The Biology, Ecology and Vulnerability of Deep-Water Coral Reefs

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Executive Summary

Deep-sea coral reefs live in the cold, dark waters of the oceans but likege

What are the current threats?

- The main threat to deep-sea coral reefs is trawling by modern fishing vessels
- Direct evidence of destruction of deep-sea coral reefs includes submersible observations of complete removal of the coral framework in some areas, trawl scars running into reefs and high by-catches of deep-sea coral in the nets of deep-sea trawlers^
- Deep-sea coral reefs are vulnerable to fishing because they are very fragile and easily broken
- Deep-sea corals grow slowly; mature deep-sea coral reefs take many thousands of years to accumulate
- Recovery from trawling impacts is likely to be slow and where corals are completely destroyed and habitats altered by trawling recovery is unlikely
- Destruction of deep-sea coral reefs also mean the destruction of the associated animal communities and in some cases essential habitat for commercially valuable fish

Where are deep

Deep-water reef-forming corals are widely distributed in the world's ocean but the fairly precise environmental requirements of these organisms mean that they only form reefs in specific localities, usually on the upper reaches of the continental slope and on offshore ridges, plateaus, banks and seamounts. *Lophelia pertusa* is at present the best-studied deep-water reef-forming coral. In the northeast Atlantic it forms reefs and reef-mounds on the continental slope and offshore banks between 200 and 1,000m depth and also occurs in fjords as far north as 71°N. *Lophelia* reefs have also been found further south off the coast of West Africa and off the eastern coast of the United States and Brazil. Along with *Lophelia pertusa*, the coral *Enallopsammia profunda* is also a major component of the deep-water coral reefs on the Blake Plateau and other areas in the north-wetern Tj 3 975 0 TD -0.13452 Tc 0.2123 Tw (itlantic . Tj 43.25 0 TD / Tc 0.17

colony grows parts of the coral skeleton are attacked by boring organisms such as sponges and worms. Pieces of the initial colony fall off as a result of this process of bioerosion. As these are still alive they form daughter colonies around the initial colony. This entire structure forms a hemispherical or "cauliflower" shaped growth. Eventually the daughter colonies grow sufficiently large that water circulation is cut off from the centre of the growing coral framework and this then dies forming a characteristic ring-shaped colony known as a "Wilson Ring". Amongst the dead, eroded and broken coral fragments sediment begins to accumulate, originating from the action of bioeroding organisms breaking up the coral and by particulate matter falling out of the water as it is slowed down by the coral framework. These structures coalesce to form mature deep-water coral reefs that characteristically have a living coral layer overlying a framework of dead coral mixed with sediments.

Deep-water *Lophelia* reefs show many types of shapes. In the north east Atlantic these range from "haystack-shaped" mounds have been observed with a base size of up to 4km and a height of up to 165m from the surrounding seabed. Similar conical-shaped reefs of *Goniocorella dumosa* have been observed on the Campbell Plateau off New Zealand with a base-size of 700m and a height of 40m above the seabed. *Oculina varicosa* is also associated with reef-mounds with a base diameter of up to 1000m and a height of up to 17m. Sometimes mound-shaped reefs can coalesce to form barrier like structures. Alternatively, as in the Sula Ridge, off the coast of Norway, a complex of *Lophelia pertusa* reefs can form. At this locality the individual reefs are up to 70m across but the entire reef complex is 14km long and up to 35m in height. The distribution of corals is strongly influenced by ice-berg ploughmarks[5]. The coral reefs formed by *Solenosmilia variabilis* on the Tasman Seamounts appear to be large coalesced coral frameworks though details of the structure of these reefs have not been published. Recently an even larger *Lophelia* reef has been found to the west of the island of Røst in the Lofoten Islands in the Norwegian EEZ. This reef lies in 300-400m depth, is 40km long and 2-3km wide, covering an area of 100km[2]. *Lophelia* also occurs as much smaller, isolated frameworks of up to 50m across. The Darwin Mounds, in the northern Rockall Trough, which have recently been protected under the European Habitats Directive, consist of sediment mounds of a few metres elevation and of a 100m diameter with coral framework on top[8]. There are several hundred of these low-relief mounds in a small area.

[8] The Darwin Mounds have recently been protected by an emergency measure (European Commission Regulation No 1475/2003), which prohibits the use of bottom trawl or similar bottom towed nets in this area, and might be designated as a Special Area of Conservation, under the European Habitats Directive (92/43/EEC).

Influence on biodiversity

Deep-water coral reefs like shallow water tropical reefs consist of a complex three-dimensional coral framework with many sub-habitats that can be occupied by other animals. These sub-habitats include the living coral itself, the spaces between the coral branches, exposed dead coral framework, sediment-clogged dead coral framework and the coral rubble surrounding a reef. Large organisms live mainly attached to dead coral framework or rubble (other corals, sponges, anemones, clams, starfish, sea urchins), burrowing in to or living within cavities inside the dead coral branches (sponges, worms) or in associated with the reef. Examples include the relationship between large predatory sea anemones and the clown fish that live amongst their tentacles.

Evidence for commensal relationships is sparse for deep-water reefs but these habitats are difficult to observe and have only been studied for a short time. One example of such an interspecies relationship has been identified between the reef-building coral *Lophelia pertusa* and a large, predatory, tube-dwelling polychaete worm called *Eunice norvegicus*. These worms build paper-like tubes amongst the bran ches of the reef and the corals secrete calcium carbonate that solidifies around the tubes providing protection for the worms[11]. The worms in turn are extremely aggressive and will attack predators such as sea urchins that approach the living parts of the corals. The worms may also steal food from the coral polyps (kleptoparasitism). There is even evidence that the worm tubes may act as a substrate for the settlement of coral larvae. These worms are found associated with *Lophelia pertusa* wherever it forms reefs in the NE Atlantic.

Lophelia pertusa also acts as a nursery area for many juvenile animals. This includes the juvenile stages of commercially valuable fish species such as redfish (*Sebastes* spp). Damage to deep-water corals reefs can effectively destroy these nursery grounds potentially having marked knock-on effects on the surrounding ecosystem.

Human impacts on deep-water coral reefs

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Deep-sea corals grow slowly and deep-sea reefs take thousands of years to develop. There is evidence from recent research that recruitment of coral larvae is sporadic. Also genetic and reproductive studies strongly suggest that in areas where deep-water corals are impacted by trawling, the colonies can be reduced to a small size where sexual reproduction is no longer viable[15]. Given these factors, recovery of deep-water corals reefs from significant trawling impacts is likely to be extremely slow and where the habitat is altered may never happen. On the Tasman seamounts impacted areas were reduced to bare rock grazed by sea urchins and in such a case re-growth of a deep-water coral reef is unlikely. Given that these coral reefs are also essential habitat for other organisms including commercially valuable fish species[16], these animals will also be removed. Destruction of essential fish habitat may be one reason that many deep-water fisheries that have been depleted in the last 20 years have not recovered.

Evidence of destruction of deep-sea coral reefs has caused governments to legislate to protect these habitats. Coral sites are now closed to fishing off Norway, the north west coast of Britain, off Florida[17] and in the Tasman Seamounts area. However, all of these sites are in EEZs and as yet no sites have been protected on the high seas. Exploitation of fisheries associated with seamounts and other deep-sea habitats is continuing in an unrestrained and unmanaged fashion on the high seas all over the world. Scientists, governments and even the fishing industry itself are unaware of the environmental damage that is being caused by these activities. Many deep-water coral habitats and associated animals are being removed before they have even been studied and their species diversity assessed. There is no other human activity related to the gathering of biological or mineral resources for which impacts on the environment are so poorly understood or managed.

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[13] Roberts J.M. et al., (2003) Marine Pollution Bulletin 46: 7 - [illegible]

Further Reading

Freiwald A, Hühnerbach V, Lindberg B, Wilson JB, Campbell J (2002) The Sula Reef complex, Norwegian shelf. Facies 47: 179-200.