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REPORT OF THE

STUDY GROUP ON MAPPING THE OCCURRENCE OF COLD WATER CORALS

By correspondence

May 2002

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

1.1 Participation

The following members of the Study Group participated in producing this report (see Annex 1 for addresses):

Mark Tasker (Chair)	UK
Brian Bett	UK
Jan Helge Fosså	Norway
André Freiwald	Germany
Anthony Grehan	Ireland
John Gordon	UK
Jason Hall-Spencer	UK
Pascal Lorance	France
Pål Mortensen	Canada
Murray Roberts	UK
Sigmar Arnar Steingrímsson	Iceland
Andy Wheeler	Ireland

1.2 Terms of Reference

At the 88th Statutory meeting, a Study Group on Mapping the Occurrence of Cold Water Corals (SGCOR) was established to work by correspondence to compile maps identifying the areas where cold water corals occur in the Northeast Atlantic. SGCOR will circulate these maps to ACE and a selection of Working Group Chairs for comment in order to enable ICES (through ACE) to provide advice to the European Community. In addition, SGCOR will compile relevant reports for further consideration by the Working Group on Ecosystem Effects of Fishing Activities (WGECO) in relation to fishing areas. SGCOR will report by 18 October 2001 for the immediate attention of ACE and thereafter of WGECO, and subsequently again of ACE and the Marine Habitat Committee.

1.3 Justification of Terms of Reference

This Term of Reference and the Study Group is based on a request for urgent advice sent by the European Commission in July 2000 asking ICES "to identify areas where cold-water corals may be affected by fishing." There is strong evidence of recent, permanent damage to cold-water coral features in the ICES area. Scientific advice is required to inform possible management measures to avoid further damage. Input from EU projects ACES and ECOMOUND will be used.

1.4 Acknowledgements

We thank Stein Hjalti í Jákupsstovu (Faroes) and Charlotte Johnston (UK) who provided additional help in producing this report. Comments that have helped improve the report have been received from Jake Rice and Eric Jagtman.

2 COLD WATER CORALS

2.1 Introduction

Many species of coral grow in cold water. If the terms of reference provided by the ICES process were interpreted widely, these corals occur throughout the ICES area and the entire ICES area would be identified. However, the origin of the term of reference was a request from the European Commission to help meet recent concerns about the impacts of fishing on cold water coral reefs. It is therefore assumed for the purposes of this report that cold water corals refer to those coral species that contribute to reef formation in waters less than about 20^{o} C. In Northeast Atlantic waters these include the azooxanthellate scleractinarian corals *Desmophyllum cristagalli, Enallopsammia rostrata, Lophelia pertusa, Madrepora oculata* and *Solenosmilia variabilis*. The main reef building species is *Lophelia pertusa*. Other coral species often occur in association with *Lophelia pertusa* and none has been found forming reefs away without *Lophelia pertusa* being present. Zibrowius (1980) gave a good general review of the distribution of cold water coral in European waters.

2.2 Ecology and growing habit of *Lophelia pertusa*

Lophelia pertusa appears to prefer oceanic waters with a temperature of between 4 ^{o} C and 12^{o} C, and a relatively high water flow. It has also been proposed that the water needs to be relatively clean of entrained sediment. It has long been thought that the species also required a hard substrate to attach itself to, although recent evidence (see Section 2.3.4 below) indicates that this is not always the case. Once established in an area, the species appears to be able to spread across the seabed by growing on dead and fallen pieces of itself (as with some other biogenic reef forming organisms). There are several recent records from oil installations in the North Sea (including the Brent Spar), indicating that larval colonisation can also occur. Much of the Northeast Atlantic's waters meet the above environmental conditions and the species was first described by Linnaeus in 1758. Many further records followed in the nineteenth century.

Lophelia pertusa can occur in a variety of forms; in larval form it can presumably move widely, but once settled it can grow upon itself, as mentioned above, to form large reefs or reef complexes. Sars (1865) was the first to suggest that *Lophelia pertusa* can build reefs. However, the use of the term "reef" has been debated in the scientific literature, and different authors suggest various terms to be applied for accumulations of azooxanthellate coral colonies and skeletons. These terms include: "reef", "massifs", "bank", "patch", "mound" and "bioherm". "Reef" is used in this report for such accumulations.

The greatest of these reefs known in the Northeast Atlantic (and globally) is on the Sula Ridge on the mid-Norwegian shelf. This structure is more than 13 km long and up to 450–500 m wide. The average height is about 15 m, but some individual sub-structures are 35 m high (Dons 1944; Freiwald *et al.* 1999). This reef provides a habitat for a diverse associated community of marine life, with some associated fish species at much higher densities than surrounding waters (Jensen and Frederiksen 1992; Mortensen *et al.* 1995).

Spectacular reefs such as that on the Sula Ridge appear to be rare however and elsewhere the species forms "patches" (Wilson 1979; Mortensen *et al.* 1995, 2001). On the Rockall Bank, such patches have been recorded 15–30 m across and about 1.5 m high (Wilson 1979), whereas some on the Norwegian shelf are slightly larger (Mortensen *et al.* 1995, 2001). Wilson (1979) suggests a mechanism of growth and breakage of colonies, with subsequent growth on the fallen parts as a way that these patches might form. Elsewhere, isolated clumps of *Lophelia pertusa* have been observed.

In the Northeast Atlantic reefs occur from the Iberian Peninsula to Ireland (Le Danois 1948), around the Rockall Bank, the Faroe Islands (Wilson 1979; Frederiksen *et al.* 1992), and near the coast and on the shelf along the Norwegian coast between 60° N and 71° N (Dons 1944). Further survey work has occurred in most of these areas and modern references are included in the following sections.

Most records of the species are samples grabbed or trawled up. Thus the structural context that the species is growing in at most recorded sites is not known (and is likely to have been changed by the sampling or trawl gear). The precise growing habit of the species is likely to be dependant on oceanographic conditions and the degree of disturbance and turbulence at each site.

2.3 Distribution of *Lophelia pertusa*

As noted above, *Lophelia pertusa* appears to prefer oceanic waters with a temperature of between 4 ^{o} C and 12^{o}C, with relatively high water flow. These conditions occur widely in the Northeast Atlantic. Broadly though, they occur at shallower depths in some Norwegian fjords (within 40 m of the surface in Trondheimsfjorden (Strømgren 1971; Rapp and Sneli 1999) and at much greater depths off the Iberian peninsula. Several review papers have described distribution in parts of the Northeast Atlantic.

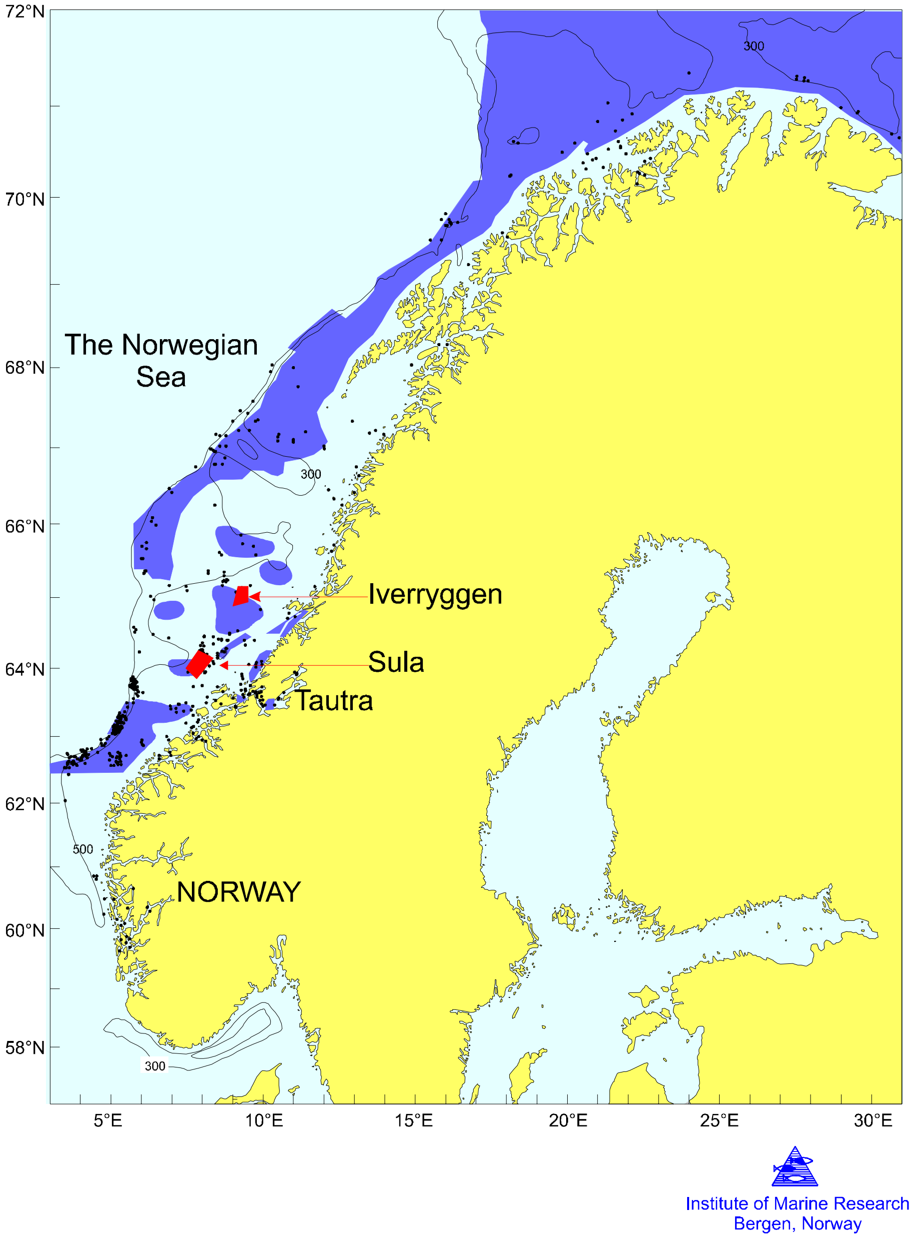
2.3.1 Norway

Fosså *et al.,* 2000 provide an overview of *Lophelia pertusa* distribution in Norwegian waters and estimate that between 1500 and 2000 km^2 of the Norwegian EEZ is covered in coral. Most is concentrated between 200 and 400 m depth on the continental shelf break, but with numbers of records from the entrances to some fjords (Figure 2.3.1.1). One particularly large reef complex is found on the Sula Ridge (e.g., Ottesen *et al.* 2000). These authors also surveyed, through fishermen's interviews and direct observation, the effects of trawling activity. They concluded that between a third and a half of the total reef area of Norway has been damaged to an observable extent. Given the slow growth rate of *Lophelia pertusa*, the recovery of some of these reefs will, at a minimum, take centuries and may never happen.

As a consequence of damage caused by fishing activities to coral reefs, two areas have been closed on the Norwegian continental shelf to fishing by towed gear to prevent further damage to relatively pristine areas. These are at the Sula

Ridge and at Iverryggen (Figure 2.3.1.1). The use of long lines in these areas is still allowed. Appendix 1 of Fosså *et al.*, (2000) reprints the relevant regulations.

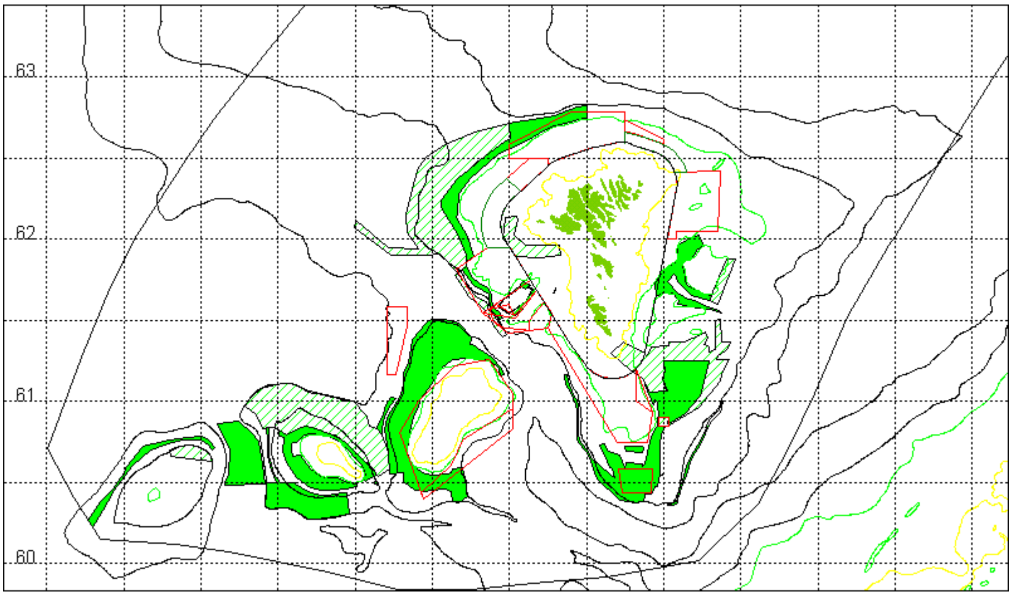
Figure 2.3.1.1. Distribution of *Lophelia pertusa* (dots) and major trawl grounds (blue) in Norwegian waters, showing the degree of overlap between coral and trawling distribution. Two areas on the shelf, Sula and Iverryggen (red) are protected from trawling gear. Map from J.H. Fosså, Institute of Marine Research, Bergen.



2.3.2 Faroes

Frederiksen *et al*., (1992) provide a review of the distribution of *Lophelia pertusa* around the Faroe Islands, including some waters within the UK 200 NM limit (EU fishing limits). The species occurs only in areas in contact with Northeastern Atlantic water (as opposed to Arctic water), with all records in the average bottom temperature range of 6.2 ^{o}C to 8.6^{o} C. The majority of records around the Faroe Islands were from, at, or near areas with a critical slope angle that would intensify mixing of bottom waters. The depth of the records ranges from about 300 m on the Rockall Bank to 750 m on the Hatton Bank. Stein Hjalti í Jákupsstovu has provided a map (Figure 2.3.2.1) based on interviews with fishermen indicating areas of occurrence of *Lophelia pertusa* along with those areas with evidence of damage by fishing.

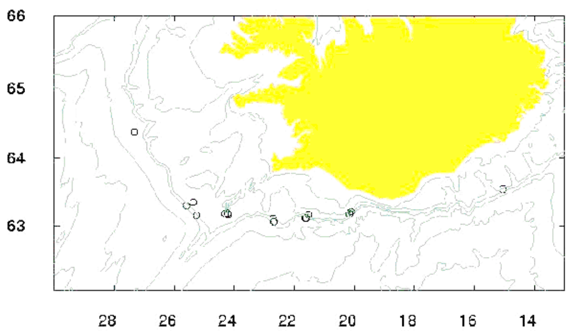
Figure 2.3.2.1. Distribution of current (solid green) and past (hatched green) areas containing *Lophelia pertusa* reefs in waters around the Faroe Islands (S. H. í Jákupsstovu). It is assumed that reefs in the hatched areas have been lost through fishing activity. The red lines are areas presently closed for trawling, for fisheries management reasons.



2.3.3 Iceland

Information on the distribution of *Lophelia pertusa* around Iceland is based on literature (Carlgren, 1939; Copley *et al*. 1996) and records from the BIOICE programme database (material identified by Helmut Zibrowius, 199 8). The species occurrence is near the continental shelf break off the south and west coast of Iceland (Figure 2.3.3.1), depth range 114 m to 800 m, with bottom temperature between 5.5 ^{o} C to 7.3^{o} C. Copley *et al*., (1996) found the species growing further south on the mid Atlantic ridge.

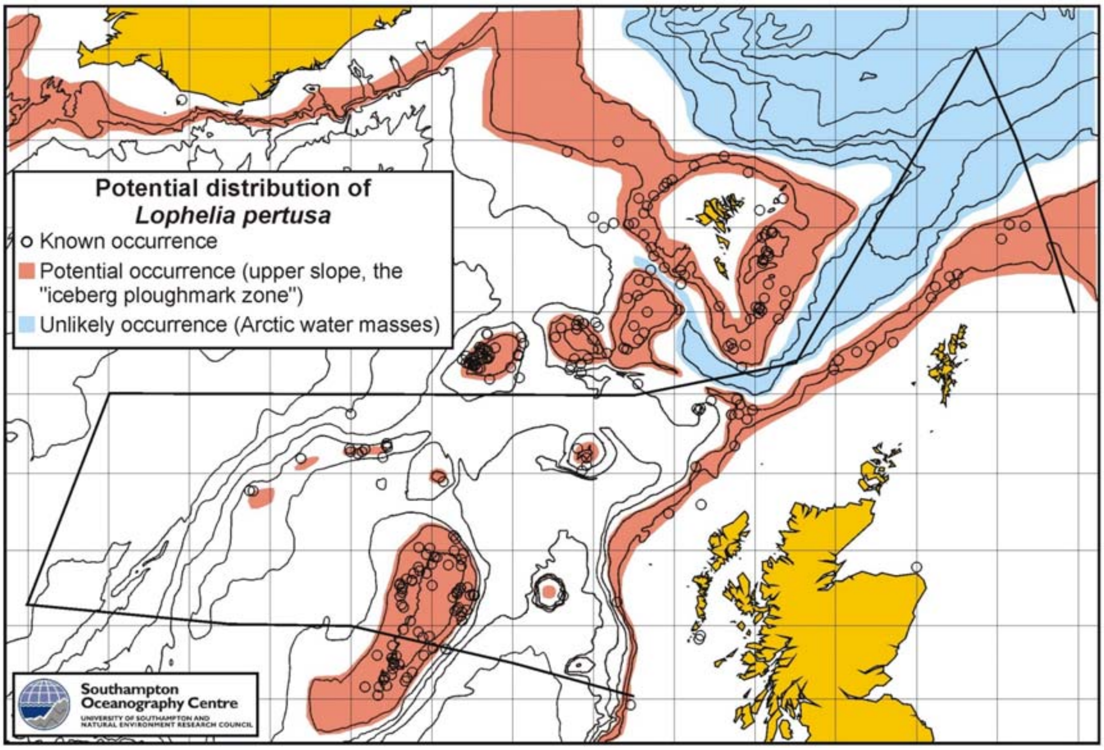
Figure 2.3.3.1. Distribution of records of *Lophelia pertusa* made during the BIOICE programme in Icelandic waters (map provided by S.A. Steingrímsson).



2.3.4 United Kingdom

Wilson (1979) was the first to review the distribution of *Lophelia pertusa* in UK waters as well as in nearby waters of the Northeast Atlantic. Both Long *et al*., (1999) and Rogers (1999) updated this review. The two main areas where the coral occurs are on the Rockall Bank and on the shelf break north and west of Scotland between 200 m and 500 m in depth (Figure 2.3.4.1). South of the Wyville Thomson ridge, the lower depth limit is deeper than to the north due to the inability of *Lophelia pertusa* to grow in the deep cold Arctic waters occurring below 500 m north of the ridge. The ability of the coral to colonise newly-available suitable habitats has been demonstrated by the occurrence of records from several oil platforms in the northern North Sea, including the now decommissioned Brent Spar installation (Bell and Smith, 1999).

Figure 2.3.4.1. Potential and actual distribution of *Lophelia pertusa* in northwestern waters of the United Kingdom (map courtesy of Southampton Oceanography Centre.



The best-researched *Lophelia pertusa* features in UK waters are the Darwin Mounds, named after the research vessel “Charles Darwin”. These are in two parts and are located in about 1000 m of water some 150 km to the NW of Lewis (Outer Hebrides, Scotland) in the Northeast corner of the Rockall Trough, immediately south of the Wyville Thomson Ridge (Figure 2.3.4.2). The mounds cover an area of approximately 100 km^2 and contain some hundreds of mounds in two main fields (referred to as Darwin Mounds East (about 13 km × 4 km with about 75 mounds) and Darwin Mounds West (13 km × 9 km with 150 mounds) (see Figure 2.3.4.3). Other mounds are scattered at much lower densities in nearby areas. Each of the mounds is approximately 100 m in diameter and 5 m high. Most of the mounds are also distinguished by the presence of an additional feature visible on the side-scan sonar referred to as a “tail”. The tails are of a variable extent and may coalesce, but are generally a teardrop shape and are orientated Southwest of the mound.

The mounds are comprised mostly of sand, interpreted as sand volcanoes. These features are caused when fluidised sand “de-waters”. Sand volcanoes are common in the Devonian fossil record in UK, and in seismically active areas of the planet. In this case, tectonic activity is unlikely; some form of slumping on the Southwest side of the Wyville Thomson Ridge being a more likely cause. The tops of the mounds have living stands of *Lophelia pertusa* and blocky rubble (interpreted as coral debris).

Figure 2.3.4.2. Location of Darwin Mounds in Northeast Atlantic.

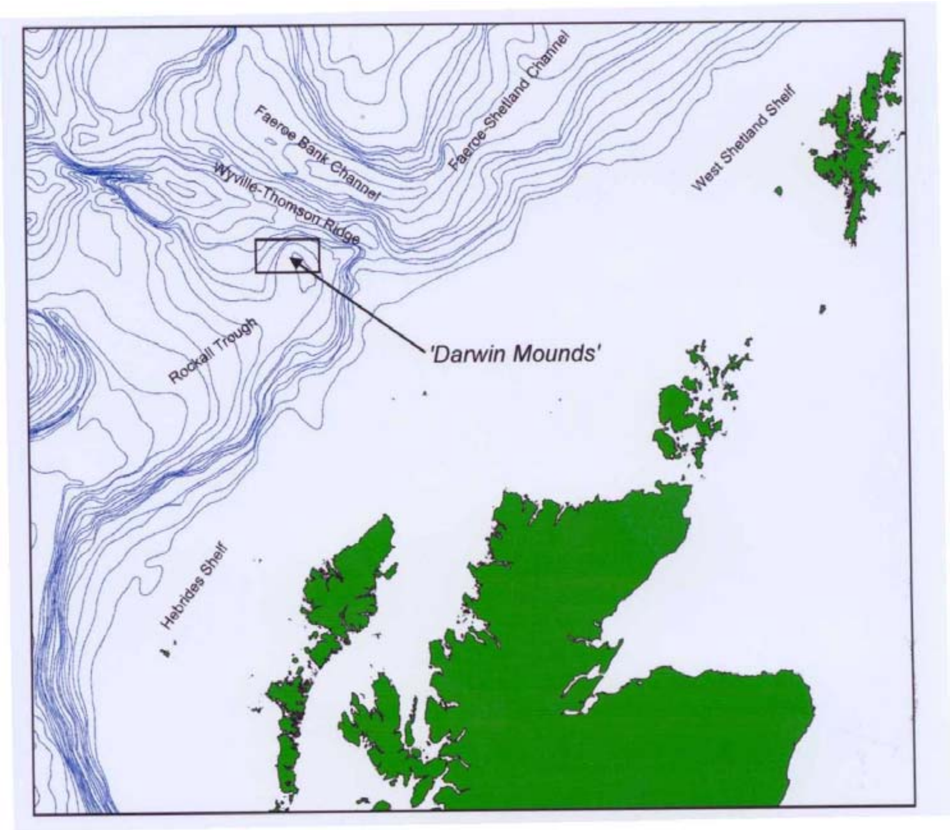
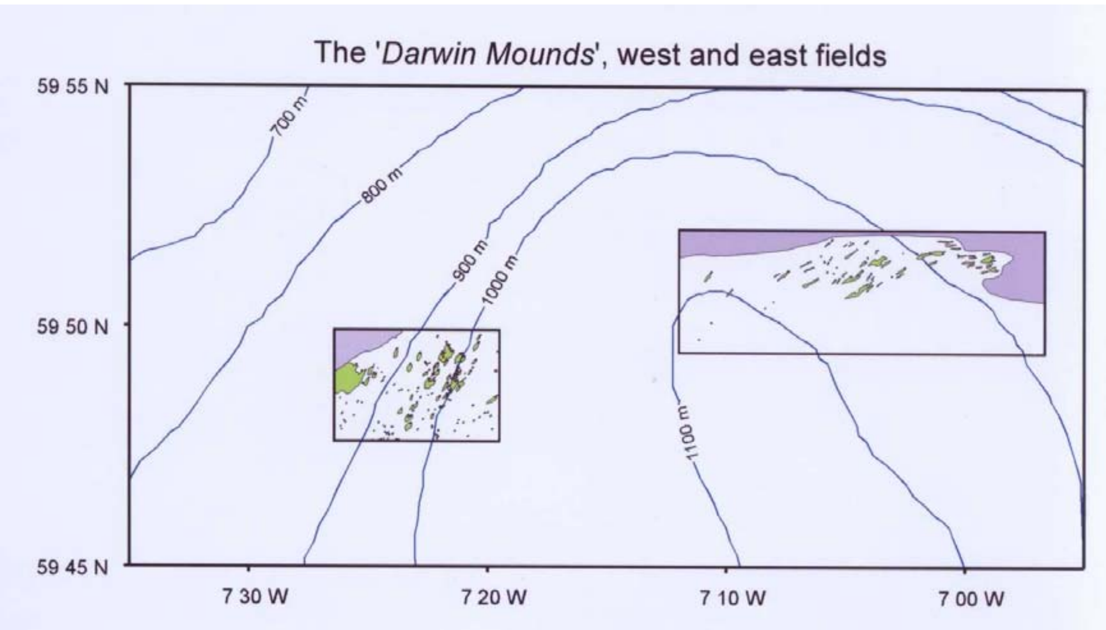


Figure 2.3.4.3. Detail of location of Darwin Mounds west and east fields. The red point is the mound, while the green areas are the 'tails'.



The tails also support significant populations of the xenophyophore *Syringammina fragilissima*. This is a large (15 cm diameter) single celled organism that is widespread in deep waters, but occurs in particularly high densities on the mounds and the tails. The corals themselves provide a habitat for various species of larger sessile or near sessile invertebrates such as sponges and brisingiids. Various fish have been observed, but not apparently at significantly higher densities than the background environment. This contrasts with studies at other *Lophelia pertusa* sites where elevated numbers of saithe *Pollachius virens*, redfish *Sebastes* spp. and tusk *Brosme brosme* have been found (Mortensen *et al*. 1995; 2001; Fosså *et al*. 2000).

The mound-tail feature of the Darwin Mounds is apparently unique globally. The mounds are also unusual in that *Lophelia pertusa* appears to be growing on sand rather than a hard substrate. Prior to research on the mounds in 2000, it was thought that *Lophelia pertusa* required a hard substrate for attachment.

2.3.5 Ireland

There does not appear to have been a formal review of records of *Lophelia pertusa* in Irish waters, but those of Wilson (1979) and Rogers (1999) contain many records (Figures 2.3.4.1 and 2.3.5.1). The south end of the Rockall Bank and the shelf on the opposite side of the Rockall Bight (to the north-west of Donegal) and the Porcupine Seabight all hold large structures (Hovland *et al*. 1994). These larger structures were described as being "haystack" shaped but some had a less regular shape and may extend in ridge-like forms. The base sizes are up to 1,800 m across with a height of 65–165 m. Kenyon *et al*., (1998) studies twelve reef mounds in the Northern Porcupine Seabight. The mounds varied from approximately circular to elongate (or were compounds of these elements). The mounds were approximately 1 km in diameter, and the largest reached 120 m in height. Many of these mounds had a buried segment underlying them, indicating a long history of the structure that has included sedimentation events. Kenyon *et al*., (1998) further describe a line of nineteen mounds running southwards at about 11^{o} 40' W from 51^{o} 40'N to 51^{o} 20'N (Figure 2.3.5.2). One of these (the Theresa Mound at 51° 25′ N 11° 46′ W) is home to some of the best-developed coral (*Lophelia pertusa* and *Madrepora oculata*) ecosystems known in the Northeast Atlantic (Bett *et al*. 2001). Most of the records in the Porcupine Seabight and vicinity are from depths of 400–1000m.

Figure 2.3.5.1. Early observations of the distribution of deep-water corals (mainly *Lophelia pertusa*) in the Porcupine Seabight and Bay of Biscay areas, compiled from the records of commercial fishing vessels. (Adapted from Teichert, 1958; after Joubin, 1922a, b). The Galicia Bank is also indicated, this site is now known to hold a significant population of *Lophelia pertusa* (G. Duineveld pers. comm.).

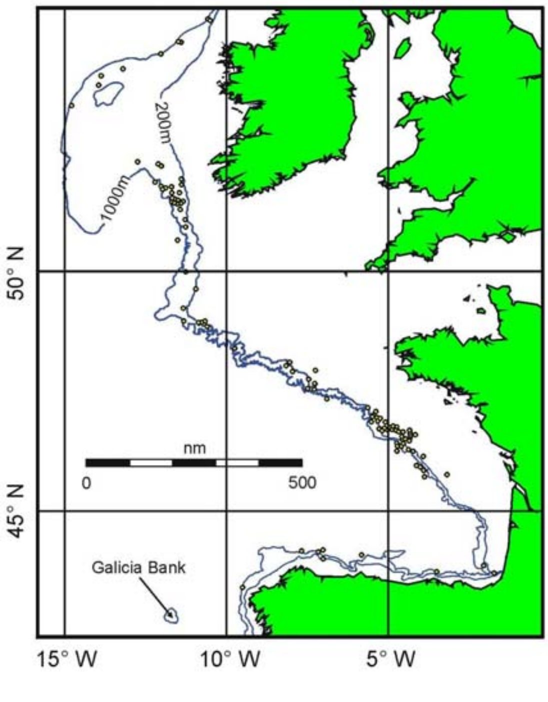
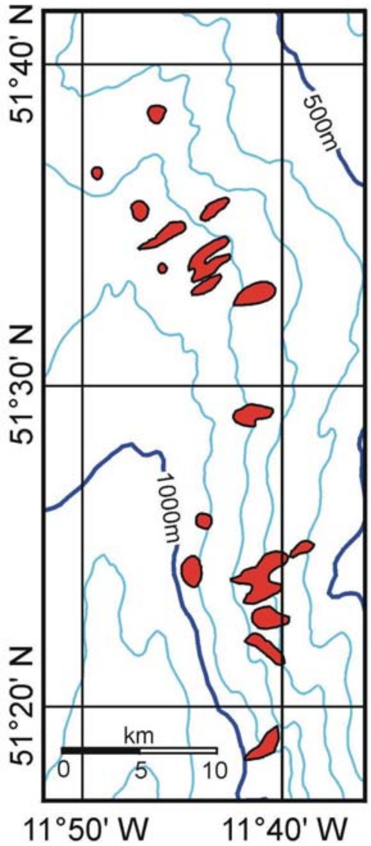


Figure 2.3.5.2. Schematic representation of the large carbonate mounds (red areas) in the "Belgica Mound Province" of the Porcupine Seabight, based on 9.5 kHz OKEAN sidescan sonar data. Deep-water coral communities are known from most, if not all, of these mounds. (Adapted from Kenyon and Akhmetzhanov, 1998).



2.3.6 France, Spain, Portugal

There are a number of records from the Bay of Biscay and *Lophelia pertusa* is abundant in some areas including the Chapelle Bank (47^{o} 30'N, 7^{o} 10'W, 48^{o} 10'N, 04^{o} 10'W) (Rogers 1999) and on the Galicia Bank (Figure 2.3.5.1). The Galicia Bank has its summit at 500 m water depth. It is approximately 1500 m long with a very steep eastern slope of bare rock. The west slope levels out at about 800 m to an extensive sandy plateau. Current speeds are high, producing a seafloor of coarse foraminiferal sand that is formed into mega-ripples with a wavelength of about 25 m and amplitude of 50 cm. Surprisingly, the corals (*Lophelia* and *Madrepora*) occur in this dynamic sandy area rather than on the bare rock slopes. The corals form longitudinal patches of about 1 m wide and 1 m high, and can run for over 10 m (G. Duineveld pers. comm.). *Lophelia pertusa* has also been recorded off the Canary Islands and in several sites off Portugal and at depths mostly greater than 1000 m around the Atlantic islands of Madeira and the Azores.

2.3.7 Mediterranean

Rogers (1999) notes a number of records of *Lophelia pertusa* from the Western basin of the Mediterranean.

3 EFFECTS OF FISHING IN *LOPHELIA PERTUSA* REEFS

3.1 Introduction

The following section is a brief review of the documented cases of *Lophelia pertusa* damage from fishing gear. Trawling is very widespread in areas holding *Lophelia pertusa*. Photographic and acoustic surveys have recently located trawl marks at 200–1400 m depth all along the Northeast Atlantic shelf break area from Ireland, Scotland and Norway (Rogers 1999; Fosså *et al.* 2000; Roberts *et al.* 2000; Bett 2000). Any trawling over *Lophelia pertusa* is likely to cause harm.

There have been a number of documented instances of damage to *Lophelia pertusa* reefs in Northwest European waters. These, though, must represent a minute fraction of the number of instances when such reefs have been damaged, given how widespread trawling has been, and the amount of habitat that is potentially suitable for corals in the Northeast Atlantic. Another indication is that damage to corals by trawling has been widespread is that many records of occurrence of *Lophelia pertusa* come from records from commercial trawl hauls, where the coral was only known to occur because broken pieces were brought back by the gear.

The most obvious impact of trawling on *Lophelia pertusa* is mechanical damage caused by the gear itself. The impact of trawled gear will kill the coral polyps and break up the reef structure. The breakdown of this structure will alter the hydrodynamic and sedimentary processes, as well as cause a loss of shelter around the reef. Organisms dependent on these features will have a much less suitable habitat and recovery may not be possible, or could be seriously impaired. The scale of effects will depend on the scale and frequency of any trawling operations. Damage will range from a decrease in the size of the reef, and a consequent decrease in abundance and diversity of associated fauna, to a complete disintegration of the reef and its replacement with a low-diversity disturbed community (Fosså *et al*. 2000). Trawling may also have the effect of evening out the seabed by scraping off high points and infilling lows, as well as redistributing boulders. Since *Lophelia pertusa* seems to require some of the high points to grow initially, the seabed habitat following trawling may become unsuitable for *Lophelia pertusa* growth.

Trawls may also cause resuspension of sediments that may in turn have effects on corals growing downstream (including entrapment in the coral framework). Such impacts may be proportionately greater in high-relief mound areas such as in the Porcupine Seabight, where trawling over the mounds is uncommon due to the risk of gear damage and large unwanted bycatch. However, the sediment areas immediately adjacent to the mounds are heavily trawled. Quantitative evidence for such impacts was found by the French ROV Victor during the “Caracole” cruise in August 2001 (A. Freiwald pers. comm.).

3.2 Effects of fishing on Norwegian reefs

Fosså *et al*., (2000) estimated that between a third and a half of Norway’s *Lophelia pertusa* reefs are damaged or affected by fishing. Damage is illustrated from a number of areas by comparing photographs (such damage is difficult to quantify by sampling as such sampling also causes damage). Fosså *et al*., (in press) describe these surveys. In order to distinguish natural decay from impacts by human activities, such as bottom trawling, they looked for broken living colonies tilted, turned upside down and/or in unexpected/awkward positions on levelled sea bottom. The remains of fishing gear such as gillnets, anchors, and trawl nets among corals added to the evidence while recent furrows or scars in the sea bottom are unmistakable evidence of trawling activity.

Three localities on Storegga (continental shelf break between 62° 30’ N and 63° 50’ N) were inspected between 1998 and 1999: Aktivneset, Korallneset and Sørmannsneset. During 1999, two localities were inspected on the shelf: Maurdjupet and Iverryggen. All these localities and surrounding areas are subject to extensive bottom trawling.

Two inspections with ROV were made at Sørmannsneset, covering a vertical range from 370 to 225 m and distances between 2.5 and 2.9 km. The observations confirmed that the most severe damage occurred at shallowest depths (200 m) as crushed remains of *Lophelia pertusa* skeletons were spread over the area while living corals were rarely found (Figure 3.2.1). Many signs of human activity: lost gillnets, an anchor, wires, a buoy, and remains of a trawl net entangled with corals were encountered. In addition, sonargrams from the side scan sonar detected furrows penetrating into areas of damaged corals. These were interpreted as furrows as caused by trawl doors or other parts of a trawl gear cutting through the surface of the bottom.

At Korallneset, almost 2.6 km of the sea bottom was inspected between 305 and 205 m depth. Almost all corals observed were crushed or dead. Aktivneset is subject to heavy trawling and the ROV-inspection showed this location to be very rich in corals all along a 7 km ROV-transect between 350 and 270 m depth. The reefs were neither large nor high, but smaller colonies covered significant areas. However, damage was evident as well as signs of human activity such as a rubber boot, ghostfishing gillnets and furrows in the seabed. Damage at Maurdjupet was severe, especially on the slopes of a smaller basin or depression in the shelf. Five inspections at Iverryggen revealed severe damage to colonies of *Lophelia pertusa* and other corals such as gorgonians (Figure 3.2.2). Every inspection verified damage to corals that exhibited all stages of degradation, e.g., from almost intact living coral colonies to completely crushed reefs. Damage due to passive gear was confirmed at this location by the presence of lost gillnets (Figure 3.2.3). The nets and the anchor-ropes may sometimes disturb the corals by breaking down and tilting parts of the colonies.

Figure 3.2.1. Video photograph from Sørmannsneset at the Norwegian continental break, 220 m depth taken from a height of about 1.2 m above the seabed on 16 May 1998, showing a barren landscape with crushed remains of *Lophelia pertusa* skeleton spread over the area. This is a region subject to considerable bottom trawling. A track can be seen stretching from bottom-left to up-right of the photograph, indicating the path of a trawl. From Fosså *et al*., (in press).

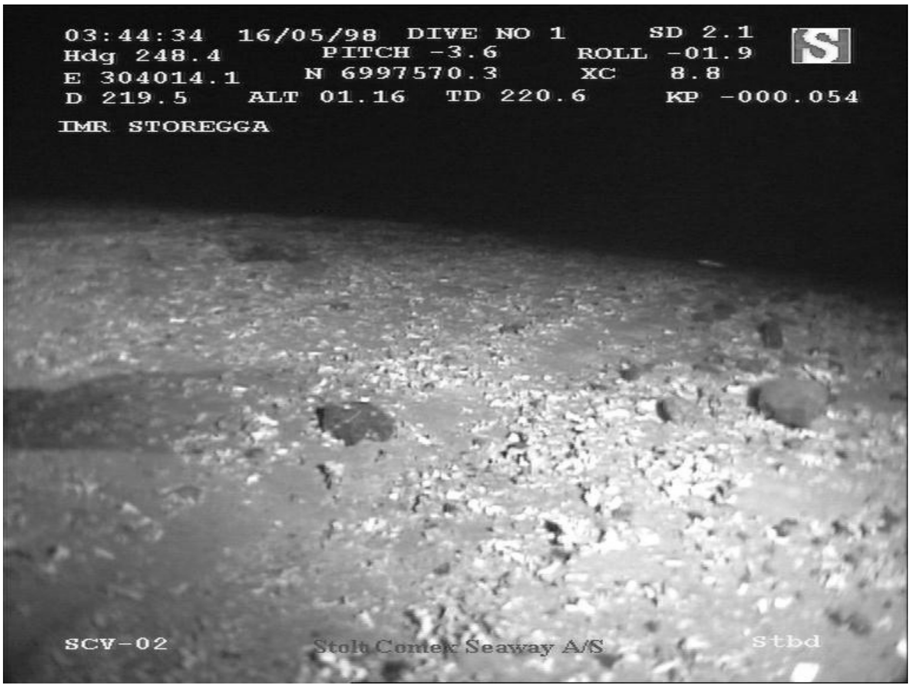


Figure 3.2.2. Fragments and larger pieces of dead *Lophelia pertusa* from a trawling ground near Iverryggen on the Norwegian continental shelf at 190 m depth, taken from a height of about 2 m above the seabed on 17 May 1999. The bottom substrate is apparently severely disturbed. From Fosså *et al*., (in press).

Figure 3.2.3. Two ropes of the type usually used on gillnets. *Lophelia pertusa* reefs are damaged and torn apart by passive fishing gear such as anchored longlines and gillnets. Iverryggen 17 May 1999 at 200 m depth. From Fosså *et al*., (in press).

3.3 Effects of fishing on the Darwin Mounds

The Darwin Mounds were discovered using remote sensing techniques in May 1998 during surveys funded by the oil industry and steered by the UK industry-government group the Atlantic Frontier Environment Network (AFEN) (Masson and Jacobs 1998). They have been further investigated in June 1998 (Bett, 1999), August 1999 (Bett and Jacobs, 2000) and twice during summer 2000 (Bett 2001; B. Bett, pers. comm.). Instruments deployed during the studies have included sidescan sonar, stills and video cameras and piston corers. A typical mound as detected by side-scan sonar is shown in Figure 3.3.1.

The Darwin Mounds are vulnerable to damage from bottom-trawling, and evidence of new damage was visible over about a half of the Darwin Mounds East during summer 2000 (Wheeler *et al*. 2001). This damage was visible as smashed coral strewn on the seabed along with visible parallel scar marks (Figure 3.3.2). A trawler was operating nearby during the surveys. Given that *Lophelia pertusa* appears to need (or favour) the elevation provided by the sand volcanoes for growth in this area, it seems likely that this damage will be permanent. This site must be regarded as at particularly high risk of further permanent damage.

Figure 3.3.1.. Sidescan sonar image of an individual Darwin Mound. This mound is about 100 m across. Each dark spot is either a *Lophelia pertusa* clump or blocky rubble (likely to be formed from dead *Lophelia pertusa*). Note lighter patch forming the "tail" stretching to bottom left of image. The red line is an indicator of distance to the centre of the sidescan path. Image courtesy of Andy Wheeler (University College, Cork).

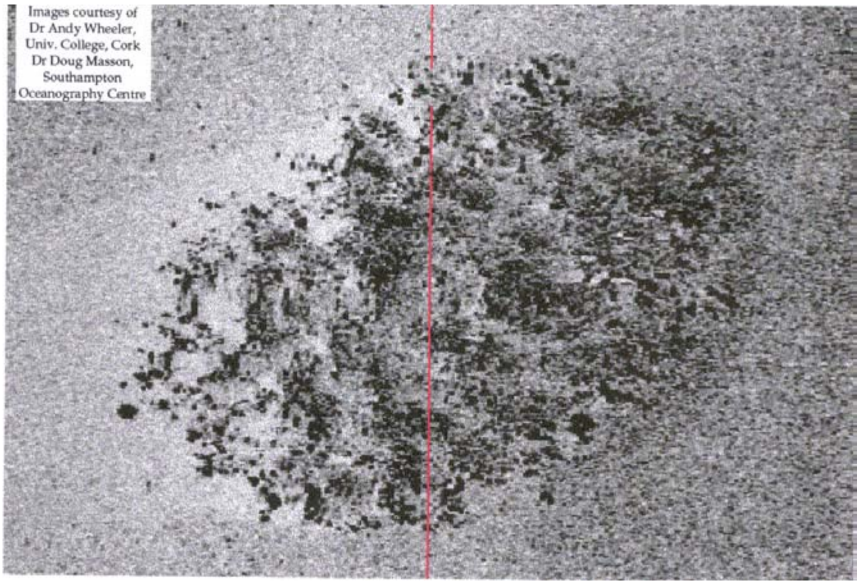
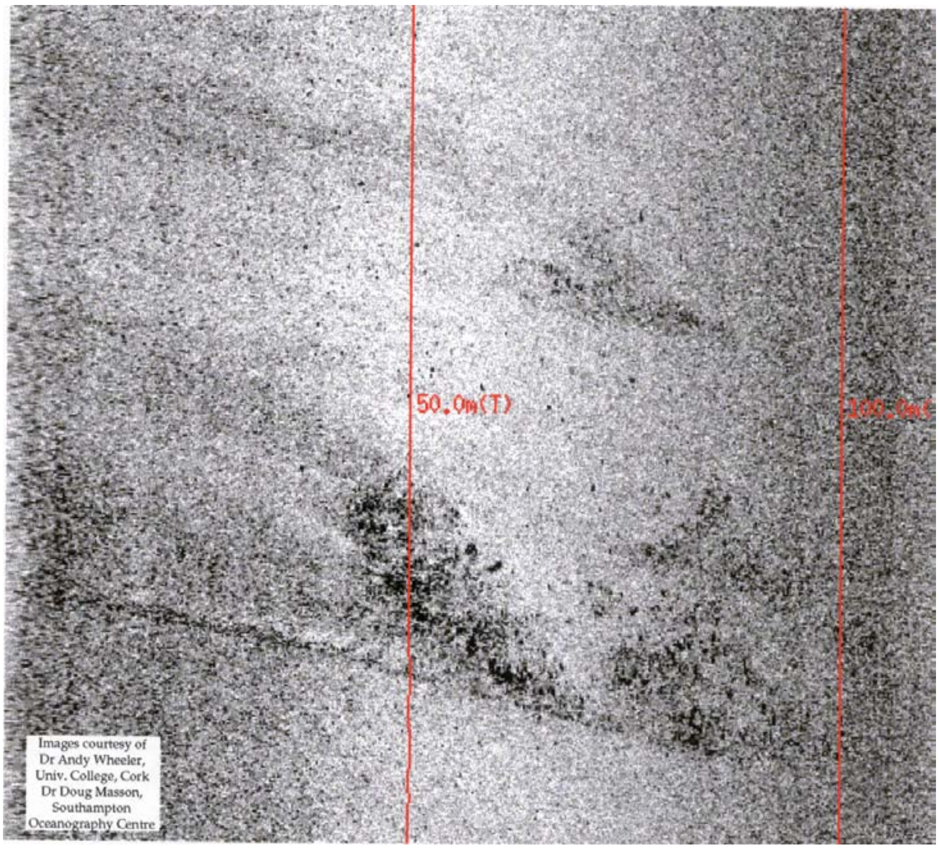


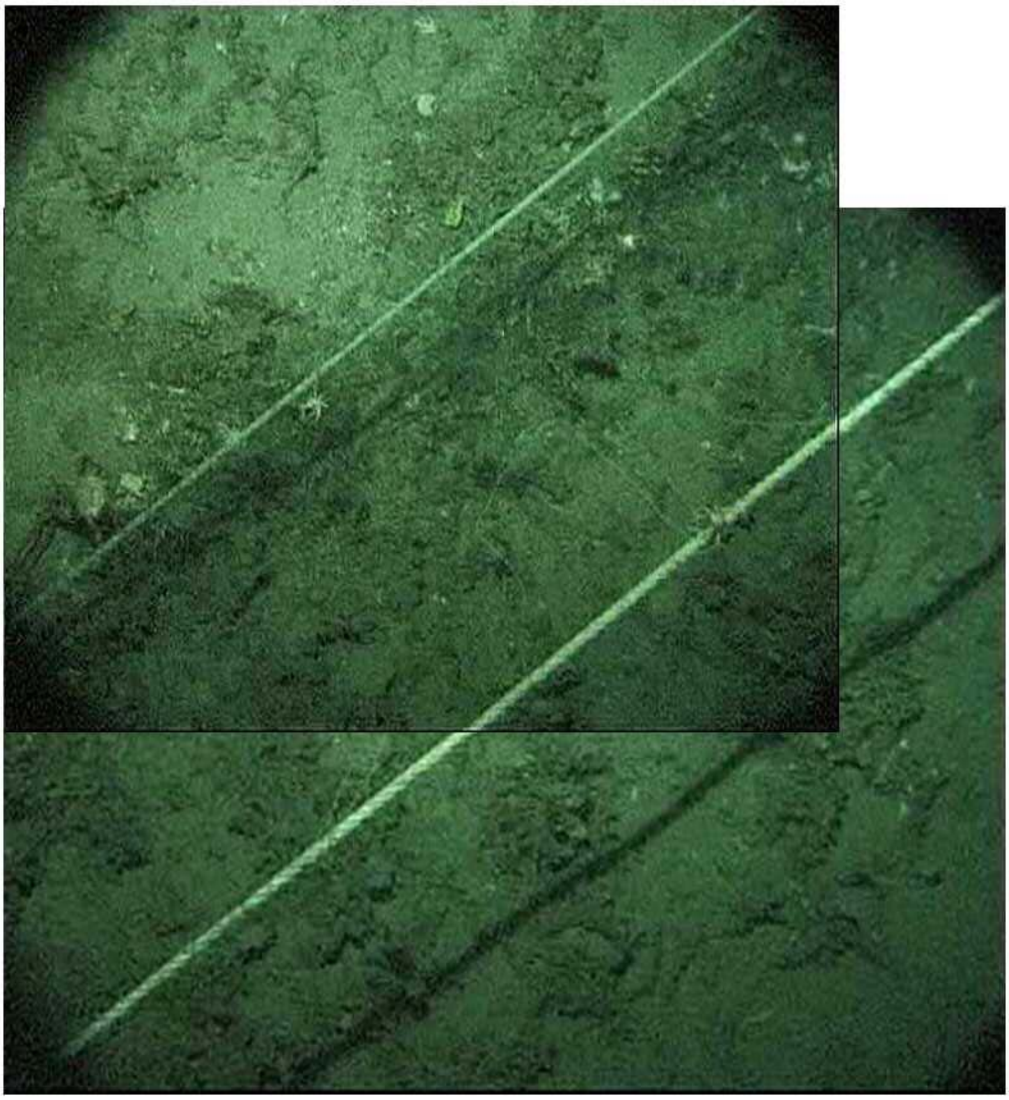
Figure 3.3.2. Sidescan sonar image of an individual Darwin Mound following trawling damage. This image is about the same scale as Figure 3.3.1. As with Figure 3.3.1 each dark spot is either a *Lophelia pertusa* clump or blocky rubble (likely to be formed from dead *Lophelia pertusa*). Note the parallel tracks running across the image presumably caused by towed trawl gear. The red lines are indicators of distance to the centre of the sidescan path. Image courtesy of Andy Wheeler (University College, Cork).



3.4 Effects of fishing on Irish reefs

There have been no published studies of the effects of fishing in Irish waters, however, recent studies funded by the European Commission have found evidence that such effects are occurring (Wheeler *et al*. 2001; Bett 2001; Hall-Spencer *et al*. 2002). Hall-Spencer *et al*., (2002) found significant coral bycatch in five of 229 hauls observed of French trawlers working in Porcupine seabight area. From research surveys, damaged coral is evident in a number of areas, well illustrated by the fishing related debris found on the Theresa Mound at 51° 25′ N 11° 45′ W (Figure 3.4.1) (Wheeler *et al*. 2001; Bett *et al*. 2001). This mound is home to some of the best-developed coral (*Lophelia pertusa* and *Madrepora oculata*) ecosystems known in the Northeast Atlantic.

Figure 3.4.1. Stranded net on the Theresa mound in the Porcupine Seabight. Montage of two video stills from SOC WASP vehicle deployment (station 54918#1) during RRS *Challenger* cruise 142 (16 May 1999) on the large (1000 m diameter, 120 m height) carbonate mound known as Theresa (51° 25′ N 11° 45′ W). The stranded net (partly decayed and not very easily visible on this image) still appears capable of ghost fishing and a number of crabs are visible on the net, possibly taking advantage of the carrion. Image courtesy of Southampton Oceanography Centre.



References

Bell, N., and Smith, J. 1999. Coral growing on North Sea oil rigs. *Nature* 402: 601.

Bett, B.J. 1999. RRS Charles Darwin cruise 112C Leg 2, 19 May–24 June 1998. Atlantic Margin Environmental Survey: seabed survey of deep-water areas (17th round tranches) to the north and west of Scotland. Southampton Oceanography Centre, Cruise Report No 25, 171 pp.

Bett, B.J. 2000. Signs and symptoms of deep-water trawling on the Atlantic Margin. Man-Made Objects on the Seafloor, pp 107–118. In: Man-Made Objects on the Seafloor 2000. The Society for Underwater Technology, London. (ISBN 0 906940 36 0).

Bett, B.J., and Jacobs, C.L. 2000. RRS Charles Darwin cruise 119C leg B, 13 August–24 September, 1999. White Zone (WhiZ) Environmental survey: Seabed survey of the deep waters to the north and west of Shetland. Southampton Oceanography Centre Cruise report. Report to the UK Department of Trade and Industry.

Bett, B.J., Billett, D.S.M., Masson, D.G. & Tyler, P.A. 2001. RRS Discovery cruise 244, 07 Jul–10 Aug 2000. A multidisciplinary study of the environment and ecology of deep-water coral ecosystems and associated seabed facies and features (The Darwin Mounds, Porcupine Bank and Porcupine Seabight). Southampton Oceanography Centre, Cruise Report No. 36, 108 pp.

Carlgren, O. 1939. Actiniaria, Zoantharia, and Madreporaria. The Zoology of Iceland, vol.II(8), 20 pp.

Copley, J., Tyler, P.A., Sheader, M., Murton, J. and German, C.R. 1996. Megafauna from sublittoral to abyssal depths along the Mid-Atlantic Ridge south of Iceland. Oecologica Acta 19: 549–559.

Dons, C. 1944. Norges korallrev. Det Kongelige Norske Videnskabers Selskabs Forhandlinger 16: 37–82.

Fosså, J.H., Furevik, D.M., Mortensen, P.B. and Hovland, M. 1999. Effects of bottom trawling on *Lophelia* deep water coral reefs on the continental shelf of Norway. Poster and abstract in ICES/SCOR Symposium on Ecological Effects of Fishing. Montpellier, France, 15–19 March 1999.

Fosså, J.H., Mortensen, P.B., and Furevik, D.M. 2000. *Lophelia*-korallrev langs Norskekysten forekomst og tilstand. Fisken og Havet 2–2000. Havforskningsinstituttet, Bergen.

Fosså, J.H., Mortensen, P.B. and Furevik, D.M. in press. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. Hydrobiologia

Fredericksen, R., Jensen, A., and Westerberg, H. 1992. The distribution of the scleractinian coral *Lophelia pertusa* around the Faroe Islands and the relation to internal tidal mixing. Sarsia 77: 157–171.

Freiwald, A., Wilson, J.B., and Henrich, R. 1999. Grounding Pleistocene icebergs shape recent deep-water coral reefs. Sedimentary Geology 125: 1–8.

Hall-Spencer, J., Allain, V., and Fosså, J.H. 2002. Trawling damage to NE Atlantic ancient coral reefs. Proceedings of the Royal Society of London, B. Online paper 01PB0637.

Hovland, M., Croker, P.F, and Martin, M. 1994. Fault associated seabed mounds (carbonate knolls?) off western Ireland and north-west Australia. Marine Petroleum Geology 11: 233–246.

Jensen, A., and Frederiksen, R. 1992. The fauna associated with the bank-forming deepwater coral *Lophelia pertusa* (Scleractinaria) on the Faroe shelf. Sarsia 77: 53–69.

Joubin, L. 1922a. Distribution géographique de quelques coraux abyssaux dans les mers occidentales européennes. Compte rendu hebdomadaire des séances de l'Académie des sciences 175: 930–933.

Joubin, L. 1922b. Les coraux de mer profonde nuisibles aux chalutiers. Notes et mémoires. Office scientifique et technique des pêches maritimes, 18. 16pp.

Kenyon, N. & Akhmetzhanov, A. 1998. Long-range sidescan sonar data, I.3. In: Kenyon, N.H., Ivanov, M.K. & Akhmetzhanov, A.M. (1998). Cold water carbonate mounds and sediment transport on the Northeast Atlantic margin. Intergovernmental Oceanographic Commission Technical Series 52. UNESCO 1998.

Kenyon, N.H., Ivanov, M.K., and Akmetzhanov, A.M. 1998. Cold water carbonate mounds and sediment transport on the Northeast Atlantic margin. Preliminary results of the geological and geophysical investigations during the TTR-7 cruise of "Professor Logachev" in co-operation with the CORSAIRES and ENAM2 programmes July-August 1997. Intergovernmental Oceanographic Commission Technical Series, 52. UNESCO, Paris. 179pp.

LeDanois, E. 1948. Les profundeurs de la mer. Trente ans de recherche sur la faune sous-marine au large des cote des France. Payot, Paris. 303 pp.

Long, D., Roberts, J.M., and Gillespie, E.J. 1999. Occurrences of *Lophelia pertusa* on the Atlantic Margin. British Geological Survey Technical Report WB/99/24. British Geological Survey, Edinburgh.

Masson, D.G., and Jacobs, C.L. 1998. RV "Colonel Templar" cruises 01 and 02/98, 22 Apr–18 May, 20 May–18 Jun 1988. TOBI surveys of the continental slope north and west of Scotland. Southampton Oceanography Centre Cruise Report. AFEN UKCS 17^{th} Round Atlantic Margin Environmental Survey Data CD-ROM.

Mortensen, P.B., Hovland, M., Brattegard, T. and Farestveit, R. 1995. Deep water bioherms of the scleractinian coral *Lophelia pertusa* (L.) at 64^{o} N on the Norwegian shelf: structure and associated megafauna. Sarsia 80: 145–158.

Mortensen, P.B., Hovland, M.T., Fosså, J.H., and Furevik, D.M. 2001. Distribution, abundance and size of *Lophelia pertusa* coral reefs in mid-Norway in relation to seabed characteristics. Journal of the Marine Biological Association of the United Kingdom 81: 581–597.

Ottesen, D., Thorsnes, T., Rise, L., Fosså, J.H., Mortensen P,B., and Olsen, K. 2000. Multibeam swath bathymetry mapping of cold-water coral reefs on the Mid-Norwegian shelf. Paper presented at the First International Symposium on Deep Sea Corals, Halifax, Canada.

Rapp, H.T., and Sneli, J.A. 1999. *Lophelia pertusa* - myths and reality (abstract only). - 2nd Nordic Marine Sciences Meeting, Hirtshals, Denmark 2–4 March 1999.

Roberts, J.M., Harvey, S.M., Lamont, P.A., and Gage, J.A. 2000. Seabed photography, environmental assessment and evidence for deep-water trawling on the continental margin west of the Hebrides. Hydrobiologia 44, 173–183.

Rogers, A.D. 1999. The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. International Review of Hydrobiology 84: 315–406.

Sars, M. 1865. Om de i Norge forekommende fossile dyrelevninger fra Quartærperioden. Universitetets program for første halvaar 1864. Christiania, 134 pp.

Strømgren, T. 1971. Vertical and horizontal distribution of *Lophelia pertusa* (Linne) in Trondheimsfjorden on the west coast of Norway. Det Kongelige Norske Videnskabers Selskabs Skrifter 6: 1–9.

Teichert, C., 1958. Cold- and deep-water coral banks. Bulletin of the American Association of Petroleum Geologists 42: 1064–1082.

Wheeler, A.J., Billett, D.S.M., Masson, D.G., and Grehan, A. 2001. The impact of benthic trawling on NE Atlantic coral ecosystems with particular reference to the northern Rockall Trough. ICES CM 2001/R:11.

Wilson, J.B. 1979. The distribution of the coral *Lophelia pertusa* (L.) [*L. Prolifera* (Pallas)] in the north-east Atlantic. Journal of the Marine Biological Association of the United Kingdom 59: 149–164.

Zibrowius, H. 1980. Les Scléractiniaires de la Méditerranée et de l'Atlantique nord-oriental. Memoires de l'Institut oceanographique, No 11, 226 pp.

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