Scottish Environment LINK

Evidence for damage to marine habitats: a literature review.

Cold-Water Coral reefs (*Lophelia pertusa*)

Introduction:
Lophelia pertusa (L.) is the most common habitat-forming, reefbuilding cold-water coral. It forms bush-like colonies measuring several metres across and consisting of thousands of coral polyps. As the colony develops, adjacent branches tend to join together, thus considerably strengthening the entire framework. Although *Lophelia* is known as 'white coral', there are several colour variations of the generally translucent tissue, with yellow, orange or red patterns (Freiwald et al., 2004). *L. pertusa* is found in deep, dark, oceanic waters of 4-12°C. Unlike tropical corals, *L. pertusa* does not contain symbiotic algae (it is ahermatypic), but captures food directly from the water column. It is therefore found in current-swept areas, where the local topography or hydrography accelerates the current flow, and where sediment accumulation is low. These currents keep the corals free from settling silt, carry suspended food and remove waste. *L. pertusa* is typically found offshore, on the continental shelf and shelf break, most commonly between 200-400 m depth. It can occur down to 3000 m on oceanic banks and seamounts, but is also found at 50 m in the sheltered, clear but dark coloured waters of Norwegian fjords (UK Habitat Plan for *Lophelia pertusa*).

Lophelia pertusa can reproduce asexually by intratentacular budding but currently little is known about the reproductive biology of *L. pertusa* and no larvae have ever been sampled (Gass & Roberts, 2006). However, the discovery of *L. pertusa* colonies on North Sea oil platforms and the absence of evidence of living *L. pertusa* before the development of the offshore oil and gas industry, suggests that these colonies were recruited from larvae transported in the North Atlantic water mass entering the North Sea (Gass & Roberts, 2006). Growth rate estimates for *L. pertusa* polyps vary between 4 and 19 mm per year. These growth rates are comparable with some tropical corals, which is impressive considering the absence of symbiotic algae and the cooler water temperatures (UK Habitat Plan for *Lophelia pertusa*).

Estimating the distribution of *L. pertusa* is complicated by the difficulties encountered in detecting and sampling the discrete patches of *L. pertusa* that are scattered over wide areas of the seabed, on offshore banks and steep continental slopes. The majority of the *L. pertusa* records come from the north-east Atlantic, where *L. pertusa* is widely distributed. Many of these records are from Norway, where *L. pertusa* cover between 1550 and 50,600 m _ of the seabed. Nearly all of the records of *L. pertusa* in UK waters are of small fragments either sampled by trawl or grab (Johnston & Tasker, 2002). One better known site is the wreck of the 'Hurtside' (west of Shetland) which supports a small clump of *L. pertusa* (Johnston & Tasker, 2002). It is probably protected from damage from towed trawl gear by being on this wreck. Recent survey work to the north and west of Shetland and to the west of the Outer Hebrides has been funded by the oil industry, largely ahead of drilling activity in the area. The Darwin Mounds area of *L. pertusa* was discovered in 1998, approximately 185km to the northwest of Scotland at a depth of around 1000 m. A unique feature of the mounds is the growth of *L. pertusa* on a sand base, rather than hard substrate, and this area is considered to be an exceptional example of the coral (Johnston & Tasker, 2002).

During a recent project, (Mapping Inshore Coral Habitats – MINCH) the current distribution and status of cold-water coral habitats to the east of Mingulay, the Sound of Rum and to the West of Skye were examined. Characteristic seabed mounds formed by *L. pertusa* were identified to the east of Mingulay and colonies confirmed by drop-down camera, as well as indications of small colonies of *L. pertusa* at the other study areas.

The importance of *Lophelia pertusa*:
Unlike most other species of deep-water coral *L. pertusa* forms long-lasting, three-dimensional coral debris, due to its large and robust calcareous skeleton. Cold-water corals are arguably the most three-dimensionally complex habitats in the deep ocean providing niches for many species of invertebrates and fish, with up to 1300 species having been found living on *L. pertusa* reefs in the NE Atlantic (Roberts et al., 2006). *L. pertusa* pseudo-colonies and reefs provide at least four main habitats: the surface of living *L. pertusa*, the detritus laden surface of dead *L. pertusa*, the cavities formed inside *L. pertusa* skeletons by boring species, and the free space between the coral branches. The diversity of the taxa associated with the *L. pertusa* reefs is around three times as high as that of the surrounding soft sediment seabed (Fosså et al., 2002), indicating that these reefs create biodiversity hotspots and increased densities of associated species.

Experimental fishing with long-lines and gill nets was conducted by Husebø et al. (2002) on the continental shelf off southwestern Norway in depths of 150-350 m. This study registered redfish (*Sebastes marinus*), tusk (*Brosme brosme*) and ling (*Molva molva*) in considerable numbers on *Lophelia* reefs. Furevik et al. (1999; quoted from Fosså et al., 2002) reported that long-line catches of *Sebastes* spp. may be six times higher, and for ling and tusk two to three times higher, on *L. pertusa* reefs compared to non-reefs areas. These findings suggest that *L. pertusa* reefs may be important for both carnivorous (tusk and ling) and planktivorous (redfish) commercially important species, providing these fish with enhanced feeding opportunities, shelter and nursery areas (Husebø et al., 2002). Planktivorous fish such as redfish may benefit from enhanced food availability arising from hydrographically mediated factors which increase the density of zooplankton on the coral reefs.

In 1999, the UK high court ruled that the EC Habitats directive applies to the UK continental shelf waters up to a limit of 200 nm. As a result the Darwin mounds are to be protected as the first UK Special Area of Conservation (SAC) beyond the 12 nm limit. The implementation of the UK's national legislation implementing the Directive in its offshore waters came into force on 21 August 2007 (DEFRA, 2007). The Darwin Mounds were previously protected by a permanent regulation adopted by the EU Fisheries Council in March 2004 to protect them from the effects of trawling. Prior to this permanent regulation an emergency measure (EC Regulation No 1475/2003), which prohibited the use of bottom trawl or similar bottom towed nets in the area was implemented.

Evidence of damage to *Lophelia pertusa*:
Lophelia pertusa corallites grow 5–10 mm per year and the growth rate of a *L. pertusa* reef is estimated to be 1.3 mm per year. Consequently, it will take hundreds of years for a colony to reach a diameter of 1.5–2 m while it will take thousands of years to build a reef structure 10–30 m thick (Fosså et al., 2002). This extremely slow growth rate means that *L. pertusa* reefs are particularly sensitive to disturbance and recovery and restitution of their ecological function following disturbance would take many hundreds of years.

According to Roberts et al. (2006) human activities threaten cold-water coral reefs in three ways: (i) bottom trawling causes damage, (ii) hydrocarbon drilling and seabed mining have potential impacts, and (iii) ocean acidification has potentially severe effects on calcifying reef fauna. These potential threats are considered in greater detail below.

Trawling: Due to their widespread use, bottom trawls have the largest disruptive impact of any fishing gear on cold water coral ecosystems (Freiwald et al., 2004). There is global evidence that *L. pertusa* reefs have been damaged by trawling for deep-water fish, causing severe physical damage from which recovery to formal reef status will take several hundreds or thousands of years, if at all (Fossa et al., 2002; Hall-Spencer et al., 2002; Roberts et al., 2006). Estimates of the fishery impact in Norwegian waters, using in situ observations by remotely operated vehicles, indicated that between 30 and 50% of *L. pertusa* reef areas are damaged or impacted (Fosså et al., 2002). Video surveys show that deep-water coral systems are especially fragile and easily reduced to rubble by towed fishing gear (Hall-Spencer et al., 2002). This contrasts with exposed shallow-reef systems where wave action favours corals with sturdy, compact growth forms and there is sufficient light for calcareous coralline algae to consolidate and strengthen the reef structure. Such a reduction in the structural complexity of coral grounds would be expected to lead to a reduction in species diversity and survivorship of species (Freiwald et al., 2004). In the past decade, bottom trawls used in commercial fisheries have been fitted with rockhopper ground gear designed to minimise escape of fish under the footrope. These heavy gears cause severe negative effects to sensitive benthic habitats, such as *L. pertusa* reefs (Fosså et al., 2002). Due to increased trawling activity on the deeper continental shelves and slopes, there is an urgent need for better knowledge of the biology and ecological function of deep-sea coral reefs (Husebø et al., 2002). Several nations, including Canada, Norway, UK and USA, have responded by closing cold-water coral habitats to bottom fishing (Roberts et al., 2006). It is now also becoming clear that the Atlantic Frontier region is scarred by trawl marks and that, at least in UK territorial waters, the previous extent of cold-water coral habitats has already been substantially reduced by trawling activity. (Hall-Spencer et al., 2002; Roberts et al., 2000). Given the paucity of baseline information and the difficulty and expense of wide-area survey in these environments, it is unlikely that the extent and significance of this damage will ever be fully appreciated (Roberts et al., 2003).

Hydrocarbon exploitation: There would appear to be little evidence that hydrocarbon exploitation substantially threatens cold-water coral ecosystems. *L. pertusa* colonises North Sea oil platforms and seems to have formed a self-seeding population, despite proximity to drilling discharges (Gass & Roberts, 2006). These authors found some evidence of contamination from drill muds and cuttings on colonies on drilling platforms, but such contamination was limited to regions close to drilling discharge points and these effects were highly localised in comparison with the effects of bottom trawling (Gass & Roberts, 2006). In many areas, such as European waters, oil companies are required to conduct environmental impact assessments before carrying out most activities. It should be noted that, as a result, oil companies have financed survey work that has discovered cold-water coral reefs, and activities that would have affected these reefs have been avoided (Freiwald et al., 2004). Mining activities risk causing local extinctions on seamounts supporting endemic species, but to date there has been little interest in mining the mineral deposits found in some seamounts and oceanic ridge systems (Roberts et al., 2006).

Ocean acidification: There is general consensus that atmospheric carbon dioxide levels are rising sharply, and modelled scenarios suggest that this could cause the largest increase in ocean acidification over the last 300 million years (Caldeira & Wickett, 2003). Increases in ocean acidification will decrease carbonate ion concentrations, making it more difficult for marine calcifying organisms to form biogenic calcium carbonate (Orr et al., 2005). Cold-water coral species form their calcareous endoskeleton from aragonite, a common polymorph of calcium carbonate. It is predicted that tropical coral calcification would be reduced by up to 54% if atmospheric carbon dioxide doubled (Royal Society, 2005). Given the lowered carbonate saturation state at higher latitudes and deeper waters, cold-water coral species may be even more vulnerable than tropical corals (Roberts et al., 2006). It is also predicted that the depth at which aragonite dissolves could shallow by several hundred meters, thereby raising the prospect that areas once suitable for cold-water coral growth will become inhospitable (Orr et al., 2005).

In addition to the potentially damaging activities above, Freiwald et al. (2004) suggested a number of additional human activities that could potentially threaten cold-water coral reefs. Cables for telecommunication and electricity are laid across seas and oceans, and whilst there are no known examples of cables cutting through coral areas, there has also been little examination of this possibility (Freiwald et al., 2004). The authors also noted that burying cables will resuspend sediment which could in turn smother corals living nearby. Finally, the capturing and sequestration of CO_2 from the atmosphere into deep waters has been proposed. There are concerns about the consequences, including the risk of lowering the pH of seawater and further impairing the ability of corals to lay down calcium carbonate framework structures (Freiwald et al., 2004).

Conclusion:

Lophelia pertusa reefs are clearly of considerable importance both in terms of their high biodiversity and for providing shelter, feeding opportunities and nursery areas for commercially important species of fish. An obvious way to protect this habitat is to designate selected areas as marine protected areas in which no deleterious activities can occur. *Lophelia pertusa* reefs are easily disrupted by environmental change and are vulnerable to damage by human activities especially considering their slow growth rate. The relatively recent discovery of *L. pertusa* in Scottish inshore waters habitats to the east of Mingulay highlights the urgent need to designate selected areas as marine protected areas in which no deleterious activities can occur.

References:

Caldeira, K. and Wickett, M. E. (2003). Anthropogenic carbon and ocean pH. *Nature* **425**, 365-365.

DEFRA (2007) http://www.defra.gov.uk/news/2007/070720b.htm

De Santo, E.M. & Jones, P.J.S. (2007) Offshore marine conservation policies in the North East Atlantic: emerging tensions and opportunities. *Marine Policy* **31**, 336-347.

Fossa, J. H., Mortensen, P. B. and Furevik, D. M. (2002). The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. *Hydrobiologia* **471**, 1-12.

Freiwald, A., Fosså, J.H., Grehan, A. Koslow, T. & Roberts, J.M. (2004) Cold-water coral reefs. UNEP-WCMC, Cambridge, UK.

Gass, S. E. and Roberts, J. M. (2006). The occurrence of the cold-water coral *Lophelia pertusa* (Scleractinia) on oil and gas platforms in the North Sea: Colony growth, recruitment and environmental controls on distribution. *Marine Pollution Bulletin* **52**, 549-559.

Hall-Spencer, J., Allain, V. and Fossa, J. H. (2002). Trawling damage to Northeast Atlantic ancient coral reefs. *Proceedings of the Royal Society of London Series B-Biological Sciences* **269**, 507-511.

Husebø, A., Nottestad, L., Fossa, J. H., Furevik, D. M. and Jorgensen, S. B. (2002). Distribution and abundance of fish in deep-sea coral habitats. *Hydrobiologia* **471**, 91-99.

Johnston, C. & Tasker, M. (2002) Darwin Mounds Proposed Special Area of Conservation. JNCC report (JNCC 02 P10).

Orr, J. C., Fabry, V. J., Aumont, O., Bopp, L., Doney, S. C., Feely, R. A., Gnanadesikan, A., Gruber, N., Ishida, A., Joos, F. et al. (2005). Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* **437**, 681-686.

Roberts, J. M. (2005) A coral reef in Scottish waters! SAMS Newsletter 29: 8-9.

Roberts, J.M., Harvey, S.M., Lamont, P.A., Gage, J.D. & Humphery, J.D. (2000) Seabed photography, environmental assessment and evidence for deep-water trawling on the continental margin west of the Hebrides. *Hydrobiologia* **443**, 173-183.

Roberts, J. M., Long, D., Wilson, J. B., Mortensen, P. B. and Gage, J. D. (2003). The cold-water coral *Lophelia pertusa* (Scleractinia) and enigmatic seabed mounds along the north-east Atlantic margin: are they related? *Marine Pollution Bulletin* **46**, 7-20.

Roberts, J. M., Wheeler, A. J. and Freiwald, A. (2006). Reefs of the deep: The biology and geology of cold-water coral ecosystems. *Science* **312**, 543-547.

Royal Society (2005) Ocean acidification due to increasing atmospheric carbon dioxide. Royal society policy document 12/05.

UK Habitat Action Plan for *Lophelia pertusa* (http://www.ukbap.org.uk/UKPlans.aspx?ID=45)

For further information please contact.

Alan Wells

Marine Bill Research Officer, Scottish Environment LINK

Tel: 01350 728200, Mobile: 07920 287086, Email: alan@scotlink.org