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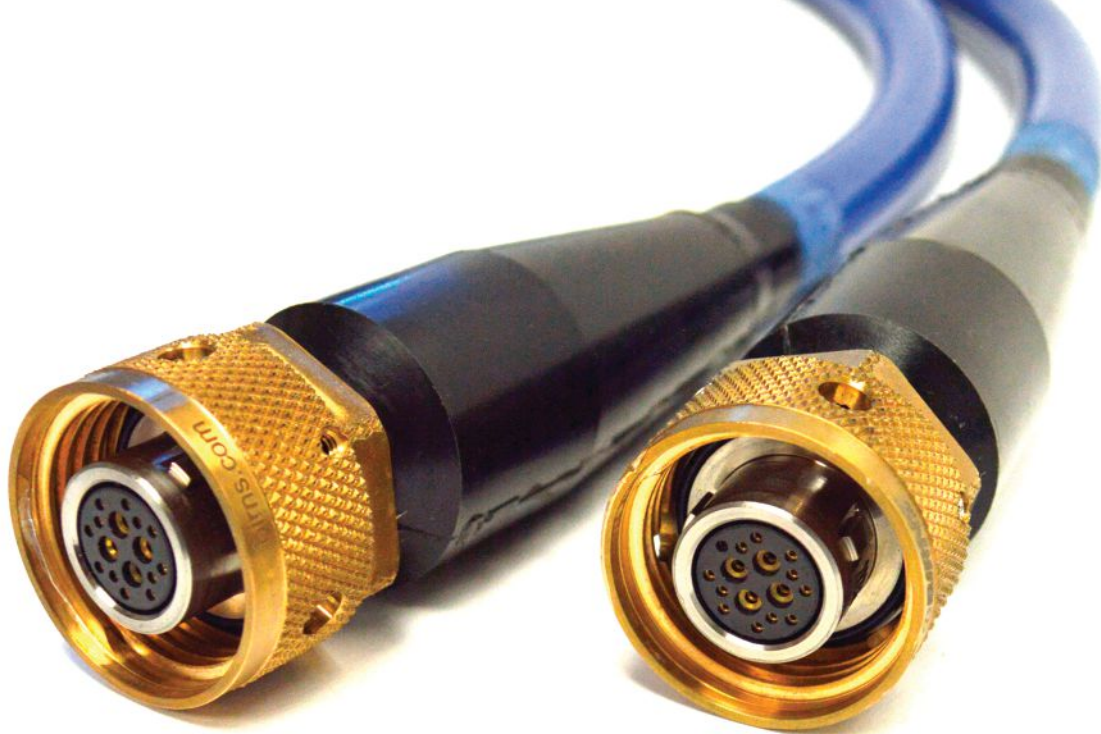
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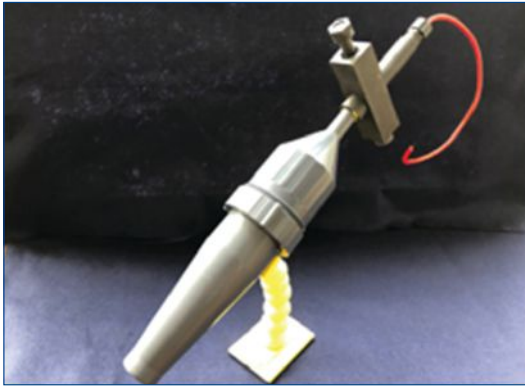
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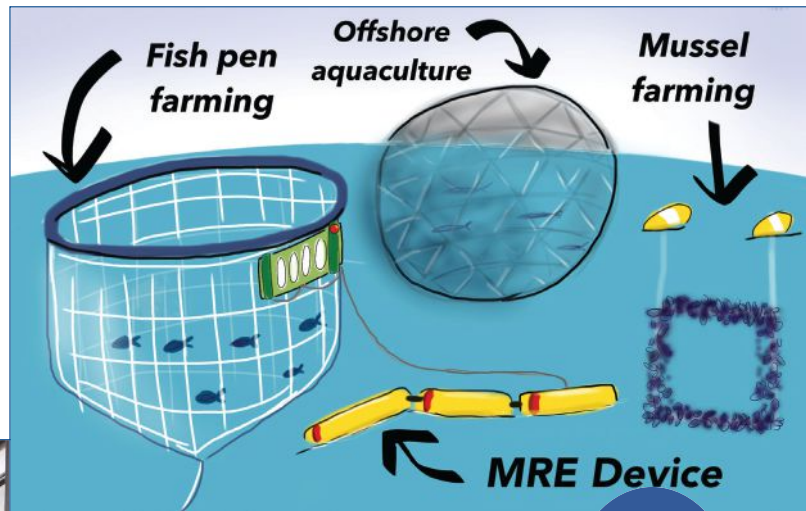




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Farmers harvest lines of ribbon kelp in Doyle Bay, Alaska. (Credit: Seagrove Kelp Co.) See story on page 13.

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)) Results of First US Marine Economy Satellite Account. The U.S. marine economy contributed about \$397 billion to the nation's gross domestic product in 2019 and grew faster than the nation's economy as a whole, according to the latest results of the first official Marine Economy Satellite Account released by two Department of Commerce agencies. For these statistics, experts from NOAA and the Bureau of Economic Analysis (BEA) described 10 sectors representing businesses dependent on the nation's oceans, coasts and Great Lakes between 2014 and 2019. Marine-related gross domestic product grew 4.2 percent from 2018 to 2019, faster than the 2.2 percent growth of the total U.S. gross domestic product as measured in inflation-adjusted dollars. Businesses included in the report also generated a total of \$665.7 billion in sales and supported 2.4 million jobs in 2019. The 10 sectors ranked by their sales are: tourism and recreation, including recreational fishing (\$235 billion); national defense and public administration (\$180 billion); offshore minerals (\$93 billion); transportation and warehousing (\$64 billion); commercial ship and boat building (\$31 billion); living resources, including commercial fishing and aquaculture (\$27 billion); utilities (\$12 billion); research and education (\$10.4 billion); construction (\$7.0 billion); and professional and technical services (\$6.3 billion).

)) UK to Lead '30x30' Commitment to Marine Conservation. The U.K. is taking the lead in an ambitious new 30 percent by 2030 marine conservation target, according to UN Climate Action. With signatories including India and South Korea, this target commits nations to protecting 30 percent of the world's land and 30 percent of its oceans by 2030, alongside meeting "30x30" targets on domestic scales. This commitment results from a successful G7 meeting of Climate and Environment ministers, where all members supported the goal. The U.K. government is also launching a pilot Highly Protected Marine Areas (HPMAs) scheme in England's waters. An outcome of the independent Benyon Review, these areas will enjoy higher levels of protection and will drive marine ecosystem recovery. Natural England and the Joint Nature Conservation Committee are set to identify suitable sites for the scheme in the coming year. These advances come as the findings of the largest ever survey of English and Welsh public opinion toward oceans was published by Defra and the Ocean Conservation Trust. The results show that 85 percent of people perceive oceans as holding personal importance, 84 percent view coastal environments as positive for their mental health, and 80 percent see them as beneficial for their physical wellbeing.

)) Fugro to Preserve Prehistoric Art Threatened by Rising Sea Levels. The French Ministry of Culture has awarded Fugro a further contract to complete the scanning of the astonishing Cosquer Cave, located in the Urgonian limestone at Cap Morgiou near Marseille, France. Rising sea levels are gradually effacing the cave's display of 177 irreplaceable paintings and engravings dating back to 27,000 B.C. Fugro will use its geodata scanning technology to create a permanent record of huge cultural significance. In challenging conditions, and together with Immadras, a French professional diving company, Fugro will use the latest photogrammetric, 3D laser scanning and lighting technology to digitize and map the cave. The artwork above the surface is recorded in full color and meticulous detail (0.1-mm resolution), and a lower resolution will be used for the underwater section, which accounts for around two-thirds of the cavity. Fugro will then produce a highly accurate, georeferenced 3D model of the entire cave structure. This will provide invaluable insights for archaeological, paleontological and climatological research, and for future generations. Fugro will also model the landscape surrounding the entrance, 37 m below sea level, as well as the narrow, 120-m underwater access tunnel leading up to the cave. The project is scheduled for completion early next year.

)) Infrastructure Needed to Support Hydrogen Economy. Energy professionals identify lack of investment in infrastructure as the joint highest risk their organizations face in relation to hydrogen, and 78 percent say repurposing existing infrastructure will be crucial to developing a large-scale hydrogen economy. DNV's report "Rising to the Challenge of a Hydrogen Economy" draws on a survey of more than 1,100 senior energy professionals and in-depth interviews with industry executives on emerging hydrogen value chains, from production to consumption. Some 84 percent of senior energy professionals believe that hydrogen has the potential to be a major component of a global, low-carbon energy system, while 73 percent say Paris Agreement targets will not be possible without a large-scale hydrogen economy. By 2025, 44 percent of energy companies involved in hydrogen expect it to account for more than a tenth of their revenue, rising to 73 percent of companies by 2030. This is up significantly from just 8 percent of companies today.

)) MTS, SUT Add Certifications. The Marine Technology Society (MTS) and the Society for Underwater Technology (SUT) have launched three professional certification programs for marine technologists and technicians. The Institute of Marine Engineering, Science and Technology (IMarEST) has licensed MTS and SUT to offer their members the opportunity to apply for registration as chartered marine technologist (CMarTech), registered marine technologist (RMarTech) and marine technician (MarTech). IMarEST has a royal charter in the U.K. and can add suitably qualified and experienced applicants to these registers. Details are available at: www.mtsociety.org and www.sut.org. **ST**

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How to Manage Overfishing

There are many threats to our environment and our oceans but few are as powerful and dangerous as overfishing. What many see as a rational reaction to supply and demand is much deeper than that. It's not as simple as: "We're eating more fish."

Overfishing occurs when the stock of a certain fish becomes depleted faster than it can reproduce. It's gotten so bad that many believe the majority of our seafood could be completely depleted by the year 2048. Could that be an exaggeration? Yes, but it should be a realization for us.

While people are consuming twice as many fish as they were 50 years ago, it's large-scale commercial fishing backed by massive government subsidies that are the problem.

The realization we should have is that government subsidies don't support the fishing community: They harm it. As megaships throughout the Western world and China scoop up everything in their path, they leave nothing for the small local fisheries that rely on their fish harvest to survive. The "little guys" can't keep up with government money; as a result, they're left in the dust and forced to charge more for their fish to barely make any money at all.

Thankfully, there are solutions to prevent this problem. They all start with awareness and appreciation. We need to respect the water we fish. Whether you're dropping a line from a fishing drone on the dock or commercially fishing to make a living, we all share the water, and it's our duty to protect it.

There are marine protected areas in the world where no one is allowed to fish, and the environment is supposed to thrive. Unfortunately, these areas make up less than 3 percent of the ocean, but the goal of the Marine Conservation Institute is to increase that number to 30 percent by the year 2030.

Another sad fact is that enforcement of marine protection laws is lacking. Countries like China do not abide by the environmental laws put in place, so it's crucial that enforcement divisions stay on top of things.

Furthermore, trawling contributes to overfishing because large ships drag nets through the ocean and scoop up everything along the way. This results in a tremendous amount of bycatch, and a lot of these fish will end up dying when they're returned to the water. These fish are needlessly dying simply because better systems aren't being used. The measures in place to prevent bycatch aren't enough, and trawling needs to be eliminated completely.

Also, setting in place catch limits rather than time limits on when you can fish is a better policy. Fishermen won't feel like they need to rush out like maniacs and chase after as many fish as they can in a short amount of time. Catch limits, rather than time limits, would make it easier to abide by the rules because fishermen won't be in such a hurry to make their money. An American/British Columbian study found that catch shares increased the total catch by 19 percent while decreasing bycatch by 66 percent. There were less accidents, everyone made more money, and they all followed the rules.

It's critically important that we take overfishing seriously. If you want to get involved, there are a variety of organizations to help you get started. The Environmental Defense Fund aims to preserve all natural systems, and the life that depends on those systems. They tackle critical problems with the environment by developing partnerships grounded in science. Greenpeace International is an independent global campaign designed to change our behaviors as they pertain to conservation and the environment. It works primarily on global warming, deforestation and overfishing. The Sea Shepherd Conservation Society is a nonprofit aimed at ending habitat destruction. It focuses on protecting endangered species, such as seals, sharks and dolphins, and uses investigative strategies to expose illegal fishing. These are just a few organizations that help combat overfishing. With your help, we can manage the problem. **ST**

Green UXO Solutions

Low-Order Munitions Disposal Decreases Environmental Impact

By Andrew Woollven • Hardeep Sidhu

Human intervention and encroachment into the marine environment are growing at an unprecedented rate. For example, it is predicted that, soon, more than 70 percent of the U.S. population will be located in coastal regions. Furthermore, growing global population demands increased infrastructure developments that, in turn, require connectivity for power transmission and communications. Moreover, as our reliance on renewable energy grows, large areas of coastal zone and shallow seas are being occupied by offshore wind farms and will no doubt be followed in the near future by wave and tidal power generation.

These developments face a significant threat from one other human activity: conflict. It is estimated that the two World Wars left approximately 1.6 million tonnes of munitions in the German North Sea and Baltic Sea. WWII resulted in excess of 3,800 shipwrecks with unknown quantities of unexploded ordnance (UXO) in the East Asia-Pacific region alone. Munitions from conflicts, firing ranges, training exercises and wrecks include air-delivered bombs, land and sea mines, torpedoes, depth charges, projectiles, and chemical weapons. These munitions not only present the risk of explosion but also risks from carcinogens and chemicals (metals and organics).

UXO disposal therefore demands techniques that offer the highest level of safety and lowest impact on the environment. Disposal by low-order (LO) deflagration safeguards marine life and the seabed and is as cost effective as conventional high-order (HO) detonations. Consequently, support for LO deflagration is growing among environmental groups and offshore sectors.

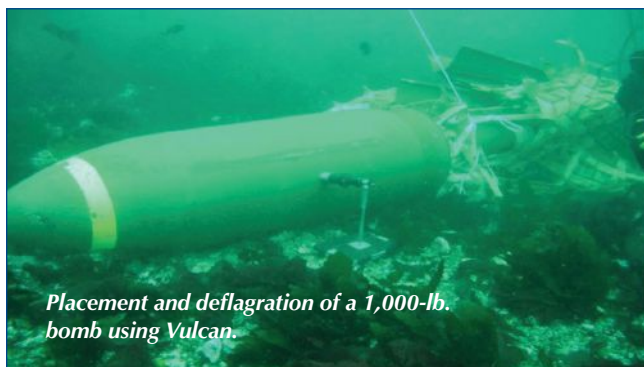
Low-Order Deflagration

The conventional HO detonation method of UXO disposal is effectively unchanged since the end of WWII and requires a bulk donor charge (usually 5 to 25 kg of explosive) to be placed next to the unexploded ordnance



and detonated. This causes the UXO to detonate with its full design force, with highly destructive results to both the seabed and marine life.

In contrast, LO deflagration is the process of burning out the explosive fill of an item of UXO to render it safe, provided the munition casing is intact. A small, shaped charge (typically 15 to 300 g) is used to inject



Placement and deflagration of a 1,000-lb. bomb using Vulcan.



a high-velocity plasma jet through the UXO casing to instantaneously ignite (not detonate) the explosive contents of the UXO. The explosive content burns at very high temperatures (circa 5,000° C), releasing gases, increasing the internal pressure and causing the casing to burst open, without the UXO detonating. The explosive contents are oxygen enriched, containing sufficient oxygen to burn without needing air, which is why UXO is able to function underwater where there is no air to fuel the detonation. The explosive material/fill is contained within the munition during deflagration and not spread over the surrounding environment.

LO deflagration technology was developed in the United Kingdom by Alford Technologies, a world-leading supplier of specialist user-filled explosive tools to militaries and law enforcement agencies. The technology is over 15 years old and is in use by the navies of the U.K., U.S. and 15 other nations. Deflagration has been used extensively in underwater UXO disposal for military applications and for a commercial operation to clear ordnance from a former sea firing range in Hawaii, now designated as a protected national marine park.

Two of Alford's LO deflagration systems are currently available for commercial operations, depending on the nature of the UXO to be disposed of. Though the Vulcan system has been operational for the last 15 years, it has been commercially available only in the last two years. This system has been deployed against a wider range of munitions more than any other system, from grenades to rockets and deep-penetration bombs. It carries an explosive charge weight of 15 to 50 g.

Pluton is a larger variant of Vulcan with the ability to carry 50 to 300 g of explosive charge and is used against larger or thicker-skinned munitions. Pluton is configurable with different projectile types for a variety of underwater explosive ordnance disposal (EOD) techniques and is intrinsically safe from radio frequency interference. It also has three independent safety breaks, including a safe-to-arm system, providing both the operator and deployment systems maximum safety during any disposal operation. These systems are currently the only proven LO deflagration systems available on the commercial market, with an extensive track record of success against a range of munitions.

Trials and Verifications

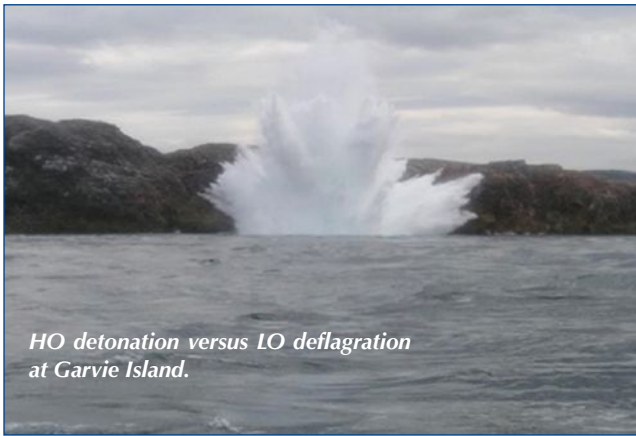
In 2002, the U.S. Navy and Alford Technologies con-

ducted successful underwater LO deflagration trials in Hawaii to reduce the impact of disposal on migrating cetaceans. This success led to further testing the following year at Garvie Island off the north coast of Scotland, involving the U.K.'s Royal Navy. This trial demonstrated that a small charge with only 30 to 50 g of explosive could cause a 1,000-lb. bomb to LO deflagrate consistently. Since then, numerous navies have adopted LO deflagration systems for underwater UXO clearance.

In October 2019, Eodex and Alford Technologies directly supported a U.K. study to understand the difference in magnitude between LO deflagration and conventional HO detonation. The National Physical Laboratory and Loughborough University (both in the U.K.) were able to validate the very significant blast noise mitigation benefits of using the Vulcan system. The results showed that for LO deflagration, noise does not increase with increased size of the target UXO; deflagrating a 5-kg charge yielded the same peak noise as deflagrating a 500-kg UXO item. In contrast, the results showed that the peak noise for HO detonation increases linearly with explosive weight of the UXO. The largest high-order charge tested of 18.7 kg was 11 times louder than the equivalent low order. For 250 kg of explosive charge, peak noise for HO detonation was 700 times that of LO deflagration. Video footage of this is available at www.eodex.co.uk, and it is worth noting that LO deflagration never produces any more noise than you hear in the video.

To put this into an environmental context, LO deflagration greatly reduces the danger distances for marine life, particularly marine mammals. These zones of influence are reduced from tens of kilometers for HO detonations to literally tens of meters for LO deflagration, with the added benefit of maintaining seabed integrity. This allows all mitigation measures to be conducted on a very local level without risk of harm to marine life. For example, the zone of influence of detonation and deflagration for a 500-lb. bomb in 30 m of water comprises a "kill zone" out to 50 m for HO detonation, while there is no "kill zone" for deflagration, and the zone of minor disturbance extends over 30 km for detonation, versus 750 m for deflagration.

No data exist comparing the shock waves produced by LO deflagration and HO detonation, but experience has shown that LO deflagration is probably equivalent to less than 1 percent of the magnitude of a full HO detonation. Until the U.K. trial, no independent data existed



HO detonation versus LO deflagration at Garvie Island.



comparing deflagration and detonation blast noise. The final results provide compelling justification for deflagration as the default means for disposing of UXO. They also provide various regulatory and advisory agencies, such as the U.K.'s Marine Management Organisation, the ability to apply appropriate mitigation measures for licensing offshore UXO clearance operations.

Operational Aspects

The final objective of a disposal campaign is to ensure that the risk of encountering UXO during any planned activity, such as cable lay and burial, is reduced to "as low as reasonably practicable" (ALARP). The process commences with pre-operational mission consultancy, whereby a clear plan is developed detailing objectives, resources, methodologies, risks, contingencies and desired outcomes.

The next step is to mobilize resources for UXO investigation and positive identification, which, depending on the water depths and conditions, will be diver and/or ROV spreads. Targets will be investigated that were previously determined to be unavoidable potential UXO during an earlier, comprehensive geophysical survey. Items found to be non-UXO may be left in situ or recovered for shoreside disposal, and an ALARP certificate issued.

If a target is confirmed to be UXO, a disposal strategy is formulated based on an assessment of the UXO itself, existing assets, secondary hazards and operational risks. Deflagration requires greater insight and expertise than detonation, and the precise methodology will be specific to the UXO at hand. Parameters regarding the UXO need to be understood, such as country of origin, role/function, net explosive quantity, fusing, identification of component parts, nature of fill (high explosive, phosphate, chemical, other), sensitivity, initiation method, environmental factors (water depth, visibility, currents, etc.), complexity (single or multiple targets), and the presence of any self-destruct mechanisms. Possible damage to assets and secondary hazards must be considered in terms of personnel, vessels, existing subsea infrastructure, marine life, blast damage to the seabed, and terrestrial impacts if close to land or in intertidal areas.

Operational risks must be considered, such as personnel experience levels, possible outcomes of lifting

a UXO (seabed suction or uncontrolled ascent, unless using a remote lift system), unplanned detonation, changing weather conditions, and effectiveness and application of cordons. The EOD supervisors (qualified advanced maritime EOD operators) are responsible for further mitigating risk through effective communications and comprehensive briefings.

Based on the outcome of this analysis, a decision will be made to proceed with the preferred LO deflagration method, or, if that is not possible, some other means of disposal, such as HO detonation. The munition must be intact to apply LO and HO disposal methods; neither should be applied to chemical weapons as they have unique disposal requirements.

If the UXO is not intact, it will be disposed of using a small charge that will not deflagrate the item nor detonate as an HO event. In the event of having to neutralize a munition that is not intact, only charges with the minimum amount of explosive content to deliver the required disposal outcome should be used.

For some time now, the Polish Navy has been actively neutralizing WWII ordnance using LO deflagration in support of civil and commercial maritime programs in the Baltic Sea. Most notably, LO deflagration was recently used to dispose of a 12,000-lb. British Tall Boy air-dropped bomb discovered in a port. While the media coverage spoke of the weapon detonating, the majority of the yield actually deflagrated, and only a small percentage of the bomb's explosive fill transited to detonation, rupturing the casing in the final instance. It was clear that had this weapon fully detonated in 10-m water depth where it originally sat, it would have produced a plume of water over 700 m high and a shock wave akin to that witnessed in Beirut Port in August 2020. It would have caused significant collateral damage and risk to life. This operation, in being able to tackle a weapon of this magnitude, outlined the significant capability that deflagration systems have over other solutions in the commercial EOD market.

It is commonly accepted that HO detonation of UXO causes significant harm to the environment and increases the risk of injury to personnel and damage to high-value assets. It is also equipment and time intensive, making it significantly more costly than a low-order approach. Conservative estimates on the use of LO deflagration



Beirut Harbor explosion in 2020.

point to a 15 to 30 percent savings over the course of a full UXO clearance campaign.

Environmental Safeguarding

In addition to its commercial advantages, LO deflagration offers a number of highly significant benefits over HO detonation. It dramatically reduces physical and environmental damage to the UXO site, protecting marine ecosystems by preventing cratering and liquefaction. It minimizes the noise impact by avoiding the full destructive detonation of the unexploded ordnance, protecting wildlife, particularly marine mammals such as the harbor porpoise. It minimizes the toxic and carcinogenic residues that remain in suspension in the water column after the HO detonation of both the bulk charge and ordnance. It avoids the detonation of the ordnance, itself an uncontrolled and unpredictable activity that risks personnel and equipment. It eliminates bubble curtains and other costly mitigations, thereby reducing the overall costs and timetable of the UXO clearance effort. It also utilizes advanced explosive technology to reduce charge size and therefore risk to the environment, property and people.

Conclusion

LO deflagration has been used successfully and documented on a large number of UXO on land and at sea. The initial success rate for the first 100 firings was 100 percent, and even with the global increase in usage, the success rate remains above 98 percent. The slight reduction has been attributed to operator error rather than system failure.

LO deflagration requires the UXO to be intact as the explosive fill must burn to create sufficient pressure buildup to split open the casing. Any residual explosive remaining in the UXO after deflagration (a rare occurrence) can be cleared with a second cleaning shot. The same requirement for an intact casing applies to HO detonation, and neither method can be used against chemical munitions.

The delivery and LO deflagration system provided by Eodex can be prepared for deployment in less than 10 min. This system can be deployed using very high-resolution sonars, so it is not restricted by poor underwater visibility. Typically, deflagration is instantaneous. However, with large bombs, there can be a slight delay (in seconds) as the pressure builds up.

A successful deflagration will depend on a number of factors, such as the extent to which the UXO has been broken open and the volume of explosive that has been deflagrated. Following an inspection of the deflagrated UXO, the EOD supervisor can quickly determine if an incomplete combustion has occurred (which is very rare); the remaining fill, if deemed necessary, can then be removed with a second cleanup shot.

There is no risk when recovering disposed UXO to deck following LO deflagration. Any remaining explosives inside a munition are not toxic, are safe to handle, and cannot function without an initiation train, which will have been removed during deflagration. Explosive remains from a deflagration can be safely recovered, packaged and stored on board a vessel for disposal ashore. Additionally, with old explosives being hygroscopic, it is not considered dangerous to leave small explosive rem-

“Disposal by low-order (LO) deflagration safeguards marine life and the seabed and is as cost effective as conventional high-order (HO) detonations.”

nants behind to weather out over a period of time.

Thus far, no commercial use of LO deflagration has been undertaken on a large scale, such as on an offshore wind farm or subsea interconnector cable project, primarily because this technology was not commercially available until recently. It is significant that the U.K. Department for Environment, Food and Rural Affairs will update government guidelines on maritime UXO disposal following the success of recent LO trials, and members of Parliament seek change in the regulatory guidance following the recent Stop Sea Blasts campaign (www.stopseablasts.org).

In addition to the U.K. government and renewables sector, several overseas government bodies have expressed interest in the use of low-order techniques, and an increasing number of marine licenses and project requirements now specify LO deflagration as the preferred or only disposal technique.

Eodex continues to lead the effort to replace environmentally damaging HO detonation with more environmentally friendly and cost-effective LO deflagration. Further sea trials are ongoing to allow greater visibility of the

system and its advantages, while the concept is already proven and can be provided globally.

We have the technology to reduce harm, and we should use it as we further develop ocean resources. **ST**

Andrew Woollven is a former naval warfare commander and mine clearance diving specialist. Throughout his career he has been involved in extensive EOD and underwater clearance operations around the world. After his naval career, he worked as an offshore EOD superintendent before becoming managing director at Eodex UK Ltd., a company formed to bring the best maritime explosive ordnance disposal and underwater explosive cutting processes to the commercial subsea sector, with safety, environmental safeguarding and cost efficiency as central pillars. He is a master's graduate of Kings College and a member of the Institute of Explosive Engineers.

Hardeep Sidhu is associate director at Eodex. He has 39 years of international experience in offshore telecommunications, renewable energy, oil and gas, mining, dredging, and environmental and geophysical surveys. Since 2014, he has focused on the design, specification, business development and management of UXO clearance services for offshore cables and facilities installations. He has promoted innovation with respect to survey, identification and disposal techniques in order to safeguard the marine environment from the disruptive effects of conventional methods. He holds postgraduate degrees in marine geosciences and technology and innovation management.



Ocean Sensor Systems

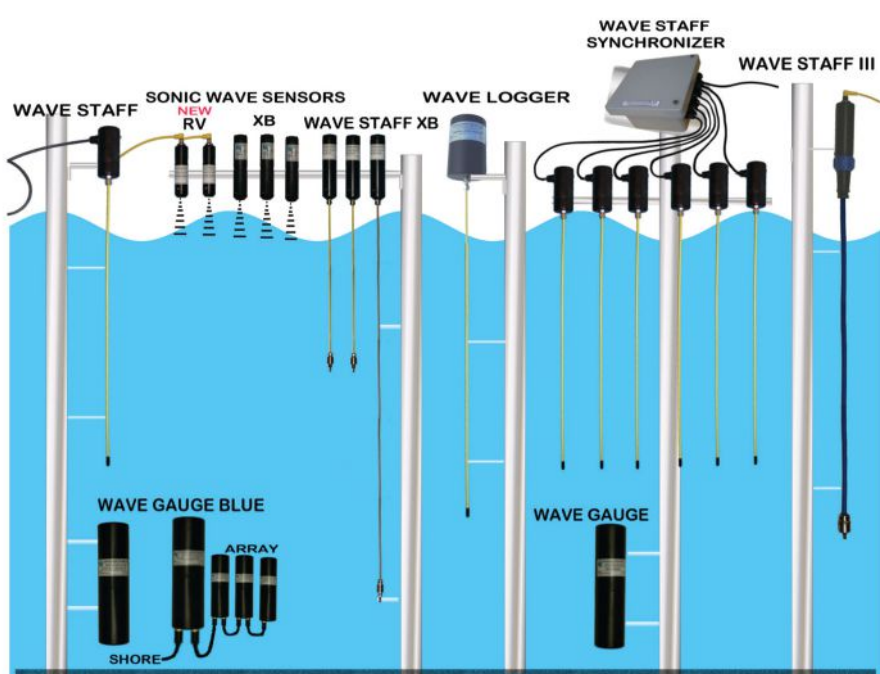
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The diagram illustrates various ocean sensing equipment deployed in a water body. On the left, a 'WAVE STAFF' is shown with a 'SONIC WAVE SENSORS' array including 'NEW RV', 'XB', and 'WAVE STAFF XB' units. A 'WAVE LOGGER' is connected to the system. To the right, a 'WAVE STAFF SYNCHRONIZER' and 'WAVE STAFF III' are depicted. At the bottom, 'WAVE GAUGE BLUE' and 'WAVE GAUGE' are shown, along with an 'ARRAY' on the 'SHORE'.

Ocean Energy for Ocean Farms

Assessing Ocean Energy and Marine Aquaculture Co-Development

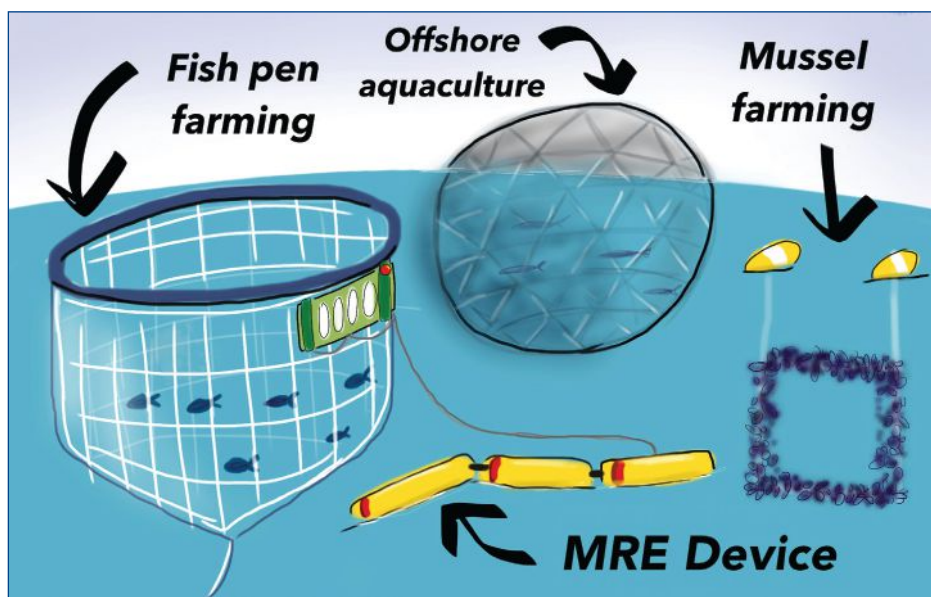
By Sarah Loftus

Alaska-based ocean engineer Molly Gear has a freezer full of kelp in her kitchen that she picked while kayaking. Growing seaweeds like kelp at even larger scales, on horizontal ropes tethered to the ocean floor, has been gaining momentum in Alaska, as well as globally. Global production of seaweed tripled between 2000 and 2018 according to the Food and Agriculture Organization, and seaweed production in Alaska increased six-fold between 2017 and 2019.

Gear applied her expertise in marine renewable energy to investigate how waves and tides could help power Alaska's growing kelp industry. Coastal communities relying on diesel fuel could benefit from a local renewable energy supply to power the processing steps that turn kelp into food or other products. The combination of renewable energy and kelp, which removes carbon dioxide from the ocean as it grows, also reduces carbon emissions that lead to climate change.

Gear and other U.S. National Laboratory researchers applied for seed funding from the U.S. Department of Energy's Water Power Technologies Office (WPTO), which developed a "seedling" program to promote new and exploratory water power ideas. This funding has supported Gear's research, as well as another team's work to find offshore locations suitable for powering fish farms with wave energy.

Farming seaweeds, shellfish and finfish in the ocean can provide sustainable sources of food and other prod-



Depiction of marine renewable energy (MRE) devices used to power ocean farms. (Credit: Molly Gear)

ucts, such as fertilizers and potentially biofuels, when sited and managed responsibly. Shellfish and seaweed can also provide environmental benefits like uptake of excess nutrients and carbon dioxide, and don't require humans to provide food or fertilizer.

While permitting, production and supply chain challenges are some of the more immediate hurdles for ocean farming, farms also need energy for operating, monitoring, processing and transporting.

"Globally, aquaculture is set to explode, and there will be a lot of associated energy costs," said Mikaela Freeman, a marine science and policy analyst at the Pacific Northwest National Laboratory, or PNNL, who re-

searched the spatial overlap of wave energy and potential fish farm sites.

Freeman and her colleagues wanted to contribute to how fish farming could be done sustainably, using renewable energy. Renewable energy solutions for ocean farms might require multiple energy sources, such as waves, wind and solar. Some ocean farms are embracing renewable energy by testing wind and solar to power hybrid barges that feed fish in offshore cages, called net pens.

Teams at PNNL and the National Renewable Energy Laboratory, or NREL, in the U.S. are researching emerging technologies that convert the movement of ocean water into electricity in locations that can't connect to the grid, as part of a broader WPTO initiative called Powering the Blue Economy (energy.gov/eere/water/powering-blue-economy). PNNL and NREL researchers have shown potential for pairing ocean energy technologies with ocean farming or processing needs.

"This effort has improved our understanding of both the energy demands of aquaculture and of the ways wave energy can potentially diversify how aquaculture meets those energy demands," said David Greene, a research engineer at NREL who assessed the feasibility of powering fish farms with wave energy.

Ocean Energy for Kelp Processing

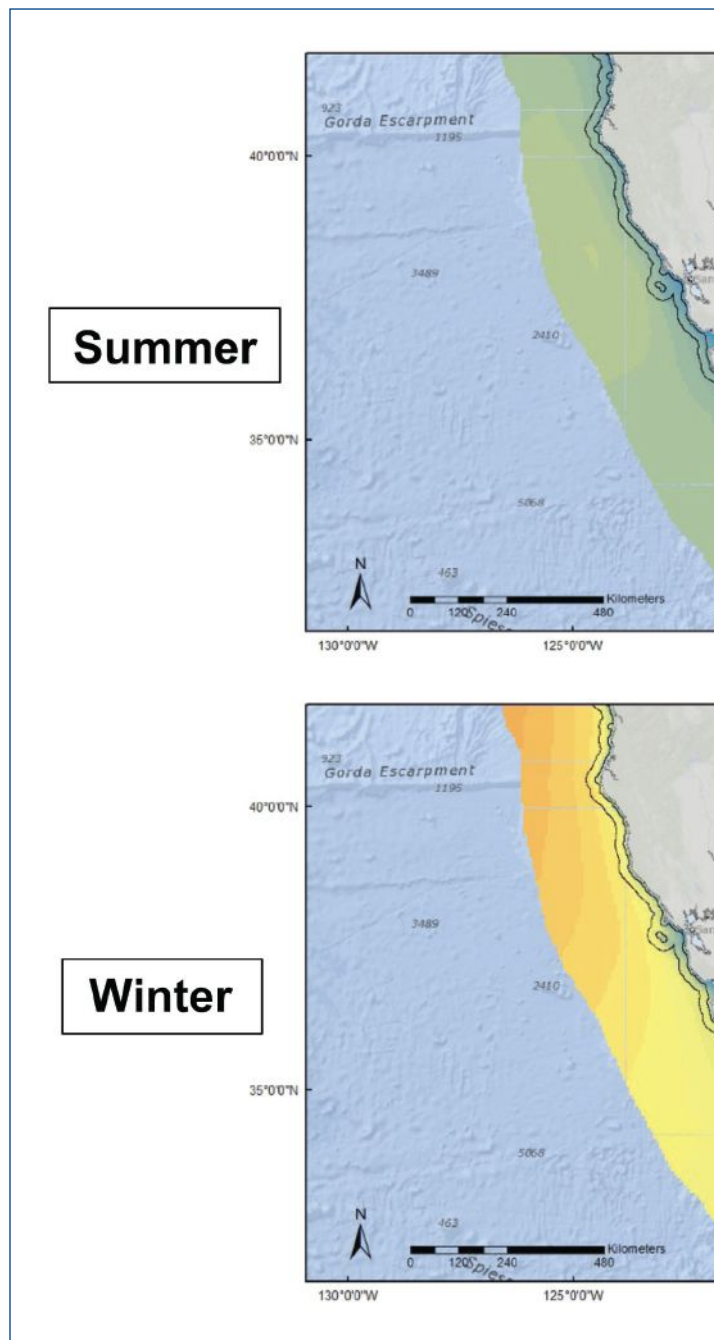
Kelp grown in Alaska is primarily eaten as food, but using kelp and kelp processing waste to make biofuels is also a possibility. A team of 12 PNNL researchers studied how the Alaskan kelp industry could expand sustainably and published their findings in a report this March.

The team worked with a steering committee representing kelp producers, fish processors, Alaska Natives, energy developers and local economic development organizations. This committee wanted to understand which types of kelp products to make, whether they could process kelp using existing infrastructure such as fish processing facilities, and whether it made financial sense to create biofuels from kelp and fish waste.

"Having it be a community-driven process is important for making this happen," said Michael Rinker, the manager of renewable energy and energy efficiency work at PNNL. The researchers evaluated data from specific communities on the Alaskan coast, including electricity usage and cost, population size, number and location of fish processing facilities, and distance to wave and tidal energy sources.

While the Alaskan coastline has a lot of potential for wave and tidal energy, historically there hasn't been much demand for it, said Gear. Wave and tidal energy converters, the devices that use moving water to ultimately run a generator, are still in relatively early stages of development. A new need for energy though, such as for processing an increasing supply of kelp, combined with high costs of diesel shipped on barges, might create more interest in investing in these energy technologies.

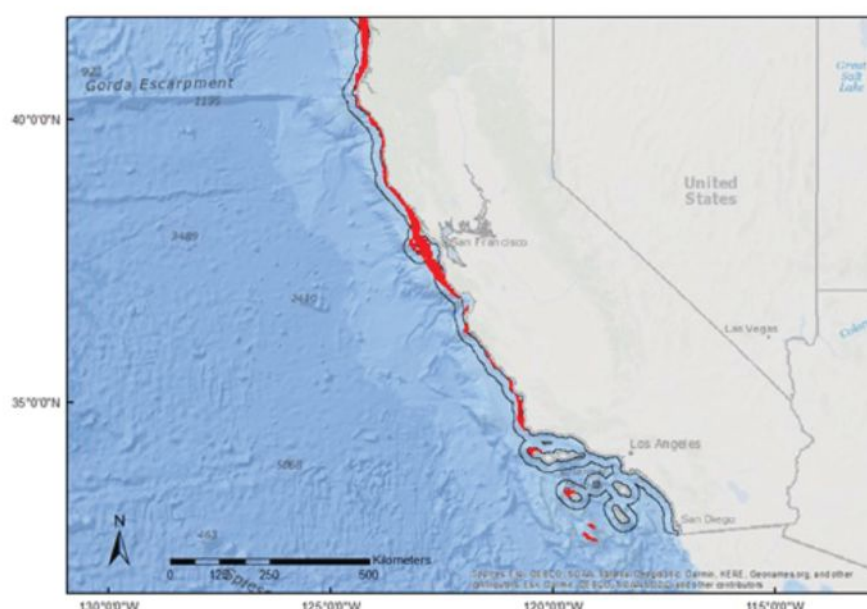
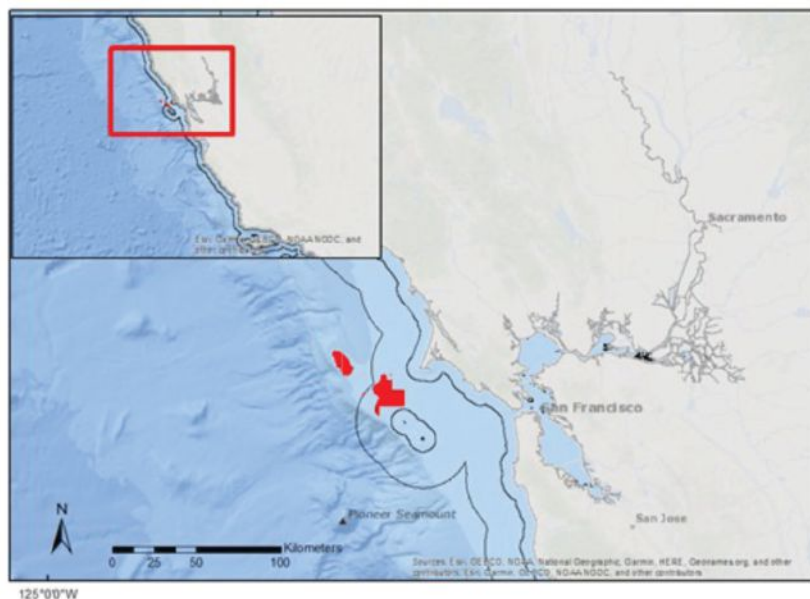
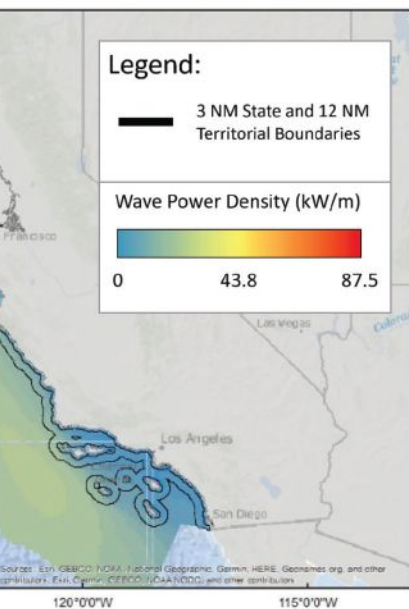
Growing kelp on the coast is not considerably energy-intensive, but processing the kelp could have higher energy costs. If sold as food, kelp might be dried. Dry-



Maps of wave power density in summer (top left) and winter (bottom left) and favorable areas (in red) for co-locating offshore finfish farms and wave energy in summer (top right) and winter (bottom right) off the coast of California. (Credit: Lysel Garavelli, Mikaela Freeman and Levy Tugade)

ing in the sun requires no electricity, but oven drying or freeze drying are more costly. Creating biofuels from kelp would require different processes, such as hydrothermal liquefaction, which applies extremely high pressures and temperatures to create crude oil from the plants.

Gear and PNNL researcher Orlando Garayburu Caruso calculated whether waves and tides on the Alaskan coast could provide enough energy for kelp process-



ing. They calculated how much energy waves and tides could generate near seven Alaskan communities by modeling different marine energy technologies as if they were operating at optimal spots near those communities. One of these technologies was a tidal turbine with two rotors on top of a post. Another device was a wave point absorber moored to the seafloor, with a donut-shaped float that moves up and down a column as waves pass by. The third device was a WaveStar prototype, a structure with four posts and extended floating arms that move up and down with the waves to drive a hydraulic motor.

Gear also determined the energy needed for different kelp processing pathways, such as producing food, converting to biofuels or extracting alginate, a component of seaweed used in many products from ice cream to dental

molds. Energy needed for kelp processing was roughly similar to the energy needed for fish processing, which meant that communities could process kelp during the fishing off-season with the same energy supply. Processing kelp for biofuels and alginate is more energy intensive than food processing though, and might require additional electricity beyond a community's current capacity.

The researchers calculated that waves or tides could provide enough energy for kelp processing, but that laying transmission lines between potential marine energy devices and the processing facilities would cost somewhere between \$3 million to \$98 million, depending on the community. That cost is prohibitively expensive, but Gear suggested potential intermediary facilities closer to the shore to decrease transmission construction costs.

***“PNNL and NREL researchers have shown potential
for pairing ocean energy technologies
with ocean farming or processing needs.”***

Alternatively, she and other researchers are looking into the feasibility of marine energy-powered monitoring devices on kelp farms, which would operate in the water and wouldn't require transmission lines. Sensors on monitoring devices could measure environmental conditions such as nutrient concentrations, so that farmers can potentially monetize the ecosystem benefits of their farm.

The Alaskan kelp industry is still expanding and figuring out how to optimize production. Marine energy developers could use the opportunity to develop alongside the industry, meeting specific needs of coastal seaweed farmers. PNNL's research on Alaskan kelp helps recommend next steps.

“This is just scratching the surface,” said Rinker.

Wave Energy for Offshore Fish Farms

Unlike kelp, farmed finfish like salmon need to be fed by humans. Pellets or a food slurry are pumped through a tube to the net pens. This feeding equipment, as well as the farm monitoring devices, refrigerators, lighting and maintenance equipment, requires energy. Some farms rely on diesel generators running constantly.

With seed funding from WPTO, a team of PNNL and NREL researchers, including Freeman, Greene and biological oceanographer Lysel Garavelli, determined potential locations in U.S. federal waters where waves

were energetic enough to power an entire fish farm yet also calm enough to prevent harming the farm crew and equipment.

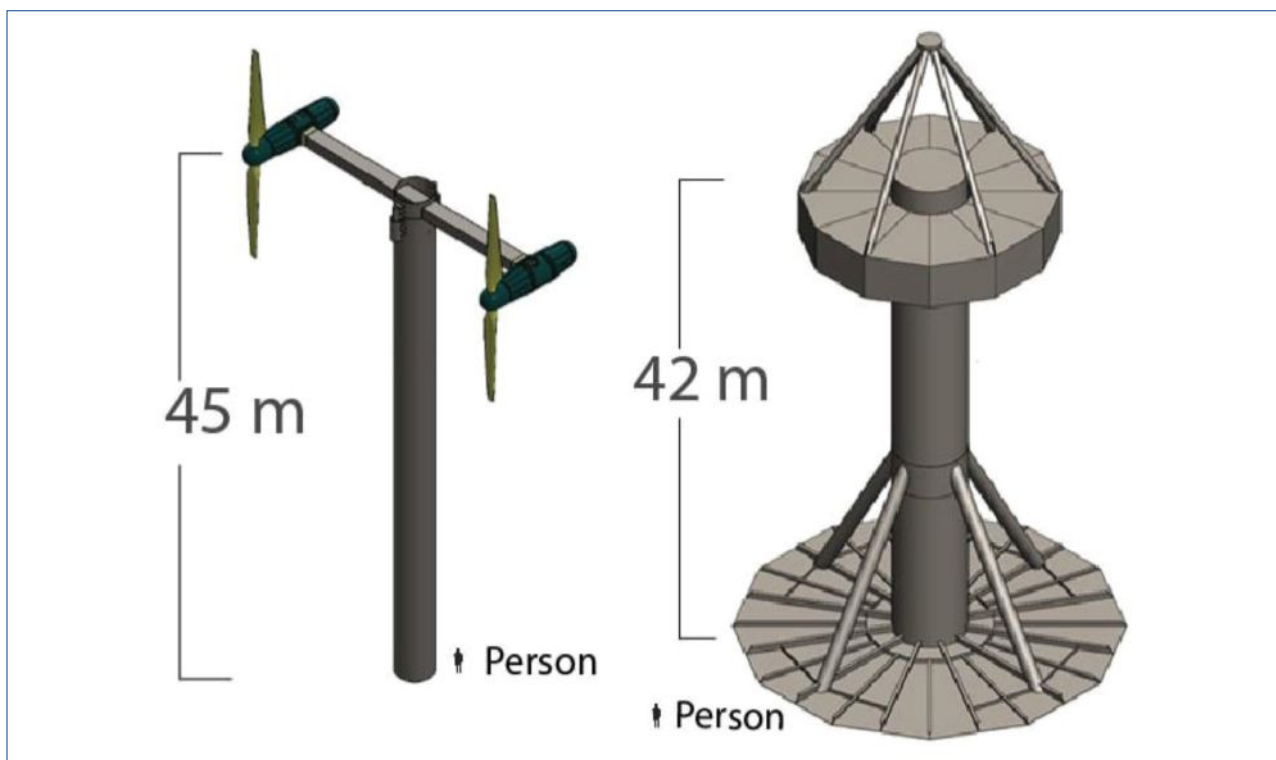
They chose to study areas at least 3 nautical miles from shore because deep, well-flushed waters are important for preventing environmental degradation from fish wastes and uneaten fish food. Almost no fish farms in the U.S. currently operate beyond this distance, known as the Exclusive Economic Zone, partly because of regulatory barriers. These barriers could change in the next decade though. A 2020 U.S. executive order called for streamlining permitting processes and finding offshore areas that are environmentally suitable for fish farming and don't conflict with other uses, such as commercial fishing.

The researchers interviewed aquaculture and policy experts to understand important factors for deciding where to locate an offshore fish farm. They also consulted previous research to calculate how much energy a fish farm might need. There was a clear need for more diverse and updated data on fish farming energy requirements, said Greene. The team ultimately used studies of Norwegian coastal salmon farms' energy usage, as well as energy specifications from hybrid barges, to calculate how much wave energy is needed to fully power a farm.

Focusing on the U.S. Pacific coast and Hawaii, where wave energy is greatest, the researchers conducted

*Farmers harvest lines of ribbon kelp in Doyle Bay, Alaska.
(Credit: Seagrove Kelp Co.)*





Models of a tidal current turbine (left) and wave point absorber (right) used for estimating energy generation from tides and waves. (Credit: Sandia National Laboratory Report 2014-9040)

spatial analyses to look for available ocean areas that matched the constraints of both fish farming and wave energy. Wave energy requirements limited location options the most. They found more feasible sites in winter than in summer, when waves are smaller. For example, most of California had favorable locations offshore in winter, while in summer only a couple areas were suitable off the coast of San Francisco. In Hawaii there were no feasible areas in the summer, but in winter there were some suitable areas on northern shores of the western islands.

The research team is planning to analyze specific areas more closely and with higher resolution data, such as in southern California where NOAA is studying suitable offshore aquaculture areas. By requiring that only a portion of the farm's energy demand be powered by wave energy, they also plan to find more potential areas for co-locating farms with marine energy technologies. For example, a hybrid aquaculture barge might be powered mostly by waves in the winter and mostly by sun in the summer.

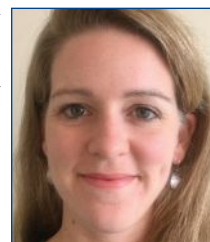
The team plans to write a guide for aquaculture developers that highlights the important environmental, regulatory and logistical constraints for siting farms in areas with adequate wave power. In the future they may also shift their focus to other energy needs for fish farming. Boat transportation to and from an offshore farm and hatcheries that raise juvenile fish in onshore facilities are

much greater energy consumers than ocean farm operations. Other technologies that convert tidal energy or ocean thermal energy closer to the coast might be appropriate for these applications.

Laying the Groundwork for Marine Energy Solutions

WPTO's "seedling" program is one example of how the agency funds research that builds a foundation for pairing marine energy with off-the-grid applications, such as ocean farming. The office also supports foundational research by providing funding to nonfederal institutions like universities. For example, this year WPTO announced a fourth National Marine Renewable Energy Center to be located at the University of New Hampshire with a focus on WPTO's Powering the Blue Economy Initiative. The office also supports an annual Marine Energy Collegiate Competition, where teams of college students design and pitch business ideas, gaining experience to become ocean energy and blue economy innovators. Cultivating new research and development ideas can lead to marine energy solutions that reduce the need for fossil fuels and contribute to the sustainability of ocean activities. **ST**

Sarah Loftus is a fellow in the U.S. Department of Energy's Water Power Technologies Office, through the American Association for the Advancement of Science's Science & Technology Policy Fellowship program. She earned her Ph.D. from the Duke University Marine Laboratory, where her research focused on cost-saving methods of microalgae cultivation for making products such as biofuels.



Making Waves in CCUS

Developments in Carbon Capture, Utilization and Storage on the Rise

By Jørg Aarnes

Carbon capture, utilization and storage (CCUS) is widely acknowledged to be an enabler to accelerate the energy transition, decarbonize hydrocarbon use and create low-carbon markets. Scaling the technology will be critical to a range of industries, including maritime, to align with national and international climate targets. When attached to a fossil fuel power plant, for example, the technology could reduce CO₂ emissions by more than 90 percent.

However, while the UN estimates CCUS technologies could mitigate between 1.5 and 6.3 gigatonnes of CO₂ equivalent per year by 2050, DNV's 2020 Energy Transition Outlook forecasts that it will not begin to scale until 2030. The annual report further predicts this will not happen to a significant level until 2040 without government incentives and with industry focusing on finding ways to reduce the cost of carbon capture and sequestration (CCS) technology. A key parameter is the assumed



Technology Centre Mongstad. (Credit: Technology Centre Mongstad)

carbon price, with the amount of carbon captured via CCS being very sensitive to this price change.

Fast-Tracking Carbon Capture

In October 2020, DNV, SINTEF and Technology Centre Mongstad (TCM) joined forces and signed a memorandum of understanding (MoU) to find new ways to accelerate the adoption of CCUS technology in emissions-heavy industries.

The Norwegian Longship CCS project, supported by \$2.6 billion USD from the Norwegian government, boasts many first-of-a-kind elements. This includes capturing emissions from at least one industrial facility, a cement plant, with the addition of a waste incineration plant to be decided in the future. It will also see carbon dioxide transported by ship to an offshore rig, then piped into a reservoir under the seabed for storage.

Beyond demonstrating the value of CCS at scale in Europe, the project is one of few, if any, to use a ship for CO₂ transportation, allowing more businesses to participate in carbon storage.

The aim of the MoU is to assist technologies and projects to move more rapidly from demonstration to commercial deployment. TCM will facilitate large-scale testing and verification of emerging CO₂ capture technology to help developers mitigate technical and financial risk.

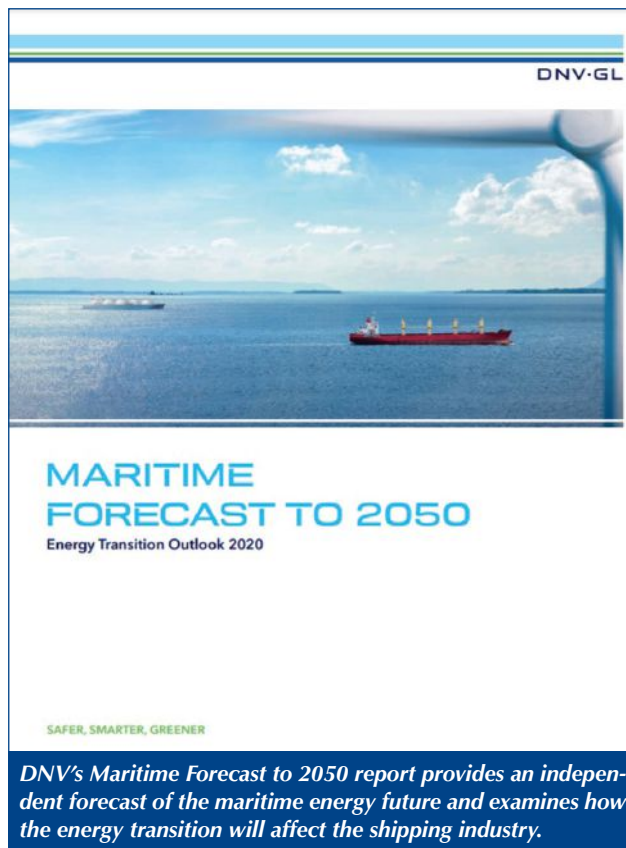
Together, DNV and SINTEF will provide guidance and support to qualify the solutions and provide verification of assets, infrastructure and storage sites.

Transporting CO₂ by Sea

CCS has become increasingly important to tackle climate change, with the Intergovernmental Panel on Climate Change (IPCC) saying the technology is essential to reach zero carbon at low cost.

In response, the International Maritime Organization's (IMO) strategy is to reduce: the total annual greenhouse gas (GHG) emissions by at least 50 percent by year 2050 as compared to 2008 levels (known as the "IMO absolute target"); and CO₂ emissions per transport activity by at least 40 percent by 2030, further pursuing 70 percent reduction by 2050, as compared to 2008 levels (known as the "IMO intensity target").

This represents a significant shift in climate ambitions for a sector that accounts for almost 90 percent of world trade and contributes to 2 to 3 percent of global CO₂ emissions.



On this front, DNV predicted in its Maritime Forecast 2050 report that: "to reach the 50 percent reduction necessary by 2050, low or zero-emission fuels are needed, such as ammonia and other carbon-neutral fuels to drive the emissions reductions into the middle of the century. Pathway modeling indicates that carbon-neutral fuels need to supply 30 percent to 40 percent of the total energy in 2050, to meet the IMO strategy."

The sector can also play its part in the evolution of carbon capture technologies and solutions. The transport of CO₂ by sea is emerging as an essential link in the decarbonization chain and could open up new industrial markets.

The use of ships to provide flexibility for where

CO₂ is sourced is a key component of the Northern Lights project, part of a collaborative Norwegian initiative to achieve full-scale CCS involving Equinor, Shell and Total. DNV provided technical support to the approval of ship design for the Northern Lights projects, which transports CO₂ at so-called medium pressures around 15 to 20 bar and temperatures around -25° C to -30° C.

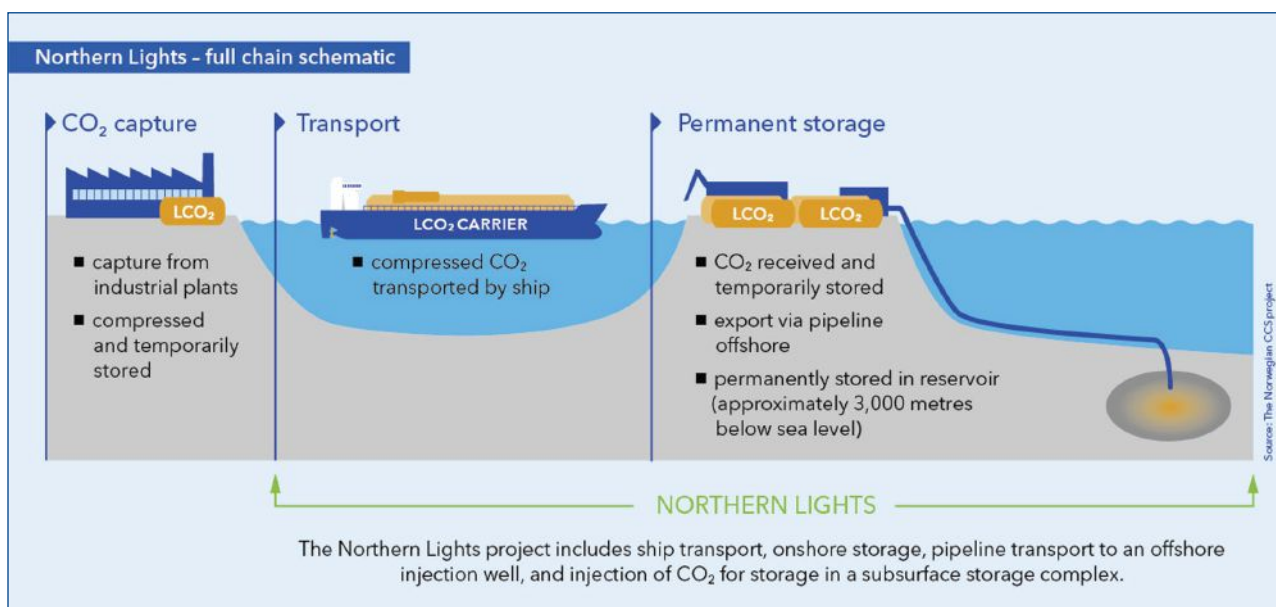
The tanks for the Northern Lights project have been designed to withstand pressure accumulation during laden voyages and the corrosive effects of liquid CO₂. The chosen design resolves the competing demands of economical tank manufacturing while meeting strict safety requirements by replacing standard low-temperature steel for pressure vessels with a high tensile strength property to withstand higher extreme loading and ensure resistance to cracking.

DNV concluded the pre-class evaluation of the innovative type C containment tanks for liquefied CO₂ in October 2019. The medium-pressure system reduces refrigeration requirements and provides relatively high-volume efficiency when applied on ships typically used for LPG transportation.

A new low-pressure concept to transport CO₂ is also under development. In this concept, CO₂ is kept at a temperature around -50° C, with a pressure of 7 bar, in line with LPG containment systems. Higher pressures combined with higher (ambient) temperatures are also possible.

CO₂ Carrier Fleet of the Future

According to a report by the International Energy Authority (IEA), CCUS targets a 15 percent reduction in



(Above) The Norwegian Ministry of Petroleum and Energy has approved the development plan for storage in the Longship carbon capture and storage project. (Left) The design approval statement for the type C containment tanks was issued November 2019.

3,600 m³, or roughly 1,770 tonnes. All are operated by Larvik Shipping AS and classed by DNV.

As an example of the significant growth expected in the liquefied CO₂ ocean transport market, in March 2021, Japan's Mitsui O.S.K. Lines Ltd. (MOL) acquired a stake in Larvik Shipping in step with the increasing adoption of CCUS. Likewise, Japanese shipbuilder Mitsubishi Heavy Industries (MHI) rolled out plans earlier this year to commercialize a CO₂ carrier design by 2025 to support its diversification into the carbon capture sector.

Further development efforts are needed to qualify safe and reliable solutions for low-pressure transport of CO₂ at pressures up to 40 to 60 bar based on compressed natural gas transportation principles. DNV is currently involved in a joint industry project with Equinor, Shell, Total and Gassco to assign technology qualification to de-risk the low-pressure solution and enable larger ships to carry higher volumes.

Phase one of the initiative was completed in 2020 to assess the feasibility of the liquefaction and conditioning plant, develop a concept for the ship and cargo handling system, and study a thermodynamic and simulations tool.

Phase two, encompassing execution of the qualification activities, is now underway with support from Climit and Gassnova. This involves: basic ship, tank design and manufacturing; tank material qualification; dynamic process simulation of loading/offloading operations; and experimental tests. Trials are expected to begin in the third quarter of 2021.

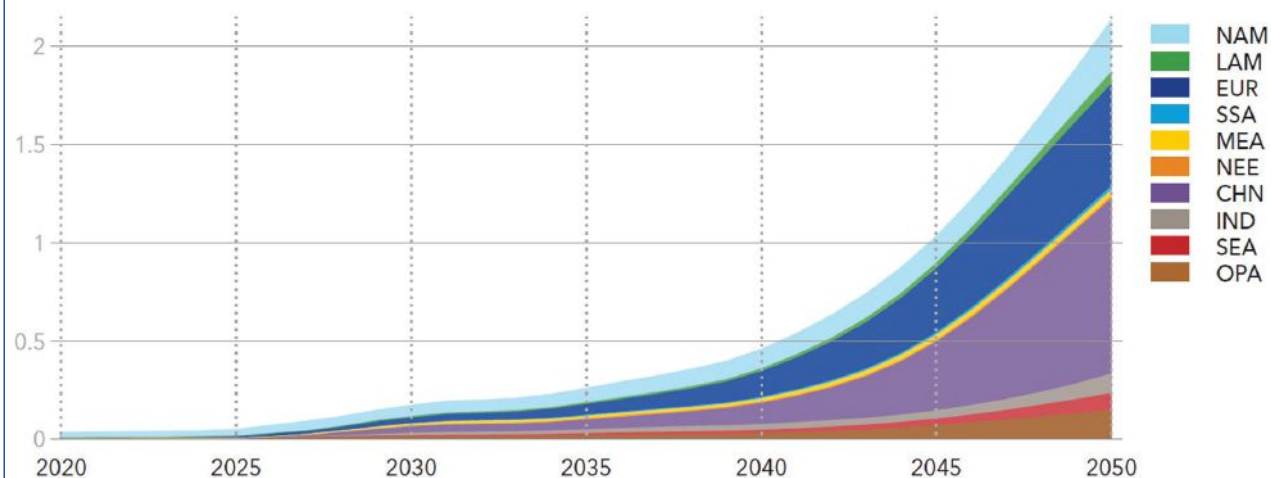
cumulative CO₂ emissions by 2070. This is expected to contribute to a reduction of about 6.9 billion tons per year when carbon neutrality is achieved.

Currently, maritime transportation of CO₂ is exclusively for commercial trade (food and beverage, cleaning, chemicals) and has limited volumes. This is served by a handful of smaller ships with cargo capacities in the range of 1,200 to 1,850 m³. Here, CO₂ is transported in liquid form at operating pressures of 13 to 15 bar and temperatures of approximately -22 to -28° C. For larger quantities of CO₂, cargo may need to be transported at lower operating pressures, for example from 7 to 8 bar and -50 to -55° C.

A total of seven vessels so far have been built for the dedicated transport of CO₂. Currently, the maximum capacity for transporting liquefied CO₂ is approximately

World CCS capacity by region

Units: GtCO₂/yr



Another collaborative project is ongoing with Stella Maris on CO₂ transport and injection. The Star of the Seas project will investigate the feasibility of large-scale shuttling, offshore loading, intermediate storage and continuous injection of liquid CO₂ for permanent storage in sub-sea saline aquifers. The case is based on shuttling batches of volumes around 50,000 m³, making the total amount of CO₂ injected up to 10 million tons per year.

World CCS capacity by region. NAM: North America, LAM: Latin America, EUR: Europe, SSA: Sub-Saharan Africa, MEA: Middle East and Africa, NEE: new Eastern European countries, CHN: China, IND: India, SEA: Southeast Asia, OPA: OECD Pacific.

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“Industrial-scale CCS has been defined as an integral part of the solution to reach the COP21 1.5° C target.”

The injection of CO₂ direct from the vessel to the storage site is also being investigated. Such ships will be high-pressure concepts with pressures between 40 and 60 bar. Two key aspects will need to be scrutinized: the change in CO₂ conditions necessary between the ship transport and the injection well, and the physical connection between the ship and the well.

A Matter of Urgency

As acknowledged by all major energy and climate mitigation scenarios, CCUS is expected to play a major role in a portfolio of solutions to achieve global decarbonization. However, with only about 40 million metric tonnes of anthropogenic CO₂ currently captured and stored in geological formations each year, CCS will not begin to scale until the 2030s, and not to a significant level until the 2040s, without swift government intervention.

The urgent need for CCUS is to avoid exceeding 2° C global warming, meaning that either more than 70 percent of the currently known fossil fuel resources is left in the ground or CCUS will be applied to the reserves that will be used.

Realizing its potential towards achieving net-zero more broadly depends on risk-based regulatory regimes that provide investment predictability. This will: promote investment in the best projects first; limit liability; require CCUS readiness for fossil fuel power generation; require CO₂ storage site exploration; and require CO₂ transport pipelines as part of pipeline infrastructures.

The problem is that CCS won't move down the cost learning curve unless the industry significantly increases its rollout of the technology. This isn't expected to happen imminently. However, the overall CO₂ reduction cost of CCUS is expected to fall as economies of scale and innovation potentials are realized. However, while forecasts indicate that CCS will scale, they also show, when taken with further research, that it will not scale early enough to help countries and the world meet the targets set by the Paris Agreement.

Many challenges to address social acceptance, environmental credentials and, crucially, techno-economic issues remain. The speed of adoption varies globally depending on economic and environmental impetus. It is widely accepted that the decarbonization of natural gas through CCS and the use of hydrogen as a vector to reduce emissions from natural gas consumption will be led by Europe, China, North America and OECD (the Organisation for Economic Co-operation and Development) Pacific.

In Europe, for example, multiple policy and market mechanisms are in play to deliver the net-zero target.

Among them is setting a price on carbon emissions to reach levels that will allow CCS to scale.

North America, like China, is also investing in and incentivizing uptake of CCS, though policies are not set to address emissions throughout the oil and gas value chain, including consumption, to the same degree as in Europe. Narrowing the learning curve will bridge the cost of technology development and deployment.

More than this, infrastructure and safety considerations, both real and in the minds of the public, are yet to be resolved.

CCS and the Climate Change Challenge

Industrial-scale CCS has been defined as an integral part of the solution to reach the COP21 1.5° C target. Global capture and storage capacity has increased by a third since 2019, and in Europe, there are currently 14 commercial facilities in operation or in various stages of development. Realizing its potential towards achieving net-zero depends on a cost race with different applications to drive down relative and absolute costs.

In the ongoing transition to low-carbon economies, CCUS is expected to be applied for the fossil fuel resources that will not be left in the ground. Technology is already available for a number of projects that are either low cost or do not compete with other low-carbon options (or both), and as such are considered “no regrets” in their deployment and should receive immediate support.

When investors' uncertainty to support the development of CCUS is abated, a broader application can then be fast-tracked across industries and markets. It is the near-term actions to spend, scale up and succeed that will ensure CCS fulfills its promise to create opportunities for business and society and mitigate the harmful consequences of climate change on the planet.

References

For a list of references, contact Jørg Aarnes at: jorg.aarnes@dnv.com. **ST**

Jørg Aarnes is the global lead of low-carbon energy systems at DNV, based at the company's headquarters in Høvik, Norway. DNV is an independent assurance and risk management provider, operating in more than 100 countries. Aarnes has spent more than a decade working in various functions for DNV, predominantly in the low-carbon space. He has been involved in developing DNV's Technology Outlook 2025, publishing a position paper on hydrogen as an energy carrier, developing a framework for certification of sites and projects for geological storage of carbon dioxide, and leading market analysis for climate adaptation services. He has a Ph.D. in applied mathematics, with emphasis on reservoir modeling and simulation.



Improving Heave Compensation

New Hydraulic Passive Heave Compensation Winch for North Sea

By Chad Murray • Dean Carey



Over the course of its 20-year history, Logan Industries has worked on countless projects that called for hydraulic and heave compensation and cylinder repair. This bedrock of experience with a variety of applications of heave compensation recently enabled the company to venture into the passive heave compensation winch market for the first time.

In making this move into the realm of passive heave compensation winches, skilled operators applied the same technology and principles that were carefully honed for compensated coiled tube lift frames, a core company product for many years. Over that time, innumerable lessons have been learned through observing and fixing the flaws that have occurred in other companies' machines, leading to a unique approach to flexible design. With specialists drawn from diverse backgrounds,

The yellow and blue skids each have a pair of winches that can passively compensate 18,500 lb. over a distance of 40 ft. The red HPU facilitates setup and control.

from mooring winches for boats to offshore winches to winches used to lift people in Vegas-style shows, Logan is able to bring together and apply these different technologies to design and build a quality product that works for a range of client-specific applications.

Every component and piece of machinery should be exceptionally robust to ensure longevity of the entire operation. To this end, no short cuts should be taken. Only high-quality components are used in repairs, and if the right component cannot be sourced, Logan has created the capacity to manufacture it in house. Redundancy



is built into systems, with backups put in place in the event of machinery failure. In short, by selecting only high-quality components, engineers are able to build winches that operate correctly every time.

Advantages of Active Compensation Versus Passive

Although both active and passive heave compensation have their advantages and disadvantages, passive heave compensation is undoubtedly more affordable than active heave. Primarily, there are fewer electronics that have the potential to fail. Passive heave is cheaper and less power intensive, and large hydraulic power units (HPUs) are not required in the mix.

However, it is important to help clients understand the difference between active and passive heave compensation to enable them to decide on the most suitable choice for their specific operations. The client knows the degree to which their vessel heaves, as well as the degree of load variation they want from their system. Logan will ask questions such as: How much tension variation of your load can you accept, and what are your fatigue allowables?

Budget and space constraints will also play into the choice between the two options. If the client has a system that is fixed to the earth while the vessel they are on is heaving, it may be impractical to have a large HPU to power the compensation of the system; in this case, pas-

The gas-powered spring, seen here in the form of gas bottles and accumulators, is tunable for various loads. It provides the passive power to the winch pairs to pull a constant tension on the suspended load as the rig heaves.

sive heave would be the best choice, as remotely stored gas bottles would be all that is required.

Passive heave compensation technology is well known across the industry, but to be effective, it is essential that it is applied and installed correctly.

Case Study

An offshore operator approached Logan in 2018 with a problem, which led to a close and creative collaboration between the two teams from commissioning to the design stage, right through to placing the passive heave winch equipment on the client's rig in 2019.

Not only was this a new venture into passive heave winches for Logan, but it was also the first venture for Logan in the North Sea (a well known and difficult environment for any compensator). Logan has a long history of many different types of cylinder compensators, but this project needed a set of winch compensators due to the length of stroke, variability in height above the splash zone and tight deck constraints.



On this particular project, there were only inches to spare between the end of Logan's frame and the next piece of kit. As a result, Logan was required to work intimately with the clients' structural engineers on the rig to make sure that the winches would be an adequate fit. To this end, there followed a great deal of design changes throughout the build to accommodate the size constraints, and subsequently the final frame was not exactly rectangular.

The client situated a quality surveyor on site 24/7 to oversee the entire build, working alongside Logan's project managers. Once the frame was shipped out, a Logan quality engineer was transferred on site to help commission the project to make sure everything was in order and help the client with all their heave compensation procedures.

North Sea Challenges

The project design phase enabled Logan to learn about the adaptations required to work in a North Sea application. The North Sea is a harsh environment and sustains large temperature fluctuations. Because the North Sea is considered relatively shallow water and is very active, oceanic heaves are much larger than those found in the Gulf of Mexico. Therefore, identifying components that adhere to this specific environment was challenging. Finding components that were ATEX Zone rated (qualification related to flammability) that would operate and function correctly in those harsh environments was another challenge.

Although Logan began with a high-quality motor, as the design process progressed, the motor manufacturer design engineers recommended a newer model motor with upgraded lower stall torque and higher efficiencies. This would make the winches perform better and provide a better response overall. Engineers agreed and upgraded the system entirely. This solution was more costly, but the right thing to do to make the system more robust and efficient for the client.

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Motor Upgrades, Added Safety Features

In this project, a purpose-built motor was used that was intended for low stall torque. As the motor heaves back and forth, it eases the winch through smooth transitions with no jerking movements. Condition monitoring was introduced for fluid running through the motors on board the skid, which checks for any kind of pollutants that might affect the efficiency of the system.

A custom programmable logic controller program for filling accumulators was introduced in lieu of a technician manually using a directional control valve and filling and emptying as the vessel heaves up and down. With this technique, the computer reads the levels of the

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Each winch skid was specifically designed to fit into the space available to provide the compensation assist to the rig.

bottles and fills and empties them as needed. As a safety feature, flow fuses are also built into the system. In the event of a catastrophic failure (e.g., a wireline break or some other type of breakaway subsea) during winch operation, the flow fuses will shut off the gas, preventing motor overspeed and ensuring the robust motors are not torn from the frame or damaged.

Custom manifolds and pressure-actuated ball valves for the compensation system mean that when switching back and forth between manual mode and compensation mode, a user can manually flip a switch and the ball valves automatically actuate.

An additional feature affecting the smoothness of the system heaving up and down is integrated encoders placed directly on the winch, which are specially designed for this motor and system.

With all of these features and safety measures, the system behaved as intended and delivered the load variation that was promised in the design phase.

Conclusion

The hydraulic passive heave compensation winch system that was developed is the culmination of 15 years of heave compensation design, manufacturing and repair experience, along with 20 years of winch building, design, manufacturing and repair capability. Heave compensation is a very difficult operational feature to design,

construct and operate correctly, and not many equipment suppliers get this right.

It is important that proper attention is afforded to customer engagement throughout the entire process, so that machinery is delivered to clients that will ultimately save them money down the road. Clients receive a set of very detailed procedures for their heave compensation systems, as each individual system works differently, and it is important to ensure the client knows how to properly use their individual system. As a consequence of years of paying close attention to repairs, actively learning and caring about the bigger picture for its clients, Logan has experienced no failures or requests for servicing in its heave compensation system in the field to date, and estimates to have saved its clients millions of dollars in the process. **ST**

Chad Murray is Logan Industries' sales manager and oil and gas and application sales engineer. With degrees in mathematics and engineering technologies, he has been with Logan for more than 12 years, working closely with Dean Carey to oversee the growth of the company from the procurement, engineering, design and sales departments.



Dean Carey is Logan Industries' technical director and has been with the company as a part-owner and founder for more than 16 years. He has overseen significant company growth, expansion and acquisitions. Carey has degrees in physics and aerospace engineering and a background in a variety of heavy machinery engineering roles.



Innovative Lionfish Trap

Device to Protect Threatened Ecosystems, Aid Fishing Communities

By Suzi Webster

Over the last 20 years, invasive lionfish populations have dramatically increased throughout the western Atlantic Ocean, Gulf of Mexico and Caribbean Sea. Lionfish have already caused a decline in native species that have significant ecological, cultural and commercial value. Further impacts on coral reefs and other important ecosystems are anticipated, but not yet fully understood. Fortunately, as the threat of lionfish has intensified, so too have the levels of awareness and concern among not just scientists and fishers but among members of the public.

In recent years, state-sponsored lionfish fishing derbies have incentivized divers to remove lionfish from coastal waters, and the growing demand for this tasty and widely promoted sustainable seafood has surpassed the

supply. Although spearfishing has proven to be an effective approach for managing populations in shallow areas, lionfish remain uncontrolled in deeper waters, where they continue to threaten fragile ecosystems (and evade dinner plates). Therefore, there is a demonstrated need and resounding demand for effective, nondestructive ways to capture lionfish that linger beyond recreational scuba depths.

Design

A new lionfish trap, recently patented by NOAA, could be a solution that offers both ecological and commercial benefits. The trap is shaped like a change purse and is constructed primarily out of a hinged steel frame,



Gittings shows off a 1/6th-scale model of the patented lionfish trap design.



attached netting and a centrally located vertical panel called a “fish attraction device.” Once deployed from the surface, the lionfish trap descends vertically through the water until it hits the bottom, where two curved extensions cause the jaws to spring open and lay flat on the bottom. The fish attraction device is then revealed, drawing lionfish toward the center of the 6-ft.-diameter net. Later, the trap can be recovered by pulling on a surface line, which closes the trap’s hinged jaws and captures the fish within the ring of netting.

This innovative technology was designed with specific operational and conservation-related goals in mind, and, as a result, has several benefits over conventional fish traps. For example, the lionfish trap’s open noncontainment design prevents “ghost fishing,” which is when gear “continues to fish” after being lost or abandoned. The lack of bait in the trap minimizes bycatch, or the capture of unwanted fish. Furthermore, the trap causes minimal damage to the ocean floor, is easily transportable on fishing boats due to its flat design, and is relatively simple to construct, deploy and retrieve.

Pathway to Patent

The lionfish trap was invented by Dr. Steve Gittings, who serves as the chief scientist of NOAA’s National Ma-

rine Sanctuary Program. Gittings first had the idea for the trap in 2014, after attending a colleague’s presentation about modifying lobster traps so they could be used for deepwater lionfish capture. Looking at her photos, Gittings noticed that far more lionfish were hovering around the trap than inside it. This observation inspired Gittings to design a trap that would take advantage of lionfishes’ tendency to aggregate around vertical structures.

“It started in my garage as a PVC cube,” said Gittings, who describes himself as a “garageineer.” Over the next couple of years, the invention progressed through several phases of design and testing, during which the trap was modified to be less bulky, easier to deploy and more enticing to lionfish. Throughout the process, Gittings engaged recreational and commercial fishers from numerous places, including Florida, North Carolina, Aruba, Mexico and Belize. Incorporating the input and expertise of these partners enabled Gittings to improve the lionfish trap so that it meets everyone’s needs. Testing of the trap prototypes was supported by NOAA, Lionfish University, the Florida Fish and Wildlife Conservation Commission, and ReefSave, and involved numerous volunteers and graduate students. The patent for Gittings’ trap, formally known as the “Apparatus for Harvesting Lionfish,” was filed April 2018 and issued February 2021.



These maps show increasing lionfish distribution from 1985 to 2020. (Credit: U.S. Geological Survey)

The Role of Technology Transfer

Initially, Gittings did not consider patenting the trap. “My interest in developing these traps, as a civil servant, was to keep it as open-source as possible, so that anybody can use these to not only help support their fishermen, but to protect ecosystems around the Caribbean,” he explained.

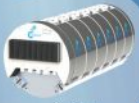
Gittings reached out to NOAA’s Technology Partnerships Office (TPO) after a colleague recommended that he speak with someone about potentially patenting the trap. TPO is NOAA’s research-to-commercialization office. Among other functions, TPO helps NOAA inventors patent their scientific and technological innovations and transfer them into the commercial marketplace, where they can more broadly impact ecosystems, communities and economies.

After speaking with TPO’s Technology Transfer Program Manager, as well as a representative from the National Institute of Standards and Technology General Counsel Office, Gittings said he realized that the best way to continue testing and improving the trap so that

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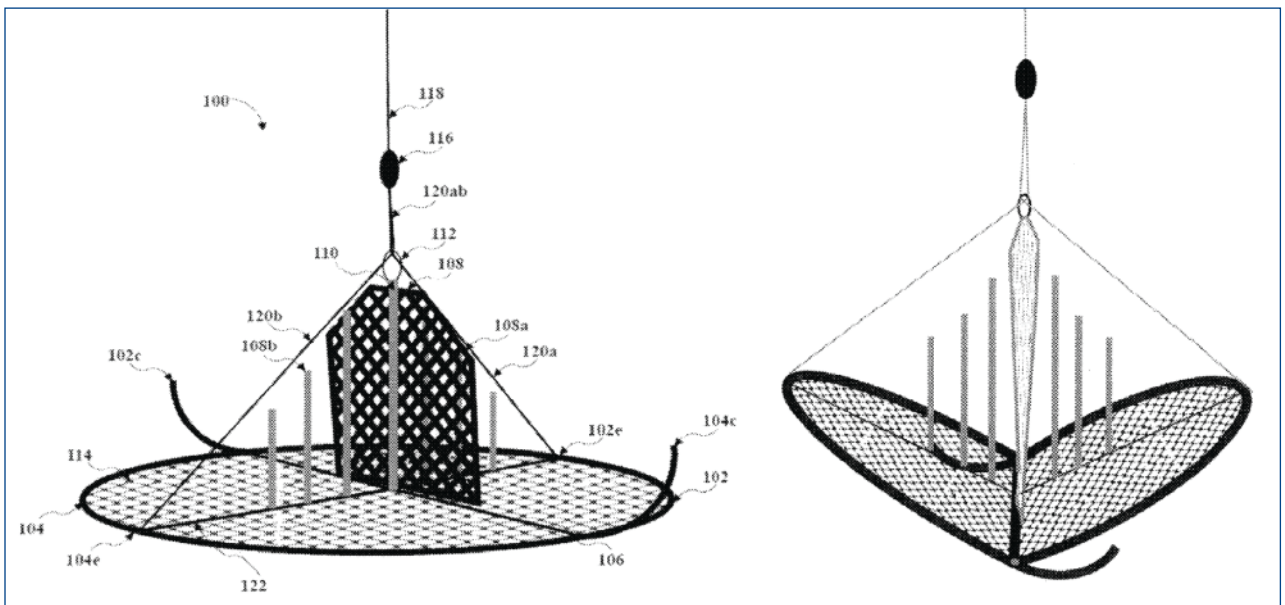
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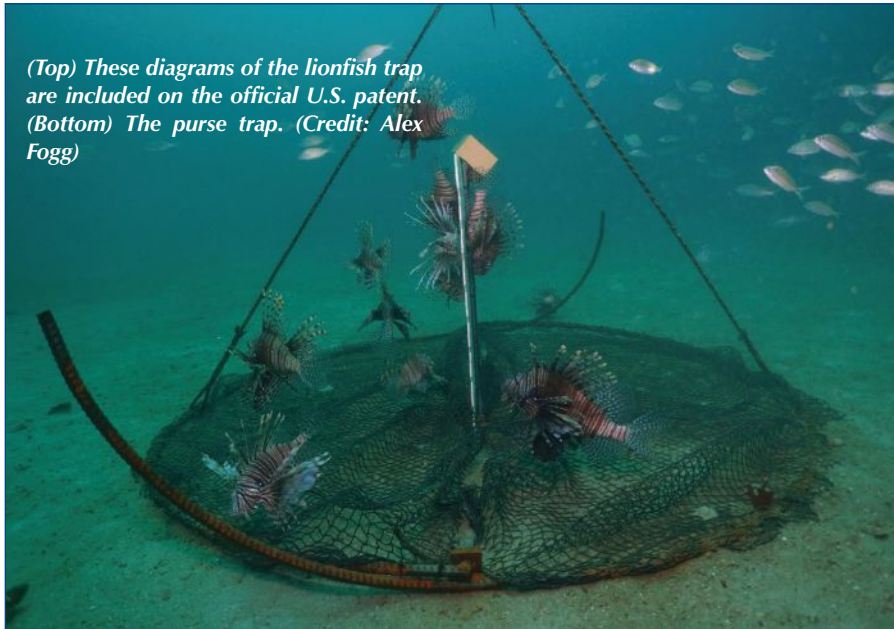
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(Top) These diagrams of the lionfish trap are included on the official U.S. patent. (Bottom) The purse trap. (Credit: Alex Fogg)



Competitive Grant to pursue this research and commercialization testing. REEF plans to collaborate with members of the Florida Keys lobster fishing community and test and improve various aspects of trap design, deployment and long-term effectiveness.

Gittings' long-term vision for the lionfish traps, should they prove to be an effective conservation method, is for fishers to use the traps outside of their primary fishing season. In using these lionfish traps, "The fishermen would be supplementing their income and be doing conservation at the same time," he said.

Gittings added that a supplemental fishery targeting lionfish could also reduce the pressure on

he could accomplish his goals was to "get control over the trap through patenting so that nobody else could stop us."

Gittings expressed gratitude for the support he received during the process of filing for the patent. "They interpreted everything I told them, going through every detail of the trap, and then put them on paper in language that the Patent Office understands. It was absolutely essential to have them do that work."

Looking Ahead

The next step is to determine whether the traps are effective for controlling lionfish populations in deepwater habitats; the prototypes were tested at depths of about 100 ft., but lionfish can be abundant down to several hundred feet below the surface.

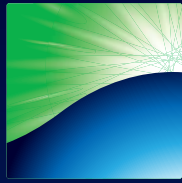
In October 2020, the Reef Environmental Education Foundation (REEF) received a NOAA Saltonstall-Kennedy

native species, such as snapper and grouper, which are overfished in some areas. And, of course, commercial use of the trap would provide an environmentally friendly and reliable harvest for the seafood industry and its hungry customers.

If the lionfish trap is successful, it will serve as another example of how technology transfer at NOAA contributes to the agency's guiding vision of supporting healthy and resilient ecosystems, communities and economies.

You can visit the NOAA National Marine Sanctuaries website to read more about lionfish and watch a step-by-step video to learn how to build the lionfish trap at: <https://sanctuaries.noaa.gov/lionfish>. **ST**

Suzi Webster is a stakeholder engagement and communications specialist and Knauss Marine Policy Fellow at NOAA's Technology Partnerships Office.



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UK Funds Greenhouse Gas Removal Research

Research teams across the U.K., coordinated by University of Oxford experts, have been chosen to probe innovative ways of removing greenhouse gases to help stabilize the climate. Encompassing a dozen universities and with funding for nearly five years, this is the U.K. government's largest-ever research program to understand and scale-up greenhouse gas removal (GGR) techniques. The program comprises five GGR demonstration projects around the country and a Directorate Hub.

The Oxford-led consortium, CO₂RE, has been chosen as the Directorate Hub. It will have a strong research function and liaise with demonstrators, business, policy makers and the public to evaluate approaches.

GGR aims to capture and remove CO₂ and other greenhouse gases already in the air to progress toward U.K. net-zero emissions by 2050.

CTI Group Expands in China

CTI-Maritec, a fuel and environmental technical advisory company, has opened a new fuel testing center in Shanghai, China. The new state-of-the-art testing lab forms part of CTI Group's strategy to expand its fuel, ballast water, hazardous material and environmental testing services in major maritime hubs around the world.

Vipo Rebrands

Vipo AS, a global pioneer in polymer solutions with a long successful track record in the oil and gas sector, has relaunched under new ownership. Formally Trelleborg Offshore Norway AS, Vipo will refocus its operation, creating a more balanced portfolio by expanding into new sectors while increasing collaboration, innovation and performance.

Its site at Krokstadelva in Norway has been part of the Trelleborg brand since 1987, and before that, the company was named Viking. The name Vipo derives from the "Vi" from "Viking" and "po" from "polymer."

Ocean Infinity Acquires Ambrey

Ocean Infinity, a marine robotics company, has acquired maritime services company Ambrey. Ambrey's team of maritime professionals deliver a range of bespoke offshore services, including, security, crisis and risk management, intelligence, insurance, fleet operation, and vessel design and build.

Ocean Infinity's data and software capabilities will revolutionize Ambrey's intelligence and insurance services, and its robotic surface and subsurface vessels have huge potential for Ambrey's shipping and offshore client base. Ocean Infinity is set to move closer to mobilizing its Armada fleet of robotic vessels, expected to be the largest fleet of its kind in the world.

Sonardyne Targets Carbon Neutrality

Sonardyne aims to become carbon neutral by the end of 2025. It is the first company of its type in the U.K. subsea

industry to publicly announce such an ambitious target. The goal covers direct and indirect emissions, including those associated with manufacturing and supply chain activities, from its U.K. sites and operations. The target will be guided by and certified to PAS 2060, the internationally accepted standard for carbon neutrality.

UKHO, Teledyne CARIS Support Seabed 2030

The Nippon Foundation-GEBCO Seabed 2030 Project has entered a technical cooperation agreement with the UK Hydrographic Office (UKHO) and Teledyne CARIS. The memorandum of understanding will see the parties work together to advance the effort associated with producing the definitive map of the seafloor by the year 2030.

The latest GEBCO Grid figure has 20.6 percent of the world's entire seabed now mapped. When Seabed 2030 was launched in 2017, only 6 percent of the oceans had been mapped to modern standards. The latest figure has seen a growth of 1.6 percent from last year's data, an increase equating to around half the size of the U.S.

Trial of Tugboat Controlled by Joystick

ABB, together with Singaporean shipyard Keppel Offshore & Marine (Keppel O&M), has successfully carried out South Asia's first remote joystick control of a tugboat in the busy Port of Singapore. The Port of Singapore, with more than 130,000 vessels calling annually, presents one of the most complex settings for autonomous harbor operations in the world. The trial marks a major milestone in validating the increased safety and efficiency of tug operations utilizing digital solutions already available today for nearly any kind of vessel.

Partnership to Enhance Sustainability

GoodFuels, a marine biofuels supplier, and Norwegian environmental nonprofit ZERO have partnered to enhance sustainability in the maritime supply chain. The organizations will work together to accelerate the shift to a renewable transport sector, with a focus on sustainable biofuels for the maritime industry. They will collaborate on establishing framework conditions for sustainable biofuels in the Nordic region.

GoodFuels and ZERO will also work together on driving increased demand for renewable shipping solutions by analyzing policy making, engaging with decision makers, and advocating for uptake of sustainable biofuels with the industry and political leaders.

ZERO also joins GoodFuels' independent sustainability board, comprising leading NGOs and academics in the sustainable transport and biofuels segments.

Iridium Invests in DDK

Iridium Communications Inc. has made a strategic investment in DDK Positioning (DDK), an Aberdeen, Scotland-based provider of enhanced Global Navigation Satellite System (GNSS) accuracy solutions. DDK uses the Iridium network to provide global precision positioning services that can augment GNSS constellations, including GPS and Galileo, to significantly enhance their ac-

curacy. DDK is also developing similar services for other GNSS constellations, such as GLONASS and Beidou.

Picotech Names First US Distributor

SUBSEA 20/20 Inc. was named as the first U.S. distributor of U.K. sonar manufacturer Picotech Ltd.'s products. Picotech's product line includes the PicoCAT USV and the world's smallest integrated multibeam sonar, the PicoMB-130. Picotech sonars are built on a scalable hardware and firmware platform called PicoSonar, which is also supplied to Kraken Robotics for the AquaPix MIN-SAS and AquaPix InSAS sonar systems.

Knowledge Building for Mooring Chains

Kraken Robotics Inc. has joined the LifeMoor project, an industry collaboration to improve the lifetime estimate of subsea mooring chains. This four-year "Knowledge Building Project for Industry" started in 2018. LifeMoor is supported by the Research Council of Norway and run by SINTEF, Norway's largest independent research institution. Industry partners are NTNU, Equinor, MacGregor, Aker BP and Nosted, alongside Kraken Robotics.

METIS Moves into Canada

Maritime data analytics specialist METIS Cyberspace Technology (*Sea Technology*, March 2021) has opened a fully owned subsidiary in Vancouver, Canada, to enhance its service to local customers and generate new business throughout North America. The establishment of this regional office enables METIS to support local shipowners with their digital transformation journeys and help them to meet sustainability requirements.

The new subsidiary is led by Dimitris Bouras, managing director of METIS Cyberspace Technology (Canada) Inc. Bouras specializes in IoT and distributed cloud technologies for the maritime industry.

Side-Power Returns to Original Brand Name

IMTRA, a manufacturer and importer of solutions and products for the marine, energy and transportation markets, has announced that the Side-Power thruster brand has rebranded under its original name, Sleipner.

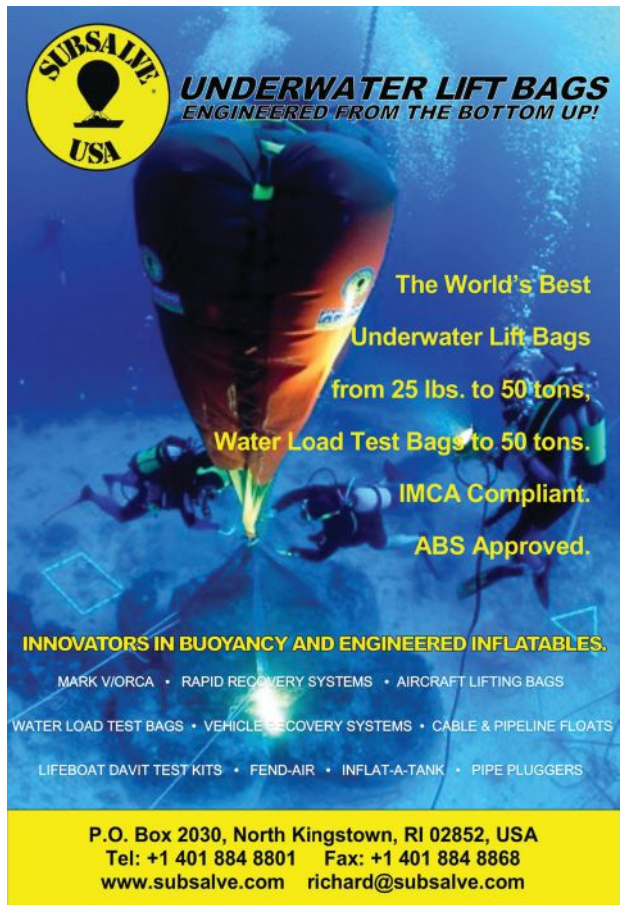
Sleipner services the recreational and commercial marine industries and has also achieved success with other product lines, such as its Vector fin stabilizers.

TDI-Brooks Turns 25

TDI-Brooks is celebrating 25 years in business. It was formed in 1996 when Dr. James Brooks and Dr. Bernie Bernard recognized the market need for specialized oceanographic research.

TDI-Brooks specializes in high-end environmental chemistry; multidisciplinary oceanographic and environmental projects; surface geochemical exploration and heat flow; and geotechnical and offshore survey projects for the oil and gas industry, as well as federal and state agencies.

The corporate headquarters is located in South College Station, Texas, and the company staff numbers close to 100. **ST**



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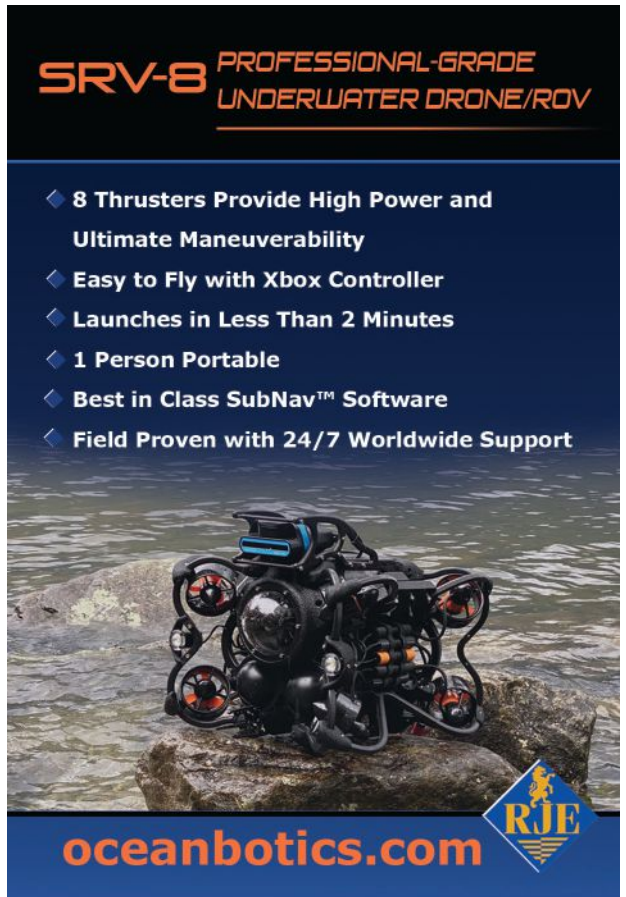
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al for inland water environments, base mapping for coastal zones and shoreline. Teledyne Optech and Teledyne CARIS.

USV

APACHE 4 provides unmanned operation with shallow drafts, high navigational accuracy and stable hovering to hydrographers conducting flow velocity and discharge measurements of current sections. It is compatible with a wide variety of ADCP sensor brands. CHC Navigation.

Shipboard Cybersecurity

Ra Endpoint Detection and Response (RaEDR) is a security information and event management application configured specifically for low-bandwidth connectiv-

ity encountered across merchant shipping fleets. It also provides enhanced security for the offshore and passenger shipping sectors. Episco-Ra.

Offshore Internet

TracPhone LTE-1 Global is a marine communications system designed to provide recreational boaters and commercial mariners in more than 150 countries with Internet access up to 20 mi. offshore. The system utilizes LTE Advanced (LTE-A) cellular network technology, which is faster than regular 4G LTE. KVH Industries Inc.

Hydrogen Electric Boat



Hydrogenia is South Korea's first commercialized hydrogen electric boat. It is 32.8 ft. long, has a maximum capacity of six people and can operate at 10 kt. for 6 hr. Danfoss Editron provided the electric drivetrain and subsystem for the boat. Vinszen.

Deep-Cycle Lithium Battery

The HLX+ series of solar lithium batteries is the first battery for all climates, hot and cold. Upgrades allow for ease of use and battery bank performance. The optional HLX+ Bridge enables communications between strings of batteries in a bank, providing coordinated charging, discharging and heating cycles. KiloVault LLC.

Ballast Water Treatment

M-Series BWTS incorporates a novel reactor arrangement to increase the flow rate capacity of existing technology without the need for manifolds. This design allows ship-owners to optimize installation time and costs, while keeping the number of reactors required to an absolute minimum: only one or two depending on the required flow rate. BIO-UV Group SAS.

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UT Thickness Gauge

Cygnus Mini ROV ultrasonic thickness (UT) gauge can be mounted onto small observation ROVs with or without a manipulator. Cygnus worked with Deep Trekker to achieve full integration with polyvalent ROVs. The unit is pressure tested to 1,640 ft. (500 m) and suits the vast majority of thickness testing applications. Cygnus Instruments Ltd.

Underwater Acoustic Modem

Version 2.7 features an improved user interface and multiple user connection to a single modem. It allows for remote acoustic switching through the default pshell, or via the Python, C++, JSON or MATLAB APIs. Popoto Modem.

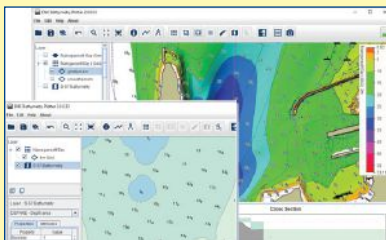
Voyage Optimization Platform

Optimise uses algorithms that enable voyage optimization and calculation of the U.S. dollar and CO₂ impact of recommended decisions. This can increase earnings and reduce emissions. ZeroNorth.

Shoreline Waste Collectors

BeBot is the first product in the Searial Cleaners range. It is a beach-cleaning robot that is remotely controlled and moves over sand to meticulously clean the shore. Poralu Marine.

ENC Bathymetry Plotter



This new software can assist hydrographic offices in the production of nautical charts. Improvements have been made in the generation of ENC contours and in selecting soundings, greatly reducing the manual workload required to develop ENCs. SevenCs GmbH.

Adapter

HBL105GF enables use of a 30-A, 125-V marina power pedestal to

run 15-A, 125-V devices. Plugged into the shore power source, it offers a standard three-prong outlet with integrated ground fault circuit interrupter (GFCI). It automatically stops power from flowing if it senses a short. Hubbell Marine Electrical Products.

Electrical Evaluation

The Electrical Power Profile evaluation application offers a data-based evaluation for feasibility studies of alternative electrical power sources. This is in response to growing market interest in the benefits of installing alternative electrical power sources to auxiliary engines as a cost-effective and sustainable way to cover energy needs during port operations. METIS Cyberspace Technology S.A.

IMO Carbon Compliance

VeriSTAR Green enables shipowners to assess their compliance with EEXI and CII regulations. Clients with a Data Collection System (DCS) or Monitoring, Reporting and Verification (MRV) contract with BV can use this platform to report their fuel consumption data and request verification. Bureau Veritas.

Ship Design

This integrated, intelligent ship design software provides comprehensive coverage of the entire ship life cycle, from newbuild projects to retrofits and conversions. It applies to naval architecture, basic and detail design, and ship production and delivery. NAPA Group (Napa Ltd.) and CADMATIC.

Wind Turbine Installation Vessel

Atlas A-class is the latest addition to the Atlas series. It can carry four 14-MW wind turbines and is tailored for cost-effective installation of large-scale wind farms. KNUD E. HANSEN A/S.

Telemetry, UPS System

WaveWatcher is a combined telemetry and UPS module based on the recently upgraded DBT-4 Data Buoy Controller. It can accommodate additional sensors. Planet Ocean Ltd. **ST**



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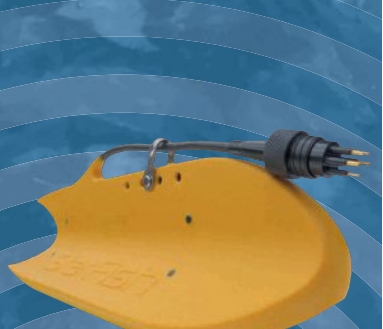
seatrac

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DriX Added to Rental Pool

WAMS has added the iXblue DriX USV to its existing pool of equipment. Available for WAMS customers in Brazil, the DriX USV will increase operational performance for shallow-water hydrographic and geophysical surveys, as well as LBL array box-in operations and ROV/AUV tracking for deepwater projects. DriX can conduct both remote-controlled and supervised autonomous operations within visual range or over the horizon. It can perform in severe weather conditions and keeps downtime to a minimum compared to traditional survey vessels. DriX can host a wide range of payloads for high-quality data acquisition and subsea positioning in shallow and deepwater.

P8X Aids Treasure Hunters

Every day, treasure hunters search sunken shipwrecks or sites

of interest to retrieve artifacts that can be sold on the open market or donated to museums for preservation. An estimate of the value of sunken treasure in the world begins with a guess at the number of sunken ships. In 2012 James Delgado, then director of the Maritime Heritage Program at NOAA, estimated that there are a million shipwrecks underwater, most of which are undiscovered.

JW Fishers' Pulse 8X underwater metal detector is a useful tool when searching for sunken treasure in wrecks. For example, the University of Rhode Island and Dr. Bridget Buxton hit the payload in 2015 when the team found more than 1,000 gold coins off the coast of Israel with their P8X system.

Unmanned Fish Farms

Norwegian researchers are working on projects to lay the ground-

work for a revolution in aquaculture. Fish farming is a multimillion-dollar business that depends on careful maintenance of the giant cage nets to prevent stock from escaping through gaps and to reduce biofouling on the nets that can affect fish health. Nortek's DVL is helping to bring autonomous navigation to ROVs used in Norwegian fish farms.

Detailed inspections are crucial to farms, and they rely on sending divers down to check the nets; a cumbersome and time-consuming process, not least because there is a lot of netting to check: a fish farm cage is typically around 50 m across and 30 m deep.

As part of the Artifex project, Nortek's DVL1000 was used on an ROV to be able to "see" a fish net as it moves along the circumference of a cage, enabling the operator to spend more time on inspection, rather than navigation.

This ROV navigation tech could pave the way for completely unmanned fish farms, with monitoring and repair controlled remotely by

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personnel on land, and repairs carried out by ROVs rather than divers.

New IMCA Guidelines on GNSS Use in Tidal Calculations

The International Marine Contractors Association's (IMCA) newly published "Guidelines on the use of GNSS for tide calculations" (IMCA S 027) provides an overview of how Global Navigation Satellite Systems (GNSS) can assist in more accurate real-time direct measurement of tidal changes.

IMCA S 027 includes sections on tide theory; geodetic reference systems and tidal datums; quality assurance and quality control; and a glossary, references and a list of further reading that includes the recently revised IMCA S 015 - "Guidelines for GNSS positioning in the Oil and Gas industry" produced with the International Association of Oil and Gas Producers.

IMCA S 027 is available at: www.imca-int.com/store/digital-publications/survey.

Ammonia Fuel Joint Research

TotalEnergies has entered into a memorandum of understanding with 22 leading companies across diverse industries to initiate a joint study on ammonia as an alternative marine fuel. These industries include: energy, mining, power utility, chemical, terminal, shipping, ship-building, manufacturing, bunkering and classification.

This joint study framework will address common challenges for ammonia to contribute to the decarbonization of the shipping industry, including the safety assessment of an ammonia-fueled ship and ammonia bunkering, ammonia fuel specification, and net carbon emissions from ammonia production.

As a carbon-free molecule, ammonia is a promising alternative fuel for large vessels and deep-sea shipping to significantly reduce greenhouse gas (GHG) emissions within the shipping industry. In particular, green ammonia (produced from green hydrogen using renewable electricity, water and air) could play a major role in enabling the industry to meet the International Maritime

Organization's (IMO) carbon emission reduction targets proposed by 2050.

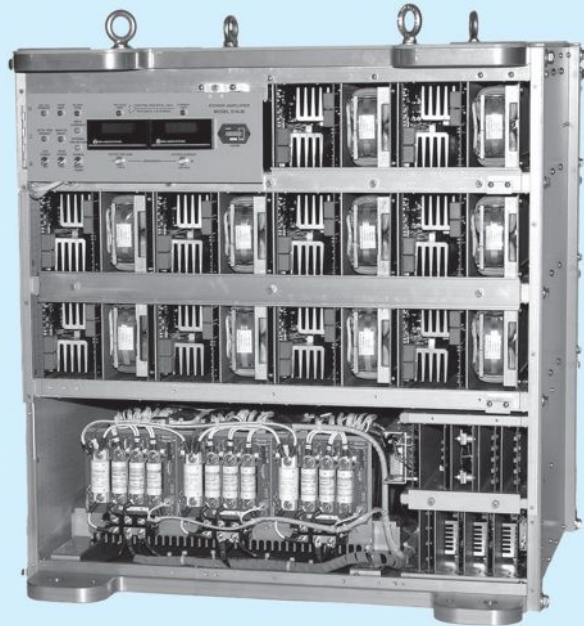
TotalEnergies is also part of a joint project with other maritime industry leaders through the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping to assess the technical, financial and environmental potential of converting existing vessels to future fuel solutions and technology, such as ammonia.

Hydrogen Chain in Singapore

DNV has signed an agreement with Keppel Offshore & Marine (Keppel O&M) to collaborate on the hydrogen value chain in Singapore. DNV and Keppel O&M will cooperate to develop: safety requirements for hydrogen as an energy source; infrastructure requirements for hydrogen storage and local transportation; and offshore applications for hydrogen technology. **ST**

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Seaweed as Solution To Nutrient Pollution

Activities on land, such as industrial-scale farming, send lots of nutrients into waterways where they accumulate and flow into the ocean in greater quantities than they naturally would. Nutrient pollution has wrought havoc on marine systems, contributing to harmful algae blooms, worsening water quality and oxygen-poor dead zones.

A team of researchers from UC Santa Barbara has proposed a novel strategy for reducing large amounts of nutrients—specifically, nitrogen and phosphorous—after they have already been released into the environment. In a study appearing in the journal *Marine Policy*, the authors contend that seaweed's incredible ability to draw nutrients from the water could provide an efficient and cost-effective solution. Looking at the U.S. Gulf of Mexico, the team identified over 63,000 sq. km suitable for seaweed aquaculture.

Diatoms Capture CO₂ Via Biophysical Processes

A first-of-its-kind study published by "Frontiers" suggests that microscopic seawater plants called diatoms initially capture carbon dioxide by biophysical, rather than biochemical, processes. Diatoms remove as much CO₂ from the environment as all of the world's forests combined, and it's vital to understand how this process will respond to rising CO₂ levels.

The international Tara expedition collected marine plankton samples around the world from 2009 to 2013. These included more than 200 metagenomes, which show the abundance of the genes responsible for five key enzymes, and over 220 metatranscriptomes, showing expression of the genes for these key enzymes, from diatoms of different size classes.

Across all of the samples measured, one enzyme was roughly 10 times more abundant than any of the other enzymes. This enzyme, called carbonic anhydrase, confirms that

diatoms are actively pumping in dissolved CO₂ inside the cell, as opposed to biochemically transforming CO₂ first.

The team also observed complex patterns of the key enzymes' gene expression, which varied depending on latitude and temperature. The researchers hope to learn more using new data sets from future expeditions.

The study indicates that despite variability in CO₂ levels, these tiny autotrophs are highly efficient in concentrating CO₂ inside the cell, which is the probable reason for their ability to fix nearly one-fifth of the global carbon fixation on earth.

Methane Release Could Amplify Global Warming

Methane bubbles regularly reach the surface of the Laptev Sea in the East Siberian Arctic Ocean, each of them a small blow to efforts to mitigate climate change. The source of the methane used to be a mystery, but a joint Swedish-Russian-U.S. investigation recently discovered that an ancient gas reservoir is responsible for the bubbly leaks. The study was published in the *Proceedings of the National Academy of Sciences*.

Methane in the Laptev Sea is stored in reservoirs below the sea's submarine permafrost or in the form of methane hydrates—solid ice-like structures that trap the gas inside. It is also produced by microbes in the thawing permafrost.

Whereas microbial methane is released in a slow, gradual process, disintegrating hydrates and reservoirs can lead to sudden, eruptive releases.

Methane is escaping as the Laptev's submarine permafrost is thawed by the relative warmth of overlying seawater. With an even stronger greenhouse effect than carbon dioxide, methane releases into the atmosphere could substantially amplify global warming.

New MBARI Research Vessel

ABB will equip Monterey Bay Aquarium Research Institute's

(MBARI) new flagship vessel with solutions for sustainable yet maximum performance for decades.

Located in Moss Landing, California, MBARI seeks to advance marine science and technology to understand a changing ocean. Earlier this year, MBARI announced construction of a new state-of-the-art research vessel named in honor of its founder, David Packard.

Upon delivery in 2023, the 50-m-long vessel with 18 scientists and a crew of 12 on board will support MBARI's work to study the depths of Monterey Bay and beyond. The vessel will enable further exploration of the Monterey Canyon, one of the deepest underwater canyons off the west coast of the U.S. that extends more than 470 km offshore and plunges 4,000 m deep.

Marine Food Chain Would Suffer with Sudden Warming

A key type of zooplankton's inability to adapt to climate change could have adverse implications for marine food chains across the world if a severe global warming event were to occur, researchers at Oxford University have found. Their study investigated how planktonic foraminifera adapted to changing climatic conditions over the last 700,000 years, or seven global ice ages, with results demonstrating that the species maintained a static thermal niche over the period. This means they would need to seek out suitable habitats or risk extinction if climate change were sudden and dramatic. In comparison, zooplankton species with flexible niches would be able to adapt to such changing conditions.

The scientists used an atmosphere-ocean global climate model to chart species' occupied mean annual temperatures at both sea surface and the depth of their habitats. They also used the fossil records of the foraminifera to build an accurate record of the species' past distribution patterns.

In case of a sudden warming event, foraminifera would likely redistribute around the world. This would have a cascade effect on the rest of the marine food chain. **ST**

Contracts to Advance Poland's Offshore Wind

Poland's Energy Regulatory Office (ERO) announced Equinor and Polenergia's Bałtyk II and Bałtyk III projects were awarded contracts for difference under the first phase of Poland's offshore wind development scheme. The projects, with a combined potential capacity of 1,440 MW, are among the first to secure offshore wind awards in Poland. The award confirms the projects' inclusion in the first phase of Poland's ambitious offshore wind development plan, contributing significantly to Poland's energy transition and the development of the local offshore wind supply chain.

Poland has the ambition to develop 5.9 GW of offshore wind by 2030 and up to 11 GW by 2040. Bałtyk II and Bałtyk III could generate enough renewable offshore wind energy to power 2 million Polish homes. They are among the largest offshore wind projects under development in Poland. Construction work could commence as early as 2024.

Grouting Services for France Wind Farm

Large Diameter Drilling (LDD), part of Acteon, has signed a contract to deliver grouting services for DEMA Offshore's installation of foundations at the Saint-Nazaire wind farm off the coast of the Guérande Peninsula, France.

It will be the world's first wind farm to use drilled XL-monopile foundations, and it will comprise 80 GE Haliade wind turbines.

LDD will provide skilled personnel and services for grouting the drilled monopiles in position and the transition pieces to monopile connections using equipment from its Core Grouting branded service.

UXO Survey for Wind Farm

James Fisher Renewables has been selected by the French transmission grid operator Réseau de Transport d'Électricité (RTE) to identify unexploded ordnance (UXO)

along the export cable routes for the Fécamp offshore wind project. The contract will be fulfilled by JF Renewables' subsidiary Mojo Maritime France. Confirmed targets will be disposed of by the French Navy in line with regional legislation.

The 18-km export cable, which will sit at depths between 5 and 35 m, will provide the electricity transmission connection for the 71-turbine offshore wind project located 13 to 22 km off the northwest coast of France.

California Makes Agreement On Offshore Wind

California has made an agreement with the federal government to advance offshore wind development. This could help achieve the state's clean energy goals, bolster renewable energy sources, and create new jobs and investments in California.

Initial areas identified for offshore wind development could bring up to 4.6 GW of clean energy to the grid over the next decade, enough to power 1.6 million homes.

As part of the agreement, the Department of the Interior's Bureau of Ocean Energy Management (BOEM) plans to offer a lease sale as early as 2022 within a 399-sq.-mi. area of the central coast northwest of Morro Bay and a separate area on the north coast of California. The areas were identified cooperatively by the Departments of the Interior and Defense and the state of California.

Renewable Energy for Ships

ClassNK has issued an approval in principle to Eco Marine Power for the development of a renewable energy system for ships: Aquarius Marine Renewable Energy with EnergySail. It is an advanced integrated system of rigid sails, marine-grade solar panels, energy storage modules, charging system and marine computers that harnesses the power provided by the wind and sun.

The array of rigid sails are automatically positioned by a computer system to best suit the prevailing

weather conditions and can be lowered and stored when not in use, or during bad weather. The rigid sails are based on EMP's EnergySail technology, and these renewable energy devices can be used when a ship is at anchor or in harbor. Each EnergySail can be configured with a mix of sensors, photovoltaic panels or other power generation devices.

Wave Energy Prototype

Mocean Energy has commenced testing of its Blue X wave energy prototype at the European Marine Energy Centre (EMEC) in Orkney.

Testing will advance to more rigorous full sea conditions this summer when the 20-m-long, 38-tonne wave machine is moved to EMEC's grid-connected wave test site at Bilia Croo.

Initial Installation at Bourne Tidal Test Site

An environmental monitoring system and the first tidal turbine were installed at the Bourne Tidal Test Site in Cape Cod Canal. The turbine is a conceptual design provided at no cost by Littoral Power Systems Inc. The two sensors installed are monitoring water conditions and fish behavior. A video camera and acoustic camera monitor the turbine and surrounding fish.

Renewables in Canada's Blue Economy Strategy

In response to the government of Canada's consultation on its Blue Economy strategy, Marine Renewables Canada has recommended actions to help ensure that marine renewable energy plays an important role in building the country's blue economy and fighting climate change. One recommendation is for the government to support reducing development and permitting risks for marine renewable energy projects.

Canada's largely untapped tides, waves, rivers and offshore wind can generate clean power; reduce emissions; slow ocean acidification, sea level rise and coastal erosion; boost the ocean industry supply chain; and support the ocean sector's transition to net zero. **ST**

Validating Data via Drone

Israeli drone service provider ER-ELIS recently conducted pilot projects using a drone equipped with a single-beam echosounder in the Mediterranean and Dead Seas. The data were validated by authorized local surveyors and reports from previous surveys of the same areas. The reference bathymetric data were collected using a manned boat and multibeam and single-beam echosounders and demonstrated a good match between the results of new drone-based and traditional methods.

The bathymetric system comprised a standard commercial DJI drone (UgCS SkyHub onboard computer and terrain following system with radar altimeter) and Echologger ECT400 single-beam echosounder provided by SPH Engineering, Latvia. Eye4Software Hydromagic was used to conduct data processing.

Management Software For Armada Robotic Fleet

Ocean Infinity is implementing ShipManager fleet management software for 17 new robotic ships and additional AUVs. Ocean Infinity will implement ShipManager's modules for planned maintenance, procurement and business intelligence for its advanced fleet of uncrewed, low-emission vessels for capturing ocean data.

The robotic ships in Ocean Infinity's Armada fleet are equipped with state-of-the-art sensors and pioneering navigational solutions that enable data to be gathered from the shallowest and deepest waters, whether for exploration, mapping or searching for wreckage. The marine robots use hybrid technology, cutting CO₂ emissions. An Armada robotic vessel emits up to 90 percent less CO₂ than a conventional survey vessel.

Argeo Buys SeaRaptors

Argeo of Norway, a newly listed company and growing subsea offshore service company, has procured two Teledyne Gavia SeaRap-

tor 6,000-m-rated AUVs. The two SeaRaptor AUVs will contribute to Argeo's growing fleet of AUVs and will enable deep-sea surveys for offshore wind, aquaculture, deep-sea minerals, and offshore oil and gas.

Volvo Penta Expands Marine Battery Business

Volvo Penta has acquired a majority stake in ZEM, a company with 12 years of market experience as a supplier of both marine battery systems and complete electric drive-lines. ZEM has a strong track record in Norway, the most mature marine e-mobility market in the world.

ZEM will remain operating under its current brand, and under the leadership of Egil Mollestad, the long-term CEO of ZEM and a recognized pioneer in the maritime sector. The collaboration between Volvo Penta and ZEM is expected to grow gradually.

USV Searches for 1962 Wreck

A research campaign that aims to find the wreck of the *Ravenel* fishing trawler, which disappeared in January 1962 off the coast of Saint-Pierre-et-Miquelon, France, has begun. For this latest attempt, the DriX USV by iXblue is being used to try to solve this mystery, which remains one of the major shipwrecks in the history of French fishing. A search area of 439 km² has been defined.

The 15 sailors aboard the *Ravenel* disappeared after eight days of sailing.

Digital Learning for Gen Z

Shipping and maritime companies hoping to attract Generation Z (Gen Z) talent should develop personalized and interactive e-learning programs featuring video content and bold colors, according to education experts.

In an FE News blog on Gen Z (those born after 1996), Sam Blyth from learning management systems (LMS) developer Instructure wrote that new technology was making it easier to create engaging, interactive experiences. Students can

control their learning by "deciding how, where and when to engage with course material, and to learn in a way that suits them best."

OneLearn Global, a digital maritime e-learning provider, has applied this to its personalized next-gen LMS, which features interactive and video content. The company also uses green in its LMS to appeal to Gen Z's eco-friendly sensibilities.

A Barnes & Noble College report finds that Gen Z, as digital natives, "expect technology to play an instrumental role in their educational experience."

DNV Sets New VR Standard

DNV has revised its ST-0033 Maritime Simulator Systems standard with the introduction of a new class D for all function areas covering cloud-based simulation. The new standard sets an industry first.

The use of remote methods to deliver training programs for seafarers has increased during the COVID-19 pandemic as a result of restricted or impossible physical attendance at training and examination centers.

New function areas and new technologies for real operations, as well as statutory requirements, must be covered in all learning programs to be compliant with Class D.

Under the validity conditions of DNV SeaSkill Learning Programme Certificates, all real, virtual and cloud-based simulators used as tools in such training and examinations are also required to be DNV certified.

Although remote simulation is not new technology, the focus of the revision was on the replacement of hardware with a software-enabled artificial environment presented in such a way that the user suspends belief and accepts it as a real environment (VR) while still maintaining the required behavioral realism.

The new class divides between: (a) interactive, synchronous, continuous online instructor-led simulation; (b) detached, asynchronous student-led simulation; or a combination of (a) and (b) when operated synchronously or asynchronously, depending on the nature of the exercise to meet training objectives. **ST**

contracts

I-Tech AB, Mölndal, Sweden, has received a frame order for Selektop, an organic, nonmetal active agent that prevents barnacle larvae from settling on a vessel hull. Chugoku Marine Paints (CMP).

Sternula, Aalborg, Denmark, has signed a partnership agreement to strengthen the maritime sector in Ghana and West Africa by using Sternula's VHF data exchange system (VDES) to enable reliable and accurate maritime navigational warnings for seafarers. Ghana Maritime Authority.

CRP Subsea (formerly Trelleborg Offshore UK), Skelmersdale, U.K., has been awarded two contracts to provide a total of 223 Njord-Guard cable protection systems for the Borkum Riffgrund 3 and Gode Wind 3 offshore wind farms in the German North Sea. Ørsted.

EDGE Navigation AS, Oslo, Norway, has chosen a partner to develop a container vessel with the patented X-BOW hull lines for non-fossil propulsion. Ulstein Design & Solutions AS.

CGG, Paris, France, has been awarded a major project for the seismic imaging of an innovative simultaneous node and streamer 3D survey over a 3,700 km² area of the Nordkapp basin in the Barents Sea. Lundin Energy Norway AS.

Wärtsilä, Helsinki, Finland, has signed a memorandum of understanding to cooperate on the inclusion of Wärtsilä propulsion systems in compressed hydrogen (C-H₂) ships. Global Energy Ventures.

OceanWise, Alton, U.K., will support port operations by installing the data management system Port-Log, which will enable pilots and port operators to access real-time data and personalized alerts that closely monitor the port's ever-changing tide and environmental conditions. Port of Waterford.

Astrup Fearnley, Oslo, Norway, has signed a memorandum of understanding to jointly deploy an emissions prediction calculator that will provide ship brokers, owners and charterers with quality assured emissions data predictions over the Veracity platform. DNV. **ST**

meetings

Note: The coronavirus (COVID-19) pandemic could affect event dates. Check event websites for the latest updates.

SEPTEMBER

September 7-10—SPE Offshore Europe, Aberdeen, Scotland. +44 (0) 1224 253807, gillian.george@bigpartnership.co.uk or www.offshore-europe.co.uk.

September 10—AUVSI XPONENTIAL, Virtual. www.xponential.org/xponential2021.

September 13-17—London International Shipping Week, London, England. +44 1296 682104, ljacobs@elabor8.co.uk or https://londoninternationalshippingweek.com.

September 19-24—Underwater Minerals Conference, St. Petersburg, Florida. lazevedo@immsoc.org or www.underwaterminerals.org.

September 20-22—Oi Middle East, Abu Dhabi, United Arab Emirates. firas.abultaif@reedexpo.ae or www.oceanologyinternationalmiddleeast.com.

September 20-23—Global OCEANS 2021 San Diego – Porto, California and Virtual. https://sandiego21.oceansconference.org/global-oceans-2021-san-diego-porto.

September 20-24—NMEA/RTCM Conference & Expo, Orlando, Florida. 410-975-9425, mreed@nmea.org or www.expo.nmea.org.

September 21-23—Sea Asia, Singapore. www.sea-asia.com.

September 26-October 1—IMAGE - International Meeting for Applied Geoscience & Energy, Denver, Colorado, and Virtual. www.imageevent.org.

September 29-October 1—Lakebed 2030 Conference, Virtual. 231-995-2500 or marinecenter@nmc.edu.

OCTOBER

October 4-5—Maritime Transport Efficiency Conference, Geneva, Switzerland. https://mte-conference.com.

October 5-6—Subsea UK Underwater Robotics Conference, Virtual. www.subseauk.com/10927/underwater-robotics-conference.

October 5-7—Deepwater Operations and Topsides, Platforms & Hulls Conference and Exhibition, Galveston, Texas. www.offshore-event.com.

October 5-7—Seawork, Virtual. www.seawork.com.

October 12-14—Ocean Business, Southampton, U.K. www.oceanbusiness.com.

October 20-22—NOIA Fall Meeting, Point Clear, Alabama. www.noia.org/2021fallmeeting.

October 26-27—Offshore Energy, Amsterdam, Netherlands. www.offshore-energy.biz.

NOVEMBER

November 2-5—Aquatech Amsterdam, Amsterdam, Netherlands. +31 (0)6 51815306 or a.koomen@rai.nl.

November 2-5—Europort, Rotterdam, Netherlands. +31 10 293 32 50, info@europort.nl or www.europort.nl.

For more industry meetings, visit sea-technology.com/meetings. **ST**

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people

The MacArtney Group has welcomed **Trine Borum Bojsen**, chief operating officer of Copenhagen Offshore Partners, to its board of directors. She brings a wealth of global experience from the offshore wind industry and strong management and strategic skills. Bojsen has an M.S. in engineering and more than 25 years of experience in marine infrastructure, with an emphasis on offshore wind farms.



TDI-Brooks has hired **Forrest Walker** for a lead role in the Marine Geotechnical service line as a field geotechnical engineer. He is skilled in soil sampling and testing techniques, CPT and seismic analysis, project reporting, lab soil testing, and environmental site investigations. Walker was previously at Fugro USA Marine, where he was a field geotechnical engineer.

Lilian Brayle has joined Naval Group as executive vice president for the Australian Future Submarine Program. Brayle will be in charge of managing the teams in France and in Australia to deliver the program on cost and on schedule, and to engage the Australian supply chain to deliver Naval Group's commitment to spend at least 60 percent of the contract value in Australia.

The U.S. Senate has approved President Biden's nomination of **Dr. Eric S. Lander** to be director of the Office of Science and Technology Policy (OSTP). Lander will be the 11th director of the White House OSTP and the first in U.S. history to serve in the president's cabinet. Lander will also serve as the president's science adviser.

INSPIRE Environmental has hired **Scott Olson** as senior field and innovation manager to enhance and expand the company's underwater engineering capabilities. Bringing more than three decades of experience in project management, systems engineering, and field operations, as well as a lifelong passion for marine exploration, Olson will play a lead role in cementing INSPIRE's place as a leading provider of seafloor habitat monitoring for the emerging offshore energy industry in the U.S.

Luke Garrett has joined Deep Ocean Engineering's engineering team. He has a background in mechanical engineering and mechatronics.

Subsea Europe Services GmbH has appointed **Jorge Ibaceta** as offshore operations manager. Highly skilled as a team leader and project manager, Ibaceta has extensive experience in marine construction, offshore dredging and reclamation. **ST**

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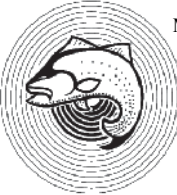
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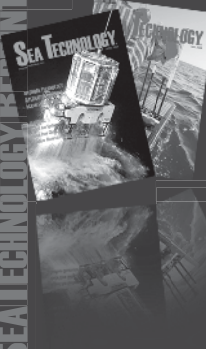
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The World Demands More from the Backbone of the Internet—Bertrand Clesca

Bertrand Clesca is director of client solutions at Pioneer Consulting. Pioneer's new report "Suppliers of Undersea Telecommunications Systems" ana-



lyzes the submarine fiber-optic systems supply market. It identifies key market dynamics and technology evolutions, profiles key market participants, and allows for comparison of the competitive positions of suppliers in the repeated and unrepeated market segments.

Supporting 99 percent of inter-continental data and voice traffic and \$10 trillion worth of transactions daily, submarine fiber-optic cable systems are essential network infrastructure for consumers, businesses and governments. To track these critical systems and take stock of supporting infrastructure, Pioneer Consulting released its new report, "Suppliers of Undersea Telecommunications Systems." It identifies notable trends: demand and investment spikes, changes in cable construction, and shifting market share.

With the COVID-19 pandemic, subsea telecommunications systems have become even more critical as the world relies more on internet traffic to support social, business, educational, cultural, gaming and entertainment activities. Submarine cable systems are key in this growing demand for content, cloud and streaming services, and in maintaining the cohesion of entire societies. Thus, submarine cable systems and data centers are gaining more attention from investors ready to support digital infrastructure.

International submarine cable systems form a submerged information superhighway to move data between large data centers. The insatiable need for more capacity in the past few years comes from content providers operating at a scale unimagined by telcos and carriers 10 years ago. Today, there is no

plan B for submarine networks, as there is simply no viable alternative networking technology that comes close to optical networks in terms of capacity, scalability, latency, reliability and economies of scale. This means, as an industry, the supplier community must continue to innovate with submarine optical networking technology. For their part, buyers must ensure that they maintain a minimum number of sellers for the sake of a robust, competitive and innovative supply chain.

Although invisible to the vast majority of bandwidth users, subsea infrastructure is a unique engineering marvel combining optical communication, information science, high-end photonics, nonlinear optics, electrical engineering, material science, engineering practices, multidimensional project management, high reliability standards, marine expertise, regulatory matters, adherence to local and international jurisdictions, and complex slowly changing operations in an adverse sea environment.

Subsea cable infrastructure can send over 25 Tbit/s (about the same as 125 single-layer Blu-ray disks or 665 single-layer DVDs per second) across the Atlantic Ocean in a single strand of optical fiber. To achieve this, submarine cable systems rely on a technical ecosystem for optical communications based on three pillars invented and developed in the past 60 years: the semiconductor laser in 1962, the optical fiber concept in the mid-1960s, and the fiber-based optical amplifier design of 1986/87, all of them operating simultaneously in the spectral region where optical fiber attenuation is minimal (around 1,550 nm, i.e., in the near-infrared region). More recently, terminal transmission equipment, connected at each end of the submarine cable, adopted coherent technology; an old concept in radio communications that made its way into optical communications at the

end of the 2000s and in subsea cable systems at the beginning of the 2010s.

While sophisticated (and expensive) system designs can maximize per-fiber capacity and minimize the gap between their operation and the fundamental Shannon-limited capacity, system designers can better use the limited electrical power fed to the wet plant from the cable landing stations by increasing the number of fiber pairs inside the cable and operating them at lower capacity (typically 16 to 20 Tbit/s per fiber pair). This high fiber count approach (HFC), or spatial division multiplexing (SDM), offers lower costs per transported bit and enables the construction of 320 Tbit/s transatlantic cable systems that will enter commercial service in 2022, while maintaining the electrical design of the cable and submerged equipment.

The cable system market is mostly supplied by four companies with 98 percent of market share: ASN (France), NEC (Japan), SubCom (U.S.) and HMN Tech of China. ASN is the only fully integrated cable system supplier providing terminal transmission equipment, power feed equipment, submarine cable and submerged repeaters, plus a fleet of six cable ships for installation and maintenance. SubCom is similar to ASN, with the exception of terminal transmission equipment. NEC and HMN offer terminal transmission equipment, cable and repeaters, but rely on subcontractors for marine installation services.

As demand for submarine cable infrastructure only grows, its supply and maintenance must expand. It is crucial for potential investors, developers, purchasers or operators of this infrastructure to remain well informed of industry trends to make educated decisions about these systems on which the world relies. You can find more information at: www.pioneerconsulting.com/reports. **ST**

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