Report of the Working Group on Deep-water Ecology (WGDEC) , 26-28 February 2007

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Executive Summary

Highlights

- Further work leading to new recommendations of suitable areas to close on Rockall Bank to protect cold-water coral habitats
- A recommendation to close an area on south Hatton Bank to protect cold-water corals
- Initial descriptions of the distributions of structure-forming sponges and soft corals in the North Atlantic
- The start of a (meta) database of scientific survey/cruise results with benthic habitat information in the North Atlantic
- A recommendation for an ICES symposium on deep-water conservation issues

The work of describing areas containing habitats in the deep sea by the group continued this year. Two of the terms of reference concerned areas closed by NEAFC to fishing in 2005 or 2007. The second chapter describes information on cold water corals on the Rockall Bank and adds new information to that available when ICES last reviewed this in 2005. The new information largely confirms that available then, but indicates that the closure recommendation on SW Rockall might need to be amended to take account of areas that are heavily fished and therefore do not apparently contain coral. The group found that three discrete patches of coral were known to Russian fishers and scientists which could be protected with one large box or three smaller isolated closures. The former might unnecessarily restrict fishing opportunities but would ensure comprehensive protection of the three patches, any other patches of coral not yet reported in the area and a sample of other habitats on the Bank. Three isolated closures might be more difficult to enforce reliably, placing any corals at greater risk of damage. It is not known if any of the closure options would have benefits to the fish stocks. A small reduction is suggested to the closure on the NEAFC controlled west Rockall closure and an extension is suggested for the Logachev mounds closure in EU controlled waters

The third chapter covers Hatton Bank; here NEAFC agreed a closure in 2007 having postponed a decision on this in 2005. New information gained by very welcome dedicated Spanish and UK surveys (following ICES/WGDEC's 2005 recommendations) indicates however that areas of coral lie outside the closed area and there is a risk that fishing activity might now be displaced into these areas. An extension to the Hatton Bank closure is suggested. The fourth chapter concerns further areas closed to fishing in the NEAFC area. No further biological data exists for these areas, but VMS data indicates that fishing is still occurring in some of them, but it is not certain whether the fishing that is occurring is illegal or not. If the fishing is of a type that touches the seafloor, it is likely that the closure is not being successful in conserving the habitat for which the closures were established.

In 2006, WGDEC had problems in knowing where surveys had been carried out in the deep North Atlantic and recommended that work start on assembling a map (and background information) to meet this need. Chapter 5 starts to address this requirement and should put ICES in a good position to seek further information to populate this (meta-) database and map.

Chapters 6 and 7 concern other 'structural' habitats in deep waters – those formed by large sponges and those by soft corals. Both of these habitats are similar to cold water (hard) corals in that they form habitat for other species and are very sensitive to impacts of fishing when gear touches the seabed. Areas known to contain habitats formed by these species have been mapped. Chapter 8 is related in that OSPAR requested a review of advice on a nomination to their list of threatened and declining species for the habitat 'coral gardens'. This review was carried out using a fast track procedure during winter 2006-07. The review is included in this report for completeness of the record of WGDEC's work.

Chapter 9 responds to a request from ICES Consultative Committee to review proposals for a symposium on conservation in deep-water areas. The group also considered and agreed with a proposal to make WGDEC a joint group between ICES and NAFO.

1 Introduction

1.1 Participation

The following members of the Working Group on Deep Water Ecology (WGDEC) participated in producing this report (see Annex 1 for addresses).

Peter Auster*	USA
Odd Aksel Bergstad*	Norway
Robert Brock	USA
Bernd Christiansen	Germany
Sabine Christiansen	Germany
Pablo Durán Muñoz	Spain
Bob George*	USA
Anthony Grehan*	Ireland
Jason Hall-Spencer	UK
John Hartley*	UK
Kerry Howell	UK
Graham Johnston*	Ireland
Gui Menezes	Portugal
Pål Mortensen	Norway
Francis Neat	UK
Karine Olu*	France
Steve Ross*	USA
Marta Söffker	UK
Thomas Soltwedel*	Germany
Mark Tasker (chair)	UK
Vladimir Vinnichenko	Russia
Les Watling*	USA

* = unable to be in Plymouth, but contributed from afar.

1.2 Terms of Reference

The 2006 Statutory meeting of ICES gave the Working Group on Deep Water Ecology the following terms of reference:

a) Examine information on cold-water corals on Eastern Rockall and Hatton Bank and report on suitable areas to close in order to protect cold-water corals;

b) Compile a map of seabed areas where biological research/survey has occurred in the deep water area (>200m) of the North Atlantic;

c) Review and report on the location of areas holding large structural sponges in the North Atlantic;

d) Review and report on the occurrence of soft-coral communities, specifically Gorgonians and Antipatharians in the North Atlantic

e) Evaluate and report on the effects of the closed areas introduced in 2005 in the NEAFC area, with special regard to species diversity or to abundance of any other living organisms, which may indicate the quality of the ecosystem.

f) Assess and report on the evidence on which the nomination of Octocoral ecosystems that include *Paragorgia arborea*, *Primnoa resaediformes* and other gorgonian corals for the OSPAR List of Threatened and/or Declining Species and Habitats is based. The purpose of the assessment is to ensure that the data used to support the nomination are sufficiently reliable and adequate to serve as a basis for conclusions that the habitats can be identified as a threatened and/or declining habitat according to OSPAR's Texel/Faial criteria. [*This Term of Reference was addressed in advance of the Working Group meeting, but the assessment is included here for completeness*].

g) Consider the needs of and plan for a possible ICES symposium on conservation issues in the deep sea in 2009. If possible identify suitable convenors, co-sponsors and an outline programme [*See ICES template*]

A further term of reference requested that the Chairs of WGDEC and WGDEEP cooperate to ensure that expertise on cold-water corals and on deep-water fishing was available at the meeting.

In relation to ToR (a) at the 25th Annual Meeting of NEAFC (November 2006), the Russian Federation expressed concern with respect to the scientific basis on the distribution of cold-water corals on the Rockall Bank. The Federation was requested to put their concerns in writing and submit them to the NEAFC Permanent Committee on Management and Science (PECMAS). A meeting of PECMAS on 19-21 February 2007 decided to send the Russian information immediately to ICES, asking for review of the paper. This information was referred to WGDEC for initial consideration.

1.3 Justification of Terms of Reference

a) A continuation of work to meet requests from both OSPAR (past) and NEAFC (current), with an addition from NEAFC.

b) Essential to understand the geographic limits of knowledge

c) Large structural sponge fields are a habitat believed sensitive to fishing.

d) Soft corals are also sensitive to fishing – information from c) and d) will be useful in providing advice to fisheries managers wishing to avoid damaging these habitats.

e) This is in support of a request from NEAFC

f) This is a request from OSPAR

g) This is a request from Consultative Committee following an external suggestion.

1.4 Acknowledgements

We would like to thank Stephen Hawkins, Jason Hall-Spencer, Nick Bloomer and Mary Lane of the Marine Biological Association and Plymouth University for hosting this year’s meeting in an excellent working environment. Several members of the ICES Secretariat were their usual very helpful selves. Kathy Scanlon, Leslie-Ann S. McGee, Brendon O’Hea, Alberto Serrano and Karl Gunnarsson all helped by supplying information used by the group.

2 Cold-water corals on Rockall

Term of Reference a) Examine information on cold-water corals on Eastern Rockall and Hatton Bank and report on suitable areas to close in order to protect cold-water corals.

2.1 Introduction

This ToR is best answered in the context of the development of closures to protect offshore benthic habitats throughout the North Atlantic, since this has been a rapidly evolving area of fisheries management. *Oculina varicosa* reefs were discovered at 60-120m depth about 40 km off the Atlantic coast of Florida in the 1970s and after years of campaigning this became the world’s first deep-water coral protected area in 1984. There followed a long hiatus in deep-water coral protection until surveys carried out in late 1990s revealed that bottom trawling and long-lining was causing long-term damage to more northern coral communities on both sides of the North Atlantic (Jones and Willison, 2000; Fosså *et al*., 2000; Hall-Spencer *et al*., 2002). This met with rapid responses by the Norwegian and Canadian Governments with the establishment of cold-water coral protected areas in 2002 (Fosså *et al*., 2002; Mortensen *et al*., 2004), followed by the first EU cold-water coral closure in 2004 (Wheeler *et al*., 2005). In

2005 the US also began to close northern areas to bottom trawling to protect benthic habitats (L-A. McGee, New England Fishery Management Council, pers comm.). The first areas of the high seas to become protected from damaging fishing activities were announced in 2005 by the North East Atlantic Fisheries Commission (NEAFC). Further closures have followed since (Table 2.1.1).

Table 2.1.1. Areas closed to bottom trawl fishing in the North Atlantic to protect deep and/or cold-water habitats.

Name of closed area	Region	Date closed	Date up for review
Oculina Bank	USA	1984	Permanent
Oceanographer Canyon	USA	May 2005	Permanent
Lydonia Canyon	USA	May 2005	Permanent
Northeast Channel	Canada	2002	
The Gully	Canada	2004	
Stone Fence	Canada	2004	
Røst Reef	Norway	January 2000	Permanent
Iverryggen Reef	Norway	January 2000	Permanent
Sula Reef	Norway	March 1999	Permanent
Selligrunnen Reef	Norway	June 2000	Permanent
Tisler Reef	Norway	December 2003	Permanent
Fjellknausene Reef	Norway	December 2003	Permanent
Hornafjarðardjúp	Iceland	January 2006	Permenent
Skaftárdjúp	Iceland	January 2006	Permenent
Reynisdjúp	Iceland	January 2006	Permanent
Orphan Knoll	NAFO	January 2007	01 January 2008 20% reopened
Newfoundland Seamounts	NAFO	January 2007	01 January 2008 20% reopened
Corner Seamount	NAFO	January 2007	01 January 2008 20% reopened
New England Seamaounts	NAFO	January 2007	01 January 2008 20% reopened
Reykjanes Ridge (part of)	NEAFC	January 2005	31 December 2007
Hekate Seamounts	NEAFC	January 2005	31 December 2007
Faraday Seamounts	NEAFC	January 2005	31 December 2007
Altair Seamounts	NEAFC	January 2005	31 December 2007
Antialtair Seamounts	NEAFC	January 2005	31 December 2007
Hatton Bank	NEAFC	January 2007	31 December 2009
NW Rockall Bank	NEAFC	January 2007	31 December 2009
W Rockall Mounds	NEAFC	January 2007	31 December 2009
Logachev Mounds	NEAFC	January 2007	31 December 2009
Darwin Mounds	EU	August 2004	Permanent
Sacken reef	EU	July 2001	
Spiran reef (degraded)	EU	July 2001	
Vadero reef (degraded)	EU	July 2001	
Azores, Madeira, Canary Islands	EU	2004	Permanent
NW Rockall Bank (EU section)	EU	January 2007	Interim
Logachev Mounds (EU Section)	EU	January 2007	Interim
NW Porcupine Bank	EU	Pending	
Hovland Mound Province	EU	Pending	
SW Porcupine Bank	EU	Pending	
Belgica Mound Province	EU	Pending	

2.2 Rockall Bank

Rockall Bank straddles the area fully managed under the European Union's Common Fisheries Policy and that regulated by NEAFC. We provide an update of available information on cold-water corals on the whole of Rockall Bank and combine this with an analysis of fishing activity based on satellite vessel monitoring data (VMS) for 2005 and records of fishing activity in the Russian fleet from 1999 to 2006. At the 25th Annual Meeting of NEAFC (November 2006) a proposal was tabled by the European Commission to close four areas on the Rockall Bank to bottom fisheries in order to protect cold-water corals, namely; South West

Rockall, North West Rockall, Logachev Mounds and West Rockall Mounds. This was based on ICES advice from 2005 that combined knowledge on the known distribution of cold-water coral *Lophelia pertusa* with an analysis of VMS to determine the distribution of fishing fleets and select areas that were a) seldom fished and b) had dense coral records (ICES, 2005).

At the NEAFC meeting it was agreed to close the international parts of North West Rockall, the international parts of the Logachev Mounds and the West Rockall Mounds to bottom trawling and static gears (including bottom gillnets and long lines); this measure came into place on 1 January 2007, with formal closure on 8 March 2007 (NEAFC recommendation IX, 2007). The North West Rockall and Logachev Mounds areas straddle the NEAFC/EU EEZ region and are the same as those proposed by ICES (2005). The EU closed both North West Rockall and Logachev Mounds (both within and outside the EEZ) on 20 January 2007 (EC 41/2006 of 21 December 2006). The Russian Federation proposed that the South West Rockall area remain open until further investigations into coral presence were made. The Russian Federation was requested to submit a paper on their concerns to NEAFC's Permanent Committee on Management and Science (PECMAS). PECMAS agreed to forward the new Russian information to ICES for consideration.

Figure 2.2.1 shows the North West Rockall, Logachev Mounds and West Rockall Mounds closed areas, in addition to the 'Haddock Box', an area closed to protect haddock stocks in 2001 which has the additional benefit of helping protect benthic habitats. Superimposed upon this figure is the most up to date information available in electronic form (i.e. not including the Russian information, see later) on the distribution of cold-water corals and VMS positions provided by NEAFC, the Irish Navy and the UK Department of Environment, Food and Rural Affairs for 2005, the most recent year of comprehensive available information on the distribution of fishing fleets in the area. The VMS data was filtered to remove non-trawling activity, by only including vessels travelling between 1.5 and 4.5 knots. Note that this filter would not remove all pelagic trawling tracks from the plot and may include some vessels travelling slowly in the area, but not fishing. Figure 2.2.1 incorporates data sets on coral distribution provided in past ICES reports, adding new information on *Lophelia* distribution from surveys carried out by the UK Government in 2005 and 2006 (Davies *et al*. 2006; Howell *et al*., in press), a Fisheries Research Services monkfish survey in November 2006 (FRS, unpublished data) and by the EU HERMES programme (Duyl and Gerard, 2005). A Dutch cruise in 2006 as part of the HERMES programme recorded the scleractinian corals *Lophelia pertusa, Madrepora oculata* and *Desmophyllum cristagali* at 60 stations in the Logachev Mound region, but this data is not yet available.

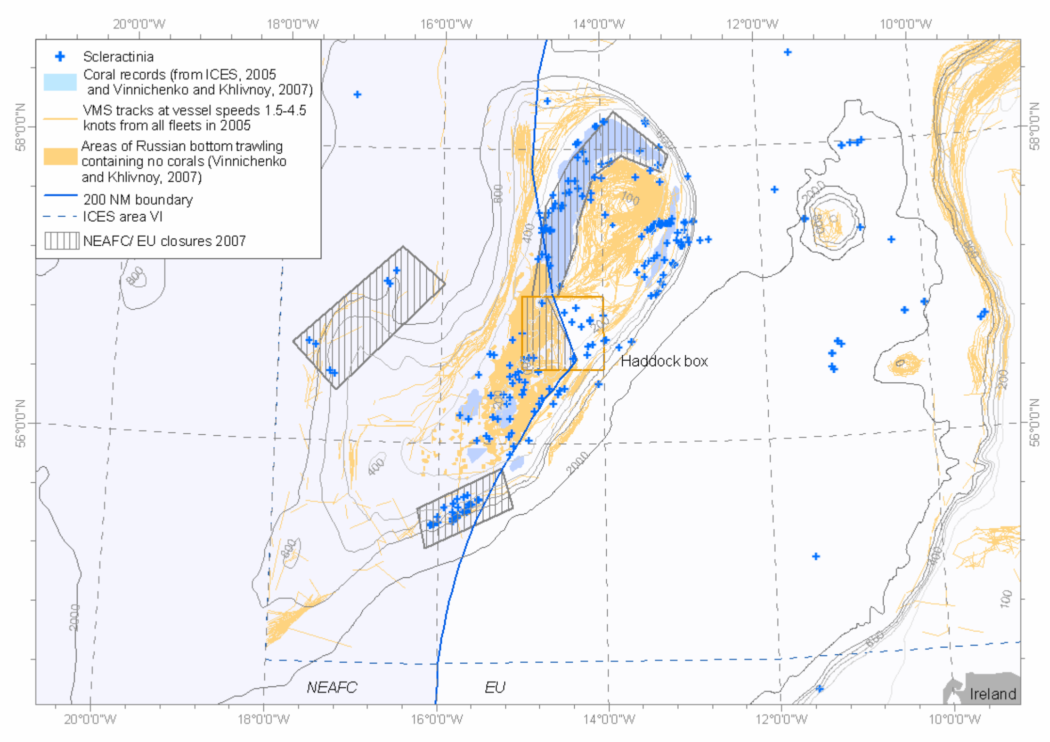

Figure 2.2.1. NEAFC closed areas introduced 1 January 2007, EU closed areas from 20 January 2007 and the Haddock Box. The known distribution of cold-water coral records and VMS fishing tracks for 2005 (see text) based on filtered VMS data (vessels moving >4.5 knots were assumed not to be trawling) are also shown.

In addition to the electronic data available to WGDEC in February 2007, Durán Muñoz *et al.* (2007) provided further information on the distribution of corals on eastern Rockall Bank from a recent exploratory survey using long-lines. Russian scientists (PINRO) provided maps showing information on the distribution of cold-water corals and Russian fishing activity on Rockall Bank (Vinnichenko and Khlinoy, 2007). In 1999-2006 Russian observations were undertaken mainly in the south-western part of the bank where coral concentrations were found in a few relatively small areas. In the Northwest Rockall closed area adjacent to the 200-mile limit of UK two areas were identified with dense accumulations of coral with coordinates at 57°12′-57°28′ N and 56°56′-57°05′ N (Figure 2.2.2). The Russian fleet had been actively fishing in the area between these coral habitats, occasionally bringing up coral fragments but trawling without damage to their gear, indicating a lack of large coral accumulations in the trawled area. In the area to the south of 56°20′ N and to the west of 15°W scientists on board research and fishing vessels reported corals in four areas (Figure 2.2.2). In 2005 a bottom trawl survey by RV *Nansen* identified corals within the 200-mile limit of Ireland with middle coordinates at 55°52′ N, 15°04′ W. Findings from the Russian studies of coral distribution conform well to data of ICES SGCOR and WGDEC.

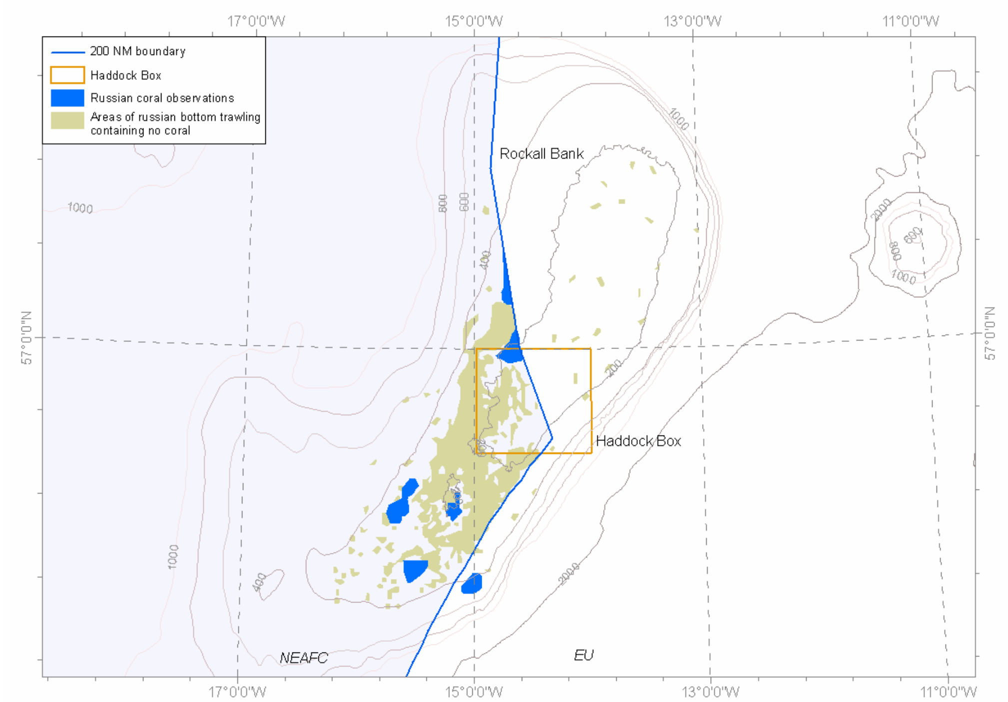

Figure 2.2.2 Distribution of corals and fishing effort on south-west Rockall Bank, based on records from observers on Russian trawlers and research vessels 1999-2006 (redrawn from Vinnichenko and Khlivnoy, 2007).

It is noteworthy that the area near the Irish EEZ between 56°00′ and 56°40′ N was fished for grey gurnard by Russian vessels in 1999-2005 (ICES, 2001; Vinnichenko *et al.*, 2005) where no corals were recorded. No fishery was conducted there by Russia in 2002 and 2003 (Vinnichenko *et al.*, 2005). WGDEC is uncertain as to why the grey gurnard fishery apparently undertaken by Russian vessels in 2005 in the area south of the Haddock Box in the NEAFC regulated area (Figure 2.2.2) does not appear in the 2005 VMS record (Figure 2.2.1). The absence of corals in the area of grey gurnard fishery and in the areas located farther north was confirmed by findings of the Russian and Scottish surveys, where a large number of hauls were made without significant net damage (ICES, 2001; Anon, 2004; Khlivnoy and Vinnichenko, 2006; Newton *et al.*, 2004; Oganin *et al.*, 2005). On the basis of their analyses the Russian Federation has proposed that the NEAFC North West Rockall closure be adjusted as shown in Figure 2.2.3, with a reduction in size of the NW coral closure and that five other closures be introduced (three in NEAFC waters and two in the EU EEZ).

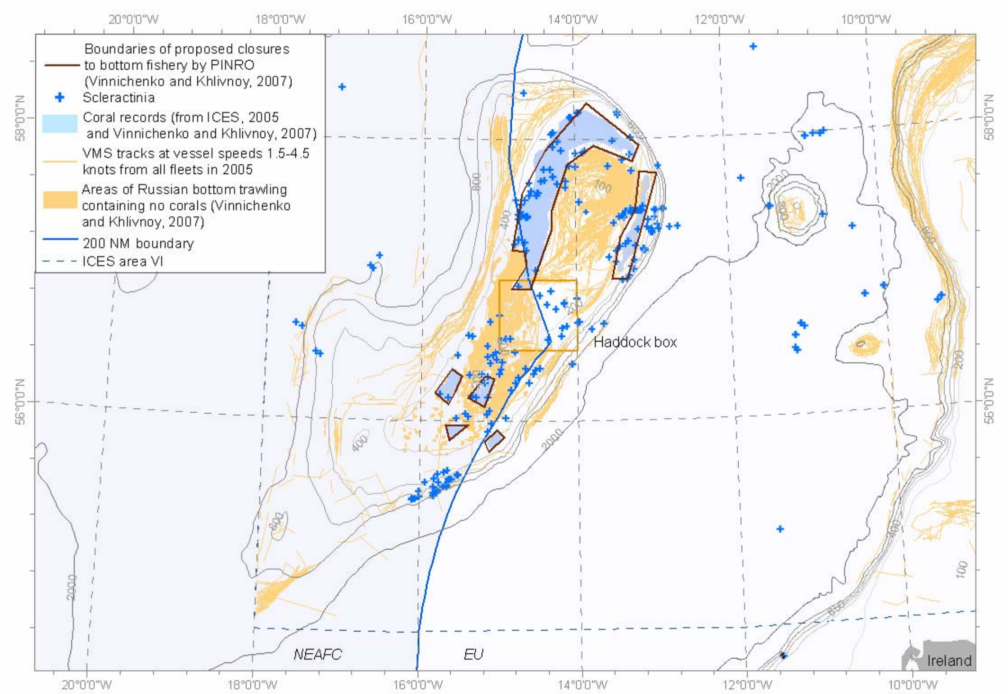

Figure 2.2.3 Boundaries of closures to bottom fishery on the Rockall Bank as proposed by scientists from the Russian Federation (after Vinnichenko and Khlivnoy, 2007).

This new data from Russian and Spanish surveys on the distribution of corals on Rockall is welcomed and largely corroborates earlier records and anecdotal reports from Scottish fishermen and other sources. WGDEC has the following suggestions to make in relation to closures to protect cold-water corals. These suggestions are split between four geographic areas.

2.2.1 South-west Rockall/ Empress of Britain Bank

As shown in previous ICES advice (ICES, 2005), *Lophelia pertusa* (and other stone coral (Scleractian) reefs occur in the 'Empress of Britain Bank' region on SW Rockall. We agree with the Russian Federation's conclusion that corals on Rockall Bank would be afforded improved protection if the Empress of Britain Bank region were closed to the use of bottom trawl and static gear. At a minimum, WGDEC would concur with the Russian suggestions, but we are not sure of the practicality of enforcement of closed areas with complex boundaries. In the past ICES advice has used relatively 'simple' boundaries with a buffer zone to avoid nets with long trawl warps being towed through areas while the fishing vessel remained outside the closed area.

WGDEC therefore puts forward two possible suggestions for closures, noting that some variations between the two would be possible. The first is very similar to that suggested by Russian scientists to NEAFC (Figure 2.2.3). The three areas of coral on SW Rockall would then be protected using three closures illustrated in Figure 2.2.1.1 (co-ordinates listed in Table 2.2.1.1) that encompass each of the three areas of coral reported by Russian fishers and scientists (Figure 2.2.2) and including a 600m buffer zone to prevent accidental damage by trawls being towed by vessels towing outside the closure. The 600m buffer is based on approximately twice the water depth in the area, assuming a towing ratio of 2:1 on depth.

However, if fisheries monitoring near the Mounds is to use the satellite-based VMS system (Hall-Spencer, 2003; Marrs and Hall-Spencer, 2003) currently in use in EU waters, then the boundary where fishing vessels should not go may need to be drawn wider still. This is because the EU VMS cycle rate is once every two hours (we note that the Russian cycle rate is once every hour). A further margin of at least the equivalent of 1–2 hours steaming time may therefore need to be added to the site boundary in order to ensure that fishing vessels cannot tow undetected over the site. An alternative might be to modify the VMS system to give more frequent positional updates, or to randomize the timing of positional updates such that it is impossible for any fisher to know when VMS signals might be transmitted.

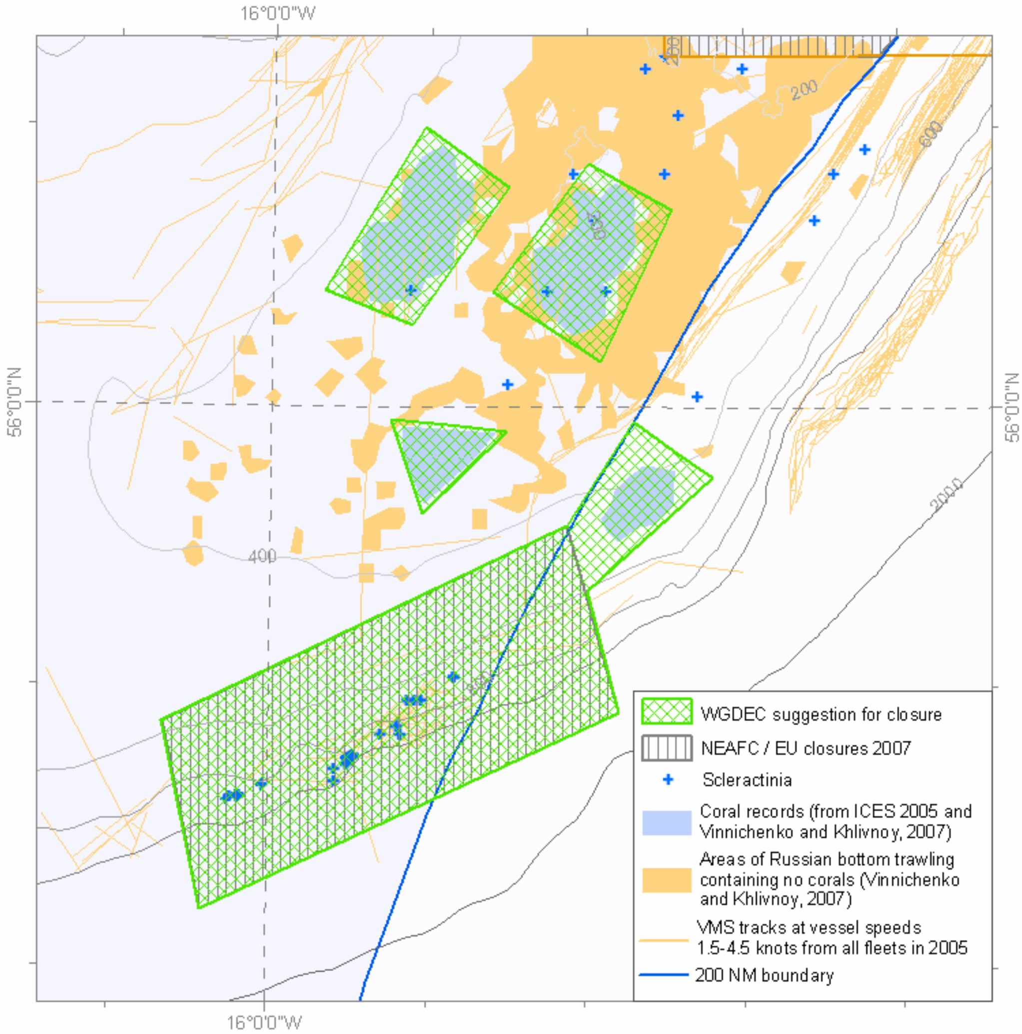

Figure 2.2.1.1 Three possible closures to protect corals on the Empress of Britain Bank, showing also an extension to the suggested Logachev mounds closure.

Table 2.2.1.1 Corner points for three possible closures on the Empress of Britain Bank. These areas individually enclose areas of coral identified by PINRO, with the addition of a 600 m buffer zone

NORTH-WESTERN	56° 24' N	15° 37' W
	56° 10' N	15° 52' W
	56° 07' N	15° 39' W
	56° 19' N	15° 24' W
North-eastern	56° 21' N	15° 12' W
	56° 10' N	15° 26' W
	56° 04' N	15° 10' W
	56° 17' N	14° 59' W
Southern	55° 59' N	15° 42' W
	55° 58' N	15° 24' W

	55° 51' N	15° 37' W

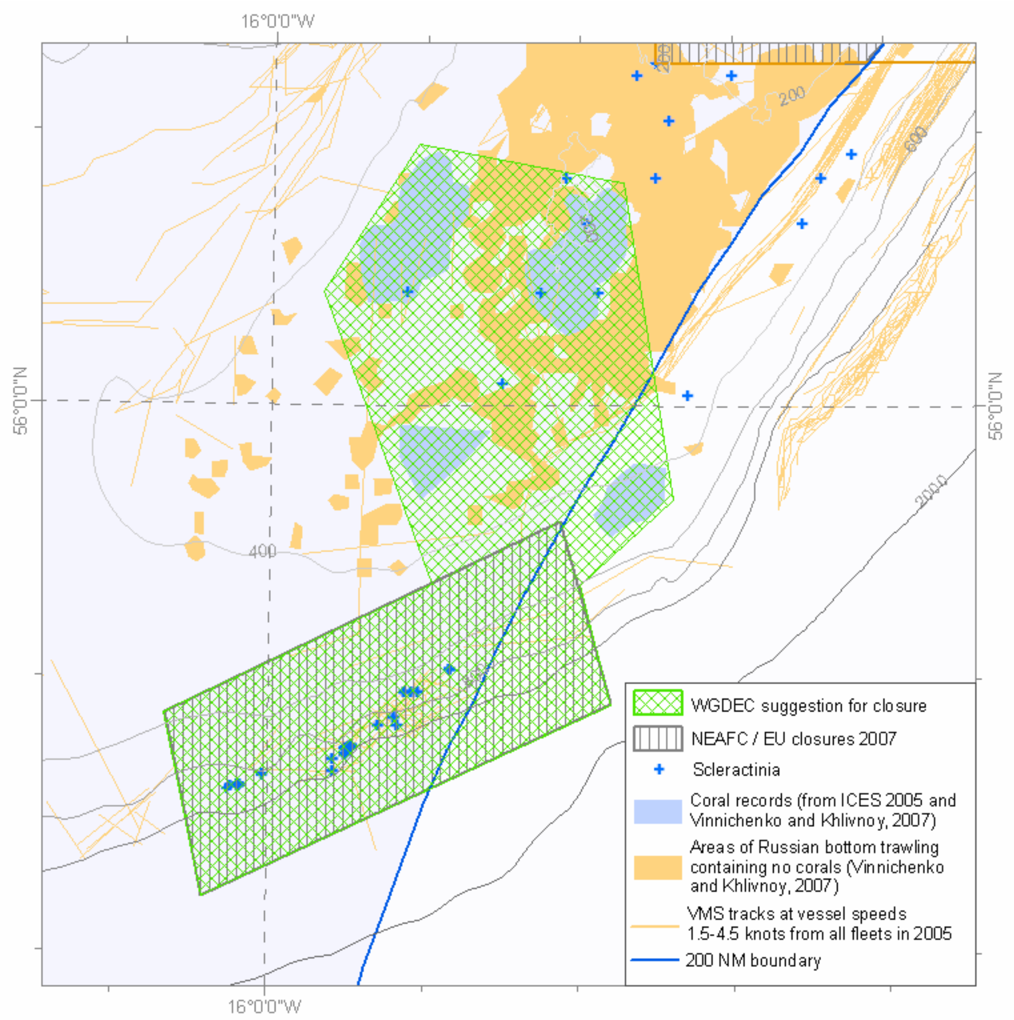

Figure 2.2.1.2 A possible closure to protect corals on the Empress of Britain Bank, showing also an extension to the suggested Logachev mounds closure.

Table 2.2.1.2 Corner points for a possible closure on the Empress of Britain Bank.

15°19' N	15°05' W
56°23' N	15°37' W
56°10' N	15°52' W
55°45' N	15°35' W
55°33' N	16°16' W
55°17' N	16°10' W
55°34' N	15°07' W
55°44' N	15°11' W
55°52' N	14°57' W

WGDEC are concerned over enforcement issues in relation to three small closures. Control and retrospective monitoring of fisheries in this area is carried out to a large extent using satellite monitoring systems (VMS). With a two-hour cycle time on VMS it would be much easier to fish illegally inside small closures than within a large area of closure. Small closures also have the disadvantage of many corners which can be fished across while the vessel still remains legally outside the closure. We thus put forward a second closure suggestion (Figure 2.2.1.2 and Table 2.2.1.2) that encompasses the three areas known to hold coral, the area between them but which to a large extent has not been examined and some parts thought not to contain coral.

2.2.2 Logachev Mounds

WGDEC consider that the area of coral known to Russian scientists close to the north-east of the closure to protect the Logachev Mounds (inside EU waters) be included in that closure if and when it occurs. Both figure 2.2.1.1 and 2.2.1.2 illustrate this suggested extension and Table 2.2.2.1 provides co-ordinates for an amended suggested closure of the Logachev Mounds.

Table 2.2.2.1 Corner points for suggested extended closure for the Logachev Mounds in EU waters

55° 33' N	16° 16' W
55° 17' N	16° 10' W
55° 34' N	15° 07' W
55° 44' N	15° 11° W
55° 54' N	14° 53' W
55° 59' N	15° 05' W
55° 50' N	15° 15' W

2.2.3 West and north-west Rockall

VMS information (Figure 2.2.1) and reports from the Russian fishery (Figure 2.2.2) both indicate that substantial fishing activity is occurring in a part of the NEAFC controlled waters just to the north of the current 'Haddock Box' on west Rockall. The Russian Federation proposed that this area be removed from the closure adopted by NEAFC for this area. Given that the intensity of trawling is apparently high in this area, it seems likely that few large accumulations of coral remain here (even if they were originally present). WGDEC would therefore concur with the suggestion to remove this area on west Rockall from the closure, noting the need to retain a 500m buffer zone similar to that outlined in Section 2.2.2. The proposed areas are detailed in Figure 2.2.3.1 and coordinates provided in Table 2.2.3.1. WGDEC again notes the risks and complexities of enforcement and control around complex-shaped closures. In addition, the EU has closed the adjacent area to the east inside EU controlled waters. WGDEC recommends that a 500m wide buffer zone to avoid accidental trawling in this area be created in NEAFC controlled waters.

Inside EU waters, further coral records on the north-west Rockall suggest that a boundary slightly further north-westwards would be appropriate (Figure 2.2.3.1).

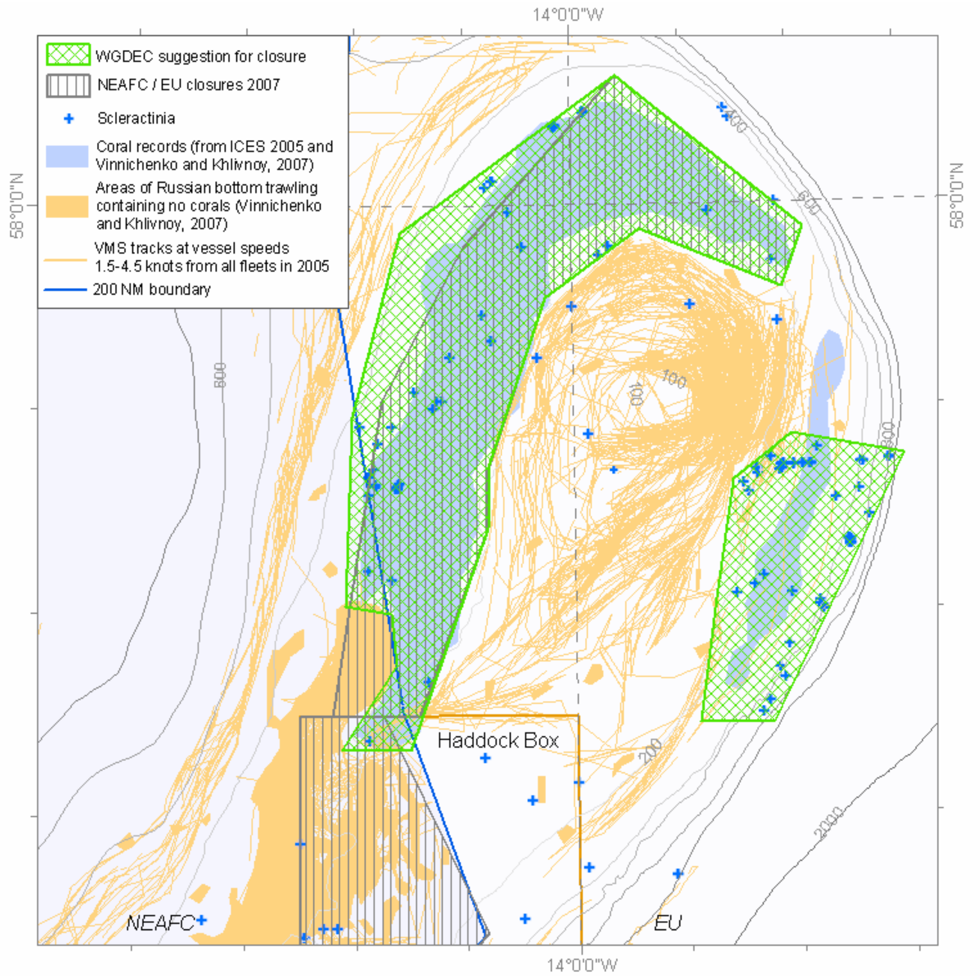

Figure 2.2.3.1 Amended closure to protect coral on west Rockall Bank and a suggested closure on east Rockall Bank.

Table 2.2.3.1 Corner points for amended closure to protect coral in NEAFC waters on west Rockall Bank

57°57' N	13°09' W
58°15' N	13°50' W
57°57' N	14°38' W
57°35' N	14°49' W
57°13' N	14°50' W
57°12' N	14°40' W
57°06' N	14°39' W
56°56' N	14°51' W
56°56' N	14°36' W
57°22' N	14°19' W
57°29' N	14°19' W
57°49' N	14°06' W
57°57' N	13°45' W
57°50' N	13°14' W

WGDEC suggests that fisheries protection authorities be consulted on any modifications to current closed areas and on the design of future closed areas to ensure that they can be managed effectively.

2.2.4 East Rockall

Several further records of coral have been made on eastern Rockall since WGDEC last described this area and these confirm the approximate shape that was suggested in 2005. Recent survey of this area by the UK Government (Howell *et al*., in press) found the eastern flank of Rockall Bank to be complex, in terms of habitat, comprising steep slopes, mixed substrates of boulders, cobbles and pebbles with areas of exposed bedrock and bedrock outcrop. In the shallower section of this area *Lophelia pertusa* reef is thought to be patchily distributed, while on the deeper flanks reef forming and non-reef forming species were observed. This area contained many VMS records from 2002 when last considered in 2005, but the 2005 VMS records appear to indicate that little trawl fishing occurs in this suggested closure (Figure 2.2.3.1). We recommend that this area be considered for closure to bottom fishing gear, however further investigation of the actual fishing activity is required in order to determine the likelihood of damage to reefs in this area. Fishing should be allowed to continue if it can be shown to be unlikely to cause significant further damage. Table 2.2.4.1 gives co-ordinates for a possible closure in this area.

Table 2.2.4.1 Corner points for suggested closures for eastern Rockall

57°30' N	12°48' W
57°33' N	13°13' W
57°27' N	13°26' W
56°59' N	13°34' W
56°59' N	13°18' W

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3 Cold water corals on Hatton Bank

Term of Reference a) Examine information on cold-water corals on Eastern Rockall and Hatton Bank and report on suitable areas to close in order to protect cold-water corals.

3.1 Introduction

As with Rockall Bank on 1 January 2007, NEAFC announced the closure of an area of Hatton Bank. This closure followed an initial proposal by Norway to NEAFC on 5th October 2004 to close six high seas areas (including Hatton Bank) to trawling to protect vulnerable deep-sea habitats. Five of these areas were accepted and closed on 1 January 2005 (see Section 4). The proposal to close an area of Hatton Bank was deferred and a request made to ICES to provide information on the distribution of cold water corals on Hatton Bank. In 2005, ICES provided a review of the current knowledge of *Lophelia pertusa* distribution on Hatton Bank (ICES, 2005a). Subsequent to this review NEAFC made a decision to prohibit bottom trawling and fishing with static gear (including bottom gillnets and long lines) on part of the bank from 1 January 2007 (see http://www.neafc.org/measures/measures-2007/docs/rec-9-2007_hatton-rockall-closures.pdf. Here we present new data on the distribution of cold water corals on Hatton Bank in light of this closure. We also take the opportunity to correct ICES' earlier review of the location of early records of *Lophelia pertusa* on Hatton Bank (particularly Table 3.1 of WGDEC's 2005 report) which contained errors (Table 3.1.1).

Table 3.1.1 Early records of *Lophelia pertusa* on Hatton Bank – this table replaces Table 3.1 of ICES (2005b) (Durán-Muñoz *et al.*, 2007a)

Position	Water depth (m)	Source
59ºN 14ºW - 59º 30'N 18ºW	457 - 604	Wilson 1979a
59º 16'N 15º 46'W - 59º 17'N 15º 41W	549 - 530	Wilson 1979a
59º 15'N 15º 52'W - 59º 15'N 15º 47W	494 - 512	Wilson 1979a
59º 11.5'N 17º 14.4'W - 59º 11.1'N 17º 14.2'W	560 – 529	Frederiksen *et al*. 1992
58º 46.7'N 18º 25.9'W - 58º 46.4'N 18º 25.0'W	646 – 591	Frederiksen *et al*. 1992
59º 18.5'N 15º 39.5'W - 59º 18.4'N 15º 38.7'W	730	Frederiksen *et al*. 1992
59º 19.8'N 15º 07.6'W - 59º 20.0'N 15º 03.9'W	747 – 673	Frederiksen *et al*. 1992
58º 46.9'N 18º 31.1'W - 58º 46.6'N 18º 30.1'W	771 – 710	Frederiksen *et al*. 1992
59º 23.2'N 15º 07.9'W - 59º 22.5'N 15º 05.9'W	1064 - 977	Frederiksen *et al*. 1992
59º 16.3'N 16º 00.6'W - 59º 16.8'N 16º 00.8'W	497	Frederiksen *et al*. 1992
59º 19.0'N 16º 02.0'W - 59º 18.7'N 16º 02.0'W	622 – 605	Frederiksen *et al*. 1992
59º 21.6'N 15º 08.0'W - 59º 20.9'N 15º 07.4'W	880 – 778	Frederiksen *et al*. 1992
59º 11.7'N 15º 12.4'W - 59º 12.8'N 15º 12.9'W	1040 - 870	Frederiksen *et al*. 1992
59º 16.4'N 15º 25.3'W - 59º 18.5'N 15º 15.0'W	500 - 650	Roberts *et al*. 2003
59º 18'N 15º 20'W	610 - 650	G. Langedal pers. comm.
59° 18.71'N 17° 04.5'W - 59° 18.03'N 17° 03.5'W	839 - 780	A. Freiwald pers. comm.
59° 18.26'N 17° 02.8'W - 59° 17.01'N 17° 00.34'W	810 - 760	A. Freiwald pers. comm.
59° 11.06'N 17° 12.7'W - 59° 10.48'N 17° 11.21'W	513 - 519	A. Freiwald pers. comm.

3.2 Recent surveys

In 2005 and 2006 UK Government (2005, DTI; 2006, DTI/Defra) funded biological and geophysical surveys of Hatton Bank. Multibeam surveys using a hull mounted EM120 (2005) and EM1002 (2006) were undertaken, supported by biological investigation using a drop-frame video and stills camera system. Both surveys were conducted in water depths of <1000m. Analysis of data from these surveys is not complete, however analysis of 2005 biological data (Narayanaswamy *et al*., 2006) provide some new information on distribution cold water corals while preliminary observations from 2006 biological data (K. Howell, pers. comm.) are presented here.

An interdisciplinary research project is also being undertaken by the Spanish Institute of Oceanography (IEO) under funding from the Spanish Government. This study is focused on investigating the deep-sea vulnerable ecosystems/habitats in the Hatton Bank area. This project is complementary to the UK Government funded surveys in that it is focused on the area between 1000-1500m depth on the western and north western flanks of Hatton Bank. As with the UK project, the IEO programme has undertaken multibeam survey (using a multibeam EM300) and high resolution seismic profiles (TOPAS PS 018 parametric echosounder) of large areas of the flanks of the bank, supported by biological survey in the form of bottom trawl, dredge and box core sampling.

3.3 Results of surveys

Video and photographic survey of Hatton Bank by the UK Government was focused preferentially on seafloor features revealed by the multibeam survey (Figure 3.3.1). These included ridges, rock outcrops, pinnacles, channels and hollows. *Lophelia pertusa*, *Madrepora occulata* and other coral species were observed associated with ridge, outcrop and pinnacle features. Within the NEAFC closed area *Lophelia pertusa* reef was observed associated with rock ridges. Coral rubble, indicative of the presence of reef habitat, was observed associated with extensive ridges and terrace structures on the bank. Small growths of *Lophelia pertusa*, *Madrepora occulata* and other coral species were observed at many sites both associated with ridge features and iceberg plough-mark zones where small growths were observed attached to isolated cobbles and small boulders.

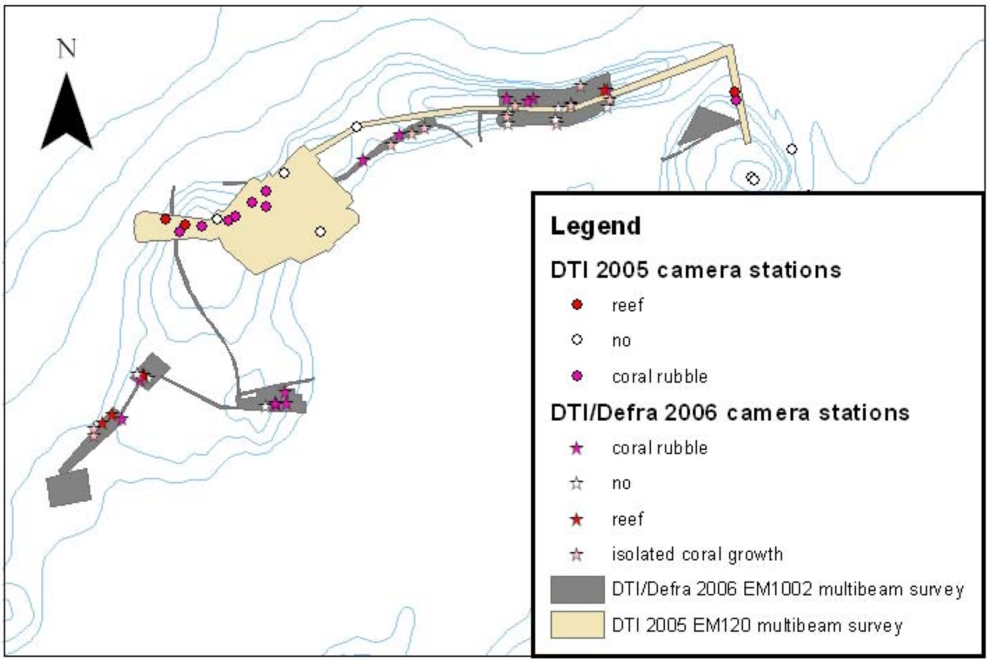

Figure 3.3.1 Preliminary map showing the sampling carried out during the UK Government funded multidisciplinary surveys (2005-06) of the Hatton Bank. The study area is <1000m water depth. (Narayanaswamy *et al.*, 2006; Jacobs, 2006; K. Howell, pers. comm.)

Away from the NEAFC closed area extensive areas of cold water coral reef were observed in the south west of Hatton Bank associated with rock outcrop and pinnacle structures. Coral rubble indicative of the presence of reef habitat was also observed associated with these features. Other coral species were also observed in these same areas, however complete analysis of these data is still in progress.

Analysis of historical records of cold water coral occurrence on Hatton Bank again suggest coral distribution is associated with seafloor features and iceberg-ploughmark areas. Preliminary analysis of IEO data has revealed several features like ridges, mounds, furrows, moats, waves and slumps on the flanks of Hatton Bank along the Drift (Sayago-Gil *et al*., 2006), some of which may support coral growth. An analysis of the distribution of fishing effort by the Spanish fleet showed that trawling is carried out mostly over soft sediments (Figure 3.3.2).

Given the apparent association of coral with seafloor features it is likely that pinnacle, outcrop and ridge areas revealed through acoustic analysis, but not surveyed biologically, also support coral reef habitat and associated fauna. Extensive ridge features are present within the NEAFC closed areas and thus this closure will provide protection for vulnerable habitats.

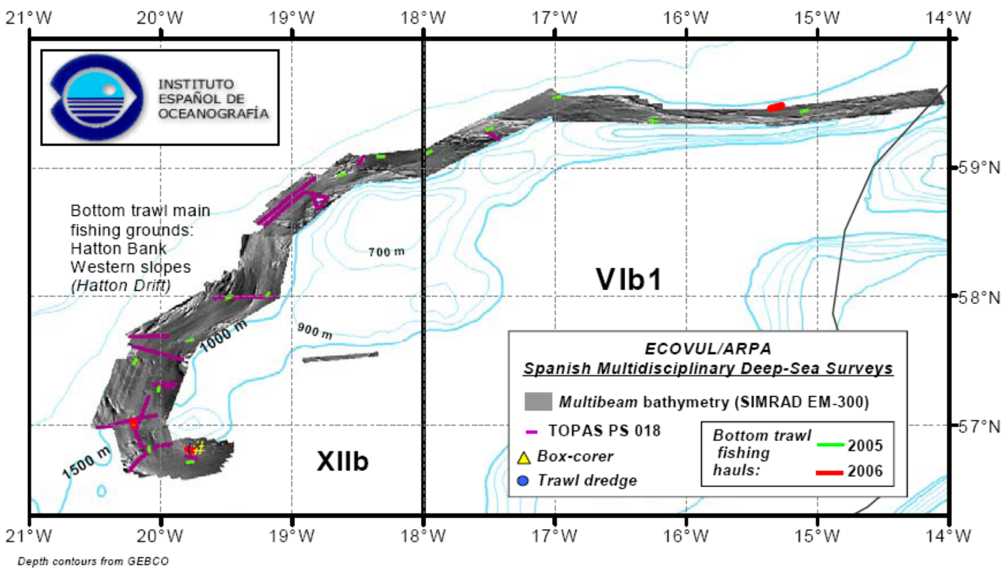

Figure 3.3.2 Preliminary map showing the sampling carried out during the ECOVUL/ARPA Spanish Multidisciplinary Deep-Sea Surveys (2005-06) on the Hatton Bank. The study area covers main trawl fishing grounds. These grounds are located on western slope of the Bank, between 1000-1500m depth, mostly over the soft sedimentary deposits called Hatton Drift.

3.4 Further area suitable for closure

The evidence available to WGDEC supports the current closure, however the largest reef structures known from new UK data on Hatton Bank occur in the southern region of the bank outside the current closure boundary. In order to determine a suitable boundary for closure, the distribution of known records of coral were plotted alongside a dataset of fishing locations of Spanish vessels between 1996 and 2006, derived from records of vessels that had scientific observers on board. It was assumed that this was representative of the distribution of the whole Spanish fleet, and that Spanish fishermen were avoiding areas holding outcrops of coral that might damage gear.

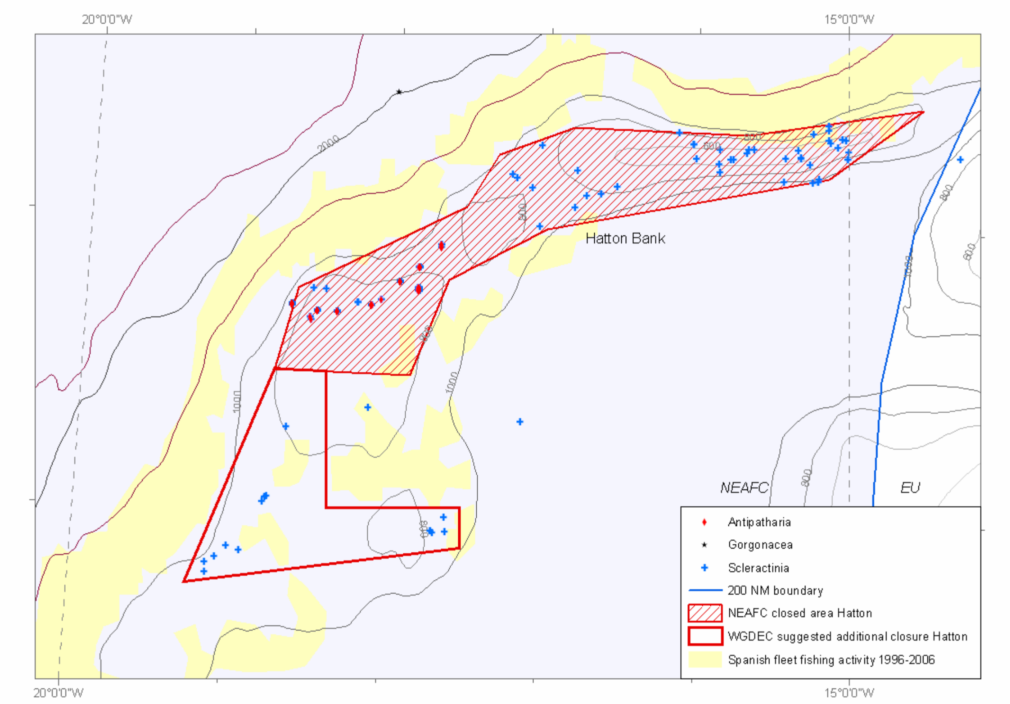

Figure 3.4.1 Chart of Hatton Bank showing areas closed by NEAFC in January 2007, records of corals and areas used by Spanish fishermen between 1996 and 2006 while scientific observers were on board. An additional area suitable for closure to protect sensitive habitats of cold-water coral is also shown.

Table 3.4.1 Corner points of suggested extension to closed area on Hatton Bank.

58°30' N	18°45' W
57°45' N	19°15' W
57°55' N	17°30' W
58°03' N	17°30' W
58°03' N	18°22' W
58°30' N	18°22' W

The boundaries (Figure 3.4.1, Table 3.4.1) have been drawn to incorporate observed coral reef habitat as well as known raised elevation seafloor features likely to support cold water coral. VMS and IEO fisheries observation data indicate areas of relatively intense fishing activity where coral is unlikely to occur. In the southern region of Hatton Bank fishing occurs on the bank summit in areas not covered by UK or Spanish surveys. The suggested boundary therefore excludes these fished areas. In general VMS and IEO observation data suggest there is very little fishing occurring on the summit of Hatton Bank with most effort being focused on the northern and western flanks mostly over the soft sedimentary deposits of the Hatton Drift feature (Durán-Muñoz *et al.*, 2007b).

As can be seen, the boundary of the suggested suitable area for closure includes areas that have neither been fished nor been surveyed. In considering whether to suggest that these areas stay open or be closed, we acted in a precautionary fashion. These areas, and areas of no-fishing near both the current closure boundary and that of the suggested further area to close should be priority for further consideration when either information deriving from the current IEO multidisciplinary project is analysed or if further surveys are planned.

3.5 References

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4 Deep-water NEAFC closures

Term of Reference e) Evaluate and report on the effects of the closed areas introduced in 2005 in the NEAFC area, with special regard to species diversity or to abundance of any other living organisms, which may indicate the quality of the ecosystem.

4.1 Introduction

On 1 January 2005 NEAFC created the first high seas fisheries closures in the Atlantic Ocean, prohibiting bottom trawling and the use of static gear (including bottom gillnets and longlines) fishing on part of Reykjanes Ridge and on mid-Atlantic seamounts called Hecate, Faraday, Altair and Antialtair in response to a proposal from the Norwegian Government. This measure is in force until 31st December 2007 to protect vulnerable deep-sea habitats. An analysis of VMS data obtained from NEAFC permits the monitoring of fishing vessel activity in these areas and thus helps assess the efficacy of the protected areas.

In 2004, fishing vessels moving at bottom trawling speed (1.5 – 4.5 knots, subsequently called 'fishing effort') were recorded to a small extent in the areas on Reyjanes Ridge, Faraday, and Antialtair, more frequently above Hekate and not at all above Altair seamount (Figure 4.1.1). When the closures came into effect in 2005, no bottom fishing effort was observed during the entire year over the closed area at Reykjanes and Hekate seamount (Figure 4.1.1). However, fishing effort increased at Faraday and Antialtair seamounts, showing a clear targeting of the two seamounts. While no fishing took place at Altair in 2004, after the closure in 2005 bottom fishing effort could be observed above one of the protected seamounts.

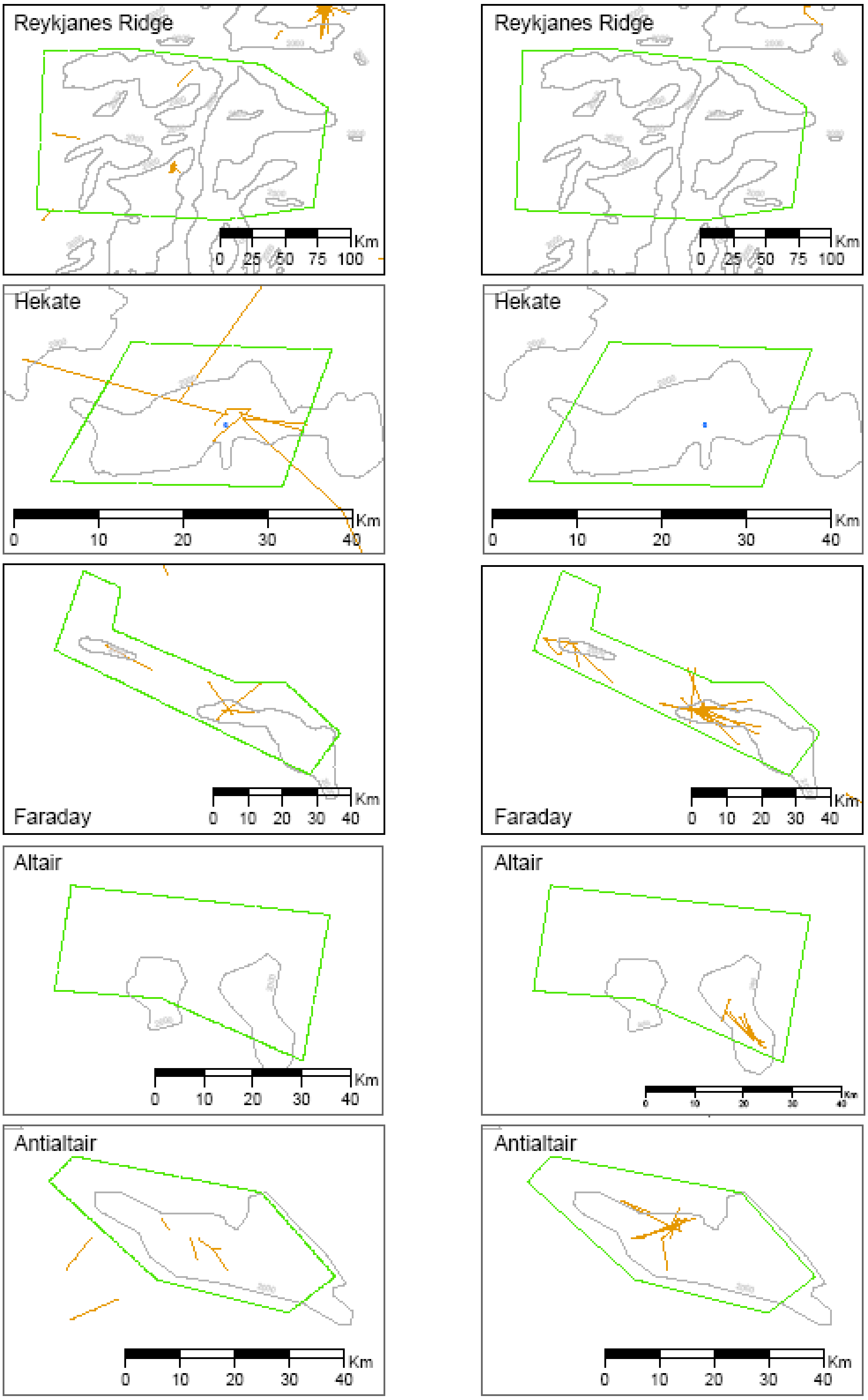

Figure 4.1.1 Fishing activity calculated using VMS data from 2004 (left) and 2005 (right) for the NEAFC high seas closures that came into place 1 January 2005.

To our knowledge there have been no studies of the marine life within these areas since the closures came into effect. In 2004 there was, however, a major survey of the mid Atlantic ridge to the south of the Reykjanes Ridge closed area (see www.mar-eco.no) where rich coral habitats were recorded in the region of the NEAFC closed areas using ROV, trawling and long-lining sampling at depths of 776 – 2355 m (Mortensen *et al*., in press). Tables 4.1.1 and 4.1.2 summarise the surveys sites and coral species diversity and abundance found during the MarEco programme at sites along the Mid Atlantic ridge.

Table 4.1.1. Information about ROV dives, vehicle (A = Aglantha, B = Bathysaurus) temperature and salinity (measured by sensors on the ROV), bottom habitats (estimated as average % bottom coverage), and number of coral taxa observed at study sites along the mid Atlantic ridge NEAFC region in 2004.

AREA	SOUTHERN			MIDDLE		NORTHERN		
Station	44	48	50	56	60	21	68	70
Dive #	4	3	5	12	10	Lander 2 insp.	15	16
Vehicle	B	B	B	A	A	A	B	B
Latitude (N)	42.942	42.873	42.942	51.753	51.513	51.523	53.127	53.016
Longitude (W)	29.507	29.104	28.501	29.583	30.335	30.333	34.789	34.879
Duration (min)	57	104	203	255	192	50	53	609
Min depth	1227	1023	2049	1209	776	862	2337	1167
Max depth	1291	1115	2110	1437	965	899	2355	1516
Temperature	3.5	6.2	3.6	3.6	4.3	4.1	2.9	3.3
Salinity	35.1	35.1	35	35.2	35	35.1	35.1	35.4
Habitat								
Sand/mud	46	21	88	54	23	54	100	55
Pebble	15	0.4	3	9	0	0.2	0	1
Cobble	8	1	3	5	1	3	0	3
Boulder	13	9	3	11	6	1	0	4
Outcrop	5	10	3	14	10	18	0	29
Coral rubble	12	39	0	2	61	24	0	8
Pteropod shell	2	20	0	2	0	0	0	0
Worm tubes	0	0	0	3	0	0	0	0
Coral taxa	10	7	8	14	11	8	1	14

Table 4.1.2. Frequency of occurrence (percentage of video sequences) of coral taxa observed during dives with the ROVs Aglantha and Bathysaurus as part of the Mar-Eco campaign in the mid Atlantic region of the NEAFC area.

STATION #	44	48	50	56	60	21	68	70
ALCYONACEA								
Alcyonacea indet.						2		
Anthomastus sp.			2	49	13	12		22
Nephtheidae indet.						2		2
GORGONACEA								
Acanella arbuscula	4	13	51		3	3		
Acanthogorgia sp.	2				42			
Chrysogorgia agassizi			1	3				
Gorgonacea cf. *Radicipes*			0.5					48
Gorgonacea indet.	32	6		2	5	4		8
Isididae indet.	19							
cf. *Iridogorgia*	2		0.5					
Keratoisis sp.		11						
Paragorgia arborea	4			5	1			
Paragorgidae indet.		3		2	1	2		2
Paramuricea sp.	13			2				
Primnoidae indet.	4				1			
PENNATULACEA								
Anthoptilum sp.			0.5	11	5			2
Funiculina quadrangularis				6	1			
Pennatulacea indet.		2	0.5	1				3
ANTIPATHARIA								
Antipatharia (c.f. *Bathypathes arctica*)	8							2
Antipatharia indet.	17			2				2
SCLERACTINIA								
Desmophyllum dianthus				8	2	2		4
Flabellum alabastrum				1				2
Flabellum spp.			0.5	1			64	2
Lophelia/Solenosmilia		11		14	66	49		18
Madrepora oculata		2						

Spain carried out a longline survey over the MAR in co-operation with its fishermen during 2004 (Duran Muñoz et al., 2005; 2007). Stony and soft coral bycatch was recorded (Table 4.1.3).

Table 4.1.3 Preliminary results of Spanish cooperative survey in MAR during 2004. Percentage of stations observed with records of sessile bottom invertebrates (stony corals and/or soft corals).

	Norwegian automatic system	Traditional semi-artisanal system	Total
No of stations observed with records of pieces of sessile bottom invertebrates tangled and/or hooked in different parts of the longline	12	21	33
No total of stations observed	33	81	114
Percentage of stations with records	36%	26%	29%

4.2 References

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5 Deep-water surveys

Term of Reference b) Compile a map of areas where biological research/survey has occurred in the deepwater area (>200m) of the North Atlantic

5.1 Summary

In total probably thousands of biological research surveys have been undertaken in the deepwater ecosystems of the North Atlantic ranging from spot samples for single taxonomic groups to large, multidisciplinary and multiyear programmes. WGDEC started to assemble this information into a database that will aim to provide a map of the geographical limits, research intensity and research discipline. To begin with the group focussed on populating the database with information from recent surveys in the north-east Atlantic region. The database should be seen as a work in progress that needs at some point to have dedicated attention if the entire North Atlantic is to comprehensively represented. Even with the limited coverage that was achieved during the time that WGDEC met it was becoming apparent where the gaps in our knowledge and where certain ‘hotspots’ of research activity were to be found.

5.2 Introduction

Over the last century a great many biological surveys were carried out in the deep waters (> 200 m) of the North Atlantic, especially in more recent years. Some of this information has been published, but much is scattered throughout the archives of European and North American research institutes. It is not only essential to understand the geographical limits of knowledge, but it can also be useful to identify areas that have been particularly intensively studied. Compiling a comprehensive relational database and generating mapped output for all deepwater biological surveys can achieve this. However, as the working group began work on this Term of Reference, it soon became apparent that to do it properly is a formidable task and too great to be completed within the time frame of a single working group meeting. Therefore it was agreed that a pilot database would be created from more recent deepwater biological surveys in the north-east Atlantic and that this would be built upon and populated over the coming years.

5.3 Data sources

Members of WGDEC provided information from their respective institutes or collaborators on deepwater surveys that included biological information rather than purely hydrological/oceanographical (Table 5.3.1). In addition cruise reports and published studies were included and the references given in the database. Several organisations and/or institutes such as IFREMER (France), NOCS (UK), WHOI (USA) and NOAA (USA) have data that will be included in the future, but there was insufficient time to assimilate these data at present. There are undoubtedly further sources of survey information, some of which may not exist in digital format.

Table 5.3.1 List of institutes from which data was included in the survey database

Institute	Information	Provider/contact
FRS Marine Lab, UK	Deepwater fish surveys (1996-2006) Zooplankton surveys (1998-2005)	F.Neat
SAMS, UK	Deepwater fish surveys (1975-1992)	K. Howell
PINRO, Russia	MAR grenadier survey (2002) Hatton/Lousy Bank fish survey (2001)	V.Vinnichenko
MARECO	MAR (2004)	Odd-Aksell Bergstad
DTI	Hatton Bank (2005-2006)	K. Howell
Marine Institute, Eire	Deepwater fish survey (2006) Orange roughy acoustic survey (2005)	B. O'Hea
IMR Bergen, Norway	coral reefs surveys Norway (2005, 2006)	P. Mortensen
Instituto Español de Oceanografía (Spain)	Deep-water fish and multidisciplinary surveys (1988-2007): NAFO RA, Porcupine Bank, Hatton Bank, Le Danoise Bank	P. Durán Muñoz, A. Serrano
IHF Hamburg, Germany	Seamount surveys deep-sea programmes on abyssal plains: BIOTRANS, BENGAL, DEEPSEAS	B. Christiansen
University of Plymouth	coral locations	J. Hall-Spencer
AWI, Bremerhaven, Germany	"Hausgarten" long-term study	T. Soltwedel
IPIMAR - Portugal	Deepwater fish surveys Portuguese mainland coast, Madeira and Azores islands	I. Figueiredo P. Machado
University of the Azores, UAç/DOP, Portugal	Deepwater fish and crustacean surveys in the Azores and Madeira islands Hydrothermal vents surveys (IFREMER, WHOI) Various seamounts surveys	G. Menezes
Department of Trade and Industry, UK	Geophysical surveys SEA 7, AFEN	J. Hartley K. Howell

5.4 Design of the database

Biological research survey data can be summarised at different spatial scales from the individual point location of a sample or trawl to an aggregated area covered within a cruise. However, depending on the cruise objectives a survey may cover a small area in much detail or a very large area in less detail. Point data is too detailed for the purpose of this database (although such data should be linked to this database). On the other hand, aggregated areas can be problematic if they cut across ecosystems and management areas. It was therefore decided that in geographically extensive cases the data would be split according to biogeographic zones or management areas. It was also necessary to decide the level of the detail of the associated information to be included.

The following criteria were included in the database:

Latitudinal limits of the survey (minimum and maximum)
Longitudinal limits of the survey (minimum and maximum)
Depth range (minimum and maximum)
Geographical locality, e.g. Rockall Bank
ICES/NAFO/CECAF areas
Whether the survey was in ‘high seas’ or within areas of national jurisdiction
The ‘target’ of research, e.g. fish, zooplankton etc
The type of survey method, e.g. trawl, acoustic, box core etc
Whether seabed acoustic surveys were undertaken, e.g. multibeam, side scan etc
Specific remarks, e.g. number of surveys/cruises
The research programme/project/funding agency
Year(s) of survey
Institution associated with the data
Reference to data (if published)

5.5 Preliminary map of survey activity in the deep North Atlantic

A total of 138 surveys were included (Figure 5.5.1). Although much information still needs to be included, there are indications that the geographical coverage is patchy with some areas clearly being far better surveyed than others. For example, the Rockall Trough is very well sampled for fish fauna, and the Porcupine Seabight is well represented for benthic fauna. The Mid-Atlantic Ridge, the Le Danoise Bank, the Porcupine Abyssal Plain/West European Basin and some seamounts have good multidisciplinary data. In recent years the Hatton Bank area has been the subject of a number of multidisciplinary surveys. However, there are also areas that are poorly surveyed or not surveyed at all. These include the area between the Rockall and Hatton Banks and the Mid-Atlantic Ridge and the abyssal plains and deep seamounts between the Portuguese mainland and the Azores. This gives some indication of how the database may be used to map survey effort across the north-east Atlantic and to query any combination of the variables.

The database should be developed in the future to become more comprehensive but also to include new information. In addition to the categories formulated at this stage, information on sampling intensity would be useful. This could take the form of an index that relates the number of sampling stations to the overall area covered by the survey. Further information on a contact responsible for information could be useful also. Ultimately the database should become fully relational and linked to the detailed databases held at individual institutes. It may also be worthwhile considering how it may be linked to other deep-water biological survey databases such as seamounts online (http://seamounts.sdsc.edu/). It was suggested that in the future the database could be hosted on the ICES website and expertise within ICES on database construction and management drawn upon for its further development and implementation. Overall it was agreed that such a resource would be widely used. WGDEC suggest that funding be sought for an individual to assume responsibility of completing the database and turning it into an active research aid.

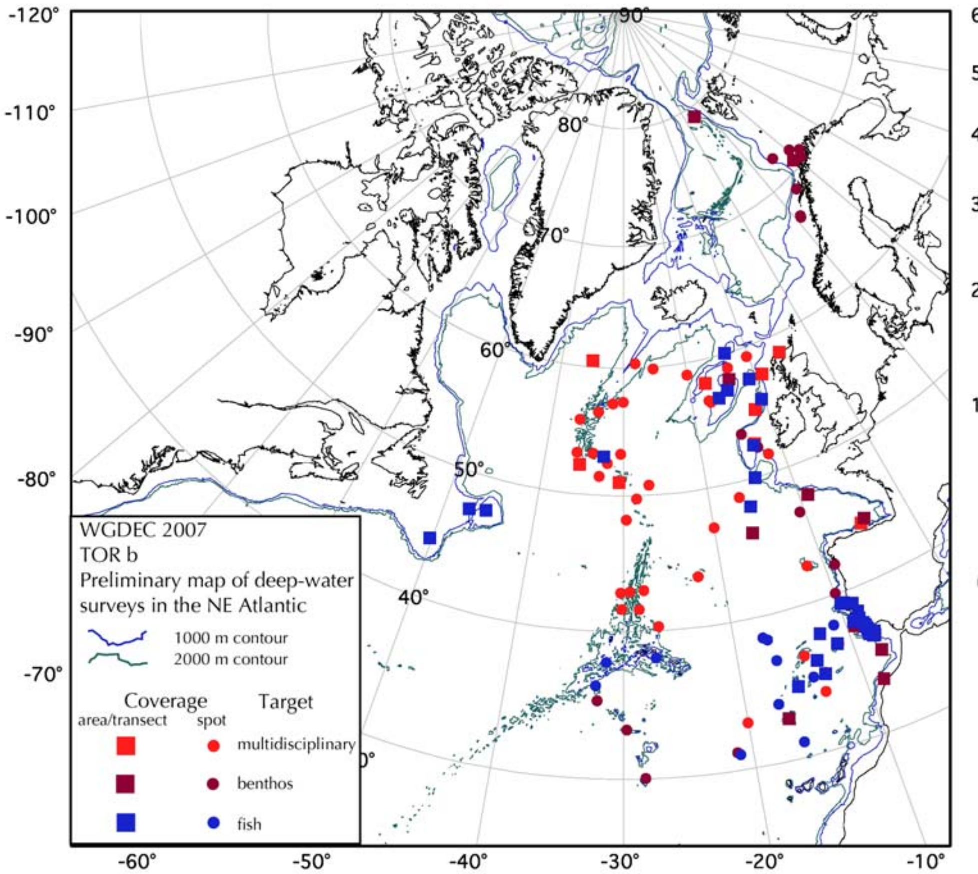

Figure 5.5.1: Locations of deep-water surveys entered into database by WGDEC in 2007.

6 Large structural sponges in the North Atlantic

Term of Reference c) Review and report on the location of areas holding large structural sponges in the North Atlantic

6.1 Introduction

Klitgaard and Tendal (2004) reviewed the geographic and bathymetric distribution of accumulations of large structural sponges termed 'ostur' or 'cheese bottom' for the north-east Atlantic. These authors also reviewed aspects of sponge growth, reproduction and sensitivity to human activities. As a result much of the following is drawn from that paper. However, new data on the distribution of structural sponges from the UK sector of the Faroe-Shetland Channel is provided by Dr K Howell from a UK Government funded survey of the region. These data are currently being analysed by Howell *et al*. and will be submitted for publication in the near future.

Two types of large structural sponge community have been described from the North Atlantic: those dominated by the Hexactinellidae and those by the Demospongiae. The former are characterised by large aggregations of *Pheronema carpenteri*; the latter are characterised by species of the genus Geodiidae. Sponge areas are found on the shelf plateau close to the shelf break (Faroe Islands, Karmoy area and western Barents Sea), on the upper slope (the Faroe-Shetland Channel, the Karmoy area, East Greenland, Porcupine Seabight), on the flanks of banks (the Faroe Islands, the western Barents Sea, and the Denmark Strait), on ridges (the Reykjanes Ridge), and on the rocky sides of fjords especially off forelands and in narrow straits (the Trondheim Fjord, and the Koster area).

6.2 Demospongiae

The Demospongiae communities or ostur are the focus of the review by Klitgaard and Tendal, (2004). These authors reviewed data from the BIOICE and BIOFAR programmes, as well as cruises from Karmoy (southwest Norway), the Trondheim Fjord (middle Norway), the Koster area (southwest Sweden) and the Denmark Strait (southeast Greenland). Additional information was acquired from Nordic and German biologists and fishermen regarding the occurrence of ostur. This paper suggests the distribution of areas of ostur follows two band shaped arcs defined by the Norwegian Atlantic Current and the Irminger Current. The local occurrence of ostur is however to a great extent dependent on areas of variable topography where a hard bottom is present. The results of this paper suggest two main types of ostur can be recognised, a boreal ostur dominated by *Geodia barretti*, *Geodia macandrewi*, *Geodia atlantica*, *Isops phlegraei*, *Stryphnus poderosus* and *Stelletta normani*, which occurs around the Faroe Islands, Norway, Sweden, parts of the western Barents Sea and south of Iceland, and rarely occurring at temperatures lower than 3°C. Secondly a cold water ostur characterised by the same genera but represented by different species, viz. *Geodia mesotriaena*, *Isops phlegraei pyriformis* and *Stelletta rhaphidiophora*, which is found north of Iceland, in most of the Denmark Strait, off East Greenland and north of Spitzbergen (Figure 6.2.1). A number of hexactinellid species are also represented in the cold water ostur, the most frequently occurring being *Schaudinnia rosea*. The ostur recently discovered on the UK continental shelf within the Faroe-Shetland Channel are most likely the boreal type (Figure 6.2.2). It is possible that ostur may be widely distributed over large parts of the Arctic Ocean.

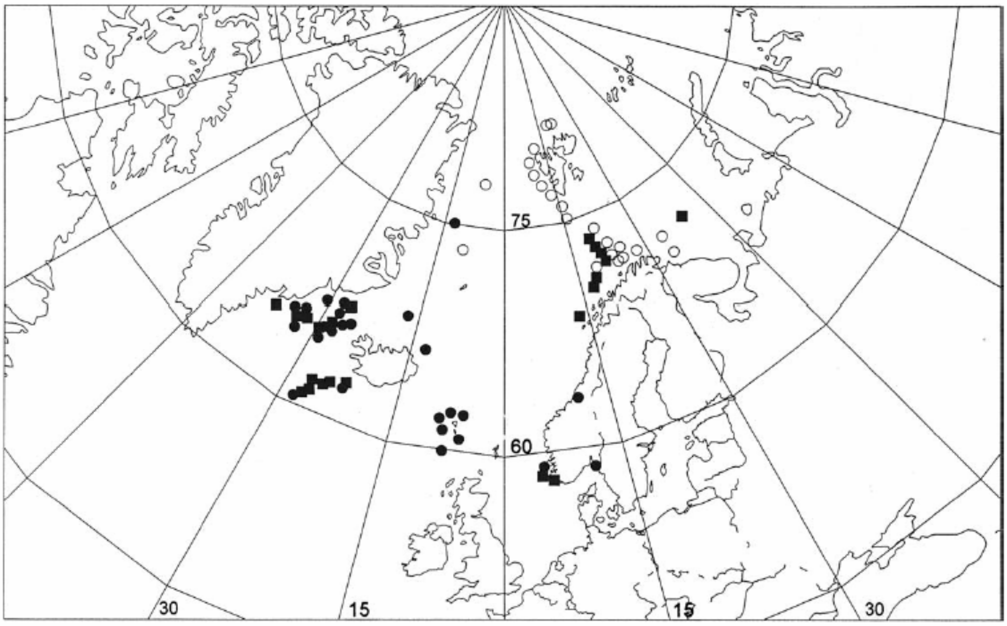

Figure 6.2.1. Geographic distribution of ostur in the northern north-east Atlantic (from Klitgaard and Tendal, 2004). Where stations are situated very close to each other, only a representative number of these are indicated.

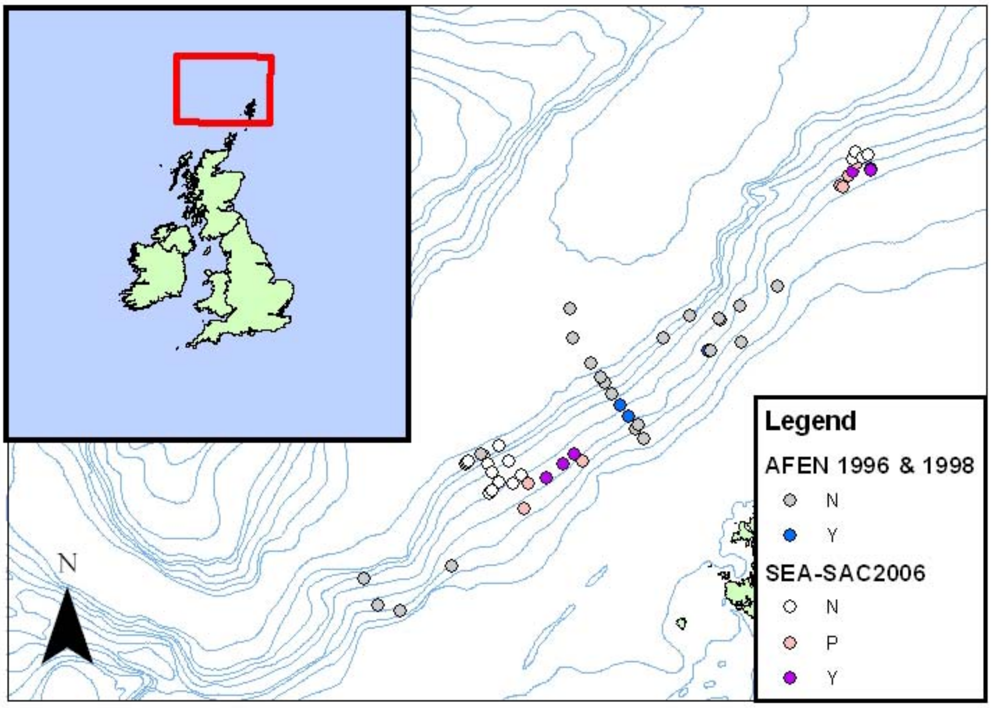

Figure 6.2.2. Presence/absence of structural sponge communities on the UK Continental Slope sector of the Faroe-Shetland Channel. DTI/Defra SEA-SAC data in the process of analysis (Howell *et al.*, in prep.) and AFEN data taken from Axelsson (2003)

In areas with ostur, up to 50 species of sponges can occur and of these about 20 species can reach sizes exceeding 5cm in maximum diameter. Dominant in terms of biomass, size and quantity per catch are four species of the family Geodiidae and the stellettid *Stryphnus poderosus* (Astrophorida, Demospongiae); single specimens are sometimes more than 70cm in diameter and 24kg wet weight.

6.3 Hexactinellidae

Communities composed of the hexactinellid *Pheronema carpenteri* have been described by Rice *et al*. (1990) from the Porcupine Seabight (Figure 6.3.1) and by Barthel *et al*. (1996) off Morocco at depths of 740-1300m and by Le Danois (1948) from Ireland to Spain in 1000-2000m water depth. These communities have been associated with 'coral mud' however their distribution in similar areas to cold water coral reefs is likely to be a result of favourable hydrographic conditions for both taxa (see section 6.4.1). *Pheronema* sp. is often associated with the Tetractinellid sponge *Thenea muricata* (Le Danois, 1948). Average maximum numerical abundance in the Porcupine Seabight is $0.34m^2$ ($0\text{-}1.5m^2$). There are indications that this species may also be common to the west of the Faroe Islands and south of Iceland at depths of between 800 and 1160m (Burton 1928); Copley *et al*., 1996). This species has also been observed on seamount and bank structures in the north-east Atlantic (K. Howell, pers. obs.) although it is not yet clear whether these occurrences are at sufficient densities to constitute a structural community.

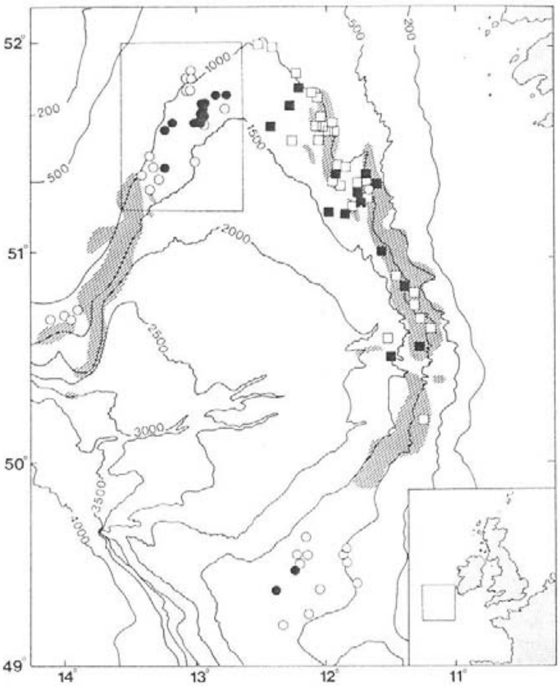

Figure 6.2.3: Distribution of *Pheronema carpenteri* in the Porcupine Seabight. Closed symbols represent presence and open symbols absence of the sponge. Circles: IOS (now NOCS) stations, squares Irish Fishery Investigation Stations (From Rice *et al.*, 1990).

Other Hexactinellid communities were described by Le Danois (1948). He reported aggregations of the large Hexactinellid sponge *Asconema setubalense* ("one of the most characteristics species of the Iberic waters"), being frequently collected by fishing trawls, between 500-1000m, on soft bottoms, from Cap Breton canyon to the south. This species was also collected deeper (1000-2000m) where it could form "sponge facies on muddy bottoms" as it is uniformly distributed along the deep slope of Northern Spain. Communities characterised by *Asconema setubalense* have been associated with 'coral muds'. Other sponge communities composed of *Abestopluma pennatula* and *Cladorhiza abyssicola* are also thought to be linked to the 'coral mud' but also colonise deeper areas. Le Danois (1948) also described muddy facies characterised by the occurrence of Elasiopod holothurians and hexactinellid sponges of genus Hyalonema from 2000-3000m.

6.4 Structural sponge distribution

Observations from the Faroe Islands, Denmark Strait and Porcupine Seabight (Rice *et al*., 1990; Klitgaard and Tendal, 2004) indicates that structural sponge communities do not constitute very large coherent areas but are patchily distributed depending on the local topography and hydrography. However data from new UK surveys (Howell *et al*., in prep) and Bett (2001), suggest there may be a continuous narrow band of ostur on the UK continental slope north of the Wyville-Thompson Ridge, focused on the 500m contour (Figure 6.2.2). The localities in which the highest concentrations of sponges occur may change over time (Barthel *et al* 1996; Klitgaard *et al*. 1997). These changes are most likely due to changes in water mass distributions (Klitgaard *et al*. 1997).

Large bycatches of sponge (estimated >500 kg) have been recorded by the Spanish Institute of Oceanography (IEO) in five hauls carried out during a recent cooperative bottom-trawl survey on the eastern flanks of Hatton Bank and in the Hatton-Rockall Basin (Durán-Muñoz et al., 2007). The species identified were the Hexactinellidae *Pheronema carpenteri* and specimens of Demospongiae, Family Geodiidae (*Geodia* sp and *Isops* sp). (P. Durán Muñoz, pers. comm.).

6.4.1 Environmental conditions

Klitgaard *et al.* (1997) extended the theories of Frederiksen *et al.* (1992) for the distribution of *Lophelia pertusa* to explain the distribution of ostur. Accumulations of large suspension feeders show tendency to aggregate near the shelf break in regions with a critical slope where the bottom slope matches the slope of propagation of internal tidal waves. The causal link is thought to be an increase in the supply of food related to the incidence of internal waves which results in resuspension. Rice *et al* (1990) noted that *P. carpenteri* is not found within the areas of enhanced current produced by the critical slope angle but is associated with them, the sponge being particularly abundant along their lower boundaries and downstream of these enhanced current regions. Again the increased food supply was cited as a possible reason.

6.4.2 Records from outside the Atlantic

Large numbers of geodiid sponges have been reported from the NE Pacific off Alaska (Kozloff, 1987). In addition mass occurrence of hexactinellids has been recorded off western Canada at depths of 150-250m consisting of three species *Aphrocallistes vastus*, *Heterochone calyx*, and *Farrea occa* (Conway *et al.*, 1991; Krautter *et al.*, 2001). The largest accumulations of sponges occur on the Antarctic shelf (Koltun, 1970; Dayton *et al.*, 1974; Barthel and Tendal, 1994). They are composed predominatly of large hexactinellids of the family Rossellidae, together with a sparse scattering of species of the demosponge families Geodiidae, Ancorinidae and Theneidae which never dominate.

6.4.3 Biological importance

Structural sponge communities increase the physical heterogeneity of the local area and number of available microhabitats. The associated fauna is dominated by epifaunal groups such as encrusting sponges, hydroids, zoantherians, bryozoans, and ascidians that use the sponges as a substratum (Klitgaard and Tendal, 2004). The spicule mats associated with the sponge communities' support increased biomass of macrofaunal species (Bett and Rice, 1992). The majority of species associated with sponge communities are facultative rather than obligate associates.

6.4.4 Sensitivity to human activities

Structural sponge habitat is extremely vulnerable to commercial trawling suffering immediate declines through direct removal of sponges and further reductions in population densities of sponges due to delayed mortality (Freese, 2001). In the case of direct removal, sponges tipped out on deck, even if they appear undamaged, will be drained of water and are unlikely to recover if they are thrown back into the sea. Even sponges brought to the surface and released before hauling on deck are unlikely to survive as sponges sinking en mass back to the bottom may end up upside-down or on the wrong type of seabed (Klitgaard and Tendal, 2004).

Experimental trawling on sponge communities at 206-209m depth in the Gulf of Alaska demonstrated that damage is significant (30 to 60% of the remaining sponges of the principle species were damaged). No damaged sponges in the trawl paths showed signs of repair or regrowth after 1 year and damage to some had been so severe that necrosis, probably as a result of bacterial or fungal agents, had led to subsequent death (Freese, 2001). No sign of recovery of the community a year after trawling was observed.

Klitgaard and Tendal (2004) suggest that the dominant ostur species are slow growing and take at least several decades to reach the sizes commonly encountered. In general, they are found in relatively constant environmental conditions that suggests they are dependant on a certain stability with respect to water mass characteristics, kinds and amount of particles in the water, and on low physical disturbance.

No investigations of the sexual reproduction of Geodiids and ancorinids from the north-east Atlantic have been carried out and the larvae have not been described. Few small specimens were found by Klitgaard and Tendal (2004) leading them to suggest that reproduction in boreal ostur areas is infrequent making ostur vulnerable to changes in hydrographic regime (climate change) as well as direct impacts of trawling.

Evidence of damage to structural sponge communities in NE Atlantic: Trawl marks have been observed in the ostur of the UK continental slope in the Faroe-Shetland channel (Howell pers. obs.). Both Rice *et al*. (1990) and Klitgaard *et al* (1997) used data provided by the fishing industry indicating where fishing vessels have taken a large sponge bycatch in their reviews of the distributions of these communities. Fishermen tend to avoid ostur because of the risk of catching several tonnes of sponges, overfilling the gear, and damaging the catch (Klitgaard *et al*., 1997). However structural sponge communities have been and will continue to be damaged (all be it accidentally) through human activities without appropriate protection measures.

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7 Soft corals in the North Atlantic

Term of Reference d): Review and report on the occurrence of soft-coral communities, with focus on Gorgonians and Antipatharians, in the North Atlantic.

7.1 Soft coral taxonomy

Corals constitute a heterogeneous taxonomic group of animals in the cnidarian classes Anthozoa and Hydrozoa that produce calcium carbonate (aragonitic or calcitic) secretions. These secretions may form a continuous skeleton, numerous sclerites, or a black, horn-like, proteinaceous matrix.

Many popular terms have been used to describe cold-water coral habitats (reef, bank, gorgonian forest, coral bed and coral garden). Here we are focusing on ‘coral gardens’, which are non-reefal habitats dominated by corals other than stony corals. More than 120 species of soft corals (Octocorallia), black corals (Hexacorallia), and lace corals (Hydrozoa) may occur in coral gardens. Habitat-forming species are found within all the three taxonomic groups, but the majority of the species have been recorded in few investigations or occur at low densities. Common taxonomic groups/*genera* are Antipatharia (*Bathypathes, Stichopathes),* and Gorgonacea (*Paramuricea, Swiftia, Callogorgia, Primnoa, Paragorgia*). The biological diversity of the coral garden community is high and often contains an array of different higher coral taxa, including non-reef building stone corals. In some areas the coral gardens can also include lace corals (Stylasteridae).

The habitats may also have significant quantities of large sponges.

The literature sources used for this review are listed with an asterisk below. Given the limited time available for the working group it was not possible to retrieve all existing data on non-reefal cold-water corals within the ICES area.

7.2 General distribution and habitat preferences

The distribution cold-water corals (including non-reefal species) in the North Atlantic have been reviewed earlier by (Madsen 1944; Zibrowius, 1980; Cairns and Chapman, 2001; Watling and Auster, 2005; Mortensen *et al.*, 2006). Non-reefal coldwater corals occur in most regions of the North Atlantic, most commonly in water with temperatures between 3 and 8ºC (Madsen, 1944; Mortensen *et al.*, 2006). The bathymetric distribution of such cold-water corals varies between regions with different hydrographic settings, but also locally as an effect of topographic features and substrate composition. On the Norwegian continental shelf corals occur mainly between 200 and 500m depth restricted by seasonal hydrographic variations above, and cold Arctic Intermediate Water below. In the Norwegian fjords, gorgonians such as *Paramuricea placomus* occur in waters as shallow as 30m due to stratification of the water column and good supply of Atlantic water. In Atlantic Canada, cold-water corals were found between approximately 200 and 600m along the continental shelf. On the northern Mid Atlantic Ridge cold-water corals are found from 800 to 2100m, with the highest number of coral taxa observed shallower than 1400m depth (Mortensen *et al.*, in press).

While stylastertids, or lace corals, are common and abundant in the coral gardens of the Aleutians (Stone, 2006), this group is less common in coral habitats of the North Atlantic. By far most records of stylasterids are from small-island areas with narrow shelf and steep slopes, seamounts, offshore reefs, and submarine ridges, while representatives of the group are rarer on continental margins.

Hydrographic conditions with elevated current speeds and high food supply, together with availability of hard bottom substrates are favourable for sessile suspension feeders, including cold-water corals. Corals (Antipatharia, Gorgonacea, Pennatulacea, Scleractinia, Stylasteriidae and Zooantharia) may occur in great abundance, especially along the edges and summits of topographic seabed structures such as banks or seamounts.

Such habitats are often subject to strong or moderate currents that prevent silt deposition on the hard substrates that most coral species need as an attachment. The hard substrate may be constituted of exposed bedrock or gravel/boulder, often from morainic deposition, but also soft sandy/clayey sediments can be used as substrate for cold-water corals (most seapens and some gorgonians within the Isididae. Areas with a high diversity of substrates support a higher diversity of corals. This is, for example, reflected in the depth distribution of coral taxa on the Mid Atlantic Ridge (Mortensen *et al.*, in press) where taxa like scleractinians, predominantly occur in the shallower depths where the percentage of hard bottom in a variety of substrata is high, whereas the soft sediment flanks of the sampled seamounts were occupied by seapens (the distribution intervals reflect the discontinuous sampling effort).

7.3 Regional distribution

Information on the distribution and habitat preference of soft coral communities is generally sparse and the depth ranges indicated clearly reflect the current knowledge based on rather patchy sampling. This is an incomplete description due to time constraints at the WGDEC meeting.

7.3.1 North East Atlantic

The occurrence and distribution of cold-water corals within the continental margins of the north Atlantic is relatively well documented compared with the open ocean regions. For Norwegian waters, Brattegard and Holthe (1997) made a compilation of benthic macro-organisms, including corals. In Faroese waters, Bruntse and Tendal (2001) reviewed the information available on cold water corals and mapped the records of *Primnoa resaediformes* and *Paragorgia arborea* (Fig. 7.3.3.1). The distribution of octocorals around Iceland was mapped by Ragnarsson and Steingrimsson (2003), however none of the above reports is based on systematic survey work, but rather collects individual records.

Antipatharians are a characteristic component of seamount fauna (Rogers 1994), but in the North Atlantic they do not form dense populations (Molodtsova 2006). Most antipatharian species in the northeastern Atlantic has a wide distribution and occur in all oceans. At the same time the fauna of the open oceanic regions is richer in species than near continental regions (Molodtsova 2006). There is a high degree of endemism among antipatharians in open oceanic regions (about 39 % of the species from the regions). The number of antipatharian species decrease distinctly from south to north in the North Atlantic. Around the Azores, seventeen species have been reported, and thirteen species are known from Gibraltar to the English Channel, whereas only four species of have been reported from north of 52º N.

7.3.2 Norway

Brattegard and Holthe (1997) lists 38 cold-water coral species from the Norwegian coast. The majority of these (31 species) are octocorals. Of these, sea pens comprise most species rich (12 species). Species known to form habitats are represented among seven gorgonian species: *Paragorgia arborea*, *Primnoa resedaeformis* and *Paramuricea placomus* are known to occur in relatively high densities. These habitats have been referred to as ‘coral forest’ among fishers. Because of the abundant occurrence of *Lophelia* reefs off Norway, most recent research on cold-water corals has been directed to studies on the distribution, ecology and fisheries impact on reefs. The large gorgonians mentioned here are all typical components of the associated fauna on *Lophelia* reefs off Norway. The distribution of ‘coral forests’ or coral gardens, outside reefs is poorly known, but it is known that Trondheimsfjord has areas with such habitats (Strømgren, 1970). Indeed, there are coral gardens also offshore, indicated by local fishers off the coast of Finnmark and observed on the continental shelf break off mid-Norway during research cruises directed by the Institute of Marine Research (Pål Buhl-Mortensen pers. comm.).

7.3.3 Faroe Islands and nearby Banks

Much of the information about distribution of cold-water corals in the Faroe region comes from the research programme BIOFAR (Bruntse and Tendal, 2001; Tendal et al, 2005). Figure 7.3.3.1 shows the distribution of the gorgonians *Paragorgia arborea* and *Primnoa resedaeformis* around the Faroes. The distribution of stylasterid corals in the Faroese region based primarily on results from this programme was reviewed by Tendal *et al*. (2005). The depth of the records of stylasterids ranged from 57 to 1100m. By far the majority of the stylasterid samples are from the outer shelf and upper slope fauna zones of the Faroe plateau and outer banks. Four species, representing the most northerly occurring stylasterid taxa, were found in samples mainly from the outer shelf and upper slope west of the Faroes. This area also holds the greatest diversity of those coral groups that are slow-growing, long-lived and reliant on long-term environmental stability.

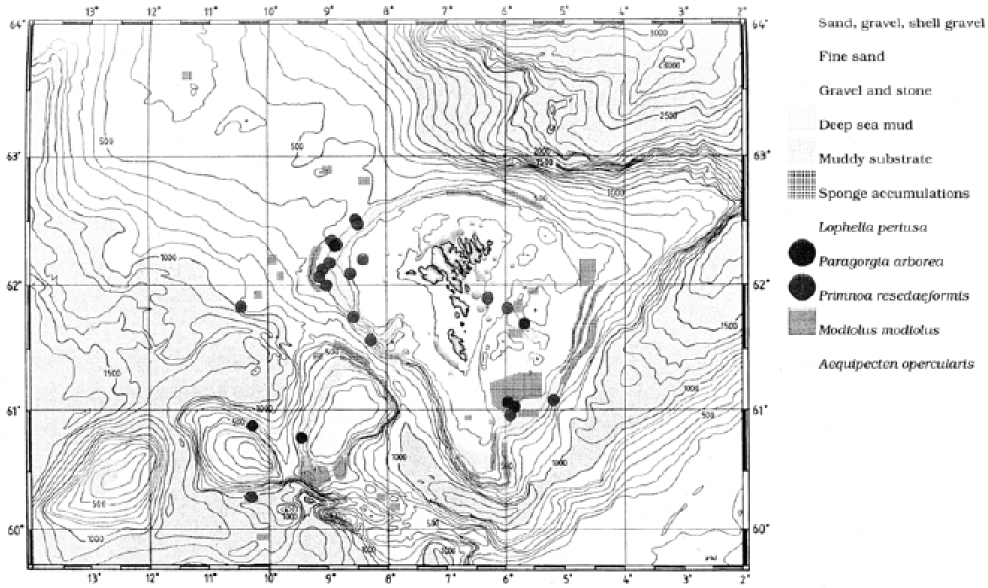

Figure 7.3.3.1 Locations of corals around the Faroe Islands (from Bruntse and Tendal, 2001)

Judged both from sample contents and from in situ photographs the bottom habitats at these depths are characterised by the presence of unlimited amounts of hard substrate (gravel, stones and boulders), good water movements and low contents of fine sediment in the bottom-near water. Cold water (less than 6°C) appears to limit the distribution of stylasterids from 600-700 m downwards.

7.3.4 Iceland

Around Iceland, Ragnarsson and Steingrimsson (2003) mapped the present occurrence of octocorals in relation to fishing pressure with otter trawl gear (Figure 7.3.4.1). However, WGDEC was unable to obtain information on the taxonomic composition of the coral community.

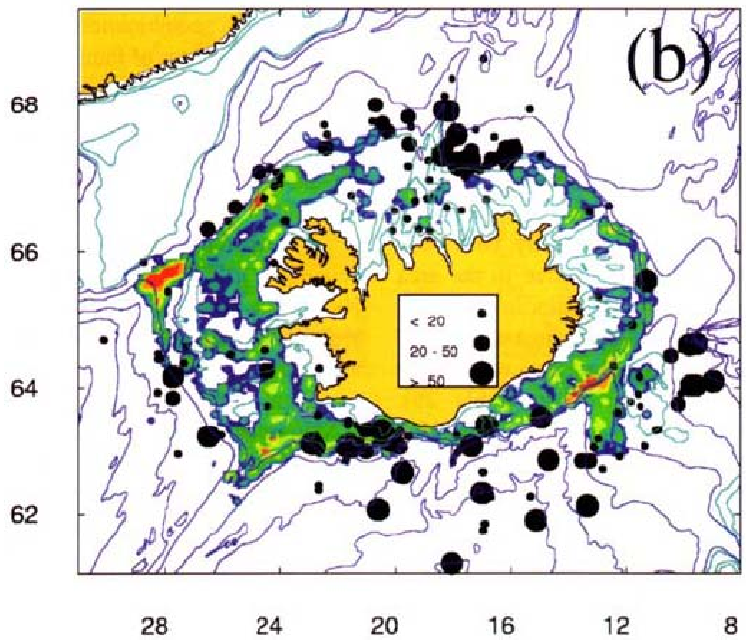

Figure 7.3.4.1 Total number of octocorals per sample collected in the BIOICE project superimposed over otter trawling effort(Steingrimsson and López-Conzález, unpublished data in: Ragnarsson and Steingrimsson, 2003). The colour scale of fishing effort ranges from blue (low effort) to red (high effort). The size of the dots represents abundance.

7.3.5 United Kingdom and nearby Banks

7.3.5.1 Hatton Bank

Spain has been undertaking an interdisciplinary research project, including multidisciplinary cruises, cooperative surveys and analysis of VMS and observers data, since 2005 on Hatton Bank (Durán Muñoz *et al*. 2007). Soft corals were recorded as part of the bycatch occurring in the Spanish bottom trawl and bottom longline cooperative surveys on the Hatton Bank and adjacent waters and in the Spanish bottom trawl commercial fishery on the Hatton slope (1000-1500m). The frequency and volume of soft-corals (Gorgonians and Antipatharians) in the catches was low on the regularly-used fishing grounds. Most of the Gorgonian records were obtained at shallow depths (<1000m), but Antipatharians were found over a wide depth range. Table 7.3.5.1.1 shows details of these records. Figures 7.3.5.1.1 and 7.3.5.1.2 show the location of records obtained from those sources. In these figures, note that the symbols correspond to the start position of the hauls (hauls in commercial fisheries, both trawl and longline, can cover long distances).

Table 7.3.5.1.1 Preliminary records of Antipatharians and Gorgonians in areas on or near Hatton Bank from the ECOVUL/ARPA project (after Durán Muñoz *et al.* 2007)

			NUMBER OF HAULS WITH PRESENCE OF:	
Data source	Total hauls	Sampling coverage	Antipatharians	Gorgonians
2005 Bottom longline exploratory cooperative survey	230	100%	7	22
2005 Bottom trawl cooperative survey	239	98%	6	14
ECOVUL/ARPA 10/2005 Multidisciplinary deep-sea survey	14	100%	1	4
2005-2006 Observer programme on commercial trawlers	409	28%	2	8

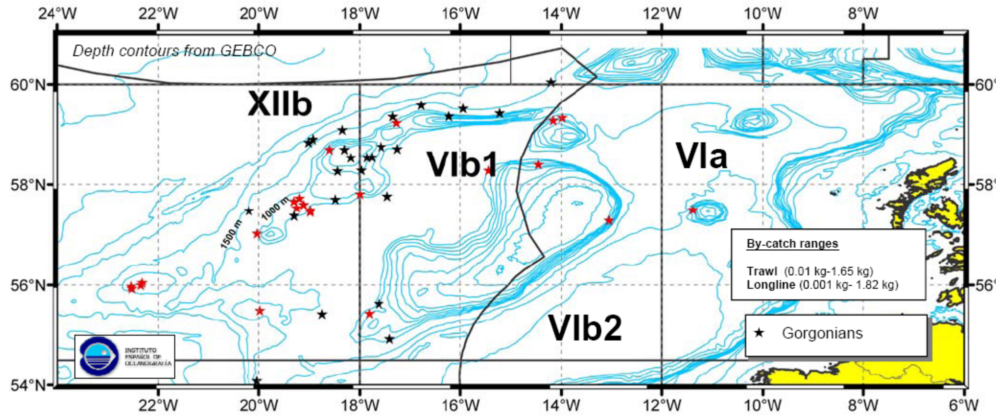

Figure 7.3.5.1.1 Preliminary map of the Hatton Bank and adjacent waters (ICES XII and VI) integrating records of soft-corals (Gorgonians) derived from ECOVUL/ARPA project data sources (2005-06). Black symbols correspond to records obtained from bottom trawl hauls. In terms of weight, bottom trawl by-catches ranged from a maximum of 1.65 kg to a minimum of 0.010 kg per haul Red symbols correspond to records obtained from bottom longline hauls. In terms of weight, longline by-catches ranged from a maximum of 1.82 kg to a minimum of 0.001 kg per haul (From Durán Muñoz *et al.* 2007).

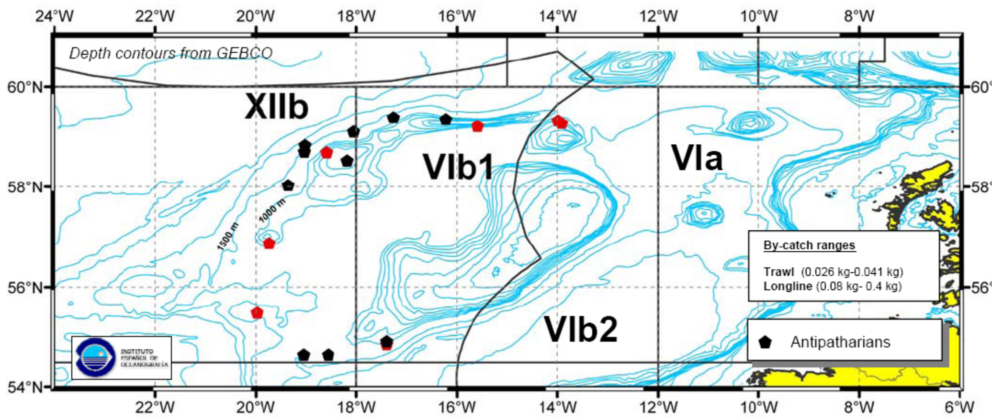

Figure 7.3.5.1.2 Preliminary map of the Hatton Bank and adjacent waters (ICES XII and VI) integrating records of soft-corals (Antipatharians) derived from ECOVUL/ARPA project data sources (2005-06). Black symbols correspond to records obtained from bottom trawl hauls. In terms of weight, bottom trawl by-catch ranged from a maximum of 0.041 kg to a minimum of 0.026 kg per haul. Red symbols correspond to records obtained from bottom longline hauls. In terms of weight, longline by-catch ranged from a maximum of 0.40 kg to a minimum of 0.08kg per haul (From Durán Muñoz *et al.* 2007).

The UK carried out surveys for Strategic Environmental Assessment purposes in 2005 and particularly in 2006 that included the Hatton Bank.

7.3.6 North-east Atlantic south of 61°N

Hall-Spencer *et al*. (in press) reviewed the literature and compiled a database of deep-water (> 200m) anthipatharians, scleractinians and gorgonians of the north-east Atlantic south of 60°N, including 2547 records from benthic sampling expeditions between 1868 and 1985 (Figure 7.3.5.1).

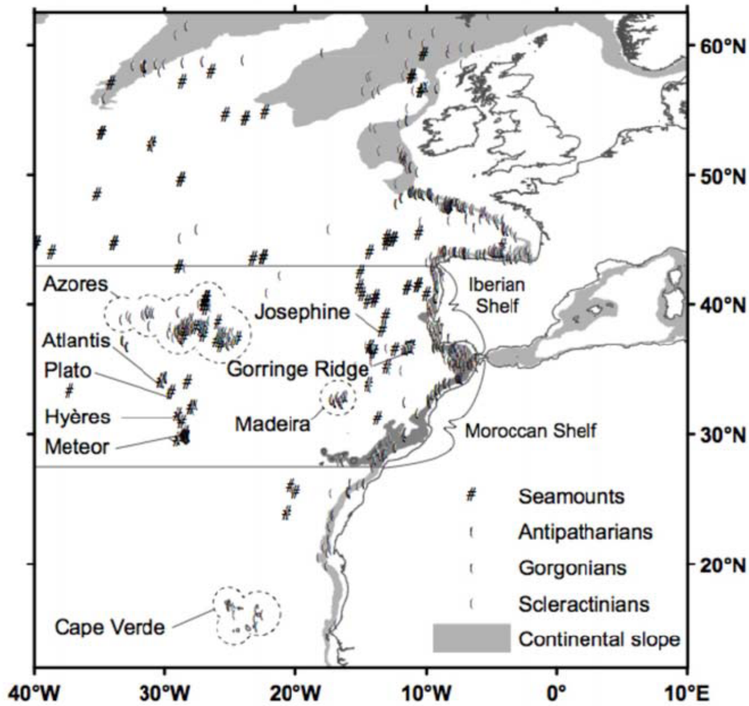

Figure 7.3.5.1 Records of deep-water corals in the north-east Atlantic south of 60°N (from Hall-Spencer *et al.* in press)

It was found that the majority of records came from steeply-sloping seabed types around seamounts, oceanic islands and the continental slope and confirmed the importance of the Mid-Atlantic Ridge as a biogeographic boundary between corals characterising the American boreal continental slope to the west and the European continental slope communities to the east (see e.g. Cairns and Chapman 2001, Watling and Auster 2005, Schröder-Ritzrau *et al*. 2005).

Molodtsova (2006) notes that several NE Atlantic antipatharians appear to be restricted to open ocean areas, with *Antipathes erinaceus*, *Distichopathes* sp., *Phanopathes* sp. and *Stauropathes punctata* only recorded on Josephine seamount, the Azores and Cape Verde Islands.

7.3.7 Mid-Atlantic Ridge

The non-hydrothermal hard bottom areas of oceanic ridges are often colonised by erect megafauna such as gorgonians, sponges, hydroids, and black corals (Grigg, 1997). The settlement patterns of the benthic fauna are controlled by topography at various scales, influencing the current patterns and velocity (Genin *et al*., 1986), and hence the transport rate and concentration of food particle for suspension feeders. Mortensen *et al*. (in press) observed corals on all sites surveyed with ROVs at depths between 800 and 2400 m on the northern Mid-Atlantic Ridge (Figure 7.3.6.1). The species richness of corals was high with a total of 40 taxa. Twenty-two species and five genera were identified. The remaining thirteen taxa were either higher taxonomic units or genera that could not be identified with absolute confidence. Octocorals (Alcyonacea, Gorgonacea, Pennatulacea) were taxonomically richer than hexacorals (Antipatharia and Scleractinia) with 27 versus 14 taxa. Gorgonacea was the most diverse order comprising 14 taxa, whereas Antipatharia and Alcyonacea were represented with the lowest number of taxa (two and three taxa, respectively).

Fig 7.3.6.1 Examples of two common habitats along the MAR. Left) Exposed basaltic outcrop with a high abundance of the alcyonarian *Anthomastus* sp. Right) Soft, sandy sediments with scattered shells or pebbles, *Acanella arbuscula* (upper right), and *Flabellum alabastrum* (lower right) (figure from Mortensen *et al.* in press)

7.3.8 Oceanic islands

Compared to the seamounts around the Azores and Madeira, and European continental slope, the diversity of corals was found to be depauperate on more isolated oceanic seamounts (Hall-Spencer *et al*. in press) therefore the seamounts close to oceanic islands are treated separately from the isolated seamounts here.

Available distribution data for the Azores stem from a variety of mostly historical sources of variable reliability, however, new data are emerging from recent investigations for example on the Condor de Terra seamount (Braga-Henriques *et al*. 2006). Overall, deep-sea corals are common around the Azores, particularly in the steep volcanic biotopes of the insular slopes and offshore seamounts. The most commonly-sampled gorgonians include large *Callogorgia verticillata*, *Dentomuricea* spp., *Acanthogorgia hirsuta* and *A. armata*, *Viminella flagellum*. These species probably form deep sea forests of considerable densities. The substrate availability may influence the patchy occurrence of the species: *Viminella flagellum* is the dominant species on boulder beds (Figure 7.3.7.1), whereas Paramuriceidae were relatively more abundant in bottoms with a sediment veneer (Figure 7.3.7.2). Other conspicuous gorgonian species such as *Paragorgia johnsoni* are also important elements. Antipatharian fauna is apparently dominated by the *Antipathella wollastoni* in the littoral of the islands and shallow seamounts below ca. 20m. The black coral *Leiopathes glaberrima* can reach up to 2m high and it forms dense forests between 200 and 600m.

Figure 7.3.7.1 ***Viminella flagellum*** **dominated coral gardens on Condor da Terra seamount, Azores (Braga-Henriques** ***et al.*** **2006, Copyright Gevin Newman, Greenpeace).**

Figure 7.3.7.2 Paramuriceidae spp. dominated coral gardens on Condor da Terra seamount, Azores (Braga-Henriques ***et al.*** **2006, Copyright Gevin Newman, Greenpeace)**

Several coral associations can be recognised. These associations can include species of the same group (e.g. *Madrepora oculata* with *Lophelia pertusa*) mixed with gorgonians (e.g. *Paramuricea* spp), stony hydroids, etc. The composition of those associations is probably depth related. The associated non-coral fauna was abundant and highly diverse.

7.3.9 Isolated North East Atlantic seamounts

7.3.9.1 Josephine Seamount

The summit region of Josephine Seamount, a seamount rising from more than 4000m to less than 200m depth is characterised by dense gorgonian beds on soft substrate (Figure 7.3.8.1.1). The species rich fauna of Josephine Seamount is typical for the eastern Atlantic, more closely related to the islands than to the continental shelf. This particularly well investigated summit region offers a wide variety of substrates which are readily populated by sometimes high densities of mostly sessile filter feeding species. Sixteen species of horny and black corals, thirteen species of stony corals, but no pennatulids and neither shelf nor deep sea benthic species were found. The gorgonian coral *Ellisella flagellum* was found to be very common on both the Josephine and Great Meteor Seamounts but was morphologically different between these sites, perhaps pointing to some degree of isolation. Dense beds of another gorgonian, *Callogorgia verticillata*, coincide with large sponges on the summit of Josephine, quite different from other seamounts (Figure 7.3.8.1.1).

Figure 7.3.8.1.1 Gorgonian bed on the summit of Josephine Seamount (ca. 200m, Photograph by A.L. Rice, copyright: DEEPSEAS Group, NOC)

7.3.10 Atlantic Canada and USA

Mortensen *et al*. (2006) reviewed the distribution of deep-water corals in Atlantic Canada and found 24 species of corals with highest abundance along the shelf break on the western side of channels and canyons. Four topographically induced 'hot spots'" areas were identified: Northeast Channel, The Gully, Stone Fence and Cape Chidley (Gass 2002; Mortensen *et al*. 2006). These have different coral communities, each reflecting its local environment. The corals were arranged in three groups based on mean depth distribution: 1) < 390 m, 2) 390-440 m, and 3) >440 m. The alcyonarian *Gersem*

ia rubiformis was common in waters shallower than 250m, while many gorgonians occurred deeper than thousand metres, with a maximum of 1740m for *Paramuricea grandis*. Environmental factors that influence the distribution of corals were identified with Canonical Correspondence Analysis. The cover of hard bottom substrates, average salinity and maximum temperature were the strongest factors underlying the observed pattern of distribution. High temperatures probably control the upper depth limit of corals, which differs between species. Due to lack of data from deeper water it is not known what controls the lower depth limit of the corals, but low temperatures and low food transport rates are likely to be important.

Bryan and Metaxas (2007) attempted to predict and map suitable habitat for the gorgonian corals *Primnoa resedaeformis* and *Paragorgia arborea*. Both corals were predicted to occur in areas of complex topography, mainly on the continental shelf break and seamounts. The predictability of the occurrence however is limited by the scale on which environmental information is available. As for most ocean areas, no detailed mapping has been undertaken so far, the mapping of suitable habitats will primarily indicate 'priority areas for mapping' for future dedicated sampling programmes.

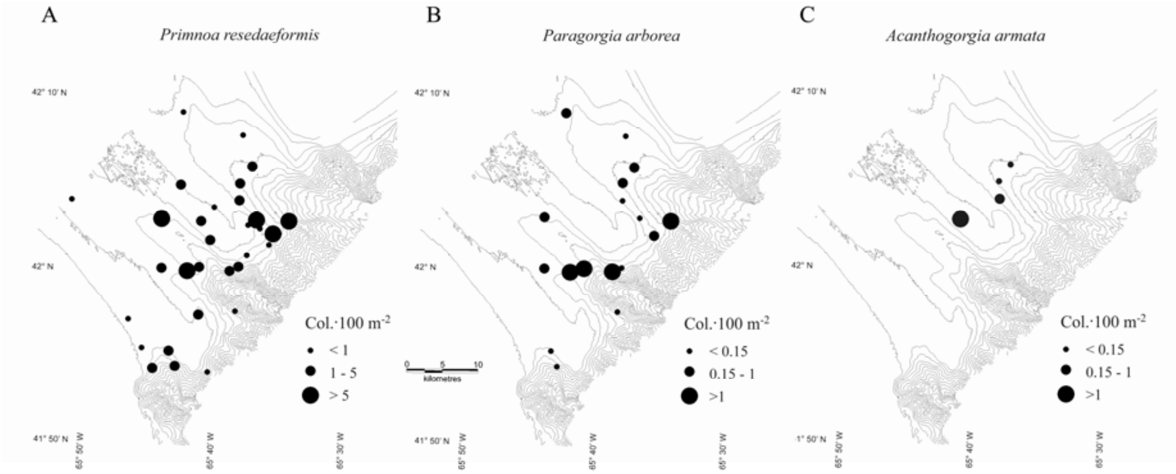

Figure 7.3.10.1 Map showing the densities of coral colonies (col·100m-2) in the Northeast Channel. A) *Paragorgia arborea*, B) *Primnoa resedaeformis*, and C) *Acanthogoria armata*. (From Mortensen and Buhl-Mortensen, 2004).

Recent video investigations of the coral communities have taken place in the Gulf of Maine, submarine canyons along the southern margin of Georges Bank, New England and Corner Rise Seamounts. Scattered octocorals (*Paramuricea grandis*, *Primnoa resedaeformis* and *Paragorgia arborea*) occur in various deeper (>100m) parts of the Gulf of Maine. A few soft coral and one hard coral species were found in shallower waters. Corals are rare on the continental shelf of the U.S.A. from Georges Bank to Cape Hatteras, primarily because the substrate consists of loose sands and gravels exposed to intense wave stress. However, where canyons cut through the continental slop and expose hard substrates (or contain glacially rafted boulders and cobble) there are abundant octocorals, and few solitary scleractinian corals. All the seamounts examined have abundant octocorals, although Bear Seamount, which has abundant sand on its flat top, has fewer species than the others.

7.4 Thoughts on the characterisation of 'coral gardens' - Density of stands, faunistic associations

One important issue for classifying coral habitats is the need for definitions that could aid objective and comparable characterisations. The observed in situ density (or abundance of coral by-catch in fishing gear) is one obvious parameter to consider. However, quantification of colony density is often not possible due to technical or operational restrictions. Qualitative or semi-quantitative approaches will in many cases be more appropriate for imagery with poor georeferencing and by-catch in fishing gear. At this point, the definition of 'coral gardens' (see Section 7.5) does not include mention of the densities of colonies. To enable comparisons between studies from different sites it would be useful to provide, as a minimum, relative densities. Mortensen and Buhl-Mortensen (2004) described the distribution and abundance of three gorgonian coral species in the Northeast Channel, off Nova Scotia. They found peak values of *Paragorgia arborea* between roughly 10 and 50 colonies per $100m^2$. For *Primnoa resedaeformis* maximum values were higher, between 50 and 140 per $100m^2$. The average densities were much lower (0.6 colonies per·$100m^2$ for *Paragorgia* and 4.8 colonies per·$100m^2$ for *Primnoa*). In the Gully, a submarine canyon off Nova Scotia, Mortensen and Buhl-Mortensen (2005) found lower densities of these two species compared to the Northeast Channel, but in stands comprising several gorgonian species they found peak values between 100 and 600 colonies per $100m^2$. In Alaska, where the term 'coral garden' was first used to describe dense stands of non-reefal corals, the densities are comparable to the studies by Mortensen and Buhl-Mortensen (2004; 2005), with a maximum for gorgonians of 232 colonies per $100m^2$ (652 colonies per $100m^2$ including stylasterids). Based on this limited information it is evident that the densities of developed coral gardens vary with taxonomic composition of the habitat forming corals. Smaller species (e.g. the gorgonians *Acanthogorgia* and *Primnoa* and stylasterids occur in higher densities [50 – 200 colonies per·100m^2]), compared to larger species such as *Paragorgia*. Coral gardens with several species may have densities between 100 and 700 colonies per·100m^2). These values could be used as a background for distinguishing between sparse and dense coral gardens.

In general, coral habitats in deep-water represent biodiversity hotspots for invertebrates (Reed *et al*., 1982; Jensen and Frederiksen, 1992; Buhl-Mortensen and Mortensen, 2005; Mortensen and Fosså, 2006) and commonly support a great abundance of fish (Mortensen *et al*., 1995; Husebø *et al*., 2002). However, the knowledge is rudimentary, and less is known about the ecology and associated community of non-reefal cold-water corals, than reef-forming cold-water corals. The high biodiversity of coral habitats is partly explained by the presence of hard bottom substrate, which is favourable both for corals and also for many other sessile suspension feeders. Buhl-Mortensen and Mortensen (2004) found that the diversity of cold-water gorgonians is comparable with that found for shallow water gorgonians, but in general, lower than for cold-water coral reefs. However, as cold-water scleractinians house very few specialized associated species (symbionts), the cold-water gorgonians have several examples of such symbionts. Thus, negative impacts on cold-water gorgonians will potentially affect their associated species to a larger degree than for the scleractinian species, due to the larger degree of host-specific occurrence.

7.5 Definition of 'Coral Garden'

The main feature of a coral garden is a more or relatively dense aggregation of colonies or individuals of one or more coral species, supporting a rich fauna of benthic and epi-benthic species. Scleractinian corals such as *Lophelia*, *Madrepora*, and *Solensosmilia*, may also be present but not as a dominating habitat component. Habitats where colonial scleractinians dominate are defined as coral reef.. Coral gardens occur on both soft and hard bottom. Soft bottom coral gardens are dominated by solitary scleractinians, sea pens, or some representatives of bamboo corals, whereas hard bottom coral gardens are most often dominated by gorgonians, stylasterids, and/or black corals.

Common gorgonian genera with a cosmopolitan distribution are *Paramuricea*, *Primnoa* and *Paragorgia*.

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8 Review of 'coral gardens' for OSPAR's list of threatened and declining habitats

8.1 Introduction

In 2003, OSPAR established an initial list of threatened and declining species and habitats in its area. In 2006, Contracting Parties and observers were asked to nominate any further species or habitats that they considered should be added to this list. As with the initial list, ICES was asked to assess the evidence upon which the nominations were based. The texts for the nominations were received in late autumn 2006, with a request to provide advice by February 2007. WGDEC was asked to review a nomination for the habitat 'coral gardens'. As some members of WGDEC were associated with the nomination, reviewers were sought among the specialist community known to members of WGDEC. The two reviews received are provided below (with some commentary in square brackets).

8.2 Review A

Based on my limited knowledge of corals in the OSPAR, I agree with the main concern of the ICES group that there is a need to define coral gardens unequivocally. In fact, I am somewhat surprised that they chose to nominate octocoral gardens rather than the *Lophelia* banks. There is very good information on the status and distribution of the *Lophelia* banks whereas I have never seen much information presented regarding octocoral gardens. There is no doubt excellent information and documentation to support the listing of the *Lophelia* banks as "threatened and declining habitat". On the other hand I have not seen similar evidence presented for octocorals there nor do the documents (attached to your email) seem to support the listing. I am certain that octocorals in the OSPAR are indeed threatened but they should provide more evidence regarding their zoogeography and fine-scale distribution. I'm not convinced (from the evidence provided) that the octocoral patches constitute "gardens", at least in the sense that we think of them in Alaska. I think one of the main reasons that we have been successful setting aside 'coral sanctuaries' in Alaska is that we can clearly define their geographical limits and provide sound argument why they are extraordinary. So in summary, I agree that octocorals in the OSPAR should ultimately be protected but that the evidence to do so could be better.

[This reviewer was unaware that Lophelia was already on the OSPAR lists]

8.3 Review B

Habitat description and selected species

The habitat "Coral Gardens" is a legitimate habitat and has been similarly described in other parts of the world. Occurrences of *Primnoa resedaeformis* and *Paragorgia arborea* (in the absence of scleractinian reef-forming corals) offshore Nova Scotia have been similarly termed as "Gorgonian Forests" (Coral conservation plan Maritimes region 2006), and coral areas off Alaska dominated by large gorgonians have been termed "Coral Gardens" (NOAA Press release, July 24, 2006).

I do not agree with the use of 'Non-reef" building colonies of Scleractinia corals being used to describe the occurrence of *Lophelia*, *Madrepora* etc. which may exist within a coral garden. Perhaps the following would be better "small colonies of Scleractinia corals such as *Lophelia*, *Madrepora* and *Solensosmilia*, may also be present". The extent to which these potential reef-forming corals exist with gorgonians and antipatharians will eventually define whether the habitat is a “reef” or a “coral garden” so it is important to be clear about the acceptable extent of potential reef forming corals within a coral garden habitat, although both habitats have similar threats and habitat requirements.

In particular *Sebastes* spp. have been found to commonly occur around/within gorgonian coral gardens as an example of a “deep living fish”.

Common genera with the cosmopolitan distribution are *Paramuricea* (not Placomus, *Paramuricea placomus* is the species name), *Primnoa* and *Paragorgia*.

Missing reference to back up the importance of this habitat the extent of associated species is Krieger and Wing (2002). They found ten mega faunal groups associated with *Primnoa* in the Gulf of Alaska: rockfish (6 species), sea stars, nudibranchs, crinoids, basket stars, crabs, shrimps, snails, anemones (3 genera), and sponges. Their definition of association was defined as megafauna which either “fed on *Primnoa* polyps, used the branches for suspension feeding, or sought protection”. They concluded that “*Primnoa* is both habitat and prey for fish and invertebrates” and that “removal or damage of *Primnoa* may affect the populations of associated species, especially at depths >300 m, where species were using *Primnoa* almost exclusively”.

Auster (2005) has questioned the importance of corals (*Paragorgia, Primnoa* and *Paramurecea*) as habitat for fish in terms of population processes. He concluded that their value as habitat is no greater than other similar habitats, such as bare boulders. He suggests that “conservation efforts for corals might do better emphasizing the intrinsic value of corals, their slow growth, high sensitivity to disturbance and the questionable potential for recovery”. His assessment did not consider the importance of corals as habitat for invertebrate species.

Geographical extent and known distribution

I agree that there is a lack of information about the occurrence of these habitats in the OSPAR region. I’m not familiar with reports from OSPAR region III. As far as I’m aware, they were not reported from the Sea of Hebrides during the MInCH project. Furthermore, the western boundary of the OSPAR region III lies along the 200 m contour west of Ireland, and gorgonians are rarely found at depths less than 200 m.

Region and biogeography zones specified for decline and/or threat

This should specify anywhere within “bottom” fishing depths to be accurate.

Sensitivity and evidence for its sensitivity

Additional evidence for the sensitivity of large gorgonians comes from the Aleutian Islands, Alaska, where over 200 000 kg of corals (mostly gorgonians and antipatharians) have been caught as by-catch in the Alaskan fishery from1990-2002 (Shester 2005).

Further evidence of their sensitivity comes from Mortensen *et al*. (2005) who reported fishing impacts on *Primnoa* and *Paragorgia* offshore Nova Scotia. In particular, they saw broken live corals, tilted corals, scattered skeletons, and lost fishing gear entangled in corals. They reported that *Paragorgia arborea* appeared more susceptible to breakage from encounters with fishing gear than *Primnoa resedaeformis*, most likely due to its larger size and less flexible skeleton.

Finally, Probert *et al*. (1997) examined benthic invertebrate by-catch from a deep-water trawl fishery off New Zealand, and found that Gorgonacea was one of the best represented groups in the catch. They concluded that large sessile epibenthic species were among taxa especially vulnerable to impacts from commercial trawling, and that large gorgonians such as *Paragorgia arborea* would be unlikely to recover “within a foreseeable future”.

Large colonies of *Primnoa* and *Paragorgia* can be over a century old and hence a recovery period of a coral garden habitat with large gorgonians after damage from bottom fishing will be significant.

Threat and evidence for threatened status

Advances in fisheries technology such as “rock hopper” gear on bottom trawls have eliminated some of the areas that would have been refuges from trawling (Watling and Norse 1998).

Threat and link to human activities

Gorgonian and antipatharian corals have been shown to be susceptible to the physical damage from bottom trawling but less is known about the potential side effects of increased suspension of sediments as a result of a trawl passing near to or through a coral area. Corals are known to be sensitive to some degree to heightened levels of suspended sediment and this is worth considering as side effect from bottom trawling.

Required further management

An approach similar to that taken by Leverette and Metaxas (2005) for predicting suitable habitat for *Primnoa* and *Paragorgia* may be useful as complementary research to gathering and mapping existing records on the distribution of this habitat.

The best way to gather historical data on the distribution of coral garden habitats, which may have already been decimated by bottom trawling in some areas, is to speak to the fishermen who used to and presently fish in the area. In particular, retired fishermen who have had long fishing careers and no longer have a stake in the fishery can provide excellent historical information on their distribution and abundance.

Conclusions

There is a lack of information about the current distribution and thus potential threat to the proposed coral gardens habitat in the whole OSPAR region. Hence, assessing whether this habitat deserves special conservation status is difficult. In light of similar habitats which have been damaged and decimated in other parts of the world (Alaska and Nova Scotia), and initial reports of gorgonian by-catch around Iceland and stories of German fishermen eliminating large gorgonians from the Rosengarten area, acting on the precautionary principle and implementing conservation measures for the coral gardens habitat in the OSPAR region becomes appropriate.

8.4 References

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9 Other business

9.1 Joint ICES/NAFO parenthood

The chair of WGDEC, Mark Tasker, had received a letter written on behalf of NAFO's Scientific Council in October 2006. NAFO is changing at present and wished to take more account of ecosystem matters. The Scientific Council had for instance recently been asked to "define criteria for safeguarding sensitive deep-sea habitats". The letter enquired as to how ICES and NAFO Scientific Council might best co-operate on this type of issue in future, given that both organisations were essentially being asked much the same questions. One current model that was working satisfactorily was to have working groups with joint ICES/NAFO parenthood. WGDEC considered that the concept of joint parenthood was a good idea and developed a proposal to establish such a group (Annex 2). The was some concern that questions from NAFO to the group might overload the current group membership, so indicated that extra work from NAFO would need to be accompanied by extra expertise for the joint group. WGDEC would not be opposed to having a co-chair from NAFO should that be considered helpful in ensuring integration and full participation by NAFO scientists.

9.2 Proposal for a symposium

In 2006 ICES Consultative Committee received a proposal for a symposium on deep-seas conservation issues. This proposal had been generated external to the usual ICES processes and was lacking certain essential details. Consultative Committee referred the proposal to WGDEC for further consideration. WGDEC noted that two relevant international meetings were planned in the near future: a deep-sea biology symposium in Goa, India in 2009, and the next in the series of cold-water coral symposia in Wellington, New Zealand in December 2008 or early 2009. WGDEC considered whether an ICES meeting might be best held alongside one or other of these and considered that a focus on conservation issues in the North Atlantic deep-sea would be more appropriate, particularly if a primary purpose was to reach all interest groups (fishers, offshore industry, conservationists) and relevant deep-sea regulators. The symposium proposal (Annex 2) was developed further with these thoughts in mind and will be refined and completed before the 2007 ICES Annual Science Conference.

9.3 New chair of WGDEC

Mark Tasker indicated that he had reached the end of a three-year term when it was usual to elect a new chair. He did not wish to continue having already been elected to the chair of ICES Advisory Committee on Ecosystems. Robert Brock (USA) had been nominated by a number of group members prior to the meeting and all agreed to put his name forward as WGDEC's proposal for its new chair.

Annex 1: List of participants

WORKING GROUP ON DEEP WATER ECOLOGY

Marine Biological Association, Plymouth, UK

26-28 February 2007

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Annex 2: WGDEC terms of reference for the next meeting

The **ICES-NAFO Joint Working Group on Deep Water Ecology** [WGDEC] (Chair: Robert Brock, USA*) shall be established and will meet in ICES Headquarters from xx-xx March 2008 to:

a) Provide advice on defining criteria for safeguarding sensitive deep-water habitats (NAFO request);

b) Continue to develop and compile a database and map of areas where biological research/survey has occurred in the deep water area (>200m) of the North Atlantic;

c) Update compilations and maps of occurrence of structural habitats (hard and soft corals, large sponges) in the North Atlantic;

d) Continue to collate information on habitats (research and survey results) and fisheries use (VMS and fisher's information) on Hatton Bank in order to refine the advice for closed areas;

e) Examine patterns of fishing in deep-water areas other than Rockall and Hatton banks, such as the seamounts and continental slope, to determine where intensive fishing is occurring and evaluate the likelihood of sensitive habitats being present in those areas;

f) Review codes of conduct for carrying out scientific research in sensitive deep-water habitats with a view to developing an ICES code of conduct;

g) Determine priority areas for multibeam or sidescan sonar survey on Rockall, Hatton Bank and adjacent seamounts.

h) Work with WGDEEP to consider suitable sized buffer zones around closed areas, taking into account ability to detect closed area infringements.

It is intended that the WGDEC meeting will at least overlap with the meeting of WGDEEP.

WGDEC will report by DATE to the attention of the ACE Committee.

Supporting Information

Priority:	High. This is the only group in ICES or NAFO providing information on deep water ecology. This is an expanding area of interest for fisheries managers and to OSPAR.
Scientific justification and relation to action plan:	A request from NAFO A start was made on this task in 2007; and this data will be useful in co-ordinating surveys needed in future as well as providing a resource to draw upon for answering future requests.
Resource requirements:	4 day meeting.
Participants:	The Group is normally attended by some 12-15 members.
Secretariat facilities:	One room for 12-15 people and the usual Secretariat support
Financial:	No financial implications.
Linkages to advisory committees:	There are no obvious direct linkages with the advisory committees.
Linkages to other committees or groups:	WGDEEP, WGECO, WGMHM.
Linkages to other organizations:	NAFO, OSPAR, NEAFC.
Secretariat marginal cost share:	

2007/3/ACE00 A **Symposium on issues confronting the deep oceans** will be held in [Galway, Ireland or the Azores] in April 2009. The prime focus will be on the North Atlantic (ICES + NAFO Areas) but relevant contributions from elsewhere will be included. Conveners/organising committee include Robert Brock (USA), Sabine Christiansen (Germany), Anthony Grehan (Ireland), Gui Menezes (Portugal), Kerry Howells (UK) and Francis Neat (UK). Other convenors will be sought from relevant scientific disciplines and regulatory authorities. In consultation with the conveners, the General Secretary will solicit appropriate co-sponsorship.

Supporting Information

PRIORITY:	HIGH. TOPICS EXPECTED TO INCLUDE EMERGING ISSUES OF HIGH PRIORITY SUCH AS (1) DEEP-SEA FISHERIES; (2) HABITAT IMPORTANCE, IMPACTS, AND PROTECTION; (3) ENFORCEMENT CHALLENGES (4) UNDERWATER SOUND/SONAR; AND (5) ACIDIFICATION. THE SCOPE OF THE MEETING MAY BE EXTENDED BY UNCLOS AND RFMO ISSUES SUCH AS DEVELOPING HIGH SEAS MARINE PROTECTED AREAS AND IUU FISHING.
Scientific justification and relation to action plan:	With increasing pursuit of new food, energy, mineral, and medicinal resources, technological advancements have made exploration and exploitation of the deep ocean (depths >200m) more possible today than ever before. With human activities expanding into the deep ocean, issues such as understanding deep ocean ecosystems, resilience of deep ocean resources to human disturbance, developing science-based regulations to ensure protection and sustainability, and being able to enforce existing and future management regulations are becoming priorities. Whether it be assessing deep ocean fisheries, habitats, potential energy and mineral resources, or potential development of high sea marine protected areas, pulling all interested stakeholders together (e.g., industry, enforcement, scientists, decision makers) under one symposia is thought never to have ever adequately occurred. This proposed symposium clearly addresses ICES goals of understanding the physical, chemical, and biological functioning of marine ecosystems as well as quantifying human impacts on marine ecosystems, including living marine resources.
Resource requirements:	There will be significant resource requirements, part of which will be met by the imposition of a Conference Registration Fee.
Participants:	A wide range of participants from ICES member countries, affiliates and other countries can be anticipated. We would like particularly to involve all relevant regulatory authorities
Secretariat facilities:	The Secretariat will be involved as normal in general professional and secretarial support, and the Secretariat should provide direct assistance during the Symposium.
Financial:	The attendance of one or two Secretariat staff at the Symposium will require travel funds.
Linkages to advisory committees:	The proposal has linkages to ACFM, ACE and ACME.
Linkages to other committees or groups:	There are linkages to LRC, RMC, MHC, OCC
Linkages to other organizations:	We hope that this symposium will be of particular interest to NEAFC, NAFO, International Seabed Authority, EU and fisheries managers from countries surrounding the North Atlantic. The topic of this symposium is also relevant to PICES. We hope that stakeholder organisations in the form of environmental and fishers NGOs, and the EU's distant water RAC would be interested.

Annex 3: Recommendations

RECOMMENDATION	ACTION
1. Continue to assemble list of deep-water areas in the North Atlantic closed to fishing activities affecting the seabed	WGDEC members (Jason Hall-Spencer)
2. Add further records of cold-water coral to database, particularly on eastern Rockall	WGDEC members (Pablo Durán Muñoz)
3. Provide advice to European Comission and NEAFC on further suitable areas to close on Rockall And Hatton Bank	Advisory Committee on Ecosystems
4. Consult with European Commision and NEAFC on suitable sized buffer zones and closure shapes to ensure relatively easy enforcement	ACE and Secretariat
5. Complete analysis of IEO multidisciplinary project and use to check suggestions on Hatton closure	WGDEC members (Pablo Durán Muñoz)
6. Seek funding in order to complile database of deep-water surveys	WGDEC members (Jason Hall-Spencer)
7. Consider hosting of database on North Atlantic deep-water surveys	ICES data centre
8. Contact NAFO about joint parentage of WGDEC	Secretariat + Mark Tasker
9. Lead on refining arrangements for prospective Symposium	Robert Brock
10. Contact other bodies in relation to Symposium, assuming agreement of CONC	Secretariat