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Arctic coral reefs
An undiscovered environment

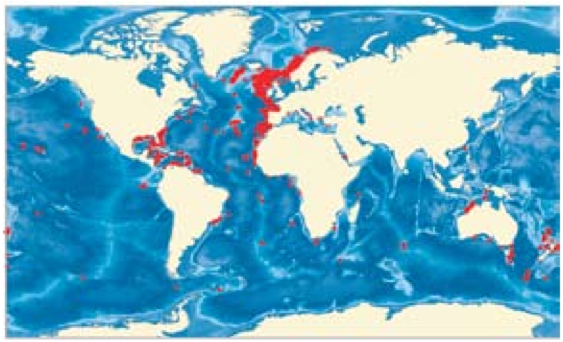
Bubble-gum coral,
Paragorgia arborea

Key words
environment
human impact
greenhouse effect
coral bleaching
climate change

Recent expeditions to the cold, northern waters of the Arctic have revealed giant deep-sea coral reefs. In this article, Tina Kerby and Jason Hall-Spencer describe the latest findings from a project to study these surprising environments.

"Coral reefs in the Arctic? That can't be right....", you might think, as all the text books say that coral reefs are restricted to the sunlit warm waters of tropical and subtropical regions. But the text books are wrong, and this just shows that major scientific discoveries still await those who, like us, are lucky enough to get to see unexplored regions of the planet!

We now know that coral reefs are not confined to warm, shallow waters. They are also found in great depths and at low temperatures, where they were not expected.



Map showing the areas where cold-water coral reefs are known to form.

Cold-water corals have actually been known about for centuries, since fishermen first brought up coral fragments entangled in their nets from deep-sea areas. But we didn't know they formed giant reefs. It is only in the last few years that scientists have been able to investigate the oceans with more and more sophisticated technology, using the latest underwater cameras mounted on robotic or manned submersibles, giving them the chance to explore deep-water environments.

It has turned out that cold-water coral reefs can be found in deep waters throughout the world's oceans. These cold water coral reefs are now known from depths of just 40 metres in the sheltered fjords of Norway right down to hundreds or even thousands of metres along the edges of continental shelves, around offshore submarine banks and on submerged volcanoes, termed 'seamounts'.

We all lived in a yellow submarine

In July 2007, we joined scientists from various European countries on a month-long expedition aboard "RV Polarstern", a research vessel run by the Alfred Wegener Institute for Polar and Marine Research in Germany. This expedition provided an opportunity to investigate cold-water reef ecosystems. The ship had a hull that was strong enough to break through polar ice and was equipped with a two-man submersible called Jago, on loan from the Leibniz Institute of Marine Sciences at the University of Kiel (Germany). This provided the opportunity to undertake the first manned submersible observations of Røst Reef, the largest reef so far found in cold-water regions of the planet. Equipped with a grabber, sampling container, digital-camera and a high definition video camera, we were able to sample very precisely within this fragile habitat.

Jason Hall-Spencer gets ready to go down in the Jago submersible.

A boyhood dream came true when Jason was able to use a little yellow submarine! Stunning close-up footage of Røst Reef was captured with digital and video cameras mounted on Jago, and samples were carefully taken at depths of 300-380 metres.

Back in Plymouth, the research team have begun studying and analysing the data and samples collected on this expedition. The samples brought to the surface demonstrated the rich diversity and abundance of species living in this habitat and illustrate that cold-water coral reefs are hot-spots of biodiversity in the deep waters of the Arctic.

Not only marine biologists were interested in this complex ecosystem; geoscientists were also onboard to study the area with sonar systems to visualise the sea bed. Compilation and processing of the sonar data with special computer software delivered insights into the reef structure and its surrounding sea bed. During the whole cruise, oceanographers took consecutive water samples to measure temperature, salinity, oxygen and pH with a so-called CTD-sensor (Conductivity-Temperature-Depth). The resulting values help to evaluate the precise characteristics of the waters that support cold-water coral development.

Jago's probe measures oxygen levels in a coral bed.

Living together

In shallow tropical waters, reef-forming corals possess single-celled symbiotic algae (zooxanthellae) which produce oxygen and nutrients through photosynthesis. The coral polyps use waste products from these algae for food, and in return the corals provide shelter due to their hard skeleton and also provide materials (e.g. carbon dioxide) that are needed by the zooxanthellae for photosynthesis.

Zooxanthellae belong to the phylum Dinoflagellata. They are unicellular algae living in symbiosis within the tissue of many marine animals, like giant clams, nudibranchs and jellyfish and play a highly important role living within tropical coral polyps. Up to 90% of tropical coral's energy requirements can be delivered by Zooxanthellae. The death of these Zooxanthellae, or a reduction in their chlorophyll content, can arise due to pollution or sea temperature changes. This is the basis of coral bleaching. Such events have become more common over the last 20 years, possibly due to global warming.

The coral on the right has a healthy population of Zooxanthellae; on the left, the coral appears bleached because these organisms have died.

Cold-water corals, living in the dark, do not have light-dependent symbiotic algae like their shallow warm-water cousins. They are dependent on particulate organic matter (POM) and zooplankton for their food and energy resource. Corals belong to the phylum Cnidaria, as do anemones and jellyfish, and extend their stinging tentacles into the water current and retract them when they capture food.

Organic matter (e.g. dead algae, faeces, dead animals) produced in the sunlit zone, sinks in the water column and transports carbon and other biogenic material downwards. This POM serves as a food-source for bacteria and more complex organisms living in the water column and on the sea bed. Biological, chemical and physical processes change the size and composition of the particles as they sink and they can aggregate and accumulate to form what looks like a floating blizzard of what is termed *marine snow*.

An abandoned length of fishing line has become entangled with this coral; in the background you can see flakes of 'marine snow' drifting down.

Coral cities

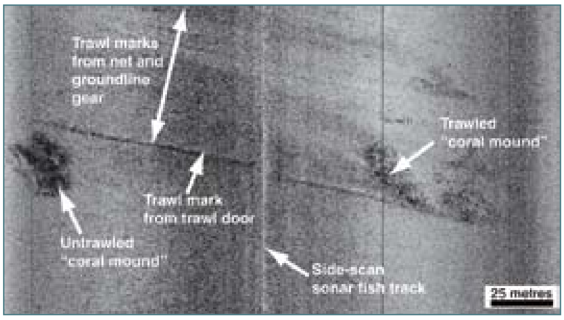
Corals, whether tropical or cold-water, can build hard calcium carbonate skeletons as they grow, forming giant and complex reefs. The reefs build-up slowly over thousands of years since the corals only grow a few millimetres or centimetres per year. In comparison to the hundreds of reef-building tropical coral species, there are only two reef-building species known in the cold waters around Britain, namely *Lophelia pertusa* and *Madrepora oculata*. These two species are widespread in deep waters of the north-east Atlantic and were the main interest of our pioneering expedition to the Arctic in 2007.

Cold-water coral reefs are important biodiversity hotspots. They are located in nutrient rich zones and provide a habitat for a variety of marine invertebrates, like sponges, polychaete worms, molluscs (e.g. mussels), echinoderms (e.g. brittle stars, sea urchins) and crustaceans (e.g. crabs, squat lobsters). They represent a spatially confined ecosystem and supply shelter and food to organisms living in, on and around the coral reef. They are also important nursery areas for various fish species in the deep-sea.

Reading the history books of the sea

Due to their banded skeletal structure, cold-water corals are good environmental archives (rather like tree rings) preserving archives of past weather conditions within their growth bands. The gathered samples and data will provide scientists with clues to the development of the reef from the last glacial period (8000 BC) onwards. As scientists begin to discover and explore cold-water coral reefs they are recognising how important these ecosystems are and the threats posed by human activities. Film footage and photos provide evidence of the disruptive impact of fishing using towed trawls across the sea-bed which smash the coral reefs to pieces. Once damaged, corals need hundreds or thousands of years to recover; many may well never recover.

Another threat to these habitats is that of increased acidity of the oceans due to rising atmospheric CO_2 levels which have been brought about by the burning of fossil fuels such as coal, oil and gas. This leads to higher CO_2 levels in seawater, resulting in a drop in alkalinity and calcium carbonate saturation of the water. Scientists predict that the ability of deep-water corals to build calcium carbonate skeletons will be impaired as the seawater becomes more acidic.



This sonar chart of a section of the seabed shows the effects of trawling by fishermen on coral reefs.

We are beginning to realise that cold-water coral reefs are very sensitive ecosystems. As scientists are discovering deep sea reefs and finding out about the ecology of the wonderful organisms that live amongst them they realise that these ecosystems need to be protected. The great news is that some marine protected areas for cold-water coral reefs have recently been established in the UK and Norway. Further recommendations for protection, conservation and sustainable management can only be achieved by a new generation of scientists willing to find out what is living in the dark, unexplored regions of our planet. These scientists will also need to make sure that the public and politicians know what natural treasures are down there.

***Tina Kerby** is carrying out MSc research into the satellite tracking of deep-sea fishing vessels with **Jason Hall-Spencer**, a Royal Society Research Fellow at the University of Plymouth.*

Look here!

Check out **www.deepseaconservation.org** for more about Britain's deep sea environments and how scientists are trying to protect them.