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Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC)

28 February–4 March
Copenhagen, Denmark



ICES

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

H. C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

The terms of reference (ToR) for the WGDEC meeting of 2011 are listed in Section 2. ToR(a), was a request for advice to update records of deep-water vulnerable marine ecosystems (VMEs) in the North Atlantic and where appropriate advice on new or revised areas to be closed to bottom fisheries for the purposes of conservation of VMEs. New data from a range of sources including multibeam echosounder surveys, trawl surveys, longline surveys, fishermen's knowledge, habitat modelling and remote seabed imagery surveys were available for several areas under the regulation of the EC, Norway, NEAFC and NAFO. In the NE Atlantic these included Rockall Bank, the Anton Dohrn Seamount, Hatton Bank, Reykjanes ridge, Norwegian shelf, and the Bay of Biscay. In the NW Atlantic the areas included the Grand Banks/Flemish cap and an area west of Greenland.

A revised boundary is suggested for the northwest Rockall closure (NEAFC regulated) based on new observations on VMEs in the area and information from fishermen. New data from multibeam and camera surveys on the Anton Dohrn Seamount (EC regulated) indicate extraordinary concentrations of VMEs on the steep sides of the seamount. Two possible closure boundary options are proposed that would confer protection to VMEs on this seamount. New data from observers on longline vessels operating in the Hatton bank area and multibeam data suggest the presence of VMEs outside the current closure. As WGDEC was aware of new trawl bycatch data from the Hatton area that could be highly informative, no revision to the boundary was suggested for the time being. New data on VMEs in the Bay of Biscay (EC regulated) was available. Several areas of VME concentrations are identified that indicate where closures would be best sited to protect VMEs in this area. In the Northwest Atlantic (NAFO regulated) new data were available from observers on trawlers suggesting the presence of VMEs in areas currently open to bottom fishing on the slope of the Grand Banks and in an area to the west of Greenland. Two historical observations from the Reykjanes ridge area (NEAFC regulated) are reported in which significant bycatch of sponges and corals were taken. One of these lies within a closed area. No revisions to boundaries in this area are proposed.

To address ToR (b) a conceptual model and template was designed for a database of VME records in the North Atlantic. As the database is to be hosted by the ICES this was agreed and developed directly with the ICES DataCentre with clear linkages to the OSPAR habitats database. The aim is to have this operational by 2012. For ToR (c) WGDEC reviewed the report of WKMARBIO with special reference to deep-water ecosystems and the development of indicators for monitoring trends in diversity and community structure. For ToR (d) a very brief review of the application of productivity/susceptibility analysis to deep-water fisheries and ecosystems is presented. A shortage of published material and higher priority ToRs meant that this was only covered in minimal detail. ToR (e) required the group to review and comment on the ICES Study Group Designing Network Marine Protected Areas under a Changing Climate. The report was taken to be a work-in progress and there was rather limited application to deep-water ecology. In particular ocean acidification and the three-dimensional location of habitats were highlighted as important issues in designing MPA networks in deep-water ecosystems. For ToR (f) new information relevant to VME encounter rules (move-on criteria) was reviewed. A simulation study on sponge bycatch in the NW Atlantic suggests thresholds levels needs to be considerably reduced to be effective. An assess-

ment of the consequences of bottom trawling on seamounts under the move-on rule was made and concluded it would not be an effective means of protecting VMEs on seamounts. In ToR (g) an examination of environmental factors influencing sponge distributions in the North Atlantic was made using updated records. For ToR (h) a joint meeting was held with WGDEEP and the European Commission to discuss the value and uses of fisheries independent survey data.

1 Opening of the meeting

WGDEC members began discussions at 13.00 on February 28th, 2011, at ICES Headquarters in Copenhagen, Denmark. Deliberations primarily focused on what was being asked of the group by NEAFC, the EC and ICES. Following introductions, the opening discussion focused on new data sources available to the group, assignments of Terms of Reference, identification of key issues for group discussion and a timetable of events for the week that included presentations by The ICES DataCentre and the meeting with the EC on future deep-water surveys.

2 Adoption of the Agenda and Terms of Reference

2010/2/ACOM28 The ICES/NAFO Joint **Working Group on Deep-water Ecology** (WGDEC), Chaired by Francis Neat, UK, will meet at ICES Headquarters, 28 February–4 March 2011 to:

- a) Continue to update cold-water coral and sponge maps and the information underpinning such maps. This should include any new information pertinent to the boundaries of existing fisheries closures for sensitive habitats/vulnerable marine ecosystems; (EC and NEAFC standing request) and provide advice on appropriateness of current closure boundaries on Hatton and Rockall banks. The advice should be based on all available information on distribution of vulnerable habitats in those areas including from research vessel surveys, observer programmes and fisheries as well as data on the size of catches and condition (live/dead) of corals and sponges (NEAFC request).
- b) In conjunction with the ICES DataCentre, design and populate a central database of coral, sponge and other offshore or deep-water VME and habitats in the North Atlantic.
- c) Review, report on and develop the outputs of the ICES SIBAS Workshop on ‘Biodiversity indicators for assessment and management’ (available February 2011) i.e.:
 - Review the outputs of the SIBAS Workshop and, based on the indicators that have been proposed and the reporting processes they are intended to support, report on:
 - i) The strengths and weaknesses of the proposed indicators for deep-water species and habitats;
 - ii) Recommended modifications to the indicators;
 - iii) The process that would be used for data acquisition, analysis and reporting of the indicators.
 - Consider and report on methods for setting limit reference points consistent with the boundary for serious or irreversible harm (from Rio Agenda 21 Principles) to the property represented by the indicator].
 - Describe the potential trade-offs between fishing opportunities and impacts on deep-water species and habitats that need to be considered when setting targets for biodiversity indicators.
- d) Review the application of productivity and sustainability indices to assess the vulnerability of deep-sea fisheries and ecosystems;
- e) Review and comment on the ICES Study Group Designing Network Marine Protected Areas under a Changing Climate workshop report which presents general guidelines for MPA network design processes that anticipate the effects of climate change on marine ecosystems;
- f) Review any new information relevant to describing the location of vulnerable marine ecosystems (e.g. move-on criteria);
- g) Summarize any new information on the environmental factors influencing sponge distribution in the North Atlantic.

- h) Evaluate the need of fisheries independent data and propose solution for the near future based on WGNEACS work, in collaboration with WGDEEP and WGEF (EC request).

WGDEC will report by 1 April 2011 to the attention of the ACOM Committee.

Supporting Information

PRIORITY:	High as a Joint group with NAFO and is essential to feeding information to help answer external requests
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	<p>a) These maps are required to meet part of the European Commission MoU request to “provide any new information regarding the impact of fisheries on sensitive habitats” and the NEAFC request “to continue to provide all available new information on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in and in the vicinity of such habitats.” The location of newly discovered/mapped sensitive is critical to these requests. The second part of the ToR refers to a NEAFC request and should be answered as a separate advice (if possible). It is essential that ICES/WG chair asks its Member Countries etc. to supply as much information that they may have on Hatton and Rockall fisheries distribution and “habitat catch” by one month in advance of the WGDEC meeting. Otherwise the answer to most of the sub-question will be “no data available to ICES.”</p> <p>b) This will make the answering of requests both more consistent and more transparent as answers based on an agreed database will have an improved and clear audit trail.</p> <p>c) This ToR is presented by the ICES SIBAS (Strategic Initiative on Biodiversity).</p> <p>d) This may help underpin future advisory needs.</p> <p>e) In 2008 the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) adopted the scientific criteria (Decision IX/20) for identifying ecologically or biologically significant marine areas (EBSAs) in need of protection (Annex I) and scientific guidance for designing representative networks of marine protected areas (Annex II). The required properties and components for MPA networks are: Ecologically and biologically significant areas, Representativity, Connectivity, Replicated ecological features and Adequate and Viable sites. The potential impact of climate change on spatial management options such as networks of MPAs have not been thoroughly considered and the report of SGMPAN will be critical to advancing the scientific basis for MPA network design in the face of climate change.</p> <p>f) The current methods for identifying VMEs are, in some aspects, controversial. It will be useful to keep this area under review.</p> <p>g) This may be based on analysis of the distribution of sponge taxa or any other science, and should not repeat the work of WGDEC in 2007.</p> <p>h) This EC request will be addressed by WGDEC, WGDEEP and the chair of WGEF at a joint meeting 3 March.</p>
RESOURCE REQUIREMENTS:	The usual helpful support from the Secretariat will be appreciated.
PARTICIPANTS:	The Group is normally attended by some 20–25 members and guests.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	N/A
LINKAGES TO OTHER COMMITTEES OR GROUPS:	There is a very close working relationship with several SCICOM working groups. It is also very relevant to the Working Group on Ecosystem Effects of Fisheries.
LINKAGES TO OTHER ORGANIZATIONS:	The work of this group is closely aligned with similar work in FAO and in the Census of Marine Life Programme.

3 Continue to update cold-water coral and sponge maps and provide new information pertinent to the boundaries of existing fisheries closures

3.1 Introduction

The Joint ICES/NAFO WGDEC received new information on the distribution of deep-water vulnerable marine ecosystems (VMEs) for both the Northeast and Northwest Atlantic. This section also highlights where new surveys were undertaken in 2010, but for which the footage has yet to be analysed. It is expected those data will be available for 2012. In each area the new records are shown in relation to existing closures, and where data were available, for fishing activity. In some areas, suggestions are made for new closures or to revise current closure boundaries to better protect VMEs.

3.2 Northeast Atlantic

New data were available for five main areas in the NE Atlantic; Rockall bank, the Anton Dohrn Seamount, the Hatton Bank, the Reykjanes ridge, and the Bay of Biscay.

3.2.1 Rockall bank

Rockall bank is a large plateau that lies some 250 km to the west of the UK and Ireland surrounded on all sides by deep water. It lies partly in the EC EEZ and partly in international waters. NW Rockall Bank has been submitted to the European Commission as a candidate Special Area of Conservation under the EC Habitats Directive. Many data on VMEs in this area has been presented in past WGDEC reports and several closures for the protection of coral reefs have been enforced by NEAFC in recent years. NEAFC has requested that ICES provide all new information on VMEs in the region and advise on appropriateness of current closure boundaries and whether they need to be revised.

New data on VMEs (including cold-water coral reefs) for Rockall Bank were made available from Marine Scotland trawl and TV 'chariot' surveys. This together with historical data that JNCC (Joint Nature Conservation Committee) was provided in 2010 by the Scottish Fishermen's Federation (SFF) on coral records observed during trawling operations from the 1970's to 2008 was used to reassess the boundary of the NW Rockall closure. These new data are presented together with past data in relation to the existing closure boundary and a revised boundary is suggested (Figure 1 and Table 1).

Rockall Bank: Updated information on presence of VMEs and advice on new or existing closures - Map 1

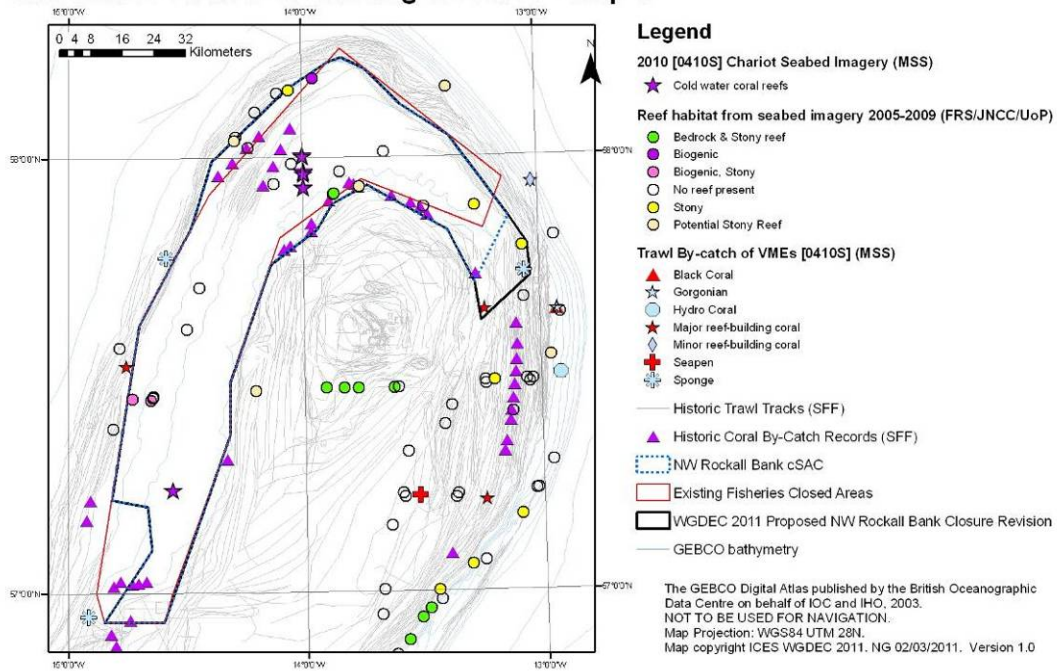


Figure 1. Map of northern extent of Rockall Bank showing existing closure in the northwest (red boundary) and a proposed revision to this closure (black boundary) in relation to historical fishing tracks and records of coral (SFF), data on habitats (mainly from previous WGDEC reports) and new data on VMEs including video footage and bycatch records from research surveys (Marine Scotland). See legend for details.

3.2.1.1 Case for boundary revision

The new data on VMEs confirms the presence of cold-water coral in the existing closed area and suggest the presence of coral and sponges in areas previously unknown that lie just outside the currently closed area (Figure 1). The SFF data on historical fishing tracks suggests that some areas within the currently closed area have been heavily trawled in the past and are therefore highly unlikely to currently contain VMEs. On the basis of these various data sources it is proposed that the existing closure boundary be modified to better reflect the presence of VMEs. The boundary is proposed to be modified in four main areas that are illustrated in detail in Figure 2 (A, B, C, D). The coordinates of the polygon that form the revised boundary are given in Table 1.

Rockall Bank: Detailed information on presence of VMEs and advice on new or existing closures - Map 2

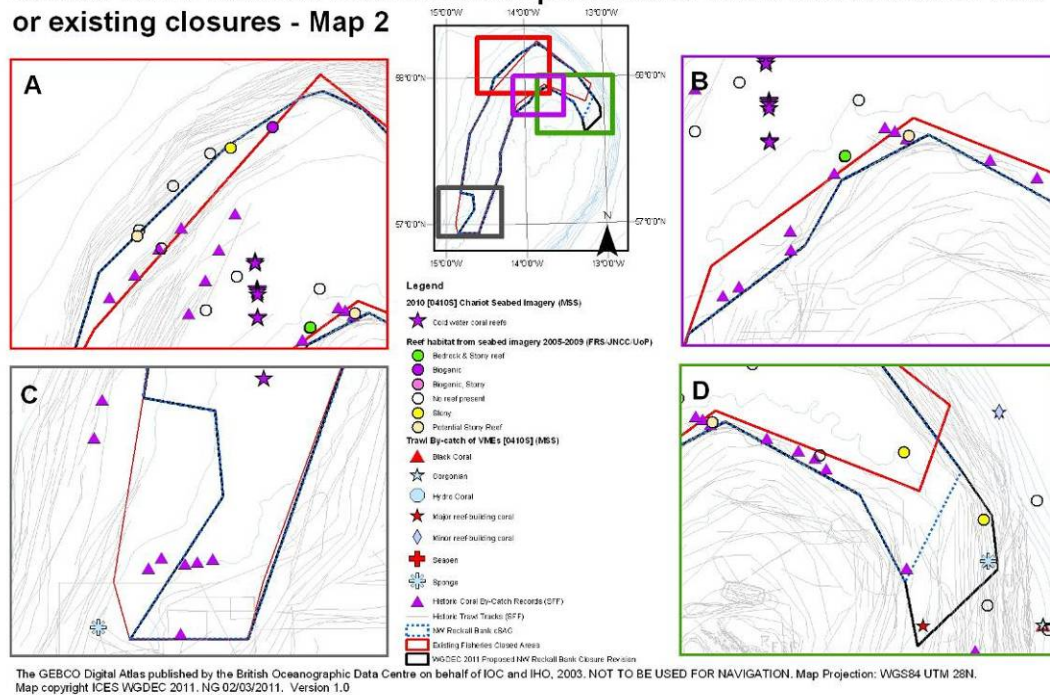


Figure 2. Detailed information on the presence of VMEs and proposed modifications to the existing boundary closure.

3.2.1.2 Specific evidence of revision of closure boundary

Box A (Red box). In the far northwest it is proposed to extend the closure west to cover records of coral in an area where there has been little historical trawling. The boundary is redrawn where trawling (grey lines in Figure 2A) has been heavy in the past. New data from Marine Scotland towed TV chariot (purple stars in Figure 2A) confirms the presence of live *Lophelia* reefs inside the closure.

Box B (Purple box). In this area, to the southeast of area A, an extension is suggested to encompass a number of historical records from fishermen that suggest the presence of coral.

Box C (Black box). In this area, in the far south of the current closure, there are historical data from the SFF suggesting coral inside the current closure (purple triangles). In the WGDEC report of 2007, however, Russian records from observers on fishing vessels suggested there was very little coral in this area. It is possible the SFF records of corals in this area pre-date the Russian observations. Thus WGDEC consider that there is insufficient new evidence to change previous advice and that the suggested boundary for this part of the closure remains as was proposed in 2007, i.e. a small area could be reopened. New data from towed video (Marine Scotland chariot imagery; purple star) provides further evidence of live *Lophelia* reefs within the existing closed area to the north. A new bycatch record of a sponge to west of the closed area is also reported, albeit in an area where historical trawl data from SFF suggest that trawling has occurred here.

Box D (Green box). In this area to the east of the current closure both new bycatch records and the SFF historical fisherman data suggests coral outside the current closure. Of note

were live specimens of *Lophelia pertusa* and a very large (>20 kg) live specimen of a *Geodia* sp. sponge (Figure 3). This is an area of historically lighter trawling than further south. To reflect this new information a southerly extension is suggested to encompass the coral and sponge records. The boundary is redrawn in line with the spatial extent to which historical trawling was heavier.



Figure 3. Photograph of a large *Geodia* sp. sponge taken as bycatch in a Marine Scotland trawl survey in the northeast area of Rockall (position shown in Figure 3.2 D).

Table 1. Revised boundary coordinates for proposed revision to NW Rockall closure.

POINT	LONGITUDE	LATITUDE	DECIMAL LONGITUDE	DECIMAL LATITUDE
1	13° 22' 25.95" W	58° 2' 49.18" N	-13.373876	58.046996
2	13° 7' 30.15" W	57° 51' 35.92" N	-13.125041	57.859977
3	13° 2' 59.41" W	57° 47' 50.44" N	-13.049835	57.797344
4	13° 2' 17.37" W	57° 43' 22.14" N	-13.038159	57.722818
5	13° 14' 55.74" W	57° 37' 15.49" N	-13.248817	57.620970
6	13° 16' 28.55" W	57° 42' 33.61" N	-13.274597	57.709336
7	13° 23' 9.04" W	57° 49' 48.98" N	-13.385845	57.830271
8	13° 43' 26.10" W	57° 56' 5.66" N	-13.723916	57.934905
9	13° 52' 28.16" W	57° 53' 37.49" N	-13.874489	57.893748
10	13° 56' 22.55" W	57° 50' 5.12" N	-13.939598	57.834757
11	14° 8' 24.02" W	57° 45' 18.44" N	-14.140004	57.755122
12	14° 19' 0.00" W	57° 29' 0.00" N	-14.316667	57.483333
13	14° 19' 0.00" W	57° 22' 0.00" N	-14.316667	57.366667
14	14° 36' 0.00" W	56° 56' 0.00" N	-14.600000	56.933333
15	14° 51' 0.00" W	56° 56' 0.00" N	-14.850000	56.933333
16	14° 39' 0.00" W	57° 6' 0.00" N	-14.650000	57.100000
17	14° 40' 0.00" W	57° 12' 0.00" N	-14.666667	57.200000
18	14° 49' 9.78" W	57° 12' 54.98" N	-14.819384	57.215272
19	14° 42' 0.00" W	57° 37' 0.00" N	-14.700000	57.616667
20	14° 28' 44.20" W	57° 50' 15.80" N	-14.478946	57.837721
21	14° 28' 25.88" W	57° 50' 42.01" N	-14.473854	57.845004
22	14° 23' 11.20" W	57° 59' 35.29" N	-14.386445	57.993137
23	14° 3' 48.86" W	58° 9' 29.55" N	-14.063572	58.158208
24	13° 53' 17.88" W	58° 13' 5.90" N	-13.888299	58.218307
25	13° 49' 41.36" W	58° 13' 43.32" N	-13.828156	58.228701
26	13° 43' 52.33" W	58° 12' 14.24" N	-13.731202	58.203954
27	13° 34' 29.10" W	58° 7' 11.72" N	-13.574750	58.119922
28	13° 22' 25.95" W	58° 2' 49.18" N	-13.373876	58.046996

3.2.1.3 South Rockall (Empress of Britain)

There was also new data from Marine Scotland's towed video chariot for the region in the south of Rockall Bank, known as the Empress of Britain bank where NEAFC has enforced closures since 2008. All observations of live coral were from inside the closed area. This confirms the closure is appropriate and there is no reason to consider revising the boundary for the time being.

3.2.2 Anton Dohrn Seamount

The Anton Dohrn seamount is a flat topped seamount or 'guyot'. It is one of three seamounts in the Rockall Trough area of the NE Atlantic. In 2005 the seamount was mapped using multibeam echosounder (DTI SEA7 2005). The seamount has a broad summit covered by extensive sandy plains which support a fauna typical of the substratum and depth in this region. Toward the centre of the summit is a large basalt outcrop. This rocky outcrop is dominated by brachiopods as well as large barnacles but few other visible fauna. Gorgonians and live *Lophelia pertusa* had been taken as bycatch in trawl surveys from deeper sections of the summit. The very steep sides of seamount are highly likely to contain VME species and this has now been demonstrated by surveys undertaken by

JNCC in 2009. The seamount is fished using bottom trawls as corroborated by VMS data. Most of the fishing activity is on the flatter deeper areas of the summit to depths of around 1000 m.

In 2009 JNCCs Offshore Natura¹ survey took place between the 1st and 29th July and was conducted by the vessel M/V Franklin. 215 line kilometres of multibeam echosounder and ten photographic “ground-truthing” sites were acquired from the Anton Dohrn Seamount. Data from this survey is the primary new source of information on the presence of VMEs on the seamount. On the northwest slopes of the seamount and parasitic cones associated with the seamount, numerous images of coral gardens were captured (Figure 4). There was also evidence of a number of fish species including orange roughy, false boarfish and roundnose grenadier (Figure 5).

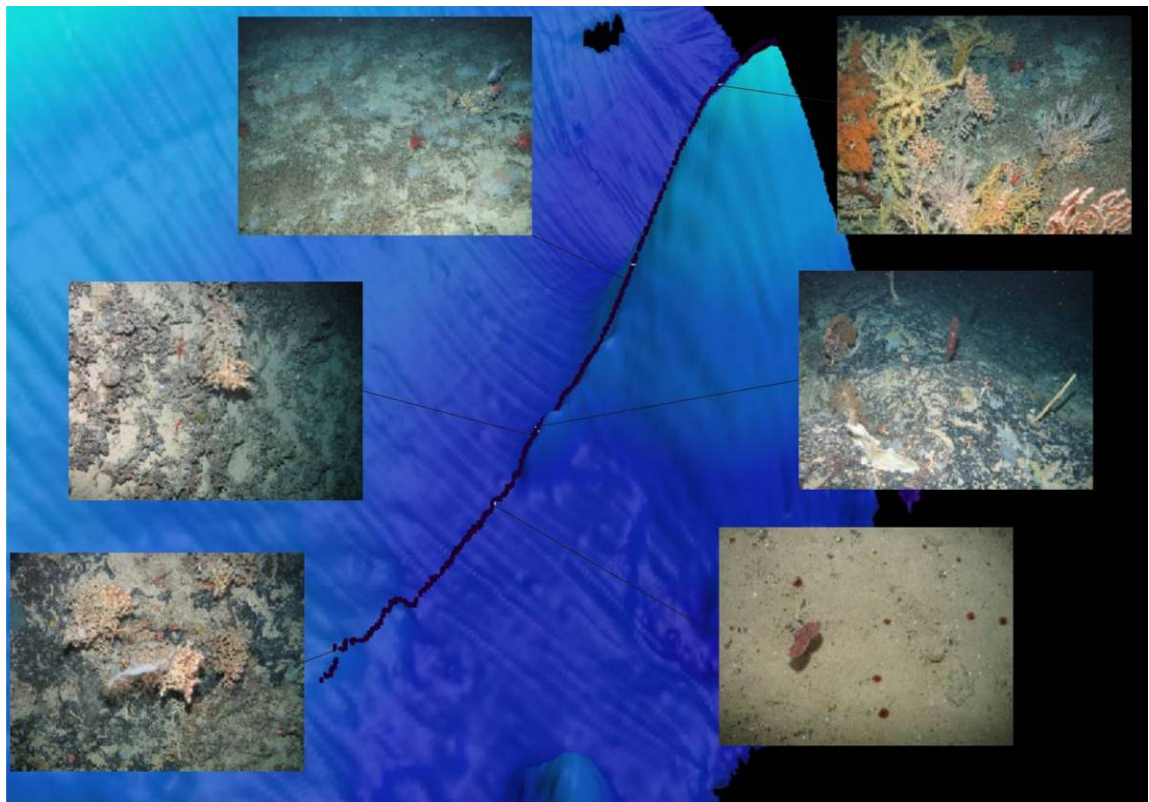


Figure 4. Multibeam data of the northwest area of the Anton Dohrn Seamount showing the flank of one of the parasitic cones next to the flank of the seamount. The track of video transect has been overlain in black and images of coral gardens observed. © JNCC. 2010.

¹ <http://www.jncc.gov.uk/page-5026>



Figure 5 An image of cold-water corals and a roundnose grenadier from the Anton Dohrn seamount. Image © JNCC, 2010.

In addition to survey observations information was available from a predictive habitat model developed by the University of Plymouth (K. Howell and J. Davies, unpublished). The model was developed from biotope mapped video overlain on multibeam bathymetry, interpreted layers of seabed substratum and geomorphology, and multibeam derived layers (slope, rugosity, bathymetric position index, aspect, curvature). From this the relationships between biotopes and environmental parameters were visually identified. These relationships coupled with expert judgement were then used to predict the spatial distribution of all biotopes across each feature. Where no clear relationships were established or there was doubt about the effect of environmental parameters not measured in the study (e.g. possible differing hydrodynamic regime on either side of the seamount), relevant polygons were labelled only with the seabed substratum. The various data sources were combined to provide a map of the seamount in relation to the observations and predictions for VMEs (Figure 6).

Anton Dohrn Seamount: Updated information on presence of VMEs and advice on new or existing closures - Map 1

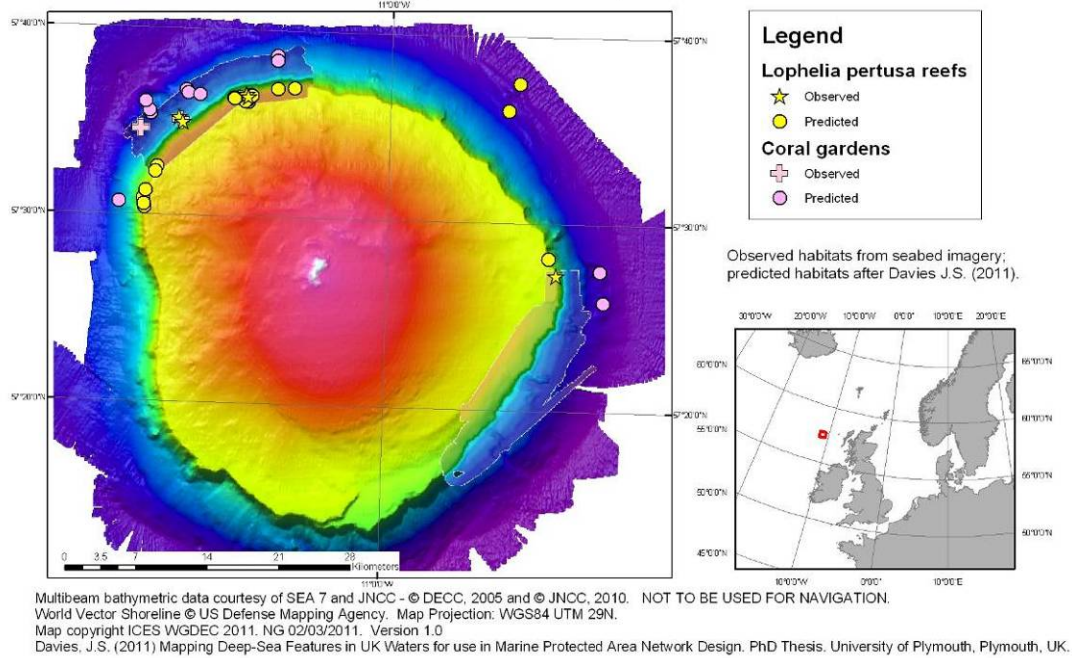


Figure 6. A composite image of the seamount built up using multibeam data. The new observations of VMEs and modelled prediction of VME habitat overlain.

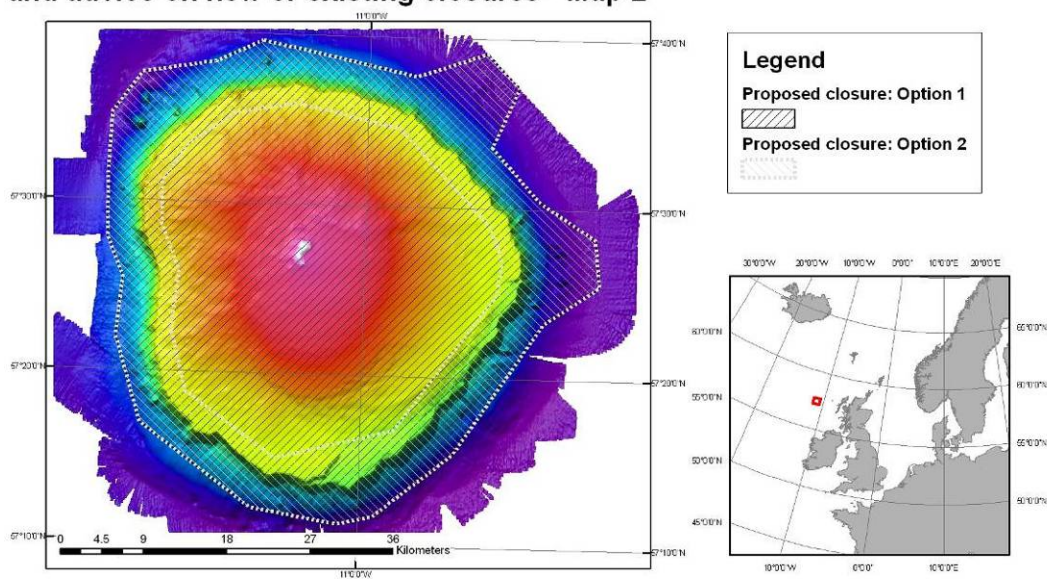
Based on this evidence it is clear that VMEs are most likely to be present down the steep flanks of the seamount and especially on the parasitic volcanic cones and peaks at the base of the seamount. There is a strong case that if these VMEs and habitats are to be protected the steep slopes of the seamount should be closed to bottom fishing.

The summit of this seamount contains large expanses of sand and area of exposed bedrock (Marine Scotland and DTI SEA7 surveys). In the sandy areas, corals are unlikely to be found in high densities, but few studies have considered the fauna of the sands found on the flat tops of seamounts and whether it constitutes a VME. In the North Atlantic a study by George and Schminke (2002) found that 54 of 56 species of harpacticoid copepods from Great Meteor seamount were new to science. Another group of small invertebrates that has been investigated on NE Atlantic seamounts is the gastropod family *Rissoiidae* (Gofas, 2007). These snails were collected by small dredge from 11 seamounts in the Lusitanian and Meteor seamount groups. In all 48 species were found, 30 of which were new. This suggests that seamounts with extensive sandy flat areas may harbour unique faunas. It is not known if the sandy summit areas of the Anton Dohrn seamount contain unique faunas, but until this can be discounted through further research, there is a precautionary basis for protecting the entire seamount from bottom fishing.

In order to protect VMEs on the seamount a closure to bottom fishing is suggested. Two closed area options have been presented (Figure 7, Tables 2 and 3). The outer extent of both closure options (Option 1 and 2) begins 3 km (approximately twice water depth) beyond where the slopes of the seamount meet the seafloor plains. This has been considered as a minimum measure to reduce the likelihood of VME damage from bottom fish-

ing (based on typical trawl warp lengths, SERAD 2001). There are minor extensions beyond this to encompass the parasitic volcanic cones that lie slightly beyond this boundary. Closure Option 1 would protect the entire seamount (flanks and summit) from bottom-trawling impacts. Alternatively a second option (Option 2) might be considered that left the summit of the seamount open to fishing. Closure Option 2 would be 'donut' in shape. The inner extent of this alternative boundary is approximately 2 km before the beginning of the steep slopes (approximately twice water depth at the break of slope). The donut design of closure does however leave the upper flanks and summit of the seamount vulnerable to straying of trawls at depth when vessels follow contours.

Anton Dohrn Seamount: Updated information on presence of VMEs and advice on new or existing closures - Map 2



Multibeam bathymetric data courtesy of SEA 7 © DECC, 2005. NOT TO BE USED FOR NAVIGATION.
 World Vector Shoreline © US Defense Mapping Agency. Map Projection: WGS84 UTM 29N.
 Map copyright ICES WGDEC 2011, NG 02/03/2011. Version 1.0

Figure 7. Map showing two options for closures to protect VMEs on the Anton Dohrn seamount. In Option 1 the outer boundary is the closure i.e. the entire seamount is closed. In Option 2 there is an inner boundary that created a 'donut' shaped closure allowing bottom fishing to take place on the summit area.

Table 2. Coordinates for Option 1 closure on Anton Dohrn seamount.

POINT NUMBER	LONGITUDE	LATITUDE	DECIMAL LONGITUDE	DECIMAL LATITUDE
1	11° 24' 36.16" W	57° 37' 33.98" N	-11.410044	57.626104
2	11° 16' 39.72" W	57° 38' 18.91" N	-11.277701	57.638586
3	11° 11' 39.76" W	57° 39' 37.27" N	-11.194379	57.660353
4	10° 54' 47.60" W	57° 37' 43.16" N	-10.913223	57.628657
5	10° 47' 11.73" W	57° 39' 8.84" N	-10.786591	57.652455
6	10° 43' 42.55" W	57° 37' 8.72" N	-10.728487	57.619090
7	10° 46' 29.61" W	57° 33' 37.51" N	-10.774890	57.560421
8	10° 41' 14.64" W	57° 30' 27.51" N	-10.687401	57.507642
9	10° 35' 7.73" W	57° 28' 18.68" N	-10.585481	57.471855
10	10° 34' 35.20" W	57° 25' 30.92" N	-10.576445	57.425255
11	10° 40' 31.56" W	57° 23' 18.74" N	-10.675434	57.388539
12	10° 50' 4.11" W	57° 15' 27.77" N	-10.834475	57.257714
13	10° 58' 28.40" W	57° 11' 44.85" N	-10.974555	57.195791
14	11° 2' 18.04" W	57° 11' 15.94" N	-11.038346	57.187760
15	11° 11' 36.97" W	57° 12' 6.98" N	-11.193603	57.201938
16	11° 23' 44.46" W	57° 16' 56.89" N	-11.395685	57.282470
17	11° 26' 35.69" W	57° 21' 58.29" N	-11.443248	57.366193
18	11° 26' 4.19" W	57° 25' 29.87" N	-11.434496	57.424963
19	11° 27' 50.55" W	57° 27' 51.01" N	-11.464041	57.464170
20	11° 27' 59.11" W	57° 31' 50.63" N	-11.466420	57.530731
21	11° 27' 45.66" W	57° 35' 11.67" N	-11.462683	57.586575

Table 3. Coordinates for Option 2 closure on Anton Dohrn seamount (including the inner ring).

POINT NUMBER	LONGITUDE	LATITUDE	DECIMAL LONGITUDE	DECIMAL LATITUDE
1	11° 11' 39.76" W	57° 39' 37.27" N	-11.194379	57.660353
2	10° 54' 47.60" W	57° 37' 43.16" N	-10.913223	57.628657
3	10° 47' 11.73" W	57° 39' 8.84" N	-10.786591	57.652455
4	10° 43' 42.55" W	57° 37' 8.72" N	-10.728487	57.619090
5	10° 46' 29.61" W	57° 33' 37.51" N	-10.774890	57.560421
6	10° 41' 14.64" W	57° 30' 27.51" N	-10.687401	57.507642
7	10° 35' 7.73" W	57° 28' 18.68" N	-10.585481	57.471855
8	10° 34' 35.20" W	57° 25' 30.92" N	-10.576445	57.425255
9	10° 40' 31.56" W	57° 23' 18.74" N	-10.675434	57.388539
10	10° 50' 4.11" W	57° 15' 27.77" N	-10.834475	57.257714
11	10° 58' 28.40" W	57° 11' 44.85" N	-10.974555	57.195791
12	11° 2' 18.04" W	57° 11' 15.94" N	-11.038346	57.187760
13	11° 11' 36.97" W	57° 12' 6.98" N	-11.193603	57.201938
14	11° 23' 44.46" W	57° 16' 56.89" N	-11.395685	57.282470
15	11° 26' 35.69" W	57° 21' 58.29" N	-11.443248	57.366193
16	11° 26' 4.19" W	57° 25' 29.87" N	-11.434496	57.424963
17	11° 27' 50.55" W	57° 27' 51.01" N	-11.464041	57.464170
18	11° 27' 59.11" W	57° 31' 50.63" N	-11.466420	57.530731
19	11° 27' 45.66" W	57° 35' 11.67" N	-11.462683	57.586575
20	11° 24' 36.16" W	57° 37' 33.98" N	-11.410044	57.626104
21	11° 16' 39.72" W	57° 38' 18.91" N	-11.277701	57.638586
22	11° 9' 9.09" W	57° 15' 3.61" N	-11.152525	57.251004
23	10° 56' 23.86" W	57° 16' 50.70" N	-10.939960	57.280750
24	10° 45' 37.39" W	57° 25' 0.61" N	-10.760387	57.416836
25	10° 45' 12.13" W	57° 27' 2.61" N	-10.753369	57.450726
26	10° 46' 31.75" W	57° 28' 55.44" N	-10.775487	57.482067
27	10° 56' 30.21" W	57° 34' 37.18" N	-10.941725	57.576994
28	11° 7' 47.86" W	57° 35' 57.91" N	-11.129961	57.599418
29	11° 14' 28.54" W	57° 35' 18.18" N	-11.241261	57.588384
30	11° 19' 28.90" W	57° 33' 20.97" N	-11.324695	57.555826
31	11° 22' 6.91" W	57° 31' 9.20" N	-11.368586	57.519222
32	11° 22' 1.12" W	57° 28' 37.64" N	-11.366977	57.477123
33	11° 19' 58.64" W	57° 25' 50.79" N	-11.332955	57.430774
34	11° 20' 42.29" W	57° 22' 32.45" N	-11.345080	57.375680
35	11° 18' 55.91" W	57° 18' 51.88" N	-11.315529	57.314410

3.2.3 Hatton Bank

Hatton Bank is a large deep-water bank lying west of the Rockall plateau that is entirely within international waters and which is regulated by the NEAFC. For the area with the UK continental shelf designated area, Hatton Bank has been recommended to UK Government as a draft SAC under the EC Habitats Directive. In addition, NEAFC closed a large portion of the upper bank to bottom fishing to protect VMEs (Figure 8). NEAFC has requested that ICES provide all new information on VMEs in the region and provide advice on appropriateness of current closure boundaries and whether they need to be revised.

New data on VMEs in the area were made available from a longline bycatch survey (Duran Munoz *et al.*, 2010; 2011 working document). Data on a variety of VME indicator species such as stony corals, black corals, and gorgonians indicate presence outside the currently closed area (Figure 8). Of note are several records of VME species just outside the northeastern boundary and the southern boundary of the current closure. Duran Munoz *et al.* (2011 working document) describe a trawl VME bycatch study in the Hatton area which will have significant bearing on this issue, but those data are unavailable at present. There is trawling activity in the area to the northeast of the bank (Benn *et al.*, 2010) and therefore these VMEs are likely to be at risk to damage.

Further to the southwest Duran *et al.*'s (2011) observations confirm the presence of VMEs in an area known as Edora's Bank. This is part of the extended continental shelf of Ireland and multibeam data has been collected by the Geological Survey of Ireland. This multibeam data were available to the group in a limited format via Google Earth (Figure 9) and suggests Edora's bank has high rugosity and elevated relief. Such physical features are characteristic of carbonate mounds, reefs or the type of seabed that VMEs are most likely to be found. Although it is unlikely that bottom trawling occurs in this area due to the rough terrain, the study of Duran *et al.* (2010) clearly demonstrated that longline bycatch of VMEs can be significant and may have cumulative impacts.

Hatton Bank: Updated information on presence of VMEs and advice on new or existing closures

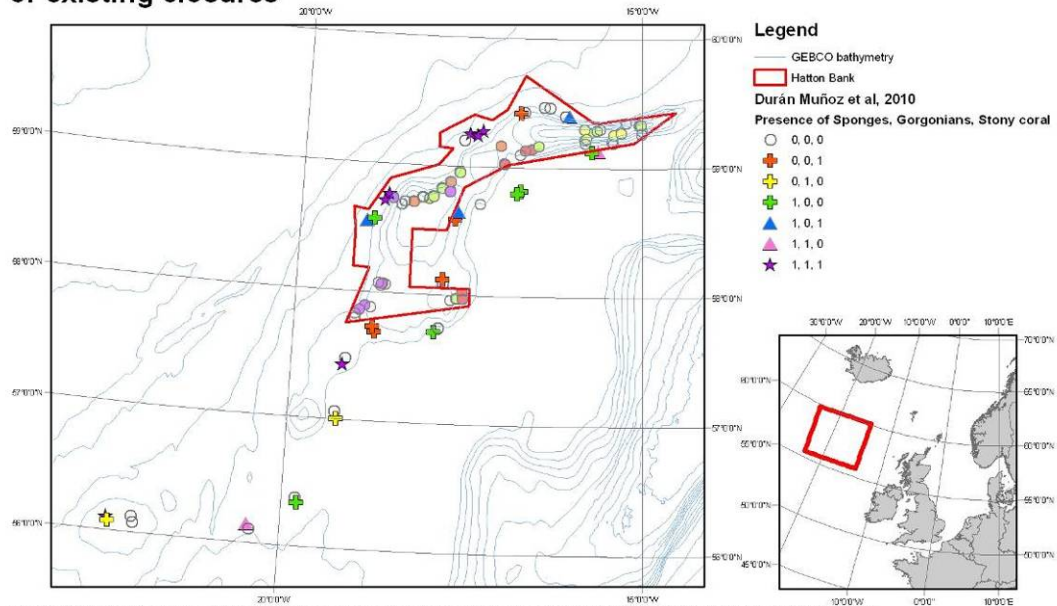


Figure 8. Map of the Hatton Bank area showing existing closure for protection of VMEs and new data provided by Duran *et al.* (2010) for VMEs taken as bycatch from longline vessels. Note the pale filled circles represent data from previous surveys (SEA7: DTI) and WGDEC reports. The area to the far southwest corner of the map is known as Edora's bank.

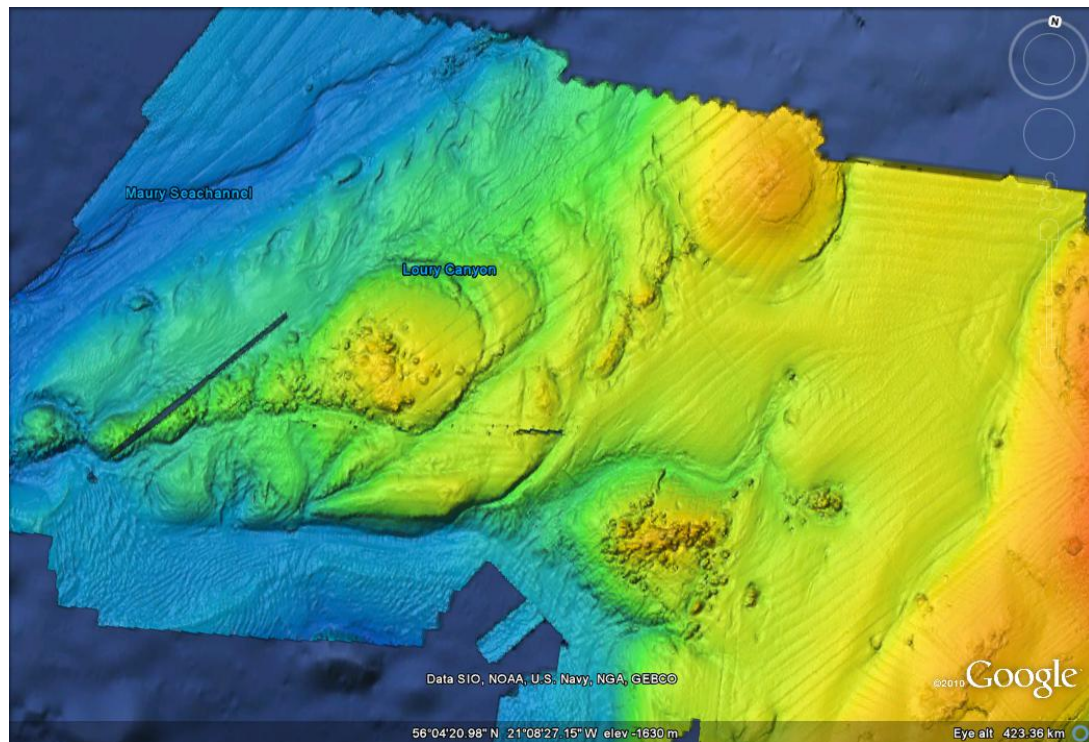


Figure 9. Image of multibeam data for the area to the southwest of Hatton Bank. Two areas of extreme seabed rugosity are evident; Edora's bank (and Loury Canyon) in the west and Fangorn bank (to the southeast of Edora's bank). Data copyright Geological Survey of Ireland.

Based on this new evidence it is clear that there are potentially important areas of VMEs in the Hatton bank region that currently lie outside the existing closure. The main source of new data are however from longline bycatch which is valuable for indicating presence of VME's, but inappropriate to assessing density of VMEs. Recent trawl survey, for which the data are currently being identified and verified (Duran *et al.*, 2011, working document), will be informative in this respect. The Working Group decided to postpone suggesting any revision to the current closure boundary until these data become available. It is recommended that next year the group obtains better resolution of the Irish multibeam data and includes new developments in predictive habitat modelling. Together these information sources will form a much stronger advisory basis for revising the current closure.

3.2.4 Norwegian sea areas

3.2.4.1 New information about occurrence of *Lophelia pertusa* reefs

New data on *L. pertusa* reefs are updated regularly by the Institute of Marine Research, Norway. The list contains information about geographic position, depth, status of reef (dead, live, damaged, etc), date and source of record. On behalf of Norway, IMR submitted new information about *Lophelia* reef occurrences to OSPAR in 2010. This list contained additional information that had been accumulated since 2008 (Figure 10).

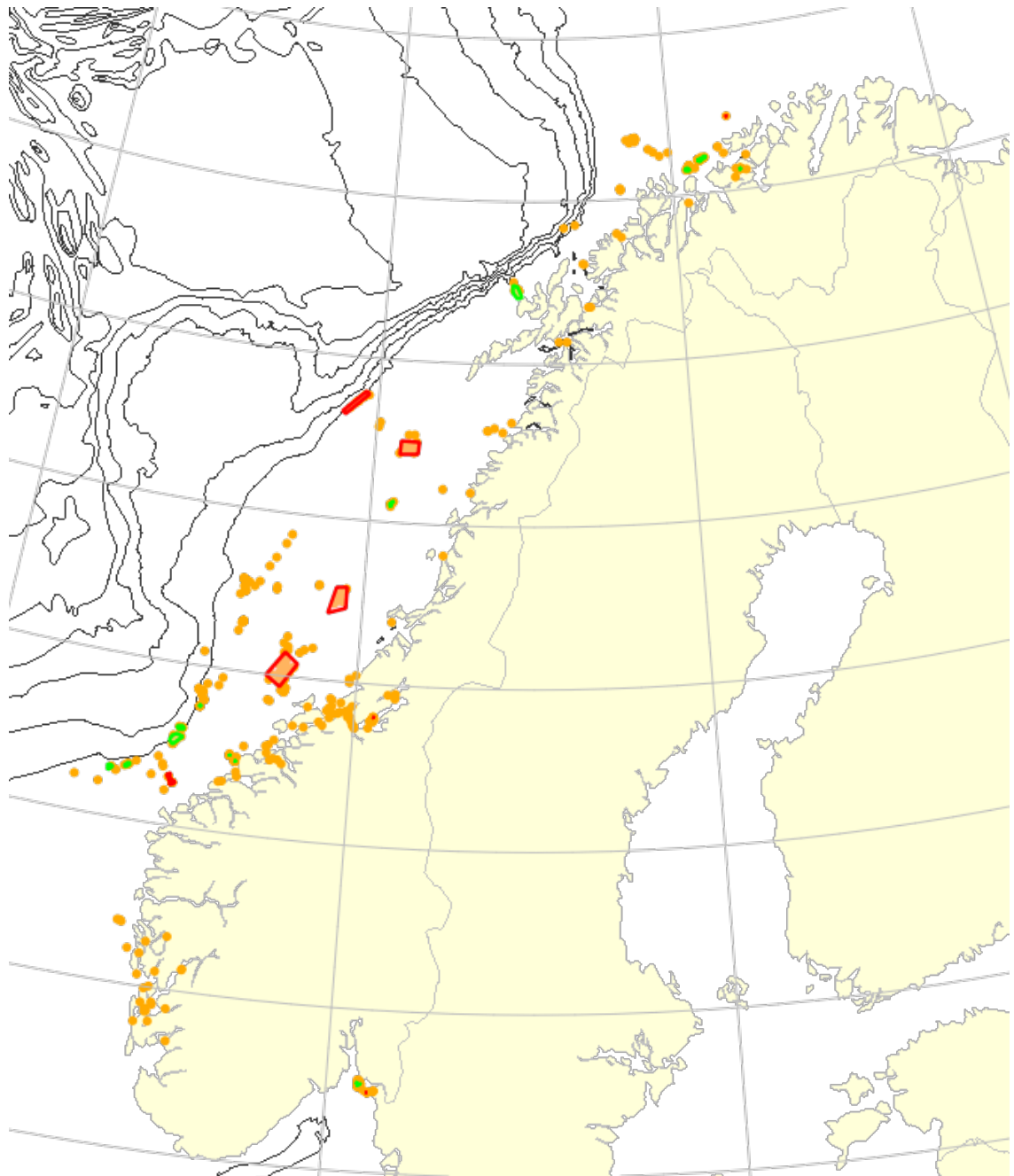


Figure 10. Updated map of distribution of *Lophelia pertusa* in Norway. Orange dots are individual records and green symbols represent areas with several reefs. Established protection areas are indicated with red polygons (www.Mareano.no).

Several new individual reefs have been reported in connection with seabed surveys of areas with planned petroleum related installations. The seabed mapping project Mareano has documented many new coral reefs off Northern Norway. In 2008 this project mapped a *Lophelia* reef area known as Hola or Floholmen (Figure 11). Reefs in this area had previously been documented by IMR, but the mapping by Mareano documented that this area contain a cluster of around 330 individual reefs. These reefs are elongated up to around 250 m long, directed with a live front facing the main current direction.

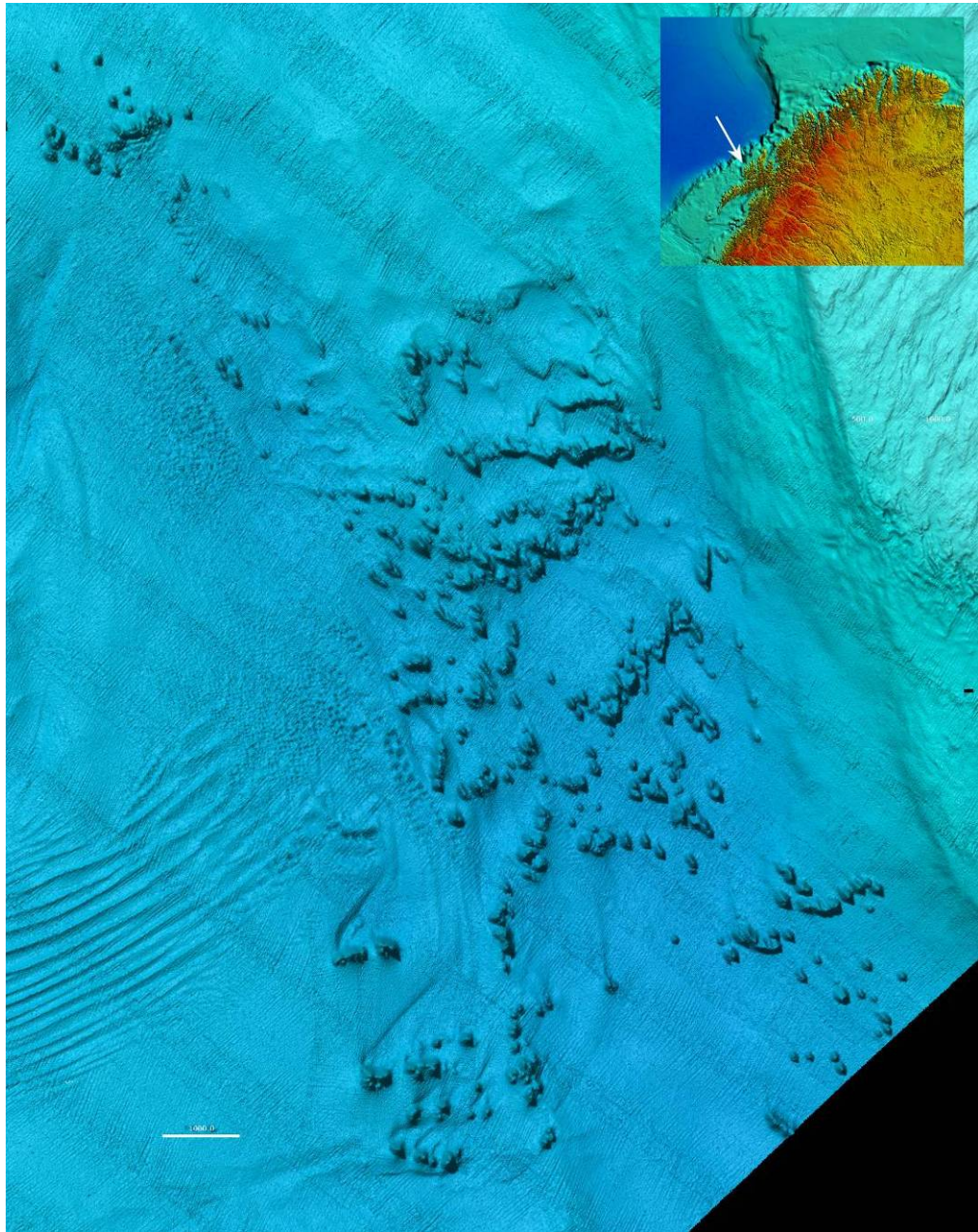


Figure 11. Bathymetry of the Hola reef area. The area to the left of the reefs contain large sand wave (www.Mareano.no).

In the area off the coast of Troms and Finnmark counties (Sotbakken and NW of Fugløy-banken), Mareano mapped eight new coral reefs in 2010 (Figures 12 and 13). Detailed studies have been continued at Korallen (the northernmost *Lophelia* reef) and LoppHAVet reef area as part of the HERMIONE project.

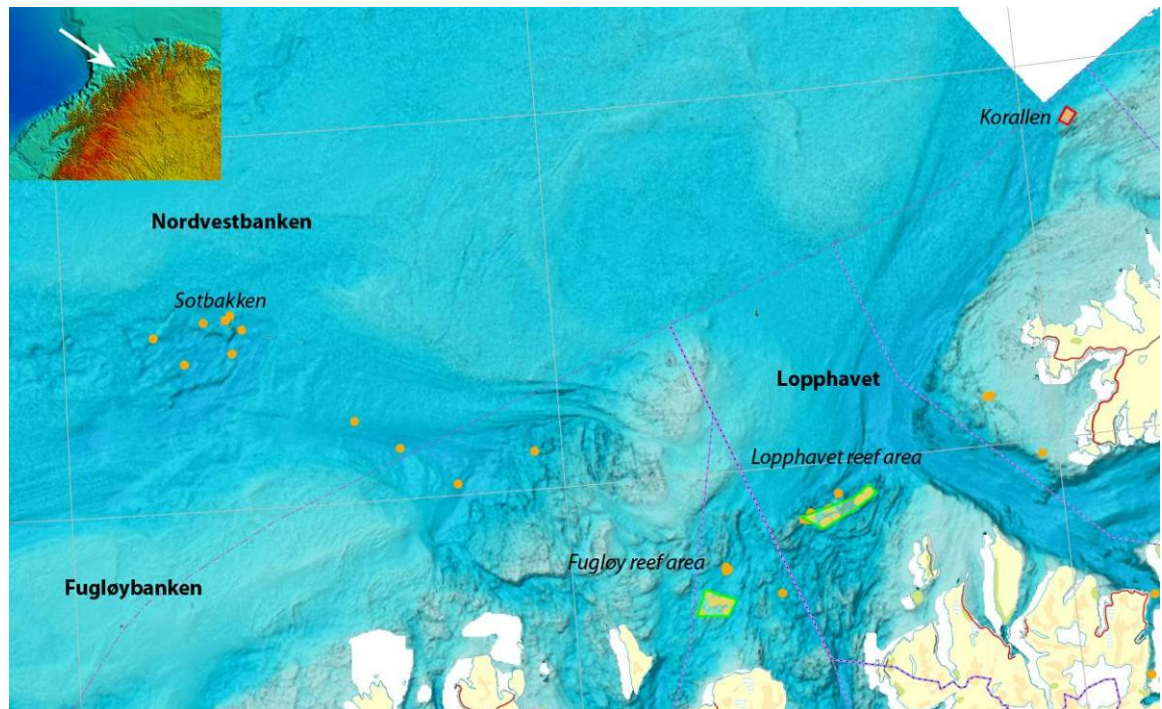


Figure 12. Locations with *Lophelia* reefs off Troms and Finnmark county, Northern Norway. The new reefs mapped by Mareano in 2010 are located in the Sotbakken area and NW of Fugløybanken.



Figure 13. Image from one of the newly discovered *Lophelia* reefs NW of Fugløybanken. The actinarian *Protanthea simplex* dominates the associated fauna on many Norwegian reefs.

As part of the HERMIONE project several reefs at Korallen and the LoppHAVET reef area have been revisited in 2010. A protection area was established around Korallen in 2009,

but all traces of impact by bottom trawling seem to be older than this (Figure 14). IMR has monitored korallen since 2006.



Figure 14. Bottom gear with bobbins from trawl, and gillnet observed at Korallen in 2010.

3.2.4.2 New information on the distribution of coral garden habitats in Norway

The information about distribution of gorgonian corals or other corals that constitute coral garden habitats have not been systematically compiled in Norway. New information about this comes through the Mareano project (Figure 15). The hard-bottom coral gardens are represented with larger gorgonians (*Paragorgia arborea*, *Primnoa resedaeformis*, *Paramuricea placomus* and unidentified gorgonians) and “meadows” of cauliflower corals (*Duva florida*, *Drifa glomerata* and *Gersemia rubiformis*). The soft bottom coral gardens are represented by *Isidella lofotensis* in the inshore Andfjorden area and *Radicipes* sp. in the offshore northern area.

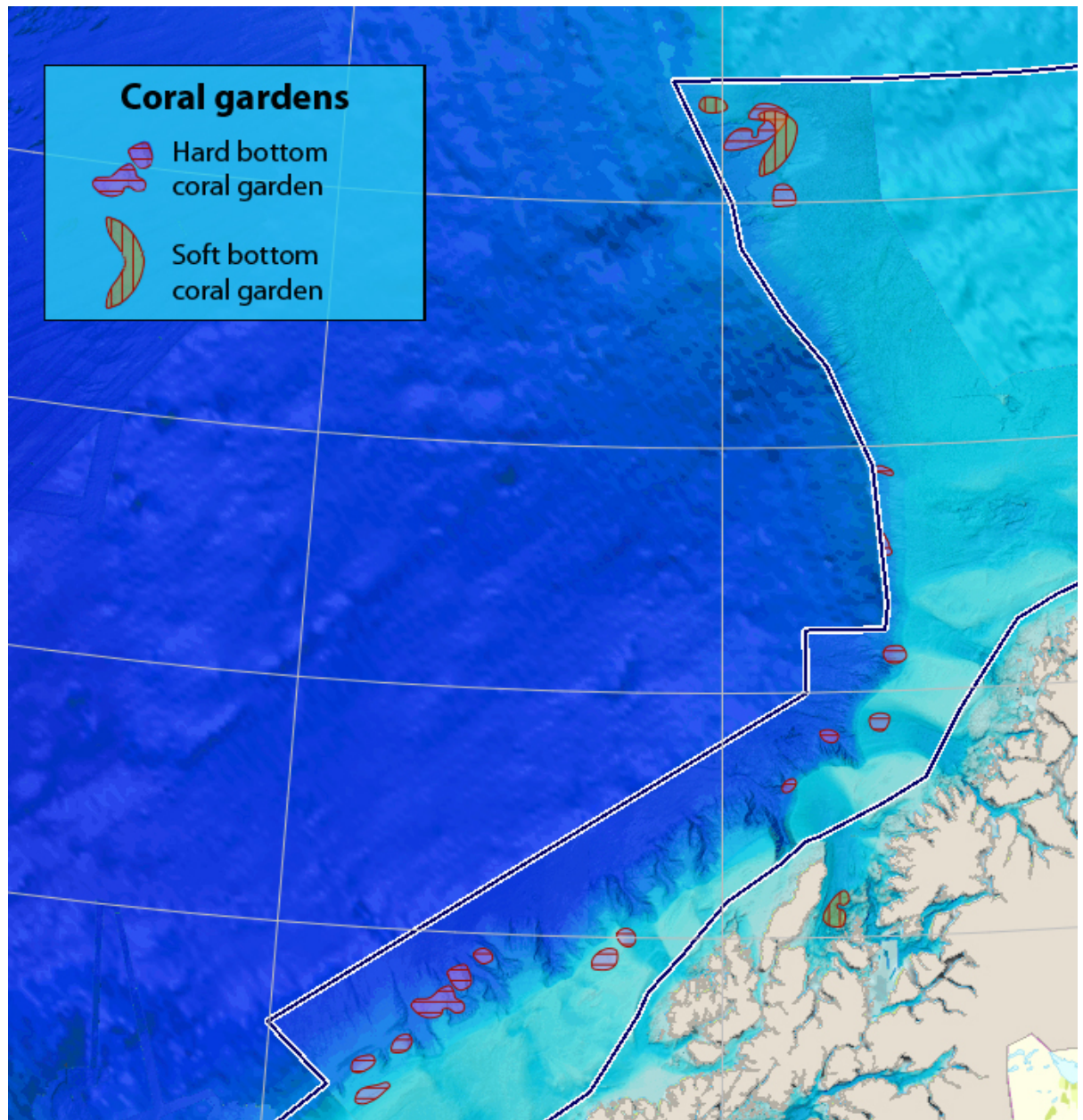


Figure 15. Coral gardens mapped by MAREANO. The hard bottom coral gardens are represented with larger gorgonians (*Paragorgia arborea*, *Primnoa resedaeformis*, *Paramuricea placomus* and unidentified gorgonians) and “meadows” of cauliflower corals (*Duva florida*, *Drifa glomerata* and *Gersemia rubiformis*). The soft bottom coral gardens are represented by *Isidella lofotensis* in the inshore Andfjorden area and *Radicipes* sp. in the offshore northern area (www.mareano.no).

In 2009 Mareano documented fields with the gorgonian coral *Radicipes* sp. (Chrysogorgiidae) at depths between 600 and 800 m in the area known as the Bjørnøya slide (71°16'N, 15°40'E; Figure 16). The density of *Radicipes* colonies was up to 5.3 per m² locally (P. Buhl-Mortensen, IMR, unpublished results). The area with occurrence of this coral had an extension of about 4000 km². Trawl marks from fisheries (most likely targeting Greenland halibut) were very common in the area.

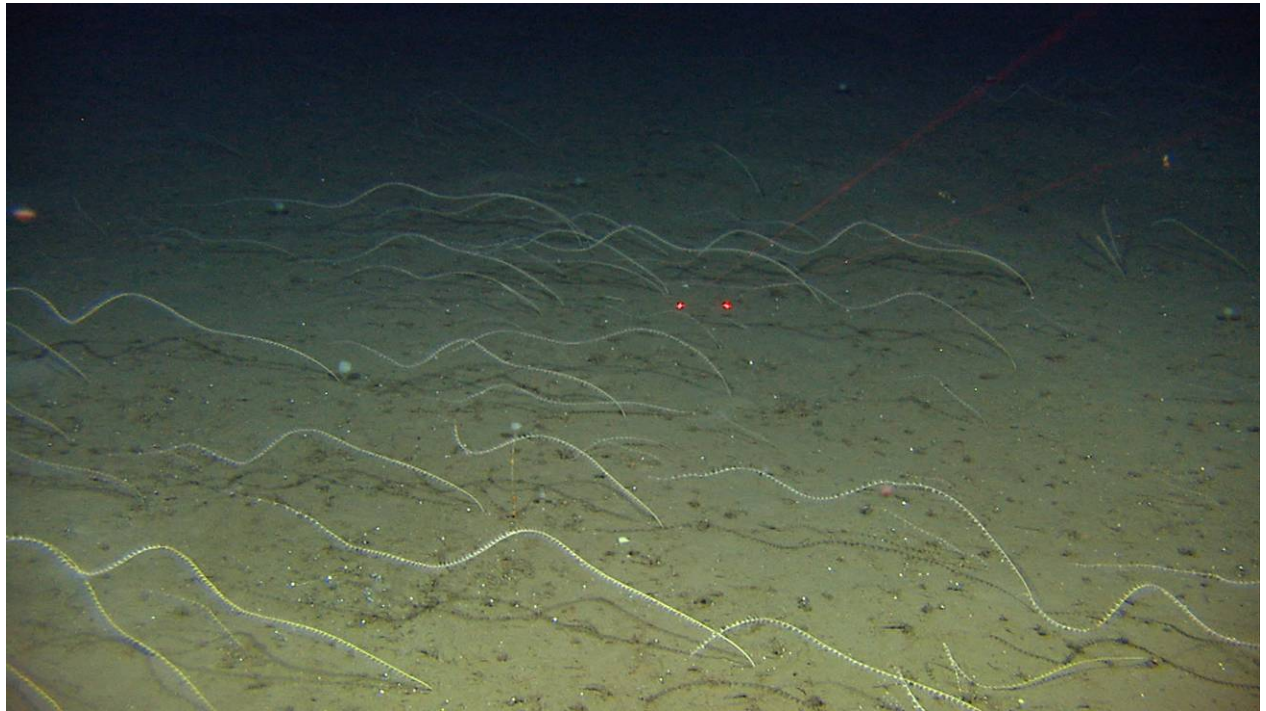


Figure 16. Field of *Radicipes* sp. colonies in the Bear Island slide area. The red dots indicate a scale of 10 cm.

3.2.4.3 New information on the distribution of sponge communities in Norway

The information about distribution of sponge species has not been systematically compiled in Norway. In 2010 WGDEC presented a map of bycatch of sponge from trawl surveys. This indicated high abundance of sponges in the southern part of the Barents Sea. New information about sponge habitats comes through the Mareano project (Figure 17). Information about distribution of different sponge species has not yet been published from Mareano, but identified “hot spots” of larger Demospongia and of Hexactinellida has been indicated on maps made available online (Figure 18, www.mareano.no). The Demospongia sponge grounds are mainly represented by larger sponges (*Geodia* spp., *Aplysilla sulfurea*, *Stelletta* sp. and *Stryphnus ponderosus*) and Hexactinellida sponge grounds are commonly represented by *Caulophacus arcticus* and different unidentified species.

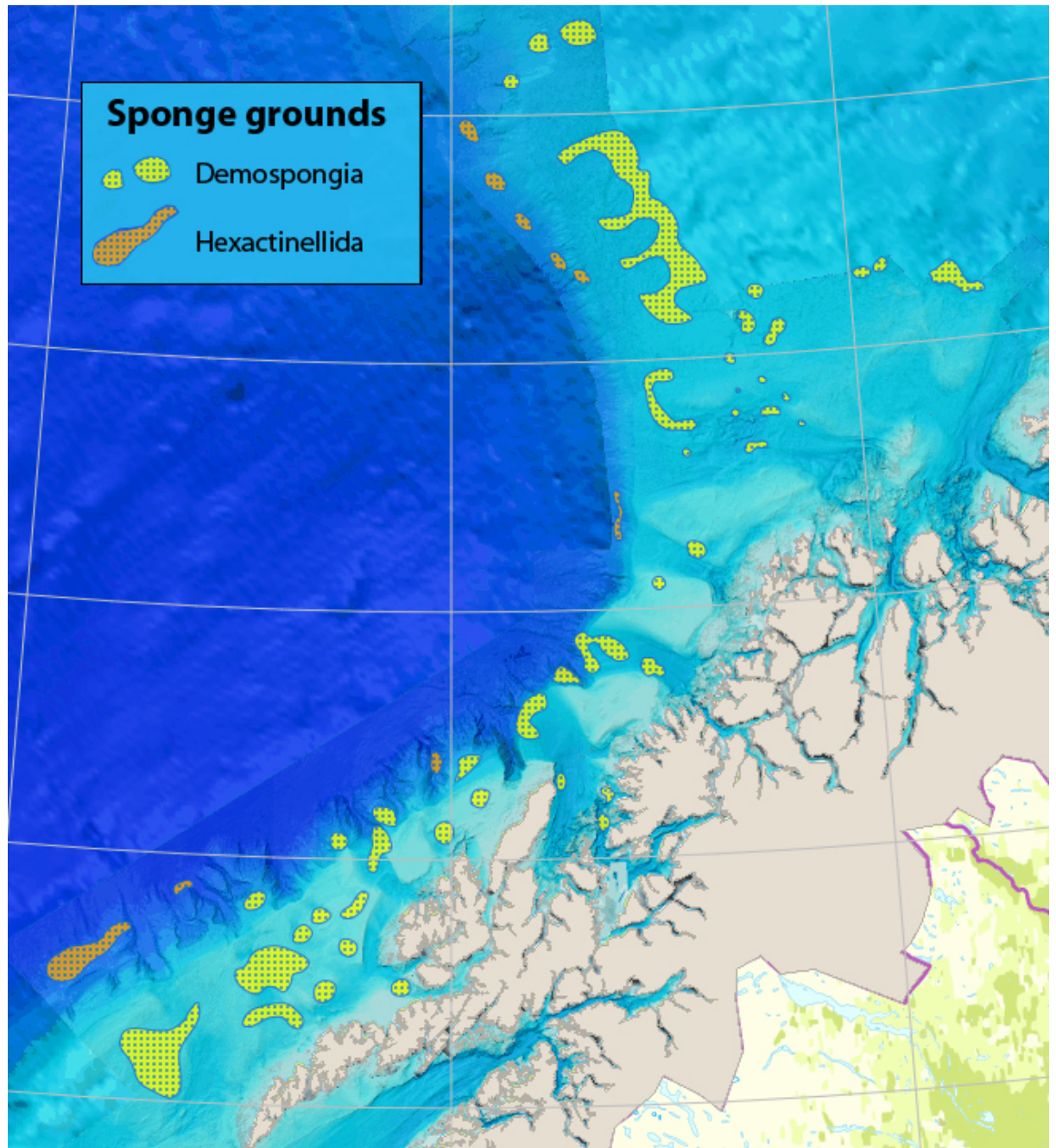


Figure 17. Sponge grounds mapped by MAREANO. The Demospongia sponge grounds are mainly represented by larger sponges (*Geodia* spp., *Aplysilla sulfurea*, *Stelletta* sp. and *Stryphnus ponderosus*) and Hexactinellida sponge grounds are commonly represented by *Caulophacus arcticus* and different unidentified species (www.mareano.no).

3.2.5 Reykjanes ridge area

Two historical (1981) observations from Russian research trawl surveys were made available (Vinnichencko and Fomin, 2011 working document) in the area of the Reykjanes ridge (northern Mid-Atlantic Ridge) in depths of around 1200 m. One record reports cold-water coral (species not identified) at the position of approx. 61.00°N, 28.42°W. The

other was a large bycatch (5 T) of sponges (species not identified) at the position of 60°20N, 29.17°W. The latter record falls within the northern most closure adopted by NEAFC in 2010. Given that these records are over 30 years old and one was within an already closed area, WGDEC did not consider this to be a sufficient basis to suggest any boundary revision.

3.2.6 Bay of Biscay

The French margin in the Bay of Biscay is shaped by a succession of more than 130 deep canyons and interfluves. Cold-water coral reefs and deep-sea sponge grounds are known to occur in the Bay of Biscay since the beginning of the 20th century. Until recently very few benthic studies have been undertaken in this area. The *Lophelia pertusa* occurrences in the OSPAR database, updated in 2008, result mainly from very old observations (Figure 18). However, since 2008, under EU CoralFISH project, multibeam surveys have been conducted in this area (Figure 19) allowing the creation of accurate Data Terrain Models (15 to 25 m grid spacing). A classification methodology based on a combination of several morphological attributes have been applied to DTM (Bourrillet *et al.*, in preparation).

From 1996 to 2010, twelve surveys using Remotely Operated Vehicles, submersibles or towed cameras have been conducted on the canyons and the open slope of the Bay of Biscay with collections of video and still images (Figure 20). Most of the images have been acquired along-transects over a depth range of 180–2000 m. Until 2008, most of the campaigns have been designed for geological purposes; the more recent ones focus on VMEs. Image analysis is conducted using an annotation procedure based on knowledge tables defined with other CoralFISH partners. The first results (Guillaumont *et al.*, in preparation) showed that VME species were encountered in most of the dives (Figure 21). Various VME habitat/communities dominated by coral or sponges have been recognized and mapped. Main coral reefs (Figures 22 and 23) have been observed in the central part of the margin. The reefs are composed of *Madrepora oculata* and *Lophelia pertusa*. The associated fauna includes various antipatharians, gorgonians and hexactinellid sponges. Main reefs have been observed in the central part of the margin. They occurred to depths of 1100 m. At depths above 500 m, only coral rubble was observed. Trawl impacts have been observed in many reef areas including deep areas. Others VME habitat/communities have been recognized including sponges and coral gardens (Figure 24) and new proposals for the habitat classification scheme being prepared. A high density of antipatharians has been observed on a mainly dead coral reef (Figure 25). Some localized areas of hard bottom substratum are colonized by demosponge beds or by coral gardens. The stony coral *Enallopsammia rostrata* occurs on vertical cliffs around 1500 m (Figure 26). On soft sediments, the two main pennatulid (sea-pen) habitats are dominated by *Kophobelemnon* and by *Funiculina quadrangularis* (in association with burrowing megafauna). Bamboo coral fields are also well represented on soft bottom with *Acanella arbuscula* or other large Isididae, sometimes associated with stalked sponges (Figure 27). The sponge grounds with *Pheronema carpenteri* are present in various localities. A new survey with RV 'Pourquoi Pas?' with ROV is planned in September 2011.

Localisation of *L. pertusa* reefs along the French margin in the Bay of Biscay, according to the OSPAR data base (updated in 2008)

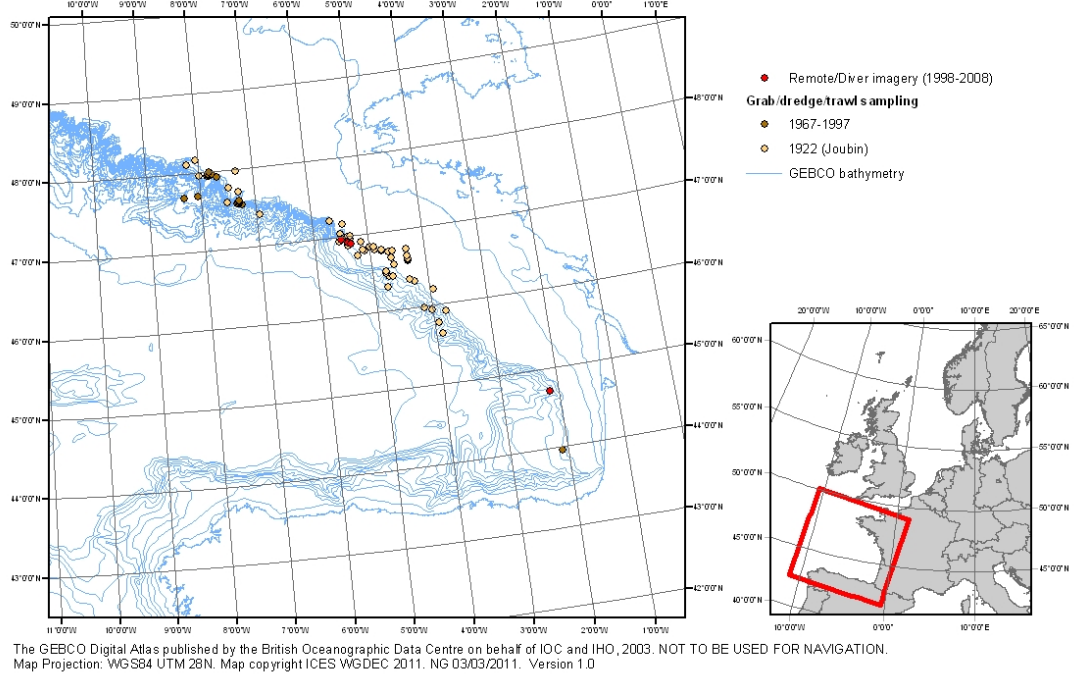


Figure 18. Map showing occurrences of *Lophelia pertusa* reefs in the Bay of Biscay according to the OSPAR database.

BOBGE01 and 2 (2009-2010) multibeam surveys along the French margin in the Bay of Biscay (Bourillet et al., under publication)

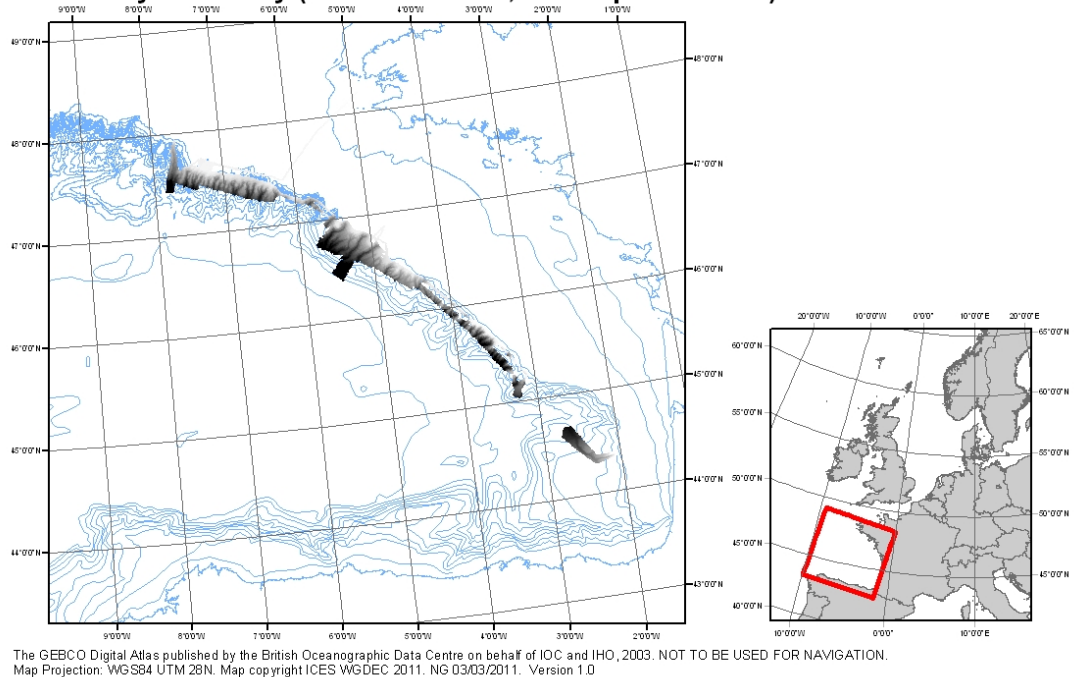
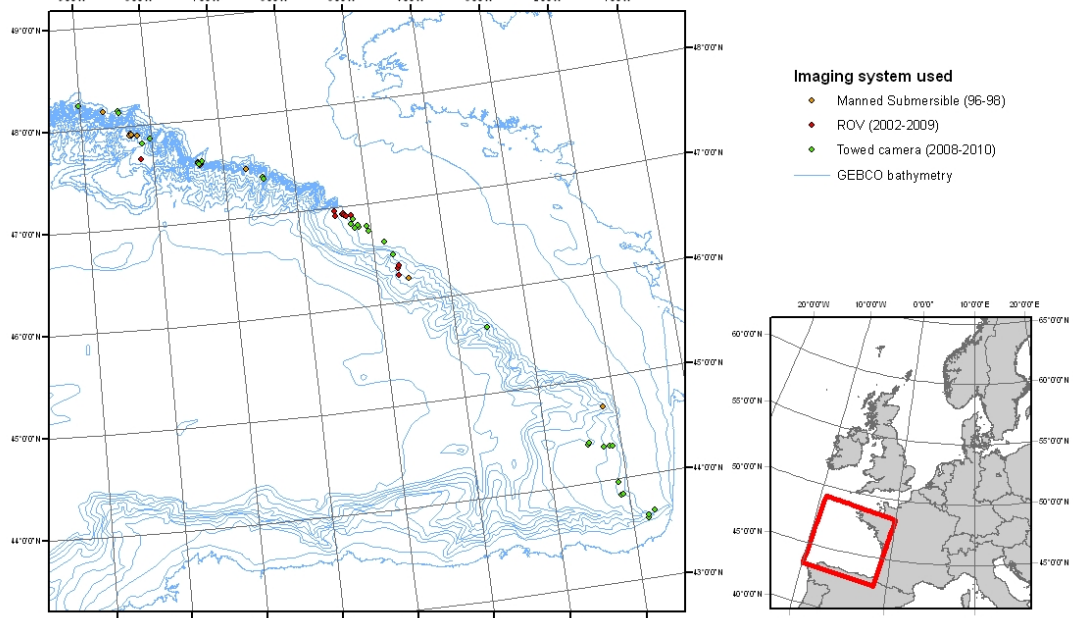


Figure 19. Map showing the extent of recent multibeam surveys carried out in the Bay of Biscay.

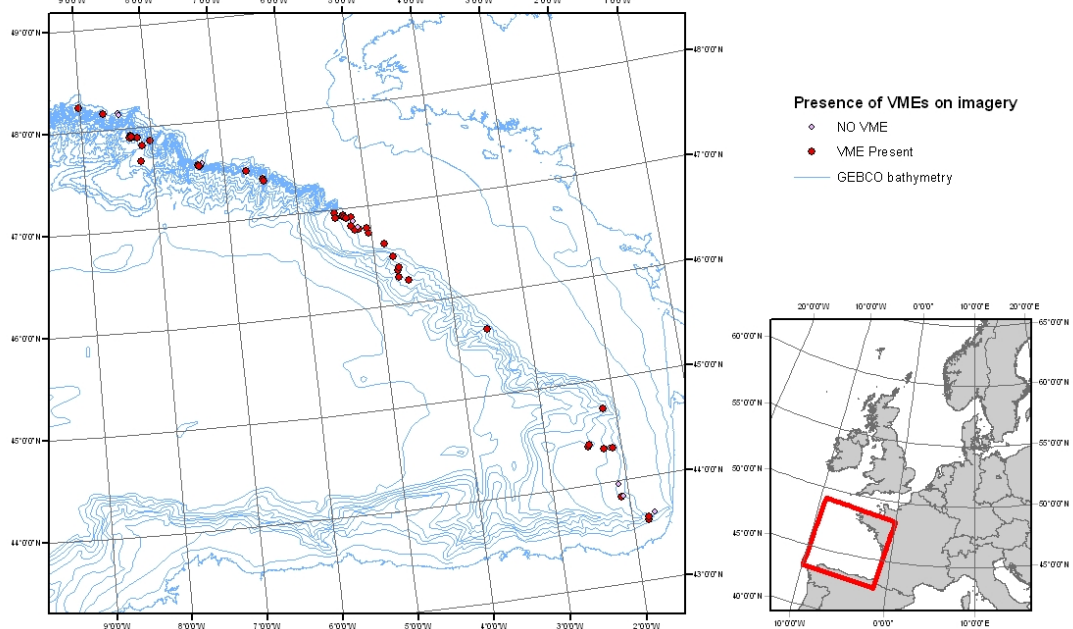
Localisation of dives with imagery along the French margin in the Bay of Biscay (IFREMER, CoraFISH and Hermione projects)



The GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003. NOT TO BE USED FOR NAVIGATION. Map Projection: WGS84 UTM 28N. Map copyright ICES WGDEC 2011. NG 03/03/2011. Version 1.0

Figure 20. Map showing recent survey sites for VMEs in the Bay of Biscay.

Updated occurrences of VME species along the French margin in the Bay of Biscay (Guillaumont et al., under publication)



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Figure 21. Map showing presence and absence of VMEs based on recent surveys.

Updated localisation of *L. pertusa* / *M. oculata* reefs along the French margin in the Bay of Biscay (Guillaumont et al., under publication)

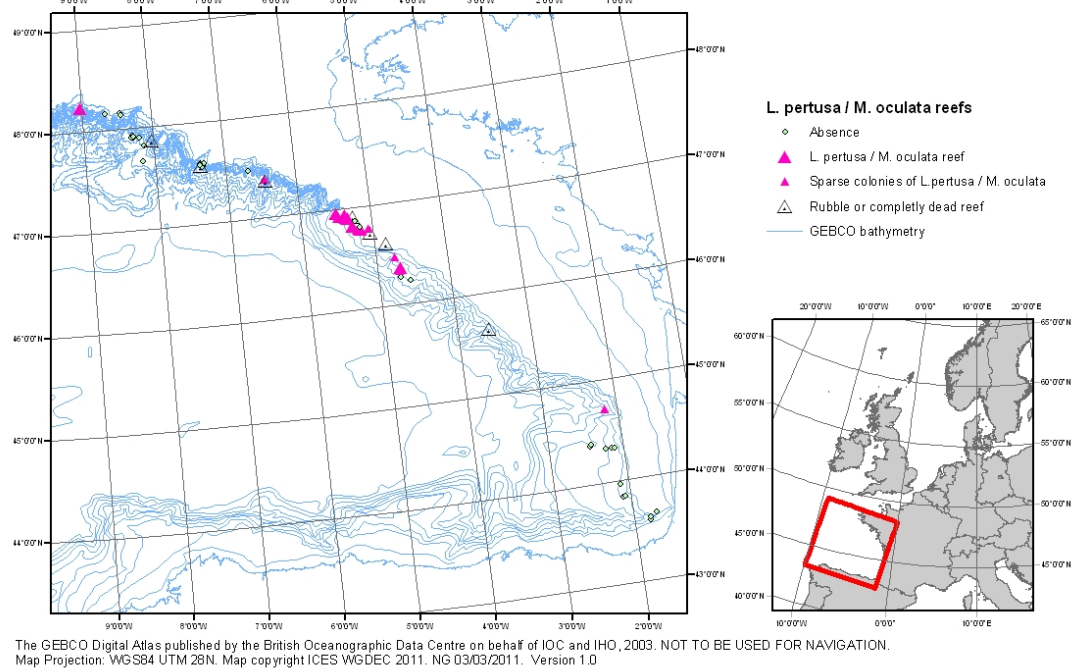
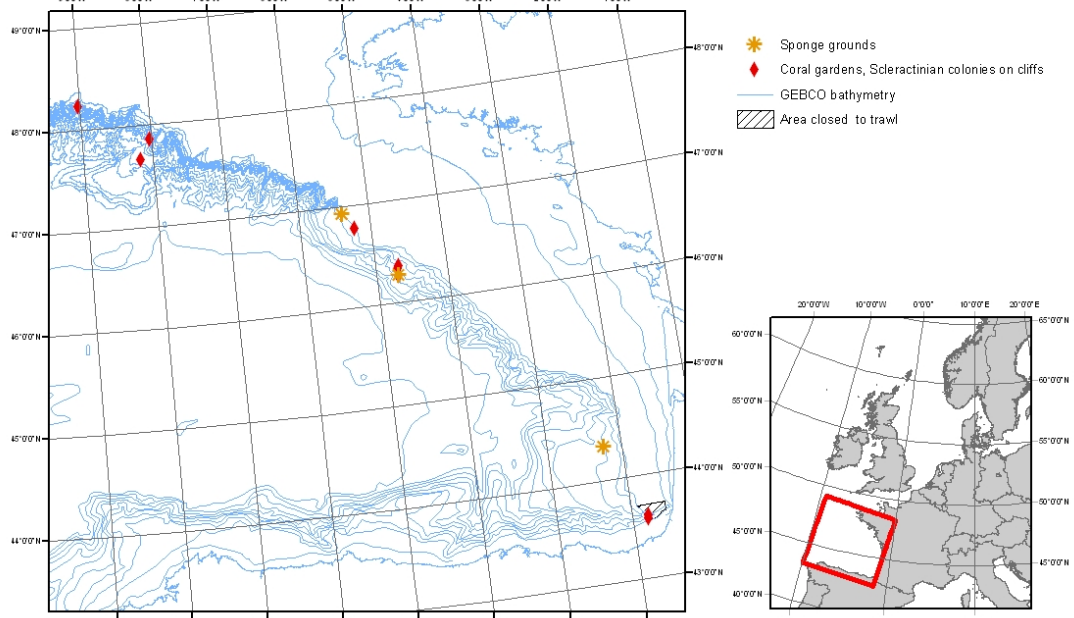


Figure 22. Map showing localities of major reef forming corals.



Figure 23. *Lophelia pertusa* and *Madrepora oculata* reefs from the Bay of Biscay. ©NUIG, CE0908.

Updated localisation of non-reefs habitats considered as VMEs along the French margin in the Bay of Biscay (Guillaumont et al., under publication)



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Figure 24. Map showing localities of sponge grounds and coral gardens in the Bay of Biscay region.

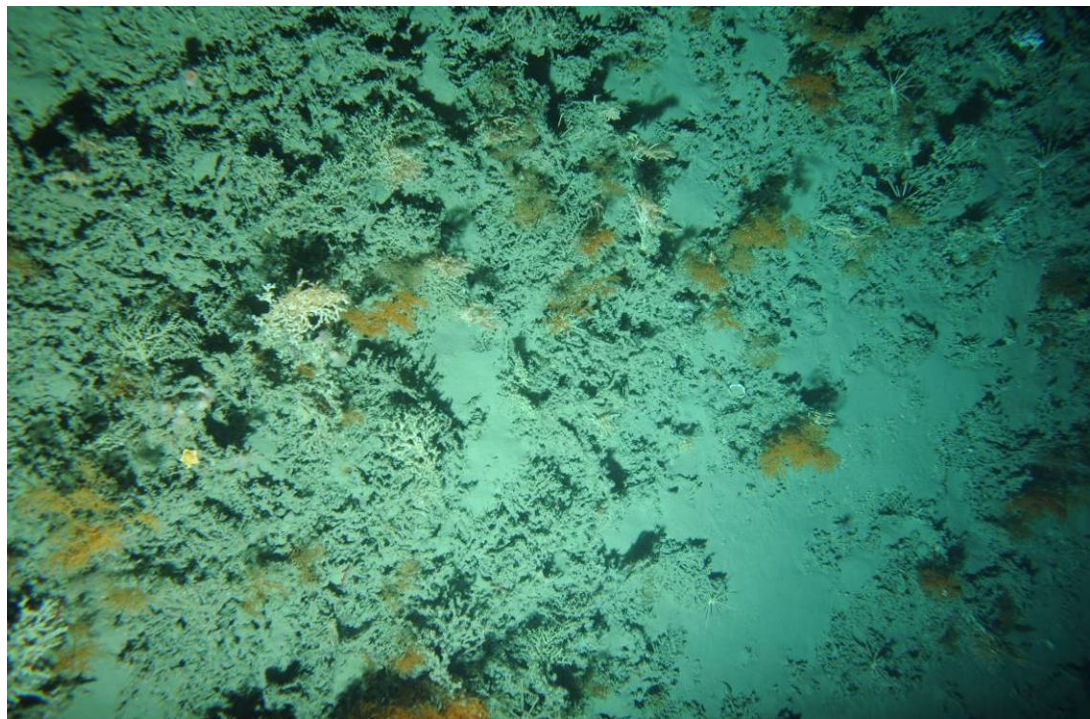


Figure 25. Coral garden dominated by Antipatharians on a mainly dead *L. pertusa* reef ©Ifremer. EVHOE2009.



Figure 26. Vertical wall colonized by *Enallopsammia_rostrata* ©Ifremer.

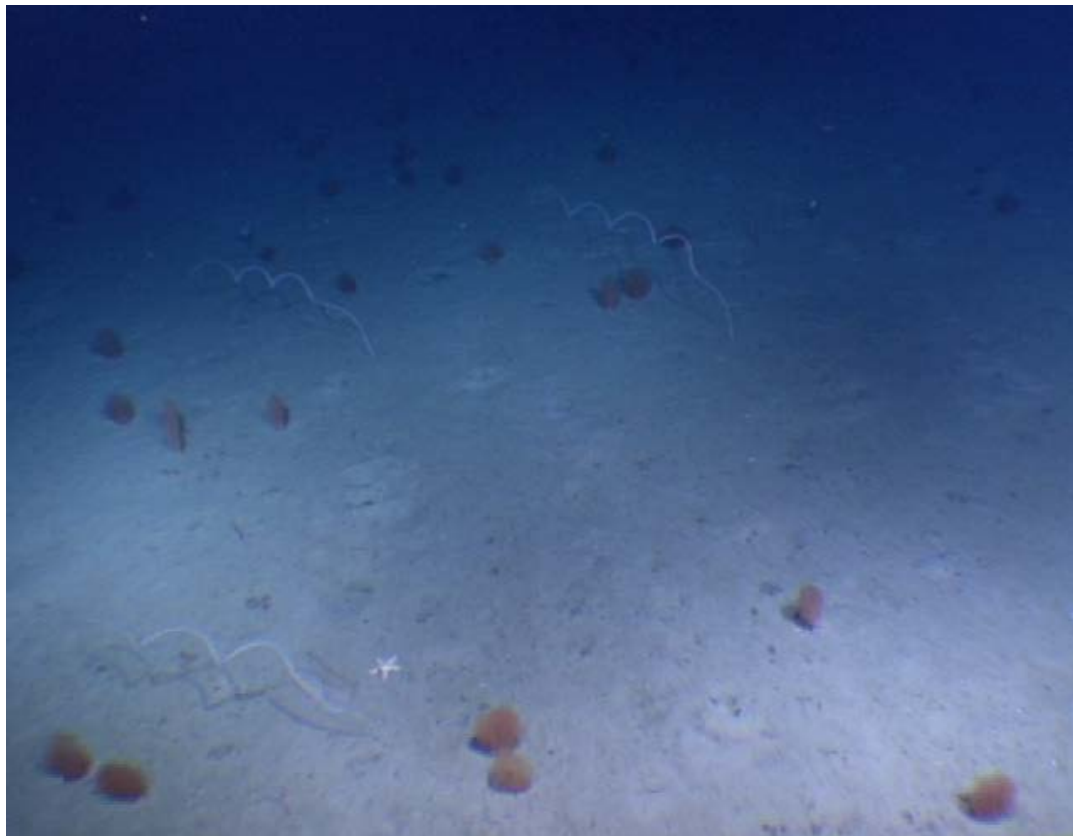


Figure 27. Soft bottom with *Acanella arbuscula*, an undetermined Isididae, and the stalked sponge *Hyalonema Thomsoni*, ©Ifremer, VITAL.

Main areas of interest considering VMEs along the French margin in the Bay of Biscay

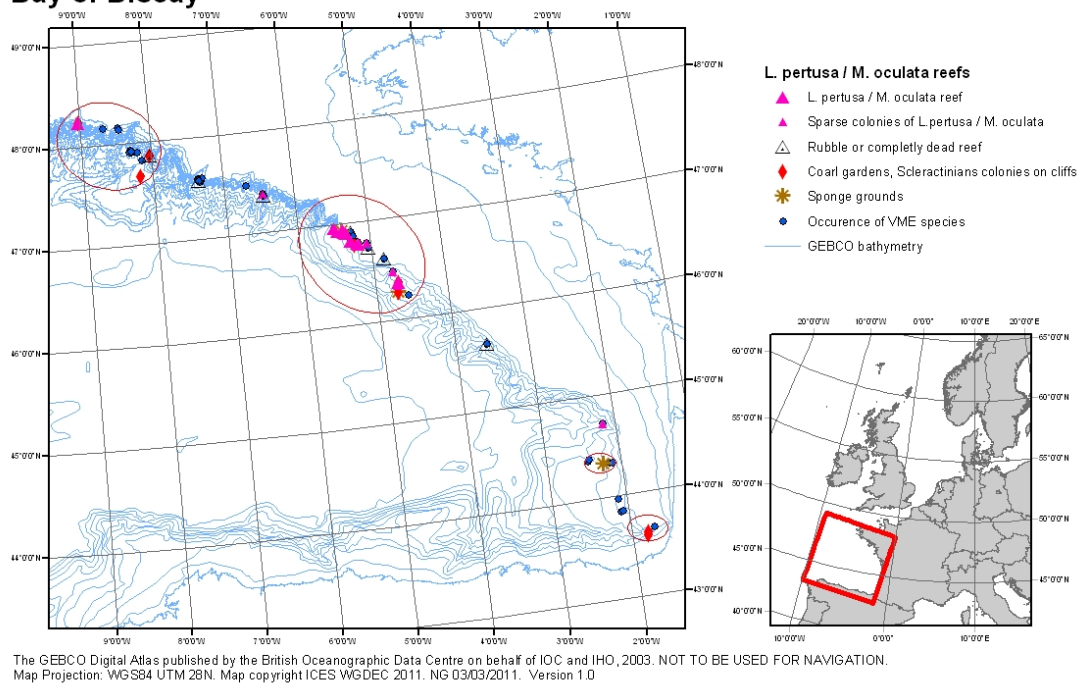


Figure 28. Map showing all categories of VMEs in the Bay of Biscay. Circled areas represent the most important concentrations of VME habitat.

Implications for closures to protect VMEs on the bay of Biscay slope

The evidence presented suggests significant concentrations of VMEs at various locations on the slope of the Bay of Biscay (Figure 28). Currently only one small area, situated in the southeastern part (Cap Breton canyon), is closed to bottom trawling. It is the only area belonging to the deep-sea-pen and burrowing megafauna community where penatulids were present in high densities. For the remainder of the area, there is the risk of impact from bottom fisheries. In particular an area situated in the central part of the Bay of Biscay (central circled area in Figure 28) appears to be especially important for reef forming corals and would benefit from protective measures from bottom contact fishing.

3.3 Northwest Atlantic

In the NW Atlantic new data were available for the slope of the Grand banks and Flemish Cap area and an area west of Greenland.

3.3.1 Grand Banks and Flemish Cap

Data on VME occurrences were collected by the NAFO observers aboard Russian fishing vessels in 2010 (Vinnichenko *et al.*, 2011, working document). The observations were conducted during the Greenland halibut, redfish and shrimp fisheries in the NAFO Regulatory Area between 42°46'–48°40'N and 44°21'–50°02'W at 180–1200 m depths. The new information suggests concentrations of seapens (Figure 29) and black corals (Figure 30) outside existing closed areas.

North West Atlantic (Grand Banks and Flemish Cap): Updated information on presence of VMEs and advice on new or existing closures - Map 1

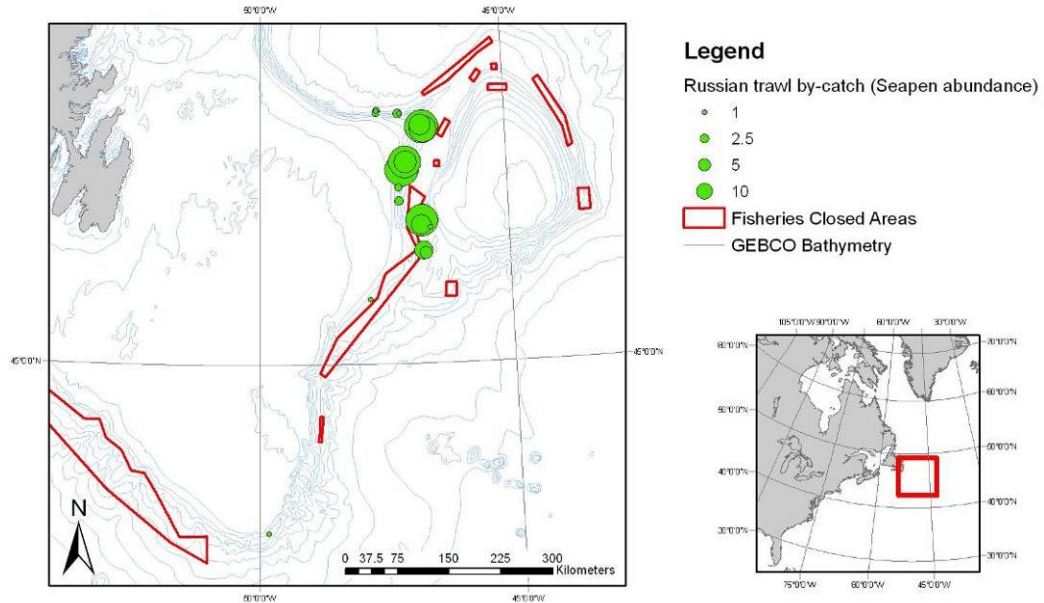


Figure 29. Map showing areas where seapens were observed as bycatch from trawl surveys.

North West Atlantic (Grand Banks and Flemish Cap): Updated information on presence of VMEs and advice on new or existing closures - Map 3

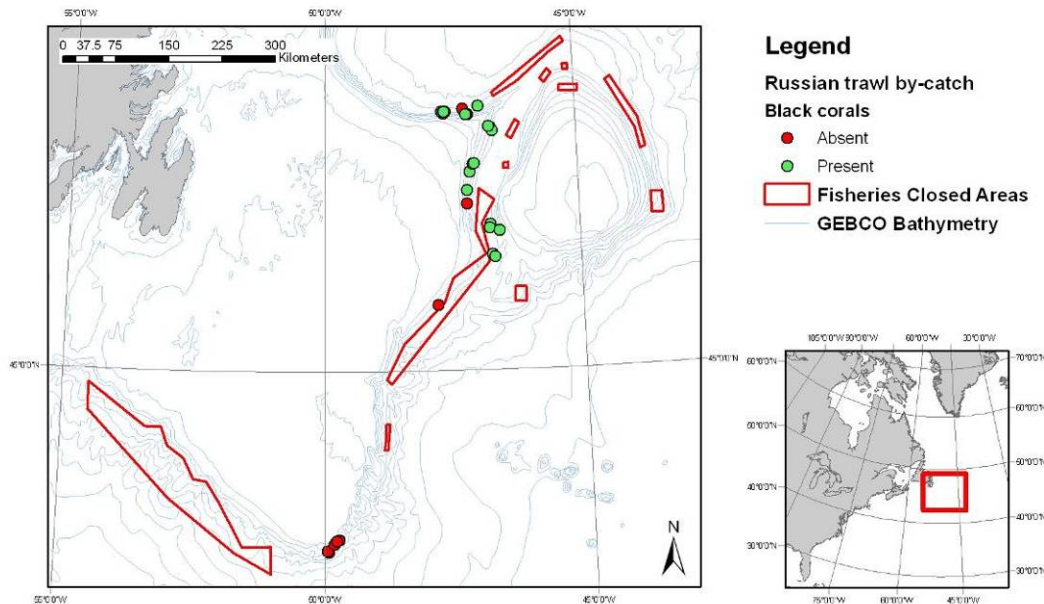


Figure 30. Map showing areas where black corals were observed as bycatch from trawl surveys.

The NEREIDA project; a new research programme expected to produce new information on VMEs in the NW Atlantic

NEREIDA is a Spanish-led multidisciplinary international research project involving active participation by Spain, Canada, the UK and the Russian Federation. The driving force for this initiative is to collect data for the identification of vulnerable marine ecosystems in the NAFO regulatory area (NRA), especially those which are dominated by large deep-water corals and sponges. NAFO is responsible for the management of these international waters and has been moving forward on ways to protect these habitats from damage by fishing gear. NAFO is anticipating the results of the NEREIDA surveys before reviewing the area closures put in place in 2010 to protect corals and sponge grounds.

NEREIDA field programmes were completed in 2009 and 2010 using two platforms, the Spanish oceanographic research vessel *Miguel Oliver* and the Canadian Coast Guard Ship *Hudson*. Research areas include geomorphology, sedimentology and benthic ecology and interrelationships among them. Data were collected using a high resolution multibeam echosounder, high resolution seismic, boxcorers (N=341), rock dredges (N=104), trawls (N≈2500), drop cameras, and ROVs. The *in situ* photographic database collected under the auspices of the NEREIDA programme consists of 2143 photographs and approximately 39 hours of video collected from closed and nearby areas of Sackville Spur, Flemish Pass, Beothuk Knoll and the southeast Grand Banks in 2009 and of approximately 77 km of high resolution video collected in 2010 from the south and eastern slopes of Flemish Cap and from Orphan Knoll (Figure 31). VMS data from the area will be used as an indicator of fishing pressure. The area of operation is illustrated in Figure 32 where the multibeam data collected from the NEREIDA programme underlies the sampling locations for the boxcorers.

The programme is expected to produce analyses that can be used to refine the boundaries of the current closed areas and to identify other areas where vulnerable marine ecosystems occur, outside the research vessel survey footprint. First results are anticipated for 2011 for the Sackville Spur Sponge Grounds Closed Area.

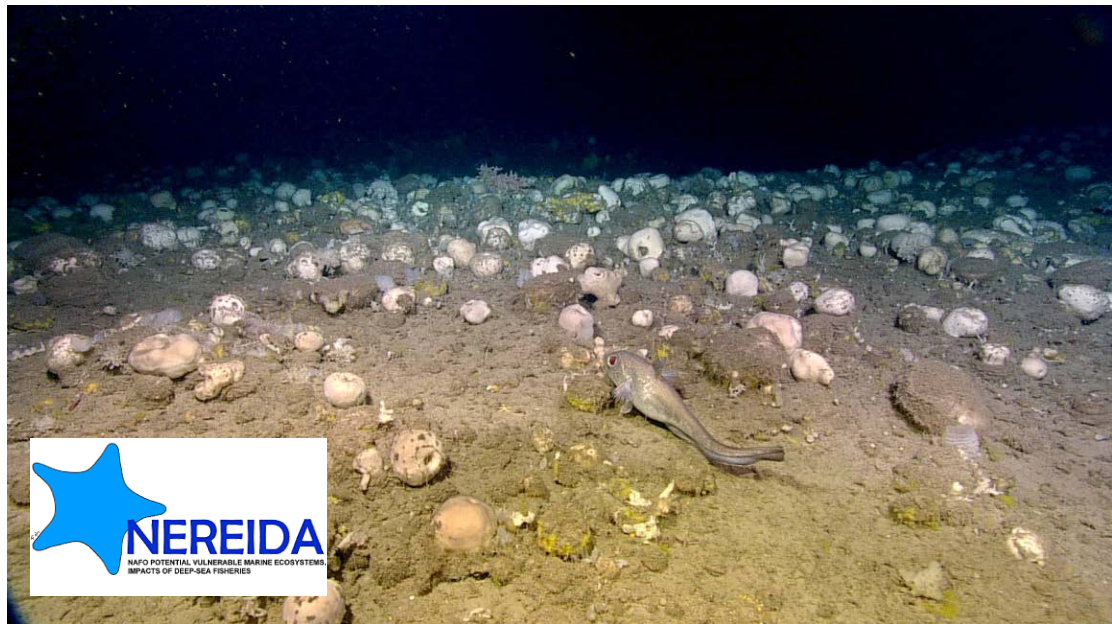


Figure 31. *Geodia*-dominated sponge grounds in the NAFO Regulatory Area. Images were collected using drop cameras and ROVs (ROPOS, Canadian Scientific Submersible Facility).

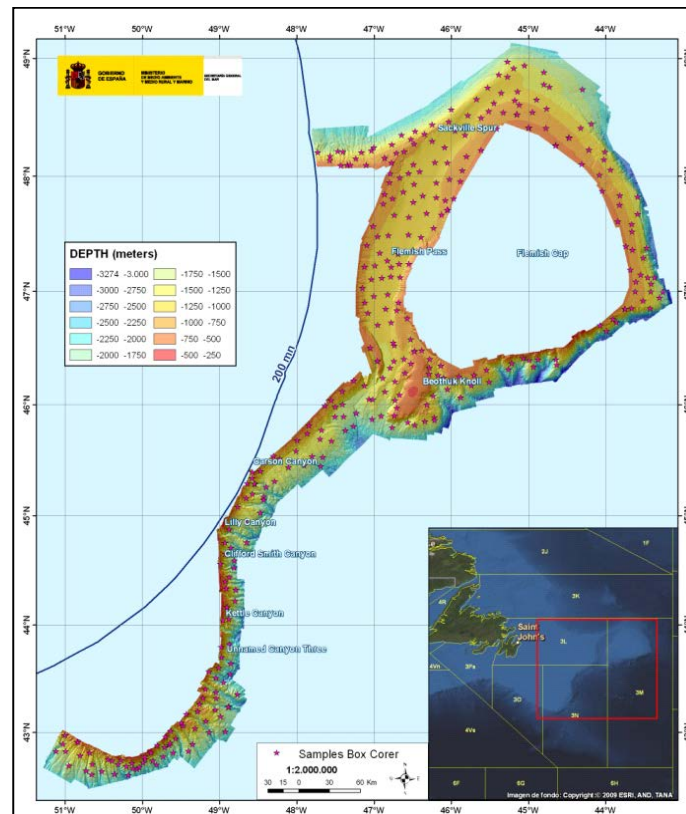


Figure 32. Multibeam bathymetric data collected during the NEREIDA surveys of the NAFO Regulatory Area from the Spanish research vessel *Miguel Oliver*. The locations of boxcorer samples are illustrated by stars.

3.3.2 West Greenland

NAFO observer data from Russian fishing vessels were also available from the Greenland halibut fisheries in the 200 mile fishing zone of West Greenland between at depths of 980–1535 m. The data suggest concentrations of seapens (Figure 33) and black corals (Figure 34) in this area. This is the first data on VMEs for this particular area. There are currently no closed areas in the vicinity of these records.

North West Atlantic (Greenland): Updated information on presence of VMEs and advice on new or existing closures - Map 2

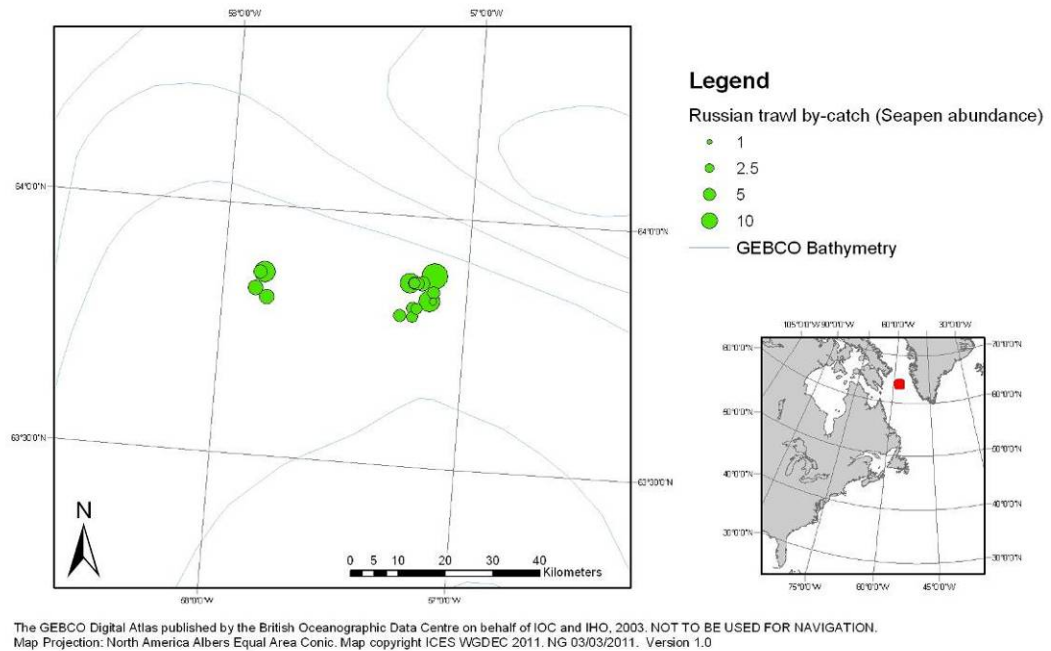


Figure 33. Map showing areas where seapens were observed as bycatch from trawl surveys.

North West Atlantic (Greenland): Updated information on presence of VMEs and advice on new or existing closures - Map 4

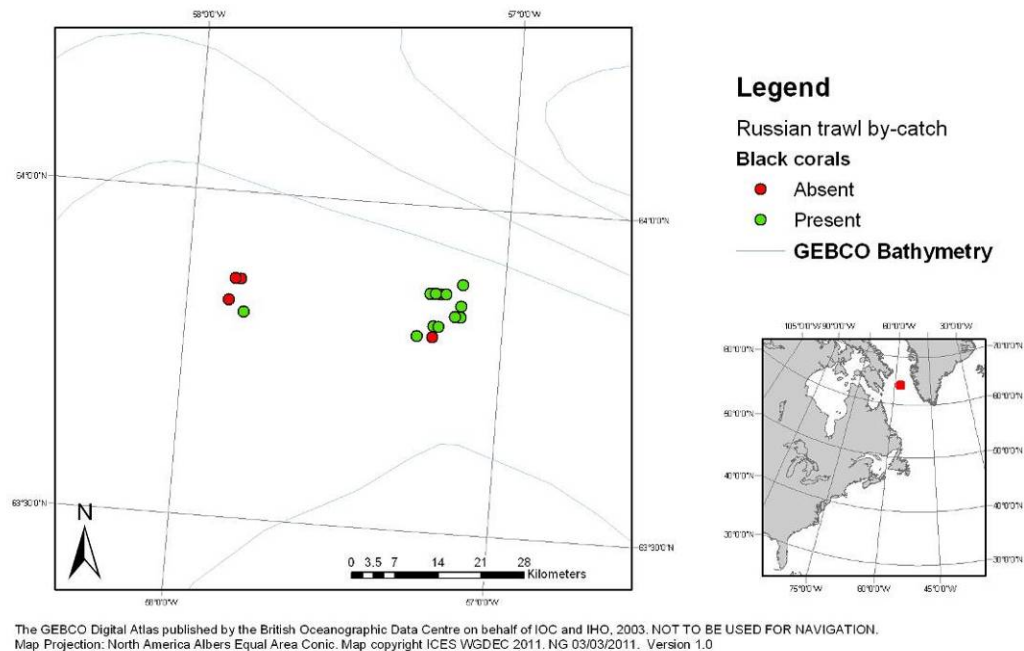


Figure 34. Map showing areas where black corals were observed as bycatch from trawl.

3.4 Concluding remarks

Several important new sources of data on VMEs were submitted to the group in 2011. Strong advice was provided when there was good information on VMEs and fishing activity such as was the case this for Rockall bank. In other areas, e.g. Hatton bank and Anton Dorhn Seamount, better access to recent information on fishing activity (VMS) would have improved the advice basis. All new data will be integrated into the ICES VME database that is under construction this year and detailed in the following section ToR (b).

3.5 References

- Benn AR, Weaver PP, Billet DSM, van den Hove S, Murdock AP, *et al.* 2010. Human Activities on the Deep-seafloor in the North East Atlantic: An Assessment of Spatial Extent. PLoS ONE 5(9): e12730. doi:10.1371/journal.pone.0012730.
- Bourillet, J-F., de Chambure, L., Guillaumont, B. In preparation. Geomorphological classification of cold water coral seabed (Bay of Biscay – NE Atlantic). MS in preparation.
- Durán Muñoz *et al.* 2010. Effects of deep-sea bottom longlining on the Hatton Bank fish communities and benthic ecosystem, north-east Atlantic. Journal of the Marine Association of the United Kingdom. doi:10.1017/S0025315410001773.
- Durán Muñoz *et al.* 2011. Data on deep-sea fishes and benthic invertebrates of the Hatton Bank (NE Atlantic): Interactions between bottom trawling and VMEs. Working document presented to ICES/NAFO WGDEC 2011.

- George, K.H. and H.K. Schminke. 2002. *Harpacticoida* (Crustacea, Copepodaisopoda) of the Great Meteor Seamount, with first conclusions as to the origin of the plateau fauna. *Marine Biology* 144: 887–895.
- Guillaumont, B., Van den Beld, I., Davies, J., Bayle, C., Bourillet, J-F. and De Mol, L. Cold-water coral reefs along the French margin in the Bay of Biscay (NE Atlantic). MS in preparation.
- Vinnichenko, V and Fomin, K.Y. 2011. Occurrence of cold-water corals and sponges in the Reykjanes ridge area according to the data from the Soviet exploratory fishery. Working Document presented to ICES/NAFO WGDEC 2011.
- Vinnichenko, V., Zelinsky, V.N, and Fomin, K.Y. 2011. Russian catches of cold-water corals and sponges in the Northwest Atlantic in 2010. Working Document presented to ICES/NAFO WGDEC 2011.

4 An ICES VME database for the North Atlantic

4.1 Introduction

WGDEC requires a unified database for submitting the data of group members in a standard way and for addressing its terms of reference more completely and effectively. Previous experience has shown that not having such a database has led to inconsistent maps, failure to facilitate data transfer when WG membership is not stable, and an inability to maintain a transparent and traceable basis to the group's advice. It would also be desirable in the longer term to have an open access front-end to at least some of the data to allow the wider scientific and stakeholder community a better insight into the types and quality of data that underlies the advice the group produces.

4.2 Development of the database in conjunction with the ICES DataCentre

The ICES DataCentre accepts a wide variety of marine data and metadata types into its databases. The data formats, guidelines and vocabularies are specific to the type of data and whether it is associated with a marine convention monitoring programme. The WGDEC met with Neil Holdsworth, Head of the ICES DataCentre, to discuss potential formats and processes for building and hosting a database on vulnerable marine ecosystem (VME) species, particularly corals and sponges. The ICES DataCentre holds ecosystem data in its DOME portal, in particular data on biological communities (phytoplankton, zooplankton, phytobenthos, zoobenthos). Trawl survey data are held under the DATRAS portal. Both of these will have links to the proposed VME database as some of the data derive from trawl survey bycatch, while others are of a more general ecological research origin, for example the OSPAR database. However, some new fields, especially regard to species level information, are required to address the particular needs of WGDEC.

There are several databases currently in use by various organizations that contain information on VMEs in the deep seas, such as the OSPAR habitats database and that of GOBI (Global Ocean Biodiversity Initiative). The Secretariat to the Convention on Biological Diversity (CBD) is also developing a database for information relevant to identifying 'ecologically and biologically significant areas' (EBSAs), and a prototype version will be made public in this year. This year FAO has plans to begin to develop a database for VMEs based on data from RFMO's fishery observer programmes and fisher's knowledge. It is important that WGDEC keeps this in mind and maintains links with existing databases so as to avoid duplication of work and more seriously duplication of results. This has recently been highlighted as a major concern. A good approach to avoid duplication can be to dynamically link databases together, whereby they can query each other for information, as requested by the user. The prototype CBD EBSA database has this functionality with OBIS (Ocean Biogeographic Information System), for example. Furthermore the existence of databases on related information such as Cruise documentation e.g. BODC, Taxonomic classification (WoRMS) mean that such databases can be linked dynamically rather than include all data associated with an individual record.

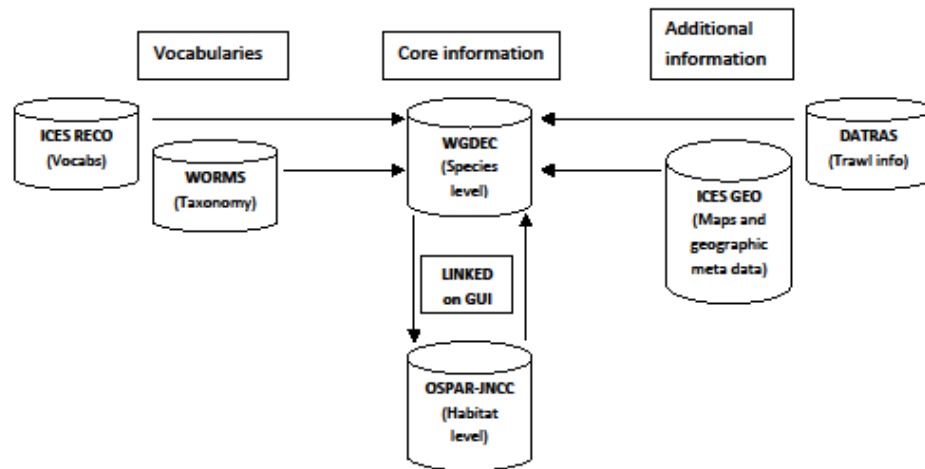
After considering existing databases WGDEC concluded that the most efficient way to proceed was to build on the OSPAR Habitats Database system as a model (OSPAR 2010). The OSPAR databases are used for mapping habitats on their List of Threatened and/or

Declining Species and Habitats, which includes relevant habitats such as Coral Gardens, Deep-sea Sponge Aggregations, *Lophelia pertusa* reefs, Seamounts, Oceanic Ridges with Hydrothermal Vents and Sea Pen and Burrowing Megafauna Communities. It is however only resolved to habitat, and requires additional functionality for dealing with the species level information which is of relevance to WGDEC when assessing ecological and conservation status. The ICES database will extend the OSPAR habitats database, but retain core compatibility to it. A schema for the relationships between the ICES WGDEC VME database to other databases is shown in Figure 35.

Of critical importance to the development of the database is an agreement within the Working Group on the fields of data that will be submitted and the format of that data. The Working Group thus set about designing a template for such purposes. The template for the fields for the WGDEC database is provided in Table 3. The OSPAR data submission protocols also allow for uploading GIS data. Contracting Parties are provided with a pre-formatted Excel spreadsheet (2010 OSPAR Habitat Data Template.xls) and ESRI™ shapefile (2010 OSPAR Habitat Data Template.shp) as templates for entering data in the correct format. We anticipate that similar data exchange could take place for the WGDEC database, i.e. the truncated habitats data can be submitted to JNCC for inclusion in the OSPAR habitats database. Metadata should also be supplied to accompany any data submitted to the ICES WGDEC VME database. This should follow the template outlined in Section below.

However, it is essential to avoid any duplication of data that may be supplied by Contracting Parties to OSPAR (via JNCC) and attendance of those same countries at the ICES WGDEC. To this end, it will be the responsibilities of the ICES WG members who are also Contracting Parties to the OSPAR Convention to liaise with their 'country leads' to ensure that no data already submitted to OSPAR (via JNCC) is included within the submission being compiled by the ICES WGDEC. The OSPAR database will also be regarded as the 'top copy' and JNCC will supply a latest copy to the ICES WGDEC in advance of the Working Group meeting each year. For those attendees of the ICES WGDEC who are not Contracting Parties to OSPAR, they will submit their data using the agreed template through the ICES WGDEC.

Quality assurance, security, data access and data ownership are clearly important issues. The primary responsibility for quality assurance and formatting data correctly will rest with WGDEC members who will submit data in time for the annual meeting. The ICES data policy states that all data held within ICES be freely available and this condition will apply to the ICES VME database. Thus submitters of data must be fully aware that the data they submit will be under this condition. Data that is not publically available will not be considered for inclusion in the ICES VME database. This is not to say that such restricted access information will not be considered by WGDEC in producing its advice.



DATA IDENTIFICATION
 Data will be linked between OSPAR/JNCC database and ICES database based on GUI that are provided with the submitted data by data submitters/contracting parties.
 Data inside the OSPAR area will use the existing GUI agreed between the contracting party and OSPAR.
 Data outside the OSPAR area will use a new GUI agreed between data submitter and ICES

DATA POLICY
 Data submitters will have to accept both the ICES and OSPAR data policies – as information will be shared between the databases

DATABASE COPY
 OSPAR/JNCC Habitats database will be provided as an Access DB copy to ICES on an annual (or other time basis) in order to allow linking the Habitats and Species information

DATA FLOW
 OSPAR/JNCC will be the primary recipient of data reporting. If the data reporting includes the extended information on species then this will be forwarded to ICES for inclusion in the WGDEC database

 If ICES receives data directly (i.e. for non-OSPAR area data), the habitats information will be forwarded to OSPAR/JNCC for inclusion in the Habitats database

Figure 35. Schema and workflow for WGDEC VME Database.

Table 3. Proposed data format for the WGDEC vulnerable marine ecosystem database building on the OSPAR habitat data format (shaded rows); in the ‘Obligation’ column, M stands for mandatory and O stands for optional.

FIELD NAME	FIELD TYPE	OBLIGATION	DESCRIPTION	GUIDANCE
GUI	Text (17)	M	Globally Unique ID for each dataset.	“OSPARHab” + year + 2-letter country code (corresponding to ISO 3166-1) + 1 alpha/numeric digit (different for each dataset) + “v” + version of dataset, e.g. if the Netherlands supplied 2 datasets, they may be called OSPARHab2010NL1v1 and OSPARHab2010NL2v1.
RecordKey	Long integer (Precision 8)	M	Unique key for each habitat record.	E.g. 1, 2, 3, 4, 5, 6.....through to 99999999.
HabType	Text (60)	M	OSPAR threatened and/or declining habitat with Coral Gardens broken into two habitat types as per the Norwegian designations.	Choose from: <ul style="list-style-type: none"> • Carbonate mounds • Coral Gardens Hard Bottom • Coral Gardens Soft Bottom • Cymodocea meadows • Deep-sea sponge aggregations • Intertidal <i>Mytilus edulis</i> beds on mixed and sandy sediments • Intertidal mudflats • Littoral chalk communities • <i>Lophelia pertusa</i> reefs • Maerl beds • <i>Modiolus modiolus</i> horse mussel beds • Oceanic ridges with hydrothermal vents/fields • <i>Ostrea edulis</i> beds • <i>Sabellaria spinulosa</i> reefs • Seamounts • Sea-pen and burrowing megafauna communities • Zostera beds
HabSubType	Text (60)	M	Sub-type of OSPAR threatened and/or declining habitat.	<ul style="list-style-type: none"> • For HabType = Zostera beds: either “Zostera marina beds” or “Zostera noltii beds” or “Unknown” • For HabType = Intertidal mudflats: either “Marine intertidal mudflats” or “Estuarine intertidal mudflats” or “Unknown” • For HabType = <i>Sabellaria spinulosa</i> reefs: either “<i>Sabellaria spinulosa</i> reefs on rock” or “<i>Sabellaria spinulosa</i> reefs on mixed (sediment) substrata” or “Unknown” • For all other habitats: “Not Applicable”

FIELD NAME	FIELD TYPE	OBLIGATION	DESCRIPTION	GUIDANCE
HabStatus	Text (20)	M	Presence or absence of habitat. This field is to allow for changes in distribution over time, where a habitat may have existed in the past but is no longer present. The original record indicating the presence of the habitat in the past should remain in the dataset.	Choose from: <ul style="list-style-type: none"> Present Absent [GUI-RecordKey of original record] E.g. if the original record has GUI = OSPARUK1 and RecordKey = 23, enter "Absent OSPARUK1-23" in a new record.
Certainty	Text (9)	M	Gives an indication of the certainty of identification of the habitat type (HabType).	Choose from: <ul style="list-style-type: none"> Certain (habitat matches the definition, and there is documentary/visual evidence that this habitat does exist/had existed previously) Uncertain (habitat is known to exist/had existed, but there is no documentary/visual evidence) Unknown
Determiner	Text (254)	M	Name of person or organization that identified the habitat.	Free text; e.g. JNCC
DetDate	Date	M	Date of identification of the habitat.	All dates must be supplied as text in the format YYYY-MM-DD (ISO date format); text format is required because Excel does not _rganizat dates before 1900-01-01 in date format.
SurveyKey	Text (30)	0	Unique key to divide up the dataset in any way you wish (e.g. representing real separate surveys, different survey techniques, data from different sources, museum collections, databases etc.). SurveyKey links to the Survey Level Metadata form (see Section 2), where survey details are described in full.	Each SurveyKey must have an associated Survey Level Metadata form (see Section 2).
StartDate	Text (10)	M	Date the habitat was first recorded at this location.	All dates must be supplied as text in the format YYYY-MM-DD (ISO date format); text format is required because Excel does not _rganizat dates before 1900-01-01 in date format.
EndDate	Text (10)	M	Date the habitat was last recorded at this location.	

FIELD NAME	FIELD TYPE	OBLIGATION	DESCRIPTION	GUIDANCE
DateType	Text (2)	M	A one or two character code that identifies the type of dates used in StartDate and EndDate. Explicitly stating the code avoids any ambiguity, which might lead to subtly different interpretations.	<p>Choose from:</p> <ul style="list-style-type: none"> • D Dates specified to the nearest day. • DD Dates specified to a number of days. • Dates specified to the nearest month (first day of the month to the last day of the month). • OO Dates specified to a range of months (first day of the start month to the last day of the end month). • Y Dates specified to the nearest year (first day of the year to the last day of the year). • YY Dates specified to a range of years. • -Y Only EndDate to the nearest year known (leave StartDate blank). • ND or U 'No date' or 'unknown'. Enter the date the dataset was compiled in EndDate and leave StartDate blank.
PlaceName	Text (254)	0	Name of place referred to in reference to the feature e.g. on a chart or in a report.	Free text; e.g. "Darwin Mounds"
DataOwner	Text (254)	M	Name of person or organization that own the data.	Free text; e.g. "JNCC"
Accuracy	Long integer (Precision 10)	M	Spatial positioning accuracy of data points/polygons.	Value in metres; e.g. "10" means the given position of the habitat is accurate to ± 10 metres.
Start Latitude	Long integer (Precision 10)	M (point data only)	Latitude of the recorded habitat (point data only).	Must use World Geodetic System 1984 (WGS84) geographic coordinate system, and decimal degrees (up to 8 decimal places).
Start Longitude			Longitude of the recorded habitat (point data only).	
End Latitude	Long integer (Precision 10)	M (point data only)	Latitude of the recorded habitat (point data only).	Must use World Geodetic System 1984 (WGS84) geographic coordinate system, and decimal degrees (up to 8 decimal places).
End Longitude			Longitude of the recorded habitat (point data only).	
Position Precision	Integer (4)	0	An estimate of the precision of the lat/long coordinates relative to the benthic feature.	Calculated or estimated precision of the benthic feature in metres. Take into account whether position is determined from the ship position or from ROV.
Extent of Area	Integer (4)	0	An estimate of the area covered by the feature	Calculated or estimated area of the benthic habitat feature in km2
Spatial Data				
Reference	Text (254)	M	A reference to the data source	Complete citation for the data source e.g. "Mortensen <i>et al.</i> , 2006"
Filename	Text (254)	0	Name of the excel or shape file submitted	
Survey Method	Text (10)	M	A description of the survey method	Please keep field names to ≤ 10 characters and free of spaces, to allow import into GIS software. e.g. Survey Method = "Trawl", "ROV", "AUV", "Literature", "Camera", etc.
Habitat Description	Text (25)	0		

FIELD NAME	FIELD TYPE	OBLIGATION	DESCRIPTION	GUIDANCE
Substratum	Text (25)	0		
Depth Upper	Integer (4)	0	For transect data (video or trawl) indicate the shallowest depth in metres	
Depth Lower	Integer (4)	0	For transect data (video or trawl) indicate the deepest depth in metres	
Depth Range	Integer (4)	0	For transect data (video or trawl) indicate the depth range covered in metres	Indicate the depth range of the transect data as a single number. For example a transect with the shallowest depth at 200 m and the deepest at 800 m would have a 600 m value for this field.
Genus	Text (30)	0		Genus name following ITIS nomenclature standards
Species	Text (30)	0		Species name following ITIS nomenclature standards if known
Binomial	Text (61)	0		Binomial combination of Genus and species, e.g. <i>Lophelia pertusa</i>
General Taxon Descriptor	Text (30)	M		Choose from: <ul style="list-style-type: none"> • "Coral" • "Sponge" • "Other"
[Optional extra fields]	-	0	Add any other data you would like to record; a description of these field(s) is then to be given in the Dataset Level Metadata form (see Section 2). Please add as many fields as you like to display extra information you may possess.	Please keep field names to ≤ 10 characters and free of spaces, to allow import into GIS software. e.g. field name = "Salinity", "Comments", "HabDescrip", "Depth", etc.

4.3 Metadata requirements

ICES require that all data submissions are accompanied by metadata. The ICES DataCentre accepts a wide variety metadata types into its databases. Codes are used to identify ships, surveys, programmes, etc. The basic metadata will require identification of the data provider, the geographic coverage, the survey tools and the data fields. The OSPAR data submission protocols also include associated metadata requirements. Data submitted to OSPAR by the Contracting Parties must contain both *contact information* and either *dataset level metadata* or *survey level metadata*. The Working Group recommend that equivalent metadata are submitted with each dataset being brought to the WGDEC, in order to facilitate transfer of data on new occurrences of VMEs to the OSPAR and vice versa.

A metadata template developed for the OSPAR database is available, and should be followed for data submitted through the ICES WGDEC VME database. Metadata requirements are outlined below.

Contact information

This may be the national co-ordinator or the specific person/organization that collated the

Dataset level metadata

Use this form to describe the dataset as a whole; this includes its geographic coverage and use constraints. Additional data fields are also defined here (see bottom row of Table 1).

Survey level metadata

A new Survey Level Metadata form is completed for each SurveyKey cited in the data. (Three are present in the metadata template file; to add a new form, right click on one the Survey Level Metadata worksheet tabs, click *Move or Copy* and select the box labelled *Click to copy*.)

The purpose of this form is to minimize the amount of repeated information in the data tables and the total size of the datasets. It is also this system that is used on the OSPAR mapping website.

Use SurveyKey to divide the dataset in any way you wish (e.g. representing real separate surveys, survey techniques, data from different sources, museum collections, databases, etc.). Survey techniques and data sources are then elaborated on in the Survey Level Metadata forms.

If no Survey Level Metadata forms are completed, Dataset Level Metadata must be completed in full.

4.4 References

OSPAR. 2010. OSPAR Habitat Data Submission Guidance. Version 1.1. Mapping Habitats on the OSPAR List of Threatened and/or Declining Species and Habitats Guidance for Supplying Data - 2010 Onwards. Released 21/04/2010. Lead Author: Helen Ellwood.

5 Review of ICES WKBIODIV Report

5.1 Introduction

The preservation of marine biodiversity is now viewed as one of the major aims of conservation. Biodiversity is seen as vital to the functioning of marine ecosystems and the delivery of associated goods and services (e.g. the Baltic Sea; HELCOM 2010). In January, 1992 at the Earth Summit in Rio de Janeiro, over 145 countries signed the legally binding agreement referred to as the Convention on Biological Diversity (CBD). Those signing Parties agreed on a programme for implementing the CBD with respect to marine and coastal biodiversity at their second Conference of Parties (COP) held in Jakarta, Indonesia in 1995. In the intervening years marine biodiversity conservation and its sustainable use has become an important policy driver globally and one influencing the operations of ICES clients such as OSPAR, EU Commission etc. It is critical for the future of ICES that it realigns its activities to address this issue. Consequently the Strategic Initiative on Biodiversity Advice and Science (SIBAS) should be viewed as an important contribution to keeping ICES relevant to its clients in a changing policy environment.

The SIBAS workshop draft report (WKMARBIO) provides an overview of the policies related to marine biodiversity that should be considered by ICES and presents a work plan to improve ICES capacity to deliver biodiversity science and advice. A key output is the development of biodiversity indicators and reference points to promote consistency in reporting across Expert Groups.

The CBD defines diversity as “the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.” The WKMARBIO report uses this structure to classify state (structure and function) and pressure biodiversity indicators that could be used in the short or medium term (see Table 1 of the WKMARBIO report). Unfortunately the WKMARBIO report refers only to classes of indicators and does not consistently detail the indicators themselves. Therefore the WGDEC term of reference cannot be directly addressed as few indicators are actually proposed and none are explicitly defined. In preparing the final report for the WKMARBIO, the co-chairs may wish to consider some general comments to the content that could improve the utility of the document.

It would be valuable to build on their Table 1 in two directions. First, the Good Environmental Status qualitative descriptors clearly link to policy directives and have been considered by a number of scientific bodies. Regardless of whether or not they are ultimately applied it would be useful to link those to the classes of indicators provided in Table 1 then to give examples of the indicators associated with those descriptors. This would allow for gaps to be identified in their relationship with biodiversity issues.

WGDEC also noted that while mention is made of the CBD and FAO criteria (their Boxes 1 and 2) those are not linked to the Table 1 classes of indicators and it is not clear how those particular drivers related to special areas (EBSAS, VMEs) fit into a biodiversity framework. More elaboration on this point would be helpful.

Lastly, the workshop report makes the important connection to the various levels of diversity highlighted in the CBD but fails to develop the genetic diversity class. The ICES Working Groups on the Application of Genetics to Fisheries and Mariculture

(WGAGFM) and on Ecosystem Affects of Fishing Activities (WGECO) have both considered indicators and reference points for genetic diversity as has the US government (Bagley *et al.*, 2002) among others.

WGDEC further offers some insights into the application of any indicator to deep-water environments:

- 1) Monitoring deep-water ecosystems is challenging, both logistically and economically and consequently information on biodiversity is generally poorer.
- 2) Indicators appropriate to shelf ecosystems are unlikely to be readily transferable to the deep-water ecosystem because information is sparser and methods of survey often different.

Given time constraints, WGDEC was unable to fully populate the workshop report Table 1 with appropriate indicators, however we provide some initial thoughts for each of the classes of indicators listed in the WKMARBIO report.

5.2 State indicators of biodiversity related to structure

The WKMARBIO report includes classes of indicators at the population, species, community, and ecosystem levels and considers genetic and habitat diversity related to structure. Elements tabulated include community structure and function diversity, population size, range and composition as well as patchiness and connectivity. Of these, Foley *et al.* (2010) identified native species diversity, connectivity and habitat heterogeneity as the three ecological attributes most commonly identified as critical for maintaining marine ecosystem functioning. However empirical data have shown a large variability of the degree to which these attributes stabilize community function, limiting generalizations or predictions drawn from such data to specific variables and trophic contexts (cf. Schläpfer and Schmid, 1999).

5.2.1 Structural properties

5.2.1.1 Measures of genetic and populations-level diversity

Extinction, extirpation, hybridization and loss of genetic variation within populations represent the major categories of threat to genetic diversity within species (cf., Ryman *et al.*, 1995). Longer term goals require the maintenance of genetic diversity in the species to allow for adaptation to environmental change and for continued speciation in order to maintain evolutionary flexibility for the future (e.g. Soule, 1980; Polunin, 1983).

Total genetic variation within a species can be partitioned into variation within and among populations. Natural selection acts within populations, while the genetic potential of the species to adapt to environmental changes depends on the total genetic diversity represented among populations. In most marine species, where the parents produce large numbers of offspring, there is large scope for local selection. It is necessary to maximize both types of variation to maintain full potential for evolutionary change within a species.

Population size is the single most important factor in sustaining a high level of genetic variation within a population of a species. Population size here refers to the genetically effective population size (N_e), and not the number of individuals in a population (N). Population geneticists define N_e as “the size of an idealized population that would have the same amount of inbreeding or of random gene frequency drift as the population under consideration (Kimura and Crow, 1963)”. N_e is consid-

ered to be the most appropriate variable for assessing population viability (Barton and Whitlock, 1997). Maintaining large N_e increases the likelihood that favourable mutations will become widespread and deleterious ones will be eliminated. N_e is nearly always less than N because generally not all individuals in a population are reproductive at spawning time. Estimates of N_e are under the influence of sex ratio, variation in the number of offspring per family, and fluctuating population numbers all of which could be developed as indicators with defensible reference points. The influence of these variables on N_e is presented by Meffe (1986) and summarized here:

Sex ratio is an important determinant of genetic variation. If the sex ratio of breeders departs from 1:1, N_e and genetic variation will be reduced. The effective population size with respect to sex ratio is determined as:

$$N_e = 4(N_m * N_f) / (N_m + N_f),$$

where N_m and N_f are the numbers of male and female breeders respectively (Frankel and Soule, 1981). It can be seen that an effective population of 50 males and 50 females is nearly 2.8 times larger, genetically, than one of 10 males and 90 females. Sex ratio is something that can easily be monitored from research vessel trawl surveys.

Variation in the number of offspring per family is expected to follow a Poisson distribution (where variance = mean). If certain matings produce disproportionately more offspring, biasing the representation of contributed gametes in the next generation, N_e will be lower. A biased progeny distribution will affect N_e approximately by:

$$4N / (2 + \sigma^2),$$

where σ^2 is variance in progeny distribution (Franklin, 1980). The effective population size can be drastically reduced by disproportionate offspring production. For example, consider two theoretical populations in a 1:1 sex ratio, one with 1000 females reproducing following a Poisson distribution with a mean of two offspring and a σ^2 of 2, and the other consisting of 1 female producing 1001 offspring and the remaining 999 females producing one each (mean of two offspring, a σ^2 of 31.6). In the first instance, N_e will be 1000 while in the second, N_e is reduced to 119.

Whenever a population declines the genetic variance for all future generations is contained in the few survivors. Because those individuals represent only a sample of genetic variance contained in the original population, N_e is reduced by fluctuations to low levels. This effect is known as FPS, fluctuation in population size. N_e is affected by the harmonic mean of population sizes in each generation, or:

$$1/N_e = 1/t (1/N_1 + 1/N_2 + \dots + 1/N_t),$$

where t = time in generations (Franklin, 1980). Population fluctuations can be seen to be very important to N_e by applying this equation to two theoretical populations, one of 100 fish for each of five consecutive generations for an arithmetic mean of 100, and one with a similar mean but with a population fluctuating each generation as 100, 10, 300, 10, and 80. In the first scenario, $N_e = 100$ while in the second, $N_e = 22$, a 78% reduction effected through population crashes. Estimates of FPS depend on time-scale. As more census records are incorporated, estimates of FPS tend to increase (Vucetich and Waite, 1998). Estimates of N_e based on only a few annual counts (i.e. ten) are statistically quite unreliable and long-term population monitoring is necessary to provide a framework for interpreting N_e estimates calculated from census data (Vucetich and Waite, 1998).

The average number of alleles per locus, and average heterozygosity per individual could be used as indicators of genetic diversity relevant to population health. Genetic drift can be an important factor in both hatchery breeding programmes and natural stocks.

Such traits as fecundity, fertility, age-at-maturity, clutch size, growth, and survivorship can be greatly depressed by inbreeding. Frankel and Soule (1981) document that a ΔF of 10% may result in a 25% decrease in population reproductive performance and suggest that even a ΔF of 1% ($N_e=50$) is only tolerable in the short term. Recent theoretical work suggests that population sizes of 1000 to 5000 are required for long-term viability of the population, to avoid reduction in fitness traits (Lynch, 1996). Previous values of 500 or more broodstock (Frankel and Soule, 1981) appear to have been underestimated. There is no absolute measure of inbreeding, as the degree to which it occurs is measured against the base population. The increase in inbreeding per generation is the usual means of evaluating this occurrence and is related to the effective population size:

$$\Delta F=1/(2N_e).$$

In terms of indicators for among population variability a simple indicator is the number of populations and/or their spatial extent if applicable. A more detailed metric could be F_{ST} which measures gene flow among populations. F_{ST} is the proportion of the total genetic variance contained in a subpopulation (the S subscript) relative to the total genetic variance (the T subscript). Values can range from 0 to 1. High F_{ST} implies a considerable degree of differentiation among populations. Related measures: θ (theta) of Weir and Cockerham (1984) and G_{ST} of Nei (1978) could also be used.

5.2.1.2 Measures of community and higher level diversity

State indicators of biodiversity status in their simplest application are purely descriptive, that is they measure the number of members belonging to an object. In an ecological context a common measure of biodiversity is the number of species (S) in a given area (e.g. biogenic habitat (e.g. a reef), geomorphologic feature (e.g. a seamount or hydrothermal vent), water mass (e.g. Gulf Stream)). S is very sensitive to sample size and species accumulation curves are used to ensure that sampling is sufficient to describe and compare S in different temporal or spatial contexts. The sampling tool also affects S and so care must be taken in comparing data using the same or similar sampling devices. Species lists can be used to derive other indicators of community or ecosystem biodiversity. These indicators include taxonomic diversity, D , and taxonomic distinctness, D^* which use information derived from a hierarchical taxonomic tree, such as a Linnaean classification or matrix of phylogenetic distances.

Extensions of species diversity measures incorporate the relative proportions of species using abundance and/or biomass data and include such measures as species richness (Margalef's D) and evenness (Pielou's J), and Shannon's species diversity (H).

These measures of species and taxonomic diversity also capture genetic diversity at a higher level of organization. Genetic diversity could also be reflected in adaptation to oceanographic conditions and so be reflected at the ecosystem level across organisms.

The SIBAS workshop report discusses a number of habitat indicators as state variables related to structure. In connection to the revision of an integrated management plan of the marine environment of the Barents Sea and the sea areas off the Lofoten Islands a set of indicators have been developed and reviewed which relate to benthic

fauna and habitat and to *Lophelia pertusa* reefs in particular (von Quillfeldt and Dommasnes, 2005; Sunnanå *et al.*, 2010):

- 1) Composition and abundance of benthic species in bottom survey trawls.
- 2) Occurrence of damaged coral colonies (applies for scleractinian reefs and gorgonian corals).
- 3) Cover of coral tissue (general indicator of “coral health”).
- 4) Density of colonies (applies for sponges and gorgonian coral).

Other indicators could relate to the area of the habitat and the degree of habitat fragmentation, both of which are amenable to quantification and the development of reference points.

5.2.2 Functional properties

5.2.2.1 Measures of community and higher level diversity

Evolutionary history may constrain responses of species to pressures through physical and chemical similarities among closely related taxa. Therefore, highly specious ecosystems may not have greater resilience to perturbations (anthropogenic or natural) than less specious ecosystems unless there is a corresponding degree of taxonomic relatedness low enough to confer a certain amount of functional redundancy to the system but high enough to ensure a diversity of responses to change among species contributing to the same ecosystem function (response diversity; Elmqvist *et al.*, 2003). Measures of functional redundancy and response diversity could be evaluated as indicators for functional properties of diversity state. The combination of response diversity and functional redundancy inherent in the species composition of the ecosystem determine the intrinsic ability of that system to compensate for perturbations without seriously altering ecosystem function (e.g. productivity, nutrient sequestration etc.). However, these properties are not easily assessed and can operate in multiple dimensions responding in nonlinear ways (Loureau, 2004).

5.3 State indicators of biodiversity related to function

5.3.1 Measures of community and higher level diversity

A number of indicators have been proposed to capture aspects of biodiversity related to function. Examples include stable isotope fractions, size-spectra slopes, declines in mean length of the fish community and declines in the coverage of key species. Key processes operating at the ecosystem level which influence biodiversity include: 1) trophic interactions, 2) phenology, and 3) foundation and ecosystem engineers with species-specific effects.

Alterations to trophic interactions and foodwebs can have pronounced effects on biodiversity. For example, alterations in the abundance and/or body sizes of species at the top trophic level may precipitate change in abundances in lower trophic levels through predator–prey relationships. There is a long history of work, from rocky shores to sea otters and sharks, which has established that top predators have a fundamental influence on the structure and function of marine ecosystems. Top predators have both direct impacts through consumption and indirect influences by altering the behaviours of prey. One specific type of top–down impact termed a trophic cascade is an alternating pattern of increased and decreased abundance in successively lower trophic levels. For example, in some ecosystems the loss of herbivores in coral reefs or sea otters in kelp forests leads to top down changes that produce a major shift in ecosystem structure and energy flow. Alternatively, changes in re-

source availability at the bottom of the trophic web, generally induced by oceanographic or climate change, may propagate upward altering similar shifts in abundances at all trophic levels. The balance of these two drivers may be mediated by water temperature and/or associated predator diversity.

Organisms that are important in structuring ecosystems, such as foundation species (dominant primary producers such as saltmarshes, seagrasses, kelp) or ecosystem engineers (any organism that creates, builds or modifies habitats such as corals, sponge grounds, bioturbators), may cause some of the most profound and non-reversible effects in ecosystems if they are removed. The abundance and distributions of such species can be used as surrogates for biodiversity.

The phenology (the annual timing of ecological events) in marine environment is a key metric that influence biodiversity. The decoupling of phenological relationships will have important ramifications for trophic interactions, altering foodweb structures and leading to eventual ecosystem-level changes in biomass and productivity. A recent meta-analysis of phenology of life-history traits across marine, freshwater and terrestrial environments found differential responses among organisms related to trophic level and thermal metabolism (Thackeray *et al.*, 2010). They found that events associate with secondary consumers advanced less rapidly than those for both primary producers and primary consumers across marine, freshwater and terrestrial ecosystems. They also found that mean rates of change were accelerated for ectotherms compared to endotherms, although the degree of variation was very high for both. Phenological changes and developing asynchronies between trophic pairings (e.g. predators and their prey) can result in reductions in individual fitness, declines in the population size and altered trophic transfers, resulting in lowered ecological efficiency and secondary productivity. Indicators may be as simple as the timing of the spring bloom, fish spawning times, etc. Phenology was not mentioned as a class of indicators in the SIBAS workshop report and is a serious omission with respect to biodiversity.

Biomass weighted indices can provide a good indication of the overall structure of a community, but they are limited in their ability to pick up species losses as species that are being lost from a system tend to make up only a very small proportion of the biomass of the system. The latter is the case for deep-sea species such as sharks, skates, rays, chimeras, which are naturally at the higher trophic levels and at lesser abundances compared with the species of lower trophic levels in the foodweb.

The Large fish indicator (LFI), defined as the proportion of large fish by weight in the assemblage/community in the area, reflects the size structure and life-history composition of the fish community and any changes in community structure are likely to be associated with a change in aspects of biological diversity. OSPAR adopted LFI as an ecological indicator EcoQ for the North Sea, to measure ecosystem health based on work from ICES (ICES 2001; 2007). Its calculation is based on data time-series from internationally coordinated bottom-trawl research surveys already in place in each area. For deep-sea fish and communities, however, an equivalent internationally coordinated survey programme does not currently exist (although a proposal for such a survey has been prepared; see Section 10 of this report).

Another indicator, referred to as conservation fish status (CFS), was also adopted in EU (COM(2008) 187), and seems appropriate to report on biodiversity of the marine environment with respect to the impact of fishing on vulnerable and threatened fish species as the deep-sea fish. The CFS indicator has been proposed and applied specifically to the list of threatened and vulnerable species by Dulvy *et al.* (2006), includ-

ing the proposal of a limit reference value of 1 which implies that on average all species in the large fish community (or assemblage) are considered 'vulnerable' according to IUCN threat criteria.

As a step towards integrating the requirements for GES into European fisheries management under MSDF, LFI and CFS were both proposed as the GES descriptor 4 (foodweb) and GES descriptor 1 (biodiversity) in work developed under the EU Project MEFEP0 (Le Quesne, 2010; Borges, 2010).

5.4 Pressure indicators of biodiversity

Pressure indicators are likely to be the only type of indicator that can readily be applied to many areas of the deep sea. For indicators of seabed/habitat integrity, if one makes the assumption that bottom-trawling impacts the seabed, then an indicator for seabed integrity may be derived using VMS data and an analysis of temporal (increasing or reducing effort) and spatial variability (extent to which previously untrawled areas are being impacted). A potential indicator developed from photographic transects that measure extent, abundance and diversity of habitats would be most useful.

Similar pressure indicators can be developed from other activities that may impact seabed/habitat integrity. Pressure indicators that assess potential impacts from oil and gas industry activity on deep-sea habitats can also be developed from video and/or photographic transects that identify community changes around drill sites. Other pressure indicators that assess cable laying and the extent and impact of marine debris (from shipping, fishing and land-based) may be developed from video/photographic transects that measure changes adjacent to cable areas and extent of debris or any damage the debris may be having on habitat or species (Smith and Hughes, 2008).

5.5 Use of existing dataseries in formulating biodiversity indicators

Indicators of deep-water biodiversity are likely to be only quantifiable in the near- to mid-term at the scales which fisheries operate on, and if trawl time-series are available. These can be very useful for state indicators for fish communities and in some cases for benthic invertebrates. Taxonomic based state indicators have successfully been applied to assess spatial and temporal variability of deep-water fish community structure. Campbell *et al.* (2011) studied the deep-water demersal fish community on the Atlantic deep continental shelf and upper slope to the northwest of Scotland using data from trawl surveys conducted by Marine Scotland-Science over the period 1998–2008. The composition and structure of the fish assemblage was described using species richness as well as the descriptors of community interrelatedness: taxonomic diversity (Δ) and taxonomic distinctness (Δ^*). Results revealed no temporal trends in community composition. The most significant factor in determining richness and taxonomic diversity of the demersal fish fauna was depth, and to a lesser extent latitude. Diversity and distinctness decreased with increasing depth and showed a complex relationship with latitude, while richness peaked at depths around 1400 m. This study shows taxonomic measures of diversity and distinctness to be sensitive indicators of ecological conditions in the deep-water fish community, with respect to depth and latitude, and the fact that no temporal trends were detected suggests that the structure of the fish community at exploitable depths on the Scottish slope has remained stable over the period 1998–2008. These findings imply that care should be taken when planning spatial measures designed to safeguard deep-water fish biodi-

versity because the optimal area recommended for protection is strongly dependent on the choice of metric used.

5.6 References

- Bagley, M.J., S.E. Franson, S.A. Christ, E.R. Waits, G.P. Toth. 2002. *Rationale for a Genetic Diversity Indicator*. pp. 4–15. IN: Genetic Diversity as an Indicator of Ecosystem Condition and Sustainability: Utility for Regional Assessments of Stream Condition in the Eastern United States. US Environmental Protection Agency, Cincinnati, OH.
- Barton, N.H., and Whitlock, M.C. 1997. The evolution of metapopulations. In: Hanski, I.A. and Gilmin, M.E. (eds.) *Metapopulation biology: ecology, genetics, and evolution*. Academic Press, San Diego, California.
- Borges M.F., Velasco F., Mendes H., Pinho M. R., Silva C. , Porteiro C., Frid C.L.J., Paramor O.A.L., Piet G.J., Rogers S.I. Le Quesne W.J.F. 2010. Assessing the impact of fishing on the Marine Strategy Framework Directive objectives for Good Environmental Status. Developing and testing the process across selected RAC regions: The South Western Region Waters . REPORT of MEFEP0 Making European Fisheries Ecosystem Plans Operational EC FP7 project # 212881.
- Campbell, N., F. Neat, F. Burns, and P. Kunzlik. 2011. Species richness, taxonomic diversity, and taxonomic distinctness of the deep-water demersal fish community on the Northeast Atlantic continental slope (ICES Subdivision VIa). *ICES Journal of Marine Science* 68: 365–376.
- COM. 2008. 187 The role of the CFP in implementing an ecosystem approach to marine management. Communication from the Commission to the Council and the European Parliament. [SEC(2008) 449].
- Dulvy, N.K., Jennings, S., Rogers, S.I. and Maxwell, D.L. 2006 Threat and decline in fishes: an indicator of marine biodiversity. *Canadian Journal of Fisheries and Aquatic Sciences* 63 1267–1275.
- Elmqvist, T., C. Folke, M. Nystrom, G. Peterson, J. Bengtsson, B. Walker, and J. Norberg. 2003. Response diversity, ecosystem change and resilience. *Frontiers in Ecology and the Environment* 1: 488–494.
- Foley, M. M., B. S. Halpern, F. Micheli, M. H. Armsby, M. R. Caldwell, C. M. Crian, E. Prahler, N. Rohr, D. Sivas, M. W. Beck, M. H. Carr, L. B. Crowder, J. E. Duffy, S. D. Hacker, K. L. McLeod, S. R. Palumbi, C. H. Peterson, H. M. Regan, M. H. Ruckelshaus, P. A. Sandifer, and R. S. Steneck. 2010. Guiding ecological principles for marine spatial planning. *Marine Policy* 34:995–966.
- Frankel, O.H. and M.E. Soule. 1981. *Conservation and evolution*. Cambridge University Press, New York.
- Franklin, I.R. 1980. Evolutionary change in small populations. In: Soule, M.E. and Wilcox, B.A. (eds.). *Conservation biology: an evolutionary-ecological perspective*. Sinauer Associates, Sunderland, MA., pp. 135–139.
- ICES. 2001. Report of the ICES Advisory Committee on Ecosystems. ICES Cooperative Research Report, 249, 75.
- ICES. 2007. Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO). Copenhagen, Denmark, ICES.
- Kimura, M. and Crow, J.F. 1963. The measurement of effective population number. *Evolution* 17:279–288.
- Le Quesne, W.J.F., Frid, CLJ, Paramor, OAL, Piet, GJ, Rodgers, SI, Velasco, F. 2010. Assessing the impact of fishing on the Marine Strategy Framework Directive objectives for Good Environmental Status. Developing and testing the process across selected RAC regions: The

- North Sea. REPORT of MEFEP0 Making European Fisheries Ecosystem Plans Operational EC FP7 project # 212881.
- Loreau, M. 2004. Does functional redundancy exist? *Oikos* 104:606–611.
- Lynch, M. 1996. A quantitative-genetic perspective on conservation issues. In: *Awise, J.C., and Hamrick, J.L. (eds.). Conservation genetics: case histories from nature.* Chapman and Hall, New York.
- Meffe, G.K. 1986. Conservation genetics and the management of endangered fishes. *Fisheries* 11:14–23.
- Nei, M. 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. *Genetics* 76: 379–390.
- Polunin, N.V.C. 1983. Marine “genetic resources” and the potential role of protected areas in conserving them. *Environmental Conservation* 10:31–41.
- Schläpfer, F., and B. Schmid. 1999. Ecosystem effects of biodiversity: A classification of hypotheses and exploration of empirical results. *Ecological Applications* 9:893–912.
- Smith, T. and J.A. Hughes. 2008. A review of indicators and identification of gaps: Deep-sea habitats. National Oceanography Centre Southampton Research and Consultancy Report No. 45, Southampton, UK. 72pp.
- Soule, M. E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. In: *Soule, M.E. and Wilcox, B.A. (eds.). Conservation biology: an evolutionary-ecological perspective.* Sinauer Associates, Sunderland, MA., pp.151–169.
- Sunnanå K., Fossheim M. and Olsen C.D. (Ed.) 2010. Forvaltningsplan Barentshavet – rapport fra overvåkingsgruppen 2010. Fisken og havet, særnr. 1b–2010.
- von Quillfeldt, C. H. and Dommasnes, A. 2005. Forslag til indikatorer og miljøkvalitetsmål for Barentshavet- Rapport fra et delprosjekt under forvaltningsplanen for Barentshavet. - Report in Norwegian 19 October 2005, 159 pp.
- Vucetich, J.A., and Waite, T.A. 1998. Number of censuses required for demographic estimation of effective population size. *Conservation Biology* 12: 1023–1030.
- Weir, B.S., and C.C. Cockerham. 1984. Estimating F-statistics for the analysis of population structure. *Evolution* 38(6): 1358–1370.

6 Review productivity/susceptibility analysis (PSA) and its application of to deep-water fisheries and ecosystems

6.1 Background

The application of ecological risk assessment methods to fisheries has gained popularity in recent years. To date there are no published studies that are specific to deep-water fisheries, but the report of a recent workshop presents such an analysis (Watling *et al.*, in press). The conclusion of that workshop was that PSA may be a promising area for development by ICES WGDEC and WGDEEP. Hence these two working groups agreed to jointly review the methodology and literature published to date with a view to applying a PSA analysis to the deep-water fisheries of the North Atlantic. Unfortunately, due to higher priority requests for advice there was insufficient time to deal with this ToR in detail at this meeting and only the briefest of reviews can be presented.

6.2 Theory and methodology of PSA

The relative risk posed to a species from fishing activities can be assessed using ecological risk assessment methods. The first attempts to do this was by Milton (2001) and Stobutzki *et al.* (2001; 2002). Termed 'productivity-susceptibility analysis' or 'PSA' (Patrick *et al.*, 2010), the method considers the 'productivity' of a species to be based on its biological attributes, e.g. life-history strategy, which determine its ability to sustain exploitation or to recover after depletion, and the 'susceptibility' of a species to be dependent on the level of interaction of that species with the fishery. The combination of these two factors determines each species' vulnerability.

The technique is considered to be simple, robust and repeatable; it is particularly valuable in data poor situations, making it an effective assessment tool for fisheries for which there is little information (Griffiths *et al.*, 2006; Stobutzki *et al.*, 2001; 2002; Zhou and Griffiths, 2008). The analysis assigns a productivity rank and a susceptibility rank to each species, the combination of which highlights those species most at risk or alternatively, most vulnerable to the fishing activity (Milton, 2001; Stobutzki *et al.*, 2001; Stobutzki *et al.*, 2002). It thus allows species-specific information on productivities to be incorporated into an assessment of fishing impacts. Given that the majority of fisheries in the deep sea are poorly understood and generally suffer from a lack of information, the PSA approach is potentially an alternative way of offering advice to managers. The approach formalizes qualitative evidence into a simplified two-dimensional assessment of each species' vulnerability. The outputs (vulnerability plots) provide a visual tool for examining the relative vulnerability of a suite of species to a particular fishery. As such it allows alternative management scenarios to be considered and the effects estimated on all species in the community.

This method only provides an assessment of relative risk, that is, species x is more at risk (higher susceptibility to the fishery and lower ability to recover from fishing) than species y. As such it cannot be used to prove or disprove the sustainability of a fishery. The results do not translate directly into "sustainability", and drawing such a conclusion for any species should be avoided. Instead, it should be used as a tool to highlight potential management strategies, vulnerable species, and areas where particular attention should be paid.

The report of Watling *et al.* (in press) presents a preliminary attempt to apply a PSA to the mixed trawl fishery of the NE Atlantic continental slope. The analysis clearly highlighted the extreme vulnerability of deep-water sharks that arises from their low

productivity. There were however other cases of vulnerable, but productive species, such as blue ling. In such cases vulnerability relates more to their tendency to aggregate at spawning. Several management scenarios, such a prohibition of trawling at depth >1000 m were considered and the effects on all species considered. The approach is clearly in an early stage of application, but shows promise as an alternative source of advice for managers dealing with data poor fisheries and ecosystems. As such WGDEC and WGDEEP should keep a watching brief on developments in this area.

6.3 References

- Griffiths, S.P., Brewer, D.T., Heales, D.S., Milton, D.A., and Stobutzki, I.C. 2006. Validating ecological risk assessments for fisheries: assessing the impacts of turtle excluder devices on elasmobranch bycatch populations in an Australian trawl fishery. *Mar Freshw Res*, 57, 395–401.
- Milton, D.A. 2001. Assessing susceptibility to fishing of populations of rare trawl bycatch: sea snakes caught by Australia's Northern Prawn Fishery. *Biol. Conserv.*, 101, 281–290.
- Patrick, W.S., Spencer, P., Link, J., Cope, J., Field, J., Kobayashi, D., *et al.* 2010. Using productivity and susceptibility indices to assess the vulnerability of United States fish stocks to overfishing. *Fish. Bull.*, 108(3), 305–322.
- Stobutzki, I.C., Miller, M.J., and Brewer, D.T. 2001. Sustainability of fishery bycatch: a process for assessing highly diverse and numerous bycatch. *Environ. Conserv.*, 28, 167–181.
- Stobutzki, I.C., Miller, M.J., Heales, D.S., and Brewer, D.T. 2002. Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. *Fish. Bull.*, 100, 800–821.
- Watling, L. In press. Can ecosystem-based deep-sea fishing be sustained? Report of a Workshop held 31 August–3 September 2010, Neuville-Bosc, France. University of Maine, Darling Marine Center Occasional Publication #11–1.
- Zhou, S., and Griffiths, S.P. 2008. Sustainability assessment for fishing effects (SAFE): a new quantitative ecological risk assessment method and its application to elasmobranch bycatch in an Australian trawl fishery. *Fisheries Research*, 91, 56–68.

7 Review of the ICES SGMPAN report

7.1 Summary from WGDEC perspective

The workshop report is focused on seas off eastern North America. While some principles that are laid out in the report apply to all marine habitats in this area, there are few examples taken from deep-water areas. The report is also a work-in-progress. Ocean acidification will likely affect deep-water habitats; this will affect the deepest areas first, thus an MPA strategy to take account of this would be to ensure that the shallowest examples of deep-water habitats (e.g. cold-water corals) are included within MPA networks. This in turn will be influenced by the three-dimensional location of habitats; an issue not addressed in this report.

7.2 Review

The SGMPAN report covers a workshop held in November 2010 that was an early step in the process of drawing up general guidelines for MPA network design that would be pre-adapted (resilient) to the effects of climate change. The report therefore needs to be viewed as part of a work in progress. In relation to the Term of Reference (Section 2) it does not yet present the general guidelines; it is understood that it will be drawn upon in establishing draft guidelines in 2012.

The chapters of the report review a number of relevant areas to the overall aims. There is limited cross-referencing between these chapters as they respond to individual ToRs, with the consequence of some disconnect between them and the same topic being dealt with in differing ways in separate chapters. Examples of this include the effects of ocean acidification and some variance in the use of “marine ecoregion” (is there a difference between a marine ecoregion and a Large Marine Ecosystem? If so, why?). A discussion of what is not known and the consequences of that insufficiency of knowledge would be a valuable addition.

There are several properties of resilience highlighted in the report that are relevant to considering the design of MPA networks in deep-water ecosystems. One of these is population size and connectivity. It is often assumed that deep-water species are wide spread and homogeneous. Research on genetic population structure of a wide range of deep-sea species, however, suggests that while this may be the case for some species at least across ocean basins, other species are highly structured and some species may be endemic to particular isolated habitats such as seamounts (see Section 7 of this report). Thus a better understanding of the population structure and connectivity of deep-water species will be critical to assessing any resilience of MPAs in deep-water areas.

In the report however, some of the “properties” referred to are not really properties, e.g. temperature and salinity. The key property is more accurately described as niche width (or similar); in other words the degree of sensitivity to temperature and salinity. Often this is indicated by the degree of natural variation in these factors that an organism is currently subject to. This tolerance of natural variation is probably of greater importance than tolerance of absolute temperature or salinity. From a deep-water perspective coverage of acidification and its effects would have been useful at this stage; especially noting the differences between the effects on aragonite and calcite saturation and therefore differing effects on organisms using these materials for calcification. These differences are very important in relation to effects on the calcifying organisms that WGDEC is particularly concerned with. As ocean acidity rises, the

depth at which calcifying organisms can lay down calcium carbonate decreases. Aragonite is more soluble than calcite (these are polymorphs of calcium carbonate), so the depth those organisms relying on aragonite (e.g. corals) will be able to calcify will be shallower than those relying on calcite (e.g. most bivalves).

The second chapter covers properties of MPA networks. The core question that it is attempting answer is; what adjustments might be needed to an MPA network in order to allow it to be resilient to climate change? Table 4.2.1 of the report tabulates network components and properties that facilitate the building of networks designed to sustain or enhance ecosystem resilience to climate change. It is comprised of three sets of criteria aggregated together; two sets of CBD criteria, and PSSA (Particularly Sensitive Sea Area-IMO) wording here and there. However, the CBD expert advice actually distinguishes between site-level and network-level criteria, which were adopted at COP 9 in 2008 (decision IX/20 annexes 1 and 2, respectively). The current table puts these two sets together, without explanation, which could be misleading and does not reflect the intention of the CBD. We would suggest keeping the site criteria separate from the network level criteria. Likewise, unless it can be explained why some PSSA criteria (which are already very similar to the CBD criteria) were added, it would be clearer for the reader to see the two sets side by side, and hence clearer regarding which mechanisms could be applied in areas beyond national jurisdiction (within national jurisdiction, the criteria will be dependent on the national system that is in use.)

The third chapter reviews atmospheric, oceanographic and biological information off eastern North America. From the perspective of WGDEC it would have been useful if the variation in oceanography and hydrography with depth across this region had been outlined; several figures (e.g. Figure 5.1.2.1.1) purport to show waterflows but do not indicate if these are surface, midwater or bottom/abyssal currents. Given that flows are often very different at depth compared with the surface (e.g. the Gulf Stream/N Atlantic drift is underlain by much colder currents flowing in different directions, see e.g. Rahmstorf, 1997 and Figure 5.1.3.6.1 in the SGMPAN11 report) there will be considerable effects on transport of organisms and therefore ecoregions may need to be defined by depth in these deeper-water areas. The second part of this chapter (5.2) focuses on how climate change will affect ecosystem components off eastern North America. This (inevitably) is very selective, and there is no mention of deep-water ecosystems, other than cold-water corals. Table 5.4.1 of the report also does not cover deeper-water habitats to any great extent and thus there is no acknowledgement of the large data gap covering many deep-water ecosystems.

Chapter 6 describes species and habitats with crucial ecosystem roles, or those of special conservation concern. These are two very different concepts and could usefully be separated in the text (it is acknowledged that sometimes species and habitats with crucial ecosystem roles are by definition species of special conservation concern depending on the selection criteria for species of special conservation concern.) This distinction is also related to the purpose of MPAs and MPA networks. In the past, MPAs have traditionally been for the purpose of adding conservation management for species of special conservation concern (conservation of biodiversity), whereas more recently emphasis has shifted to using MPAs to ensure continuing ecosystem goods and services.

The final chapter (7) deals with analytical approaches. This starts with a new (compared to chapter 3) definition of resilience “the ability of the ecosystem to with-stand stressors (both pulse and press perturbations) such as climate change without major

structural changes.” Much of the section on design considerations might usefully be moved earlier in the report, including the very useful paragraph urging precaution in the assumption that the results of studies on tropical coral reefs are applicable in other ecosystems.

This report has gathered together much of the necessary information that forms a foundation for discussions. A critical review of the balance of evidence may also be useful; the current report tends towards using evidence that justifies MPAs and makes little mention how MPAs may work in concert with other marine management options. A good summary of the applicability of MPA networks for each taxonomic group/habitat would be helpful and would serve the wider ICES community particularly well. The overall objective after all must be to find suitable management mechanisms to achieve resilience of the function needing protection to climate change, rather than the sole use of the MPA network tool to achieve this.

7.3 References

Rahmstorf, S. 1997. Risk of sea-change in the Atlantic. *Nature*, 388: 825–826.

8 New information relevant to vulnerable marine ecosystems and the 'move-on' criteria

8.1 Introduction and background

In the WGDEC report of 2010 it was noted that the UNGA resolutions 61/105 and 64/72 call for states and RFMO/As to protect Vulnerable Marine Ecosystems (VMEs) by having rules stating what action should be taken when a fishing vessel encounters VMEs or VME species. In 2010 WGDEC reviewed the encounter provisions being used by NAFO and NEAFC as well as the encounter protocols established in other high seas areas (i.e. the South Pacific), and recommended some further actions. Among the latter were a reconsideration of the catch thresholds for VME species and a need to consider the appropriateness of these thresholds within the context of the complex biogeography of the North Atlantic. Since then some progress has been made in evaluating the move-on rule and the catch thresholds. The first section of this chapter deals with new information relevant to assessing biomass levels for encounter rules in the North Atlantic. The second section, evaluates evidence on whether the move-on rule can be expected to be an appropriate management tool for protecting VMEs on seamounts.

8.2 Review of new work by NAFO on encounter rule thresholds

The Northwest Atlantic Fisheries Organization (NAFO) Working Group on the Ecosystem Approach to Fisheries Management (WGEAFM) provided a scientific basis for the selection of encounter protocols for sponges. Previously, WGEAFM had developed a GIS model for estimating commercial sponge bycatch (Kenchington *et al.*, 2010). This model has been updated and improved in this application and the details of the methods used to evaluate sponge bycatch threshold levels are found in Cogswell *et al.* (2010). The model uses a map of sponge biomass produced from research vessel survey bycatch from the Canadian and EU surveys and superimposes on it simulated commercial groundfish trawl catches. The commercial sponge bycatch is then calculated by estimating the sponge biomass under the simulated line. The commercial trawl lines were all approximately 27.8 km which is equal to the median distance fished by 1052 vessels fishing groundfish from 2005–2010. This distance was calculated by multiplying the tow duration, which was provided, by a towing speed of 3 kts/hour. To place the trawl lines in areas as representative of actual fishing effort as possible the random start positions were weighted by fishing effort and the direction of the tow was in the direction of maximum effort. The simulated trawl lines were not allowed to enter those areas on the Flemish Cap which were closed on January 1, 2010 as a result of measures adopted by the Fisheries Commission of NAFO at its Annual Meeting in September 2009 to protect corals and sponges.

The current encounter protocol threshold for sponges in the NAFO regulatory area is 800 kg. The model provides a framework for evaluating where large catches could still be obtained outside the closed areas and what proportion of the catches would be affected by altering bycatch thresholds. Given that significant adverse impacts are likely to occur with an 800 kg threshold, a precautionary approach would suggest reducing the threshold values towards smaller values, and hence less harm, especially if only a small area and/or proportion of the catches would be affected.

The model suggests that very few groundfish trawls (0.4%) would ever encounter the current encounter threshold (800 kg) under the current fishing effort patterns (Figure 36). All six of the simulated catches >800 kg came from one location (Figure 2), along

the slope of the Grand Banks, near the Canadian EEZ. By comparison, reducing the encounter threshold for sponges to 50 kg would affect 5.5% of trawls (i.e. 94.5% of fishing would be unaffected) and those encounters could be readily reduced or avoided altogether as that catches >50 kg appear to be concentrated in just two areas in Flemish Pass outside the closed areas (Figure 37).

This model does not evaluate the biological significance of the removal of sponges, nor does it make an assessment of significant adverse impacts (SAI) to the ecosystem of the removal of sponges, including assessments of the cumulative impacts of removals. WGEAFM hope to build on this model to address SAI on sponge grounds at their December 2011 meeting.

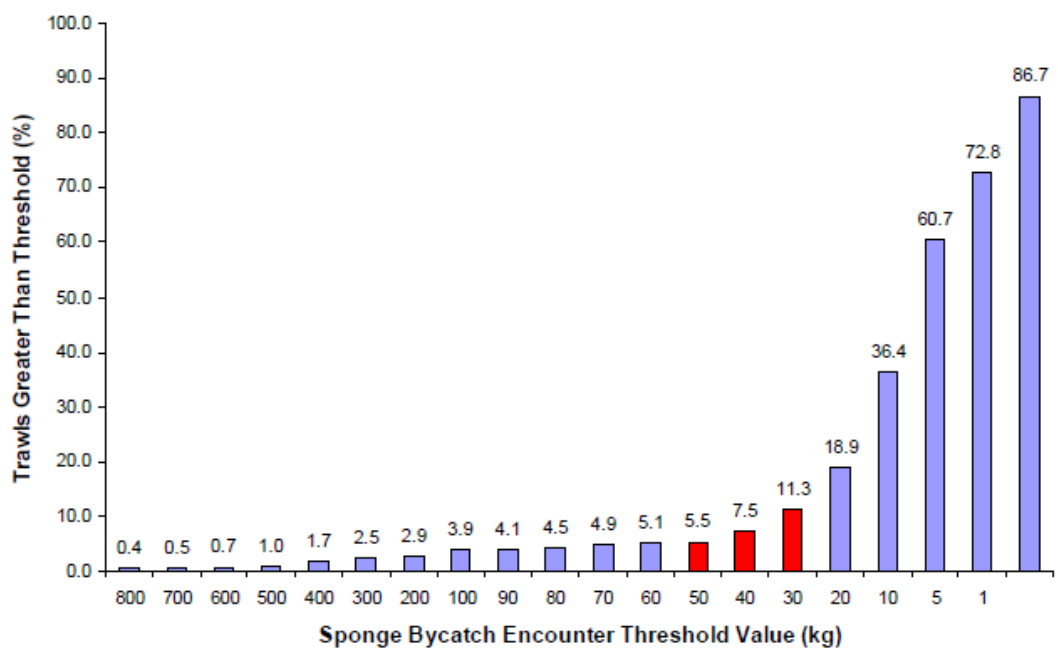


Figure 36. The proportion of simulated groundfish trawls with sponge catches greater than the sponge bycatch encounter threshold (X-axis). Red bars indicate the area where the proportion of the trawls begins to increase rapidly, with decreasing threshold.

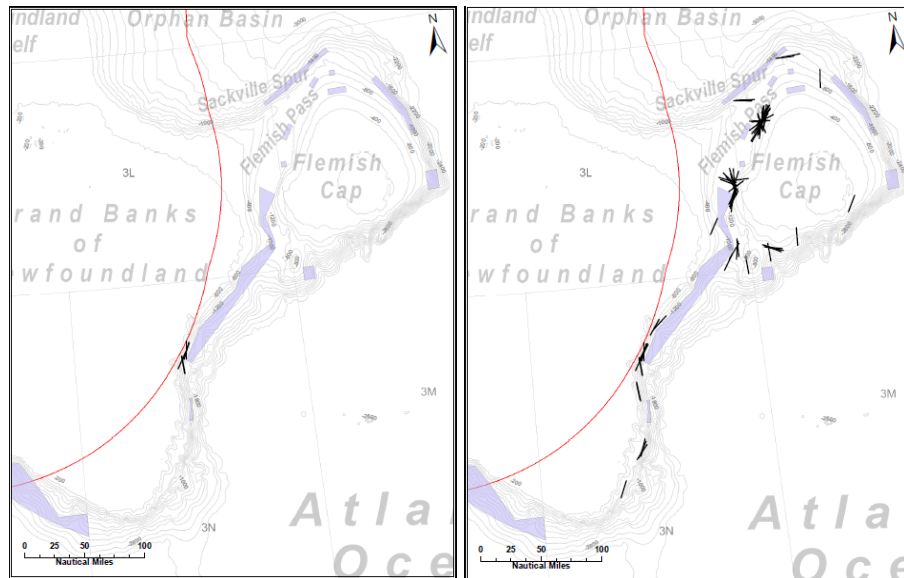
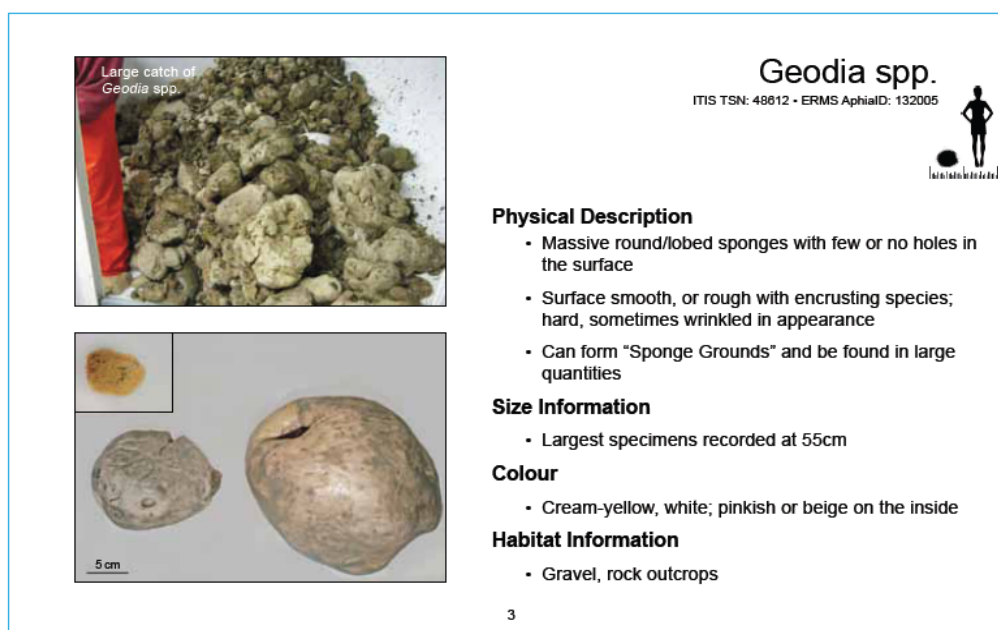


Figure 37. Location of simulated groundfish trawls catching >800 kg (left) and >50 kg (right) of sponge in the NAFO Regulatory Area.

Identification of vulnerable marine ecosystems (VMEs) by observers and fishers is critical to any encounter protocol. In 2009, a field guide to the identification of coral found in the NAFO regulatory area (NRA) was published to facilitate data collection and reporting of VMEs (Kenchington *et al.*, 2009). In 2010 a similar guide for the field identification of sponges was produced (Best *et al.*, 2010). This guide includes 33 sponge taxa known to occur in the NRA (e.g. Figure 38), one habitat-forming taxon (*Vazella pourtalesi*) known to occur on the Scotian Shelf but which may occur in the NRA, and one sponge-derived habitat, i.e. sponge spicule mats.

It was recognized that sponges as a group can be very difficult to identify, due to their malleability and variation within members of even the same species. Accurate identification to species often requires microscopic analysis of spicules, therefore several taxa are represented at the genus level to avoid incorrect reporting (for example, *Geodia* spp. represents at least three known species in the genus *Geodia*). It was also recognized that most of the intended users will use pictures to identify the taxa as they appear on deck, and will also wish to minimize reading time associated with identification. The guide therefore uses clear photos taken on-deck or laboratory photos (vs. underwater photos), and illustrates those features which help to distinguish the taxon using current taxonomic descriptors. The taxa represented in the guide are organized according to morphology or body type, as this tends to be more intuitive than organizing them taxonomically. Thus, there are six morphology groups defined, representing in all 35 sponge taxa. It is recognized that the taxon list is almost certainly incomplete, as sponge expertise in the area is developing. Thus, the guide is intended to be a 'living' document, where pages can easily be added and updated as knowledge of sponges in the NRA improves.



Solid/Massive

Figure 38. An example of a page from the NAFO Sponge Identification Guide (Best *et al.*, 2010) describing *Geodia* spp., one of the habitat-forming taxa in the NRA.

8.3 An assessment of whether the move-on rule confers protection to North Atlantic Seamounts

There has been some discussion in the literature about the degree to which seamounts are unique (McClain *et al.*, 2009; Howell *et al.*, 2010). This raises the question as to whether they should be protected under rules that are different from those imposed on areas of the high seas or continental slope (such as the move-on rule). Here we first review information on the fishable area of seamounts and assess whether move-on rules with bycatch thresholds can be expected to confer protection to VMEs on seamounts. Second we review the evidence of seamounts in the North Atlantic being unique in habitat type, biotic community composition, and degree of connectivity from communities on the continental slope. This has important implication for management and conservation.

8.3.1 Areal extent of seamounts and relative impact of seamount fisheries

Most seamounts of the North Atlantic have relatively small summit areas. There are occasional notable exceptions such as Great Meteor Seamount, but the majority are in the range of 20–40 km diameter. Others may be as much as 40 km in length, but only 3–5 km in width such as the older and more eroded seamounts of the Corner Rise and New England Seamount groups. Summit areas have been estimated for several seamounts; Gorringer is 270 km², Josephine is 210 km², Ampere is 200 km² and Seine is 160 km². These summits are all less than 500 m in depth, and thus well within fishing depths. The very large Great Meteor seamount forms a flat plateau of nearly 2000 km² at about 300 m depth, surrounded by very steep cliffs which fall away to the surrounding abyssal plains. Sedlo Smt, 75 x 30 km, has three small peaks, the shallowest of which is 780 m. The other seamounts have smaller plateaux (e.g. Irving, ca. 750 km²; Atlantis and Hyeres, ca. 350 km²). In the Northwest Atlantic the seamounts can be large, but they are heavily eroded, and so have summit areas that are complex in shape and generally are not flat topped (see Figure 39). The few seamounts within

trawlable depths (<1500 m) encompass altogether 151 km² in the New England group and 589 km² in the Corner Rise group (Thompson and Campanis, 2007).

Auster *et al.* (2011) calculated trawlable summit areas for three seamounts in the New England Seamount group: Bear, 76 km²; Kelvin, 147 km²; and Manning, 97 km² (Figure 40). They suggested a typical trawl tow with gear 80 m wide and being towed for four hours at about 7.4 km h⁻¹, would cover a track 30 km long and have a footprint of 2.4 km². There are only a few seamounts with a 30 km distance across the summit, so tows would necessarily be of much shorter duration. Nevertheless, if the tow covered 1.5 km², it would take 100–200 trawl tows to completely cover the surface of most seamounts, assuming the whole area is trawlable. Not all seamounts can be trawled and not all parts of an individual seamount are suitable for trawling. Nevertheless the area within reach of fishing vessels is relatively small.

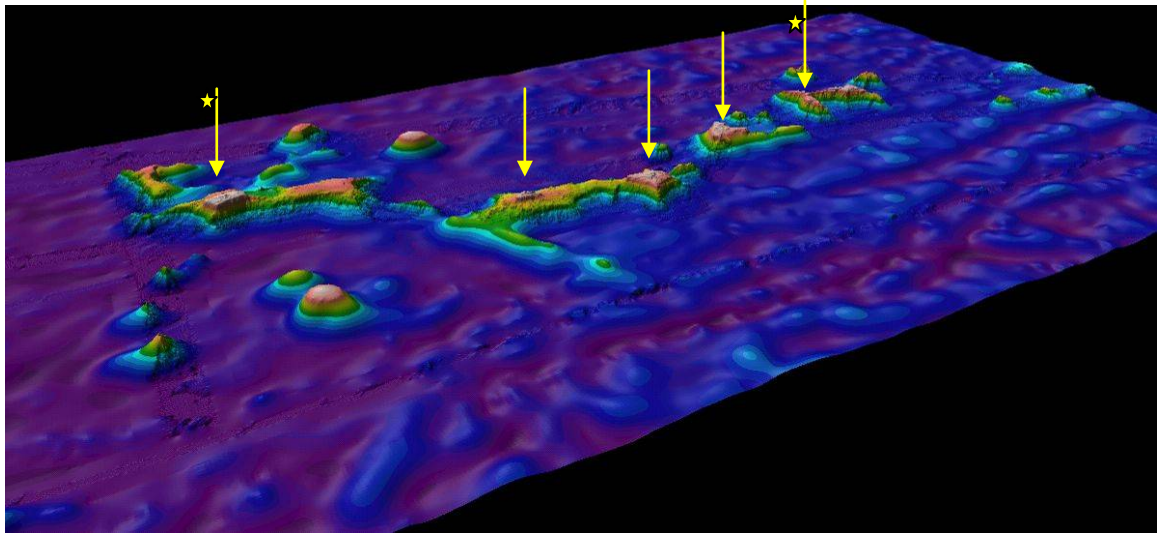


Figure 39. Reconstruction of Corner Rise seamount group based on multibeam bathymetry (Watling and Deep Atlantic Stepping Stones Team) and ETOPO2v2 data. Arrows show fishable summit areas; arrows with stars are summits of Corner Seamount (left) and Yakutat Seamount (right) where trawl impacts were observed (Watling *et al.*, 2007).

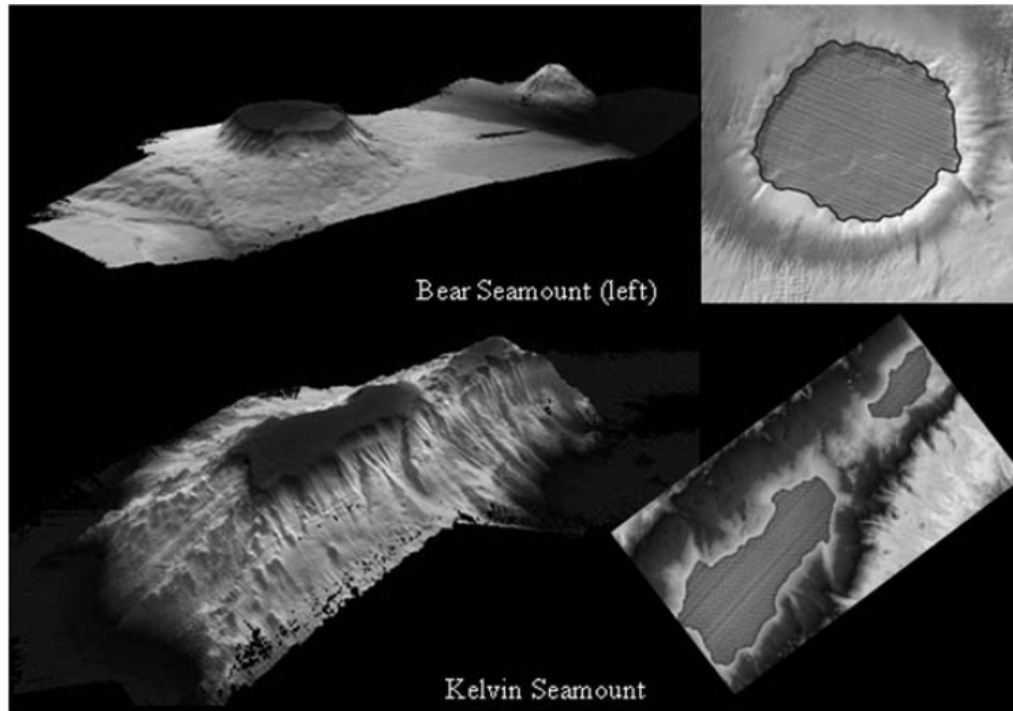


Figure 40. Trawlable areas for Bear and Kelvin Seamounts in the New England Seamount group (from Auster *et al.*, 2011).

An example of the degree to which a seamount summit can be completely covered by a vessel presumably towing a bottom trawl is given in the report of Thompson and Campanis (2007): “The New England and Corner Rise seamounts were fished by a single fishing vessel probably on an almost full-time basis, with a total of three trawls over five days and 66 trawls over 40 days, respectively (during November–December 2004). It is quite clear that a small area measuring some 16 km × 14 km on the western edge of the Corner Rise seamount was a targeted fishing area of only some 50 km² ” These estimates of number of trawls were obtained from Vessel Monitoring System data, and the probable tracks shown in Figure 41.

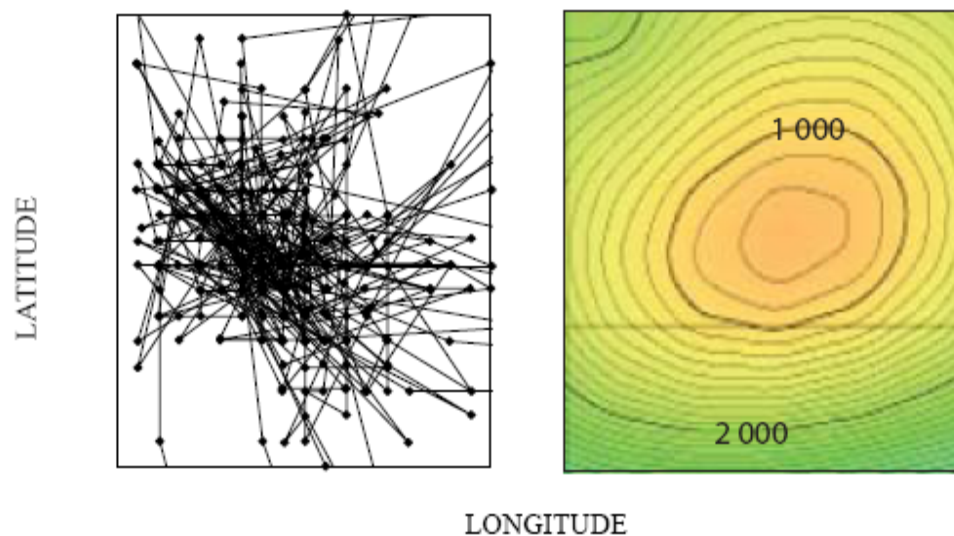


Figure 41. Left, presumed trawl tracks determined from VMS data for the summit of Corner Seamount. Right, summit contours for Corner Seamount (contrast to multibeam configuration as shown in Figure X, leftmost arrow with star). (From Thompson and Campanis, 2007).

The impact of this and most likely other trawling episodes was observed by Watling *et al.* (2007) who collected several hours of video from the summit of Corner Seamount. The carbonate crust of the seamount summit had been smashed and gouged and the underlying sediments severely eroded. Trawl impact marks could be seen at the point where the plateau rises from the surrounding basalt. No corals were present, although they were quite abundant just below the summit. Some small sponges had begun to grow on the part of the summit where the carbonate crust was still intact.

The question is whether the 'move-on' rule could have prevented the extensive impact on the relatively small area of the seamount that is fishable. Would the move-on rule have been triggered? This will depend on the local density of VME species on the seamount. Most of the VME species are not bulky, although some octocorals can be very large. The total biomass per km² is not likely to be high enough to trigger move on provisions. In the NW Atlantic, Auster *et al.* (2011) noted that if the net retained 10% of the biomass of corals impacted during a trawl tow across Bear or Kelvin seamounts, there would need to be 250 kg km⁻² of these colonies to trigger the move on rule. While overall biomass estimates for these seamounts have not been made, the counts of corals seen during video on transects at Bear and Manning seamounts (Auster *et al.* 2011; Figures 42 and 43) suggest that these threshold levels may never be met.

At two seamount peaks in the Corner Rise group (Waller *et al.*, 2007; Watling *et al.*, 2007), as well as in New Zealand waters (e.g. Clark and O'Driscoll, 2003), intensive trawling of seamount summits has resulted in the removal of the fauna from hard substrata. On sandy substrata large furrows can be produced by the trawl doors (Figure 44). Given the damage likely to occur through bottom-trawling activities, an encounter rule alone is unlikely to confer sufficient protection for these seamounts.



Figure 42. Example of coral community on New England seamounts, western end (image from Mountains in the Sea II Expedition: oceanexplorer.noaa.gov/explorations/04mountains/welcome.html).



Figure 43. Typical coral community from Corner Seamount, taken just below the summit (image from [North Atlantic Stepping Stones Expedition: oceanexplorer.noaa.gov/explorations/05stepstones/welcome.html](http://oceanexplorer.noaa.gov/explorations/05stepstones/welcome.html)).

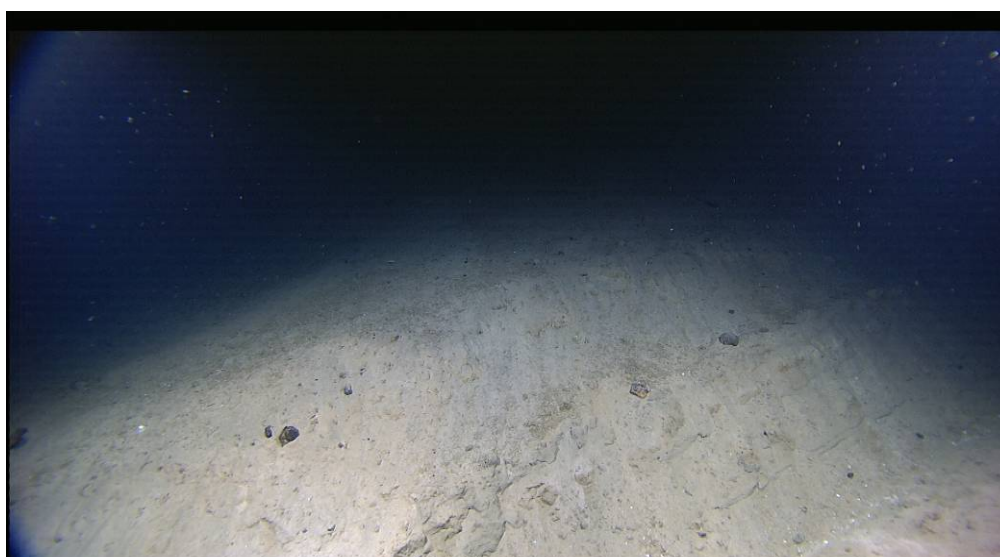


Figure 44. Image of trawl door mark on summit of Bear Seamount taken from ROV Hercules in 2004. The door mark goes from lower left to upper right across the image. From Watling Mountains-in-the-Sea II Expedition.

8.3.2 Endemicity of seamount faunas in the central North Atlantic

There is some evidence that near-slope seamounts in the NE Atlantic do not contain endemic species or unique communities (Howell *et al.*, 2010), but much less is known about more isolated seamounts. There is a pressing need to determine whether other seamounts in the North Atlantic contain a mere subset of the regional biogeographic fauna or if they contain endemic species, unique communities and isolated populations. In other words, in addition to harbouring VMEs, do seamounts meet the CBD ‘ecologically or biologically significant area’ (EBSA; XI/20 annex 1) criteria for uniqueness or rarity, the loss of which could not be compensated for by similar areas or ecosystems. If so then, then given the proportionally high fishing effort relative to the small areal extent of the seamount then the move on rule cannot be considered as an effective conservation tool.

WGDEC's report of 2010 pointed out that the biogeography of the North Atlantic bathyal provinces is not well documented or understood. A recent summary of the biogeography of the region (UNESCO 2009), suggests that there are at least two bathyal provinces that need to be considered. While the boundaries for these provinces are uncertain, it is suggested that one extends along the continental slope from Cape Hatteras on the western side, across the Greenland–Iceland Ridge to at least the Reykjanes Ridge, while the second province encompasses the seamounts of the New England and Corner Rise groups, the mid-Atlantic Ridge from about the Charlie-Gibbs Fracture Zone to about 10°N, and the seamounts of the northeastern Atlantic. Seamounts close to the continental slope of the eastern North Atlantic and the slope itself may have a sufficiently separate fauna that an additional province may need to be added to the results proposed by UNESCO (2009).

The species of octocorals found on the New England and Corner Rise seamounts continue to be described. To date nine new species and one new genus have been described, all of which are so far unique to this seamount group (Watling, 2007; Simpson and Watling, 2011; Pante and Watling, submitted). In addition, descriptions of at least an additional 20 new species in at least eight new genera of bamboo corals are in preparation. Pante and Watling (submitted) note that the species of *Chrysogorgia* from these seamounts are quite different in their phylogenetic history from the species found on the continental slopes around the North Atlantic. In fact, of all the species identified so far, only two, *Acanella arbuscula* and *Acanthogorgia armata*, are widespread in the North Atlantic. The former is widespread across the seamounts as well, but the latter is found only on seamounts close to the continental slope. Most of the octocorals studied also host, with a high degree of fidelity, one or two species of commensal invertebrates (e.g. Mosher and Watling, 2009; Watling, 2010), so loss of an octocoral species could mean the loss of one or two other invertebrate species.

In the Northeast Atlantic, octocorals from seamounts have not been studied in as much detail. Nevertheless, Grasshoff (1985) identified eleven species from Great Meteor and Josephine seamounts, of which four have been found also on the continental slope of North America. Within some genera, for example, the octocoral *Ellisella*, one species, *E. flagellum*, was found only on the seamounts, while a second species, *E. paraplexauroides*, was found only on the shelf and slope (Grasshoff, 1972). There is limited taxonomic work on other animal groups, for example, harpacticoid copepods (George and Schminke, 2002) and rissoid snails (Gofas, 2007). Both groups are very small, and usually inhabit the sandy parts of the seamounts. Both groups show very high levels of endemism (over 90%) on their respective seamounts or seamount groups. George and Schminke (2002) who found that 54 of 56 species of harpacticoid copepods found on Great Meteor Seamount were new to science. They concluded that the Great Meteor Plateau has acted as an isolated area and subsequently developed its own unique fauna. The lack of relationship of these species to those in the adjacent deep sea or from shelf or slope or other seamounts suggests that seamounts with extensive sandy flat areas may each harbour their own fauna. The rissoid snails were collected by small dredge from eleven seamounts in the Lusitanian and Meteor seamount groups. In all 48 species were found, 30 of which were new (Gofas, 2007). Only two species were common to both seamount groups. Most of these snails have either reduced or no planktonic larval development, explaining the relatively high degree of endemism.

In conclusion, because of the small size of the trawlable area on most seamounts and the fragility of the seamount fauna, use of an encounter rule alone, without additional management measures, would over time lead to a steady degradation of these habi-

tats. Hence as a single management measure it is insufficient to conserve VMEs on seamounts.

8.4 References

- Auster P.J., Gjerde K., Heupel, E., Watling L., Grehan A., Rogers A.D. 2011. Definition and detection of vulnerable marine ecosystems on the high seas: Problems with the Move-On Rule. *ICES J Marine Science* 68(2), 254–264.
- Best, M., Kenchington, E., MacIsaac, K., Wareham, V., Fuller, S.D., and Thompson A.B. 2010. Sponge Identification Guide NAFO Area. *NAFO Scientific Council Studies*, 43: 1–49. doi:10.2960/S.v43.m1.
- Clark MR, O’Driscoll R. 2003. Deep-water fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science*, 31: 441–458.
- Cogswell, A., E. Kenchington, C. Lirette, B. Brodie, G. Campanis, A. Cuff, A. Perez, A. Kenny, N. Ollerhead, M. Sacau, V. Wareham. 2010. Evaluating Sponge Encounter Thresholds through GIS Simulation of the Commercial Groundfish Fishery in the NAFO Regulatory Area. NAFO Scientific Council Research Document 10/71, 26 pp.
- George, K.H. and H.K. Schminke. 2002. *Harpacticoida* (Crustacea, Copepodaisopoda) of the Great Meteor Seamount, with first conclusions as to the origin of the plateau fauna. *Marine Biology* 144: 887–895.
- Gofas, S. 2007. *Rissoiidae* (Mollusca: Gastropoda) from the northeast Atlantic seamounts. *Journal of Natural History* 41: 779–885.
- Grasshoff, M. 1972. Die Gorgonaria des östlichen Nordatlantik und des Mittelmeeres. I. Die Familie *Ellisellidae* (Cnidaria, Anthozoa). Auswertung der “Atlantischen Kuppenfahrten 1967” von F.S. “Meteor”. “Meteor” Forschungs-Ergebnisse D, No. 10: 73–87.
- Grasshoff, M. 1985. Die Gorgonaria und Antipatharia der Grossen Meteor-Bank und der Josephine-Bank. *Senckenbergiana Maritima*.
- Howell KL, Mowles SL, Foggo A. 2010. Mounting evidence: near-slope seamounts are faunally indistinct from an adjacent bank. *Marine Ecology* 31: 52–62.
- Kenchington, E., Best, M., Cogswell, A., MacIsaac, K., Murillo-perez, J., Macdonald, B. Wareham, V., Fuller, S. D., Jørgensbye Hansen, H. I. Ø., Sklyar, V., and Thompson, A.B. 2009. Coral Identification Guide NAFO Area. *NAFO Scientific Council Studies*, 42: 1–18. doi:10.2960/S.v42.m1.
- Kenchington, E., A. Cogswell, C. Lirette, J. Rice. 2010. A GIS Simulation Model for Estimating Commercial Sponge Bycatch and Evaluating the Impact of Management Decisions. DFO Canadian Scientific Advisory Secretariat Research Document 2010/040. vi + 39 pp.
- Kitchingman, A. and Lai, S. 2004. Inferences on potential seamount locations from mid-resolution bathymetric data. Pp. 7–12, In Morato, T. and D. Pauly (eds.), *Seamounts: Biodiversity and Fisheries*.
- McClain CR, Lundsten L, Ream M, BarryJ, DeVogelaer A. 2009. Endemicity biogeography composition and community structure on a northeast Pacific seamount. *Public Library of Science ONE* 4: 4141.
- Mosher, C.V. and L. Watling. 2009. Partners for life: a deep-sea brittlestar and its octocoral host. *Marine Ecology Progress Series* 397:81–88.
- Pante, E. and L. Watling. Submitted. New species of *Chrysogorgia* from NW Atlantic seamounts. *Journal of the Marine Biological Association of the UK*.
- Simpson, A. and L. Watling. 2011. Precious corals (Octocorallia: *Coralliidae*) from the North-western Atlantic. *Journal of the Marine Biological Association of the United Kingdom* 91: 369–382.

- UNESCO. 2009. Global Open Oceans and Deep Sea-Bed biogeographic classification.
- Waller, R., L. Watling, P. Auster, T. Shank. 2007. Anthropogenic impacts on the Corner Rise Seamounts, NW Atlantic Ocean. *Journal of the Marine Biological Association of the United Kingdom* 87: 1075–1076.
- Watling, L. 2007. A review of the genus *Iridogorgia* (Octocorallia: *Chrysogorgiidae*) and its relatives, chiefly from the North Atlantic Ocean. *Journal of the Marine Biological Association of the United Kingdom* 87: 393–402.
- Watling, L., Waller, R., Auster, P.J. 2007. Corner Rise Seamounts : the impact of deep-sea fisheries. *ICES Insight* 44: 10–14.
- Watling, L. 2010. Notes on the habitat of the deep-sea caridean shrimp, *Bathypalaemonella ser-ratipalma* Pequegnat. Pp. 707–714, in C.H.M. Fransen *et al.* (eds.) *Studies on Malacostraca*. E.J. Brill, Publ.

9 Summary of new information on sponge distribution in the North Atlantic

9.1 Background

The 2007–2010 WGDEC reports documented historical and recent data on the location of sponge grounds across the North Atlantic for the first time, although for most of those areas the species composition of the sponges was not fully described. This year the WGDEC reviewed how this new information on species distributions relates to environmental variability and possible physical drivers of sponge distribution.

9.2 Taxonomic status of sponges in the NE Atlantic

Taxonomically the Porifera are a difficult group. Compared to the NE Atlantic, the tradition for sponge work has been relatively weak in the NW Atlantic. There are, however, strong scientific arguments for mapping local fauna, comparing in detail the two sides of the North Atlantic and investigating historical and contemporary biogeographical connections to the Arctic and the North Pacific. Mapping at the level of sponge grounds, i.e. mass occurrences of sponges within restricted areas, off Nova Scotia and Newfoundland is well on the way. Sampling efforts, general distribution in relation to topography and water masses and generic identity of dominating species were outlined in the 2009 WGDEC Report. In 2010, the WGDEC reported on new sponge distributional data from the Hudson Strait, the Gulf of St Lawrence and Greenland. Several species of structure forming species were identified that were particularly abundant in the Ungava Bay area of Hudson Strait and along the Newfoundland-Labrador shelves and slopes, including *Asconema foliata*, *Geodia barretti* and *Mycale lingua*. Sponge bycatch from Canadian research vessel data continues to be extensively documented (Kenchington *et al.*, 2010), and will form an important component of the new ICES WGDEC database [WGDEC 2011 ToR (a)]. An important step further has been taken in 2010 with the publication of the NAFO Sponge Identification Guide (Best *et al.*, 2010), allowing biologists, fishermen and other interested to make a preliminary identification of a series of species, and to report in a simple way on their catches from Canadian waters. A similar guide is currently planned for Greenland waters, aiming also to be useful on the Canadian side of the Davis Strait and Baffin Bay.

Work at the level of species in the NW Atlantic has progressed and supports the picture outlined in 2008, but a full overview of the fauna of the different types of sponge grounds has not yet been reached. Therefore, detailed comparisons of NE Atlantic and NW Atlantic sponge habitats is not yet feasible, apart from case studies on selected species or species groups. With the advent of the new ICES WGDEC database incorporating sponge data from Canadian, US, European and the mid-Atlantic Ridge and High Seas, environmental and species data such detailed analyses can be made and overarching trends such as relationships to water mass characteristics and seabed topography be confirmed.

9.3 Environmental forcing of sponge distribution in the North Atlantic

The UNEP-WCMC sponge report (Hogg *et al.*, 2010) identifies the need to “investigate the environmental preferences of deep-water sponge grounds and other deep-water habitats on global and regional scales in order to contribute to the modelling of potential distribution patterns.” Of particular interest are factors controlling the distribution of species forming large biogenic structures or that are part of sponge

grounds (Table 4). Distribution of individual species of large structural forming sponges can be modelled by examining the environmental niche of each species, whereas understanding the distribution of sponge grounds (usually a mixture of species in the North Atlantic) requires more complex, multispecies approaches to modelling.

Table 4. Structural sponges or those constituting a component of sponge grounds/mass occurrences and found >200 m in the North Atlantic (collated from Section 6 in WGDEC 2007 Report and Table 8.2.1 in WGDEC 2009 Report, updated species in bold). D = dominating the sponge ground; M = one of several species dominating the sponge ground; A = found on sponge ground in abundance, but not dominating as to biomass. *denotes taxonomic revision.

Hexactinellida	Demospongiae
<p><i>Pheronema carpenleri</i> (Thomson, 1869); D <i>Caulophacus (Caulophacus) arcticus</i> (Hansen, 1885); D,M <i>Rossella nodastrella</i> Topsent, 1915; D <i>Asconema foliata</i> Fristedt, 1887); A <i>Vazella pourtalesi</i> (Schmidt, 1870); D <i>Schaudinnia rosea</i> (Fristedt, 1887); A <i>Trichasterina borealis</i> Schulze, 1900; A</p>	<p><i>Axinella infundibuliformis</i> (Linnaeus, 1759) M, A <i>Aplysilla sulphurea</i> Schulz, 1878; M, A *<i>Sidonops atlantica</i> Stephens, 1915; M, A <i>Geodia barretti</i> (Bowerbank, 1858); D, M <i>Geodia macandrewi</i> Bowerbank, 1858 D, M <i>Geodia mesotriaena</i> (Hentschel, 1929); D, M <i>Isops phlegraei</i> Sollas, 1880; M <i>Isopa phlegraei pyriformis</i> (Vosmaer, 1882); A <i>Stryphnus ponderosus</i> (Bowerbank, 1866); D, M <i>Stelletta normani</i> Sollas, 1880; M, A <i>Stelletta raphidiophora</i> Hentschel, 1929; A <i>Thenia muricata</i> (Bowerbank, 1858); D, A <i>Thenia levis</i> Von Lendenfeld, 1903; A <i>Thenia valdiviae</i> Lendenfeld, 1907; A <i>Tetilla infrequens</i> (Carter, 1876); A <i>Tetilla cranium</i> (Müller, 1776); A <i>Polymastia mammillaris</i> (Müller, 1806); A <i>Polymastia uberrima</i> (Schmidt, 1870); A <i>Polymastia thielei</i> (Koltun, 1964); A <i>Phakellia robusta</i> Bowerbank, 1864; A <i>Phakellia rugosa</i> (Bowerbank, 1866); A <i>Phakellia ventilabrum</i> (Linnaeus, 1767); A <i>Mycale lingua</i> (Bowerbank, 1866); M, A <i>Antho dichotoma</i> (Esper, 1794); A <i>Petrosia crassa</i> (Carter, 1876); A <i>Oceanapia robusta</i> (Bowerbank, 1866); A</p>

The three new sponge species added to Table 1 form either a part of sponge grounds, or are important structural features in waters <200 m in the North Atlantic. *Caulophacus (Caulophacus) arcticus* is only found in the northern North Atlantic, off Norway where it occurs in abundance with other sponges. Within the MAREANO mapping area, it has been found below 1500 m, but typically it occurs around 2000 m (P. Buhl-Mortensen, MAREANO, ongoing). *Rossella nodastrella* occurs on Rockall Bank in abundance, but notably, its occurrence is negatively correlated with *Lophelia pertusa*. *Axinella infundibuliformis* is a common deep-sea species off the British Isles, but can penetrate into waters as shallow as 140 m deep on the Mingulay Reef Complex off western Scotland.

Although there are a growing number of sponge distribution maps in the North Atlantic, the region continues to lack explicit distribution models that quantify effects of environmental variables (simple or multifactorial) on sponge species and sponge grounds. For the present, sparse new data are available, but more often only a broadly qualitative approach from previously published data can be used to summarize sponge distribution in relation to environmental drivers in the North Atlantic.

At fine to local spatial scales, the distribution of sponge grounds broadly conforms to environmental conditions conducive to the growth of benthic sessile filter and suspension-feeders. Sponges require sufficient current strength to feed themselves, but this must not exceed the sponge's ability to grow. The food supply may be derived from upwelling or downwelling of nutrients and plankton, the quality and quantity of which will vary across habitat types, depth, and bottom topography, factors that also control the distribution of deep, cold-water sponges (Henry *et al.*, 2010). Sponges also require sufficient space and adequate substrata upon which they can recruit and grow; typically this is rocky or biogenic hard substrata, but some inhabit softer sandy or muddy sediments.

Across wider spatial scales, hydrographical and oceanographic conditions must be considered. In combination with bottom habitat classification schemes, these large-scale factors will certainly govern future analyses of environmental forcing of sponge species and sponge grounds in the North Atlantic. Recent research highlights continue to document sponge co-occurrence with cold-water corals and coral carbonate mounds, the role of seamount and canyon habitats, the importance of internal wave generation and bathymetry, and wider patterns of species and genetic connectivity externally forced by dispersal controlled by water mass distribution. The future remit of ICES should also consider the effects of climate change on hydrographical and oceanographic variables that drive sponge distribution.

Table 5 provides a list of environmental variables believed to be important in the distribution of sponges and sponge grounds. Note, many of these categories and variables are not mutually exclusive, and are often correlated e.g. substratum grain size and current speed.

Table 5. Categories of environmental variables believed to control the distribution of large structural sponge species and sponge grounds/mass occurrences in the North Atlantic.

CATEGORY	ENVIRONMENTAL VARIABLE	REFERENCE
seabed bathymetry	slope rugosity bathymetric position index aspect/orientation depth	Klitgaard and Tendal, 2004
habitat	presence of cold-water corals inshore/shelf/slope	Henry and Roberts, 2007; van Soest <i>et al.</i> , 2007a; Sánchez <i>et al.</i> , 2009; WGDEC 2010
substratum	type grain size distribution	Rice <i>et al.</i> , 1990; Mortensen and Fosså, 2006; Henry and Roberts, 2007; Sánchez <i>et al.</i> , 2009
oceanography	water mass temperature, salinity, density oxygen thermocline nutrients, silicium, CaCO ₃	Lundälv (unpublished data); Klitgaard <i>et al.</i> , 1997; Klitgaard and Tendal, 2004; Reveillaud <i>et al.</i> , 2010, 2011; MAREANO, ongoing
hydrography	current speed Tidal effects Internal waves Turbulence Sedimentation Resuspension Production at surface	Sánchez <i>et al.</i> , 2009
food supply	downwelling, upwelling particle kind particle spectrum, DOM, nutrients	Rice <i>et al.</i> , 1990; Sánchez <i>et al.</i> , 2009
biological	predation competition for space competition for food	van Soest <i>et al.</i> , 2007b

9.4 Sponges on cold-water coral habitats

A rich assemblage of sponges occurring with cold-water corals in the North Atlantic has been known for a long time and is well documented (Le Danois, 1948; Jensen and Frederiksen, 1992; Burdon-Jones and Tambs-Lyche, 1960; van Soest *et al.*, 2007a; Mortensen and Fosså, 2006; Henry and Roberts, 2007) and these form a diverse component of the fauna living on or nearby habitats created by *Lophelia pertusa*. To date, 330 sponge species have been found inhabiting these habitats in the North Atlantic (L-A Henry, HERMIONE project, unpublished data).

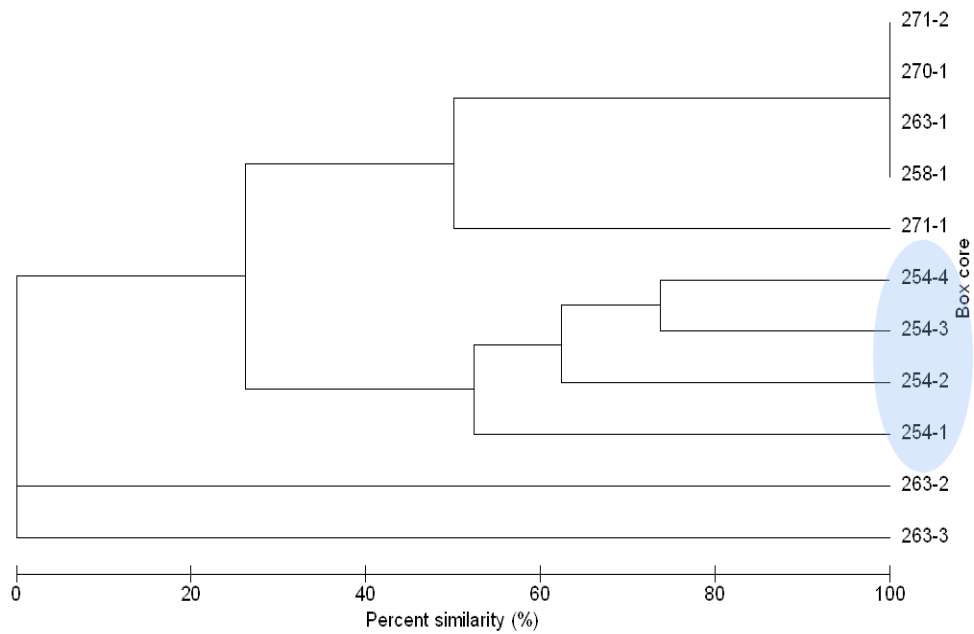


Figure 45. Cluster analysis of sponge fauna from the Belgica coral carbonate mound province in the Porcupine Seabight. Blue ellipse shows close species similarity between sponge assemblages inhabiting the summit of the largest coral bank, Galway Mound.

Within these coral habitats, sponge assemblages are richest on the summits of giant coral carbonate mounds such as the Galway Mound in the Porcupine Seabight, which are topped by living and dead *Lophelia* framework. These assemblages have a characteristic large structural forming sponge fauna including *Aphrocallistes bocagei* and *Geodia barretti* (see Figure 45 and Henry and Roberts, 2007), the former also characterizing the summit fauna of the nearby Thérèse Mound and on the nearby cluster of coral banks, the Moira Mounds (see Figure 46 and Wheeler *et al.*, in press). This relationship between mound size/developmental phase and sponge species heterogeneity suggests that large structural forming sponges preferentially grow on the stable substrata provided by the living *Lophelia* reef at the mound summit, perhaps as part of a climax successional species community.



Figure 46 *Aphrocallistes bocagei* found on the summit of a Moira Mound in the Porcupine Seabight, 932 m (copyright Ifremer/VICTOR 6000; Wheeler *et al.*, 2010).

Sedimentary regimes at the mound summit are also less erosional, with finer grained sediments deposition at the summit where corals impede current flow, trapping sediments and food (Wheeler *et al.*, 2010). “Ecosystem engineering” by *Lophelia* undoubtedly has consequences for local large slow-growing sponges because they depend on an adequate flowfield of nutrients and plankton, which the coral framework enhances by slowing fine-scale currents.

9.5 Other topographies

Globally, sponges are commonly encountered on other habitat-ecosystems such as canyons, ridges and seamounts (often containing cold-water corals as well), their distribution similarly related to substratum and seabed topography that foster sponge growth, reproduction and persistence of populations (Schlacher *et al.*, 2007; Sautya *et al.*, 2011). Environmental data generated from ongoing seamount and canyon surveys in the North Atlantic (e.g. New England Seamounts, Hudson Canyon, Anton Dohrn, Whittyard Canyon, Guilvinec canyon, and Le Croisic canyon)) could be similarly analysed in relation to accompanying sponge distribution data.

9.6 Oceanography

In the North Atlantic, the distribution of sponges closely tracks oceanography, whereby distinct sponge assemblages are distributed within certain water masses. As discussed in WGDEC2009, this seems largely due to preferred temperature ranges, as in the case of the distribution of arctic vs. cold-water ostur sponge grounds in the Norwegian Atlantic Current and the Irminger Current (Klitgaard and Tendal, 2004). It must be noted, however, that shifts in other water properties such as density, salinity, and the depth of their horizons and the permanent thermocline are all interrelated with temperature, and exert significant control on the distribution of other deep-sea fauna such as cold-water corals (Dullo *et al.*, 2008; White and Dorschel,

2010). Abrupt changes in temperature such as the month-long positive temperature anomalies up to 14°C in the Tisler Reef in Kosterfjord, Sweden caused significant mortality in populations of the large structure forming demosponge *Geodia barretti*, (T. Lundälv, HERMIONE project, unpublished data).

Although the relationship still lacks quantification, the concept of enhanced currents and food supply near the shelf break or at critical slopes very likely controls the distribution of sponges and sponge grounds, particularly when these conditions coincide with the permanent thermocline where internal tides increase and further enhance food supply and current strength. This may explain the common observation of sponges and sponge grounds, as well as *Lophelia*, large octocorals and stylasterids near the shelf break, and in areas of sloped, irregular bottom topography (Frederiksen *et al.*, 1992; Klitgaard *et al.*, 1997; Klitgaard and Tendal, 2004) It may also explain the (possible) mass occurrence of the calcareous sponge *Jenkina articulata* on the Antarctic shelf (Janussen and Rapp, in press). While internal tides at the critical slope directly enhance currents and food for some sponges, indirect/downstream effects seem to foster the development of bird's nest sponge grounds comprised of *Pheronema carpenster* (Rice *et al.*, 1990).

The role of water masses in controlling sponge distribution may also arise by the homogenization of fauna due to larval dispersal across large spatial scales. For example, sponge species track the circulation of the intermediate water mass Mediterranean Outflow Water across spatial scales as large as 5200 km, from the Ionian Sea to at least as far as Rockall Bank (Reveillaud *et al.*, 2010; 2011). Advancing knowledge of the biodiversity and biogeography of the sponge grounds in Canadian waters and the developing ICES WGDEC database will in the near future greatly inform analyses of the wider connectivity patterns of sponges between ocean "gateways" such as the Caribbean and Mediterranean Seas and across the North Atlantic and Arctic Ocean.

9.7 References

- Best M, Kenchington E, MacIsaac K, Wareham V, Fuller SD, Thompson AB. 2010. Sponge identification guide NAFO area. Scientific Council Studies 43: 1–50.
- Burdon-Jones C, Tambs-Lyche H. 1960. Observations of the fauna of the North Brattholmen stone-coral reef near Bergen. Årbok for Universitetet i Bergen, Matematisk Naturvitenskapelig Serie, 4:1–24.
- Dullo WC, Fogel S, Rüggeberg A. 2008. Cold-water coral growth in relation to the hydrography of the Celtic and Nordic European continental margin. Marine Ecology Progress Series 371: 165–176.
- Frederiksen R, Jensen A, Westerberg H. 1992. The distribution of the scleractinian coral *Lophelia pertusa* around the Faroe Islands and the relation to intertidal mixing. Sarsia 77: 157–171.
- Henry L-A, Davies AJ, Roberts JM. 2010. Beta diversity of cold-water coral reef communities off western Scotland. Coral Reefs 29: 427–436.
- Henry L-A, Roberts JM. 2007. Biodiversity and ecological composition of macrobenthos on cold-water coral mounds and adjacent off-mound habitat in the bathyal Porcupine Seabight, NE Atlantic. Deep-Sea Research I 54: 654–672.
- Hogg MM, Tendal OS, Conway KW, Pomponi SA, van Soest RWM, Gutt J, Krautter M, Roberts JM. 2010. Deep-sea sponge grounds: reservoirs of biodiversity. UNEP-WCMC Biodiversity Series 32. (UNEP-WCMC, Cambridge, UK. 84pp.

- Janussen D, Rapp HT. In press. Redescription of *Jenkina articulate* Brønsted from the deep Eckström Shelf, E-Weddell Sea, Antarctica and a comment on the possible mass occurrence of this species. Deep-Sea Research II.
- Jensen A, Frederiksen R. 1992. The fauna associated with the bank-forming deep-water coral *Lophelia pertusa* (Scleractinia) on the Faroe shelf. *Sarsia* 77: 53–69.
- Kenchington E, Lirette C, Cogswell A, Archambault C, Archambault P, Benoit H, Bernier D, Brodie B, Fuller S, Gilkinson K, Lévesque M, Power D, Siferd T, Treble M, Wareham V. 2010. Delineating coral and sponge concentrations in the biogeographic regions of the east coast of Canada using spatial analyses. DFO Canadian Science Advisory Secretariat Research Document, 2010.
- Klitgaard AB, Tendal OS. 2004. Distribution and species composition of mass occurrences of large-sized sponges in the Northeast Atlantic. *Progress in Oceanography* 61: 57–98.
- Klitgaard AB, Tendal OS, Westerberg H. 1997. Mass occurrences of large-sized sponges (*Porifera*) in Faroe Island (NE-Atlantic) shelf and slope areas: characteristics, distribution and possible causes. In: Hawkins LE, Hutchinson S, Jensen AC, Williams JA, Shearer M (Eds) *The Responses of Marine Organisms to their Environment*. University of Southampton, pp. 129–142.
- Le Danois E. 1948. Les profondeurs de la mer. Trente ans de recherches sur la faune sous-marine au large des côtes de France. Payot, Paris. 303 pp.
- Mortensen PB, Fosså JH. 2006. Species diversity and spatial distribution of invertebrates on deep-water *Lophelia* reefs in Norway. In: *Proceedings of the 10th International Coral Reef Symposium, Okinawa, Japan*, pp. 1849–1868.
- Reveillaud J, Remerie T, van Soest R, Erpenbeck D, Cárdenas P, Derycke S, Xavier JR, Rigaux A, Vanreusel A. 2010. Species boundaries and phylogenetic relationships between Atlanto-Mediterranean shallow-water and deep-sea coral associated *Hexadella* species (*Porifera*, *Ianthellidae*). *Molecular Phylogenetics and Evolution* 56: 104–114.
- Reveillaud J, van Soest R, Derycke S, Picton B, Rigaux A, Vanreusel A. 2011. Phylogenetic relationships among NE Atlantic Plocamionida Topsent (1927) (*Porifera*, Poecilosclerida): under-estimated diversity in reef ecosystems. *PLoS One* 6: e16533.
- Rice AL, Thurston MH, New AL. 1990. Dense aggregations of a hexactinellid sponge, *Pheronema carpenteri* in the Porcupine Seabight (Northeast Atlantic Ocean) and possible causes. *Progress in Oceanography* 24: 179–196.
- Sánchez F, Serrano A, Gómez Ballesteros M. 2009. Photogrammetric quantitative study of habitat and communities of deep Cantabrian Sea hard grounds. *Continental Shelf Research* 29: 1174–1188.
- Sautya S, Ingole B, Ray D, Stöhr S, Samudrala K, Kamesh Raju KA, Mudholkar A. 2011. Megafaunal community structure of Andaman seamounts including the Back-Arc Basin – a quantitative exploration from the Indian Ocean. *PLoS One* 6: e16162.
- Schlacher TA, Schlacher-Hoenlinger MA, Williams A, Althaus F, Hooper JNA, Kloser R. 2007. Richness and distribution of sponge megabenthos in continental margin canyons off southeastern Australia. *Marine Ecology Progress Series* 340: 73–88.
- van Soest RWM, Cleary DFR, Kluijver MJ, Lavaleye MSS, Maier C, van Duyl FC. 2007a. Sponge diversity and community composition in Irish bathyal coral reefs. *Contributions to Zoology* 76: 121–142.
- van Soest RWM, van Duyl FC, Maier C, Lavaleye MSS, Beglinger EJ, Tabachnick KR. 2007b. Mass occurrence of *Rossella nodastrella* Topsent on bathyal coral reefs of Rockall Bank, W of Ireland (Lyssanacinosida, Hexactinellida). *Porifera Research: Biodiversity, Innovation and Sustainability 2007*: 645–652.
- Wheeler AJ, Kozachenko M, Henry L-A, Foubert A, de Haas H, Huvenne VAI, Masson DG, Olu K. In press. The Moira Mounds, small cold-water coral banks in the Porcupine

Seabight, NE Atlantic: Part A- an early stage growth phase for future coral carbonate mounds? *Marine Geology*.

White M, Dorschel B. 2010. The importance of the permanent thermocline to the cold water coral carbonate mound distribution in the NE Atlantic. *Earth and Planetary Science Letters* 296: 395–402.

10 Requirement and need for fisheries independent deep-water surveys in the NE Atlantic

This ToR has been addressed jointly by WGDEEP, WGDEC and WGEF.

10.1 Background

ICES is required to provide fisheries and ecosystem management advice for deep-water areas. The primary source of fisheries independent stock advice and indicators of deep-water biodiversity and ecosystem status come from deep-water survey time-series. Such surveys have in past been mainly trawl surveys, but in more recent years have become increasingly multidisciplinary. As such deep-water surveys are important sources of information for ICES WGDEC, WGDEEP and WGEF. Dedicated deep-water surveys have been conducted by several countries; however these are limited in their spatial extent (Figure 47) and to date have lacked a coordinated research strategy. Lack of adequate national and/or DCF funding has resulted in the discontinuation of some of these surveys and consequent truncation of dataserries.

In 2007, ICES received requests from the EU Regional Coordination Meeting for the NE Atlantic and NEAFC to consider coordination and development of deep-water surveys for the NE Atlantic. In response ICES set up an international deep-water survey planning group, the Planning Group on the Northeast Atlantic Continental Slope Surveys (PGNEACS) in 2008. PGNEACS reviewed existing NEA deep-water and slope surveys, and developed a proposal for international coordination.

WGDEC, WGDEEP and WGEF met with a representative from the EC's DGMARE on 3rd March 2011 to discuss this term of reference. Those aspects most relevant to WGDEC are reported here, while those relevant to WGDEEP and WGEF are detailed in those WG's respective reports.

10.2 Uses of information from deep-water surveys by WGDEC

Three key uses of data for deep-water ecosystem advice from surveys were identified:

- 1) mapping the spatial and bathyal distribution of deep-water species, including benthic bycatch;
- 2) generating indices of biodiversity and any other ecosystem indicators;
- 3) VME habitat mapping.

There will be an increasing need to research and monitor the status of deep-water ecosystems within the EEZ of the EC as part of the Marine Strategy Framework Directive (MSFD). This requires the development of indicators of ecological quality or 'good environmental status' (GES). Qualitative descriptor No. 1 of the MSFD's for GES is maintaining biological diversity. This can be readily done for fish species sampled by deep-water trawl surveys (Campbell *et al.*, 2011), but is more problematic for deep-water benthic organisms. Additional methods are therefore needed. Benthic sledges and beam trawls are one way to sample benthos more effectively, but these are not desirable in deep-water ecosystems where they cause significant adverse impacts to VMEs. In cases where this is the case, alternative non-destructive methods need to be developed and adopted, such as ROV and or drop frame/towed camera surveys. Future deep-water surveys therefore need to have a multidisciplinary design in which the information gained is appropriate to the impact the sampling is likely to have on the VMEs. Deep-water surveys also provide the platform to collect acoustic

and physical data on the seabed. Such data can be valuable for modelling the likelihood of the presence of different types of deep-water ecosystems such as coral reefs or seapen/mud habitats.

10.3 Solution for the near-future

A proposal has been made for an internationally coordinated and multidisciplinary deep-water survey. This would span most of the Northeast Atlantic and be comprised of trawl surveys in the central and northern regions and longline surveys in the southern regions. Details of the survey plan can be found in the report of PGNEACS (2009) and WGNEACS (2010). The planned extent of the central trawl survey is shown in Figure 47.

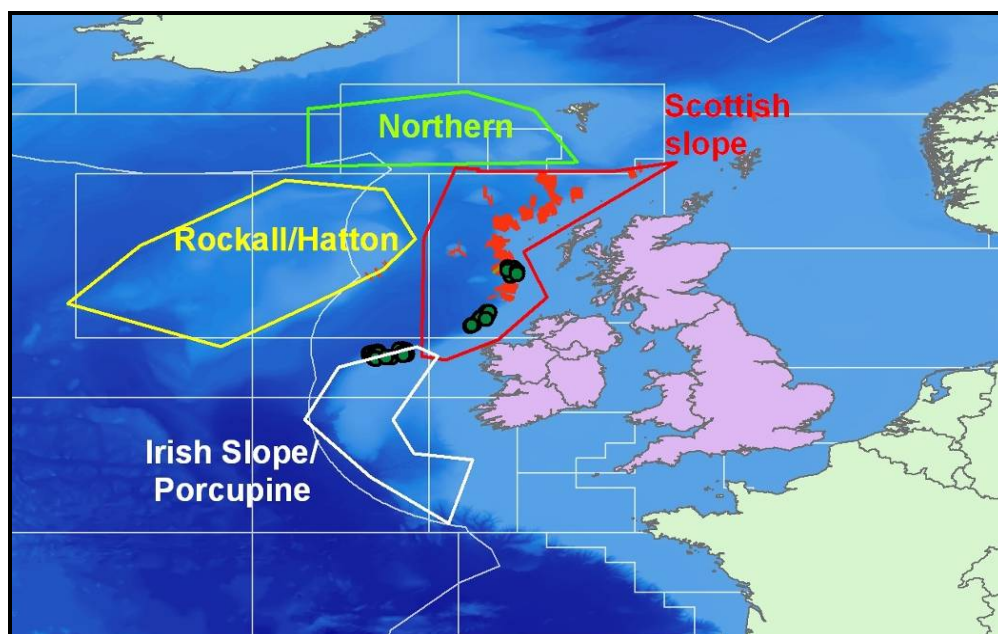


Figure 47. Area coverage of the proposed deep-water trawl survey. Red symbols = trawl hauls of the existing Scottish Deep-water survey (1998+), green symbols = trawl hauls from discontinued Irish Trawl survey (2006–2009) and polygons represent proposed sample regions.

10.4 References

- Campbell, N., Neat, F., Burns, F. and Kunzlik, P. 2011. Species richness, taxonomic diversity, and taxonomic distinctness of the deep-water demersal fish community on the Northeast Atlantic continental slope (ICES Subdivision VIa). *ICES Journal of Marine Science*, 68(2): 365–376.
- PGNEACS. 2009. Report of the Planning Group on the Northeast Atlantic Continental Slope Surveys. 9–11 June 2009. Tromso, Norway. 59pp. ICES CM 2009/LRC:03.
- WGNEACS. 2010. Report of the Planning Group on the Northeast Atlantic Continental Slope Surveys. 8–10 June 2010. Copenhagen, Denmark. 77pp. ICES CM 2010/SSGESST:16.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	E-MAIL
Jeff Ardron By correspondence	Marine Conservation Biology Institute MCBI Public Policy Office 600 Pennsylvania Avenue SE Suite 210 Washington DC 20003 United States	Phone +1 202 546 5346/+1 202 460 4960 Fax +1 202 546 5346	jeff.ardron@mcbi.org
Peter J. Auster By correspondence	University of Connecticut National Undersea Research Center Avery Point 1080 Shennecosset Rd Groton CT 06340 United States		peter.auster@uconn.edu
Maria de Fátima Borges By correspondence	INRB - IPIMAR Avenida de Brasília 1449-006 Lisbon Portugal	Phone +351 21 302 7098 Fax +351 21 301 5948	mfborges@ipimar.pt
Robert J. Brock	NOAA National Marine Protected Areas Center 1305 East West Highway Silver Spring MD 20910- 3282 United States	Phone +1 301 563 1144 Fax +1 301 713 3110	Robert.Brock@noaa.gov
Pablo Duran Muñoz By correspondence	Instituto Español de Oceanografía Centro Oceanográfico de Vigo PO Box 1552 36200 Vigo (Pontevedra) Spain	Phone +34 986 492111 Fax 34 986 498626	pablo.duran@vi.ieo.es
Konstantin Fomin	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO) 6 Knipovitch Street 183763 Murmansk Russian Federation	Phone +7 Fax +7	fomin@pinro.ru
Neil Golding	Joint Nature Conservation Committee Monkstone House City Road PE1 1JY Peterborough United Kingdom		neil.golding@jncc.gov.uk
Brigitte Guillaumont	Ifremer Centre de Brest PO Box 70 29280 Plouzané France		brigitte.guillaumont@ifremer.fr
Jason M. Hall- Spencer By correspondence	School of Marine Science and Engineering Faculty of Science and Technology University of Plymouth A428, Portland Square Drake Circus PL4 8AA Plymouth United Kingdom		jason.hall-spencer@plymouth.ac.uk

NAME	ADDRESS	PHONE/FAX	E-MAIL
Lea-Anne Henry	Heriot-Watt University School of Life Sciences Riccarton EH14 4AS Edinburgh Scotland United Kingdom	Phone +44 131 451 8267 Fax +44 131 451 3009	l.henry@hw.ac.uk
Kerry Howell By correspondence	University of Plymouth School of Biomedical and Biological Sciences Drake Circus Faculty of Science and Technology PL4 8AA Plymouth United Kingdom	Phone +44 1752 584544	kerry.howell@plymouth.ac.uk
Ellen L. Kenchington (NAFO representative)	Fisheries and Oceans Canada Bedford Institute of Oceanography PO Box 1006 Dartmouth NS B2Y 4A2 Canada	Phone 1 902 426 2030	ellen.kenchington@dfo-mpo.gc.ca
Pål Buhl Mortensen	Institute of Marine Research PO Box 1870 Nordnes 5817 Bergen Norway		paal.buhl.mortensen@imr.no
Francis Neat Chair	Marine Scotland-Science PO Box 101 AB11 9DB Aberdeen United Kingdom	Phone +44 1224 295516 Fax +44 1224 295511	F.Neat@MARLAB.AC.UK
Steve W. Ross By correspondence	University of North Carolina Wilmington Center for Marine Science CMS South Annex Campus Box 5928 Wilmington NC 28409 United States	Phone +1 901 395- 3905	rosss@uncw.edu
Mark Tasker	Joint Nature Conservation Committee Inverdee House Baxter Street AB11 9QA Aberdeen United Kingdom	Phone + 44 1 224 266551 Fax + 44 1224 896170	Mark.Tasker@jncc.gov.uk
Ole Secher Tendal	University of Copenhagen Danish Zoological Museum (SNM) Universitetsparken 15 DK-2100 København Ø Denmark		ostendal@snm.ku.dk
Vladimir Vinnichenko	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO) 6 Knipovitch Street 183763 Murmansk Russian Federation	Phone +7 8152 472192/+7 8152 47 3331	vinn@pinro.ru
Les Watling	Dept. of Zoology University of Hawaii at Manoa Honolulu, Hawaii 96822 United States	Phone +1 808 956 8621 Fax +1 808 956 9812	watling@hawaii.edu

Annex 2: WGDEC Terms of Reference for 2012

- 1) Provide all available new information on distribution of VMEs in the North Atlantic and update maps with a view to advising on any boundary modifications of existing closures to bottom fisheries.
- 2) Review the FAO criteria and definition of vulnerable marine ecosystems and consider how WGDEC could incorporate a broader range of VMEs into its work, e.g. fish species, spawning areas, etc.
- 3) Review the use of indices of biodiversity and community change in deep-water ecosystems and suggest how this may be used in an advisory capacity.
- 4) Assess new information on the degree to which seamounts are isolated and contain endemic species or unique communities with a view to alternative management options for seamount fisheries.

Annex 3: Recommendations

- 1) WGDEC recommends that the ICES DataCentre consider the database request detailed in ToR (b) for implementation prior to the 2012 meeting of the Working Group, along with the recommended suite of data fields shown in Table 3 and metadata fields detailed in Section 4.3, in order to ensure compatibility with the OSPAR database. The ICES DataCentre is asked to provide some guidance and provision of 'vocabularies' that can be utilized within the data entry spreadsheet. The ICES DataCentre is asked to provide guidance on whether provision can be made on ICES servers to store data layers such as VMS data and multibeam geotiffs for use each year by WGDEC.
- 2) WGDEC recommends that all new information on VMEs (e.g. trawl by-catch), and seabed topography (multibeam data) in the Hatton bank region be prepared and submitted in time for the meeting in 2012. This should include the area to the southwest (Edora and Fangorn banks).
- 3) WGDEC recommends that up-to-date NEAFC and EU VMS data for deep-water areas be made available for WGDEC for the 2012 meeting. A term of reference is suggested for the ICES SGVMS to help process VMS data so that it can be used by WGDEC. Ideally this will be filtered by gear type and vessel speed so that the intensity of actual bottom fishing activity can be readily assessed.
- 4) WGDEC recommends that for seamounts in the North Atlantic that have summits shallower than 1500 m an alternative management measure to the 'move on' rule be developed to protect VMEs.

Annex 4: Technical minutes from the Vulnerable Marine Ecosystems Review Group (RGVME)

- RGVME
- By correspondence, 10 May, 2011
- Participants: Margaret M. McBride, Norway (Chair); Nicole LeBoeuf, USA; Pascal Lorange, France; Lance Morgan, USA; Francis O'Beirn, Ireland, Francis Neat, UK (WGDEC Chair); Claus Hagebro (ICES Secretariat).
- Working Group: WGDEC Report 2011 (ICES CM 2011/ACOM:27)

EC and NEAFC Request

Continue to update cold-water coral and sponge maps and the information underpinning such maps. This should include any new information pertinent to the boundaries of existing fisheries closures for sensitive habitats/vulnerable marine ecosystems.

Provide advice to update records of deep-water vulnerable marine ecosystems (VMEs) in the North Atlantic and, where appropriate, advise on new or revised areas to be closed to bottom fisheries for the purposes of conservation of VMEs.

NEAFC Request

Provide advice on appropriateness of current closure boundaries on Hatton and Rockall banks. The advice should be based on all available information on distribution of vulnerable habitats in those areas including from research vessel surveys, observer programmes, and fisheries as well as data on the size of catches and condition (live/dead) of corals and sponges.

EC Request

Provide any new information regarding the impact of fisheries on other components of the ecosystem including small cetaceans and other marine mammals, seabirds and habitats. This should include any new information on the location of habitats sensitive to particular fishing activities.

Review of Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC)

Preface

New data from a range of sources including multibeam echosounder surveys, trawl surveys, longline surveys, fishermen's knowledge, habitat modelling and remote seabed imagery surveys were available for several areas under the regulation of the EC, Norway, NEAFC and NAFO. In the NE Atlantic these included Rockall Bank, the Anton Dohrn Seamount, Hatton Bank, Reykjanes Ridge, the Norwegian shelf, and the Bay of Biscay. In the NW Atlantic the areas included the Grand Banks/Flemish cap and an area west of Greenland.

Northeast Atlantic

Rockall Bank

Advice

A revised boundary is suggested for the northwest Rockall closure (NEAFC regulated) based on new observations on VMEs in the area and information from fishermen.

Basis for Advice

New data on VMEs (including cold-water coral reefs) for Rockall Bank were made available from Marine Scotland trawl and TV 'chariot' surveys. This together with historical data on coral records observed during trawling operations from the 1970s to 2008—that JNCC (Joint Nature Conservation Committee) was provided in 2010 by the Scottish Fishermen's Federation (SFF)—was used to reassess the boundary of the NW Rockall closure. These new data are presented together with past data, in relation to the existing closure boundary. A revised boundary is suggested.

The new data on VMEs confirm the presence of cold-water coral in the existing closed area and suggest the presence of corals and sponges in areas just outside the currently closed area. SFF data on historical fishing tracks suggest that some areas within the currently closed area have been heavily trawled in the past, and therefore are highly unlikely to currently contain VMEs. Based on these various data sources, it is proposed that existing closure boundary be modified to better reflect the presence of VMEs. Proposed boundary modifications are in four main areas (Figure 2: A, B, C, D). Coordinates of the polygon forming the revised boundary are given in Table 1.

There were also new data from Marine Scotland's towed video chariot for the region in the south of Rockall Bank—known as the Empress of Britain Bank—where NEAFC has enforced closures since 2008. All observations of live coral were from inside the closed area. This confirms the closure is appropriate. There is no reason to consider revising the boundary at this time.

RGVME comment

Suggested changes in protected areas seem properly based upon recent observations of VMEs. The report states that sponge bycatch was recorded in an area where trawling has occurred. Data or expert knowledge should be provided to indicate the intensity/spatial extent of fishing activity. It is otherwise suggested that experts expect no epifauna to remain after fishing occurs; this cannot be true. Fishing vessels typically return to previously identified safe trawl paths, i.e. after initially exploring a large area, the same tracks are followed as long as catch rates are high enough. The initial exploration is carried out using echosounders to avoid trawling on unsafe bottom. Types of bottom considered unsafe depend upon the gear type used (size of rock-hoppers, shape/material of the trawl-net). As result, fishing distribution may be patchy at small spatial scales (Piet and Quirijns, 2009). It is not unlikely to observe epifauna in areas where fishing has occurred. Also, the mention of "historical trawl data" is confusing, as it suggests that trawling has occurred. If the fishing is indeed "historical", has it now ceased? Another relevant question would be: To what size are sponges expected to have grown after one, five, or ten years?

While no advice was provided in 2010, the 2009 report discussed existing closures on Rockall Bank and proposed new ones. Specifically, it suggested a western expansion

of the closure boundary. It is apparent based upon this year's (2011) report that this advice was not acted upon; if we read the maps correctly and allow for differences in projection. It seems that 2011 advice for expansion of closed area boundaries in 2011 broadly reflects the advice provided in 2009. While RGVME has no issue with this, it might be interesting to identify the reason the 2009 advice was not implemented. It is unclear from the text if the sustainable fisheries framework (SFF) data has been recently received. And, the new definitive data applied to the area (Chariot seabed imagery) seem to fall broadly within areas already closed to fishing; hence, the proposed expansion seems to be based totally on old data.

References

Piet, G. J., and Quirijns, F. J. 2009. The importance of scale for fishing impact estimations. *Canadian Journal of Fisheries and Aquatic Sciences*, 66: 829–835.

Anton Dohrn Seamount

Advice

New data from multibeam and camera surveys on the Anton Dohrn Seamount (EC regulated) indicate extraordinary concentrations of VMEs on the steep sides of the Seamount. Two possible closure boundary options are proposed that would confer protection to VMEs on this seamount.

Basis for Advice

Gorgonians and live *Lophelia pertusa* have been taken as bycatch in trawl surveys from deeper sections of the summit. Joint Nature Conservation Commission (JNCC) 2009 surveys documented VME species on very steep sides of the seamount that is fished using bottom trawls, as corroborated by Vessel Monitoring System (VMS) data. Fishing activity occurs primarily on flatter deeper areas of the summit at depths of around 1000 m.

The JNCCs Offshore Natura survey (1–29 July, 2009) acquired at the Anton Dohrn Seamount 215 line kilometres of multibeam echosound measurements, and photographs “ground-truthing” ten different sites. These data are the primary new source of information on the presence of VMEs on the Seamount. On the Seamount's northwest slopes, and on parasitic cones associated with the Seamount, numerous images of coral gardens were captured. Observed fish species included: orange roughy; false boarfish; and roundnose grenadier.

Additional information was available from a predictive habitat model developed at the University of Plymouth (K. Howell and J. Davies, unpublished). Output from this model coupled with expert judgment was used to predict spatial distribution of all biotopes across each feature. Various data sources were combined to provide a map of the seamount in relation to observations and predictions of VMEs. Results suggest that VMEs are likely to occur down the steep flanks of the seamount, especially on parasitic volcanic cones and peaks at the base of the seamount. If these VMEs and habitats are to be protected, the steep slopes of the seamount should be closed to bottom fishing.

Marine Scotland and Department of Trade and Industry Strategic Environmental Assessment 7 (DTI SEA7) survey data indicate that the summit of this seamount contains large expanses of sand and exposed bedrock. In the sandy areas corals are unlikely to be found in high densities. Few studies, however, have considered whether the fauna inhabiting these sandy areas on the flat tops of seamounts are

VME species. In the North Atlantic, George and Schminke (2002) found that 54 of the 56 species of harpacticoid copepods inhabiting Great Meteor Seamount were new to science. Results from studies of gastropods in similar areas (Gofas, 2007) suggest that seamounts with extensive sandy flat areas may harbour unique faunas. It is not known if the sandy summit areas of the Anton Dohrn Seamount contain unique faunas, but until this can be discounted through further research there is a precautionary basis for protecting the entire seamount from bottom fishing.

To protect VMEs on the Seamount, two options for a closure to bottom fishing are suggested: The outer extent of both closure options (Option 1 and 2) begins 3 km (approximately twice water depth) beyond where the slopes of the seamount meet the seafloor plains. This is considered a minimum measure to reduce the likelihood of VME damage from bottom fishing (based on typical trawl warp lengths, SERAD 2001). There are minor extensions beyond this to encompass parasitic volcanic cones that lie slightly beyond this boundary. Closure Option 1 would protect the entire Seamount (flanks and summit) from the impacts of bottom trawling. Alternatively, a second option (Option 2) might be considered that would leave the summit of the Seamount open to fishing. Closure Option 2 would be 'doughnut' in shape. The inner extent of this alternative boundary is approximately 2 km before the steep slopes begin (approximately twice water depth at the break of slope). This 'doughnut' closure design does, however, leave the upper flanks and summit of the Seamount vulnerable to straying trawls at depth where vessels follow contours.

RGVME comment

This section is a bit inconsistent. It is stated that "very steep sides of seamounts are highly likely to contain VME", yet two closure options are given: 1) protecting the entire Seamount—based on the possible occurrence of endemic species on the top; and 2) protecting the side of the Seamount. Although a precautionary approach is favourable, it should be pointed out that: (1) the occurrence of endemic species on the top of Anton Dohrn is thus far only speculative; and (2) the endemic species mentioned are gastropods and copepods. Salient questions include: Do these qualify as VME species? And; can the mortality induced by trawling be unsustainable for these species?

A precautionary approach would suggest that the entire seamount should be closed. Whereas RGVME is not in a position to comment on which fisheries could be impacted by this management action, it would be interesting to speculate on the level of fishing likely to be carried out on the mount. At a minimum, it seems appropriate that Option 2 be applied.

Hatton Bank

Advice

New data from observers on longline vessels operating in the Hatton Bank area and multibeam data suggest the presence of VMEs outside the current closure. As WGDEC was aware of new trawl bycatch data from the Hatton Bank area that could be highly informative, no revision to the boundary was suggested for the time being.

Basis for Advice

New data on VMEs on Hatton Bank—made available from a longline bycatch survey (Duran Munoz *et al.*, 2010; 2011 working document)—show a variety of VME-indicator species such as stony corals, black corals, and gorgonians outside the currently closed

area (Figure 8). Of note are several records of VME-indicator species just outside the northeastern boundary and outside the southern boundary of the current closure. Duran Munoz *et al.* (2011 working document) describes a VME trawl bycatch study in the Hatton area that will have significant bearing on this issue. These data, however, are unavailable at present. There is trawling activity in the area northeast of the Bank (Benn *et al.*, 2010); these VMEs are likely at risk.

Observations further southwest (Duran *et al.*, 2011) confirm the presence of VMEs in an area known as Edora's Bank on Ireland's extended continental shelf. Multibeam data has been collected by the Geological Survey of Ireland; these data were available in a limited format via Google Earth (Figure 9). They suggest that Edora's Bank has high rugosity and elevated relief. Such physical features are characteristic of carbonate mounds, reefs, and seabed types where VMEs are most likely to occur. Although it is unlikely that bottom trawling is carried out in this area due to its rough terrain, Duran *et al.* (2010) clearly demonstrate that longline bycatch of VME species can be significant and may have cumulative impacts.

Based on this new evidence, it is evident that potentially important VMEs in the Hatton Bank region lie outside the existing closure. The source of this new information, however, is longline bycatch data which reliably indicate the presence of VMEs, but is not reliable to assess the density of VMEs. Data from recent trawl surveys which are now being processed (Duran *et al.*, 2011, working document) will be valuable in this respect. The Working Group decided to postpone suggesting revision of the current closure boundary until these data become available. It is recommended that next year the group obtains better resolution of the Irish multibeam data, and that new developments in predictive habitat modelling be included. These combined sources will form a much stronger basis for advice on closures.

RGVME comment

VME areas are identified, e.g. Edora's Bank. Yet, the decision to offer advice for closures has been postponed: This seems inappropriate. If the precautionary approach is properly applied based on data (albeit limited) examined, then appropriate closures should be recommended until new data suggest otherwise.

This last point raises a basic question regarding information analyses and subsequent provision of advice. It is unclear from this report, what constitutes sufficient information to form an opinion on whether or not an area should be closed. For example, WGDEC advises expansion closed areas on Rockall Bank based primarily on fisheries bycatch data (SFF). While on Hatton Bank, they seem unwilling to apply the same criteria based on a similar type of data, i.e. longline fisheries bycatch. Both might be regarded as anecdotal or qualitative information at best. This inconsistency should be addressed. It is also important that the context for which closures are recommended be provided with the advice:

- What are the criteria for recommending a closure?
- If it is based upon quantitative data, is there a threshold value of density of VME species?
- How are the boundaries defined; is there a buffer drawn around the point reflecting likely interaction with fishery gear (based upon VMS data)?
- Do "move-on" criteria play a role in defining the boundaries?

In this regard it might be useful to justify the advice given by drawing on some of the material in Chapter 8 of this report.

Norwegian Sea Areas

Advice

No specific advice offered.

Basis for Advice

Data on *L. pertusa* reefs are updated regularly by Norway's Institute of Marine Research (IMR), including information on: geographic position; depth; reef status (dead, living, damaged, etc.); date; and source of report. In 2010, IMR submitted information collected since 2008 on *Lophelia* reef occurrences to OSPAR (Oslo/Paris convention for the Protection of the Marine Environment of the Northeast Atlantic; Figure 10).

Several new reefs have been reported as result of seabed surveys in areas considered for increased petroleum activity. The Marine AREAL database for NORwegian waters (MAREANO) seabed-mapping project has documented a number of new coral reefs off Northern Norway. In 2008, the *Lophelia* reef area known as Hola or Floholmen was shown to have a cluster of around 330 individual reefs (Figure 11). These elongated reefs reach up to 250 m in length, and face into the main current.

In 2010 MAREANO mapped eight new coral reefs in areas off the coast of Troms and Finnmark counties (Sotbakken and NW of Fugløybanken; Figures 12 and 13). As part of the Hotspot Ecosystem Research and Man's Impact on European Seas (HERMOINE) project, detailed studies are being carried out at Korallen—the northernmost *Lophelia* reef where IMR has monitored since 2006—and LoppHAVet reef areas. Norway established a protected area around Korallen in 2009, but indications are that impacts from bottom trawling had occurred earlier (Figure 14).

Information on distribution of gorgonian corals or other corals forming coral garden habitats have not been systematically compiled in Norway, however new information is being gathered through the MAREANO project (Figure 15). Hard-bottom coral gardens consist of larger gorgonians (*Paragorgia arborea*, *Primnoa resedaeformis*, *Paramuricea placomus*, and unidentified gorgonians) and “meadows” of cauliflower corals (*Duva florida*, *Drifa glomerata* and *Gersemia rubiformis*). Soft-bottom coral gardens consist of *Isidella lofotensis* in the inshore Andfjorden area and *Radicipes* sp. in the offshore northern area.

In 2009, MAREANO documented fields of gorgonian coral *Radicipes* sp. (Chrysogorgiidae) extending approximately 4000 km² in the area known as Bjørnøya (Bear Island 71°16'N, 15°40'E) at depths ranging from 600 to 800 m (Figure 16). The local density of *Radicipes* colonies was up to 5.3 per m² (P. Buhl-Mortensen, IMR, unpublished results). Trawl marks, most likely from fisheries targeting Greenland halibut, were very common in this area.

Information on the distribution of sponge species in Norway has not yet been systematically compiled. In 2010, WGDEC presented a map of sponges caught in trawl surveys that indicated high abundance in southern regions of the Barents Sea. New information characterizing sponge habitats is being gathered through the MAREANO project (Figure 17). Data on the distribution of sponges have not yet been published, but “hot spots” of larger Demospongia and Hexactinellida have been identified, mapped, and made available online (Figure 18; www.mareano.no). Demospongia sponges primarily consist of larger sponges (*Geodia* spp., *Aplysilla sulfurea*, *Stelletta* sp. and *Stryphnus ponderosus*); Hexactinellida sponge grounds commonly consist of *Caulophacus arcticus* and various unidentified species.

RGVME comment

Response to WGDEC ToR for 2011

- Updates have been provided on newly reported cold-water coral reefs/coral gardens surveyed and/or mapped in Norwegian Sea Areas. Information on sponge communities is also provided including maps, and the information underpinning these maps.
- Traces of the impacts from bottom trawling—as observed through the MAREANO project—are briefly mentioned in a couple of Norwegian areas (Korallen and LoppHAVet Reef areas, Bjørnøya / 71°16'N, 15°40'E).
- A brief review of environmental factors influencing sponge distribution is included.
- A review of the science pertaining to assessment of protected areas in Norwegian Sea Areas (e.g. threshold weights) has not been provided.
- Mapping of coral reefs in the Norwegian EEZ is expected to continue for a number of years. It would be useful to report (in 2012) progress made thus far on work—done in conjunction with the ICES DataCentre—to incorporate data from Norway's MAREANO project into the central database being developed for coral, sponge, and other North Atlantic VMEs.

General comments

- The terms “Norwegian Continental Shelf” and “Norwegian Sea Areas” describe different areas and should not be used interchangeably. Paragraph 1 of the Introduction list the ‘Norwegian shelf’ as one of several areas of the NE Atlantic where new data are available. Attention should be called to the fact that Norway's continental shelf extends beyond its EEZ and spans three major Norwegian Sea Areas (the North Sea, the Barents Sea, and the Norwegian Sea). Most of the Norwegian Seabed is not part of a continental shelf, and has about two kilometres average depth. Norway has jurisdiction over its continental shelf beyond 200 nautical miles. This encompasses an area measuring some 235 000 square km, reaching depths up to 3000 to 4000 meters.
- Perhaps it is beyond the scope of the ICES WGDEC task, but to focus primarily on bottom trawling as the major threat to VMEs may be too narrow a focus. Norwegian Sea Areas, for example, are exposed to increasing levels of oil and gas activity. Thus, VMEs in Norwegian waters are not only threatened with physical destruction from bottom trawling. Other threats include toxic contamination from oil spills for which relatively little is known about the potential long- and short-term effects (Fosså and Kutti, 2010). It is known, however, that coral reefs can be killed off by direct exposure to oil, and that all corals are vulnerable. Oil can mix with sediment, or thin out from sun exposure/oil dispersants before it sinks. In either case, deep-water corals can literally be smothered (Shafir *et al.*, 2007). Oil pollution also makes coral reefs more susceptible to bleaching, which can damage or kill them. This threat may increase as the extent of ice cover decreased in Norwegian Sea Areas, that will likely lead to increased levels of oil extraction and oil shipment.

The impacts on deep-sea sponges of drilling fluids and drill cuttings discharged directly from oil and gas drilling activities remain poorly investigated. However, scientists at the Institute of Marine Research in Norway are conducting studies on the

response of deep-water sponge fauna to oil drilling discharges. The time frame for this relevant project is January 2011 through December 2014.

<http://www.forskningsradet.no/servlet/Satellite?c=Prosjekt&cid=1253964167752&pageName=havkyst/Hovedsidemal&p=1226994156419>

- A number of sites in Norwegian Sea Areas have been closed—restrictions on bottom trawling, shellfish trawling, or all human activities—to protect coral reefs, including: Røst Reef; Iverryggen Reef; Sula Reef; Selliggrunnen Reef; Tisler Reef; and Fjellknausene Reef. The ongoing appropriateness of current closure boundaries for these reef areas should be evaluated and included in future WGDEC reporting.
- The Norwegian Government aims to establish integrated management plans—including surveys, mapping, and measures to protect deep-water VMEs—for all Norwegian waters. This process should be followed closely, and included in WGDEC reporting.
 - The “Integrated Management Plan for the Barents Sea and Sea areas off the Lofoten Islands” has recently been revised (11 March, 2011). New licences for oil production must include requirements for surveys to identify coral reefs or other valuable benthic communities; which could be affected by petroleum activities, and ensure that VMEs are not damaged.

<http://www.regjeringen.no/mobil/en/dep/smk/press-center/Press-releases/2011/updated-version-of-the-integrated-manage.html?id=635620>

- The plan for the Norwegian Sea will be revised in 2014.
- Norway will play a leading role in efforts to develop an international management plan for the entire North Sea. A national management plan for Norway’s part of the North Sea similar to the ‘Integrated Management Plans for the Barents Sea–Lofoten Area’ is under development, and should be presented by 2013.

References

Fosså, J.H. and T. Kutti. 2010. Impacts of Human Activities on Benthic Habitat. Arctic Biodiversity Trends 2010 – Ecosystems. Indicator # 17.

Marine AREAl database for NORwegian waters (MAREANO)

<http://www.mareano.no/english/>

NOAA: How does an oil spill affect coral reefs?

http://coralreef.noaa.gov/aboutcorals/facts/coral_oilspill.html

NOAA: Coral Reefs and Oil Spills

http://coralreef.noaa.gov/aboutcrp/news/featuredstories/may10/oilspill_coral/

Shafir, S., J. Van Rijn, and B. Rinkevich. 2007. Short and Long Term Toxicity of Crude Oil and Oil Dispersants to Two Representative Coral Species. Environ. Sci. Technol., 2007, 41 (15), pp 5571–5574. DOI: 10.1021/es0704582

Reykjanes Ridge Area

Advice

No revisions to boundaries in this area are proposed.

Basis for Advice

Two observations from 1981 Russian research trawl surveys around Reykjanes Ridge (northern Mid-Atlantic Ridge) at 1200 m depths were made available (Vinnichencko and Fomin, 2011, working document). One reports cold-water coral (species not identified) at the position of approx. 61.00°N, 28.42°W. The other reports a large by-catch (5 T) of sponges (species not identified) at the position of 60°20'N, 29.17°W. The latter report falls within the northern most closure adopted by NEAFC in 2010. Given that these records are over 30 years old and one was within an area that is now closed, WGDEC did not consider this a sufficient basis to suggest boundary revision.

RGVME comment

The Review Group was unable to turn up any new information on this area. In as much as no changes in existing boundaries have been proposed, we are without substantial comment. We recommend that efforts be expanded to obtain new information on the distribution of vulnerable habitats in this area.

Bay of Biscay**Advice**

No specific advice offered.

Basis for Advice

New data on VMEs in the Bay of Biscay (EC regulated) was available. Several areas of VME concentrations are identified that indicate where closures would be best located to protect VMEs in this area.

The French margin in the Bay of Biscay is shaped by a succession of more than 130 deep canyons and interfluves. Cold-water coral reefs and deep-sea sponge grounds have been known to occur in the Bay of Biscay since the beginning of the 20th century. Until recently, very few benthic studies have been undertaken in this area. Although the OSPAR database was updated in 2008, occurrences of *Lophelia pertusa* are primarily based on very old observations (Figure 18).

Since 2008, however, multibeam surveys have been conducted in this area under the EU CoralFISH project (Figure 19); this has allowed creation of accurate Data Terrain Models (DTM) with 15 to 25 m grid spacing. A classification method based on several combined morphological attributes has been applied to DTM (Bourrillet *et al.*, in preparation).

Between 1996 and 2010, twelve surveys using Remotely Operated Vehicles (ROV), submersibles, or towed cameras, have been conducted along the canyons and open slopes of the Bay of Biscay with collections of video and still images (Figure 20). Most of the images were gathered along-transects at depths ranging from 180–2000 m. Until 2008, most studies were designed for geological purposes; more recent studies focus on VMEs. Image analysis is conducted using an annotation procedure based on knowledge tables defined with other CoralFISH partners. The first results (Guillaumont *et al.*, in preparation) showed that VME-indicator species were encountered during most dives (Figure 21).

Various VME habitat/communities dominated by coral or sponges have been identified and mapped. Coral reefs—largely composed of *Madrepora oculata* and *Lophelia pertusa* (Figures 22 and 23)—have been observed in the central part of the margin. Associated fauna include: various antipatharians; gorgonians; and hexactinellid

sponges. Major reefs have been observed in the central part of the margin occurring at depths up to 1100 m. Impacts from trawling have been observed in many reef areas including deep areas, however at depths less than 500 m, only coral rubble was observed.

Other VME habitat/communities have been identified including sponges and coral gardens (Figure 24) and proposals for a habitat classification scheme are being drafted. A high density of antipatharians has been observed on a largely dead coral reef (Figure 25). Some localized areas of hard-bottom substratum are colonized by demosponge beds or by coral gardens. The stony coral *Enallopsammia rostrata* occurs on vertical cliffs at around 1500 m depth (Figure 26). On soft sediments, the two main pennatulid (sea-pen) habitats are dominated by *Kophobelemnon* and by *Funiculina quadrangularis* in association with burrowing megafauna. Bamboo coral fields are also well established on soft bottom with *Acanella arbuscula* or other large Isididae sometimes associated with stalked sponges (Figure 27). Sponge grounds with *Pheronema carpenneri* occur in various localities. A new survey with RV 'Pourquoi Pas?' with ROV is planned in September 2011.

The evidence presented suggests significant concentrations of VMEs at various locations on the slope of the Bay of Biscay (Figure 28). Currently only one small area, situated in the southeastern part (Cap Breton canyon) is closed to bottom trawling; this is the only area inhabited by deep-sea-pen and burrowing megafauna communities, and where pennatulids were present in high densities. For the remaining area, there is risk of impact from bottom fisheries. In particular the central part of the Bay of Biscay (central circled area in Figure 28) appears to be important for reef-forming corals and would benefit from protective measures from bottom contact fishing.

RGVME comment

The section properly summarized information on vulnerable benthic species, communities and ecosystems in the Bay of Biscay with appropriate account of past and ongoing projects and surveys. The writing is clear, but some definitions are missing which would clarify the topic. There are a number of compound phrases such as "VME habitat/communities" and "VME species" which do not help the scientific reader, and may confuse other readers, e.g. managers. It has been recognized that the definition of VMEs from the FAO guidelines (FAO 2008) "does not provide explicit metrics, threshold values, or analytical approaches for identifying if one area contains a VME and another does not" (Auster *et al.*, 2011). This makes understanding and use of the term difficult for everyone. In Section 3 of the ICES WGDEC Report 2011 it would be helpful to provide a list of identified VMEs by group in each geographic area of interest. For example, it was unclear if the 'high density of antipatharians observed on a mainly dead coral reef' (9th line from bottom of page 30) was considered a VME or not. Similarly, should stony coral *Enallopsammia rostrata* be considered a VME (based upon Auster *et al.* (2011) and FAO (2009)? The answer most likely is yes, but this should be made clear. All geographical areas of interest included in Section 3 of the WGDEC Report should include a paragraph or table for each VME type with criteria i-v of Section 42 of the FAO Guidelines (FAO 2009). This would help clarify topics of discussion to managers, and could be completed with priorities for conservation/implementation of protection.

Figure 27 shows soft bottom with *Acanella arbuscula*, unidentified Isididae, and the stalked sponge *Hyalonema Thomsoni*. Do such habitats as these require the same management/protection that *Lophelia* reefs? Do they have similar levels of unique-

ness/rarity, functional significance, fragility, life-history/structural complexity (FAO 2009)?

The last paragraph in the Bay of Biscay discussion reports that "Currently only one small area, situated in the southeastern part (Cap Breton canyon), is closed to bottom trawling". This, however, is not an EU regulation. The status of the regulation should be specified: Is it French; bilateral; or other type of regulation? And, to whom does it apply?

Whereas properly synthesized data and up-to-date information on the Bay of Biscay slope is provided, it is surprising that no specific advice is provided. In other words, if all available data/information is presented, advice should be based on that. It is not precautionary to delay provision of management advice until scientists have collected full high-resolution data to describe each ecosystem component.

Evidence is shown that some VMEs in the Bay of Biscay, mainly down to 500 m, are impacted by fishing; evidence is also shown that some VMEs are unimpacted (Figure 23 and 26). Figure 23 shows a rather dense *Lophelia pertusa* and *Madrepora oculata* reef. Figure 28 shows major VME areas in the Bay of Biscay. Based on this information, an appropriate advice would be to:

- 1) Provide a list of identified VMEs that require conservation measure in the Bay of Biscay;
- 2) Provide guidelines on the level of protection required (e.g. in line with World Summit on Sustainable Development (WSSD, 2002) commitments and the Marine Strategy Framework Directive (Directive 2008/56/EC of the European parliament and of the council of 17 June 2008) which proportion of the Bay of Biscay slope, from 200 to 2000 m, should be protected from human activities coming into contact with the bottom; and
- 3) Suggest an incremental approach to reach the target level of protection
 - Start with protecting some known unimpacted areas;
 - Add new areas as survey provide new information on VME locations;
 - Supplement the list of unimpacted areas; adding contiguous areas that have been impacted. Such protection would allow VMEs to become re-established.

References

- Auster, P. J., Gjerde, K., Heupel, E., Watling, L., Grehan, A., and Rogers, A. D. 2011. Definition and detection of vulnerable marine ecosystems on the high seas: problems with the "move-on" rule. ICES Journal of Marine Science.
- EC. 2008. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).
- FAO. 2009. International guidelines for the management of deep-sea fisheries and the high-seas. 92pp.
- WSSD. 2002. Report of the World Summit on Sustainable Development, Johannesburg (South Africa), 26 August–4 September 2002. A/CONF.199/20. Available at: http://www.un.org/jsummit/html/documents/summit_docs.html.

Northwest Atlantic

In the Northwest Atlantic (NAFO regulated) new data were available from observers on trawlers suggesting the presence of small amounts of VMEs in areas currently

open to bottom fishing on the slope of the Grand Banks, and in an area to the west of Greenland.

Grand Banks and Flemish Cap

Advice

No specific advice offered.

Basis for Advice

Data on VME occurrence were collected during 2010 by NAFO observers aboard Russian fishing vessels (Vinnichenko *et al.*, 2011, working document). Observations were conducted during fisheries for Greenland halibut, redfish and shrimp in the NAFO Regulatory Area between 42°46'–48°40'N and 44°21'–50°02'W at 180–1200 m depths. New information suggests the presence of sea pens (Figure 29) and black corals (Figure 30) outside existing closed areas. Bycatch weight was between 10–40 g per haul.

RGVME comment

The bycatch weight reported for the Grand Banks and Flemish Cap is very small, but some comment on the ability of nets to retain these species would be useful. Only the biggest and most robust framework-forming corals are likely to survive in a trawl net. Evidence from samples brought up in the net reflects only a very small proportion of corals likely to have contacted the fishing gear.

A related concern is the degree to which observers are trained to identify and record these VME species and invertebrates in general. Training of observers is seldom sufficient to accurately identify many taxa, and corals are often afforded low priority for observer effort. As such, observer records may offer limited insights into the impacts of fishing. More field research is needed that incorporates modelling work from studies such as Davies and Guinotte (2011) to help identify priority areas to evaluate. Modelling work can help optimize future efforts, and develop more cost-effective study designs.

References

Davies A.J., Guinotte J.M. 2011. Global Habitat Suitability for Framework-Forming Cold-Water Corals. PLoS ONE 6(4): e18483. doi:10.1371/journal.pone.0018483

West Greenland

Advice

No specific advice offered.

Basis for Advice

NAFO observer data from Russian fishing vessels were also available from the Greenland halibut fisheries in the 200 mile fishing zone of West Greenland between at depths of 980–1535 m. The data suggest the presence of seapens (Figure 33) and black corals (Figure 34) in this area (generally less than 90 g per haul). This is the first data on VMEs for this particular area. There are currently no closed areas in the vicinity of these records.

RGVME comment

There may not be enough data to provide useful advice. However, it is not precautionary to postpone giving advice in the absence of data. The precautionary approach specifies explicitly that the absence of data should not be a reason for not taking management action. A simple precautionary option here would be to suggest a freeze on fishing to reduce its footprint and protect currently un-impacted VMEs. Freezing the footprint should not be considered as adverse for fisheries, because it has often been reported that deep-water stocks are overexploited; Greenland halibut certainly is. This option also implies that the current spatial extent for fisheries is sufficient to exploit the targeted resource.