life during the first-ever deployment of an ocean cleanup system by the Dutch non-profit, The Ocean Cleanup. Hydrophones deployed via PAM buoys will be installed and operated by Seiche personnel. Assistance will also be provided by SWTG to ensure that the highest environmental standards are met throughout.



Upcoming Conferences

Baltic Blue Biotechnology Conference www.submariner-network.eu/projects/ balticbluebioalliance/conference	August 22-24 Greifswald, Germany	BLUE BIOTECHNOLOGY IN THE BALTIC SEA REGION From Science to Business
Asian Wave and Tidal Energy Conference www.awtec2018.com/	September 9-13 Taipei, Taiwan	awtec
Challenger conferences.ncl.ac.uk/challenger-2018/	September 10-13 Newcastle University, UK	Challenger Conference 2018
Ocean Renewable Energy Conference pacificoceanenergy.org/orec2018/	September 18-19 Portland, Oregon	Ocean Renewable Energy Conference Leadership, experience, solutions
FAEP www.cfaep.org/faep-conference	September 19-21 Orlando, Florida	CFAEP
WindEnergy www.windenergyhamburg.com/en	September 25-28 Hamburg, Germany	WindEnergy Hamburg The global on & offshore expo
RENEW www.centec.tecnico.ulisboa.pt/renew2018	October 8-10 Lisbon, Portugal	RENEW 2018
AWEA Offshore WINDPOWER www.awea.org/events/event.aspx?eventid=50111	October 16-17 Washington, DC	AWERA. AMERICAN WIND ENERGY ASSOCIATION
OCEANS'18 charleston18.oceansconference.org	October 22-25 Charleston, South Carolina	OCEANS CONFERENCE & EXPOSITION
Offshore Energy www.offshore-energy.biz	October 23-24 Amsterdam, The Netherlands	OFFSHORE ENERGY18

Ocean Infinity Donates Data from Malaysian Airliner Search to Seabed 2030 Project

The Nippon Foundation-GEBCO Seabed 2030 Project, which aims to map the entirety of the world's ocean floor by 2030, is to receive 120,000 square kilometers of data from Texas-based surveying company, Ocean Infinity. This data will be incorporated into the latest version of the global map of the ocean floor.

So far, only a fraction of the ocean floor has been mapped with direct measurement. Ocean Infinity's data was collected by a fleet of eight autonomous underwater vehicles (AUVs), enabling the surveying company to gather data much more quickly than traditional mapping missions during its recent Indian Ocean search for the missing Malaysian airliner, MH370.

"Our deep-water search for MH370 demonstrated the most rapid collection of high-resolution sonar data in history, and we are thrilled, on World Hydrography Day, to announce our donation to such a pioneering initiative," announced Oliver Plunkett, CEO of Ocean Infinity. The AUVs were transported to the search area by the research vessel, *Seabed Constructor*, and each housed industry-leading technology including a multibeam echosounder, sub-bottom profiler, HD camera and a wide array of sensors.

Commenting on the partnership, Plunkett continued, "We are very proud to be supporting the Seabed 2030 initiative, which is leading the effort to collect previously unknown data of the ocean floor. Given how little of the seabed has been charted to date, we see this as an immensely significant project to promote a greater social understanding and sustainable use of the oceans."

"The Nippon Foundation-GEBCO Seabed 2030 project is hungry for data and this is a priceless contribution to ocean science," said Seabed Director, Satinder Bindra, adding "Their donation will undoubtedly encourage other companies to contribute data, so we can all collectively support one of the UN's Sustainable Development Goals to use our ocean resources sustainably."

Several research organizations, academic institutions and other regional mapping initiatives have long been contributing data for the production of a global map of the seafloor, but the Ocean Infinity initiative underscores how Seabed 2030 aims to crowdsource data by leveraging assets already at sea from sources such as surveying company ships, transport vessels, and cruise liners to contribute to a global bathymetric map.

Crowdsourcing also paves the way for small organizations and individuals to get involved in the global movement to map the seafloor by 2030. Many fishing boats and pleasure-craft are equipped with basic sonar for navigation, with readings recorded by on-board computers.

Earlier this year it was announced that Fugro, an offshore private surveying company, donated almost 100,000 square kilometers of transit data – acquired while travelling between client projects- bringing the total private sector data donated to the project to 220,000 square kilometers, equivalent to almost the entire land mass of the U.K.

With the inclusion of 710,000 square kilometers of open source bathymetric data released by Australia, this year's map will incorporate at least 930,000 square kilometers of data not previously included in the global grid – an area larger in size than Nigeria.

Recognizing the power of crowdsourced data as a tool to empower all those who use our oceans to contribute to science, Seabed 2030 has been requesting donors to deposit their data with the International Hydrographic Organization's (IHO) Data Centre for Digital Bathymetry (DCDB), a digital repository in Boulder, Colorado, USA.

"As the recognized archive for global bathymetry, we're excited to be a part of this international effort to map our oceans by continuing to provide access to the world's largest collection of digital bathymetry," said Jennifer Jencks, Director of the IHO DCDB.



Unmanned Aerial Vehicle for Cost-Effective & High-Quality Topography & Photogrammetry Surveys

Titan Environmental Surveys Ltd have recently achieved Civil Aviation Authority Permission for Commercial Operation of a newly acquired Sensefly eBee Plus fixed wing unmanned aerial vehicle (UAV). The UAV is fitted with a Sensefly S.O.D.A camera (the first camera specifically designed for photogrammetry applications) and incorporates built in RTK / PPK capability. Horizontal and vertical positioning accuracies of 3 centimeters are possible and can provide extremely detailed topography and photogrammetry data with 1120 XYZ data points per m2. For more information visit www.titanSurveys.com

New RBRquartz³ Bottom Pressure Recorder Enables Tsunami Monitoring Programs

The RBRquartz³ BPR uses an integrated Paroscientific Digiguartz® pressure sensor for the best-in-class initial accuracy, resolution, and low drift performance. It is intended for deep long-term autonomous or real-time observations of water level and tsunamis, and rated to 10,000m. Despite being located on the sea floor, the high resolution (10ppb) quartz pressure sensor is able to detect 100µm changes in surface water level from 1.000m below the surface. Flexible measurement schedules with continuous, averaged, or burst sampling permit applications for tide, sea level, or tsunami measurements. For more information visit www.rbr-global. com

The Underwater Centre Signs Major Japanese Trials Contract

Subsea training and trials center, The Underwater Centre, has signed a basic agreement with Kawasaki Heavy Industries Ltd in Japan to carry out a verification test of a prototype AUV equipped with a robot arm for subsea pipeline inspection. The test, scheduled for October 2018 at The Underwater Centre in Fort William, will be the first test of its kind in the world. In November 2017, Kawasaki successfully completed a 15-day verification test at The Underwater Centre for the automated underwater docking of a prototype AUV to its charging station, involving contactless charging and large-capacity optical communication. For further information visit www. theunderwatercentre.com



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Opportunities

PSO, MMO, ESO, MAMU Opportunities (U.S.)

Saltwater Inc has positions for observers in Texas, Florida, California, and Massachusetts (U.S. citizen or appropriate working visa only). Experience is a plus although there are opportunities for people who are newly certified. ESO with manatee, sawfish, seabird, turtle trawlers, cetaceans, pinnipeds, all along the U.S. EEZ are needed for placement. They anticipate immediate openings for Jacksonville, Florida, the Gulf of Mexico, and California. Send your resume, certifications, letter of pre-approval, and a summary of jobs with a listing of target species to Nicole.Daigneault@SaltwaterInc.com. Be sure to include your home location.

Principal Investigator in Satellite Oceanography (U.K.)

National Oceanography Centre (NOC) is offering an exciting opportunity for a dynamic scientist with initiative and creativity to provide scientific leadership and develop new ideas and proposals within the Satellite Oceanography team at NOC. They are particularly interested in scientific expertise related to exploiting satellite remote sensing to monitor and understand atmosphere-ocean processes, upper ocean dynamics and/ or long-term environmental change in global, coastal and/or polar oceans. Deadline August 31, 2018. Please go to www.noc.ac.uk/jobs for more information about this position and how to apply.

Director, California Sea Grant (U.S.)

Scripps Institution of Oceanography (SIO), University of California San Diego (UCSD), seek a vibrant, accomplished, and collaborative leader to serve as the Director of California Sea Grant (CASG). The Director assumes overall responsibility for leadership and programmatic oversight of CASG, and has national, state-wide, and university-wide responsibilities. This management and senior- professional (MSP)-level staff position will be filled as a permanent, 12-month, full time position subject to annual review according to UCSD policies. Deadline August 24, 2018. Go to www.ucsd.edu for more information.

OPPORTUN

Engineer, Alfred Wegener Institute Helmholtz Centre Polar and Marine Research (Svalbard)

The Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) together with the French Polar Institute Paul Emil Victor (IPEV) operates the Arctic research base AWIPEV on Spitsbergen. Starting each January 1, Logistics Department of AWI is appointing an Engineer within the field of optics, electronics, physical technique, or electro technique as a technical staff member and winterer at the joint German-French Arctic station (AW-IPEV Base) in Ny-Ålesund on Svalbard. Please send your application before August 31, each year. For more information go to www.awi.de or email Dr. Roland Neuber (roland.neuber@awi.de).

Scientist with Knowledge and Experience in Coastal Modeling and Data Analysis (Germany)

The Institute of Coastal Research at the Helmholtz-Zentrum, Geesthacht is looking for a highly motivated Scientist with knowledge and experience in modelling and data analyses. The position is initially three years. The successful candidate is expected to conduct research focused on both data analyses and numerical simulations. A strong emphasis will be laid on process-oriented studies and improving predictability in the coastal areas. Application of new techniques, allowing for the assimilation of newly available observations in numerical models, will be part of the candidate's activity. Deadline August 15, 2018. For more information email personal@hzg.de

Cluster Hire for Coastal or Marine Science Faculty Positions at Lumcon (U.S.)

The Louisiana Universities Marine Consortium for Research and Education (LUMCON; https://lumcon.edu) seeks to hire two new Assistant Professors in the second phase of a multi-year faculty expansion. Well-gualified coastal or marine scientists should apply. The position carries a nine-month salary. The initial appointment is for three years; following a review, the contract may be renewed for three more years. A six-year review similar to tenure is conducted for promotion to Associate Professor, but LUMCON is not a tenure-granting institution. Review of applicants will begin September 15, 2018 and continue until the positions are filled. Check website for more details.

Academic Research E-Boat SPECTRE Module

Dynautics Ltd, a leader in intelligent marine electronics for unmanned boats, is offering academic research organizations a low-cost entry point into marine autonomous electronics. Applicants will be assessed for the suitability based on the nature of their research, projects and objectives of their curriculum. The applicants will have the option to purchase the module outright after 24 months or return the module to Dynautics. The module is for research and development only and is not to be sold to a third party or used in any commercial context without the prior written permission of Dynautics Ltd. For further information. visit www.dynautics.com

IMCA Annual Seminar with Sessions on Marine and Diving

The International Marine Contractors Association (IMCA) will hold its Annual Seminar with the theme 'Working Together: getting back to business - oil companies and contractors finding new ways of working,' on November 28-29, 2018 at the World Forum in The Hague, The Netherlands. Executives from Shell. BP, Equinor and Neptune Energy will be taking part in the Seminar, talking about safety, the environment, and new ways of working. The head of the global oilfield practice of leading management consultants Bain & Co will give a big picture presentation of changes that are moving the industry.

Outreach Officer, The ECORD Managing Agency (FRANCE)

The European Consortium for Ocean ResearchDrilling(ECORD-www.ecord.org), is a management structure of 15 members (14 European countries and Canada) for scientific ocean drilling as part of the first international scientific program in earth sciences: The International Ocean Discovery Program (IODP - www.iodp.org). Starting date is January 2019. Work includes website updates, designing ECORD publications, developing outreach and exhibition resources, and organizing ECORD booths and international science conferences. Deadline October 7, 2018. Visit the website, www.ecord.org, for more details.

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Founded in 1985, Morgan & Eklund, Inc. (M&E) is a Florida-based land and hydrographic survey firm specializing in boundary, topographic, GPS and hydrographic surveying. Proficient in leading-edge mapping technology, M&E has been providing services to the public and private sectors across Florida for more than 30 years and has offices in Wabasso, Deerfield Beach and Miami. M&E is a group of extremely talented professionals who are committed to providing a professional product in a timely fashion. Our staff includes four registered land surveyors, three survey crews and two hydrographic survey crews.

Ocean Optics

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Ocean Optics combines innovative products and systems, integration development capabilities and applications knowledge to help people solve problems using spectroscopy, imaging and sensing technologies. We offer a full spectrum of optical sensing instruments, methods and expertise to help customers control harmful emissions, protect water quality and preserve coastline ecosystems. Our devices can be embedded into other devices to monitor environmental conditions in situ with remote data access points. "Unlock the Unknown" with Ocean Optics.

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Ohmsett is an outdoor saltwater wave/tow tank facility where full-scale oil spill response equipment testing, R&D, and training are conducted with oil in a controlled marine environment. Providing independent and objective performance testing that produces the most accurate and reliable results, Ohmsett represent an intermediate step between small scale bench testing and open water testing. The tank measures 203 meters long by 20 meters wide by 2.4 meters deep and filled with 10 million liters of saltwater.

Seiche

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Seiche provides environmental monitoring, measurement and mitigation solutions for the offshore energy, science and civil engineering sectors. Seiche designs and manufactures underwater measurement/acoustic systems and advanced visual detection technology. Seiche also provides end-to-end service solutions including provision of: MMO, MFO and PSO, PAM operators/equipment, FLOs, environmental scientists/reps, marine mammal risk and impact assessments, noise modelling and monitoring, and baseline surveys.

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TDI Brooks and our laboratory affiliate B&B Laboratories, strive to be the preferred analytical service provider in the markets we serve. Throughout our 20 year history we have established a client base built on our commitment to data quality, timely performance and date submissions as well as competitive pricing. Our laboratories provide high-quality analytical services and scientific interpretation with a focus on petroleum geochemistry, surface geochemical exploration, oil spill response, environmental chemistry, and environmental assessments.

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Wayfarer Environmental Technologies (WET), founded in 2005, implements successful shoreline protection and remediation projects in cooperation with state municipal and conservancy groups. Our OysterBreak[™] shoreline protection structures provide long-term, effective wave attenuation, shoreline erosion mitigation, and sediment accretion. Highly configurable and proven stable over time, our artificial oyster reef OysterBreak[™] structures are locally manufactured, easily engineered, and quietly installed to improve water quality and enhance marine wildlife habitat while saving and rebuilding shorelines.

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Editorial Focus	Products & Services Focus	Show Distribution	🖸 Pending 🖵 Digital
January/Febuary			
Coastal Construction and Engineering	Environmental Consulting, Monitoring, Permitting Underwater Inspection, Maintenance, and Monitoring Artificial Reefs	GoM Oil Spill & Ecosystem	February 5 - 8
Ports/Dredging		Oceanology International	March 13 - 15
March/April:			
Risk Management & Mitigation	Environmental Consulting, Monitoring, Permitting	All-Energy	May 2 - 3 🖵
Decommissioning & Abandonment AUVs and ROVs	Environmental Risk/Impact Assessment Risk Management Tools and Services AUVs and ROVs	State of the Coast	May 30 - June 1
May/June:			
Restoration & Remediation	Environmental Consulting, Monitoring, Permitting	Clean Pacific	June 19 - 21 🖵
Ocean Environmental Law, Policy & Regulation	Impact Assessments, Surveys	Dredging Summit & Expo	June 25 - 28 💻
Oil Spill Prevention and Response	Underwater Inspection		
July/August:			
Shipping Sustainability	Ballast Water Management Systems	FAEP	September 19 - 21
Emission Regulation	Deck Gear	WindEurope	September 25 - 28
Offshore safety	Safety Equipment Mooring & Anchoring Products Ship Efficiency Systems		
September/October:	· · · · · · · · · · · · · · · · · · ·		
Fisheries & Aquaculture	Environmental Consulting, Monitoring, Permitting Fisheries Monitoring Technologies	Teledyne Marine Tech Workshop	October 9 - 11 🗖
Marine Sound	IUU Tracking Technology / AIS	AWEA	October 16 - 17
	PAM/MMO Tools and Services	OCEANS '18	October 22 - 25
		Offshore Energy	October 22 - 24
		WOC SOS	November 13 - 15
November/December:		wee 303	
Ocean Observing Systems	Modeling, Simulation, and Visualization Tools	RAE Summit	December 8 - 15
Modeling, Simulation & Visualization	Acoustic Modems, Releases & Transponders		
Subsea Imaging	Subsea Imaging		
Subsea lelecom	Underwater Inspection Scientific Data Provision, Processing, and Analysia		
	In Situ Observation and Monitoring		

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