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Submarine Cable Protection and the Environment

An Update from the ICPC, Written by Marine Environmental Adviser, Dr Mike Clare

Topics Covered in this Issue:

- Ocean Gliders
- Autonomous Underwater Vehicles (AUVs)
- Seeing Under the Ice
- The Future of Underwater Robotics
- Decommissioning & Recycling Subsea Cables

SUBMARINE CABLE PROTECTION AND THE ENVIRONMENT

An Update from the ICPC, Written by the Marine Environmental Adviser (MEA)

PUBLISHER

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EDITOR'S CORNER

Often in the submarine cable industry, both telecoms and power, there is a lot of research and development effort and industry attraction to advancements in technology. Whether it be increased fibre count or higher capacities resulting from modern transmission equipment, as is the case for fibre optic cables, or higher power transmission, longer route distances, and deeper deployments as is the case for power cables, these advancements are at the forefront of the cable industry. What gains a lesser degree of attention, however, are all the technologies that make the installation, operations, maintenance and recovery of cables systems viable in the first place.

The seafloor has to be mapped and measured, surface and sub-surface sediment characterised, obstructions such as wrecks avoided, other seabed infrastructure identified, all done in high resolution and over long distances. The industry has relied on vessel mounted or towed acoustic equipment for much of these activities, particularly where such equipment can reasonably meet the resolution and corridor width requirements to identify and engineer a cable route. But this no less underscores the fact that the field of ocean surveying and monitoring equipment is and has been revolutionising around us and is being adopted in other maritime sectors.

This publication discusses those advancements, and as users of our world's oceans, summarises particular aspects of the marine technology landscape that is, if anything, ever evolving in ways that can be applied to the submarine cable industry. We no longer live in the days of quiet enjoyment of our subsea infrastructure. We live in an increasingly complex world, and the use of our oceans are no different. But technology is helping us meet those challenges in a productive and sustainable way to ensure that the global demand for broadband as well as power can be met today and in the future.

Sincerely,
Ryan Wopschall
ICPC General Manager

INTRODUCTION

The use of autonomous robotic systems is no longer a vision for the future. Instead, it is part of a rapidly growing reality; from robot vacuum cleaners that navigate and tidy your home, self-driving tractors that sow and harvest crops, to the Curiosity Rover that explores the surface of Mars. Autonomous robotic systems learn from and respond to the surrounding environment, with an aim of reducing errors, improving safety, and increasing efficiency. The ability to use autonomous systems to perform tasks is particularly useful in situations that are too dangerous for humans, such as decommissioning contaminated nuclear facilities[1] and accessing remote, harsh or hazardous environments that could not be observed otherwise[2]. One such remote and harsh environment is the deep ocean, an environment that plays a critical role in buffering

the effects of climate change, hosts important resources, and represents the largest habitat on Earth[3,4]. Though areas of the deep ocean have been mapped with remote sensing tools mounted or towed from vessels, and crewed vehicles have descended the depths of the oceans in various locations, the great pressures at deep water depths, often-powerful ocean currents, and large areal extents of the open ocean mean that actual direct observation by humans is challenging, and sometimes impossible. The development of autonomous robotic systems therefore provides new opportunities to better access and understand this important and extensive part of our planet in new ways never experienced before.

In this issue we aim to provide an overview of how uncrewed vehicles are increasing our understanding of the ocean. We touch on how these autonomous tools can be used to reduce the reliance on large ocean-going ships for a range of purposes, and their potential to tackle emerging challenges including decommissioning of oil and gas structures. Finally, we discuss opportunities for the recovery and recycling of subsea cables.

Thank you to Mr Simon Appleby for contributions on cable recovery and recycling to an earlier report that have been incorporated here and to Dr Daniel Jones and Dr Veerle Huvenne concerning AUV monitoring and oil and gas decommissioning.

RISE OF UNDERWATER ROBOTS

- Underwater robotic systems are now routinely used in ocean science and a wide array of industrial applications
- Underwater gliders can make long-term measurements of the ocean across vast distances
- Autonomous Underwater Vehicles can fly close to the seafloor and provide extremely high-resolution observations in remote deep sea environments
- Technological advances are enabling greater endurance for these autonomous platforms to the point that they can be launched from shore, reducing reliance on ships
- Next generation technology can tackle a host of new applications, including the environmental surveys needed prior to the decommissioning of offshore oil and gas structures

The deployment of autonomous robotic systems to monitor the ocean is far from a new endeavour. In fact, autonomous systems have been used to monitor parts of the ocean for more than 100 years, including early devices that measured ocean current speed and direction[5,6]. Major advances then came in the form of robotic Argo floats that drift with ocean currents to measure chemical, oceanographic and biological variables (see last issue of this publication). Advances in technology over the past two decades have led to the rapid development of far more sophisticated systems that can travel across the ocean by themselves and deploying a far wider array of sensors, revolutionising our understanding of the ocean and deep seafloor[5]. Increasing fuel costs for vessels and a push towards Net Zero means that such autonomous systems are also increasingly an attractive prospect. We focus here on two main types of marine technology - gliders and Autonomous Underwater Vehicles (AUVs) - and discuss how they are used to explore the ocean. Other types of autonomous vehicles are also increasingly used at sea, including uncrewed surface vehicles (USVs) such as that used to sail over the top of the recently-erupted Hunga Tonga-Hunga Ha'apai volcano.

OCEAN GLIDERS MAKING SUSTAINED MEASUREMENTS ACROSS THE OCEAN (pages 7-8)

A glider is a torpedo-shaped float that uses an onboard pump to repeatedly take in and let out water to change its buoyancy; allowing it to float up and down to make measurements along vertical profiles in the ocean[6]. Its torpedo shape and wings produce an overall forward motion as well as moving up and down, creating a 'sawtooth' profile (typically within the top 10-1000 m below the sea surface), which can be controlled so the locations of measurements can be decided before and during deployment[7]. A glider is set to periodically surface, allowing it to position itself using a GPS receiver and make use of iridium or acoustic communications to transfer data to the end user that may be based on shore. Some of the applications of gliders include:

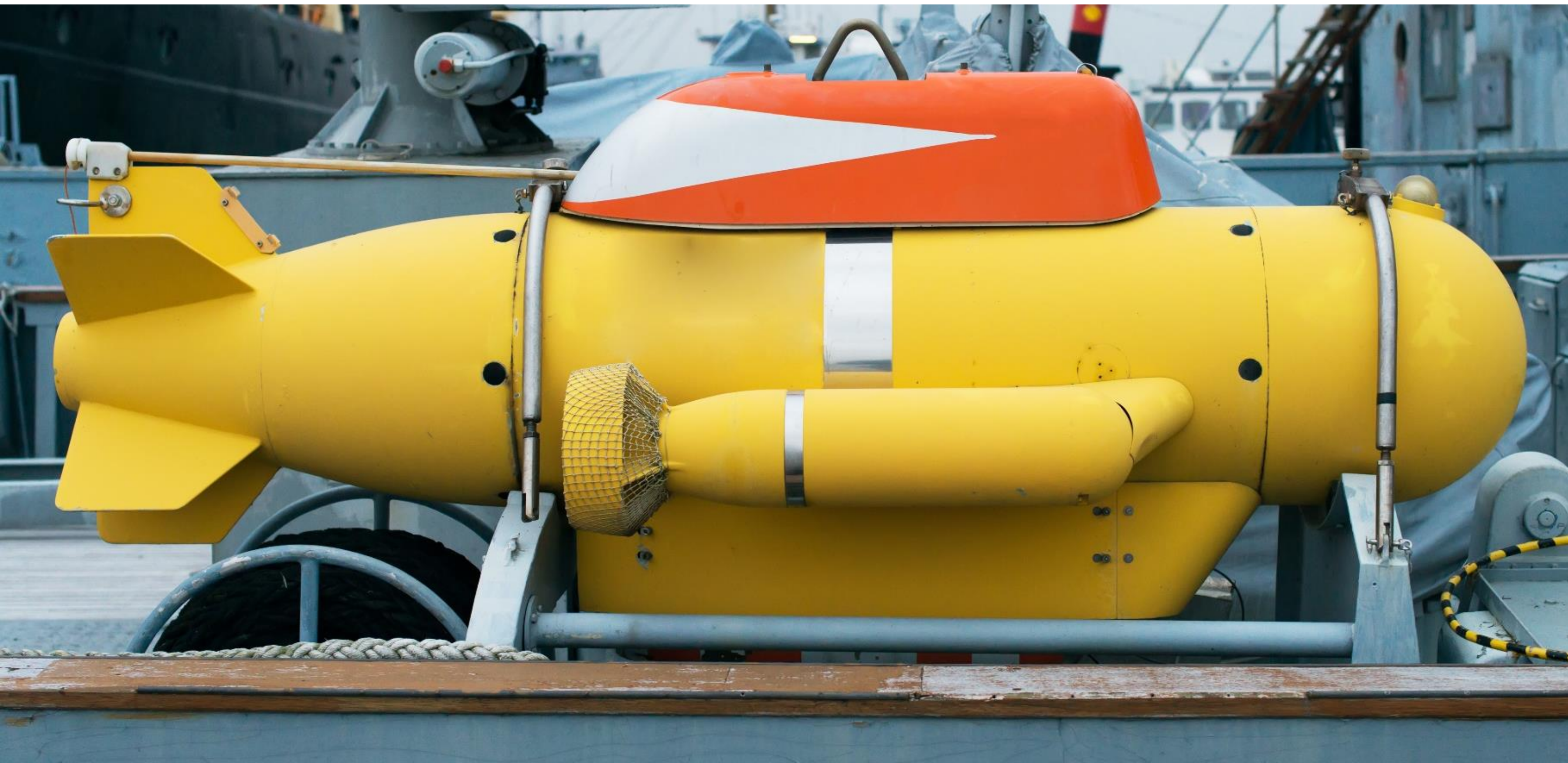
- **Observing changes in ocean conditions:** Gliders were initially developed to reduce reliance on expensive ship time, and to make continuous ocean measurements at high

resolution. The sensors that gliders carry typically include those that make measurements of fundamental ocean properties, which affect its circulation, how it will respond to climate change, and the services it provides to a wide range of marine ecosystems. These include measurements of salinity, temperature, oxygen, pH, and nutrients. Compared to AUVs, gliders have a relatively small payload (i.e., they can only carry lightweight sensors) but have a significantly longer endurance (months) over 10,000s of km and have been deployed in many marine settings to improve our understanding from the coast to the open ocean. As gliders are much less expensive than AUVs, they are sometimes deployed in a fleet to make concurrent measurements at different locations, forming autonomous sampling networks that can cover large areas[7]. In 2003, the coordinated deployment of a fleet of 15 gliders measured ocean conditions along more than 13,000 profiles offshore a 100 km stretch of the California coastline over just one month[6].

- **Monitoring traces of life across the ocean:** Organisms leave a trace of their DNA behind in the environment as they shed skin, scales, particles, or excrement. These traces can be extracted from seawater to provide a record of the presence of different species over the period that this 'environmental DNA' (eDNA) remains in the ocean[8]. This method of biological monitoring is increasingly being performed from gliders, which can travel vast distances as they self-power themselves for weeks to months, to track the migrations of different species across the ocean, to determine long-term changes in animal behaviour and their response to the impacts of climate change and human pressures in the ocean[9].

Like gliders, most AUVs are shaped like a torpedo, but others are more complex to enable them to move more flexibly[5]. They are self-powered, but unlike gliders, AUVs rely upon an onboard power supply (usually batteries) to power propellers or thrusters to move them through the water at faster speeds than gliders. AUVs generally follow a pre-programmed course and navigate using acoustic beacons that are placed on the seafloor, using a combination of acoustic communications, GPS, and other navigation system, or more recently in response to the terrain. As AUVs are usually larger than gliders and carry a higher capacity power supply, they can carry a much larger range of sensors, including geophysical instruments that are much more power hungry. The duration and distance covered by deployments is generally much smaller for AUVs than gliders.

AUVs have a number of benefits compared to conventional ship-based techniques for ocean monitoring or mapping. The ability for the AUV to fly close to the seafloor (in some cases as close as a few metres) means it is possible to acquire seafloor and sub-seafloor data at far higher resolution than is possible using surface vessels and towed instruments. This also means that AUVs can be deployed in far shallower water than ocean-going vessels, but also can be sent down to thousands of metres to explore some of the deepest parts of the



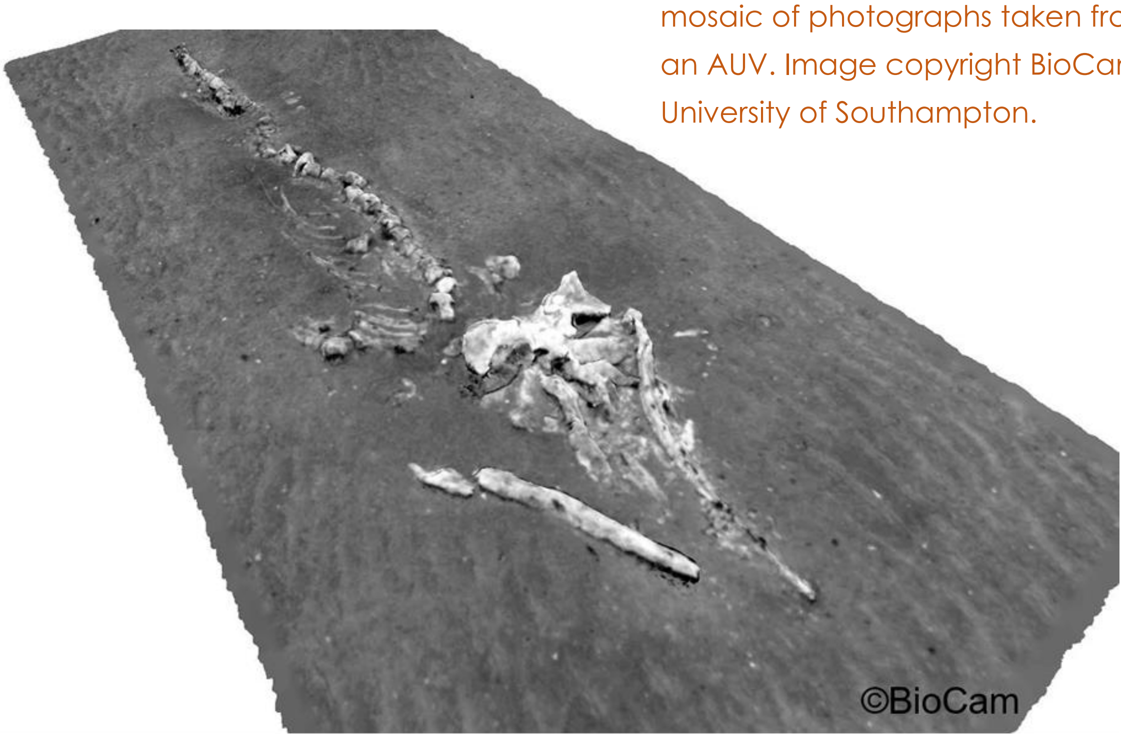
ocean. Because AUVs operate below the surface of the water, they are unaffected by bad weather once deployed. Some of the applications of AUVs include:

- **Getting up close to erupting volcanoes and other natural hazards**. There are over one million underwater volcanoes and, while most of these are extinct, major hazardous eruptions such as the January 2022 eruption of the Hunga Tonga – Hunga Ha'apai, offshore Tonga, demonstrate that they pose a real risk to coastal communities and seafloor infrastructure such as telecommunications cables[10]. AUVs can map underwater volcanoes in unprecedented detail using sonars and acquire data to provide a clearer picture of the risk that they pose; accessing sites that would otherwise be too hazardous for crewed missions. Some underwater volcanism creates hydrothermal vents that emit hot fluids heated by the underlying magma. These vents can be located using sensors that 'sniff' the water to detect traces of chemical-rich fluids, which precipitates out of the fluid[5]. Hydrothermal vents can host important chemosynthetic communities; organisms that feed on bacteria or microbes that harvest these chemicals in a similar way to how plants use carbon dioxide in the atmosphere. AUVs provide a means to access these actively erupting sites that can lie thousands of metres below the sea surface and make measurements close to the superheated and corrosive fluids.
- **Monitoring seafloor habitats and human impacts in the deep sea**. AUVs are now regularly used to survey the seafloor from shallow coastal settings to the deepest sea trenches, performing important baseline assessments to map out habitats that can host diverse seabed biology. This use is particularly growing to monitor the effectiveness of Marine Protected Areas (MPAs)

in limiting human impacts in environmentally sensitive locations. An example includes the Darwin Mounds that are located offshore U.K., where deep sea cold-water coral mounds were damaged by bottom trawling. As a result, the area was closed to fishing and designated as an MPA in 2004[11]. Repeat surveys using AUVs have been used to monitor the recovery. Recently this has included thousands of high-resolution seabed photographs taken from the AUV that are stitched together to create a vast dataset from which individual organisms can be identified and providing calibration for the interpretation of seafloor type from geophysical data[12].

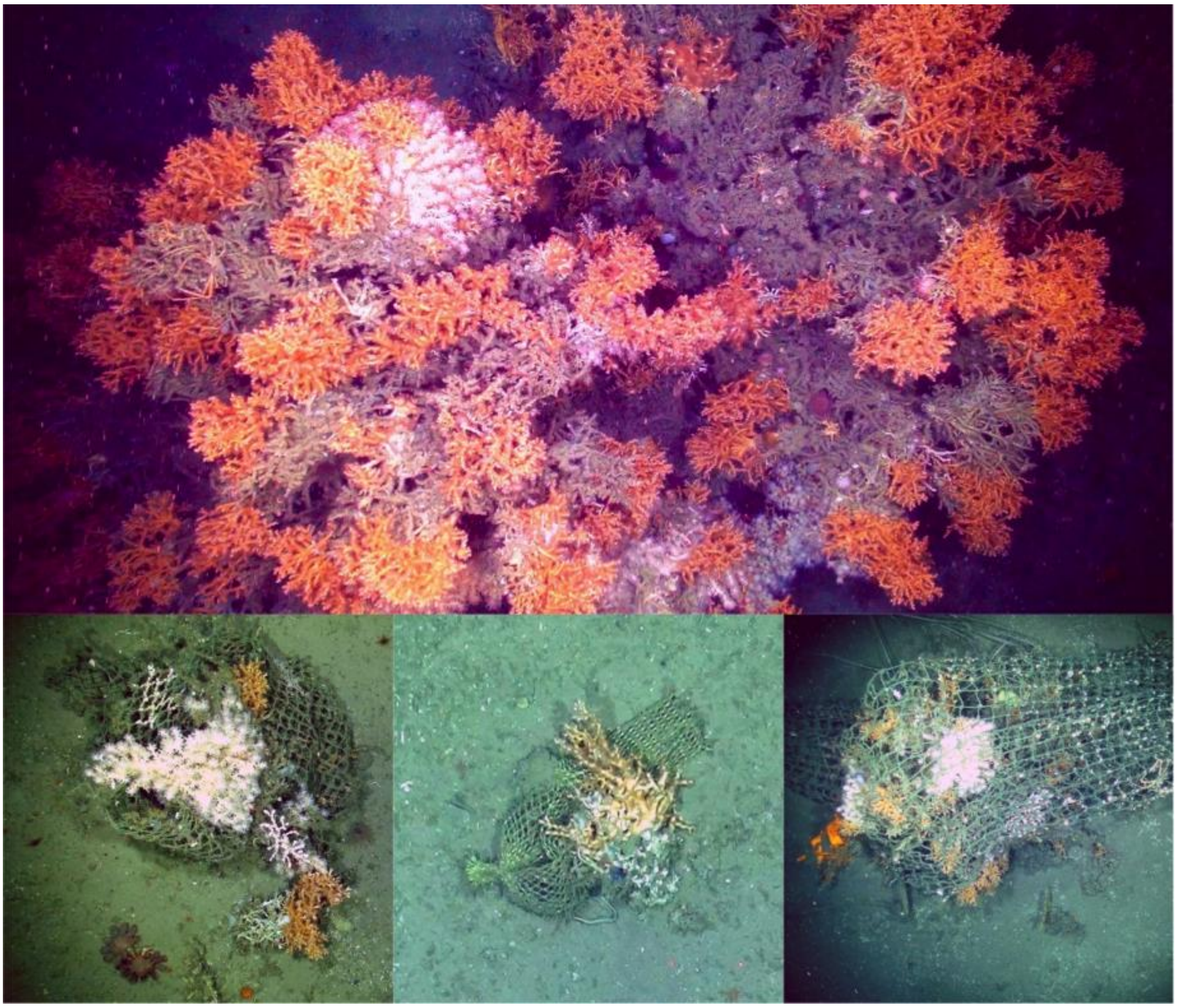
- **Hunting for wreckage.** When Malaysia Airlines Flight 370 disappeared on its journey between Malaysia and China, a major international search was mobilised to survey extensive areas of seafloor where it was thought that any wreckage might be found. This event demonstrated how sparse the

▼ **Figure 1:** Whale skeleton imaged on the seafloor using a mosaic of photographs taken from an AUV. Image copyright BioCam, University of Southampton.



coverage of detailed seafloor mapping is in some regions of the world, which often extend to vast water depths. The surveys performed to hunt for MH370 needed to include AUVs that are capable of reaching thousands of metres water depth[13] and that can provide sufficiently detailed seafloor images so that any wreckage could be detected. While the searches have not yielded conclusive evidence of a crash site, they have discovered new seafloor features such as underwater volcanoes that were not previously known[14].

▼ **Figure 2:** Healthy seafloor corals (above) and snagged fishing gear on corals (below) at the Darwin Mounds Marine Protected Area, offshore UK (from [15])



UNDER THE ICE—THE NEXT FRONTIER

(pages 13-15)

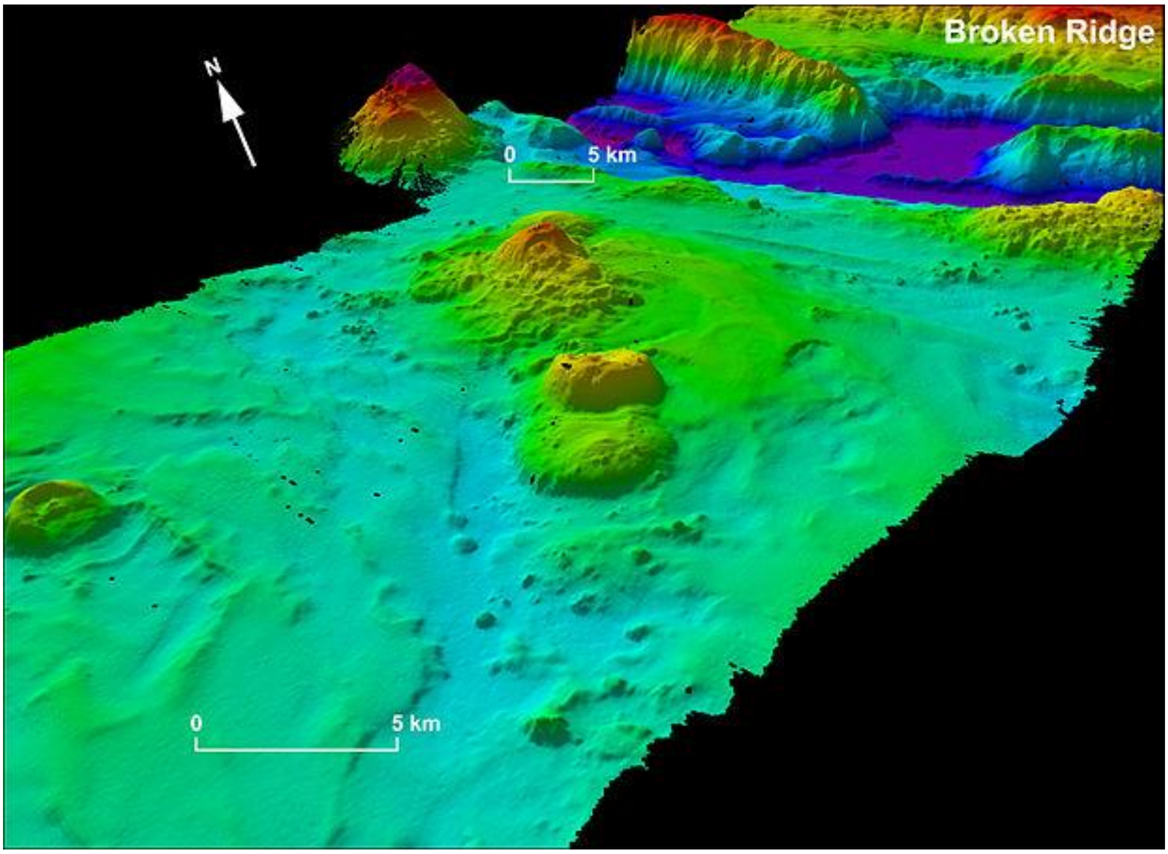
Perhaps the hardest to access parts of the ocean are those that are still covered by ice; however, these are also regions of particular scientific interest given their importance in climate and sea level changes. Autonomous underwater vehicles provide a means to access this remote setting and to make measurements under the ice where humans cannot go.

- The first un-crewed under-ice deployment was in 1972, when the Unmanned Arctic Submersible was sent through a hole in the ice to dive beneath an iceberg near the North Pole[29]. This first survey recovered pioneering data that mapped the shape of the underside of the iceberg. Remarkably, this vehicle was then recovered through the same hole from which it was deployed, having been tracked using an acoustic homing system.
- In 1996, an 8.6 tonne, almost 11 metre-long AUV called Theseus was designed to not just transit under ice, but also to lay a seafloor fibre optic cable along

its passage. Also launched through a hole in the ice, Theseus was deployed offshore Ellesmere Island in the Canadian Arctic and completed missions up to 350 km[29].

- Various AUV missions under sea ice in both the Artic and Antarctic, have provided new insights into the unique biology and seafloor conditions that exist. These missions have not been without complications, including the loss of an AUV beneath Fimbul Ice Shelf in Antarctica[29].

▼ **Figure 3:** Three-dimensional rendering of the seafloor in part of the search area for MH370[16]. (Available under a Creative Commons Licence; http://www.atsb.gov.au/media/5155208/3d_model_seafloor3_26sept2014.jpg)



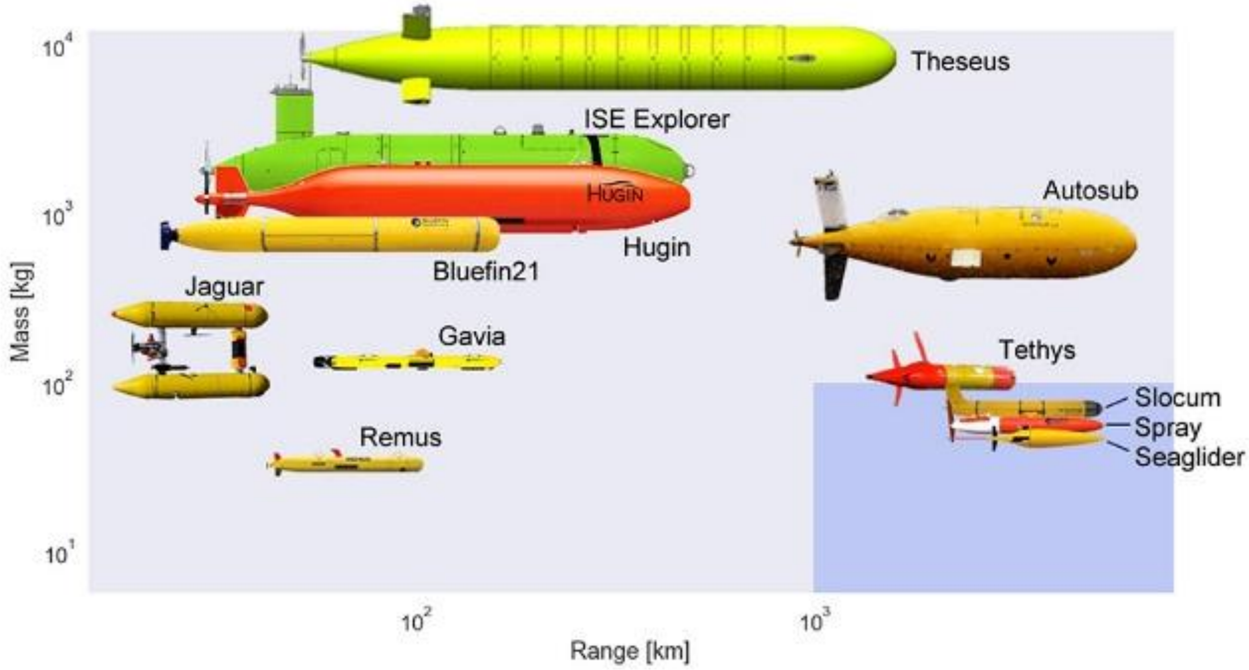
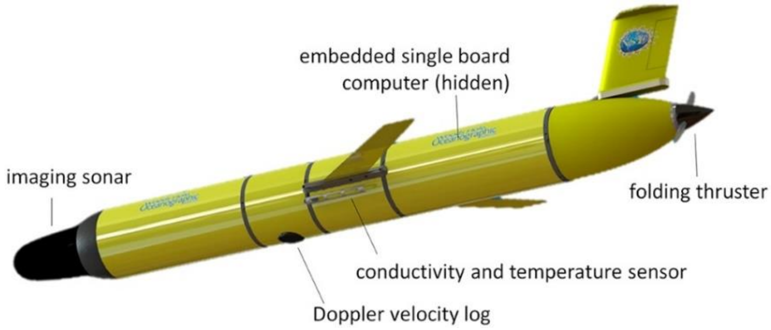
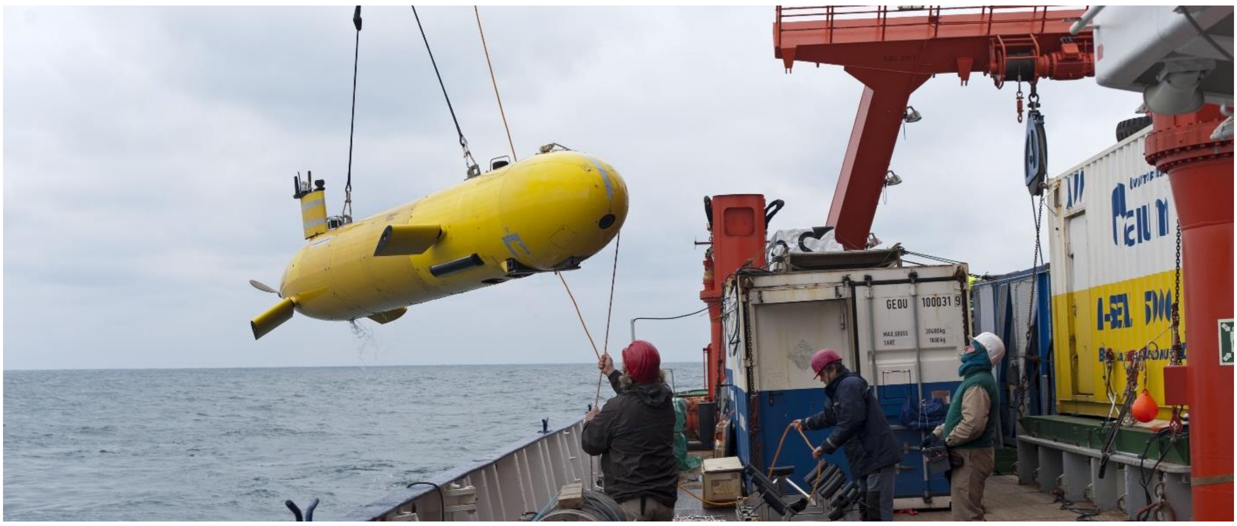


Figure 4: (Top) Examples of AUVs and gliders (bottom right) used to survey and monitor the ocean and deep seafloor (from 17); (Middle) Schematic of a typical ocean glider (from 17); (Bottom) An AUV being recovered at sea. Image courtesy of V.Diekamp at MARUM – Zentrum für Marine Umweltwissenschaften; Universität Bremen; (https://www.marum.de/Entdecken/Technologien.html).





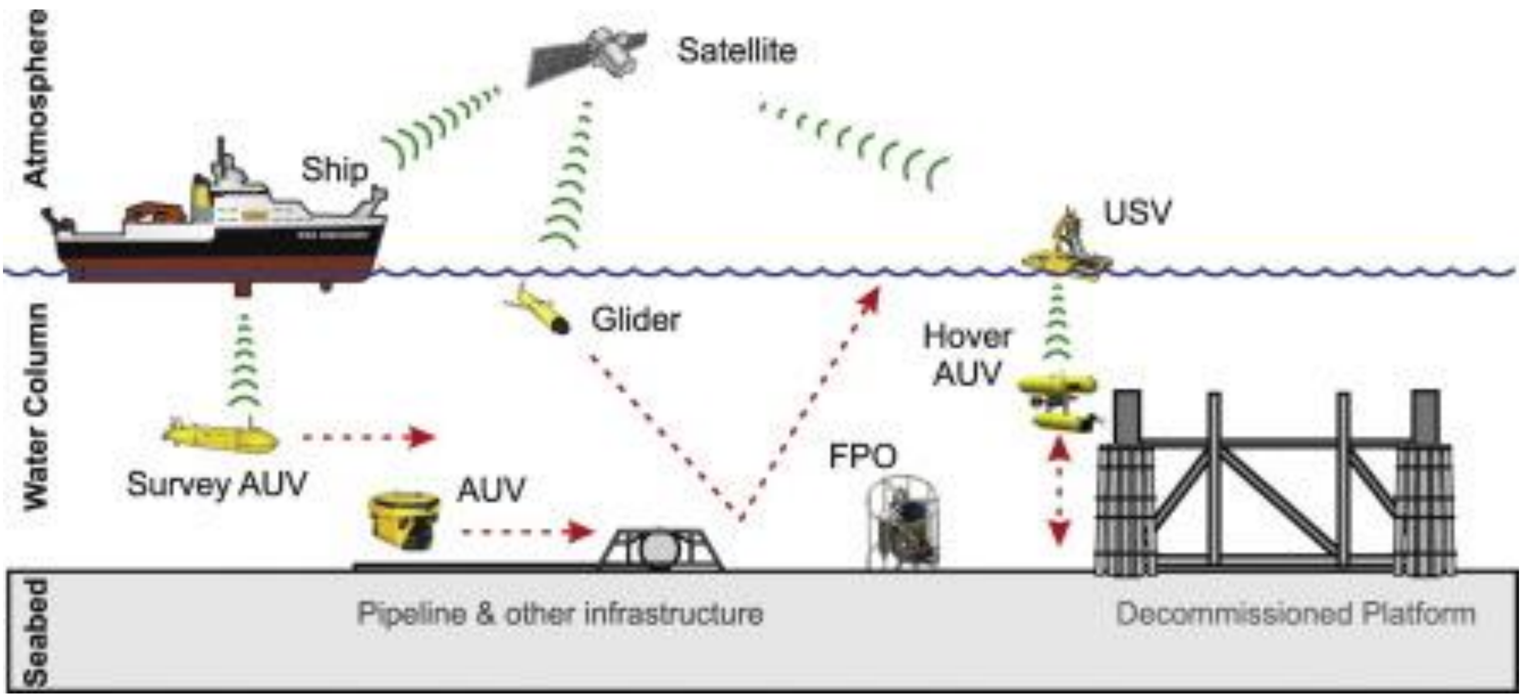
LOOKING TO THE FUTURE

The use of autonomous underwater robotics has been growing over the past few decades, and is now widely used in a range of industries and across all ocean settings. Most AUVs still have relatively limited endurance and typically require a support vessel to deploy and or recover them. However, longer endurance AUVs that can be deployed from shore have started to emerge, which removes a reliance on a larger ship and hence reduces the overall carbon footprint of their operation. Other approaches are also developing to enable more effective operations, including subsea docking systems where AUVs can recharge to increase their endurance, and the deployment of swarms of AUVs that communicate with each other. Such technology is unlikely to replace traditional vessels fully, however. Fast tidal and deep-sea currents can limit the effective operation of AUVs, while regions that experience intense fishing or other human activities that pose a collision risk are generally avoided. However, there is growing interest in the use of autonomous technology to assist with the environmental monitoring of human structures in the ocean.

USE OF MARINE AUTONOMOUS TECHNOLOGY FOR DECOMMISSIONING (pages 17-19)

Increasing demands for energy, seabed resources and digital communications are among the drivers in the growth of offshore developments worldwide, which also include coastal defences, marine tourism, and fisheries. It is estimated that there will be a global increase of up to 70% in the areal extent of the footprint associated with these activities by 2028[18]. Only an area of 55 million km^2 is largely free of human impacts, equating to 13% of the world's ocean[19,20]. Many of the structures that have been installed are reaching or have reached the end of their original design lives. This is particularly the case for oil and gas developments. There are 475 oil and gas installations in the UK offshore sector alone that require decommissioning as required by the OSPAR Convention which states that most must be fully removed, although some large structures may be exempt[20]. This issue specifically applies to legacy oil and gas structures, but will become a growing issue for other more recently installed structures such as offshore wind farms.

However, the environmental consequences of decommissioning remain relatively poorly understood. Indeed, the process of removal itself may have unintended environmental impacts. By removing oil and gas structures, there exists the potential



USE OF MARINE AUTONOMOUS TECHNOLOGY FOR DECOMMISSIONING (pages 17-19)

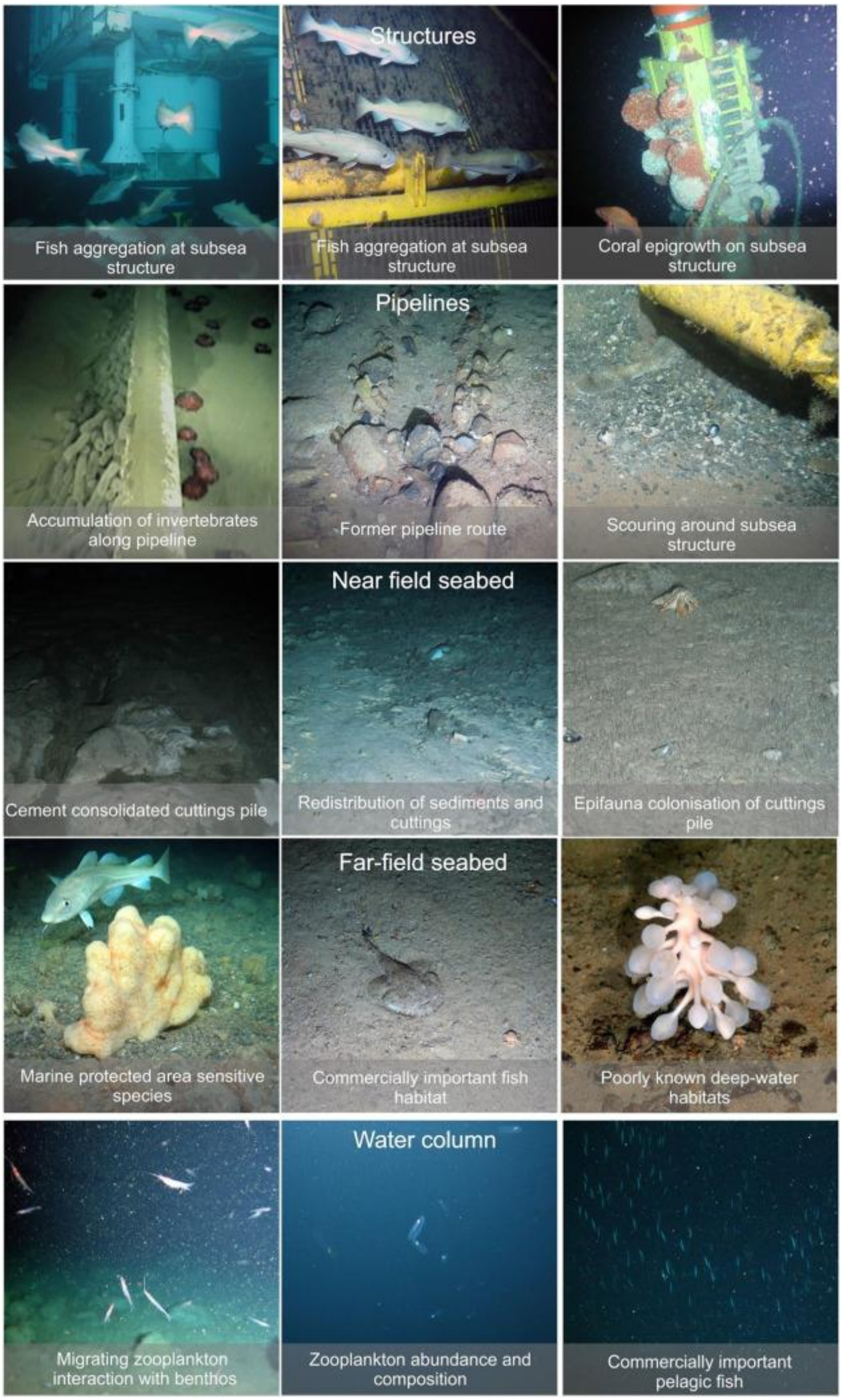
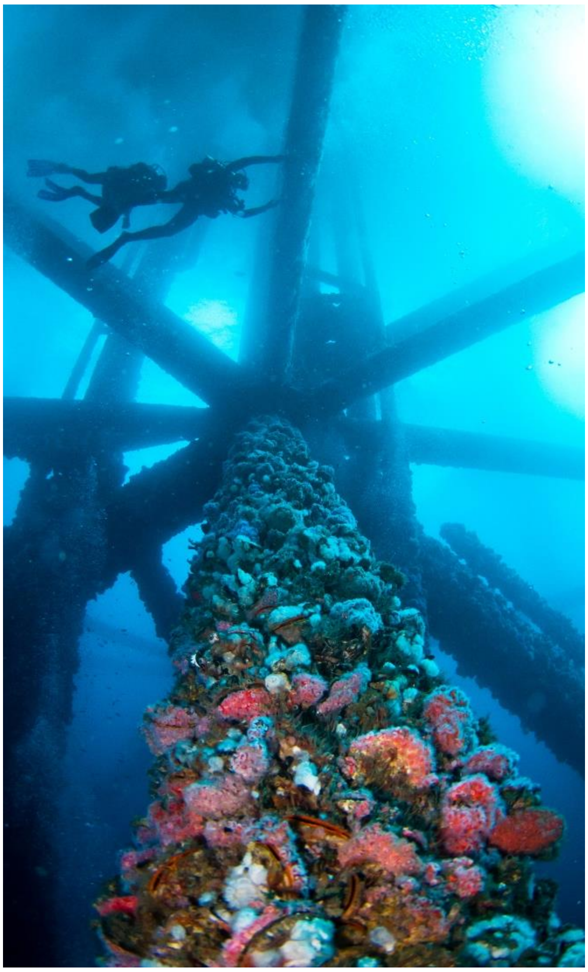


Figure 5: Photographs showing examples of habitats and at and around active oil and gas drilling sites (from [20])

for the release of pollutants and radioactive residues into the water column, the release of contaminants such as toxic drilling mud that have built up in cuttings piles underneath or adjacent to the structures when they are disturbed, and noise impacts that may affect whales and certain fish[20]. Structures in the marine environment may also provide positive services, acting as habitats for organisms that need hard surfaces to colonise, providing artificial reefs for vulnerable species such as cold-water corals, or providing protection from the impacts of fishing which has to avoid an exclusion zone around such structures. Therefore, there is a pressing need to understand the environmental impacts associated both with leaving structures in place as well as removing them. The European Marine Board stressed the need for '*a greater evidence base in assessing potential impacts and determining good practice for the decommissioning of offshore installations*'[21]. The sheer scale of oil and gas decommissioning will require an extremely cost-effective and efficient survey programme that requires innovative approaches to offshore surveys. A number of trials are underway to explore how marine autonomous technology may help to address this issue, enabling enhanced data collection over large areas and in a systematic and repeatable manner[22].



Oil and gas developments are just one aspect of offshore development, and there is growing interest in the decommissioning of legacy seafloor cables once they have reached the end of their typical 20-30 year design life. However, the construction and environmental impacts of seafloor cables are markedly different to oil and gas infrastructure.

With respect to telecom-unications cables in deep water (>2000 m) at least 80% of the 1.8 million kms of trans-oceanic, fibre-optic cables are lightweight, have no armouring, and are of a similar diameter to a normal domestic garden hose (17-22 mm)[22]. These cables are laid directly on the seabed surface and the laying operation is such that the cables are not dragged across the seabed. Therefore, seabed disturbance is minimal and is generally limited to the cable touching down on the seabed. For depths less than 2000 m, a cable may be (i) surface-laid where the risk of damage from human activities is small (these are the main causes of cable faults; i.e., accidental anchor drops or fishing-related) - or (ii) the cable is buried to protect it[22]. Burial will temporarily disturb the seabed along a very narrow path; however, scientific studies have shown that any disturbance to benthic ecosystems is minor and temporary with the seabed quickly returning back to its natural state[23-25]. The rate of seabed recovery depends upon (i) the method of burial, (ii) ocean conditions, (iii) rates of sediment supply to the ocean, (iv) seabed topography and geology and (v) biological activity[23]. The continental shelf, where most cable repairs take place, is subject to waves, ocean currents and tides that restore the seabed back to its normal state on times scales of days (for strong tidal regions) to years.

Power cables are larger, with typical diameters of 80 to 150 mm, and hence have a larger physical footprint than telecommunication cables. They may be surface-laid or buried depending on the risk and suitability of the seabed, and are deployed mainly on the continental shelf and upper continental slope (<~1000 m).

AN ECONOMIC CASE FOR RECYCLING SUBSEA CABLES

(pages 21-23)

There is an economic case for recycling and this now forms the core business for several companies, and represents one use of cables once they are decommissioned. While cables in the photic zone (generally <200 m water depth) may become colonised by a range of marine life (e.g., anemones), below the influence of light they are rarely found with similar attached fauna in deeper water. A recent example of a project by a cable recovery company recovered 2500 MT (1200 km) of cable from the South Atlantic by carrying out one cutting run and one holding run which recovered the cable and 97 repeaters. Other sustainable uses of out-of-service cables include their repurposing as artificial reefs to encourage biodiversity (such as coils of cables strategically placed off Maryland and New Jersey), and the repurposing of telecom cables to make scientific measurements of the ocean (see September 2021 issue of this publication).

As previously detailed in the September 2020 issue of this series, studies of recovered sections of cables from the deep water central Pacific, North Atlantic and Mediterranean Sea that had lain on the seafloor between 38 and 44

years found that the cables were remarkably well-preserved and physically intact with no biological encrustation[26].

- Such is the condition of these cables that they are targets for recycling for their high-grade plastic, steel and copper components. However, this also means that leaving them in situ after their use will also likely have no detrimental environmental effect.
- Recycling can return high quality materials into the product chain with reduced energy requirements when compared to virgin materials production.
- Recovery can open up areas of seafloor for new systems and reduces pressure on pinch points (i.e., where there are lots of cables laid in one area)
- Recovery of out-of-service fibre optic systems provides opportunities for re-purposing cables to less economically developed regions and markets around the World, especially where the prevailing economics do not support the installation of new cable systems.
- Recovery activities have a minimal physical impact on the environment; the main contributor being the grapnels used to cut and hold the

Figure 6: Subsea cable recovery and recycling; steel coils; Photograph courtesy of Mertech Marine.

cables being recovered. This is the same approach that is used in cable repair and is an environmentally benign activity.

- Where cables have been buried, they are typically not recovered for economic and logistical reasons, as well as the fact that such structures tend to become colonised by diverse benthic fauna and recovery would unnecessarily disturb them. However, some jurisdictions now require recovery of buried cable sections.
- Deciding whether to recover and recycle a cable system, or to leave it in place, will require careful consideration and assessment of the local environmental conditions.

▼ **Figure 7:** Subsea cable recovery and recycling; polyethylene pellets; Photograph courtesy of [Mertech Marine.]

Sharing the seabed in harmony with others

The International Cable Protection Committee (ICPC) was formed in 1958 and its primary goal is to promote the safeguarding of international submarine cables against human made and natural hazards. The organisation provides a forum for the exchange of technical, legal and environmental information about submarine cables and, with more than **180 MEMBERS** from over **65 NATIONS,** including cable operators, owners, manufacturers, industry service providers, and governments, it is the world's premier submarine cable organisation. The ICPC comprises of an 18 Member Executive Committee (EC)-led organisation voted in by its Full Members. In addition to the Marine Environmental Adviser (MEA), General Manager (GM) and Secretariat team, the ICPC also has an appointed International Cable Law Adviser (ICLA) as well as a United Nations Observer Representative (UNOR).

Prime Activities of the ICPC:

- Promote awareness of submarine cables as critical infrastructure to governments and other users of the seabed.
- Establish internationally agreed recommendations for cable installation, protection, and maintenance.
- Monitor the evolution of international treaties and national legislation and help to ensure that submarine cable interests are fully protected.
- Liaison with UN Bodies.

Recommendations:

- Taking into account the marine environment, the ICPC authors Recommendations which provides guidance to all seabed users ensuring best practices are in place.
- Educating the undersea community as well as defining the minimum recommendations for cable route planning, installation, operation, maintenance and protection as well as survey operations.
- Facilitating access to new cable technologies.

Advancing Regulatory Guidance:

- Promoting United Nations Convention for the Law of the Sea (UNCLOS) compliance.
- Championing uniform and practical local legislation and permitting
- Protecting cable systems and ships.
- Aiding education of government regulators and diplomats.

Working with Science:

- Supporting independent research into cables.
- Publishing reviews for governments and policy makers.
- Working with environmental organisations.
- Effective public education via various media.

To learn how to become of Member organisation of the ICPC, please click on join here.

EDITORIAL STAFF

Author: Dr Mike Clare

Mike is the Marine Environmental Adviser for the International Cable Protection Committee (ICPC) and is a Principal Researcher at the National Oceanography Centre, UK, where he works as part of the Ocean BioGeoscience Research Group. His research focuses on better understanding the dynamic seafloor, the implications of past and future climate change, impacts of human activities, and quantifying risks to critical infrastructure. Prior to his research role at NOC, he worked for ten years as a geohazard consultant to a range of offshore industries.

Editor: Ryan Wopschall

Ryan is the General Manager for the ICPC. He has spent the last 15 years in the telecommunications industry with a focus on international undersea and terrestrial backhaul telecommunications.

Design & Layout: Christine Schinella

As part of her Secretariat role, Christine coordinates marketing activities for ICPC. With a background in graphic design and publishing, Christine has been working in the telecommunications industry since 2000.

FURTHER READING & REFERENCES

Further information on submarine cables and the marine environment can be found in the references and text within the peer-reviewed UNEP-WCMC report via: **'Submarine Cables and the Oceans: Connecting the World'** as well as other resources via: https://iscpc.org/publications.

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