ICES WGDEC REPORT 2012

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

26–30 March 2012

Copenhagen, Denmark

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Executive summary

The terms of reference (ToR) for the WGDEC meeting of 2012 are listed in Section 2. ToR(a),was a standing 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, habitat modelling and seabed imagery surveys were available In the NE Atlantic new evidence came from video transects, sidescan sonar surveys, and trawl bycatch of coral from Rockall Bank. For the NW Rockall closure, these data largely support WGDEC 2011 advice for boundary revision, with the exception that WGDEC advises a much reduced reopening of the southwest corner of the current NEAFC because corals have since been found there. New trawl bycatch data from southwest Rockall suggest the presence of VMEs outside the current NEAFC closures in this area. Two options for greater protection of VMEs in this area are presented. New data from observers on longline and trawler vessels operating in the Hatton bank suggest areas of deep-sea sponge aggregations and other VMEs that should be protected. Four closure boundary revision options are presented. Longline records and high resolution multibeam imagery of Edora's Bank (southwest of Hatton bank) suggest it is likely to contain concentrations of VMEs and thus a precautionary closure around the base of the bank is suggested. New data from the Whittard Canyon in the Bay of Biscay was available and this area is highlighted as an important area for VMEs that requires closer attention and consideration for protection. New records for the Norwegian Sea area are presented. New records of VME indicator species were obtained from the Josephine seamount (a NEAFC existing fishing area and an OSPAR MPA site) and attention is drawn to 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 to the east and west of Greenland.

To address ToR (b) a review is made of different species and habitats considered as potential VMEs in the NAFO and CCAMLAR regulatory areas. It is concluded that WGDEC should consider rarity or uniqueness more in its assessment of VMEs. Of particular significance for WGDEC to consider in more detail are the communities found around hydrothermal vents and seeps.

For ToR (c) a brief review is made of how indicators of biodiversity have been developed in the NAFO regulatory area. Methods for survey data, e.g. trawl bycatch or video transects, that allow quantification of the spatial distribution coral beds and sponge grounds may be used a proxies for monitoring biodiversity.

For ToR (d) there is a clear message that seamounts are not now generally considered to be sites of endemic species, but may nevertheless have faunal communities that are ecologically distinct. Alternative management advice for seamount fisheries is given as part of ToR e (iii).

To address ToR e (i), theoretical assumptions underlying VME distribution were considered in relation to empirical evidence from cumulative bycatch curves for VME species. As so little is known about VME distribution and patchiness, it is concluded that a 50% reduction in the threshold to 30 kg coral and 400 kg sponges would be an ecologically broader and more realistic indicator of a VME encounter. A further suggestion is made to account for cumulative encounters below threshold levels, e.g. two

bycatch events of 15 kg of corals in the same area is considered to be equivalent to a 30 kg threshold that triggers a move-on.

In ToR e (ii) the move-on rule is discussed in relation the different habitat types, fishing gear types and whether fishing is occurring in new or existing fishing areas. The move on rule is more appropriate for existing fishing areas, but less so in new fishing areas; moving off or away from a readily identified geo-morphological feature (such as distinctive outcrops, banks, ridges) may be a more effective means of avoiding further impacts on VME communities than moving a minimum distance. The move-on rule is not considered to be appropriate for seamount fisheries.

For ToR e (iii) WGDEC discussed alternative management options to encounter thresholds and move-on rules. Technical conservation measures that lessen seabed impact are discussed and are certainly to be encouraged, but WGDECs main conclusion is the best solution is to invest heavily in high technology monitoring of the fishery and mapping of the habitat so as to avoid impacting VMEs as much as possible. For seamounts fisheries in particular this should be an unconditional requirement in their regulation.

ToR e (iv) discusses uncertainty in our state of knowledge of VME occurrence and how different sources of information are to be interpreted at different geographical scales. In particular the outputs of habitat suitability models are discussed. Where there are unequivocal occurrences of VMEs in the NEAFC RA, e.g. visual validations of *Lophelia pertusa* reefs, there have been closures to bottom fisheries enforced.

For ToR (f) the NAFO observer guides for corals and sponges were reviewed and an analysis was made of how appropriate these guides would be for the NEAFC RA. While the guides are seen as very useful and there is some overlap between species in the NAFO and NEAFC RAs there was consensus that separate guides would be needed for the NEAFC area, especially in the case of the sponges. Advice is presented on which key species such a report should focus on.

1 Opening of the meeting

WGDEC members began discussions at 09.00 on March 30th, 2012, 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. From 27th through 29th March two representatives from the European Commission DGMARE joined the meeting in a purely observational capacity.

2 Adoption of the Agenda and Terms of Reference

2012/2/ACOM28 The ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), Chaired by Francis Neat, UK, will meet at ICES Headquarters, 26–30 March 2012 to:

a) 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.

b) 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.

c) 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.

d) 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.

e) Support to NEAFC review of bottom fisheries regulations (See Consolidated text of all NEAFC recommendations on regulating bottom fishing, on the website www.neafc.org).

  i) Encounter thresholds:

  Assess the appropriateness of the current quantitative thresholds of VME indicator organisms, i.e. live coral and sponge, adopted in the NEAFC bottom fishing regulations. The assessment should include an evaluation of the likelihood of achieving conservation objectives, i.e. the prevention of significant adverse impacts on VMEs as defined in the FAO guidelines.

  ii) Move-on-rule:

  Assess the appropriateness of the current move-on-rule adopted in the NEAFC bottom fishing regulations. The assessment should take into account the different habitats where bottom fisheries occur, e.g. continental slopes, mid-ocean ridges and seamounts, as well as the variable amount and quality of information on the relevant spatial distribution of VMEs.

  iii) Alternatives to thresholds and move-on-rules:

  Inform on alternative or additional measures to the currently adopted encounter thresholds and move-on-rule, especially technical measures that may reduce the risk of encounters with VME indicators.

  iv) Identifying vulnerable marine ecosystems:

  Using the best available scientific information including bio-geographic information, to identify in the NEAFC Regulatory Area:

    1) Areas where VMEs do not occur;

    2) Areas where VMEs are not likely to occur;

    3) Areas where VMEs are likely to occur;

    4) Areas where VMEs are known to occur.

f) NAFO guide for identification of corals and sponges i) Assess whether the NAFO coral and sponge guides are appropriate for use in the NEAFC area as onboard tools to identify and quantify VME indicator organisms as defined in the NEAFC bottom fishing regulations; and

ii) Advise on species that should be added to the guide, and species that are superfluous.

WGDEC will report by 11 April 2012 to the attention of the ACOM Committee.

Supporting Information

Priority:	**High as a Joint group with NAFO and is essential for feeding information to help answer external requests**
Scientific justification and relation to action plan:	a) These maps are required to meet part of the European Commission MoU requerst 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”” 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. c) This ToR is presented by the ICES SIBAS (Strategic Initiative on Biodiversity). d) This may help underpin future advisory needs e) NEAFC request. These issues are a central operative part of the existing bottom fisheries regulations, and the possibilities to develop them further are necessary for the planned revision. f) NEAFC request. Fishermen, and observers, in the NEAFC RA should have a tool that can be used to help identifying corals and sponges at species level. As such a manual does not exist for the NEAFC areas but guides has been made for use in the NAFO area, NEAFC may wish to use the NAFO guide if appropriate.
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 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

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. In each area the new records are mapped in relation any existing closures and other relevant information. All new information on VMEs made available to WGDEC has been included within the Group's VME database (See Appendix I). Regrettably no new information was made available to the group on fishing activity (VMS data) either in EEZ or high seas areas and thus this year's advice is presented irrespective of fisheries that may be operating in the area. In some areas, suggestions are made for new closures or to revise current closure boundaries to better protect VMEs. WGDEC notes that there is some discrepancy between the coordinates of the closures on the NEAFC website and those recommended by ICES WGDEC in past years.

WGDEC considers each area on a case by case basis. Some areas are information rich, e.g. Rockall bank while others are information poor, e.g. Edora's Bank. It is important to appreciate that very few of the data that WGDEC draws upon provide unequivocal evidence for the presence of VMEs; rather most of the records should be treated as 'indicators' that suggest the presence of VMEs. There are varying degrees of uncertainty associated with the data, for example, a 100 kg bycatch of sponges from a trawl need not necessarily be evidence of a deep-sea sponge aggregation, if the tow was 20 miles long. On the other hand a 1 kg bycatch of gorgonians on a longline may be strong evidence of a coral garden. We simply do not know enough about catch retention efficiency of fishing gears and the natural distribution and patchiness of VMEs to confidently designate an area as containing a VME on the basis of such data. Only visual or ground-truthed acoustic survey data can provide direct evidence of VME presence. This problem of uncertainty is addressed in ToR e (IV) and WGDEC takes it into account in the advice it provides on closing areas to protect VMEs. The group agreed that no universal weighting system is appropriate and therefore why each area under scrutiny must be considered on a case by case basis. The precautionary principal underlies much of WGDEC's reasoning. Justification for boundary demarcation is provided in as much detail as is possible. Soon the ICES WGDEC database (Appendix I) will (at least partially) be made available to the public so that it can be directly queried with respect to the types of data that are used to in the advisory process.

New data were available for several areas in the NE Atlantic;

- Rockall bank;
- Hatton Bank;
- An area to the SW of Hatton Bank known as Edora's Bank;
- The Whittard Canyon in the Irish margin/Bay of Biscay area;
- Josephine Seamount (approx. 460 km west of Portugal);
- Norwegian waters;

- East Greenland.

In the NW Atlantic new data were available from;

- West Greenland;
- NAFO regulatory area including the Grand banks and Flemish Cap.

3.2 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 regulated by NEAFC. Many data on VMEs in this area have been presented in past WGDEC reports and four closures for the protection of coral reefs have been enforced by NEAFC in recent years. NW Rockall Bank was submitted to the European Commission as a candidate Special Area of Conservation (cSAC) under the EC Habitats Directive in August 2010, and has since been approved by the European Commission as a Site of Community Importance (SCI).

3.2.1 New evidence of coral based on towed video observations

New data on *Lophelia pertusa* reefs for Rockall Bank were made available from Marine Scotland towed video surveys. The towed video or 'chariot' is flown about 3–10 m above the seabed at speeds of between about 1–2 knts. Provided sea state is not above force 5–6 significant distances can be covered (Table 1). The deployments are usually made at night. The image quality varies depending on distance to seabed and clarity of the water. It is not of sufficient resolution to distinguish species, but it is clearly sufficient to identify coral presence. In total, just over 600 km of transects have been completed both inside and outside currently closed areas. Presence and absence of coral (either *Lophelia pertusa* or *Madrepora oculata*) is recorded through subsequent analysis of the video. At present this includes observations of both live and dead coral and no information on size of colonies is available yet, simply presence and absence. These surveys were undertaken in 2007 through 2011. At WGDEC last year data were only available from 2010 (due to the large task of analysing the extensive footage). The video has now been scored for coral presence (dead or alive) for all years (Table 1). For every second of video a 1 or 0 is assigned according to presence or absence respectively. To summarise the data, the number of presence records was summed for each 0.001 decimal degree to give an indication of density.

Table 1. Summary of video transect data collected by Marine Scotland at Rockall Bank since 2007.

Year	N tows	Approximate Distance (km)
2007	4	61
2008	10	134
2009	10	101
2010	6	94
2011	14	212

3.2.2 Evidence for coral based on trawl bycatch observations

New data from three Marine Scotland surveys was obtained in 2011. These records span the plateau, some in deeper areas and one transect of trawls on the east side of the bank that covered depths to 1750 m.

3.2.3 New evidence for cold water coral reefs based on high resolution acoustic data and remotely operated vehicle observations

A new survey on Rockall Bank in 2011 (Huvenne *et al*., 2011) led by the National Oceanography Centre (NOC) identified a number of new areas of cold water coral reef within the ICES WGDEC 2011 NW Rockall closure recommendation. The survey mapped areas of the seabed on Rockall Bank using both vessel mounted multibeam echosounder and an Autonomous Underwater Vehicle Autosub6000, which was equipped with a high resolution sidescan sonar, chirp profiler and monochrome stills camera. Other equipment such as an inspection class ROV with high resolution imagery equipment was also used. The data are currently being processed and interpreted by NOC and its cruise partners, although some preliminary observations can be seen in (Figure 1 and Figure 2).

Blocks of high resolution sidescan sonar data were gathered in three areas focused on the central area of the NW Rockall closure; in the NW, centre and in the SE of this central area of the WGDEC 2011 closure recommendation. Cold water coral reefs were clearly visible on the sidescan sonar imagery (see Figure 2) and these were confirmed using the ROV. These preliminary observations of cold water coral reef VMEs support the NW Rockall closure recommended by ICES WGDEC in 2011. They also highlight the patchy distribution that is characteristic of the cold water coral reef communities present on the summit of Rockall Bank.

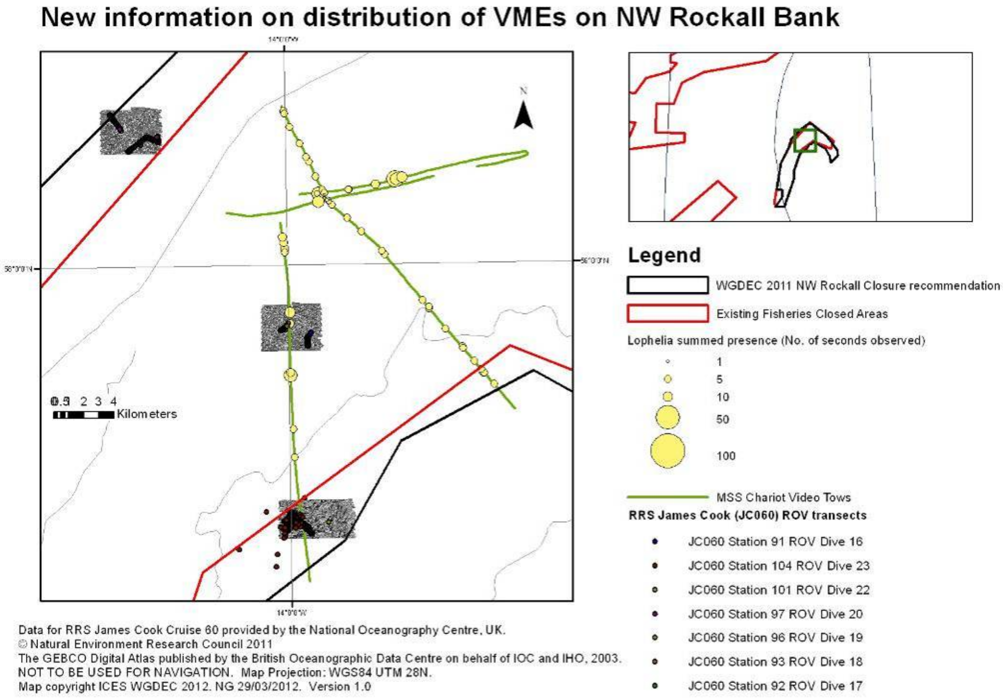

Figure 1. Map showing new evidence on the presence of VMEs on NW Rockall Bank. Green lines show towed video transects from Marine Scotland Science (yellow circles show observations of cold water coral VMEs). Grey boxes show Autosub 6000 side-scan data from Huvenne *et al*., 2011. ROV transects are shown within these acoustic areas.

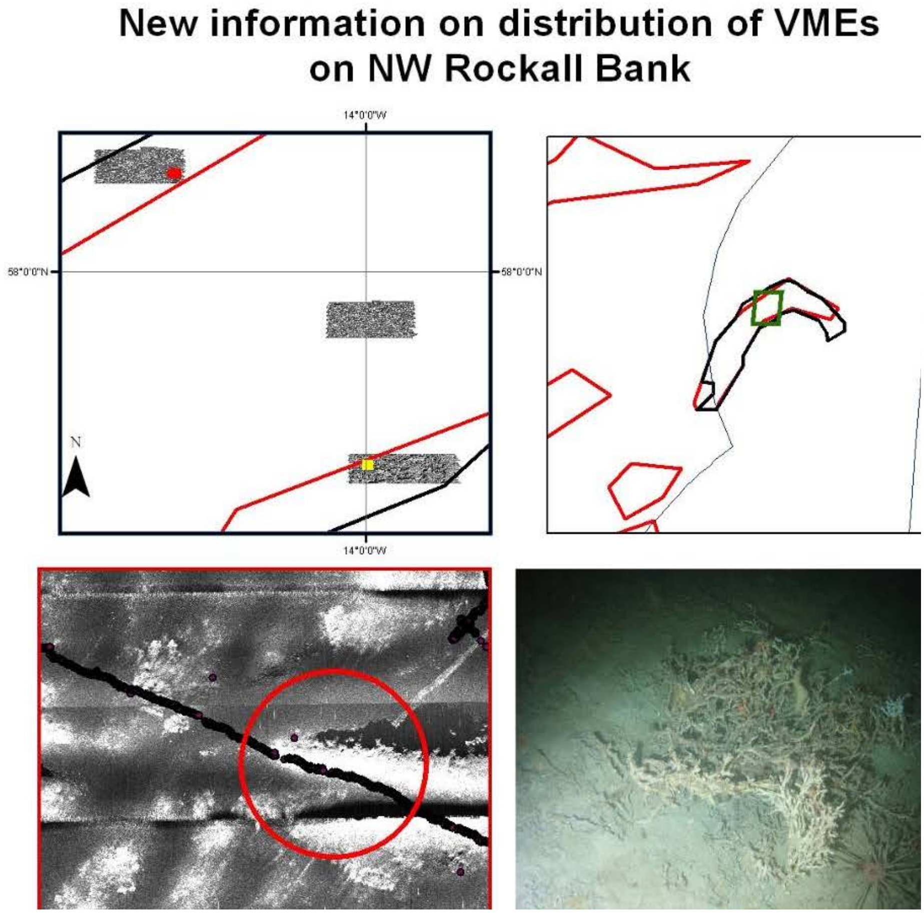

Figure 2. Preliminary observations from data gathered on RRS James Cook Cruise 60 showing new evidence on the presence of VMEs on NW Rockall Bank. Cold water coral reef VMEs can be observed on the high resolution sidescan sonar data. Red circles highlight locations of images shown on right.

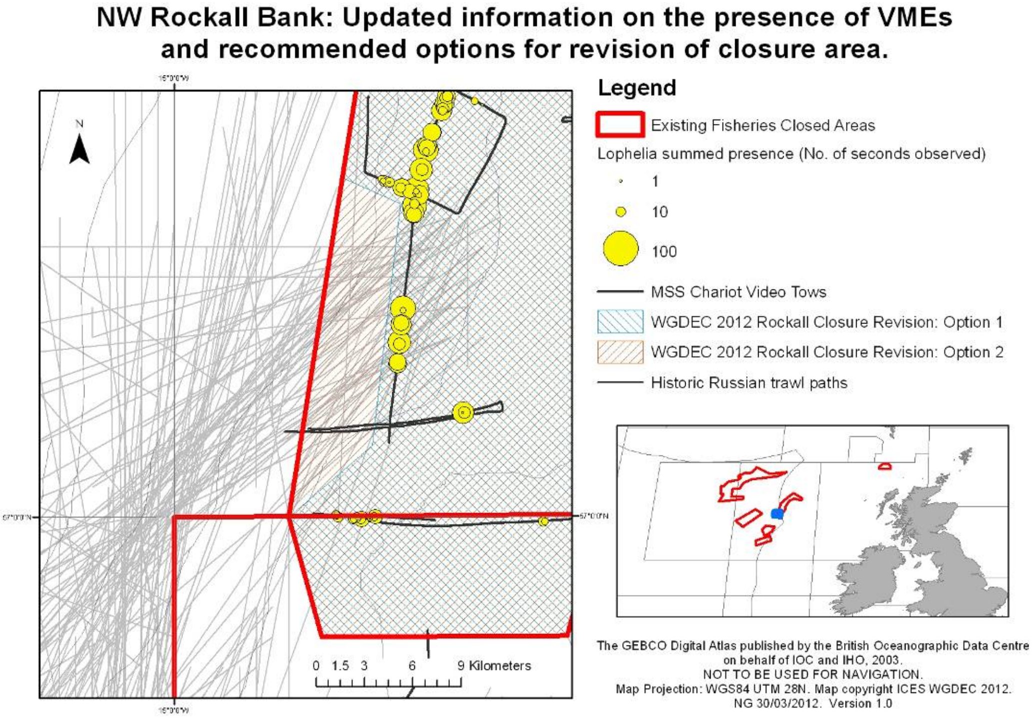

Figure 3. Map showing proposed revision to boundary of the SW corner of the NW Rockall closure.

3.2.4 Case for boundary revision of NW Rockall closure

In light of the new data on the presence of VME indicator species inside the existing closed area as well as outside the current closed area (but within the modified closure recommended by ICES WGDEC, 2011), WGDEC maintains its advice from 2011 for the boundary revision in the north of the closure. This is based on a video transect work showing corals outside the current closure obtained in 2011 (see Figure 4) and advice submitted in the WGDEC 2011 report. ICES WGDEC also maintains its advice from 2011 for the western boundary of the closure, especially in light of the new 'Autosub 6000' side-scan data provided by the James Cook survey (Huvenne *et al*., 2011) suggesting coral in this area (Figures 1 and 2). ICES WGDEC also maintains its advice from 2011 for the eastern boundary of the closure, again in light of the new 'Autosub 6000' side-scan data provided by the James Cook survey that suggested coral is present (Huvenne *et al*., 2011). (Figure 1 and 2).

In a departure from past advice in which ICES WGDEC suggested a reopening of the SW corner of the closure, WGDEC now advises a reduced area for reopening because of the evidence provided by the video transects suggesting the presence of *Lophelia pertusa* in this area. (Figure 3). Despite the fact that corals were not recorded by Russian observers in this area during extensive Russian trawling activity that took place in the past (Figure 3), evidence provided by Marine Scotland's video surveys demonstrate that coral is still present in some parts of this area, especially the north. There remains the question as to whether these observations represent live coral and further analysis of the video data is needed before a final consensus can be reached. Until such time that this analysis has been undertaken, however, this area must be considered as likely to contain coral and from a precautionary standpoint the area delimited as Option 1 in Figure 3 and Table 2 should remain closed.

As it is not certain if coral is present to the west of the area termed 'Option 1', an alternative proposal would be to maintain the current NEAFC closure 'as is' in this corner for 2012; i.e. Option 2 in Figure 3 and Table 3. Surveys to this area are planned in 2012 and may provide additional evidence to delimit precisely where the closure boundary should be drawn and whether Option 1 or Option 2 is more appropriate.

Table 2. Coordinates of points for WGDEC 2012 recommended closure: Option 1 for NW Rockall Bank closure.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	58 02 49.20	13 22 25.96	58.04700	-13.37388
2	57 51 35.92	13 07 30.14	57.85998	-13.12504
3	57 47 50.42	13 02 59.42	57.79734	-13.04984
4	57 43 22.15	13 02 17.37	57.72282	-13.03816
5	57 37 15.49	13 14 55.75	57.62097	-13.24882
6	57 42 33.62	13 16 28.56	57.70934	-13.27460
7	57 49 48.97	13 23 09.02	57.83027	-13.38584
8	57 56 05.67	13 43 26.11	57.93491	-13.72392
9	57 53 37.50	13 52 28.16	57.89375	-13.87449
10	57 50 05.13	13 56 22.56	57.83476	-13.93960
11	57 45 18.43	14 08 24.00	57.75512	-14.14000
12	57 28 59.98	14 19 00.01	57.48333	-14.31667
13	57 22 00.01	14 19 00.01	57.36667	-14.31667
14	56 55 59.98	14 36 00.00	56.93333	-14.60000
15	56 55 59.98	14 51 00.00	56.93333	-14.85000
16	57 00 00.00	14 52 59.98	57.00000	-14.88333
17	57 02 23.02	14 47 51.39	57.03973	-14.79761
18	57 10 26.36	14 46 04.65	57.17399	-14.76796
19	57 11 19.03	14 49 40.51	57.18862	-14.82792
20	57 37 00.01	14 42 00.00	57.61667	-14.70000
21	57 50 15.79	14 28 44.22	57.83772	-14.47895
22	57 50 42.00	14 28 25.86	57.84500	-14.47385
23	57 59 35.30	14 23 11.18	57.99314	-14.38644
24	58 09 29.55	14 03 48.85	58.15821	-14.06357
25	58 13 05.91	13 53 17.88	58.21831	-13.88830
26	58 13 43.32	13 49 41.37	58.22870	-13.82816
27	58 12 14.22	13 43 52.32	58.20395	-13.73120
28	58 07 11.71	13 34 29.10	58.11992	-13.57475

Table 3. Coordinates of points for WGDEC 2012 recommended closure: Option 2 for NW Rockall Bank closure.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	58 02 49.20	13 22 25.96	58.04700	-13.37388
2	57 51 35.92	13 07 30.14	57.85998	-13.12504
3	57 47 50.42	13 02 59.42	57.79734	-13.04984
4	57 43 22.15	13 02 17.37	57.72282	-13.03816
5	57 37 15.49	13 14 55.75	57.62097	-13.24882
6	57 42 33.62	13 16 28.56	57.70934	-13.27460
7	57 49 48.97	13 23 09.02	57.83027	-13.38584
8	57 56 05.67	13 43 26.11	57.93491	-13.72392
9	57 53 37.50	13 52 28.16	57.89375	-13.87449
10	57 50 05.13	13 56 22.56	57.83476	-13.93960
11	57 45 18.43	14 08 24.00	57.75512	-14.14000
12	57 28 59.98	14 19 00.01	57.48333	-14.31667
13	57 22 00.01	14 19 00.01	57.36667	-14.31667
14	56 55 59.98	14 36 00.00	56.93333	-14.60000
15	56 55 59.98	14 51 00.00	56.93333	-14.85000
16	57 00 00.00	14 52 59.98	57.00000	-14.88333
17	57 37 00.01	14 42 00.00	57.61667	-14.70000
18	57 50 15.79	14 28 44.22	57.83772	-14.47895
19	57 50 42.00	14 28 25.86	57.84500	-14.47385
20	57 59 35.30	14 23 11.18	57.99314	-14.38644
21	58 09 29.55	14 03 48.85	58.15821	-14.06357
22	58 13 05.91	13 53 17.88	58.21831	-13.88830
23	58 13 43.32	13 49 41.37	58.22870	-13.82816
24	58 12 14.22	13 43 52.32	58.20395	-13.73120
25	58 07 11.71	13 34 29.10	58.11992	-13.57475

3.2.5 East Rockall (deep slope)

A video transect was undertaken in 2011 that ran along the foot of the very steep northeastern margin of the Rockall bank. Numerous occurrences of coral (most likely *Madrepora occulata*) were observed on the steep sloping bedrock. Clearly the northern section is an important VME area that deserves conservation attention. This is an area that is currently being consulted on as a possible Special Area of Conservation under the EC habitats directive.

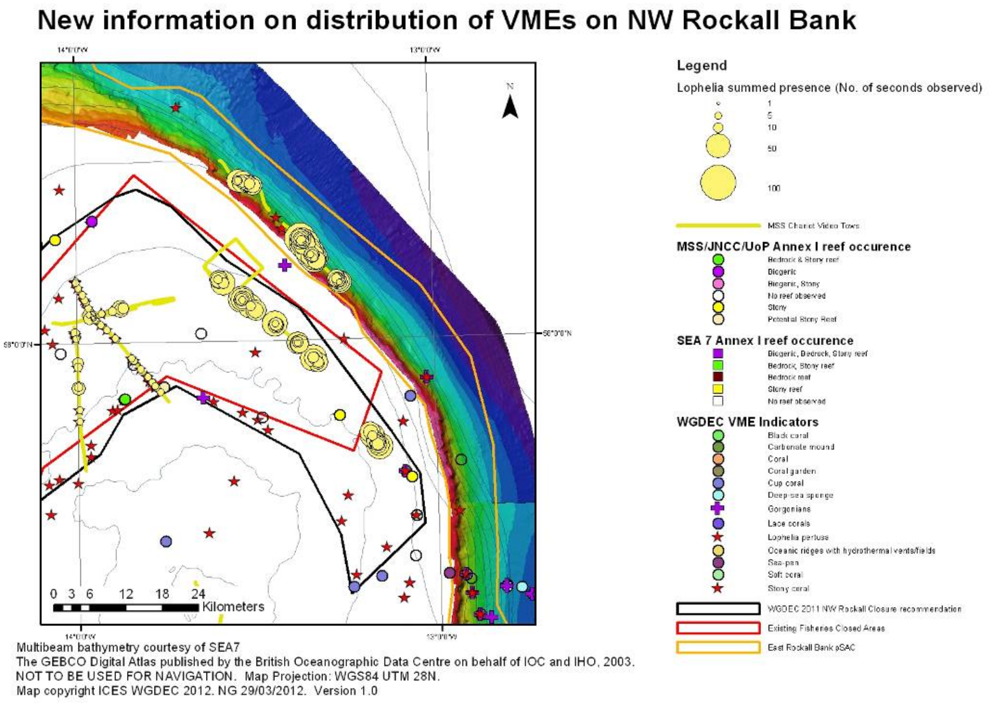

Figure 4. Map showing the Northeastern section of Rockall Bank with records of VME indicators from transects of towed video and other information sources.

3.2.6 Southwest Rockall (Empress of Britain)

There was also new data from Marine Scotland's towed video chariot for the region in the southwest of Rockall Bank, where NEAFC has enforced closures since 2008.

Two new research survey trawl bycatch records were obtained in 2011, two of these significant; 3.8 and 0.25 tonnes of *Lophelia* (a mixture of dead and alive *Lophelia*). These bycatch levels exceed the threshold value that would have triggered move-on rules had this been a commercial fishing vessel. Clearly these data strongly indicate VMEs in this area and consequently a closure should be considered. Two options are presented (Figure 5). The first option (Option 1) is the minimum that can be done to protect both sites within one closure. This encompasses both tows with a buffer distance of three times the water depth around the tow path (straight line between start and end positions of the tows). The second more precautionary option (Option 2 in Figure 5), joins the two new sites with the existing SW Rockall closure, making one single, larger closure. This is based on an assumption that there is coral between the recent encounter areas and the area where coral VME is known to occur. Although this would seem likely given it is appropriate depth for *Lophelia*, there is a notable lack of information in this area; only a single historical (2001) record of *Lophelia pertusa* (Figure 5) of unknown quantity is mapped to this area. Moreover there has been Russian fishing activity in this area and corals were not found here during the Russian haddock survey of 2005. The coordinates for Option 1 and 2 proposed above are shown below in Table 4.

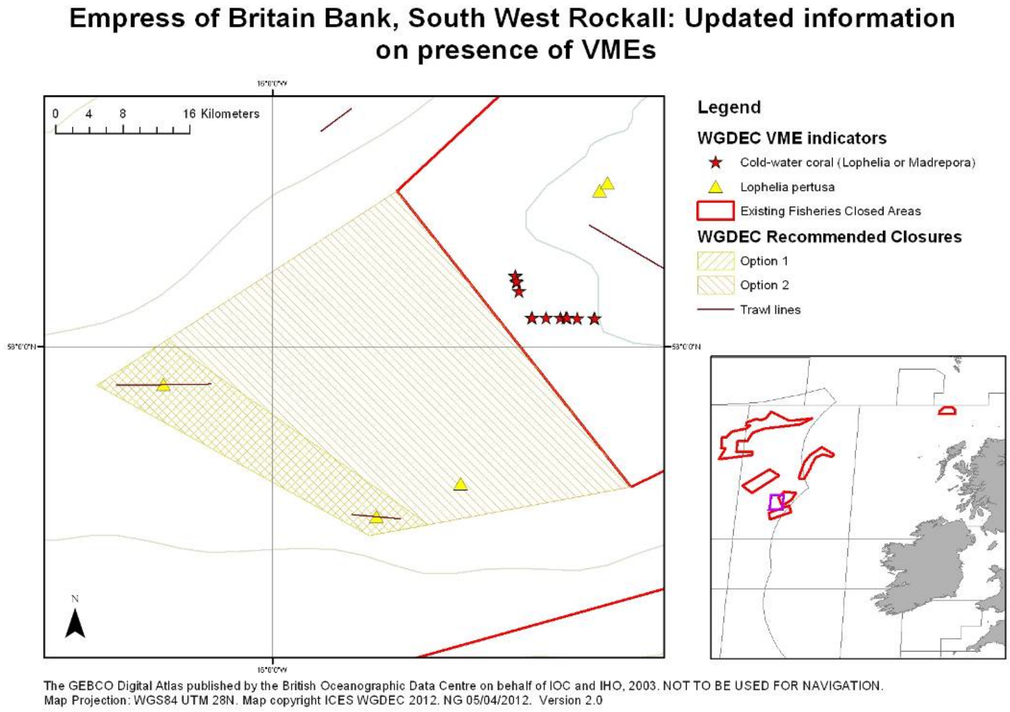

Figure .5. Two options proposed to protect areas where new occurrences of VMEs have been recorded.

Table 4. Coordinates of points for WGDEC 2012 recommended closure Option 1: Empress of Britain Bank, SW Rockall.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	55 57 30.85	16 11 18.56	55.95857	-16.18849
2	56 00 25.16	16 06 48.99	56.00699	-16.11361
3	55 48 34.20	15 50 01.24	55.80950	-15.83368
4	55 47 51.82	15 53 48.37	55.79773	-15.89677

Table 5 Coordinates of points for WGDEC 2012 recommended closure: Option 2: Empress of Britain Bank, SW Rockall.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	56 10 00.01	15 52 00.01	56.16667	-15.86667
2	55 51 00.00	15 37 00.01	55.85000	-15.61667
3	55 47 51.82	15 53 48.37	55.79773	-15.89677
4	55 57 30.85	16 11 18.56	55.95857	-16.18849

3.3 Hatton Bank

Hatton Bank is a deep-water bank lying west of the Rockall plateau that is entirely within international waters and therefore regulated by the NEAFC. NEAFC has closed a large portion of the upper bank to bottom fishing to protect VMEs (Figure 6).

New data on VMEs in the area were made available from longline, trawl bycatch and dredge surveys (Duran Munoz *et al*., 2010; 2011; 2012 working document). Data on a variety of VME indicator species such as sponges, stony corals, black corals, and gorgonians indicate presence outside the currently closed area. Four extensions to the current closure are suggested to reflect these new data and offer protection to likely VME areas.

3.3.1 Case for boundary revision of Hatton Bank closure

Area 1 (extension to northeast and eastern margin)

Several sponge records come from outside the northeastern and eastern margin of the boundary of the current closure. These records in some cases were in excess of 1 tonne (Duran *et al*., 2012) and clearly suggest the presence of deep-sea sponge aggregations even if no species level information is available. An extension (area 1 in Figure 6) is suggested that would ensure protection for what is very likely to be a VME in this area.

Area 2 (extension to east central area)

Several records of corals and other VME indicator species from both trawl and longline were recorded in the central region. An extension (area 2) that covers this area is suggested in Figure 6). Bycatch of stony corals was recorded in this area (25 kg in one case).

Area 3 (extension to southeast corner)

Large sponge bycatch records (>100 kg) were also recorded from the southeast corner of the closure for which an extension is proposed (area 3 in Figure 6). Again this is very likely an important area for VMEs.

Area 4 (extension to southwest corner)

In the southwest corner of the current closure a number of other VME indicator species including gorgonians were taken as bycatch from the longline surveys. An extension is suggested to protect this area (area 4 Figure 6). It should be noted that although a range of VME indicators species were recorded, all were very small specimens and thus there is less certainty over whether this area contains VMEs or sparsely distributed indicator species. This closure recommendation is therefore precautionary.

No further revision is suggested to the western margin of the closure, other than to note that IEO multibeam data (Sayago-Gil *et al*., 2010) suggests an area in the far north of outcropped bedrock (Risk area in Figure 6). There is no information on VMEs in this area, but it an area that WGDEC highlights for further research or observer work if fisheries are operating there.

Overall the new boundary revision would protect a variety of VME indicators species, especially deep-sea sponges.

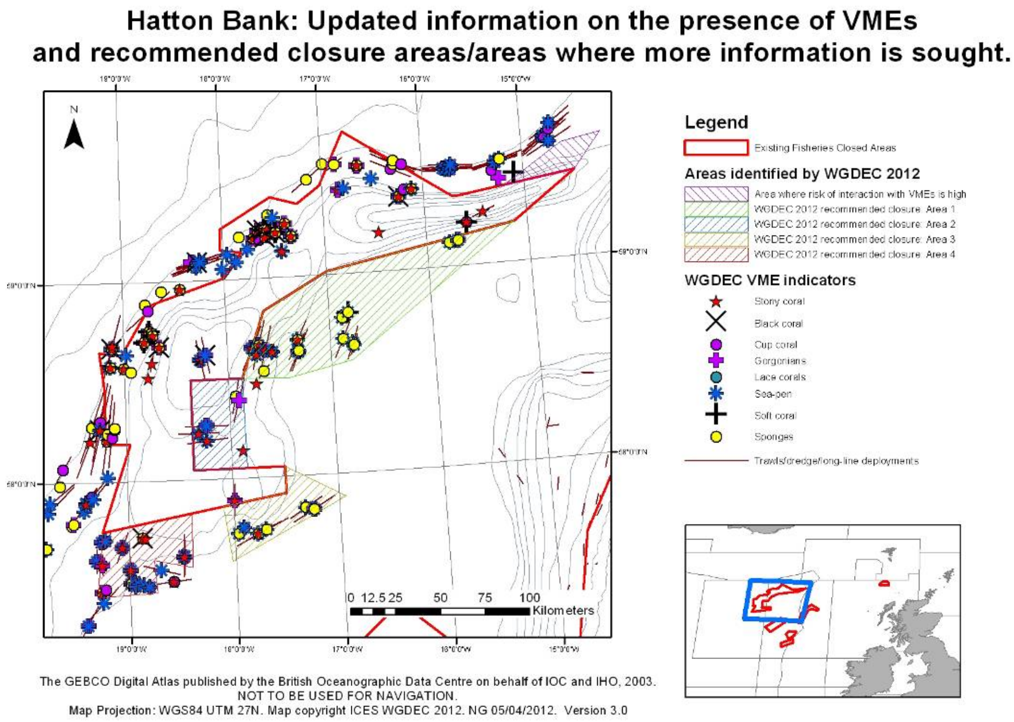

Figure 6. Map of the Hatton Bank showing the four proposed extensions to the current NEAFC closure. New records of VME indicators are shown.

Table 6. Coordinates of points for WGDEC 2012 recommended closure: Area 1.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	59 12 00.00	15 07 59.98	59.20000	-15.13333
2	58 33 48.74	16 47 36.74	58.56354	-16.79354
3	58 29 36.63	17 25 01.27	58.49351	-17.41702
4	58 30 00.00	17 52 00.01	58.50000	-17.86667
5	58 49 59.98	17 37 59.98	58.83333	-17.63333
6	59 01 00.01	17 00 00.00	59.01667	-17.00000

Table 7. Coordinates of points for WGDEC 2012 recommended closure: Area 2.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	58 30 00.00	17 52 00.01	58.50000	-17.86667
2	58 03 00.00	17 51 28.08	58.05000	-17.85780
3	58 03 00.00	18 22 00.01	58.05000	-18.36667
4	58 30 00.00	18 22 00.01	58.50000	-18.36667

Table 8. Coordinates of points for WGDEC 2012 recommended closure: Area 3.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	57 35 06.25	18 02 00.45	57.58507	-18.03346
2	57 51 45.46	18 05 52.08	57.86263	-18.09780
3	57 55 00.01	17 30 00.00	57.91667	-17.50000
4	58 03 00.00	17 30 00.00	58.05000	-17.50000
5	57 53 06.18	16 56 19.64	57.88505	-16.93879

Table 9. Coordinates of points for WGDEC 2012 recommended closure: Area 4.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	57 33 40.24	18 24 31.28	57.56118	-18.40869
2	57 36 15.44	18 46 13.51	57.60429	-18.77042
3	57 26 17.01	18 44 45.60	57.43806	-18.74600
4	57 25 27.26	19 18 34.77	57.42424	-19.30966
5	57 45 00.00	19 15 00.00	57.75000	-19.25000
6	57 50 04.48	18 23 44.59	57.83458	-18.39572

Table 10. Coordinates of area where risk of interaction with VMEs is considered high.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	59 22 58.69	15 12 18.18	59.38297	-15.20505
2	59 34 34.75	14 36 27.43	59.57632	-14.60762
3	59 36 34.66	14 12 45.46	59.60963	-14.21263
4	59 25 59.98	14 30 00.00	59.43333	-14.50000

3.4 Edora’s Bank

Further to the southwest of Hatton Bank Duran *et al*. (2011) observations confirm the presence of VMEs in an area known as Edora’s Bank. This is not a NEAFC existing fishing area. High resolution multibeam data from the Irish National Seabed Survey were available to the group (Figure 7). These data confirm Edora’s Bank is an area of unusually complex terrain and high rugosity. Furthermore many of the coral records originate from the peaks and pinnacles on the summit of the bank. 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.

3.4.1 Case for boundary revision of Edora’s Bank closure

On the basis of the longline bycatch records and the clear delimitation of the bank on the basis of multibeam data, WGDEC advises on an area closure for Edora’s Bank, as shown in Figure 7. As this is a data-deficient area WGDEC also highlights it as an area for future research.

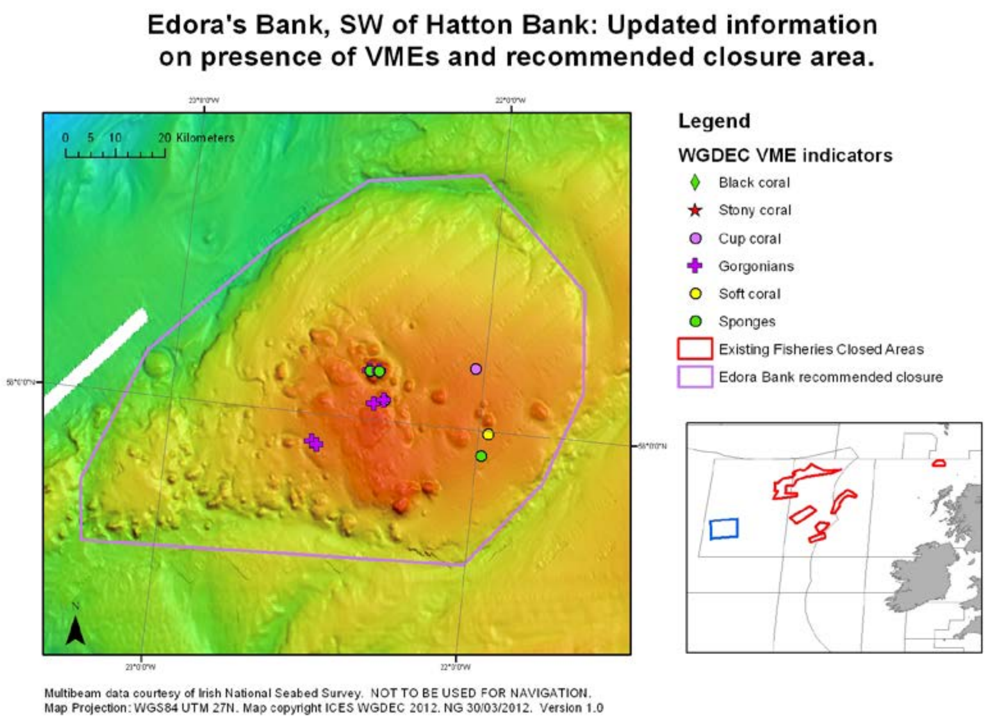

Figure 7. Edora’s Bank with a proposal for a precautionary closure boundary that would encompass the entire bank.

Table 11. Coordinates of points for WGDEC 2012 recommended closure around Edora's Bank.

Point Number	Latitude (N) (Degrees Minutes Seconds)	Longitude (W) (Degrees Minutes Seconds)	Latitude (decimal)	Longitude (decimal)
1	56 25 53.58	22 26 17.66	56.43155	-22.43824
2	56 27 43.09	22 03 55.94	56.46197	-22.06554
3	56 16 08.79	21 42 01.80	56.26911	-21.70050
4	56 05 09.63	21 40 22.54	56.08601	-21.67293
5	55 54 52.88	21 46 39.46	55.91469	-21.77763
6	55 45 18.97	22 00 21.78	55.75527	-22.00605
7	55 43 27.62	23 14 10.46	55.72434	-23.23624
8	55 50 01.64	23 15 36.10	55.83379	-23.26003
9	56 04 52.50	23 05 36.49	56.08125	-23.09347
10	56 18 00.57	22 43 20.17	56.30016	-22.72227

3.5 Josephine Seamount

New historical evidence provided from a database used by Yesson *et al*. (2012) on the distribution of gorgonians (VME indicator species) suggest concentrations on Josephine Seamount (Figure 8), which is currently a NEAFC existing fishing area. It is also a site that OSPAR has put forward for inclusion as a high seas marine protected area. As such WGDEC recognises it as an area that is likely to contain VMEs but with only historical data available on VMEs and no information on current fishing activity, no closure boundary can be seriously evaluated at present.

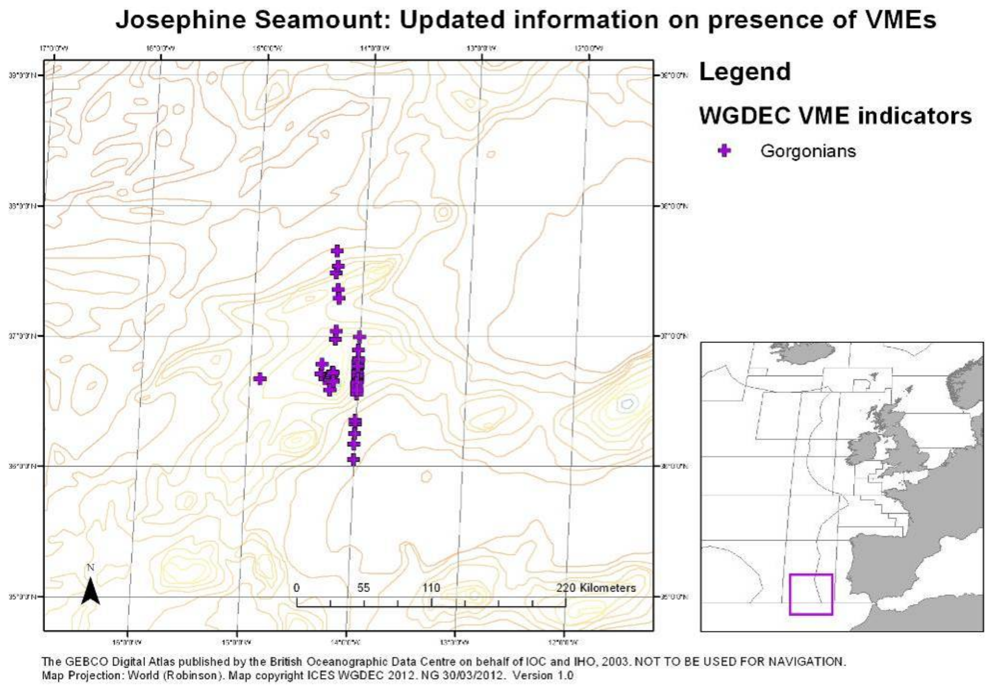

Figure 8. Evidence of gorgonians on Josephine Seamount (from data included in Yesson *et al*. 2012).

3.6 Norwegian sea areas

New Norwegian records of *Lophelia pertusa* from research surveys were provided to WGDEC, and can be seen in Figure 9. A dense area of Lophelia is evident west of the Lofoten islands.

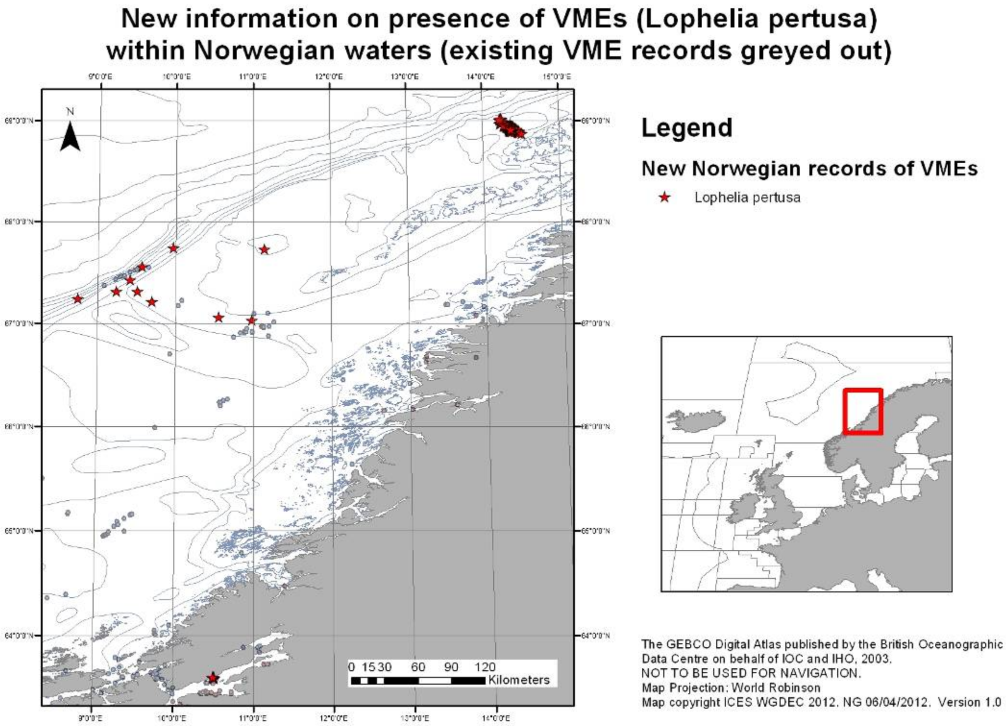

Figure 9. New information on VMEs within Norwegian waters provided to WGDEC.

3.7 Mid-Atlantic/Reykjanes Ridge area

To the knowledge of the group no new data are available for this area. It should be noted however that progress has been made to analyse historical footage from Russian submersible dives on the Mid-Atlantic Ridge and that this information may be available for next year.

3.8 Whittard Canyon (Irish Margin/Bay of Biscay)

3.8.1 New evidence of VMEs from the Whittard Canyon

Within the framework of the EU FP7 HERMIONE project, the Whittard Canyon along the Irish Margin/Bay of Biscay has been investigated (Figure 10). In 2007, cold water coral reefs were found at water depths ranging 880–3300 m (Huvenne *et al.*, 2012). These were dominated by *Anthomastus* sp., the scleractinian coral *Lophelia pertusa* and the octocorals *Primnoa* sp., *Acanthogorgia* sp. and *Acanella* sp. Most corals were located on locally steep slopes although some occurred on relatively level surfaced (Huvenne *et al.*, 2012). *Lophelia pertusa* was found between 1300 and 1880 m water depth. By means of forward-looking ROV-mounted multibeam, a particularly dense aggregation of *Lophelia pertusa* was found on a 120 m high cliff, about 1600 m long and overhanging by about 20 m, representing one of the densest coral communities observed in deep waters, of similar density and extent as the Thérèse Mound in the Porcupine Seabight (Huvenne *et al.*, 2012). The results presented suggest that vertical coral reefs could form a significant contribution to the cold water coral reef occurrence in the NE Atlantic. These coral reefs can form natural refuges for faunal communities and have the potential to fulfil the role of larval replenishment of damaged sites elsewhere on the margin (Huvenne *et al*., 2012).

In 2010 further ROV video transects were performed in the head of the Whittard Canyon between 400 and 1050 m water depth (Van Rooij *et al*., 2010). The preliminary data processed indicates the presence of relatively dense aggregations of various sea pen species (particularly *Kophobelemnon* sp., Figure 11) and *Lophelia* and/or *Madrepora* cold water coral reef structures (Figure 12) (Ingels *et al*., in preparation).

At present is may be premature to suggest a closure in this area until some assessment of fishing activity has been undertaken and the extent to which other adjacent canyons in the area are important sites for VMEs has been evaluated. WGDEC therefore for now simply highlights it as an important new area for VMEs.

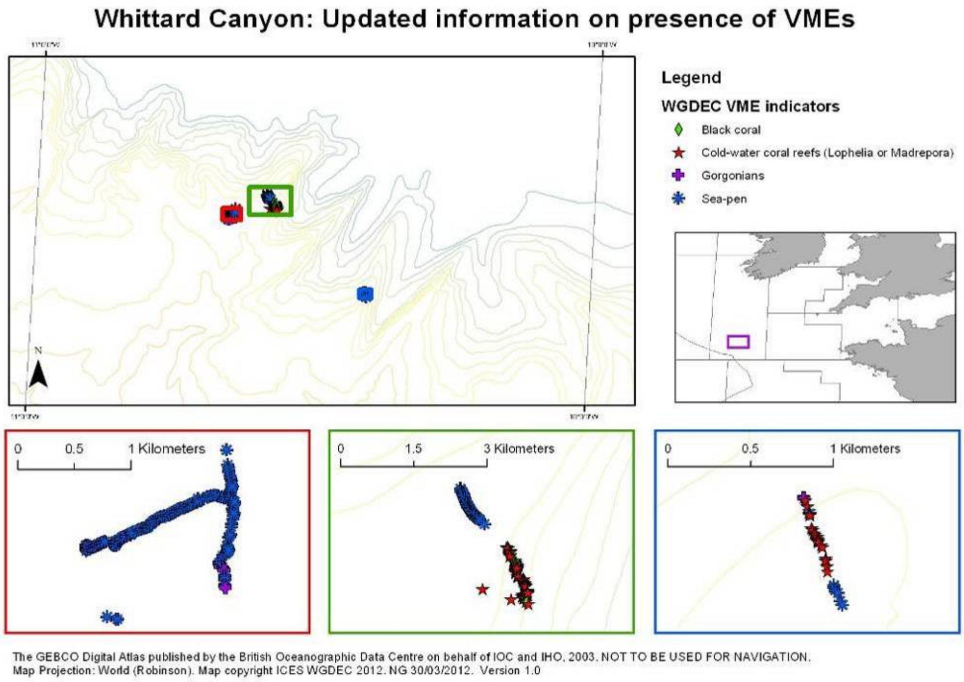

Figure 10. Map of the area that includes the Whittard Canyon showing observations of VME indicator species from ROV dives.

Figure 11. Deep-sea pen and burrowing megafauna community with high densities of pennatulids, *Kophobelemnon* sp. (copyright UGent/ROV Genesis).

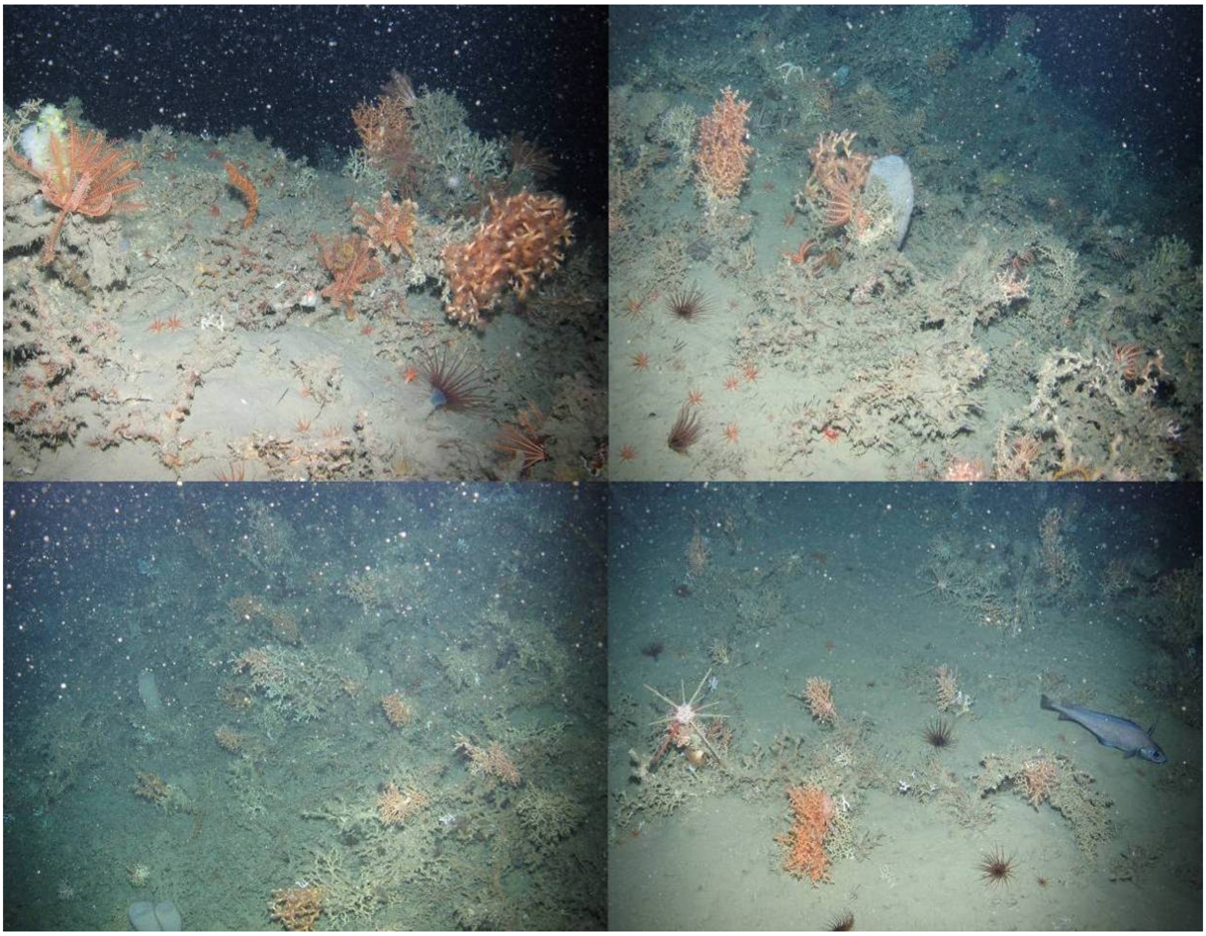

Figure 12. Coral gardens in the upper Whittard Canyon with actinarian, antipatharian and scler-actinian hexacorals, crinoids and sponges, amongst others (copyright UGent/ROV Genesis).

3.9 East Greenland

In the East Greenland area, new data from Russian observer on board fishing vessel were available for sponges. When hauling with eight hour duration, at 63°24'4 N, 39°07'3 W and 63°25'8 N, 38°24'9 W, at 950–1050 m depths, about 1200 kg sponges were caught (Figure 13). This big catch of sponges affords the ground to consider that VME is located. For now it is not possible to determine the exact boundaries of the sponge fields in this area. For this purpose it is necessary to carry out special additional research in this area and await further results before considering protection measures. There were no cold-water corals found in the catches.

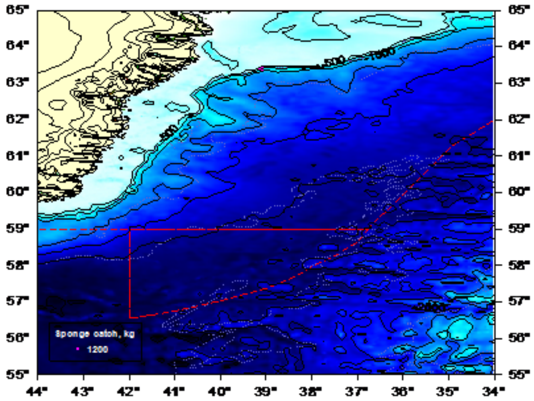

Figure 13. Positions of hauls and catches of sponges by Russian trawler with an observer aboard in the East Greenland in 2011.

3.10 Northwest Atlantic

In the NW Atlantic new data from Russian observers onboard fishing vessels were available for the slope to the east and west of Greenland and the NAFO regulatory area that includes the slopes of Grand banks and Flemish Cap.

3.10.1 West Greenland

In the area west of Greenland, where the hauls were made at 975–1500 m the catches of cold-water corals did not exceed 2.5 kg (Figure 14). Four species from the orders Antipatharia and Pennatulacea were found. *Anthoptilum* spp. predominated in catches. Besides, single specimens of *Pennatula* spp., *Halipteris finmarchica* and *Stauropathes arctica* were registered. All species were captured at 975–1500 m. Sponges were not registered in the catches.

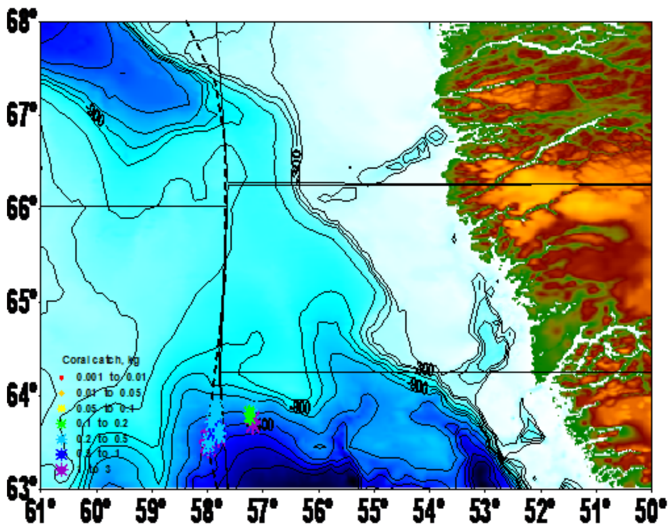

Figure 14. Distribution of cold-water coral catches taken by the Russian trawlers with observers aboard in the West Greenland in 2011.

3.10.2 NAFO regulatory area (Grand banks and Flemish Cap)

In NAFO Regulatory Area, cold-water corals were recorded in the areas of the Flemish Cap and the Grand Bank. The catches were taken from 320–1205 m depths. Their capture per a haul varied from 6 to 2500 g (Figure 15). In the catches six species from orders Alcyonacea, Antipatharia and Pennatulacea were found. *Anthoptilum* spp. which occurred practically at all the fishing depths was mostly taken. The rest species were observed only at the depths of more than 750–1050 m. In NAFO RA sponges were not registered in the catches. The species composition of cold-water corals catches in NAFO Regulatory Area was more diverse as compared to the West Greenland area. Probably, it is caused by wider range of fishing depths and greater number of hauls in the first mentioned area. As before, the cold-water corals catches in the Russian traditional fishing areas of the North Atlantic were much lower than the threshold level established by NAFO Fisheries Commission.

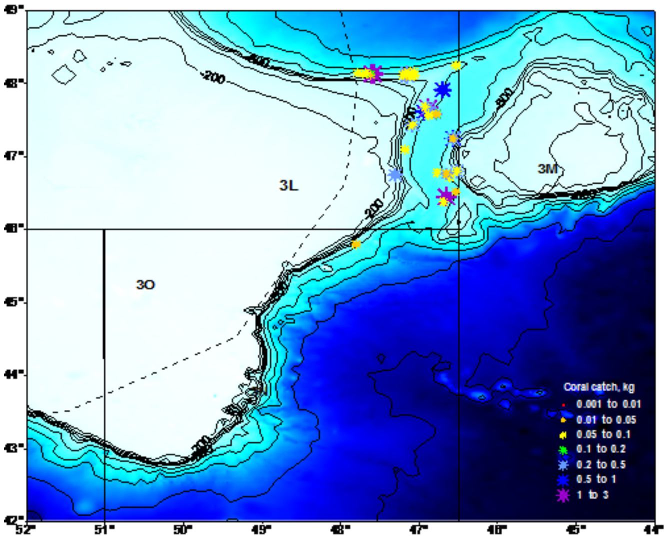

Figure 15. Distribution of cold-water coral catches taken by the Russian trawlers with an observer aboard in the NAFO RA in 2011.

3.11 Concluding remarks

Several important new sources of data on VMEs were submitted to the group in 2012. New records of VMEs have been included within the WGDEC VME database (discussed in more detail in Appendix I). It is WGDEC's intention for this database to be maintained by the ICES Data Centre, and for it to be supplemented with new information on VMEs as and when this becomes available.

New closures or closure boundary revisions are suggested in some areas where WGDEC considered there to be strong evidence for definable concentrations of VME indicator species. Had WGDEC had better access to recent information on fishing activity (VMS) and could assess the likelihood of presence of VMEs in areas where actual observations of VMEs were scant, the advice basis could have been improved. In some areas, although VME indicators were clearly present, no closures are suggested at present due to uncertainty of defining where the VME is likely to begin and end, e.g. the Whittard Canyon and the East Greenland sponge grounds.

3.12 References

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4 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.

4.1 Introduction

Background to the FAO Criteria

The United Nations General Assembly Resolution 61/105 calls upon "States to take action immediately, individually and through Regional Fisheries Management Organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and protect vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, from destructive fishing practices, recognizing the immense importance and value of deep-sea ecosystems and the biodiversity they contain".

To provide States and Regional Fisheries Management Organizations with guidance for implementing Resolution 61/105, FAO sponsored an Expert Consultation in Bangkok, Thailand in September 2007 which resulted in a set of "International Guidelines for the Management of Deep-Sea Fisheries in the High Seas" (FAO 2009), hereafter referred to as the FAO Guidelines. In this context, vulnerability is assessed with respect to species and habitats that come into contact with bottom-contact fishing gears. The two inter-locking concepts to be considered when identifying VMEs and the potential impacts of bottom fisheries are *vulnerability* and *significant adverse impacts,* respectively.

In the FAO Guidelines, the following list of characteristics is presented as criteria to be considered in the assessment of vulnerability:

i) **Uniqueness or rarity;** an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:

- habitats that contain endemic species;
- habitats of rare, threatened or endangered species that occur;
- only in discrete areas; or

ii) **Functional significance of the habitat;** discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.

iii) **Fragility;** an ecosystem or faunal community that is highly susceptible to degradation by anthropogenic activities.

iv) **Life-history traits** of component species that make recovery difficult; ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:

- slow growth rates;
- late age of maturity;
- low or unpredictable recruitment
- high longevity

v) **Structural complexity;** an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

These traits are expanded upon in the FAO Guidelines Annex which also provides examples of species groups, communities and habitat-forming species and of topographical, hydrographical or geological features which may indicate the presence of vulnerable marine ecosystems. The FAO Guidelines state that these proxies should be evaluated on a case by case basis, referring back to the relevant provisions in the Guidelines.

Regarding significant adverse impacts, the FAO Guidelines suggest: "Significant adverse impacts are those that *compromise ecosystem integrity* (i.e. ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively." The FAO Guidelines view non-significant or temporary impacts as those that allow ecosystem recovery to occur in less than 20 years. However, "if the interval between the expected disturbance of a habitat is shorter than the recovery time, the impact should be considered more than temporary" (FAO 2009).

These traits are expanded upon in the FAO Guidelines Annex which also provides examples of species groups, communities and habitat-forming species and of topographical, hydrographical or geological features which may indicate the presence of vulnerable marine ecosystems. The FAO Guidelines state that these proxies should be evaluated on a case by case basis, referring back to the relevant provisions in the Guidelines.

4.2 The need for a process for WGDEC to follow to identify VME

In their 2009 report (ICES 2009), WGDEC considered a list of other structure-forming benthic species that could also be VME indicators. However, to date, WGDEC has not performed a systematic evaluation of the species, habitats and communities or their physical proxies against the FAO Guidelines. Here we outline the procedures used to identify VME by NAFO and CCAMLR and discuss whether either of these approaches could be applied to the Northeast Atlantic.

4.2.1 NAFO process for identification of VME indicators and VME

NAFO has attempted to provide a systematic assessment of species, communities or habitat-forming species in the NAFO Regulatory Area (NRA) that should be considered VMEs or VME indicators. They have considered fish, marine mammals, benthic invertebrates and topographic features in their assessments. Unique and rare species as well as those with significant ecosystem function were evaluated against life-history criteria and potential for significant adverse impact of fishing.

4.2.1.1 Fish and marine mammals

WGEAFM previously outlined a four step process that it used to identify VMEs for mobile organisms (fish) (NAFO 2008). They reviewed taxa known to occur in the NRA and on seamounts with respect to the uniqueness/rarity, functional significance of the habitat and life-history traits identified in the FAO Guidelines (NAFO 2008). For the uniqueness or rarity criterion, factors such as NAFO moratoria on fishing, and Canadian species at risk - COSEWIC - designations were important. This produced an initial list of 27 "Tier 1" species which fit one of more of these criteria and so were believed to be the best candidates to help identify areas suitable for consideration as potential vulnerable marine ecosystems. The 27 Tier 1 species were examined in more detail and resulted in a reduced list ("Tier 2") of 21 species that were considered to be indicators of vulnerable marine ecosystems, or had discrete areas or habitats "that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species (FAO 2009)". For the Grand Bank and Flemish Cap section of the NRA, maps for Tier 2 species were produced. These maps were based on Canadian RV survey data for the period 1995–2004 and the EU survey for the period 1988–2007 and illustrated average abundance. From these species-specific maps, the areas containing approximately 90% of the entire abundance were extracted. These multiple maps were then overlaid to produce a single map depicting the most relevant areas for the selected species (NAFO 2008 Figure 18). There was very little overlap in distribution, with only a few areas proving critical to more than two species and no areas in common with five. A similar procedure was used at their December 2011meeting to update the list of VME (WGEAFM in prep.). A list of 50 fish species from research vessel survey data in the NRA was examined, along with the list of marine mammals known to occur in the general area. Following the initial selection, only species which were taken as bycatch (or were distributed) in the NRA were considered.

4.2.1.2 Benthic epifaunal invertebrates

Fuller *et al*. (2008) worked through a similar procedure with the benthic taxa identified in the FAO Guidelines, that is, primarily corals and sponges. They evaluated those groups against the criteria noted above and provided justifications for the inclusion or exclusion of different taxa while proposing other groups that could be considered in future as potentially meeting the criteria. At the most recent WGEAFM meeting Murillo *et al*. (2011) provided a systematic assessment of additional benthic species, communities or habitat-forming species in the NAFO Regulatory Area (NRA) that should be considered VMEs or VME indicators. Known taxon lists were created from records from Spanish/EU bottom-trawl groundfish surveys and from rock dredge records from the NEREIDA programme (Murillo *et al*., 2011). Approximately 500 taxa were considered. The biological traits against which the taxa were assessed are indicated in Table 1 and were designed to reflect the FAO criteria noted above. For each trait the literature used to make the assessment was retained and made available upon request. In many cases biological traits were inferred from other similar species if there were no direct studies to support the assessment. For all benthic taxa their ecological role was evaluated (Table 1). For highly aggregating taxa considered to be ecosystem engineers, the WGEAFM has further determined, using quantitative methods previously reported by WGDEC (ICES 2010), where significant concentrations of these occur.

4.2.1.3 Topographical features

In data deficient areas NAFO *topographical features* have been used as proxies for VME habitats. WGEAFM (NAFO 2008) provided justification for including seamounts as VME with respect to traits referred to above and in the FAO Guidelines. Murillo *et al*. (2011) have identified two different types of canyons based on the location of the canyon head; namely: 1) shelf-indenting canyons whose heads indent the shelf of the Grand Banks and 2) canyons whose heads are at >400 m water depth and occur on the upper slope. They also identify areas of steep seabed on the continental slope as potential VME habitats, using slopes >6.4° alternating with less steep intervals (Murillo *et al*., 2011).

4.2.2 CCAMLR process for identification of VME indicators and VME

In the same year that the FAO published its Guidance, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) held a workshop on VMEs in which it was agreed to evaluate Antarctic benthic taxa on seven criteria (Table 1).

For each of these criteria, Antarctic benthic species / taxa were evaluated as having life-history characteristics of "Low", "Medium", or "High" susceptibility to lasting damage from bottom fishing activities. They felt that absolute measures are difficult to determine and unnecessary as they can be affected by the overall productivity of one region compared with another, and the specific regional context is important to retain to ensure appropriate fisheries management. For example, where estimates of maximum longevity for a taxon were available, they were scaled as Low (<10 years), Medium (10–30 years) and High (>30 years). Such relative criteria (high–low) are necessary if species of a region are to be compared with one another. The better-studied characteristic species, habitats, and ecosystems or faunal communities of the region can form benchmarks by which higher or lower relative measures can be based. These criteria were used to indicate the presence of species associated with VMEs but are not VMEs themselves; rather, they are VME indicator taxa. Ecological significance was not explicitly considered (Table 1).

In CCAMLR, 23 taxa were assessed for which at least one of the seven criteria was rated as "high". These assessments also considered the fisheries interactions; i.e. how susceptible the taxa were to bottom fisheries, which in the case of CCAMLR is limited to bottom longlines. However, in places where more than one type of bottom fishing gear is permitted (e.g. bottom trawling), it is likely that a taxon could receive differing VME scores based on its vulnerability to each particular fishing gear type.

Achieving a high ranking for one criterion should be sufficient for a species or habitat to be considered as a VME indicator. However, vulnerable marine ecosystems are a continuum; that is, some species or habitats are more vulnerable than others, and it is therefore difficult to define exactly when an ecosystem becomes a VME or not, especially for those that do not form habitats but fall under the uniqueness/rarity criteria. Tabulating relative measures can allow for combined scores to be produced that can give an indication of where on that continuum a particular indicator species or habitat lies, and can inform the setting of encounter thresholds and move-on distances.

4.2.3 Comparison of NAFO and CCAMLR approaches

In reviewing the two approaches used by NAFO and CCAMLR (Table 2.2.3.1) we can see that each has been optimized for the species/habitats and fisheries which occur in their areas. In NAFO Regulatory Area the current fisheries are conducted using bottom trawls, while in CCAMLR all fishing is done using longline gear. In NAFO most VMEs fall under the functional significance criteria with the benthic invertebrate taxa being highly aggregated over large areas and with few unique or rare fauna except for the black coral (Murillo *et al*., 2011). The area is data rich in that annual trawl surveys are conducted for fish assessments and the NEREIDA project (led by Spain with collaboration from Canada, UK, Russia; Durán Muñoz *et al*., 2012) has done a complete multibeam survey of the entire regulatory area from 700 to 2000 m and sampled with sediment cores and small rock dredges, with *in situ* camera surveys completed in targeted areas. Conversely, CCAMLR has a larger proportion of species/taxa falling under the Uniqueness/rarity criterion with associated patchiness of distribution. They also know less about the distribution of these taxa as most of the area is data deficient.

Both RFMOS have developed novel methods to identify VME and apply regulations for their protection. NAFO has been able to develop quantitative methods to detect the VME in their region, while CCAMLR has come up with the approach described above which identifies areas where rare species co-occur by moving vessels off areas with accumulations of their VME indicators above certain thresholds. The Northeast Atlantic and the NEAFC area in particular is a difficult area to manage as it has areas within its regulatory area that are similar to that of NAFO and it has other areas that are more similar to CCAMLR. Both trawl and longline fisheries are prosecuted and some deep net gillnetting occurs, and both structure forming, highly aggregated VME taxa are present (e.g. *Lophelia* reefs, sponge grounds or "ostur") while there are likely many taxa which fit the uniqueness/rarity criterion. There are also different biogeographic regions within the regulatory area. Acknowledgement of this complexity is an important first step in determining an overall management strategy for protecting VME in the Northeast Atlantic.

Table 2.2.3.1. Comparison of criteria suggested in the FAO Guidelines with those used by NAFO and CCAMLR to identify VME indicator taxa.

FAO Guidelines	NAFO	CCAMLR
Uniqueness/rarity	Rare or unique populations	Rare or unique populations
Fragility	Fragility	Fragility
Life history:	Life History:	Life history:
• slow growth	• slow growth	• slow growth
• late age of maturity	• late age of maturity	• [none]
• low or unpredictable recruitment	• irregular or episodic recruitment	• [none]
• high longevity	• lifespan (>20 yr)	• longevity
		• lack of adult motility
		• Larval dispersal potential
Structural complexity	Height off bottom >5 cm	Habitat-forming
"ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms"		
Functional significance of the habitat	Significant Role in Ecosystem (Function)	
"discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species"	• structural engineer	
	• predator	
	• bioturbator	
	• carbon sequester	
	• benthic pelagic coupling	
	• benthic production	

4.2.4 Evaluation of key species/habitats in the Northeast Atlantic against FAO criteria for VME

In this section we produce a preliminary checklist of the criteria highlighted in the FAO Guidelines and assess five of the species/habitats that are commonly dealt with in WGDEC or known to occur in the Northeast Atlantic (Crinoid Fields) against those criteria (Table 2.2.4.1). Observations of high density crinoid fields have been identified in the southern Minch near the Mingulay Reef Complex (*Leptometra celtica* (unstalked); Moore and Roberts, 2011), the Bay of Biscay (*Endoxocrinus* (*Diplocrinus*) *wyvillethomsoni* (stalked); Conan *et al.*, 1981) and on the Wyville Thomson Ridge (JNCC 2011). Not surprisingly, given the selection and their explicit mention in the FAO Guidelines, all can be identified as VMEs. For evaluation of biological traits, online databases such as BIOTIC (http://www.marlin.ac.uk/biotic) may prove useful.

Table 12. A cursory evaluation of potential VMEs in the Northeast Atlantic. This table is populated by WGDEC expert opinion.

Biological Traits Relevant to FAO Guidelines For Identification of VME	Potential VME Element				
	Lophelia Reefs	Sponge Grounds	Soft bottom coral gardens	Hard bottom coral	Crinoid Fields

		(ICES 2009)	(Isididae, Chrysogorgiidae)	gardens (Gorgonian corals)	
Fragility, Vulnerability and Recoverability					
Fragility	x	x	x	x	x
height off bottom > 5 cm	x	x	x	x	x
lifespan (> 20 yr)	x	x	x	x	x
slow growth rates	x	x	x	x	?
late age of maturity	?	?	?	?	?
irregular or episodic recruitment	?	?	?	x	mass spawning, annually
poor regeneration ability (> 20 years)	?	variable	x	x	good regeneration
low fecundity	?				?
lack of adult motility	x	x	x	x	x
short range larval dispersal potential	?	x	?	?	?
Unique or Rare Species an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:habitats that contain endemic species; habitats of rare, threatened or endangered species that occur only in discrete areas	na	na	na	na	na
Primary Significant Role in Ecosystem (Function)					
Structural engineer	x	x	x	x	x
Predator					
bioturbator					
carbon sequester					
benthic pelagic coupling	x	x		x	x
benthic production					
benthic diversity	x	x	x	x	x
Carbonate production	x			x	x
Primary Susceptibility to Bottom-Contact Fishing Gear (Indicate if specific to Trawl (T) or Longline (L))					
detachment		x	x	x	x
severe wounding/damage	x	x	x	x	x
smothering		x			x
increased vulnerability to predators			?		

4.3 A broader range of VMEs to be considered by WGDEC in future meetings

The Annex of the FAO Guidelines gives examples of species groups, communities and habitat forming species that may potentially be VME. Those not considered by WGDEC to date include: hydrocorals (Stylasteridae), xenophophores and seep and vent communities. Other benthic invertebrate species/habitats that have been identified by NAFO and so may apply to the Northeast Atlantic are sea pens (Fuller *et al*., 2008), erect bryozoans, crinoids and stalked tunicates (Murillo *et al*., 2011). Although we evaluate crinoid fields here (Table 2.2.4.1), they have not been previously reported by WGDEC. However others may be identified from area-specific species and habitat lists following the process described in Section 2.2 or through a similar screening protocol.

While corals and sponges are usually the first to be identified as VME indicators, there are many other taxa that WGDEC should consider, including teleost fishes and elasmobranchs, marine mammals and reptiles. In particular, attention should be given to taxa/habitats that may fit under the uniqueness/rarity criterion. IUCN designations could help to establish an initial list of taxa to screen for the uniqueness/rarity criteria. Many of these species will have life histories that make them vulnerable. WGDEC should take this opportunity to also consider making certain life stages indicators of VMEs such as eggs, nursery areas and gravid females in addition to spawning grounds.

However, many deep-sea species remain scantily studied and, for these, assessments will have to rely on expert judgment. Further, the threshold at which one or more VME indicator taxa constitute a VME will vary according to biogeographic region and the composition of biological communities. The process for setting of such thresholds is still being worked out, with different regions taking different approaches according to their data sources, species and fisheries (see 2.2.3 above). In the Northeast Atlantic protocols developed by NAFO and CCAMLR may each be appropriate for certain cases while in others, novel solutions may be required. One possibility is to introduce thresholds that combine VME taxa as has been done for longline fisheries by CCAMLR with associated weighting schemes. For example if a VME shark is caught in association with coral it would have more weight than either record in isolation. Clearly more work is needed on this topic (see ToR e).

Some key hydrographic features underlie biodiversity and ecosystem function, including upwelling/downwelling of production, internal tides, diapycnal mixing, Taylor columns etc., all of which interact with seabed bathymetry. Examples of topographical, hydrophysical or geological features that the FAO Guidelines name as potentially supporting VME species groups or communities and not previously considered by WGDEC are: submerged edges and slopes, canyons and trenches, hydrothermal vents and cold seeps. The use of physical proxies has been used by NEAFC and others to close areas to protect VME in a precautionary framework (e.g. the NEAFC closure on the Mid-Atlantic Ridge).

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5 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

5.1 Introduction

In their 2009 report WGDEC previously examined the use of biodiversity indices in some detail. This was done in response to their ToR e). Consider how the status of biodiversity of deep-water ecosystems could be measured, for example by using diversity indices (in conjunction with WGDEEP; see ICES 2009 Section 7). Rather than repeat that exercise we focus here on indicators for biodiversity monitoring and how they may be used for the provision of advice.

Cold-water coral reefs/gardens and sponge grounds are considered to be ecosystem engineers. Dense aggregations formed by the large structure-forming species which constitute the habitat framework can alter bottom currents and provide niche space for other organisms; often increasing biodiversity compared with surrounding areas. The location of coral beds and sponge grounds can therefore be used as proxies for areas of high biodiversity for both invertebrates and fish species.

The development of a suite of indicators for monitoring the status of these habitats is well suited to current fisheries management strategies that are based on indicator frameworks. Such monitoring activities can be classified into two groups: 1) monitoring ecosystem components to collect information on long-term trends in response to environmental or anthropogenic factors and to enable predictions on future states of the component in relation to environmental or anthropogenic change and 2) monitoring threats or stressors to ecosystem components. The former are often referred to as state indicators, while the latter are referred to as threat or stressor indicators.

5.2 Potential indicators for monitoring coral and sponge grounds

Kenchington *et al*. (2012) review both state and threat indicators for monitoring coral and sponge habitats as proxies for biodiversity in the context of monitoring marine benthic biodiversity in Canadian Arctic waters.

Table 13. A summary of potential indicators for monitoring coral and sponge grounds. Level of confidence is derived from statistical evaluation in the Kenchington *et al.* (2012) and from published literature [table extracted from Kenchington *et al.* (2012) with permission].

Indicator (Source)	Primary Link with Biological/Ecosystem Property	Data Source/Sampling Tool	Level of Confidence in the Data
State Indicators			
1. Abundance (CAFF[1], Gully[2])	Biodiversity; ecological function; reproductive success	Trawl Survey; Common gear and area *In situ* Photographic/video Transects	Low High
2. Biomass (CAFF, Gully)	Ecological function; reproductive success	Trawl Survey; Common gear and area	Low
3. Distribution (CAFF)	Ecosystem resilience; ecosystem function; genetic diversity	All records; Trawl surveys; Fisheries Observers	Medium
4. Diversity Indices (e.g. Shannon, Simpson, Evenness, Taxonomic Redundancy, Response Diversity) (CAFF, Gully)	Biodiversity, ecosystem resilience; ecosystem function; genetic diversity	Trawl Survey; Common gear and area *In situ* Photographic/video Transects	Low High
5. Size Structure (Gully)	Ecological function; reproductive success	*In situ* Photographic/video Transects	Medium
6. Live:Dead ratio (Gully)	Mortality rate; Physiological stress	*In situ* Photographic/video Transects	Medium
7. % zoanthid cover (Gully)	Physiological stress	Trawl Survey; Common gear and area *In situ* Photographic/video Transects	Medium High
8. Patch area	Biodiversity; ecological function; reproductive success	Trawl Survey; Common gear and area	High
9. Patch density	Reproductive success	Trawl Survey; Common gear and area	Medium
10. Patch Isolation/Proximity	Reproductive success; genetic diversity	Trawl Survey; Common gear and area	High
11. Patch Connectivity	Reproductive success; genetic diversity	Trawl Survey; Common gear and area	Medium
12. Patch Dispersion	Reproductive success	Trawl Survey; Common gear and area	High
Stressor Indicators			
13. Distribution of fishing activities (MSFD)	Fishing mortality; Abundance/Biomass	VMS data	High
14. Aggregation of fishing activities (MSFD)	Fishing mortality; Abundance/Biomass	VMS data	High
15. Areas not impacted by mobile bottom gears (MSFD)	Ecological function; reproductive success	VMS data	High
16. Timing and duration of anomalous events	Abundance/Biomass	Various	Low
17. Timing of phytoplankton bloom	Reproductive success; productivity	Chl *a*; satellite data	Medium
18. Timing, duration and path of sea ice melt	Productivity	Satellite data	Medium
19. Biomarkers	Physiological stress	Various	High

[1]CAFF: Conservation of Arctic Flora and Fauna; [2]Gully: the Gully Marine Protected Area Monitoring Plan (DFO 2010; Kenchington, 2010).

Nineteen potential indicators for monitoring corals and sponges in the Eastern Canadian Arctic were considered (Table 3.2.1). Four were put forward by the Arctic Marine Biodiversity Monitoring Plan (Gill *et al.*, 2011), three from the Gully Marine Protected Area monitoring plan (Kenchington, 2010), three from the European Commission (EC 2008) and one from an ICES study group (ICES 2011). The remainder were novel contributions drawn primarily from geospatial statistics and known stressors. Geo-referenced biomass/abundance data by species collected by either trawl surveys or from underwater video allow for the calculation of nine of the twelve state indicators.

5.2.1 Details of geospatial indicators for the monitoring of coral and sponge aggregations

Five geospatial indictors proposed by Kenchington *et al.* (2012) are detailed as follows:

Patch area and density: The habitat area occupied by corals and sponges can be expressed using summary statistics drawn from the population of habitats or patches in the broader survey landscape (e.g. mean, median, max, variance, etc). Patch density is the number of patches per unit area. Patch perimeter is usually highly correlated with Patch area but in some cases may have better distributional properties and so could be seen as an alternative to Patch area.

Nearest neighbour measurements: Isolation/Proximity: Isolation or proximity refers to the tendency for patches to be relatively isolated in space from other patches. If dij is the nearest-neighbour distance from patch i to another patch j of the same type, then the mean nearest-neighbour distance over all patches is a measure of relative isolation.

Connectivity: Isolation/Proximity of patches can be interpreted in terms of connectivity. If ecological or oceanographic knowledge governing the dispersal of gametes or larvae is available then the information can be used to predict a neighbourhood size that reflects a gamete dispersal range or other ecological process. The number of patches that fall into the neighbourhood size could then become a measure of connectivity.

Dispersion: Dispersion refers to the tendency for patches to be regularly or contagiously distributed (i.e. clumped) with respect to each other. Dispersion can be calculated for patches, tow locations with coral or sponge bycatch or individuals.

These geospatial indicators could also be used to monitor coral reefs and mounds, including the cold-water coral *Lophelia* reefs common in the Northeast Atlantic. All of these indicators will reflect biological and ecological properties such as reproductive success, ecosystem function, ecosystem resilience and intraspecific genetic diversity.

5.3 Comments on data sources for the calculation of diversity indices

Due to concerns over the reliability and performance of biomass estimates from trawl surveys (and more so with abundance), the use of mean biomass from trawls was not recommended. The other indicators were calculated from the spatial array of sponge and coral patches. These were also determined from trawl survey data but only to locate high density areas relative to other areas, and could equally be applied over smaller spatial scales to data collected from underwater video. The location of these patches, especially ones made including more than one set, was relatively stable from year to year as expected for sessile fauna with long lifespans and low recruitment. All of the geostatistic-based indicators performed well in their initial assessment on the sponges. That is they had distributional properties that were amenable to hypothesis testing using either parametric or non-parametric statistics. They also showed no significant trend across the six year study, despite small variances, which accords with expectation. It remains to be seen whether those indicators are sensitive to environmental or other change but they appear to be good candidates for future monitoring of coral beds and sponge grounds, and hence of biodiversity.

5.4 References

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6 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 and suggest how this may be used in an advisory capacity

6.1 Introduction

Seamounts have long been thought to be sites of increased endemism. Wilson and Kaufman (1987) reported that seamounts could have endemism levels up to 36%, and Richer de Forges *et al*. (2000) suggested that the fauna of seamounts would change every 1500 km or so. In both cases, the authors acknowledged that one might get a different picture were there more sampling. Recent genetic sampling suggests that many seamount species can be found over very large areas and on continental slopes adjacent to seamounts, and that the overall likelihood of seamounts containing an endemic fauna is quite small (Rowden *et al*., 2010). This short review will look at this question and suggest that the issue might be one of substrate availability and not of any particular intrinsic attribute of seamounts per se.

6.2 Case studies, survey methods and sampling effort

Seamount sampling rarely involves a comprehensive look at the fauna, rather a select group or groups of animals are sampled, increasingly only with video. In the Northeast Pacific, Parker and Tunnicliffe (1994) identified 117 species from Cobb Seamount. This seamount has a very shallow summit (24 m) with a major terrace at 120–180 m. Most species appear to have arrived as pelagic larvae but a few direct developers were also seen. The deeper parts of the seamount were not sampled. Hall-Spencer *et al*. (2007) found very low levels of endemism (<3%) of corals on seamounts in the Northeast Atlantic, but also noted that the coral communities of the seamounts were significantly different from those of the adjacent continental slope. Lundsten *et al*. (2009) found low levels of endemism for species on seamounts near the continental shelf off California. They focused primarily on epibenthic megafauna much of which was new to science. Howell *et al*. (2010) found no endemism among the epifaunal species investigated for two deep banks and one seamount in the Northeast Atlantic. These features are close to the continental shelf and were sampled by video only. In the South Pacific, O'Hara (2007) noted that the ophiuroid fauna of seamounts extending over a large latitudinal range did not exhibit elevated levels of species richness or narrow-range endemism when compared with non-seamount areas in the same geographic region. On the Rockall bank, not strictly a seamount, but nevertheless an isolated submarine ecosystem, a recent study found that the fish fauna (as sampled by bottom trawl) shows only about two thirds of the species richness of the adjacent continental slope (Neat and Campbell, 2011). The fish assemblage was however very different with respect to the proportional composition of the species present.

Thus, modern detailed sampling so far does not support the idea that seamounts harbour increased endemism for the larger components of the fauna. On the other hand, it may be that endemism levels for the smaller infaunal species will show a different pattern. Studies on harpacticoid copepods (George and Schminke, 2002) and rissoid snails (Gofas, 2007) were reviewed by WGDEC in 2011 and it was concluded that both groups show very high levels of endemism (over 90%) on their respective seamounts or seamount groups.

With increased seamount sampling it is becoming clear that the larger seamount faunas are most likely widely distributed across ocean basins, and may have close relatives in adjacent ocean basins, with the overall pattern matching the proposals for bathyal zoogeographic provinces (Watling *et al*., submitted). These distributions are best documented for deep-sea corals as the taxonomy of the species become worked out. Watling *et al*. (2011) tabulated the octocorals from the northeastern and northwestern Atlantic and found that only nine of the 125 species occurred on both sides of the Atlantic. Those nine species are widespread and have been found on many of the seamounts investigated. The remaining 31 western species and 74 eastern species are found only in their respective basins, but many have been found on more than one seamount. In their review of the three characteristically deep-sea octocoral families Chrysogorgiidae, Primnoidae, and Isididae, Watling *et al*. (2011) note that while genera may be widespread, species within the genera may be restricted to one, usually bathyal, deep-sea zoogeographic province.

6.3 Genetic approaches

Genetic techniques are now being used to determine the extent to which larvae are able to spread throughout the world ocean. In the case of seamount faunas, there have been investigations of a few groups of organisms at scales including seamount chains as well as across basins. Samadi *et al*. (2006) examined the distribution of haplotypes of galatheid and chirostylid squat lobsters sampled from the Norfolk Ridge and compared the patterns observed with that of two gastropods, one with a planktonic larva and one with direct development. The haplotypes of the squat lobsters and the gastropod, all of which have a planktonic larva, were distributed throughout the Norfolk Ridge, and one haplotype of *Munida thoe* also was found 2200 km away at Wallis and Futuma Island. Cho and Shank (2010) found the haplotypes of four ophiuroids to be widely distributed across the New England and Corner Rise seamount groups, a series of seamounts spanning a distance of 1200 km. Thoma *et al*. (2009) found several haplotypes of seven octocorals and black corals to be widespread across the western North Atlantic seamounts sampled. Pante and Watling (2011) discovered that within the genus *Chrysogorgia*, the haplotypes represented four new species that they then described, the haplotypes extending over nearly the whole seamount range.

6.4 Biogeography of seamounts in the NE Atlantic

Within the North Atlantic, there are three main types of seamounts: those that are associated with the continental slopes, those that are associated with the Mid-Atlantic Ridge, and those that are isolated within the interior of the ocean basins. For example, in the North Atlantic there seems to be a distinct octocoral fauna on each side of the mid-Atlantic Ridge at mid-bathyal and lower depths. Currents along the MAR run north to south and undoubtedly influence the direction of larval transport (Machin *et al*., 2006). The continental slope seamounts are more likely to harbour species characteristic of the basin margins, whereas the seamounts on the MAR and in the interior of the basins may be biogeographically different from the seamounts of the slope. The available evidence so far suggests that the seamounts of the North Atlantic reside within two and probably three bathyal depth biogeographic provinces (Watling *et al*., submitted). These are the northern North Atlantic Boreal Province, from about 45°N and extending to the Iceland-Faroes Ridge, and the North Atlantic Province, which extends from 45°N to about 10°N. There is some evidence that the latter province should be subdivided into eastern and western subprovinces or perhaps are separate provinces. The octocoral fauna of the seamounts in these three areas seem to be quite different (Watling *et al.*, 2011) suggesting that the seamounts should be managed as separate units according to these biogeographic considerations (WGDEC 2011).

6.5 Alternative management options for fisheries on seamounts

WGDEC has in past reports made the case that current fisheries management of seamounts is insufficiently precautionary to prevent damage of VMEs. The encounter thresholds and the move-on rule are simply inappropriate. An alternative bases on high-etch fisheries monitoring and detailed seabed mapping is possible. This is elaborated on in detail in ToR (e) III.

6.6 Conclusions

In sum, seamounts do not appear to be sites of special levels of endemism, *per se*. However, seamounts often provide abundant sediment-free hard substrate (Auster *et al.*, 2005), and since it is well known that benthic organisms are strongly limited by substrate type, the unusual and sometimes unique epifaunal organisms may simply be responding to an abundance of the appropriate substrate that seamounts provide relative to adjacent continental slopes. Additionally, most deep-sea species have strong associations with water masses, and at depths below 400 m the water mass characteristics may determine which species of octocorals and sponges might be present. As seen by the genetic data, it is likely that most seamount species with pelagic larva are widely distributed amongst seamounts at the depth of particular water mass.

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7 Support to NEAFC review of bottom fisheries regulations

7.1 Encounter thresholds

Assess the appropriateness of the current quantitative thresholds of VME indicator organisms, i.e. live coral and sponge, adopted in the NEAFC bottom fishing regulations. The assessment should include an evaluation of the likelihood of achieving conservation objectives, i.e. the prevention of significant adverse impacts on VMEs as defined in the FAO guidelines.

7.1.1 Introduction

The current quantitative encounter thresholds for VME indicator taxa in the NEAFC area are 60 kg of live coral or 800 kg of sponge landed on deck per tow. These threshold values mirror earlier regulations in the adjacent NAFO area to the west (that were changed for sponges in 2012 to 400 kg sponge outside of the fishing footprint, and to 600 kg sponge inside of the fishing footprint but outside of the closed areas). These values were put in place as interim measures until the NAFO Scientific Council could suggest scientifically based measures. That report is anticipated in June 2012. Previous advice from WGDEC (e.g. ICES 2010, 2011) and a review by Auster *et al*. (2011) addressed general issues about encounter thresholds related to the non-random distribution of VME indicator species in deep-sea habitats as well as issues related to variation in gear type and size, tow times and retention efficiency of coral and sponge bycatch. In general, previous advice has been that current threshold values are too high, but did not include a definitive approach for moving forward. Here we link the distribution of VME indicator species to classes of habitat selection models and discuss how uncertainties in model fit lead to a more precautionary interpretation of bycatch data and recommended use of lower encounter thresholds in order to meet conservation objectives.

7.1.2 Quantification of VME indicator bycatch

Summaries of approaches that can be used for developing encounter threshold alternatives using cumulative catch statistics of VME indicator species can be found in past ICES WGDEC reports (2010, 2011). For example, cumulative catch of octocorals in research survey trawl data from the Northwest Atlantic have a highly skewed distribution (Figure 16) with a small number of large catches (NAFO 2008). This pattern suggests few dense patches of octocorals with large areas of octocorals at low densities. Similar patterns have been observed elsewhere, such as in commercial trawl catch statistics in the South Pacific (Penny *et al*., 2008; Parker *et al*., 2009).

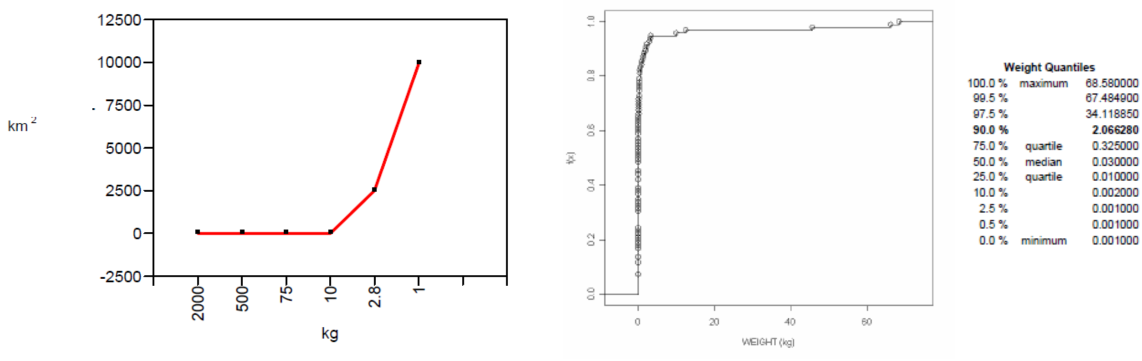
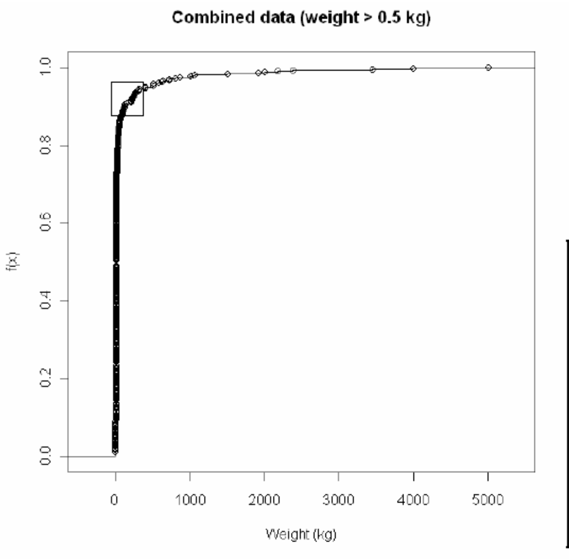


Figure 16. Left graph: An example of the relationship between research vessel trawl catch of a highly aggregating species and the area occupied by those catches. High weights of large and very patchy species occupied a small area while smaller catches, based on a 10 kg threshold, exhibit an exponential increase (from Kenchington *et al.*, 2009). Right graph: An example of the relationship between research vessel trawl catch of highly aggregating VME indicator species; here the cumulative distribution of large gorgonians *Paragorgia* spp., *Primnoa resedaeformis*, *Keratoisis ornata*, *Acanthogorgia armata*, and *Paramurciea* spp. from 95 survey tows). The values of catch weight are presented as quantiles (from NAFO 2008).

In the same manner, alternatives for existing threshold values of sponge grounds can be developed based on patterns in cumulative catch curves from research surveys; such that the inflection point for the asymptote or values for particular quantiles (e.g. 50%, 90%, 97.5% of catch distribution) are indicative of ecologically relevant reference points (Figure 17; NAFO 2008, 2009; Kenchington *et al*., 2010). However, these measures should be used in combination with geospatial information to determine whether they come from aggregations or are indicative of habitats (NAFO 2009; Kenchington *et al*., 2010). It is important to recognize that the shape of cumulative catch distribution curves could be shallower for species that are more regularly or evenly distributed.



N = 415		
Weight quantiles		
100%	maximum	5000
99.5 %		3370.58
99%		2151.38
97.5 %		953.13
95%		430.00
90%		124.46
85%		52.52
80%		25.81
75%	quartile	16.10
50%	median	3.50
25%	quartile	1.25
20%		0.97
15%		0.85

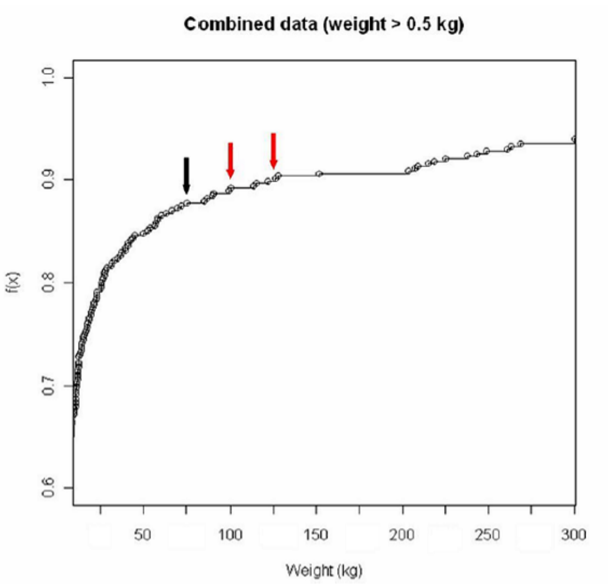


Figure 17. Examples of cumulative catch distributions of sponges from research vessel surveys illustrating the identification of change of curvature as a threshold indicative of potential biological thresholds (from NAFO 2009). The information regarding each example is quoted directly from captions in the original text: (Top graph) Cumulative catch distribution of sponges from combined RV Spanish surveys (30 min tows) and Canadian surveys (15 min tows). The values of catch weight are presented as quantiles. The box represents the general area of the point of maximum curvature. (Bottom graph) Cumulative distribution of sponges [from graph at top] zoomed in to show the section between 10 and 300 kg from RV Spanish/EU surveys (30 min tows) and Canadian surveys (15 min tows). The black arrow indicates the first clearly long step in the general region where the point of maximum curvature is expected to be located; this point correspond to a value of 75 kg and coincides with one of the thresholds identified by the spatial analysis. Red arrows represent the 100 kg and 125 kg thresholds also indicated from the spatial analyses. Note that all three threshold points identified by the spatial analysis (75, 100 and 125 kg) correspond to relatively longer steps in the cumulative distribution. This match between methods strengthens the notion that these values correspond to natural discontinuities in the data.

7.1.3 Theoretical basis for distributional patterns of VMEs

In order to appreciate why VMEs are likely to exist in a variety of distributional patterns it is important to consider in some detail the ecological theory underpinning species distribution. The ecological assumptions implicit in the protection of aggregations is that high density patches of VME indicator species: (1) sustain population and geographic ranges of those particular species as well as functional roles (e.g. as habitat for commensal species), (2) are a primary source of recruits to surrounding areas (or within patches) in order to sustain connectivity and resilience of populations, and (3) serve as an indicator or umbrella taxa for a VME (e.g. as *Lophelia pertusa* is an umbrella for a diverse reef associated fauna). The first two of the three assumptions stated above are tightly linked to the demography of VME indicator species and the type of species-habitat distribution model that each population operates within. Note that here we are not discussing the life-history parameters that make a species vulnerable or fragile (e.g. long-lived, low fecundity, slow growth to maturity) but the demographic relationships between population size, local density, and the area occupied by the population as they relate to long-term conservation objectives (i.e. sustainable populations).

There are three conceptual models that describe the variation in the spatial patterns of species distributions and related variation in population size (Petitgas 1999; Shepherd and Litvak, 2004). These are; 1) the proportional density model (Houghton, 1987; Myers and Stokes, 1989; Hilborn and Walters, 1992; Petitgas, 1997), 2) the constant density model (Iles and Sinclair, 1982; Hilborn and Walters, 1992; Rodenhouse *et al*., 1997; McPeek *et al*., 2001), and 3) the basin model (MacCall, 1990). While these types of models were originally developed to address distributions of mobile animals, there has been validation that such models are useful constructs for examining processes that mediate the distribution of sessile organisms as well (e.g. Gersani *et al*., 1998; Li and Wang, 2006). Table 1 summarizes the relevant properties of each model as they relate to approaches for understanding patterns of habitat use by VME indicator species (see also ToR (c) where we discuss indicators for capturing some of these attributes).

Table 14. Properties of populations based on three different habitat use models.

	Proportional density model	Constant density model	Basin model
Density	Local density increases and decreases in phase with population size.	Local density constant.	Local density increases and decreases in phase with population size.
Geographic range	Range is constant	Range expands and contracts in phase with variation in population size.	Range expands and contracts in phase with variation in population size.
Population responses	Local growth	Geographic expansion	Local growth and geographic expansion
Localvs.regional scale processes	Local refugia from predators are a potential mechanism to explain local variation in density and size.	Local competition for resources but individuals in adjacent patches has no population-wide effect on density and size.	Optimal habitats fill first. Range expands to suboptimal habitats as habitat value decreases with increased density.
Example species and references	North Sea cod *Gadus morhua* (Myers and Stokes, 1989)	Atlantic herring *Clupea harengus* (Iles and Sinclair, 1982); Whiting *Merluccius merluccius* (Caset and Pereiro, 1995)	Gulf of St Lawrence cod *Gadus morhua* (Swain and Wade, 1993); Scotian Shelf haddock *Melanogrammus aeglefinus* (Marshall and Frank, 1995)

The type of model that each VME species fits is critical for interpreting patterns in the bycatch data and therefore assessing threshold values. Currently we are assuming that the highest catch weights reflect the presence of high density patches and optimal habitats of VME species (i.e. optimal based on fitness measures such as growth rate, survivorship, and fecundity) but we should not assume that this is always the case. If the VME indicator taxa fit the basin model, then such patchy distributions and associated habitats are of critical importance to sustaining populations. Ideally optimal habitats are identified and conserved such that population tipping points are not exceeded. However, while such patches may be indicative of population status for those taxa that fit the proportional density model, the link between high density patches (some of which are potentially the result of local-scale level processes) is unclear.

Identifying and conserving only high density patches can result in mortality rates that exceed tipping points for population persistence. The same problem interpreting the value of high density patches applies to taxa whose distribution fit the constant density model, although based on different mechanisms. That is, high density patches may be identified within the ecological noise produced by local competition for resources and that focusing conservation only on high density patches can again exceed tipping points.

7.1.4 Discussion

At this point, we do not have adequate knowledge to understand which model applies to each VME species, how variation in local-scale processes mediate local density (based on recruitment, growth, and reproduction as well as role of species interactions such as predation, competition and facilitation), or patterns of connectivity between patches (i.e. sources and sinks of propagules from patches, especially spillover from inside to outside protected areas). Data linking population size, geographic range, and spatial variation in local density and growth across habitats (as a measure of fitness) are required simply to test model predictions. In the absence of such spatially comprehensive data on population parameters and habitat maps for

VME species, that would provide a route to tactical approaches for VME conservation strategies, it is unclear what would be the best way forward.

Cumulative catch curves can provide information for developing encounter thresholds in the absence of VME population data. Using the highest quantiles in the data distribution as reference points are potentially effective for those species that are distributed based on the basin model and for which we have requisite data to forecast population viability. Alternatively, the 50% level includes the upper half of the density distribution of VME indicators and therefore excludes encounters with indicators at the lowest density levels (i.e. the occasional detection found within an existing fishery footprint). In areas where exploratory fishing takes place, any catch could be considered as an encounter given the wholesale lack of understanding of distribution of VME species within such areas. Only after mapping, non-destructive surveys for VME species to assess distribution patterns, analysis of bycatch patterns from the exploratory fishing, and subsequent consideration of designating VME closures based on such data should the encounter threshold be raised to a level appropriate for the gear and local geospatial context.

The general uncertainty should provide incentive for both government and industry to invest in survey data to improve our overall understanding of VME distributions. Even to improve use of bycatch data there is an immediate need to calibrate catch curves based from research survey trawls with actual commercial bycatch rates. Furthermore threshold values even for the same indicator species may vary across biogeographic boundaries (as discussed in advice provided by WGDEC in ICES 2010).

7.1.5 Consensus and suggested modification of VME bycatch thresholds

Current experience with the thresholds introduced by NEAFC is that no reports of encounters were received (NEAFC, pers. comm. 2012). This possibly reflects a combination of a general decline in bottom fishing activity in the NEAFC Regulatory Area, the recent introduction of closures that effectively exclude vessels from the areas most likely to produce encounters, and an enhanced awareness and capability of vessels to avoid coral and sponge areas. It cannot be excluded, however, that the lack of reports also reflects some failure to report actual encounters.

Based on the general knowledge of VME indicators and their distribution patterns, WGDEC remains of the view that current thresholds are too high and that a 50% reduction in current thresholds to 400 kg (sponges) and 30 kg (corals) would better reflect the likelihood that a VME was encountered (i.e. based on the logic derived from the arguments presented in the discussion above). There are still problems even with values such as these as they are unlikely to indicate encounters with certain VMEs such as coral gardens and in no way takes into account the diversity of different types of VME indicator species.

In the interim, and until further research can be completed to provide a scientific basis for thresholds, ICES WGDEC further recommends that encounters at or above half the newly proposed thresholds, i.e. 200 kg (sponge) and 15 kg (coral), should warrant the following actions:

1) New fishing areas: the encounter is reported to the Secretariat and the fleet, and a move-on response should be taken. If in the same fishing area, a second encounter at or above these threshold limits occurs, this requires reporting, move on, but also a further assessment of the spatial proximity of the two encounters. If the encounters occurred within a distance of 2–3 nm of each other, i.e. indicating the presence of a VME, then it is assumed the

cumulative total has exceeded the threshold and a temporary closure should be implemented.

2) Existing fishing areas: encounters at the lower thresholds given above should trigger reporting and the established move-on response. Two such encounters within 2–3 nm of each other should count as a single full encounter and trigger responses as required for a single full encounter (Article 2.1. of the NEAFC regulations).

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7.2 Move-on rule

Assess the appropriateness of the current move-on-rule adopted in the NEAFC bottom fishing regulations. The assessment should take into account the different habitats where bottom fisheries occur, e.g. continental slopes, mid-ocean ridges and seamounts, as well as the variable amount and quality of information on the relevant spatial distribution of VMEs.

7.2.1 Introduction

Encounter provisions, including the move-on rule, currently in force are given in Annex 4 of the *consolidated text of all NEAFC recommendations on regulating bottom fishing.* These apply in both 'existing fishing areas' and 'new fishing areas'. These subareas of the NEAFC regulatory area are defined by a procedure described in Article 3 of those recommendations. The encounter provisions are intended to limit accidental significant adverse impacts on VMEs in these subareas. It should be noted that the provisions inherently assume that a significant proportion of known and unknown VMEs have been protected by bottom fishing closures and other regulatory measures aimed to achieve sustainable bottom fisheries.

For 'existing fishing areas' the following regulations apply:

Vessels shall quantify catch of VME indicator species, i.e. coral and sponge

If the quantity of VME elements or indicator species caught in a fishing operation (such as trawl tow or set of a gillnet or longline) is beyond the threshold defined in paragraph 4 below, the following shall apply:

a) The vessel master shall report the incident to the flag state, which without delay shall forward the information to the Secretary. Contracting Parties may if they so wish require their vessels to also report the incident directly to the Secretary. The Secretary shall archive the information and report it to all Contracting Parties. The Contracting Parties shall immediately alert all fishing vessels flying their flag.

b) The vessel master shall cease fishing and move away at least 2 nautical miles from the position that the evidence suggests is closest to the exact encounter location. The master shall use his or her best judgment based on all available sources of information.

c) The Secretary shall make an annual report on single and multiple encounters in discrete areas within existing fishing areas to PECMAS. On the basis of an assessment by ICES, PECMAS shall evaluate on a case-by-case basis the information and provide advice to the Commission on whether a VME exists. The advice shall be based on annually updated assessments from ICES of the accumulated information on encounters and PECMAS's advice on the need for action, using FAO guidelines for management of deep-sea fisheries in the high seas as a basis.'

The Paragraph 4 referred to in Section 2.2 provides the threshold levels of corals and sponges, and these are discussed further under TOR e, i) of this report. This chapter focuses on that component of the regulation surrounding what action must be taken when a VME is encountered.

In 'new fishing areas' only exploratory fisheries are permitted (ref. Article 4 of the NEAFC recommendations), and such fisheries are regulated under the NEAFC Exploratory fishery protocol (Annex 1 of the recommendations). In 'new fishing areas ' similar encounter provisions, including the same move-on rule, as listed above apply. There is the additional condition that there is an observer requirement and that any encounter with VME indicators immediately leads to the introduction of a temporary closure around the reporting site. The full provision is given in the NEAFC recommendations (Annex 4, pt. 3).

Current experience with the NEAFC regulations is that <u>no</u> encounters have been reported (see TOR e, i.), hence the move-on rule has not been triggered and no temporary closures implemented. No applications for exploratory fisheries (in 'new fishing areas') were received. There is thus no experience with the currently adopted move-on rule; hence there is also a limited basis for discussing its appropriateness other than on the basis of theoretical considerations. In the context of this lack of information it is important to note that, while no encounters have been reported, the logbooks of fishing vessels may contain important information of the distribution of VMEs because bycatch of VME indicators at levels <u>below</u> the thresholds are also required to be recorded (although no action need be taken). To date WGDEC has not requested access to these logbook data, and hence not analysed the incidence or quantity of VME indicators in the relevant fisheries. These logbook records could be a valuable source of further data on the quantities and spatial distribution of VME indicators in normal fishing operations with bottom gears in the NEAFC regulatory areas. Such information could be used to estimate what an appropriate distance to move would in fact be. WGDEC therefore recommends that NEAFC consider if such information could be made available to ICES. Until such time that a quantitative analysis can be undertaken and provide a scientific basis for move-on distances, several theoretical factors should be considered in assessing how appropriate the move-on rule could be.

7.2.2 Appropriateness of the move-on rule in different habitats

The current NEAFC encounter protocol applies across all habitats in which bottom fishing takes place including continental slopes, mid-ocean ridges, seamounts and banks. WGDEC considers that the encounter protocols are likely to be most effective in habitat types comprising of gently sloping sedimentary substrate, e.g. continental slopes and areas such as the Hatton Bank western drift area, and least appropriate for hard, steep sided substrate habitats, e.g. seamounts. This is primarily because of the relatively small surface area of seamounts and the relatively high densities of VMEs found on them. On a seamount, moving a short distance is unlikely to result in lowering the probability of encountering another patch of VME, unless it means moving off the seamount itself. Furthermore fishing operations vary significantly from seamount habitats to sedimentary deep-water habitats. Shorter trawl tows tend to be used in steep slope and seamount areas. In very rugged terrain longlines may also be modified to prevent snagging, e.g. by suspending a free-floating line to a single anchor. In some seamount fisheries longlines set at the bottom are suspended by floats between anchors and only the anchors touch the bottom (Hareide *et al*., 2001). But in others, the bottom longlines used normally have a stone/float configuration, and different elements of the gear can touch the seabed (Simpatico *et al*., 2012). Consequently WGDEC considers the current move-on rule to be inappropriate for seamounts and an alternative management option to the move-on rule is suggested in ToR E (iii). What follows is therefore considered to apply to sedimentary deep-water habitats.

7.2.3 Appropriateness of the move-on rule for different fishing gear types

The move-on protocol does not differentiate between gear types, and current rules were primarily designed with a view to prevent adverse impacts from traditional bottom trawling. Bottom contact gear types currently in use in the NEAFC regulatory area include bottom trawl and longline. Bottom gillnet fishing may also be prosecuted, but since NEAFC has prohibited gillnetting deeper than 200 m, the fishable area is now a very small fraction of the NEAFC regulatory area and by definition not a deep-water problem. Furthermore as WGDEC is not aware of any bottom gillnet fishing currently occurring, it is not considered further. Bottom trawling and longlining, however, do differ significantly in their potential impacts on various VME indicator taxa. While trawl and longlines are usually set in roughly linear formations, longline sets are generally shorter in distance (less than 5 nm/9 km) than trawl tows, that are routinely longer than 10 nm (18.5 km), but do not often exceed 20 nm (37 km).

The move-on rule requires an assessment of the most likely geographical position of the encounter with VME indicators. Currently the rule requires the vessel to move away at least two miles from this position in a direction least likely to result in a new encounter. The NEAFC regulations leave the responsibility for a posterior positioning of a VME encounter to the skipper's best judgement. Unless there were clear indications during the fishing operations of the position at which an encounter occurred, for example, the gear holding fast on the seabed, this judgement will have to be based on experience from previous fishing in this and other grounds and whatever information was available to the skipper during the operation, for example echosounder trace, winch tension readings, gear geometry data and previous plotter data. It is likely that situations will occur in which the judgement results in the simple assessment that the encounter happened somewhere along (or near) the line between start and endpoints of the tow or set. This distance which will normally be spatially more constrained with shorter longline sets than with longer trawl tows. It is however recognised that longlines can drift at right angles to the set direction and hence there is still some crosswise spatial uncertainty. Nonetheless, this crosswise uncertainty would not exceed the length of the longline (or trawl) set itself. Thus positioning based on best judgement is difficult with both longlines and trawls, and precision in the positioning is likely to be relatively low. The uncertainty could be reduced by undertaking shorter trawl tows and longline sets. This variability in precision suggests that move-on distances may be more appropriate if they are shorter for longline operations than with long trawl tows.

7.2.4 An alternative move-on rule for longline vessels

For longline fisheries NEAFC may wish to consider introducing an approach similar to that adopted by CCAMLR as an alternative to the current provisions. In the CCAMLR protocol larger and smaller encounters with VME indicator taxa are recognised at least ten or five "VME indicator units" respectively. Specifically a VME indicator unit means either one litre of those VME indicator organisms that can be placed in a 10-litre container, or one kilogramme of those VME indicator organisms that do not fit into a 10-litre container. In either case, a "Risk Area" is determined as a 1 nautical mile circle from the midpoint of the affected longline *segment* (which is 0.65 nautical miles in length). If a larger VME encounter occurs, the vessel shall not to set any further lines intersecting with the Risk Area and it shall immediately communicate to the CCAMLR Secretariat and to its Flag State the location of the midpoint of the line segment from which those VME indicator units were recovered along with the number of VME indicator units recovered. The CCAMLR Secretariat will then, within one working day of receipt, notify all fishing vessels in the relevant fishery and their Flag States that the Risk Area is closed; and all vessels shall immediately cease setting any further lines intersecting with the Risk Area. If a smaller VME encounter occurs, it must be reported, but fishing may continue. Upon receipt of five or more such smaller reports, the CCAMLR Secretariat shall notify all fishing vessels in the relevant fishery and their Flag States of the coordinates of the fine-scale rectangle, indicating that VMEs may occur within that area. Although more managerially complex than the current NEAFC move-on rule, the CCAMLR approach is more precautionary.

7.2.5 Appropriateness of the move-on rule in existing and new fishing areas

In existing fishing areas, it is reasonable to assume that there is less likelihood of encountering a VME by moving away from the encounter position than towards it. This is because the density of VMEs is assumed to be sparse especially in heavily fished areas where VMEs will have been reduced in size and fragmented by previous fishing activities. Moreover, given the uncertainties associated with where encounters occur, it is reasonable that this spatial uncertainty will exceed the size of most (if not all) remnant VMEs in existing fishing areas. As a proxy for the unknown size of the encountered VME, the move-on distance in existing fishing areas can be estimated by using the spatial uncertainty of the encounter. The spatial uncertainty should not exceed the length of the trawl tow or longline set. For simplicity, this could be generalized to the mean trawl tow and longline set lengths, as the case may be. Until such data are made available for the various fishing areas of the NEAFC regulatory area, relevant revisions on move-on distance cannot however confidently be made on this basis.

In the heavily fished/existing fishing areas the current distance of at least 2 nautical miles may be as good as any other. However, it should be emphasised that in some fishing areas, significantly longer distances may have to be moved if there is no fundamental change in habitat type. Rather than moving a certain fixed distance, moving away from structures such as bed-rock outcrops, mounds or particular depth strata likely to have VME indicators is essential. In addition, moving toward or into the most favoured or traditional fishing areas would usually be advisable. The opposite, i.e. moving into marginal or locally less fished subareas where unmapped VMEs are more likely to occur would be far less precautionary. In most 'existing fishing areas' steadily improving information on already mapped or recorded features, as well as historical encounter locations, should be made readily available to vessels and feature on their chart plotters (see TOR e, iii). The latter would reduce the dependence on skipper's best judgement for taking appropriate action in terms of move-on distances and directions.

In new fishing areas, the risk of accidentally hitting large and perhaps pristine VMEs will almost certainly be higher than in existing fishing areas that presumably were fished more extensively both currently and in the past. One important consequence of entering an area of high VME patch density is that there is a possibility that the current move-on rule could lead to increasing rather than decreasing the likelihood of significant adverse impacts. It may thus not be sufficiently precautionary to have the same move-on distances in new and existing areas and particular precaution is recommended in the implementation of encounter protocols in new fishing areas. Only through accurate survey information can such likelihoods be estimated in new fishing areas. As mentioned before, it may be that in new fishing areas moving off or away from a readily identified geo-morphological feature (such as distinctive outcrops, banks, ridges or seamounts) may be a more effective means of avoiding further impacts on VME communities.

While WGDEC recognises a probable value of differentiating the minimum set move-on distance between new and existing fishing areas, there is currently no scientific basis for selecting exact different distances. Considering the current situation where no exploratory fishing is occurring or imminent, there does not appear to be an urgent need for revising the move-on-rule in this respect. However, there is greater need to focus on existing fishing areas and carry out analyses of information on encounters in such areas, both encounters that do and do not trigger the move-on rule.

7.2.6 General considerations for modifying the current move-on rule or developing an alternative

Regardless of gear type and fishing procedure, the current NEAFC regulation requires vessels to cease fishing and move away at least 2 nautical miles from the likely encounter position. This rule applies in both existing and new fishing areas. The ideal move-on rule would take into account the spatial size and shape of the VME encountered, VME patchiness, and the level of precision of encounter location positioning. The theoretical move-on distance should at least be equal to the longest dimension of the VME feature plus the spatial uncertainty of the reported encounter. The biggest hindrance to progress is the lack of information on the size, shape and patchiness of most VMEs within the NEAFC regulatory area.

7.2.7 References

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7.3 Alternatives to thresholds and move-on-rules

Inform on alternative or additional measures to the currently adopted encounter thresholds and move-on-rule, especially technical measures that may reduce the risk of encounters with VME indicators.

7.3.1 Introduction

Thresholds and move-on-rules, modified to become more effective in achieving management objectives and data acquisition, will most likely have to be maintained. The current measures, while appropriate for some existing fishing areas that exploit generally sedimentary seabed habitats, are however considered inappropriate for fisheries operating in rugged terrain where the densities and distribution patterns of VME indicators are poorly known. Such areas include seamount summits and edges, canyons, and rocky outcrops. In such areas bottom trawling is characterised by short tows with limited but still potentially damaging bottom contact. Longlining is conducted in all such habitats. Bottom trawling and longlining, however, do differ significantly in their potential impacts on various VME indicator taxa (Durán Muñoz *et al.*, 2011, 2012).Additional measures should facilitate enhanced precision in the recording of encounters and/or reduce the likelihood of encounters. This is especially important in exploratory fisheries in 'new fishing areas' but remains relevant in 'existing fishing areas'. Lessening the risk of significant adverse impact can be achieved either by the use of fishing gear that reduces the extent of bottom contact, or by restricting the use of bottom-contact gears in certain areas where the likelihood of encounters is high. In the NEAFC regulatory area, fisheries are conducted mainly by trawls and longlines, and it is important to try to reduce bottom contact in both these gear types.

7.3.2 Technical measures to minimise gear impact

Closely monitored fishing with trawls towed just above the seabed is technologically feasible. Such bathypelagic trawling was for example used extensively when trawling for round nose grenadier on the mid-Atlantic Ridge. This kind of fishing should be encouraged as an alternative to traditional bottom trawling whenever feasible. While accidental bottom contact is probably unavoidable in such fisheries, the overall impact is probably significantly reduced compared with traditional bottom trawling. Other efforts that may reduce bottom contact would be developing alternative or lighter groundgear to the rock-hopper and bobbins typically used. There may also be potential to design trawl doors/otter boards that have a reduced bottom contact or have a lower impact. Reduction of sweep length (wire between trawl doors and net) may also be a means of lessening the area impacted by the gear. WGDEC suggests that the question would benefit from consideration by the ICES Working Group of Fishing Technology and Fish Behaviour (WGFTFB).

While the impacts on VMEs from longline fishing are considered minor compared with that from traditional bottom trawling, longlines also have bycatch of VME indicators that can be cumulatively significant (e.g. Mortensen *et al.*, 2008; Durán Muñoz *et al.*, 2011). With current threshold levels, these bycatches will rarely trigger the NEAFC encounter rules. Nonetheless effort should be made to reduce bycatches. A technological alternative is to deploy vertically suspended longlines that are attached to the seabed with a single anchor. This was used successfully in fishing for demurral fish in rugged terrain on the mid-Atlantic Ridge (e.g. Hareide and Garnets, 2001). Vertical longlines are expected to have significantly less bycatch of VME indicators than bottom-set longlines.

Every effort should be made to avoid fishing with bottom-touching trawls or bottom-set longlines in areas where there is a high likelihood of encountering VME indicators. Such 'high-risk' areas include those in which VMEs are likely to occur but where documentation by relevant observation techniques is lacking, hence they were not proposed as bottom fishing closures. Even in poorly mapped areas guidance on habitats and geomorphologic features that are likely to have VME indicators should be taken into account. Such areas might be mapped and made available to vessels engaging in established and exploratory fisheries. It is possible to offer relevant guidance based on general scientific knowledge and e.g. habitat suitability models (ToR e IV). Provision of such data would be in line with Article 5.1 of the 'NEAFC recommendations on regulating bottom fishing'.

7.3.3 High-tech monitoring and mapping

Most vessels engaging in high seas fisheries are technologically advanced, and as the number of vessels is declining, the additional cost and effort incurred by new measures may not be prohibitive. It is feasible to keep electronic records of bottom contact and exact tracks of individual tows. All vessels currently use advanced echosounders (and sometimes multibeam), gear geometry monitoring equipment, and advanced chart plotting software. This might be implemented as an additional requirement, at least in exploratory and seamount fisheries, in addition to the established requirement for VMS and logbook recording. It is also suggested that the feasibility of using headline cameras to monitor tows should be explored. This would facilitate documentation of occurrence of VME indicators at a relevant spatial scale and document whether or not adverse impacts are occurring. Visual documentation would furthermore enhance the precision of the recording of encounter sites should an encounter result from the tow. Videos from individual tows and plotter tracks submitted together with catch and bycatch information would facilitate subsequent analyses of VME indicator records and assessments of whether or not a VME was encountered. Taken together such information would provide strong evidence as to whether the fishery is having any significantly adverse impacts on VMEs.

In exploratory fisheries (in new fishing areas where observers are required) it is recommended to introduce pre-fishing mapping (ideally multibeam) as a requirement before the gear is deployed. Most vessels will carry out such mapping as a precaution anyway. In the event that such mapping reveals habitats or features likely to be inhabited by VME indicators fishing should not commence and the vessel should explore other areas. That such mapping was carried out should be recorded in observer reports. NEAFC may consider introducing some or all of these requirements in its 'Exploratory Bottom Fishing Protocol for New Bottom Fishing areas' and the 'VME Data Collection Protocol'. NEAFC might furthermore consider the utility of requiring a more extensive impact assessment requirement such as introduced in NAFO.

Extensive mapping of fishing areas and associated VMEs have been conducted in recent years, not only in the NEAFC regulatory areas (Duran Muñoz *et al*., 2012) but in several other high seas areas (e.g. Duran Muñoz *et al*., 2011). Such surveys using multibeam acoustics and ground-trusting by video recording and sampling can map large areas efficiently and provide detailed information of occurrence, densities and distribution patterns of VME indicators allowing for a much stronger spatial management strategy.

In 'existing fishing areas', an extensive mapping programme of the seabed (multibeam, dredges, boxcorer, trawls, ground thru thing, etc.) in relation to the fishery footprint, can be an effective method to avoid significant impacts of the bottom fisheries on the VMEs (Durán Muñoz *et al*., 2012). A good knowledge of the distribution of the seabed features and mega habitats (sedimentary drifts, rocky outcrops, ridges, canyons, etc.) in the fishing grounds may result in introduction of spatial management regimes that are more satisfactory than the current move-on rule schemes. In such 'existing fishing areas ', seabed mapping can be an alternative management option (see ToR E (iii))".

For those areas that have already been extensively mapped, it is strongly advised that data from such mostly national efforts are made available to vessels from all contracting parties. Mapping efforts may result in introduction of spatial management regimes that are more satisfactory than the current schemes that to a high degree reflects the current lack of exact spatial information. An example is the scheme introduced based on mapping efforts on the Patagonian Shelf (Portola *et al*., 2012). The 'existing fishing areas' where current fisheries are most likely to be carried out are relatively small and should be given priority in future mapping efforts. Enhanced mapping would be beneficial to fisheries and inform science, thus reduce impacts on VMEs and enhance the precision of future management advice.

7.3.4 An alternative management option for seamount fisheries

All seamount fisheries should be prepared to prove that their operations are not causing significant adverse impacts on VMEs through high-technology solutions to habitat mapping and fishery monitoring. Evidence needs to be provided that;

1) current fishing practices are focused within existing trawled areas (based on logbooks , fishing tracks, etc.);
2) that these areas are precisely mapped (sonar/multibeam data) at a fine spatial resolution;
3) that these areas do not contain VMEs (net-mounted camera evidence)
4) that the vessels have the technology and experience to keep their fishery precisely within the existing fishery footprint (gear monitoring sensors, skipper's experience).

There may still be an outside chance that a VME encounter will happen in such circumstance for reasons of poor weather or unexpected tidal currents that cause the gear or vessel to stray out of the local footprint. If this happens the fishing operation can no longer be assumed not to pose significant risk to VMEs. There may be no alternative but for that vessel to move off that seamount and a temporary closure be enforced.

7.3.5 References

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Mortensen, P.B., Buhl-Mortensen, L., Gebruk, A.V. and E.M. Krylova. 2008. Occurrence of deep-water corals on the Mid-Atlantic Ridge based on MAR-ECO data. Deep-Sea Research II, 55: 142–152.

Portela, J., Acosta, J., Javier Cristobo, J., Muñoz, A., Parra, S., Ibarrola, T., Del Río, J.L., Vilela, R., Ríos, P., Blanco, R., Almón, B., Tel, E., Besada, V., Viñas, L., Polonio, V., Barba, M., and Marín, P. 2012. Management Strategies to Limit the Impact of Bottom Trawling on VMEs in the High Seas of the SW Atlantic. In Marine Ecosystems. Ed by A. Cruzado. ISBN: 978-953-51-0176-5.

7.4 Identifying vulnerable marine ecosystems

Using the best available scientific information including bio-geographic information, to identify in the NEAFC Regulatory Area:

1) Areas where VMEs do not occur;

2) Areas where VMEs are not likely to occur;

3) Areas where VMEs are likely to occur;

4) Areas where VMEs are known to occur.

7.4.1 Introduction

To date the majority of VMEs are considered to be patchily distributed, i.e. aggregated in space. This is because VMEs tend to be found in association with particular physical, environmental and hydrographical conditions and geological or topographic features. This is likely to apply to VMEs such as cold-water coral reefs, deep-sea sponge aggregations and hydrothermal vents. Conditions will however vary regionally, for example, in the Rockall Bank area no *Lophelia pertusa* have been recorded at depths shallower than 200 m which probably reflects thermal conditions, whereas in the colder Norwegian Sea areas *Lophelia pertusa* reefs are found as shallow as 40 m. Thus there are large areas of seabed that do not qualify as VMEs. Not all VME indicator species, however, are patchily distributed; some such as black corals (Antipatharians) may be sparsely and relatively evenly distributed. These species pose particular problems for mapping and predicting the likelihood of occurrence.

7.4.2 Variable certainty of different information sources

Information on the presence and absence of VMEs derives from a number of sources including visual surveys, trawl bycatch, fishing effort analyses, geo-physical surveys and predictive habitat models. Each of these data sources has its strengths and weaknesses in addressing these questions. It is important to appreciate both the degree of certainty that can be ascribed to each information source and the appropriate geographical scale that the information is most meaningful to managers (Figure 18).

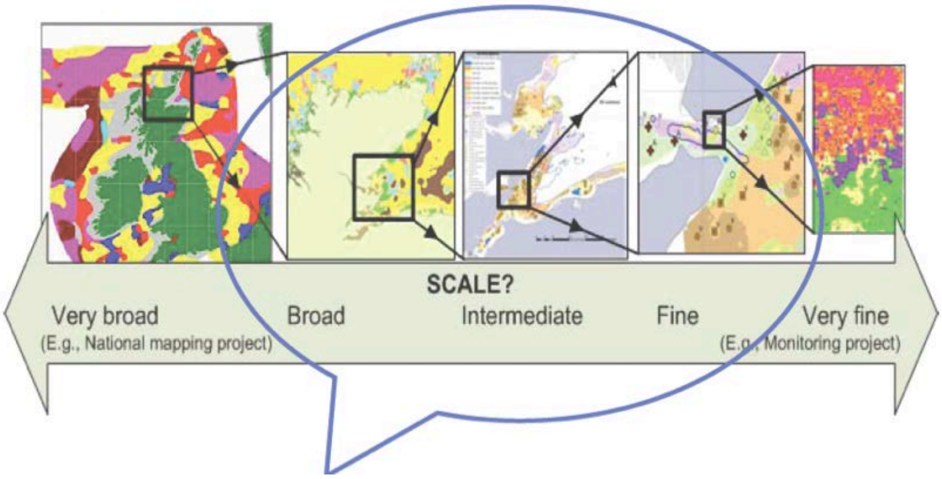

Figure 18. Schematic illustration of the purpose and scales of habitat maps. Broadscale habitat prediction and mapping is helpful for determining biogeographic distribution patterns, whereas fine scale modelling is needed if regional or local spatial management is to be effective.

7.4.3 Visual surveys

Visual surveys (drop camera, ROV observation, submersible, towed camera) are the most reliable source of information for the absence of VMEs, although the areal coverage in such surveys tends to be small. It follows that such information can be very useful at small spatial scales, for example in delimiting boundary closures, but on its own is not very helpful for determining broad areas where the presence of VMEs can be ruled out. If large areas can be covered, for example, by using towed video cameras, a survey design may be possible in which interpolation across broader areas becomes possible.

7.4.4 Trawl bycatch

Trawl bycatch data are a less reliable source of absence data due to the fact that trawls are designed to catch fish not fragile, benthic organisms. The retention of VME indicator species in trawlnets is poorly understood and there is some good evidence that benthos can be impacted by the groundgear, but never actually enter the net. Nevertheless a large number of tows in the same area that have zero bycatch can be taken as evidence of absence. Such data are available for some areas such as the Hatton drift area, the Rockall Bank and the continental slopes.

7.4.5 Fishing effort analyses

Analyses of fishing effort can be used an indirect method to infer the likelihood of absence of VMEs. If an area has been systematically trawled for many years it may be fairly safe to assume that either no VMEs were ever present, or that if they were present they have by now been destroyed. However, this cannot be taken as certain, unless the data are resolved to a geographical scale fine enough to assess precisely whether enough ground was left unimpacted to allow some remnants of VME to persist. On the Rockall Bank for example, information on a thin strip of coral reef has been provided by fishermen (WGDEC 2011, ToR a). This strip which may be no more than 500 m wide, but is in the region of 10 km long, is avoided by fishermen. At a crude level of aggregation of fishing effort, it is not evident, but on a tow-by-tow basis is quite obvious. This reinforces the need for tow-by-tow data to be made available in the assessment of VME absence.

7.4.6 Geophysical and acoustic surveys

Geophysical surveys, such as sidescan sonar and backscatter analysis can potentially identify areas of VMEs at very fine scales as well as indicate where VMEs do not occur (Durán Muñoz *et al*., 2009). For example, consistently uninterrupted rippled sand (so far not considered to support any type of VMEs) can be detected by such methodology which contrasts strongly with rock outcrops, biogenic reefs and soft mud. Such information again tends to be on small geographic scales and while of use in delimiting local closure boundaries cannot give broadscale definition of areas where VMEs do not occur. Such information is also only able to detect the presence of VMEs that sit well proud of seabed, such as *Lophelia* colonies, possibly large sponges, but is unlikely to be able to detect VMEs such as soft-bottom coral gardens.

Multibeam echosounder data are a rich source of information for seabed morphology, habitat mapping and classification. Seabed morphology has been shown to play a crucial role in the distribution of benthic biota in recent years (Wilson *et al*., 2007; Dolan *et al*., 2008; Guinan *et al*., 2009a; Guinan *et al*., 2009b; Holmes *et al*., 2008; Kostylev *et al*., 2001; Lundblad *et al*., 2006; Verfaillie *et al*., 2008; Rengstorf *et al*., 2012).

7.4.7 Predictive habitat models

Predictive habitat model or habitat suitability models (HSM's) have become an important new source of information in the debate over VMEs. It is often not intuitive what information is input into these models and at what geographical scales outputs can be expected to be useful. Rengstorf *et al*., 2012 have undertaken an in-depth review of these models and the state-of-the-art. The first attempts to develop habitat suitability models for VMEs were based on coarse scale topographic data (see Table 1: from Rengstorf *et al*., 2012 summarizing the range of published cold-water coral habitat suitability models (HSMs) developed at different spatial scales and using different modelling techniques). The dominant environmental factors for coral growth vary over scales of investigation. In global HSMs for example, cold-water coral distribution is determined by the availability of suitable temperatures, oxygen and aragonite saturation state, as well as enhanced surface productivity. At the global scale they were useful in identifying the broad ocean basin scale areas where different types of VMEs were likely to be found. However, they were unable to discern fine scale features like small mounds, iceberg plough marks, small scours which are associated with presence of some of these VMEs. This is a critical shortfall because such fine scale features when occurring in sufficient density combine to emerge at the regional scale and may be those areas of greatest habitat significance.

	Target Taxon	Predictive Model	Environmental Data	Cell Size	Source
GLOBAL	Cold-water corals on Seamounts	ENFA	Alkalinity; Aragonite saturation state; Bathymetry; Current velocity; Dissolved inorganic carbon; Dissolved oxygen; Export primary Productivity; Productivity; Salinity; Seamount location; Temperature; % oxygen saturation	1°	Clark *et al.*, 2006
	Scleractinian corals (*Lophelia pertusa*)	ENFA	Alkalinity; Aragonita saturation state; Bathymetry; Aspect; Dissolved inorganic carbon; Dissolved oxygen; Hydrocarbon seeps/Pockmarks; Nitrate; Phosphate; Productivity; Salinity; Silicate; Slope; Temperature	1°	Davies *et al.*, 2008
	Sclerectinian corals on seamounts	ENFA; MAXENT	Alcalinity; Aragonite saturation state; Bathymetry; Current velocity; Dissolved inorganic carbon; Dissolved oxygen; Export primary productivity; Nitrate; Phosphate; Productivity; Salinity; Seamount location; Silicate; Temperature; % oxygen saturation	1°	Tittensor *et al.*, 2009
	Sclerectinian corals	MAXENT	Alkalinity; Apparent oxygen utilisation; Aragonite; Bathymetry; BPI; Calcite; Carbonate ion concentration; Current velocity; Dissolved inorganic carbon; Dissolved oxygen; Eastness /Northness; Nitrate; pH; Phosphate; Productivity; Salinity; Silicate; Slope; Rugosity; Temperature; Vertical flow; % oxygen saturation	0.0083°	Guinotte *et al.*, 2009
REGIONAL	Gorgonian corals (*Paragorgia arbore, Orimnoa resedaeformis*)	ENFA	Bathymetry; Current speed; Productivity; Slope; Substrate; Temperature	9km	Leverette and Metaxas, 2005
	Gorgonian corals (Paragorgiidae, Primnoidae)	ENFA	Bathymetry; Current velocity; Productivity; Slope; Temperature	a) 0.03° b) 0.08°	Bryan and Metaxas, 2007
	Scleractinian corals (*Lophelia pertusa*)	ENFA; GARP	Aspect; BPI; Current velocity; Curvature; Rugosity; Salinity; Slope; Temperature	550m	Guinan *et al.*, 2008
	Scleractinian corals (*Lophelia pertusa*)	ENFA	Aspect; Bathymetry; Current speed; Iceberg ploughmark areas; Productivity, Salinity, Slope, Temperature	0.25°	Davies *et al.*, 2008
	Cold-water corals	Logistic regression	Bathymetry, Rugosity, Slope	15-50m	Woodby *et al.*, 2009
LOCAL	Scleractinian corals (*Lophelia pertusa*)	ENFA; GARP	Aspect; BPI; Current velocity; Curvature; Rugosity; Salinity; Slope; Temperature	30m	Guinan *et al.*, 2008
	Scleractinian corals (*Lophelia pertusa*)	ENFA	Aspect; BPI; Curvature; Fractal Dimension; Rugosity; Slope; TRI	0.5m	Dolan *et al.*, 2009

Table 15. Local, regional and global scale habitat suitability models for cold-water corals.

More recently, terrain attribute models have been developed at local geographical scales. Due to their scale dependent nature, a realistic representation of terrain attributes is crucial to the development of reliable habitat suitability models (Rengstorf *et al*., 2012). In regional and local HSMs, bathymetric terrain index (BPI) have shown good potential as environmental predictors as they act as proxies indicating areas of enhanced currents and food supply for the filter-feeding corals. The summary of HSMs in Table 1 further demonstrates the frequently encountered trade-off between spatial (cell size) and thematic (range of environmental variables) resolution. For example, a 1x1 minute temperature grid was shown to be too coarse to accurately resolve rapid changes in water temperature, leading to a mismatch between coral occurrences and temperature values beyond the species' thermal tolerance limit. A precise spatial matching between presence data and environmental variables is necessary in order to avoid an artificial expansion of the species niche width, especially when modelling the distribution of sessile organisms (Guisan and Thuiller, 2005). The global 1x1 minute resolution GEBCO grid for example proved to be too coarse to resolve many of the ocean's seamounts, which are known to be ecologically important biodiversity hot spots (Davies *et al*., 2008; Clark *et al*., 2006). By employing the GEBCO bathymetry with a 30 arc-second resolution, Guinotte *et al*. (2009) significantly improved the terrain detail in their global model, revealing suitable coral habitat on thousands of previously undetected seamounts.

In Irish waters, cold-water corals such as *Lophelia pertusa* and *Madrepora occulata* are often associated with areas of raised topography known as carbonate mounds. These are discrete morphological features of varying shape with heights ranging from tens to hundreds of metres. In their study, Rengstorf *et al*. (2012) investigated the effect of initial bathymetric grid resolution in the production of terrain attribute maps for carbonate mound areas on the Irish continental margin. The Irish National Seabed Survey bathymetric dataset was re-gridded at a grain size of 50 m x 50 m, to provide a high resolution benchmark to measure the quality of terrain attributes derived from coarser resolutions. A grain size of 1000 m x 1000 was chosen to be the upper limit of investigation, as it roughly corresponds to the 30 arc-second GEBCO grid (GEBCO 2009) used in the Guinotte *et al*. (2009) global model. The effects of terrain attribute resolution on the applicability of HSM were explored by means of preliminary "terrain suitability models" (i.e. habitat suitability models based on terrain parameters only) for cold-water corals.

The generated terrain attribute maps varied considerably with resolution and terrain information content. Even though dominant features were roughly preserved over a range of resolutions, terrain detail and smaller features were gradually lost with increasing cell size. For example steep slopes were not resolved at coarse resolutions as they were increasingly aggregated with the adjacent valley bottom. Smaller features such as sediment waves entirely dissolved with coarsening resolution.

Habitat suitability modelling was carried out using MAXENT (Phillips *et al*., 2006). This modelling software estimates the distribution of a certain species by relating known species occurrences with a series of environmental variables via a machine learning maximum entropy algorithm. It provides a user-friendly interface and has shown good performance in recent comparative modelling studies. MAXENT produces logistically scaled habitat suitability maps for each study area, with each pixel estimating the probability of species presence. Values close to zero indicate low probability, values close to one suggest high probability of species presence. Preliminary terrain suitability maps produced by MAXENT clearly reflect that high resolution initial bathymetry successfully identifying areas of small-scale terrain complexity as suitable coral habitat whereas coarser bathymetry (equivalent to 30 arc-second GEBCO) did not.

The Rengstorf *et al*., 2012 study clearly demonstrates that habitat suitability models based on terrain parameters derived from high resolution multibeam generated bathymetry are required to detect many of the topographical features found in Irish waters that are associated with coral. This has implications for the use of HSM models to predict the distribution of vulnerable marine ecosystems (VMEs). Effectively, global and regional HSM generated using terrain parameters derived from 30 arc-second GEBCO are adequate to provide broad scale indications of the likely occurrence of VMEs but likely overpredict the occurrence of VMEs. For the most accurate prediction of VME spatial occurrence, high resolution local scale HSM are required. Understanding the underlying resolution of parameters used in the construction of models is therefore essential in determining the purpose for which maps can be used by managers/industry.

We now consider how each of these sources of information can in combination inform the 4 questions posed in the ToR for the NEAFC RA and give a summary of case studies of two accepted VMEs (*Lophelia pertusa* reefs and *Pheronemia* deep-sea sponge aggregations).

7.4.8 Areas where VMEs do not occur

Observational records of no VME are available for some areas, for example there are camera observations where no coral has been observed over large tracts of the Rockall Bank (Figure 19). This indicates the highly patchy distribution of *Lophelia pertusa* reefs. Geophysical surveys that use technology such as multibeam or sidescan sonar on automated submersibles can identify local areas that do not contain certain types of VMEs such as *Lophelia pertusa* reefs. They cannot however be expected to identify all types of VMEs, e.g. coral gardens. Although there is multibeam data for some NEAFC areas, it is not of sufficient spatial resolution to provide conclusive evidence of a lack of VMEs. Trawl bycatch date as noted above cannot be considered to give an absolute assurance of absence of VME. It is therefore not considered further in this section. Predictive habitat modelling as discussed above (e.g. Davies *et al*., 2011; Yesson *et al*., 2012; Howell and Ross, in prep.) can potentially identify areas where VMEs do not occur, but cannot by their probabilistic nature give a 100 % assurance of absence of VME. Such models tend to be better at predicting where VMEs are not, than where they are, without further ground-truthing. However the new generation of terrain based habitat models appear to be able to resolve habitat suitable at a geographical scale that will be especially useful to managing fisheries better with respect to lessening the impact on VMEs. In sum we do have unequivocal evidence for areas of the seabed where no VMEs are present, but these areas tend be rather small in area due to the limitations of surveying the deep sea.

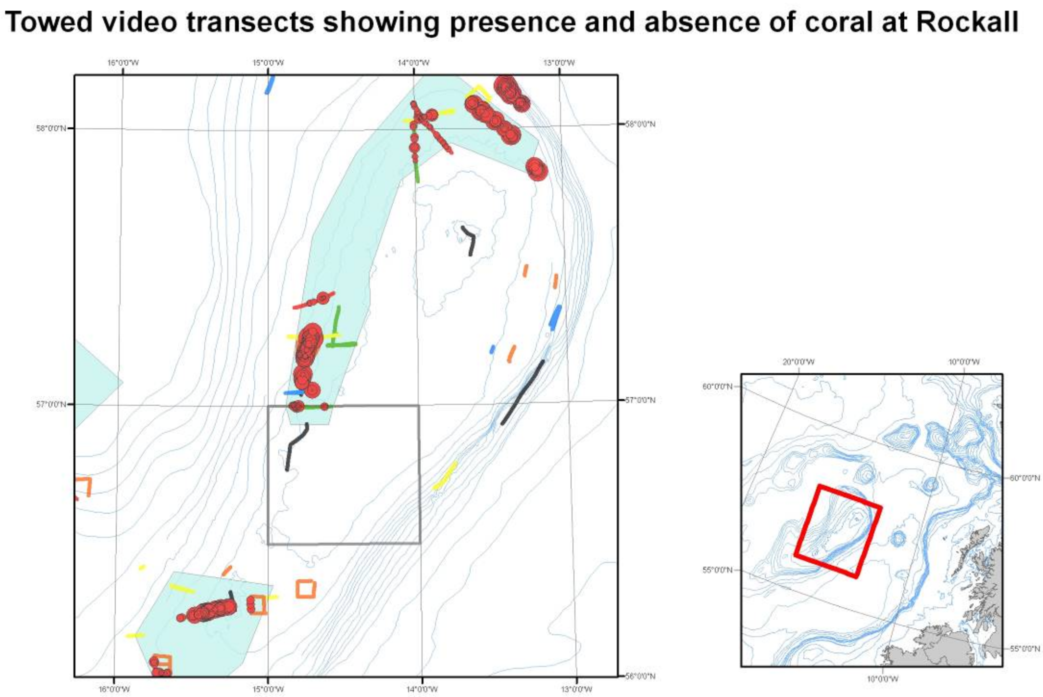

Figure 19. Map showing video transects undertaken by Marine Scotland on Rockall Bank. Each coloured line is one transect with red dots indicating coral. Where no dots are indicated, coral is known to be absent. The transects indicate a clear areas in the northwest and southwest of the bank where coral is present and other sections of the bank where no coral has ever been recorded. For reference the NEAFC closures are shown.

7.4.9 Areas where VMEs are unlikely to occur

Output from HSM (e.g. Davies *et al*., 2011; Yesson *et al*., 2012; Howell and Ross, in prep.) is useful to address this because the outputs of such models give a high degree of certainty where corals do not occur. In addition, trawl bycatch data can be used to indicate potential absence of VMEs. However, trawl 'absence' data should be used in conjunction with other sources of information. Analysis of fishing effort patterns can also be informative in this context. If an area has been consistently trawled for many years, there is strong likelihood that that area does not contain any VME species. The historical context of fisheries and whether such areas did once contain VMEs is also important to try to ascertain. In combination these data sources can be used to infer where VMEs are unlikely to be found. *Lophelia pertusa* reef habitat is unlikely to occur above 200 m depth in the Rockall-Hatton area. It is also unlikely to occur on the deep (>1500 m) sedimentary plains of Rockall Hatton Basin or the sedimentary Hatton drift area (>1000 m). *Pheronema carpenteri* sponge aggregations are not likely to occur within the Rockall-Hatton area at depths shallower than 1000 m or deeper than 2000 m. *Pheronema* aggregations are unlikely to occur on any of the summits of the banks and seamounts.

7.4.10 Areas where VMEs are likely to occur

Most of the records used in assessing the presence of VMEs are in fact records of species that may indicate the presence of a VME, not an actual observation of a VME. For example, a specimen of the gorgonian *Paramuricea biscaya*, does not necessarily correspond to the VME category 'coral gardens'. Thus most of the data used in scientific advice is actually most appropriately used to infer where VMEs are likely to occur. This applies always to trawl survey bycatch data and often to visual surveys of occasional observations of VME indicator species. It is also the most appropriate inference to be taken from published predictive habitat models. Such models tend toward overprediction, i.e. predict more suitable habitat than is observed. An important development however in habitat modelling is the high resolution terrain based model described above which show promise in giving much more realistic predictions at local and regional scales.

This report and past WGDEC reports show that *Lophelia pertusa* presence points, i.e. potential indicators of Lophelia reef, are located on Hatton Bank, Rockall Bank, the mid-Atlantic Ridge and a number of seamounts. For deep-sea sponges there are indications that that aggregations of *Pheronema carpenteri* may be common to the west of the Faroe Islands and south of Iceland at depths of between 800 and 1160 m (Burton, 1928; Copley *et al*., 1996). The distribution of this habitat is thought to be closely related to areas of internal wave formation at water mass boundaries and where the ray slope is exceeded by the slope of the seabed (Rice *et al*., 1990; White, 2003). In the Hatton-Rockall region this may occur over a very tight depth range focused around the 1300 m contour (Howell and Ross, in prep.). Ground-truthed *Pheronema carpenteri* aggregation presence points are found in Rockall-Hatton Basin and new data on sponges in this area are presented in the Hatton Bank section of ToR (a) in this report.

7.4.11 Areas where VMEs are known to occur

There are relatively few records of known occurrences of VMEs, relative to the amount of VME indicator species data. Only visual or geophysical surveys (and ideally a combination of the two) can unequivocally demonstrate the presence of a VME. *Lophelia pertusa* coral reef habitat (not just species occurrence) has been shown to occur on Rockall Bank (Figure 19) (see also Wilson *et al*., 1979; Mienis *et al*., 2006; Wienberg *et al*., 2008) and Hatton Bank. In addition to past WGDEC reports on occurrences Wheeler *et al*. (2007) and Roberts *et al*. (2009) reviewed known occurrences of cold-water coral carbonate mounds. Most proven sites of *Lophelia pertusa* reef in the NEAFC regulatory area are now closed to bottom fishing. Aggregations of the sponge *Pheronema carpenteri* have been reported from the Rockall-Hatton Basin at 1100 m (Durán Muñoz *et al*., 2012).

7.4.12 Conclusions

There is many data indicating the presence of VMEs throughout much of the existing fishing grounds of NEAFC. There are fewer data that provide unequivocal evidence for areas that contain VMEs, e.g. Rockall and Hatton Banks and the Mid-Atlantic Ridge. In such areas where there is strong evidence for the actual presence of VMEs in the NEAFC area, areas have been closed to bottom contact fishing. However not all potential VME areas in the NEAFC regulatory area are protected from bottom fishing and this will continue to be the case as new information comes to light and WGDEC will continue to advise on this. The amount of information needed to unequivocally demonstrate the presence of VMEs often requires multidisciplinary research with information from the following sources;, multibeam, side-scan, geo-physical analysis, boxcore sampling, visual surveys/ROV, habitat maps and predictive models with confidence limits.

To use HSM as a tool to support the delineation of boundaries of areas to protect VMEs from impacts by fishing, the models should be generated using terrain parameters derived from high resolution multibeam generated bathymetry. Given that multibeam data may often be collected by the fishing industry prior to fishing in areas of complex terrain, collection of some additional bottom tow video/photographs from such areas and sharing of the data could provide the basis for a successful collaboration with habitat suitability modellers. The resulting maps of topography and predicted occurrence of VMEs could facilitate pragmatic spatial zoning identifying safe areas for deployment of fishing gears and areas of VMEs to be avoided.

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8 NAFO guide for identification of corals and sponges

1) *Assess whether the NAFO coral and sponge guides are appropriate for use in the NEAFC area as onboard tools to identify and quantify VME indicator organisms as defined in the NEAFC bottom fishing regulations and,*

2) *Advise on species that should be added to the guide, and species that are superfluous.*

8.1 Introduction

Information on bycatch from commercial fishing vessels or research vessels represents an important source for gathering of distribution data for species that otherwise would require extensive funding to obtain. The results from various sources of bycatch information of course cannot replace dedicated scientific research but represent important background information in cases where other data are lacking.

The NAFO guides are intended for non-experts (fishers, fishery observers, scientific technicians and others who may not be familiar with identification of coral and sponges) to identify and record various species caught in fishing trawls. The results from identification from such bycatch material are meant to aid management and increase the information about coral distribution. The guides are meant to be simple to use, with photographs of caught specimens taken on the deck. This is thought to give the best picture of what is actually seen.

Whether the NAFO coral and sponge guides are appropriate for use in the NEAFC area as onboard tools to identify and quantify VME indicator organisms depends largely on how similar is the species composition of such organisms in these two areas. Hiscock, 1996 suggests six provinces within the economic zones of countries in the OSPAR area (Figure 20). How well these provinces are reflected in the deep sea is uncertain, but we here refer to these zones for when comparing faunas of different areas in the Northeast Atlantic. In this report we treat the requests separately for corals and sponges.

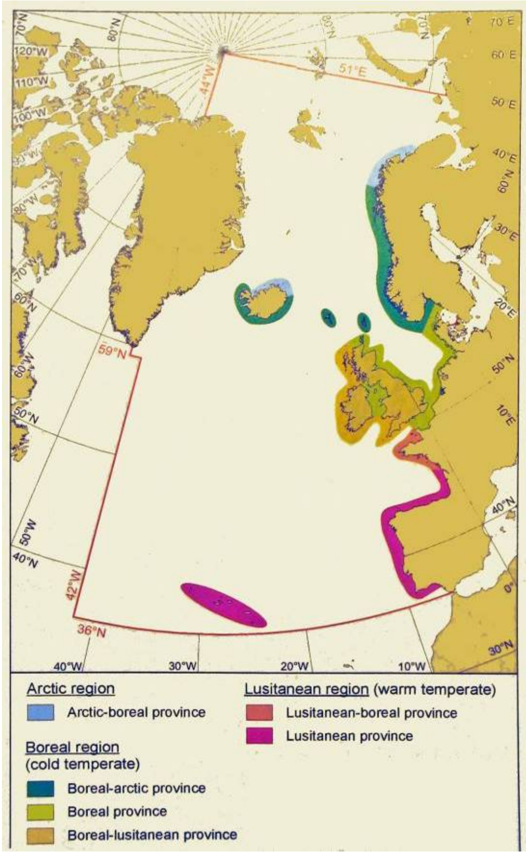

Figure 20. Biogeographic zones in the OSPAR area after Hiscock (1996).

8.2 The NAFO guide for identification of corals

How geographically specific is the coral fauna of the North Atlantic?

An overview of coral species occurring in seven areas (Norwegian Sea, Northeast Atlantic Banks, Mid-Atlantic Ridge, Atlantic Canada, Eastern USA, Iberian offshore areas, and the Azores) of the North Atlantic is provided in the Appendix. The area called Northeast Atlantic banks in this report includes banks and mounds in the Rockall/Hatton area from the Wyville Thomson Ridge in the north to the Porcupine Seabight in the south. The area called Iberian offshore includes the area from the Bay of Biscay in the north to Gulf of Cádiz in the south. From the available literature (Durán Muñoz *et al*., 2011, 2012; Molodtsova *et al*., 2008; Watling and Auster, 2005; Wareham and Edinger, 2007; Sampaio *et al*., 2012) and the Seamount online database (http://seamounts.sdsc.edu/) 170 species or taxa of corals were used for comparison of similarity between the areas. Fifty-two species are recorded from the Northeast Atlantic banks and 48 species from Atlantic Canada. The NAFO guide includes 25 species. Fourteen of these are also present on the Northeast Atlantic banks. Thirty-eight of the species from Northeast Atlantic banks are not included in the guide.

A useful means to assess similarity across regions is to use cluster analysis. WGDEC undertook such an analysis of the seven areas based on occurrence of corals and it is clear that the cluster patterns strongly reflect known general biogeographic patterns (Figure 2). Atlantic Canada and Eastern USA represent two areas with high similarity of coral species. The Azores and the Iberian offshore areas are grouped together and represent a biogeographic province very different from the rest.

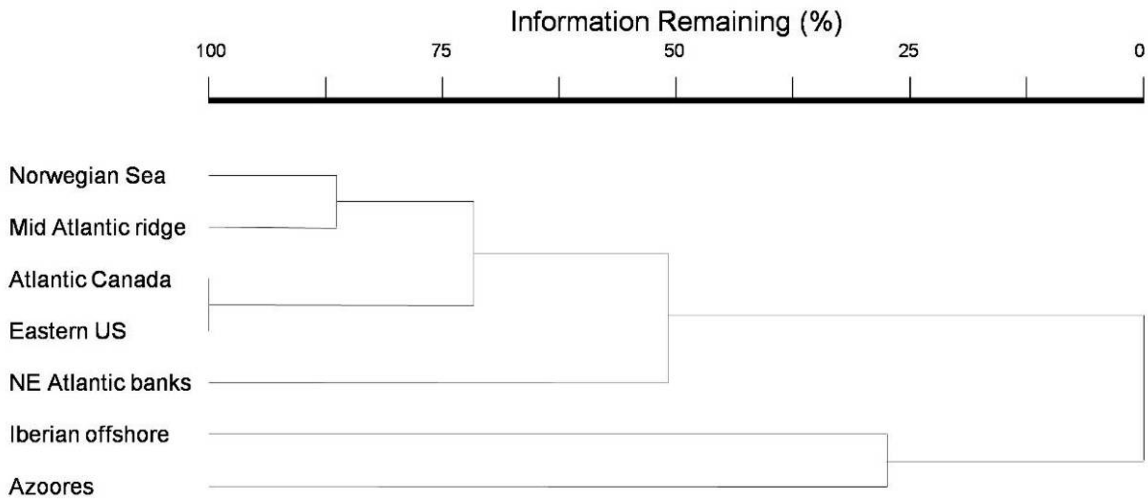

Figure 2. Cluster dendrogram of similarity (Bray–Curtis with group average linkage) of the areas based on presence of coral species.

What species should be added or removed from the NAFO guide in order to make it useful for the NEAFC area?

It is our opinion that a field identification guide for non-experts should not include all species that may occur, but focus on the most common and important species from a management point of view.

Table 16 lists 33 species or higher taxa suggested to be included in an identification guide for corals in the Rockall Plateau area. This selection is based on documented occurrences and those species are not too rare or difficult to identify. Thirteen of these species are also included in the NAFO guide. Ten of the species from the NAFO guide are not included in the suggested guide for the Rockall/Hatton area. This is based on lack of documented occurrences and also to make the guide useful in cases where similar species would make the guide difficult to use (e.g. the genera *Isidella* and *Acanella* would be hard to distinguish without examining morphological details).

Table 16. List of common species suggested being included in an identification guide for corals in the Rockall/Hatton area. * indicates species are currently included in the NAFO coral identification guide.

Order	Family	Species	Order	Family	Species
Alcyonacea			Antipatharia		
	Alcyoniidae			Antipathidae	
		Anthomastus sp.*			*Stichopathes* sp.
	Nephtheidae				*Tylopathes* sp.
		Drifa glomerata		Aphaniphacidae	
		*Duva florida**			*Phanopathes* sp.
		*Gersemia rubiformis**		Schizopathidae	
		Nephtheidae indet.*			*Parantipathes* sp.
Gorgonacea					*Bathypathes* sp.
	Acanthogorgiidae		Scleractinia		
		Acanthogorgia sp.		Caryophylliidae	
	Anthothelidae				*Caryophyllia* sp.
		Anthothela grandiflora			*Desmophyllum dianthus**
	Chrysogorgiidae				*Lophelia pertusa**
		Radicipes sp.			*Solenosmilia variabilis*
	Isididae				*Stephanocyathus* sp.
		Isididae indet.		Flabellidae	
		Keratoisis sp.			*Flabellum alabastrum**
	Paragorgiidae				*Flabellum* sp.
		*Paragorgia arborea**		Oculinidae	
	Plexauridae				*Madrepora oculata*
		Paramuricea sp.*			
		Swiftia sp.			
	Primnoidae				
		Callogorgia verticillata			
		*Primnoa resedaeformis**			
Pennatulacea					
	Anthoptilidae				
		Anthoptilidae indet.			
	Funiculinidae				
		*Funiculina quadrangularis**			
	Halipteridae				
		*Halipteris finmarchica**			
	Pennatulidae				
		Pennatula spp.			
	Umbellulidae				
		Umbellula sp.*			

8.3 The NAFO guide for identification of sponges

The sponge fauna of the NAFO region can be estimated to comprise less than 200 species, while that of the NEAFC region is more than 500 (van Soest, 1994; Tendal, own experience). The NAFO region is from a biogeographical point of view comparable to the northern part of the NEAFC region (north of 50°N), in which about 350 species of sponges have been found. That area is also where most sponge grounds have been located and investigated.

Table 1 lists the most important (as to number and biomass) species found on or near sponge grounds in the NW and NE Atlantic. Although there is a large overlap in the composition of the sponge faunas, the NAFO guide seems not immediately suited for use in the NEAFC area because of the fewer number of species. Extending the guide for use in both areas would make the work in the NAFO area much more complicated. So, if a sponge guide is intended for the NEAFC area it should be made separately and it should aim only at the northern section of the NEAFC regulatory area.

In both guides it should be considered to concentrate on species dominating the sponge grounds. That would make the work on deck easier and therefore more likely to be reported on. There would be a rest group called 'Other sponges' but that would in any case for non-specialists be nearly impossible to work through and describe. The NAFO sponge guide has only been available for a short time and therefore there is little experience of it and thus how useful it really is.

Table 17. Sponge species reaching 5 cm or more maximum dimension (except for species of *Hymedesmia* and calcareous sponges) regularly occurring on or near sponge grounds in the Northwest Atlantic, the Northeast Atlantic or both regions. Species dominating sponge grounds as to biomass (size, number and weight) are marked with an asterisk. Apart from the division into classes (Demospongiae, Calcarea, Hexactinellida) the grouping of species is according to body morphology as used in the NAFO Sponge Guide, making comparison easier. (Based on the NAFO Sponge Guide; Klitgaard *et al*., 1997; Klitgaard and Tendal, 2004; van Soest *et al*., 2007; Murillo *et al*., In press; Tendal, own observations).

Species	Author	NW only	NE only	Both
Solid/massive demosponges				
Biemna varianta	(Bowerbank, 1858)			x
Forcepia forcipis	(Bowerbank, 1866)		x	
Forcepia thielei	Lundbeck, 1905			x
Geodia atlantica *	(Stephens, 1914)		x	
Geodia barretti *	Bowerbank, 1858			x
Geodia Hentscheli *	Cardenas *et al*., 2010		x	
Geodia macandrewi *	Bowerbank, 1872			x
Geodia phlegraei *	(Sollas, 1886)			x
Hamacantha carteri	Topsent, 1904			x
Hamacantha johnsoni	(Bowerbank, 1864)		x	
Hamacantha papillata	Vosmaer, 1885		x	
Melonanchora elliptica	Carter, 1874			x
Melonanchora emphysema	(Schmidt, 1875)		x	
Mycale lingua *	(Bowerbank, 1866)			x
Esperiopsis villosa	(Carter, 1874)			x
Spongionella pulchella	(Sowerby, 1804)			x
Stelletta normani *	Sollas, 1880			x
Stryphnus ponderosus *	(Bowerbank, 1866)			x
Suberites ficus	(Johnston, 1842)			x
Suberites luetkeni	Schmidt, 1870		x	

Species	Author	NW only	NE only	Both
Thenea levis *	Lendenfeld, 1907	(x)	x	
Thenea muricata *	(Bowerbank, 1858)			x
Tethya aurantium	(Pallas, 1766)		x	
Tetilla infrequens	(Carter, 1876)			x
Petrosia crassa *	(Carter, 1876)		x	
Oceanapia robusta	(Bowerbank, 1866)		x	
Leaf/vase-shaped demosponges				
Iophon piceum	(Vosmaer, 1882)			x
Phakellia ventilabrum *	(Linnaeus, 1767)			x
*Phakellia robusta**	Bowerbank, 1866		x	
Axinella arctica	(Vosmaer, 1885)		x	
Round with projections				
Craniella cranium	(Mueller, 1776)			x
Craniella polyura	(Schmidt, 1870)		x	
Polymastia boletiformis	(Lamarck, 1815)			x
Polymastia penicillus	(Montagu, 1818)			x
Polymastia thielei *	Kolktun, 1964		x	
Polymastia uberrima *	(Schmidt, 1870)		x	
Weberella bursa *	(Mueller, 1806)			x
Radiella hemisphaerica *	(Sars, 1872)			x
Stalked demosponges				
Asbestopluma pennatula	(Schmidt, 1875)			x
Asbestopluma furcata	Lundbeck, 1905		x	
Chondrocladia gigantea	(Hansen, 1885)			x
Cladorhiza gelida *	Lundbeck, 1905	x?	x	
Cladorhiza oxeata *	Lundbeck, 1905	x?	x	
Rhizaxinella				x
Stylocordyla borealis *	(Loven, 1868)			x
Demosponges of various forms				
Cliona, several spp.				x
Haliclona,several spp.				x
Homaxinella sp.				
Hymedesmia many species		>20	> 40	10?
Quasillina brevis	(Bowerbank, 1861)			x
Tentorium semisuberites	(Schmidt, 1870)			x
Calcareous sponges				
Sycon spp.		several	many	several
Other calcareous species		several	many	several
Hexactinellids				
Vazella pourtalesi *		x		
Pheronema carpenteri *			x	
Hyalonema thomsoni	Marshall, 1875		x	
Asconema foliatum *	(Fristedt, 1887)			x
Chonelasma choanoides	Schulze and Kirkp., 1910			x
Euplectella suberea	Thomson, 1877	x?	x	
Rossella nodastrella *	Topsent,1915		x	

Species	Author	NW only	NE only	Both
Schaudinnia rosea *	(Fristedt, 1887)		x	

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9 Appendix 1: ICES VME indicators database for the North Atlantic

9.1 Introduction

WGDEC 2011 recognised the need for 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.

9.2 Development of the database in conjunction with the ICES Data Centre

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 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.

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, maintained by the JNCC, 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 is available at http://ebsa.cbd.int/. The FAO has plans to begin to develop a database for VMEs based on data from RFMO's fishery observer programmes and fisher's knowledge; however, this is currently on hold. 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.

In 2011, 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 database is 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. The ICES database will extend the OSPAR habitats database, but retain core compatibility to it (ICES WGDEC report 2011).

The VME indicators database itself is currently being developed by the ICES DataCentre and will be stored in a Microsoft SQL Server database, which accepts both point and polygon data, with the data accessible through a simple web interface. The data format for submission of data has been agreed upon through WGDEC. This year data on VME indicator species was submitted by Spain, Russia, Belgium, Norway and the UK.

9.3 Data format

A template spreadsheet has been developed, based on the OSPAR habitats data format with additional fields. It contains all the mandatory and optional fields to be filled in when entering data. Three worksheets are contained within the template (currently entitled WGDEC_DATA_TEMPLATE_2012_V3.xls):

1) Presence of VME indicator – this is the main data table in which the VME indicator species and habitats information is entered. It was initially modelled on the OSPAR habitats data template, with additional fields taken from the OSPAR survey level metadata template. The fields are described in Table 1.
2) Survey key metadata – when a new SurveyKey is entered in the data table (described above), a new survey key metadata record is entered here. The purpose of this additional table is to minimize the amount of repeated information in the data table and the total size of the database. This was initially modelled on the OSPAR habitats survey level metadata template. The fields are described in Table 2.
3) Drop down lists – this contains several lists that are used to populate fields with drop-down lists.

9.4 Data submission

WGDEC members will be supplied with the data template, which can be filled in with new data and submitted to ICES. This year, while the database has been under construction, WG members brought data to the meeting and the data were compiled into a single spreadsheet. When the database is built, these data will be imported and future datasets will be submitted according to the standard ICES accessions system (http://www.ices.dk/env/submitting_data.asp) in which datasets are e-mailed to the ICES DataCentre.

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.

An important development for the ICES database was a classification of VME indicator data type by WGDEC. In the database this takes name 'WGDECgroup' and reflects what WGDEC's expert opinion of what the datapoint represents. example, single records of *Lophelia pertusa* or *Madrepora occulina* are assigned 'stony coral' not 'coral reef'. Only in those cases where there is unequivocal evidence of reef habitat e.g. visual evidence, would it be assigned '*Lophelia pertusa* reefs'.

9.5 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, JNCC.

Table 1. 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, O stands for optional and C stands for conditional.

Field name	Field type	Obligation	Description	Guidance
OSPARGUI	Text	C	Globally Unique ID for each dataset, as used in the OSPAR database.	This field is required for OSPAR habitat data. It will already exist for data that has come from the OSPAR database. For OSPAR habitat data that is added to the WGDEC database before the OSPAR database, OSPARGUI must be filled in later. Format: "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	Text	M	Unique key for each habitat record.	May be numeric, text or a combination of numbers and text.
WGDECgroup	Text	M	Grouping of species/habitats used by WGDEC.	Choose from: Black coral Carbonate mound Coral garden Coral garden hard bottom Coral garden soft bottom Cup coral Deep-sea sponge Gorgonians Hydroid Lace corals Lophelia pertusa Oceanic ridges with hydrothermal vents/fields Sea-pen Soft coral Sponges Stony coral
OSPARHabType	Text	C	OSPAR threatened and/or declining habitats relevant to WGDEC.	Choose from: • Carbonate mounds • Coral Gardens • *Lophelia pertusa* reefs • Oceanic ridges with hydrothermal vents/fields • Seamounts • Sea-pen and burrowing megafauna communities
Status	Text	M	Presence or absence of habitat or species	Choose from: Present Absent

Field name	Field type	Obligation	Description	Guidance
OSPARCertainty	Text	C	Gives an indication of the certainty of identification of the OSPAR habitat type (OSPARHabType).	Choose from: 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
GeneralTaxonDescriptor	Text	M	Most detailed name of taxon (according to Highest Taxonomic Resolution)	e.g. Porifera, Lophelia pertusa, soft coral
HighestTaxonomicResolution	Text	C	Highest taxonomic resolution described in GeneralTaxonDescriptor	Only use if a scientific taxon name is given. E.g. order, species, genus.
Genus	Text	C	Genus of taxon, if known	If not known, use “NA”
Species	Text	C	Species of taxon, if known	If not known, use “NA”
Dead_alive	Text	O	Indication of whether most of sample was dead or live	Choose from “dead” or “alive”
Number	Integer	O	Number of individuals	If relevant. If not known, leave blank
Weight_kg	Double	O	Mass of animal, in kg	If relevant. If not known, leave blank
TaxonDeterminer	Text	M	Name of person or organization that identified the GeneralTaxonDescriptor.	Free text; e.g. JNCC
TaxonDeterminationDate	Date	M	Date of identification of the GeneralTaxonDescriptor.	All dates must be supplied as text in the format YYYY-MM-DD (ISO date format).
ObsDate	Date	M	Date the habitat or species was recorded.	All dates must be supplied as text in the format YYYY-MM-DD (ISO date format).
ObsDateType	Text	M	A one or two character code that identifies the type of dates used ObsDate. Explicitly stating the code avoids any ambiguity, which might lead to subtly different interpretations.	Choose from: D Dates specified to the nearest day. O Dates specified to the nearest month (Y Dates specified to the nearest year ND No date U Unknown
StationID	Text	O	ID of the survey station, if known.	May be numeric, text or a combination of numbers and text.
SurveyKey	Text	O	Unique key to divide up the dataset in any way you wish (e.g. representing real separate surveys, data from different sources, museum collections, etc.). SurveyKey links to the Survey Key Metadata worksheet, where survey details are described in full.	Each SurveyKey must refer to a record in the Survey Key Metadata worksheet (see Table 2).

Field name	Field type	Obligation	Description	Guidance	
SurveyMethod	Text	O	A description of the survey method(s) used.	Survey technique(s). Choose one or more from: Multibeam echosounder Single beam echosounder Side scan sonar Interferometric sonar AGDS Multibeam ground discrimination 3D seismic imagery Sub bottom profiling Grab Core	Trawl Commercial trawl bycatch Survey trawl bycatch Survey longline bycatch Dredge Particle size analysis Geotechnical measurements Towed camera Drop camera ROV Sediment profile imagery
PlaceName	Text	O	Name of place referred to in reference to the feature.	Free text; e.g. "Rockall Bank"	
StartLatitude	Double	M	Starting latitude of the record (if point rather than line, it will =EndLatitude).	Must use World Geodetic System 1984 (WGS84) geographic coordinate system, and decimal degrees.	
StartLongitude			Stating longitude of the record (if point rather than line, it will =EndLongitude).		
EndLatitude	Double	M	Ending latitude of the record (if point rather than line, it will =StartLatitude).	Must use World Geodetic System 1984 (WGS84) geographic coordinate system, and decimal degrees.	
EndLongitude			Ending longitude of the record (if point rather than line, it will =StartLongitude).		
GeometryType	Text	M	Point or line	"point" or "line"	
RecordPositionAccuracy	Integer	O	Accuracy of spatial position of record.	Value in metres; e.g. "10" means the given position of the habitat is accurate to ± 10 metres.	
ShipPositionPrecision	Integer	O	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.	
Reference	Text	M	A reference to the data source	Complete citation for the data source e.g. "Mortensen *et al.*, 2006"	
Filename	Text	O	Name of the excel or shape file submitted		
DataOwner	Text	M	Name of person or organization that owns the data.	Free text; e.g. "JNCC"	
DataAccess	Text	M	Data access constraints	e.g. "public" or "restricted"	
Depth Upper	Integer	O	For transect data (video or trawl) indicate the shallowest depth in metres	e.g. 110	

Field name	Field type	Obligation	Description	Guidance
Depth Lower	Integer	O	For transect data (video or trawl) indicate the deepest depth in metres	e.g. 150
Comments	Text	O	Any other comments or information	e.g. "sample was 60% live coral and 40% dead"

Table 2. Proposed data format for the 'survey key metadata' table of the WGDEC VME indicators 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
SurveyKey	Text	M	Unique key to divide up the dataset in any way you wish (e.g. representing real separate surveys, data from different sources, museum collections, etc.). SurveyKey links to the SurveyKey in the data worksheet.	Each record must be referred to in the SurveyKey field in the data worksheet (see Table 1).
Country	Text	M	2-letter country code (corresponding to ISO 3166-1 standard)	Choose from: BE Belgium CA Canada DE Germany DK Denmark ES Spain FI Finland FO Faroe Islands FR France GB United Kingdom GB-ENG England GB-NIR Northern Ireland GB-SCT Scotland GB-WLS Wales GL Greenland IE Ireland IS Iceland NL Netherlands NO Norway PT Portugal SE Sweden US United States
Institute	Text	M	Institute that collected the data.	For European data, please use institute name as in the European Directory of Marine Organisations: http://seadatanet.maris2.nl/edmo/
VesselName	Text	O	Name of vessel on which survey was carried out.	e.g. "RV Scotia"
VesselCode	Text	O	Unique code for vessel on which survey was carried out.	Search http://vocab.ices.dk/ to find ICES platform (SHIPC) code. E.g. "748S"
CruiseID	Text	O	ID of survey cruise, as assigned by the surveyors.	e.g. "1205S"
StartDate	Date	M	Start date of survey	All dates must be supplied as text in the format YYYY-MM-DD (ISO date format).
EndDate	Date	M	End date of survey	All dates must be supplied as text in the format YYYY-MM-DD (ISO date format).
ScientistInCharge	Text	O	Name of scientist-in-charge of survey.	e.g. "John Smith"
FundingProject	Text	O	Name of project funding the survey, if relevant.	e.g. "HERMES"
SurveyReport	Text	O	Link to online cruise report.	Link to SeaDataNet Cruise Summary Report if relevant. Find here: http://seadata.bsh.de/csr/retrieve/V1_index.html

10 Appendix 2. Table of coral species in NE Atlantic (ToR F)

List of corals used for comparison of similarity between seven areas (Norwegian Sea, Northeast Atlantic banks, Mid-Atlantic Ridge, Atlantic Canada, Eastern USA, Iberian offshore areas, and the Azores) in the North Atlantic.

Order	Family	Species	Norway	NE Atl banks	MAR	Atl. Canada	East US	Iberian	Azores
Alcyonacea									
	Alcyoniidae								
		Alcyonium cf. maristenebrosi							1
		Alcyonium cf. rubrum							1
		Alcyonium digitatum					1		
		Anthomastus agaricus			1	1			1
		Anthomastus agassizii				1	1		
		Anthomastus grandiflorus	1	1	1	1	1		
		Anthomastus sp.		1	1				
	Clavularidae								
		Clavularia sp.							1
		Clavularia modesta					1		
		Sarcodictyon roseum	1						
		Schizophytum echinatum							1
		Clavularia (Trachythela) rudis				1	1		
	Xeniidae								
		Anthelia fallax	1						
		Clavularia arctica	1						
		Clavularia borealis	1			1			
		Clavularia marioni							1
	Nephtheidae								
		Drifa glomerata	1			1	1		
		Duva florida	1	1		1	1		
		Duva multiflora	1						
		Gersemia fruticosa	1			1	1		
		Gersemia rubiformis	1			1	1		
		Nephtheidae indet.	1	1	1	1			
Gorgonacea									
	Acanthogorgiidae								
		Acanthogorgia sp.		1	1				
		Acanthogorgia armata				1	1		1
		Acanthogorgia hirsuta						1	1
		Acanthogorgia truncata							1
	Anthothelidae								
		Anthothela grandiflora	1	1		1	1		
		Anthothelidae indet.		1					
	Chrysogorgiidae								

Order	Family	Species	Norway	NE Atl banks	MAR	Atl. Canada	East US	Iberian	Azores
		Chrysogorgia agassizi			1	1	1		
		Iridogorgia pourtalesii					1		
		Radicipes cf. challengeri				1			
		Radicipes gracilis				1	1		
		Radicipes sp.	1						
	Ellisellidae								
		Viminella flagellum						1	1
	Dendrobrachiidae								
		Dendrobrachia multispina			1		1		
	Gorgonidae								
		Eunicella cavolini						1	
		Eunicella dubia							1
		Eunicella verrucosa						1	
	Isididae								
		Acanella arbuscula			1	1	1		1
		Acanella sp.		1					
		Isidella lofotensis	1						
		Isidella sp.		1					
		Isididae indet.		1					
		Keratoisis grayi				1	1		
		Keratoisis sp.		1	1	1	1		
		Keratoisis flexibilis					1		
		Keratoisis ornata				1	1		
		Keratoisis palmae							1
		Lepidisis caryophyllia					1		
		Lepidisis longiflora		1				3	
		Lepidisis sp.		1					
	Paragorgiidae								
		Paragorgia arborea	1	1	1	1	1		
		Paragorgia johnsoni				1	1		
		Paragorgiidae Indet.			1				
		Paragorgia sp.		1					
	Plexauridae								
		Bebryce mollis							1
		Dentomuricea meteor							1
		Dentomuricea sp.							1
		Muriceides cf. paucituberculata							1
		Muriceides kuekenthali	1	1					
		Paramuricea biscaya		1	1				
		Paramuricea grandis				1	1		
		Paramuricea placomus	1		1	1	1		
		Paramuricea sp.		1					
		Placogorgia graciosa		1					

Order	Family	Species	Norway	NE Atl banks	MAR	Atl. Canada	East US	Iberian	Azores
		Placogorgia intermedia							1
		Placogorgia sp.		1					
		Placogorgia terceira							1
		Plexauridae indet.		1					1
		Swiftia casta					1		
		Swiftia pallida	1						1
		Swiftia rosea	1						1
		Villogorgia bebrycoides							1
	Primnoidae								
		Callogorgia verticillata		1				1	1
		Calyptrophora josephinae							1
		Candidella imbricata						1	1
		Primnoa resedaeformis	1	1	1	1	1		
		Thouarella sp.		1					1
		Thouarella hilgendorfi							1
		Callogorgia americana americana					1		
		Narella bellissima					1		
		Narella laxa					1		
		Narella pauciflora					1		
		Narella regularis						1	
		Narella versluysi							1
		Parastenella spinosa				1			
Pennatulacea									
	Anthoptilidae								
		Anthoptilidae indet.		1		1			
		Anthoptilum murrayi		1	1	1	1		1
		Anthoptilum grandiflorum				1			
	Funiculinidae								
		Funiculina quadrangularis	1		1	1	1	1	1
	Halipteridae								
		Halipteridae indet.		1					
		Halipteris finmarchica		1		1			
	Kophobelemnidae								
		Kophobelemnon stelliferum	1			1			
		Kophobelemnon macrospinosum			1				
		Kophobelemnon sp.						1	
	Pennatulidae								
		Pennatula spp.		1					
		Pennatula phosforea	1		1	1		1	1
		Pennatula aculeata				1			
		Pennatula borealis				1			
	Protoptilidae								
		Distichoptilum gracile				1			

Order	Family	Species	Norway	NE Atl banks	MAR	Atl. Canada	East US	Iberian	Azores
	Scleroptilidae								
		Scleroptilum grandiflorum			1				
	Umbellulidae								
		Umbellula durissima			1				
		Umbellula encrinus	1		1				
		Umbellula lindahli				1			
		Umbellula thompsoni			1				
		Umbellula sp.		1		1			
		Umbellulidae indet.		1					
	Virgulariidae								
		Virgularia mirabilis	1						
Antipatharia									
	Antipathidae								
		Stichopathes abyssicola							1
		Stichopathes dissimilis							1
		Stichopathes flagellum							1
		Antipathes erinaceus							1
		Stichopathes gravieri		1					
		Cupressopathes gracilis						1	
		Antipathes grayi							1
		Antipathes virgata							1
		Stichopathes sp.		1		1			
		Thyssopathes sp.		1					
		Tylopathes sp.		1					
	Aphaniphacidae								
		Phanopates sp.		1					
	Leiopathidae								
		Leiopathes cf. *expansa*		1					
		Leiopathes cf. *glaberrima*		1					
		Leiopathes spp.							1
		Leiopathes glaberrima					1		
		Leiopathes sp		1					
	Schizopathidae								
		Parantipathes larix						1	1
		Parantipathes sp.		1					
		Stauropathes arctica			1	1			
		Stauropathes punctata							1
		Bathypathes alternata					1		
		Bathypathes sp.		1					
	Myriopathidae								
		Tanacetipathes squamosa							1
Scleractinia									
	Caryophylliidae								

Order	Family	Species	Norway	NE Atl banks	MAR	Atl. Canada	East US	Iberian	Azores
		Anomocora fecunda							1
		Caryophyllia ambrosia			1				
		Caryophyllia arcuata						1	
		Caryophyllia cornuformis			1	1	1		1
		Caryophyllia cyathus							1
		Caryophyllia foresti							1
		Caryophyllia smithii	1						
		Coenocyathus cf. cylindricus							1
		Dasmosmilia lymani				1	1		
		Dasmosmilia variegata							1
		Caryophyllia sp.		1					1
		Caryophylliidae indet.		1					
		Desmophyllum dianthus	1	1		1	1	1	
		Desmophyllum sp.		1					
		Lophelia pertusa	1	1	1	1	1	1	
		Solenosmilia variabilis		1			1		
		Stephanocyathus moseleyanus		1	1				1
		Stephanocyathus sp.		1					
		Vaughanella margaritata				1			
	Dendrophylliidae								
		Dendrophyllia alternata						1	
		Enallopsammia marenzelleri							1
		Enallopsammia profunda					1		
		Enallopsammia rostrata					1	1	1
	Flabellidae								
		Flabellum alabastrum		1	1	1	1		1
		Flabellum angulare			1	1	1		1
		Flabellum chunii							1
		Flabellum macandrewi	1		1	1			
		Flabellum sp.		1					
		Javania cailleti				1	1		1
		Placotrochides frustum			1		1		
	Fungiacythidae								
		Fungiacyathus fragilis	1		1				1
	Oculinidae								
		Madrepora carolina					1		
		Madrepora oculata	1	1	1		1	1	
		Oculina varicosa					1		1
	Pocilloporidae								
		Madracis myriaster					1		
	Dendrophylliidae								
		Dendrophyllia cornigera						1	1
		Dendrophyllia sp.							1

Order	Family	Species	Norway	NE Atl banks	MAR	Atl. Canada	East US	Iberian	Azores
	Stenocyathidae								
		Stenocyathus vermiformis	1		1				1
		Number of species	32	52	35	48	50	20	61

Annex 1: List of participants

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Annex 2: WGDEC Terms of Reference for 2013

The ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), Chaired by Francis Neat, UK, will meet in sometime XX March 2013 in Norway/Azores/Ireland (TBC) to:

a) 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.
b) Incorporate data on known hydrothermal vents and seeps in the ICES area into the ICES WGDEC VME database and maps and review the associated fauna and potential threats from anthropogenic pressures.
c) Explore the use of survey data from the ICES VME database to address by-catch thresholds in different regions, e.g. NAFO and NEAFC RA’s.

Annex 3: Recommendations

1) WGDEC recommends that recent (post 2009) VMS data are provided to ICES in advance of the 2013 WGDEC meeting. Notable areas of interest include fisheries in the Rockall-Hatton area, all seamounts, the Mid-Atlantic Ridge, and the continental slope (including the Bay of Biscay). All form of identification of vessel or nationality should be removed from the data. For the data to be useful, however, WGDEC will need;

   1.1) the data resolved at the finest possible temporal and spatial scale;

   1.2) information on gear type;

   1.3) information that links the VMS data to logbook records.

2) WGDEC recommends that ICES SGVMS considers a means of processing the VMS data so that fishing effort maps can be readily made.

3) WGDEC recommends that NEAFC consider whether logbook records of encounters with VME indicator species (below current thresholds) could be made available to the group for purposes of assessing VME indicator bycatch frequency and distribution.

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

- RGVME
- Deadline for review 14 May 2012
- Participants: Margaret M. McBride, Norway (Chair), Leonie Dransfeld, Ireland, Angel Pérez-Ruzafa, Spain and Claus Hagebro (ICES Secretariat)
- Working Group: WGDEC

RGVME general comments

- The request required to supplement the VME data with positional information on fisheries. This was not possible due to the lack of updated VMS data. This is very unfortunate particularly as these data are collected by NEAFC and these requests come from NEAFC. ICES should continue to highlight this deficiency. In the meantime other sources of information could be used to augment fisheries data albeit spatial resolution is relatively coarse. WGDEEP is attempting to update fisheries information annually by presenting species catches by statistical rectangles. This could be a useful annual product from WGDEEP to WGDEC to support reoccurring advice in answer to recurring requests. Coupled with information on species distribution by depth; this should provide needed information on ongoing fishing activities along deep-water banks which potentially occur in the vicinity of VMEs. In addition, high resolution information can be used from older studies when and where available.
- WGDEC describes the issue of uncertainty in determining VMEs based on different data sources. It is stated that this uncertainty is taken into account when providing advice. However, the overarching theory and principles guiding the provision of advice in light of uncertainty is not addressed.
- WGDEC states that justification for delineating boundaries is provided in as much detail as possible. However, it does not explain the basis/rationale for delineating boundaries. In some cases it is stated, that three times the water depth around the tow path is used as a buffer zone, but is this the general approach taken in all cases? If not, then what is the basis from which to delineate boundaries?
- WGDEC decided that no universal weighting system could be applied, and that each area is considered on a case-by-case basis. Without a set of guiding principles, on what basis can advice be provided that ensures objectivity and consistency across individual cases which may differ relative to species, source/type of data, and/or concentration/density of VME indicators.
- WGDEC states that the precautionary approach was taken. However, this does not justify not having advised closures in some areas despite reports of substantial VMEs. According to the precautionary principal that underlies much of WGDEC's reasoning, probably a proposal based in the known areas should be done with a recommendation to conduct a survey to find the precise areal coverage for these VMEs.

- If a particular area is believed to have a lower likelihood of containing VMEs, WGDEC should state whether that belief is based on recent data, historical data, or upon expert opinion.

Request 1: Vulnerable deep-water habitats in the NEAFC Regulatory Area

NEAFC requests ICES to continue to provide all available new information on the distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in and in the vicinity of such habitats.

WGDEC Response

New closures or closure boundary revisions are suggested in some areas where WGDEC considered there to be strong evidence for definable concentrations of VME indicator species.

In some areas, although VME indicators were clearly present, no closures are suggested at present due to uncertainty of defining where the VME is likely to begin and end, e.g. the Whittard Canyon and the East Greenland sponge grounds.

In the NE Atlantic new data were available for several areas

Rockall Bank

New evidence of VMEs

- New data on *Lophelia pertusa* reefs for Rockall Bank were made available from Marine Scotland towed video surveys.
- New data from three Marine Scotland surveys was obtained in 2011. These records span the plateau, some in deeper areas and one transect of trawls on the east side of the bank that covered depths to 1750 m.
- A new survey on Rockall Bank in 2011 (Huvenne *et al.*, 2011) led by the National Oceanography Centre (NOC) identified a number of new areas of cold-water coral reef within the ICES WGDEC 2011 NW Rockall closure recommendation.
- Blocks of high resolution side-scan sonar data were gathered in three areas focused on the central area of the NW Rockall closure; in the NW, centre and in the SE of this central area of the WGDEC 2011 closure recommendation. Cold-water coral reefs were clearly visible on the side-scan sonar imagery (see Figure 2) and these were confirmed using the ROV. These preliminary observations of cold-water coral reef VMEs support the NW Rockall closure recommended by ICES WGDEC in 2011. They also highlight the patchy distribution that is characteristic of the cold-water coral reef communities present on the summit of Rockall Bank.

Case for boundary revision of NW Rockall closure

In light of the new data on the presence of VME indicator species inside the existing closed area as well as outside the current closed area, WGDEC maintains its advice from 2011 for the boundary revision in the north of the closure. WGDEC also maintains its advice from 2011 for the western boundary of the closure. WGDEC also maintains its advice from 2011 for the eastern boundary of the closure.

WGDEC advises a reduced area for reopening because of the evidence provided by the video transects suggesting the presence of *Lophelia pertusa* in this area (Figure 3). The question remains as to whether these observations represent live coral, and further analysis of the video data is needed before a final consensus can be reached. Until such an analysis has been conducted, this area must be considered as likely to contain corals and from a precautionary standpoint the area delimited as Option 1 in Figure 3 and Table 2 should remain closed.

As it is not certain if coral is present to the west of the area termed 'Option 1', an alternative proposal would be to maintain the current NEAFC closure 'as is' in this corner for 2012 i.e. Option 2 in Figure 3 and Table 3. Surveys to this area are planned in 2012 and may provide additional evidence to delimit precisely where the closure boundary should be drawn and whether Option 1 or Option 2 is more appropriate.

RGVME comment(s)

- It would be helpful if the basis of WGDEC advice was reiterated in a short summary sentence.
- Sources of data available -- to determine VME presence, and establish potential boundaries -- have improved substantially since 2011. Now there is a wide range of evidence for the presence of VMEs, including: high quality data from side-scan sonar; video footage from ROVs, etc. Some data, such as counting the number of corals per area in video footage is semi-quantitative, and forms a good basis to provide advice on the presence of VMEs.
- This semi-quantitative data could be used to re-evaluate the basis for the initial closure.
  - Do counts in the closed area confirm high presence of indicators species?
  - How do the counts inside existing closed areas compare with counts in newly proposed areas for closure?
  - Are they to the same extent?
- Regarding the reopening of closed areas, there should be some agreed-upon criteria or guidelines to support such a decision, such that advice does not appear inconsistent if it changes from one year to the next, and to ensure that such swings do not occur too frequently.
- Are there no trawl spurs outside advised areas for closure that could be used to confirm the absence of corals in this area?
- The caption for Figure 3 should better explain what the red lines at the bottom of this diagram mean, i.e. which two closures the lines correspond to.

Case for boundary revision NW Rockall

- Figure 4. The revised boundary does not appear to include the corals. Why not expand the boundary to include corals to the NE of the closure?
- Has there been confirmation on the absence of corals to suggest a reopening? It appears that this is not the case. Therefore, Option 2 may be more precautionary for the time being.
- This case illustrates that having confirmation on the absence of VME-indicator species is just as important to the advisory process as having records confirming the presence of VME-indicator species.

East Rockall (deep slope)

A video transect was undertaken in 2011 that ran along the foot of the very steep northeastern margin of the Rockall Bank. Numerous occurrences of coral (most likely *Madrepora occulata*) were observed on the steep sloping bedrock. Clearly the northern section is an important VME area that deserves conservation attention. This is an area that is currently being consulted on as a possible Special Area of Conservation (SAC) under the EC habitats directive.

RGVME comment(s)

- It would be helpful if this survey could be described in greater detail. The data relate to the video counts, therefore results can be described in a more quantitative manner.
- How does this area compare to other areas?
  - The map showing records of VME indicators (Figure 4) suggests that the concentration is higher than that of the existing closure.
  - A brief explanation -- of how boundaries of the candidate special area of conservation (SAC) relate to boundaries of the existing NEAFC closure area. Information on what management measures exist inside the candidate SAC (cSAC) is needed here to evaluate whether or not this area currently has adequate protection.

Southwest Rockall (Empress of Britain)

New data was available from Marine Scotland's towed video chariot for the region in the southwest of Rockall Bank. Research survey trawl bycatch records were obtained with a mixture of dead and alive *Lophelia*. These bycatch levels exceed the threshold value that would have triggered move-on rules had this been a commercial fishing vessel. These data indicate VMEs in this area and consequently a closure should be considered. Two options are presented (Figure 5). Hatton Bank

RGVME comment(s)

- Added detail on the research survey bycatch would be helpful to determine:
  - What was the aim of the survey?
  - What sampling gear was used?
  - Is this a bottom-trawl survey for fish?
  - Are the two quantities related to single hauls?
  - Is it possible to get almost four tonnes of coral in a single tow?
- Reference is made to the Move-on rule only in this example where values exceed the threshold. However, there are other examples -- where quantities are not provided -- which might also have had VME-indicator values exceeding the threshold. The Move-on rule does not imply a permanent closure after one encounter. Hence, provision of this information is important as it allows comparison of VME-indicator species between areas that would form the basis for advising permanent area closures. Set criteria for reporting the number and quantity of repeated encounters with VME-indicator species should be used to provide consistent guidance for areal closures.

- It is noteworthy that the buffer zone is mentioned in this case, while it is not mentioned in many other recommendations for closure.
  - Is the same principle of the buffer zone being applied in the other VME-closure cases?

Hatton Bank

New data on VMEs in the area were made available from longline, trawl bycatch and dredge surveys (Duran Munoz *et al*., 2010; 2011; 2012 working document). Data on a variety of VME indicator species such as sponges, stony corals, black corals, and gorgonians indicate presence outside the currently closed area. Four extensions to the current closure are suggested to reflect these new data and offer protection to likely VME areas.

Case for boundary revision of Hatton Bank closure

Extensions of boundary closures are suggested in four areas:

Area 1 (extension to northeast and eastern margin);

Area 2 (extension to east central area);

Area 3 (extension to southeast corner);

Area 4 (extension to southwest corner).

RGVME comment(s)

- When relating this advice to last year's advice, certain questions arise:
  - Were these fisheries surveys? Or has some dedicated sampling been carried out for VME indicator species?
  - Can the catches by different gear types be related to the results and help to qualify the results?
- **Area 1:** Quantities in sponge records should be provided.
  - Is there a way that more numerical information can be displayed in the figures?
  - One large record is mentioned:
    - How does this relate to the other records?
    - Does this area have the previously mentioned buffer zone?
- **Area 2:** Very little detail is provided as to which species were caught, and at which quantities to justify modifying the boundaries.
  - Records are noted from longlines and trawl catches.
    - Can both indicate VMEs in the same way?
  - Last year's advice suggested that trawl records are more reliable.
    - What gear was used when obtaining bycatch of stony coral?
  - Diagrams are very difficult to read as the legends are small and of low resolution.
- **Area 3:** A precautionary closure is advised for this area due to only small specimen being found. It is not clear from the text whether or not the buffer was applied;
  - What is the relationship between the size of specimen and the likelihood of VMEs?

- Is there any evidence that there are no VMEs in the area between the two proposed closures?
- An alternative boundary proposal could be to link the two areas (Area 2 and 3) into a single boundary following the precautionary principle.

Edora's Bank

Observations confirm the presence of VMEs in an area of unusually complex terrain and high rugosity. This is not a NEAFC existing fishing area.

Case for boundary revision of Edora's Bank closure

Based on longline bycatch records and the clear delimitation of the bank using multibeam data, WGDEC advises on an area closure for Edora's Bank (Figure 7). This is a data-deficient area. WGDEC highlights it as an area for future research.

RGVME comment(s)

- It is not clear from text in the 2012 WGDEC report and text in the 2011 report which are the new pieces of information, and which information was already used to support advice given in the 2011 report. It appears that high resolution multibeam data were used in 2011, citing the Duran *et al*. publication about longline catch date from 2010.
- Additionally, the 2011 ICES advice stated that longline bycatch data on their own were considered 'not-sufficiently reliable' to map VME occurrence; and that trawl-survey data should be analyzed to confirm the presence of VMEs. However, the 2012 WGDEC report states that longline catch data, and clear delineation from multibeam data, support the advice for an Edora's Bank area closure.
- Questions that arise include:
  - Has new information come to light that gives a stronger basis for the closure of this area in 2012? Or, is the same information used as in 2011?
  - Are there new data from trawl records made available to the group that give greater confidence concerning the presence of VMEs?
- If this is not the case, a convincing argument needs to be made as to why the advice on areal closure is different between 2011 and 2012 although based on the same dataset.

Whittard Canyon

New evidence of VMEs from the Whittard Canyon

In 2007, cold-water coral reefs were found at water depths ranging 880–3300 m dominated by *Anthomastus* sp., *Lophelia pertusa* and *Primnoa* sp., *Acanthogorgia* sp. and *Acanella* sp. Results suggest that vertical coral reefs could form a significant contribution to the cold-water coral reef occurrence in the NE Atlantic. The preliminary data indicate the presence of relatively dense aggregations of various sea pen species and cold-water coral reef structures. At present it may be premature to suggest a closure in this area until some assessment of fishing activity has been undertaken and the extent to which other adjacent canyons in the area are important sites for VMEs has been evaluated. WGDEC therefore for now simply highlights it as an important new area for VMEs.

RGVME comment(s)

- A substantial dataset on the presence of VMEs in this area has been reported by WGDEC this year. However, full details are not given in the text on how the data is collected and analyzed. Questions arising include:
  - Is it mainly multibeam and video footage?
  - Are data being collected for ground-truthing?
  - Is the footage analysed in the same way as for the Rockall Bank, i.e. in counts per minute?
- The text explains that these findings represent one of the densest coral communities observed in deep water. There is also a short reference to damaged sites elsewhere on the margin, which might suggest that sites reported have not yet been damaged by fishing. Yet, WGDEC believes it premature to advise areal closure before an assessment of fishing activity has been carried out. This seems inconsistent with advice for other closures that was based largely on the precautionary principle, and did not take fishing activities into account. If the basis for delineating VMEs is sound, which it appears to be, then areal closure should be advised.

Josephine Seamount

New historical evidence on the distribution of gorgonians (VME indicator species) suggests concentrations on Josephine Seamount (Figure 8), a currently existing NEAFC fishing area. WGDEC recognizes it as an area likely to contain VMEs, but believes that no closure boundary can be seriously evaluated at present.

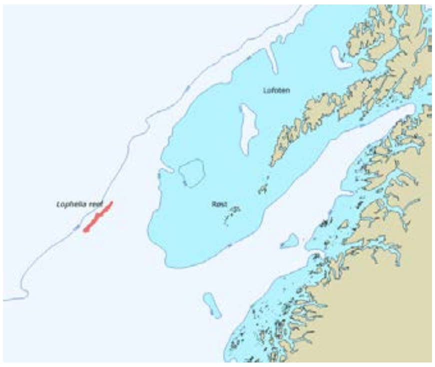
RGVME comment(s)

- As stated in the 2012 WGDEC report, the precautionary principal underlies much of WGDEC's reasoning. As such, a proposal for boundary closure based on known areas of VME-indicator occurrence should be made together with a recommendation to conduct a survey to define the boundary limits more precisely.
- The area where gorgonians (sea whips or sea fans) are known to occur covers a surface of approximately 18 500 km^2. This is quite enough to propose a no-fishing area that would at least protect the most highly concentrated components of this community until more precise boundaries can be established.
- Having no information on current fishing activity cannot be used as an argument to delay making such a proposal for protection. The fact that OSPAR has also put forward a proposal to include this community in a high-seas marine protected area (MPA) should strengthen a similar proposal coming from WGDEC.

Norwegian waters

Norwegian records of *Lophelia pertusa* from research surveys were provided to WGDEC, and can be seen in Figure 9. A dense area of Lophelia is evident west of the Lofoten Islands.

RGVME comment(s)



Indeed, Norway's Institute of Marine Research (IMR) during a MAREANO (Marine AREAl database for NOrwegian waters) survey in May 2002 discovered a large *Lophelia pertusa* reef west of Røst Island in the Lofoten archipelago. The reef was the largest recorded *Lophelia pertusa* reef at 40 km long, 3 km wide and lies mainly between 300 and 400 m depth at a steep and rugged zone of the continental break. This reef is still largely intact.

On 4 January 2003 the Norwegian Minister of Fisheries gave this coral reef special protection against bottom trawling. It is now forbidden to use bottom trawls in the area delineated by the following coordinates:

67°36.2′N, 009°32.9′E

67°33.8′N, 009°40.2′E

67°17.3′N, 008°57.1′E

67°19.8′N, 008°49.5′E

The area is about 43 km long and 6.8 km wide.

Results from the 2011 MAREANO survey are not yet available. However, other corals and sponges were observed during the 2010 MAREANO surveys which may not yet have been reported to WGDEC, including:

Lophelia (Living Reefs)

Latitude	Longitude	Depth
7030.28	1929.2	250
7045.40	1834.28	303
7044.03	1822.24	309
7041.85	1829.42	296
7042.7	1840.65	326

Lopheila (Dead Reefs)

7044.64	1843.42	277
7045.8291	1840.7954	313

Paragorgia arborea (Bubble Gum Coral) and *Primnoa resedaeformis* (Sea Fans/Red Trees)

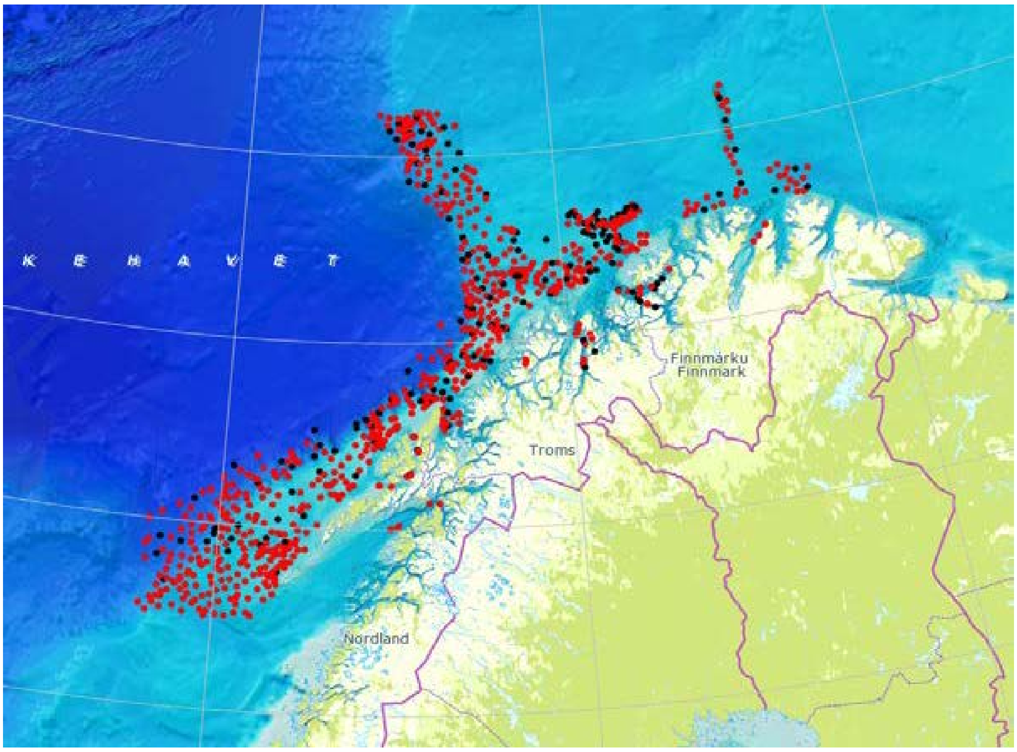
7045.40	1834.28	303
7044.030389	1822.2456	309

	7041.8526	1829.4289	296
	7042.7	1840.65	326
	7044.64	1843.42	277
	7045.82	1840.79	313
	7041.76	1851.1863	268
Drifa Forest (Octocoral)			
	7022.25	1854.57	111
Coral Gravel			
	7036.7329	1909.7895	290
Sponges			
	7051.57	2159.91	334
	7052.1953	2209.411	142
	7054.33	2213.73	102
	7051.87	2222.08	140
Sponges (*Geodia* sp. and *Apylsilla* sp.)			
	7159.9776	2551.5384	248
	7155.1027	2553.6855	263
	7147.8517	2542.3758	292
	7146.374	2559.0472	321
	7143.0468	2548.3138	295
	7138.45	2551.97	295
	7131.66	2558.71	291
	7124.91	2558.12	281
	7118.7522	2602.3351	279
	7121.17	2548.19	276
	7117.4792	2544.7707	305
Scleractinia (Stony Corals)			
	7159.9776	2551.5384	248
	7155.1027	2553.6855	263
	7147.8517	2542.3758	292
	7146.374	2559.0472	321
	7143.0468	2548.3138	295
	7138.45	2551.97	295
	7131.66	2558.71	291
	7124.91	2558.12	281
	7118.7522	2602.3351	279

7121.17	2548.19	276
7117.4792	2544.7707	305

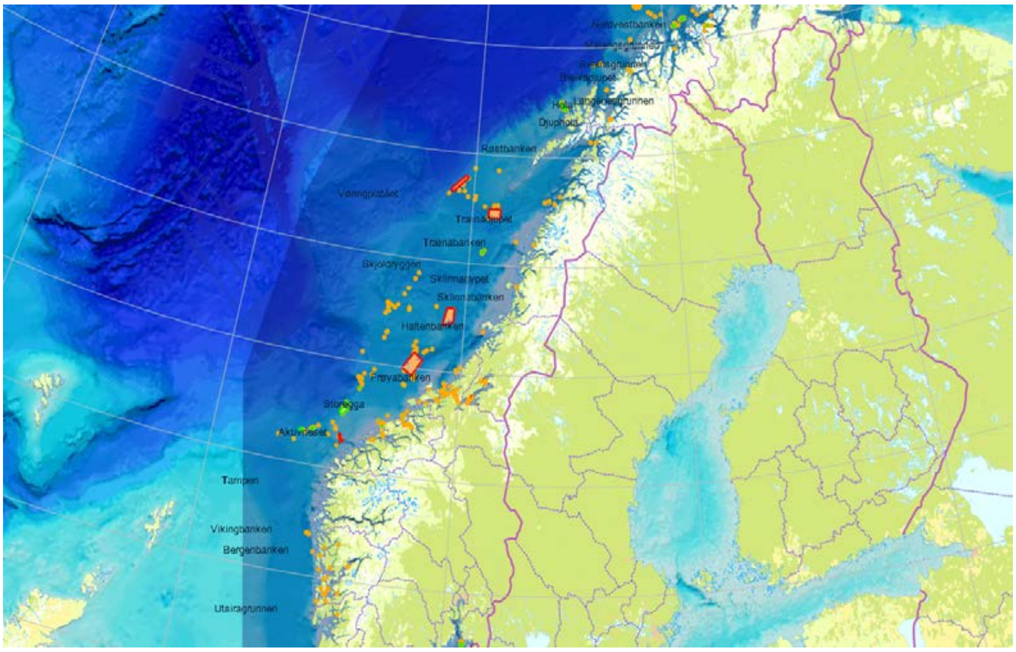
All earlier MAREANO surveys took place outside of Nordland, Troms, and Finnmark. During 2012 areas off Møre and Romsdal will also to be mapped to support revision of the management plan for the Norwegian Sea in September 2013.

The Norwegian Sea has 800 000 km^2 of deep-ocean that is considered vulnerable habitat and closed for regular bottom fishing. As of September 1, 2011 regular fishing with bottom-contact gear types (bottom-trawls, gillnets, and longlines) is prohibited at depths below 1000 meters. Only vessels with a special permit for exploratory fishing -- with strict conditions and detailed plans -- may fish at this depth. These plans include measures to avoid damage to VMEs, detailed reporting on catch and fishing activities, and possible onboard fishery observers.



MAREANO Survey Stations 2006–2011. o Video Stations o Full Stations.

Full stations include video, grabs, beam trawl, box core, RP sled, multi-cores, and CTD.



Results from MAREANO Surveys (2006–2011). Coral Reefs, Protected Coral Areas, Identified Coral Areas, Survey Areas.

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East Greenland

New data from Russian observer on board fishing vessel were available for sponges. Currently it is not possible to determine the exact boundaries of the sponge fields in this area. It is necessary to carry out additional research in this area before considering protection measures. There were no cold-water corals found in the catches.

RGVME comment(s)

- Here again the precautionary principal should be applied. When evidence exceeds the established threshold needed to consider the existence of a VME, as in this case, ignorance of the precise physical boundaries should not delay advising to protect this area. Only in cases involving serious conflicts and/or harm to fishing operations should other alternatives be considered. In any case, the coordinates stated should be used to propose a flexible closure area that is subject to revision as additional data become available.

In the Northwest Atlantic new data were available for

West Greenland

Hauls made at 975–1500 m contained cold-water corals. Four species from the orders Antipatharia and Pennatulacea were found. *Anthoptilum* spp. predominated in catches. Besides, single specimens of *Pennatula* spp., *Halipteris finmarchica* and *Stauropathes arctica* were registered. Sponges were not registered in the catches.

RGVME comment(s)

- In their 2011 report, WGDEC provided new data -- from observers' on board trawlers on the slope to the west of Greenland -- suggesting the presence of VMEs in areas currently open to bottom fishing. As frequently occurs, the information was limited and considered insufficient to support making firm proposals for protection. We recommended that the new data be presented together with a brief assessment of the implications of this data for decision-making.

Grand Banks and Flemish Cap

Cold-water corals were recorded in these NAFO regulated areas of the Flemish Cap and the Grand Bank. The catches were taken from 320–1205 m depths. Six species from orders Alcyonacea, Antipatharia and Pennatulacea were found. Species composition was more diverse than in West Greenland areas. Catches of cold-water corals in traditional Russian fishing areas were much lower than the threshold level established by NAFO Fisheries Commission.

RGVME comment(s)

- To properly assess the abundance of deep-sea corals relative to the threshold level established by the NAFO Fisheries Commission, WGDEC should incorporate the level of fishing effort/duration of trawl hauls. Notably, the report says that "in NAFO RA sponges were not registered in the catches". Have sponges been registered in the catches in the adjacent areas?

Request 2: The bottom fisheries regulations implemented in the NEAFCRA are to be reviewed in 2012. In order to facilitate the revision ICES is requested to advice NEAFC on following issues

Note: WGDEEP has already reviewed and commented on WGDEC responses to Request 2. However, additional comments from RGVME are welcome.

a) Impact assessments

ICES is asked to propose elements to be included in impact assessments, required to satisfy the NEAFC bottom-fishing regulations in the NEAFC RA.

WGDEEP/WGECO response

ICES (2011a) discussed the potential applications of ecological risk assessment (ERA) methods. WGDEEP builds upon that previous work and examines a non-exhaustive list of (1) approaches to ecological risk assessment and (2) detect elements which are relevant for impact assessment in the NEAFC RA. Approaches examined included:

- Ecological Risk Assessment of the Effects of Fishing

- Level 1: Scale-Intensity Consequence analysis (SICA);
- Level 2: Productivity Susceptibility Analysis (PSA); and
- Level 3: Sustainability Assessment for Fishing Effects (SAFE);
- The Marine Life Information Network (MarLIN) approach;
- The U.S. National Research Council approach;
- Extended Overlap Models; and
- Population Level Models.

For each approach the analyses/assessments involved, data requirements, and strengths/weaknesses are examined and discussed.

In conclusion, reservations were expressed regarding types of approaches which create the potential for poor information (selection and weighing of the input parameters) to be presented as having more reliability than it actually does, and thus running the risk of producing false outcomes. For all approaches it is critical that decision steps be fully documented to maintain transparency and increase confidence in the outcomes.

RGVME comment(s)

- WGECO is to be congratulated for providing a very thorough analysis: 1) of the principles of ecological risk assessments, providing different examples which are being used, assessing their strength and weaknesses; and 2) applying some of the principles to the NEAFC request for impact assessments for new deep-water fisheries.
- The specific advice regarding the impact assessment for NEAFC needs to be added to the Advice, i.e. WGDEC Report (Pages 15–23).
- In the WGECO response to the request for impact assessment there seems to be some confusion as to what information is required from the applicant for the impact assessment, for example:
  - Information needed **before** any permission to fish is granted; and
  - Once the permission has been granted to conduct experimental fisheries, information to be collected by on-board observers during fishing operations (e.g. position coordinates, VMS data).
- To address elements 1 and 2 of the risk assessment relative to the fishery resource itself (fishing effort level, harvesting plan, and best available scientific information on current state of fishery resource) the report of WKLIFE (ICES 2012) could give very good supporting material on methods to develop reference levels for data poor stocks. There is a dedicated section on deep-water stocks in this report. In order to address element 2 on relevant habitat and biological information in the fishing area and element 3 of the risk assessment on the description of VMEs, the VME database from WGDEC would be a very important data source as well as other existing coral and VME databases (OSPAR?).
- Answers to the subsequent elements (4 to 6) outline in a very useful way steps that are needed, and methods that can be used to carry out the impact assessments. Where relevant, it draws attention to international guidelines for fishing in deep water, i.e. FAO.
- A flow chart working through the six elements of the impact assessment would be quite useful to be included in the advice. This would guide the

reader through the different approaches that are proposed under each element.

b) Encounter thresholds

ICES is asked to assess the appropriateness of the current quantitative thresholds of VME indicator organisms, i.e. live coral and sponge, adopted in the NEAFC bottom-fishing regulations. The assessment should include an evaluation of the likelihood of achieving conservation objectives, i.e. the prevention of significant adverse impacts on VMEs as defined in the FAO guidelines.

WGDEC response

Current quantitative encounter thresholds for VME indicator taxa in the NEAFC area are 60 kg of live coral or 800 kg of sponge landed on deck per tow. Current experience with these thresholds is that no reports of encounters have been received (NEAFC, pers. comm. 2012). WGDEC believes that current thresholds are too high and that a 50% reduction to 400 kg (sponges) and 30 kg (corals) would better reflect the likelihood that a VME was encountered.

RGVME comment(s)

- We agree with the WGDEC proposal for a 50% reduction in threshold levels, but it is not enough. As available information is very scarce, in addition the presence of indicator species below the established thresholds and their abundance should be reported independently.
- It is important to map the distribution, scales of variability, and patterns in abundance of VME-indicator species. Frequency of occurrence could also be used as an indicator for relevant indicator species that occur only rarely or in low biomass/abundance.
- It is also important to incorporate fishing effort, and zero occurrences VME indicators in the data. Information on the hauls (location, number, duration, depth, etc.) should be reported for all hauls indicating, expressly, not only the presence and abundance of indicator species, but also their absence.

c) Move-on-rule

- ICES is asked to assess the appropriateness of the current move-on-rule adopted in the NEAFC bottom-fishing regulations. The assessment should take into account the different habitats where bottom fisheries occur, e.g. continental slopes, mid-ocean ridges and seamounts, as well as the variable amount and quality of information on the relevant spatial distribution of VMEs. The provisions inherently assume that a significant proportion of known and unknown VMEs have been protected by bottom-fishing closures and other regulatory measures aimed to achieve sustainable bottom fisheries.

WGDEC response

Encounter provisions, including the move-on rule, currently in force apply in both 'existing fishing areas' and 'new fishing areas'. Currently <u>no</u> encounters have been reported; hence the move-on rule has not been triggered and no temporary closures implemented. No applications for exploratory fisheries (in 'new fishing areas') have been received. Thus, there is no experience with the currently adopted move-on rule, and there is limited basis for discussing its appropriateness other than theoretical considerations.

Fishing vessels are required to record the location and bycatch of VME indicators even at levels below move-on-rule thresholds, thus logbooks may be a valuable source of data on the quantities and spatial distribution of VME indicators in normal fishing operations with bottom gears in the NEAFC regulatory areas. To date WGDEC has not requested access to these logbook data, and has not analyzed incidence and quantity of VME indicators in relevant fisheries. WGDEC therefore recommends that NEAFC consider making vessel logbook data available to ICES. Until quantitative analyses can be conducted to provide a scientific basis for move-on distances, only theoretical factors can be considered to assess their appropriateness.

Discussion is presented on appropriateness of the move-on rule: in different habitats; for different fishing gear types; and in existing and new fishing areas. General consideration of an alternative move-on rule for longline vessels, and how the current move-on rule might be modified or an alternative one developed, concluded that:

- The ideal move-on rule would take into account the spatial size and shape of the VME encountered, VME patchiness, and the level of precision of encounter location positioning;
- The theoretical move-on distance should at least be equal to the longest dimension of the VME feature plus the spatial uncertainty of the reported encounter; and
- The biggest hindrance to progress is the lack of information on the size, shape and patchiness of most VMEs within the NEAFC regulatory area.

RGVME comment(s)

- RGVME agrees with WGDEC's response.
- It is cause for concern that since implementation of the move-on rule (in 2006?) no fishing vessels have reported VME encounters that have triggered temporary closures.
    - It calls into question the effectiveness of the on-board vessel observer programme which would be expected to eliminate or minimize questions about whether or not encounters with VME indicators (of any size) occur and are reported. If observers are not deployed on all vessels in existing fisheries, perhaps a stratified random design based on vessel type and area fished could be implemented to ensure a representative coverage of fishing activities, and minimize costs.
- In the absence of other data sources to help identify and determine the location of VMEs, it seems entirely appropriate to implement a programme requiring all vessels to submit their logbooks. Additionally if observers are onboard, their duties might include monitoring and verifying the accuracy of VME indicator encounter reporting in that vessel's logbook.
- RGVME agrees with WGDEC's opinion that the encounter thresholds are too high, and should be reduced by 50% to evaluate this policy's effectiveness. Also,
- Specific conditions for the Move-on rule are complicated. To encourage cooperation and better reporting of VME encounters, it might be useful to implement a programme designed to educate/inform fishermen in the NEAFC regulatory area about the fundamental principles of benthic eco-

system ecology upon which the Move-on rule is founded, the function that VMEs play in fisheries productivity and sustainability, why closures are imposed to protect VMEs as well as the rationale, goals and objective, and requirements of the rule.

d) Alternatives to thresholds and move-on rules

ICES is furthermore asked to inform NEAFC on alternative or additional measures to the currently adopted encounter thresholds and move-on-rule, especially technical measures, that may reduce the risk of encounters with VME indicators.

WGDEC response

Every effort should be made to avoid fishing with bottom-touching trawls or bottom-set longlines in areas where there is a high likelihood of encountering VME indicators.

Current NEAFC measures, while appropriate for some existing fishing areas that exploit generally sedimentary seabed habitats, are considered inappropriate for fisheries operating in rugged terrain (e.g., seamount summits and edges, canyons, and rocky outcrops) where the densities and distribution patterns of VME indicators are poorly known.

Additional measures should facilitate enhanced precision in recording encounters and/or reduced likelihood of encounters. This is especially important in exploratory fisheries in 'new fishing areas' but remains relevant in 'existing fishing areas'. Lessening the risk of significant adverse impact can be achieved either by the use of fishing gear that reduces the extent of bottom contact, or by restricting the use of bottom-contact gears in certain areas where the likelihood of encounters is high. In the NEAFC regulatory area, fisheries are conducted mainly by trawls and longlines, and it is important to try to reduce bottom contact in both these gear types.

Minimizing gear impacts

Closely monitored bathypelagic trawling (just above the seabed) should be encouraged as an alternative to traditional bottom trawling whenever feasible. There may also be potential to design trawl doors/otter boards that have a reduced bottom contact or have a lower impact. Reduction in sweep length (wire between trawl doors and net) may also be a means of lessening the area impacted by the gear. WGDEC suggest that the question would benefit from consideration by the ICES Working Group on Fishing Technology and Fish Behaviour (WGFTFB).

While the impacts of longline fishing on VMEs are considered minor compared with those from traditional bottom trawling, longlines also have bycatch of VME indicators that can be cumulatively significant. Effort should be made to reduce bycatches. A technological alternative is to deploy vertically suspended longlines that are attached to the seabed with a single anchor. Vertical longlines are expected to have significantly less bycatch of VME indicators than bottom-set longlines.

High-tech monitoring and mapping

Virtually all vessels use advanced echosounders (and sometimes multibeam), gear geometry monitoring equipment, and advanced chart plotting software. In addition to the established requirement for VMS and logbook recording, it might be implemented as an additional requirement that vessels keep:

- Electronic records of bottom contact and exact tracks of individual tows -- at least in exploratory and seamount fisheries. This would facilitate documentation of occurrence of VME indicators at a relevant spatial scale, and document whether or not adverse impacts are occurring.
- Videos from individual tows and plotter tracks submitted together with catch and bycatch information would facilitate subsequent analyses of VME indicator records and assessments of whether or not a VME was encountered.

Taken together such information would provide strong evidence as to whether the fishery is having any significantly adverse impacts on VMEs.

In exploratory fisheries (in new fishing areas where observers are required) it is recommended to introduce pre-fishing mapping (ideally multibeam) as a requirement before the gear is deployed.

NEAFC may consider introducing some or all of these requirements in its 'Exploratory Bottom Fishing Protocol for New Bottom Fishing areas' and the 'VME Data Collection Protocol'. NEAFC might furthermore consider the utility of requiring a more extensive impact assessment requirement such as introduced in NAFO.

For those areas that have already been extensively mapped (mostly national efforts), it is strongly advised that data mapping fishing areas and associated VMSs be made available to vessels from all contracting parties.

Alternative management options for seamount fisheries

All seamount fisheries should be prepared to prove that their operations are not causing significant adverse impacts on VMEs through high-technology habitat mapping and fishery monitoring. Evidence should be provided that;

1) Current fishing practices are focused within existing trawled areas (based on logbooks, fishing tracks, etc.);

2) These areas are mapped precisely (sonar/multibeam data) at a fine spatial resolution);

3) These areas do not contain VMEs (net-mounted camera evidence

4) Vessels have the technology and experience to keep their fishery precisely within the existing fishery footprint (gear monitoring sensors, skipper's experience).

If a VME encounter occurs, regardless, there may be no alternative but for that vessel to move off that seamount and a temporary closure be enforced.

RGVME comment(s)

- RGVME agrees with these proposals. To further minimize impacts, more emphasis should be placed on establishing of a network of no-take zones where fishing is completely prohibited. Additional mechanisms to improve enforcement and ensure that fishing prohibitions are adhered to should be proposed.
- WGDEC provides an excellent account of alternative methods/approaches which can be used relative to thresholds and move on rules. Their emphasis on mitigation, avoidance, and thorough pre-planning of fishing trips to minimize impact on VMEs provides a good basis for advice issued from this request.

e) Identifying vulnerable marine ecosystems

ICES is furthermore asked, using the best available scientific information including bio-geographic information, to identify in the NEAFC Regulatory Area:

- Areas where VMEs do not occur;
- Areas where VMEs are not likely to occur;
- Areas where VMEs are likely to occur;
- Areas where VMEs are known to occur.

WGDEC response

The majority of VMEs are considered to be patchily distributed (aggregated in space) as they tend to be found in association with particular physical, environmental and hydrographical conditions and geological or topographic features. This is likely to apply to VMEs such as cold-water coral reefs, deep-sea sponge aggregations, and hydrothermal vents -- although conditions will vary regionally.

Variable certainty of different information sources

Information on the presence and absence of VMEs derives from a number of sources including visual surveys, trawl bycatch, fishing effort analyses, geo-physical surveys and predictive habitat models. Each of these data sources has its strengths and weaknesses in addressing these questions. It is important to appreciate both the degree of certainty that can be ascribed to each information source and the appropriate geographical scale that the information is most meaningful to managers (Figure 18):

- Visual surveys (drop camera, ROV observation, submersible, towed camera) are the most reliable source of information for the absence of VMEs, although the areal coverage in such surveys tends to be small. If large areas can be covered, for example, by using towed video cameras, a survey design may be possible in which interpolation across broader areas becomes possible.
- Trawl bycatch data are a less reliable source of absence data due to the fact that trawls are designed to catch fish not fragile, benthic organisms. Nevertheless a large number of tows in the same area that have zero bycatch can be taken as evidence of absence.
- Fishing effort analyses can be used an indirect method to infer the likelihood of absence of VMEs. If an area has been systematically trawled for many years it may be fairly safe to assume that either no VMEs were ever present, or that if they were present they have by now been destroyed. However, this cannot be taken as certain, unless the data are resolved to a geographical scale fine enough to assess precisely whether enough ground was left unimpacted to allow some remnants of VME to persist.

Geophysical surveys, such as side-scan sonar and backscatter analysis can potentially identify areas of VMEs at very fine scales as well as indicate where VMEs do not occur. Such information again tends to be on small geographic scales and while of use in delimiting local closure boundaries cannot give broad scale definition of areas where VMEs do not occur. Such information is only able to detect the presence of VMEs that sit above the seabed (such as *Lophelia* colonies or large sponges) but is unlikely to detect VMEs such as soft-bottom coral gardens.

Multibeam echosounder data from acoustic surveys are a rich source of information for seabed morphology, habitat mapping and classification. Seabed morphology has been shown to play a crucial role in the distribution of benthic biota in recent years.

Predictive habitat models or habitat suitability models (HSMs) have become an important new source of information in the debate over VMEs. At the global scale they are useful to identifying broad ocean-basin-scale areas where different types of VMEs are likely to occur. However, they currently are unable to discern fine scale features like small mounds, iceberg plough marks, small scours which are associated with presence of some VMEs. This is a critical shortfall because such fine scale features may combine at the regional scale to represent areas of greatest habitat significance.

Consideration was given to how the information sources above can in combination inform the four questions posed:

Areas where VMEs do not occur

Visual survey records showing non-occurrence of VMEs are available for some areas. Geophysical surveys -- using technology such as multibeam or side-scan sonar on automated submersibles -- can identify local areas that do not contain certain types of VMEs such as *Lophelia pertusa* reefs, however they cannot be expected to identify all types of VMEs, e.g. coral gardens; it is not of sufficient spatial resolution to provide conclusive evidence of a lack of VMEs. Trawl bycatch data as noted above cannot be considered to give an absolute assurance of absence of VME. Predictive habitat modelling can potentially identify areas where VMEs do not occur, but cannot give 100% assurance of absence of VME. However the new generation of terrain-based habitat models may be able to resolve habitat suitability at a geographical scale that will be useful to managing fisheries better with respect to VMEs. In sum there is unequivocal evidence for areas of seabed where no VMEs are present, but these areas tend be rather small in area due to limitations in surveying the deep sea.

Areas where VMEs are unlikely to occur

Output from habitat suitability modelling (HSM) is useful because it gives a high degree of certainty where corals do not occur. Trawl bycatch data can be used in conjunction with other sources to indicate potential absence of VMEs. Analysis of fishing effort patterns can also be informative; areas consistently trawled for many years are likely not to contain VME species. In combination these data sources can be used to infer where VMEs are unlikely to be found.

Areas where VMEs are likely to occur

Most records used to assess the presence of VMEs are in fact records of species that may indicate the presence of a VME, not an actual observation of a VME. Thus, most of the data used in scientific advice is actually most appropriately used to infer where VMEs are likely to occur. This applies to trawl-survey bycatch data, and often to visual surveys of occasional observations of VME indicator species. It is also the most appropriate inference to be taken from published predictive habitat models.

Areas where VMEs are known to occur

There are relatively few records of known occurrences of VMEs, relative to the amount of VME indicator species data. Only visual or geophysical surveys (and ideally a combination of the two) can unequivocally demonstrate the presence of a VME.

Conclusions

Many data indicate the presence of VMEs throughout much of the existing NEAFC regulatory area. Fewer data provide unequivocal evidence for areas that contain VMEs. Where there is strong evidence for the presence of VMEs, areas have been closed to bottom contact fishing. But, not all potential VME areas are protected. The amount of information needed to unequivocally demonstrate the presence of VMEs often requires multidisciplinary research with information from: multibeam, side-scan, geo-physical analysis; box-core sampling; visual surveys/ROV; habitat maps; and predictive models with confidence limits.

To be a useful tool to delineate VME boundaries, HSMs should be generated using terrain parameters derived from high resolution multibeam generated bathymetry. Given that multibeam data may often be collected by the fishing industry prior to fishing in areas of complex terrain, collection and sharing some additional bottom-trawl video/photographs from such areas could provide the basis for collaboration with habitat suitability modellers. The resulting topographic maps and predicted occurrence of VMEs could facilitate spatial zoning of safe areas to deploy fishing gears, and VME areas to be avoided.

RGVME comment(s)

Taking into account that VME indicators are primarily filter feeders, trends in levels of abundance in these communities must be viewed in association with bottom currents. Therefore, modelling these currents with consideration of bottom topography and other habitat descriptors like sediment type, habitat complexity, primary productivity in the water column, etc. could provide a powerful predictive tool.

Request 3: NAFO has produced a guide for identification of corals and sponges in the NAFO RA

ICES is asked to assess whether the NAFO coral and sponge guides are appropriate for use in the NEAFC area as on-board tools to identify and quantify VME indicator organisms as defined in the NEAFC bottom-fishing regulations. Furthermore, ICES is asked to advice on species that should be added to the guide, and species that are superfluous.

WGDEC response

The appropriateness of NAFO coral and sponge guides for use -- as on-board tools to identify and quantify VME indicator organisms -- in the NEAFC regulatory area depends largely on how similar the species composition is in these two areas.

How geographically specific is the coral fauna of the North Atlantic?

WGDEC assessed the similarity coral fauna across seven areas of the North Atlantic -- Norwegian Sea, Northeast Atlantic Banks, Mid-Atlantic Ridge, Atlantic Canada, eastern USA, Iberian offshore areas, and the Azores) using cluster analysis. Cluster patterns based on occurrence of corals strongly reflect known general bio-geographic patterns. Atlantic Canada and eastern USA represent two areas with high similarity of coral species. The Azores and Iberian offshore areas are grouped together and represent a bio-geographic province quite different from the others.

What species should be added or removed from the NAFO guide in order to make it useful for the NEAFC area?

WGDEC believes that a field-identification guide for non-experts should not include all species that may occur, but rather should focus on the most common and important species from a management point of view. They suggest that 33 species or higher taxa be included in a guide to help identify corals in the Rockall Plateau area; this selection is based on documented occurrences of species that are not as rare or difficult to identify. Thirteen of these species are also included in the NAFO guide. Ten species from the NAFO guide are not suggested for inclusion in the NEAFC guide for the Rockall/Hatton area -- based on lack of documented occurrences, and also to make the guide less confusing in cases of different species with similar characteristics (e.g. the genera *Isidella* and *Acanella* would be difficult to distinguish without examining morphological characteristics).

RGVME comment(s)

- A statement explaining the meaning of results from the cluster analysis, and what answer the results provide to the question posed in the request is not included.
- Was a similar cluster analysis conducted for sponges?
- In addition to similarities in species composition at bio-geographic scale, there may be patterns of variation in species composition and assemblage structure -- either specific or based on feeding strategies – which depend on habitat characteristics (i.e. depth, differences in substrata or turbidity, intensity the currents, biological productivity at the surface, etc.). Canonical analyses of assemblage composition and environmental conditions could be useful to associate indicator species to habitat and to detect changes due to impacts.
- RGVME agrees that too large a list of species is not useful when data must be recorded by non-specialists. In addition to the proposed species, perhaps it could be useful to include higher taxonomic levels corresponding to functional strategies that could be used to indicate ecosystem health or functioning. For example, filter feeders vs. detritivores, top predators, etc.). This would further incorporate other species groups (sponges and corals) and could be useful to get a more accurate idea of the status and major differences between different VMEs.