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ICES Advisory Committee

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

20–24 March 2017

Copenhagen, Denmark

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International Council for the Exploration of the Sea
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Executive summary

On 20th March 2017, the joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), chaired by Neil Golding (UK) and attended by fourteen members (ten in person and four via WebEx video conferencing), met at ICES HQ, Copenhagen, to consider the Terms of Reference listed in Section 2.

WGDEC was requested to provide all new information on the distribution of vulnerable marine ecosystems (VMEs) in the North Atlantic. A total of 1193 new records were submitted through the ICES VME data call in 2017 and included within the ICES VME database; 44 for the NEAFC Regulatory Area (RA) and 1149 for the EEZs of ICES Member Countries. No records originated in the NAFO regulatory area. A substantial contribution of new information on VMEs was made by Iceland, with 949 VME indicator records submitted. With respect to new information relating to VMEs within the NEAFC RA, these records originated from two areas; the Hatton-Rockall Basin and Rockall Bank. There were three new observations of *bona fide* VME from the Hatton-Rockall Basin; a recommendation to extend the current Hatton-Rockall Basin bottom fishing closure was made. New VME indicator records were submitted for Rockall Bank; no recommendations were made to modify existing or recommend new closures.

For the first time, and for all areas considered by WGDEC, all records from the VME database were presented as outputs from the VME weighting system, showing the likelihood of VMEs being encountered on the seabed along with an associated confidence assessment.

A member of the ICES Working Group on Spatial Fisheries Data (WGSFD) worked with WGDEC and analysed NEAFC VMS data from 2016. Plots of fishing effort for mobile bottom contact gear and static gear are shown for key areas where vulnerable seabed habitats are known to exist. Separate plots have also been shown for those vessels with no gear type registered.

The process by which WGDEC considers new information on VMEs, identifies sensitive areas of the seabed, and if appropriate, proposes boundaries around these sensitive habitats has been outlined. A flow chart has been developed which neatly summarises the process from beginning to end.

WGDEC undertook an extensive review looking at the current understanding and knowledge of the connectivity of deep-sea populations, with a view to the management of deep-sea ecosystems.

WGDEC commenced the development of a ‘road map’ to start exploring the concepts and outline the process for evaluating Good Environmental Status (GES) under the Marine Strategy Framework Directive. Work will continue during WGDEC 2018.

Finally, WGDEC reported on the distribution of VME indicators and habitats with the Haddock Box closure, as well as reviewing the appropriateness of NEAFC bottom fishing closures defined in Annex 2 of NEAFC Regulation 19:2014. All closures were considered appropriate, but WGDEC stressed that this may be subject to change as new information on VME distribution comes to light in future.

1 Opening of the meeting

The Working Group on Deep-water Ecology (WGDEC) commenced at 09:30 on Monday 20th March 2017 in plenary. The lead(s) for each Terms of Reference were appointed, and are outlined below:

- ToR [a] lead: James Albrecht
- ToR [b] leads: Telmo Morato and Covadonga Orejas
- ToR [c] leads: James Albrecht and Steinunn Ólafsdóttir
- ToR [d] lead: Laura Robson
- ToR [e] leads: Kerry Howell and Anna Metaxas
- ToR [f] lead: Francis Neat
- ToR [g] lead: Francis Neat

Following the review and adoption of the agenda, the WGDEC began working through the Terms of Reference. Each ToR lead outlined how they intended to tackle the ToR, and led the discussion. Dedicated plenary sessions were held every morning and afternoon; these were via WebEx allowing remote participants to participate. During these plenary sessions, ToR leads updated the group with progress and issues were discussed. Remote participants could comment on working documents via the WGDEC SharePoint site. At the end of the week, the Working Group was formally closed at midday on Friday 24th March 2017 by the Chair.

2 Adoption of the agenda

WGDEC – ICES/NAFO Joint Working Group on Deep-water Ecology

2016/2/ACOM26 The **Working Group on Deep-water Ecology** (WGDEC), chaired by Neil Golding, UK, will meet at ICES HQ in Copenhagen, Denmark, 20-24 March 2017 to:

a) Provide all available new information on distribution of VMEs in the North Atlantic with a view to identifying potential new closures to bottom fisheries or revision of existing closures to bottom fisheries. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters;

b) Begin to explore how to best define Good Environmental Status (GES) for deep-sea habitats; in particular, commence a review on progress with indicator development for the deep sea;

c) Develop a flow chart capturing how and when different information layers (including but not exclusively geomorphology, bathymetry, VME indicator/habitat layers and buffer zones) are used in order to delineate bottom fishing closures used to manage impacts of fisheries on sensitive areas;

d) Explore the development of the ICES VME Database in order to better capture 'survey effort', particularly from those trawl records where no VME indicators were recorded (absence records);

e) Review our current understanding and knowledge of the connectivity of deep-sea populations, with a view to the management of deep-sea ecosystems.

f) Review and report on the distribution of VMEs (VME Indicators and Habitats) within the Rockall Bank Haddock Box

g) Review the appropriateness of NEAFC bottom fishing closures as defined in Annex 2 of NEAFC Recommendation 19:2014, and whether significant adverse impacts on VME are still considered likely in these areas.

WGDEC will report by 5 May 2017 to the attention of the ACOM Committee.

Supporting Information

Priority:	High as a Joint group with NAFO and is essential to providing information to help answer external requests
Scientific justification and relation to action plan:	a) This information and associated maps are required to meet 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." as well as part of the European Commission MoU request to "provide any new information regarding the impact of fisheries on. sensitive habitats. The location of newly discovered/mapped sensitive habitats is critical to these requests. It is essential that ICES/WG chair asks its Member Countries etc. to supply as much relevant information as they may have by one month in advance of the WGDEC meeting. Completion of this ToR will also be facilitated by the completion of a VME Data Call by the ICES Data Centre during 2016; b) Understanding and defining Good Environmental Status is a core concept of the Marine Strategy Framework Directive. While much effort has been concentrated on shelf seas, including indicator development, further work on deep-sea ecosystems is required. In particular, this ToR will focus on reviewing the progress made to date with deep-sea indicator development – the focus of a number of European funded projects. c) Continuing on from work undertaken in WGDEC 2016 (ToR (b)), additional work is required to demonstrate a clear process for delineating bottom fishing closures to manage sensitive areas, such as through a flow chart. The importance of this clear process was highlighted by the VME review group and Advice Drafting Group. d) The ICES VME database, as it currently stands, provides an effective mechanism for storing records of VME indicator and *bona fide* VME habitat. However, WGDEC has not yet developed an effective way to store VME absence records. These absence records may be from trawl track records submitted by Working Group members, where no VME bycatch was recorded. Potential development of the VME database is required, or other mechanisms explored, to allow these VME absence records to be stored, so they can be utilised effectively in future. e) Research projects, with objectives focused on developing a better understanding of the connectivity of deep-sea populations, are currently in progress. The aim of this ToR is to review current literature and understanding (including new knowledge being generated through this research) to allow a better understanding of the connectivity of deep-sea ecosystems. This understanding is essential when considering areas of the deep sea (containing VMEs for example) to be being managed from potentially damaging activities. f) In 2015, evidence was found that bottom-towed gears were being used inside the area on Rockall Bank closed to fishing (https://www.neafc.org/system/files/Rec2_Haddock.pdf). ICES has previously noted that this area contains VMEs/VME indicators but no boundary within the haddock box has ever been proposed to cover an area that might be closed for habitat reasons. This ToR will enable ICES to advise the EU and NEAFC on the location of VMEs/VME indicators in this area. g) TOR g will assist NEAFC in 2017 to review the appropriateness of bottom fishing closures. The NEAFC Recommendation 19:2014 on the protection of vulnerable marine ecosystems in the NEAFC Regulatory Area includes regulations prohibiting bottom fishing activities in the following areas according to Article 5, within the coordinates as defined in Annex 2 of that Recommendation: (a) Northern MAR Area;

	(b) Middle MAR Area (Charlie-Gibbs Fracture Zone and subpolar Frontal Region); (c) Southern MAR Area; (d) Altair Seamount; (e) Antialtair Seamount; (f) Hatton Bank 1; (g) Rockall Bank; (h) Logachev Mounds; (i) West Rockall Mounds; (j) Edora's bank; (k) Southwest Rockall Bank; (l) Hatton-Rockall Basin; and (m) Hatton Bank 2. ICES has been requested to consider whether significant adverse impacts on VME are still considered likely in the closed subareas (a) – (i) and (k) – (m). According to Article 10, second paragraph the closures (a) – (i) and (k) – (m) shall be in force until 31 December 2017. Before that time, the measure shall be reviewed by NEAFC with the intention of extending the period that the closures are in force, unless the conclusion of the review is that the continued application of the measure or parts of the measure is not required. It is noted that the closures to be reviewed were implemented on the basis of previous ICES advice confirming that they would be appropriate and protect VMEs from significant adverse impacts. It is assumed that any new advice on modifications or advice on additional closures relevant to Rec. 19:2014 will be provided as responses to the recurrent request for scientific advice.
Resource requirements:	Support will be required from the Secretariat and the ICES Data Centre (with respect to maintenance of the ICES VME Database and VME Data Call)
Participants:	The Group is normally attended by some 15–20 members and guests.
Secretariat facilities:	None, apart from the SharePoint site
Financial:	No financial implications.
Linkages to ACOM and its expert groups	ACOM is parent group. WGDEEP and WGSFD is related, but no explicit overlap in work this year.
Linkages to SCICOM and its expert groups	No direct linkages, though in 2017, better linkages with WGMHM and BEWG will be explored
Linkages to other organisations:	OSPAR, NEAFC

3 Provide all available new information on distribution of VMEs in the North Atlantic with a view to identifying potential new closures to bottom fisheries or revision of existing closures to bottom fisheries. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters – ToR [a]

3.1 A note on Vulnerable Marine Ecosystem (VME) terminology used by WGDEC

WGDEC considers information relating to Vulnerable Marine Ecosystems (VMEs) in three ways;

1) 'VME habitat' records are those from visual survey data (e.g. remotely operated vehicle (ROV) or towed/drop camera seabed imagery) that demonstrates the presence and location of a VME with a high degree of confidence and spatial accuracy. VME habitats = VME (ICES, 2016a).

2) 'VME indicator' refers to records of VME indicator species from data sources for which there is a degree of uncertainty that a VME is, or was, present. Typical examples are trawl-survey or static longline bycatch records (ICES, 2016a).

3) 'VME element' refers to seabed topographic features, readily identified using high resolution multibeam data, and with which VMEs are often associated. Examples include seamounts, ridges, canyons (ICES, 2013a).

3.2 Background

A total of 1193 new records of Vulnerable Marine Ecosystem (VME) indicator species and VME habitats were submitted, via the ICES VME Data Call, to WGDEC in 2017, and these were incorporated into the ICES VME database. Of these, 44 records were located within the NEAFC Regulatory Area, composed of 41 VME indicator and three VME habitat records. The remainder 1149 records were located within the Exclusive Economic Zones (EEZs) of ICES member states, composed of 1140 VME indicator records and nine VME habitat records. No new records originated from within the NAFO Regulatory Area.

As the ICES VME database has expanded considerably over the last few years, it is no longer considered feasible to present existing VME data alongside newly submitted VME data on the maps within this section, primarily from a clarity perspective. However, for the first time in WGDEC, maps of existing VME data for each area considered are shown as outputs from the VME weighting algorithm as a separate series of maps.

The VME weighting algorithm generates a VME Index layer, which takes the form of a 0.05 x 0.05 degree c-square grid, and shows the likelihood of encountering a VME in each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), from seabed imagery, were presented as such, and were excluded from the VME weighting algorithm. In addition to the VME Index layer, a confidence layer is also displayed. This confidence layer takes into account aspects such as survey methodology, number of surveys and age of records. High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black. Further information regarding the VME Weighting Algorithm developed by WGDEC can be found in previous Working Group reports (ICES, 2015; ICES, 2016a)

3.3 Data providers for ToR [a]

New records of VME indicators/habitats were submitted via the ICES VME Data Call to WGDEC by the following ICES Member Countries (organisations/affiliations in brackets).

3.3.1 United Kingdom (Marine Scotland)

Marine Scotland submitted information relating to VMEs from two fisheries research trawl surveys (0416S, 1216S) (utilising a Jackson BT 184 bottom trawl with groundgear bag nets) and two habitat surveys (0915S, 1316S,) for several areas in Scottish offshore waters. These two latter habitat surveys utilised seabed imagery visual survey (towed underwater camera) and Agassiz benthic sampling trawl methodologies. From the fisheries research trawl surveys, 166 VME indicator records were submitted to ICES (Table 3.1). From the visual survey, seven records of VME habitat (deep-sea sponge aggregations and cold-water coral reefs) were submitted (Table 3.2).

Table 3.1. Summary of VME indicator records from trawl bycatch submitted by Marine Scotland

VME INDICATOR	NUMBER OF RECORDS
Black coral	3
Gorgonian	8
Cup coral	15
Seapen	37
Sponge	76
Soft coral	5
Stony coral	22
Total	166

Table 3.2. Summary of VME habitat records submitted by Marine Scotland.

VME	NUMBER OF RECORDS
Deep-sea Sponge Aggregation	6
Cold-water coral reef	1
Total	7

Most of the VME indicators records were small numbers, low weights and no records were above NEAFC thresholds. There were some more notable records, however; bycatch of seapens in one case was 130 individuals, even if the weight was only 4 kg.

The VME habitats were observed from Marine Scotland surveys in four areas; Rockall bank (Section 3.4.1.1 and 3.4.2.1), The Ymir ridge (Section 3.4.2.2), Rosemary Bank (Section 3.4.2.6) and the Hatton-Rockall Basin (Section 3.4.1.2).

3.3.2 United Kingdom (Deep Links research project[1])

The Joint Nature Conservation Committee (JNCC), on behalf of the NERC funded DeepLinks project partners (University of Plymouth, University of Oxford and British Geological Survey), submitted records of VME habitats (Table 3.3) observed on high definition video from remotely operated vehicle (ROV) transects, on survey JC136, from three areas: George Bligh Bank (Section 3.4.2.4), Anton Dohrn Seamount (Section 3.4.2.5) and Rosemary Bank (Section 3.4.2.6). These are preliminary observations from the survey (Howell *et al.*, 2016), with further records being submitted next year following a detailed video analysis which is currently ongoing for these data.

Table 3.3. Summary of VME habitat records submitted by the JNCC on behalf of DeepLinks project partners.

VME	Number of records
Cold-water coral reef	2
Coral Garden	3
Total	5

3.3.3 Ireland (Marine Institute)

Information on VME indicators from two fisheries stock assessment survey programmes were submitted by the Marine Institute, Ireland (Table 3.4). This comprised four cruises: the Irish Ground Fish Survey (three surveys from 2014 through to 2016) and the Irish Anglerfish and Megrim Survey (2016). Both of these annual surveys programmes collect demersal trawl and ancillary data in Irish waters to produce relative abundance indices for fisheries stock assessments. Both surveys use a semi-random stratified design with stations stratified by depth bands and ICES divisions, and are carried out on board the RV *Celtic Explorer*. The trawl used is a high headline “Grande Overture Verticale” (GOV 36/47), as is used throughout much of the shallow NE Atlantic shelf and North Sea areas within IBTS. A nylon 20 mm liner is used in the codend to retain juvenile fish. The trawl is towed for 30 min at 4 knots ensuring good consistent contact with the seabed. As far as is practicable, a minimum of 10 nautical miles is maintained between hauls to avoid repeat sampling of the same fish assemblage; the maximum depth trawled is 1000m. The Irish Groundfish Survey forms part of the International Bottom Trawl Survey (IBTS) programme, an international survey effort coordinated by ICES. Further survey details are available from the IBTSWG report (ICES, 2016b) or the national survey report (Stokes *et al*., 2014).

The bycatch of benthic species has routinely been recorded throughout both the above surveys’ time-series to the extent that resources and staff experience allow. The protocol involves sorting to as near species level as is practical prior to recording total weights and counts of individuals. Only those species/groups classed as VME indicators were included in the VME data call submission. These included small fragments of stony corals, sponges, seapens and anemones. In all cases amounts were below NEAFC catch thresholds (all below 1 kg). See Section 3.4.2.7 for details of record locations.

[1] https://deeplinksproject.wordpress.com/

Table 3.4. Summary of VME indicator records submitted by the Marine Institute.

VME INDICATOR	NUMBER OF RECORDS
Anemones	7
Cup coral	14
Seapen	28
Sponge	17
Total	66

3.3.4 Iceland (Marine and Freshwater Research Institute)

This is the first dataset submitted to the ICES VME database from the Icelandic EEZ area (Table 3.5). It is only a portion of the available data of VME indicator species for the Icelandic EEZ, and more data will be submitted in subsequent years.

The submitted data were collected by the Marine and Freshwater Research Institute (MFRI) during two surveys; B6-2004 and B9-2010 on the RV *Bjarni Sæmundsson*. The surveys targeted known cold-water coral areas, and were carried out as a part of an ongoing mapping project. The data from 2004 was obtained by a Mohawk remotely operated vehicle (ROV) while the data from 2010 was obtained using a Campod, a towed camera system; both collected high resolution video imagery. A positioning system was coupled to the ROV and Campod, providing accurate spatial positions for each record.

The video data were analysed for occurrences of corals, seapens, sponges and other fauna. VME Indicator species from the list provided in ICES (2016c) were extracted from the analysed dataset for this ICES VME data call submission. The submitted data include stony corals (*Madrepora oculata*, *Lophelia pertusa*), gorgonians (*Primnoa resedaeformis*, *Paramuricea* spp., *Paragorgia arborea*, *Acanella arbuscula*) and seapens (*Kophobelemnon stelliferum*, *Halipteris* sp., *Pennatula phosphorea*). See Section 3.4.2.8 for details of record locations.

Table 3.5. Summary of VME indicator records submitted by MFRI.

VME INDICATOR	NUMBER OF RECORDS
Gorgonian	42
Seapen	793
Stony coral	114
Total	949

3.4 Areas with new VME data in 2017

This chapter is split according to areas within the NEAFC Regulatory Area and those areas within the EEZs of EU countries and wider. There is no new information on VMEs from the NAFO Regulatory Area.

Areas considered within the NEAFC Regulatory Area:

- Rockall Bank
- Hatton-Rockall basin

Areas considered within the EEZs of various countries:

- Rockall Bank and the adjacent continental slope (UK)
- George Bligh Bank (UK)
- Anton Dohrn Seamount (UK)
- Rosemary Bank (UK)
- Ymir Ridge (UK)
- Faroe-Shetland Channel (UK)
- Irish Continental shelf (Ireland)
- Icelandic continental shelf (Iceland)

3.4.1 Areas considered within the NEAFC Regional Area

3.4.1.1 Rockall Bank

Rockall Bank is located off the west coast of Scotland and Ireland. The more gently sloping western side of the bank is located within the NEAFC regional area whereas the steeper, eastern side of the bank is within the EEZ of both the UK and Ireland.

In 2017, 41 new records of VME indicators were submitted from three Marine Scotland surveys (0416S, 0915S, 1216S) on the RV *Scotia*, from the area of Rockall Bank within the NEAFC Regulatory Area (Figure 3.1).

Figure 3.2 shows the outputs of the VME weighting algorithm for Rockall Bank (ICES, 2015; ICES, 2016a); note that all records from the VME database are included here. The algorithm has a gridded output layer, which shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), from seabed imagery, are presented as such, and were excluded from the VME weighting algorithm.

Figure 3.3 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.2. High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black.

Having reviewed the new information for Rockall Bank, WGDEC recommend that no changes are required to bottom fishing closures on Rockall Bank to protect vulnerable seabed habitats.

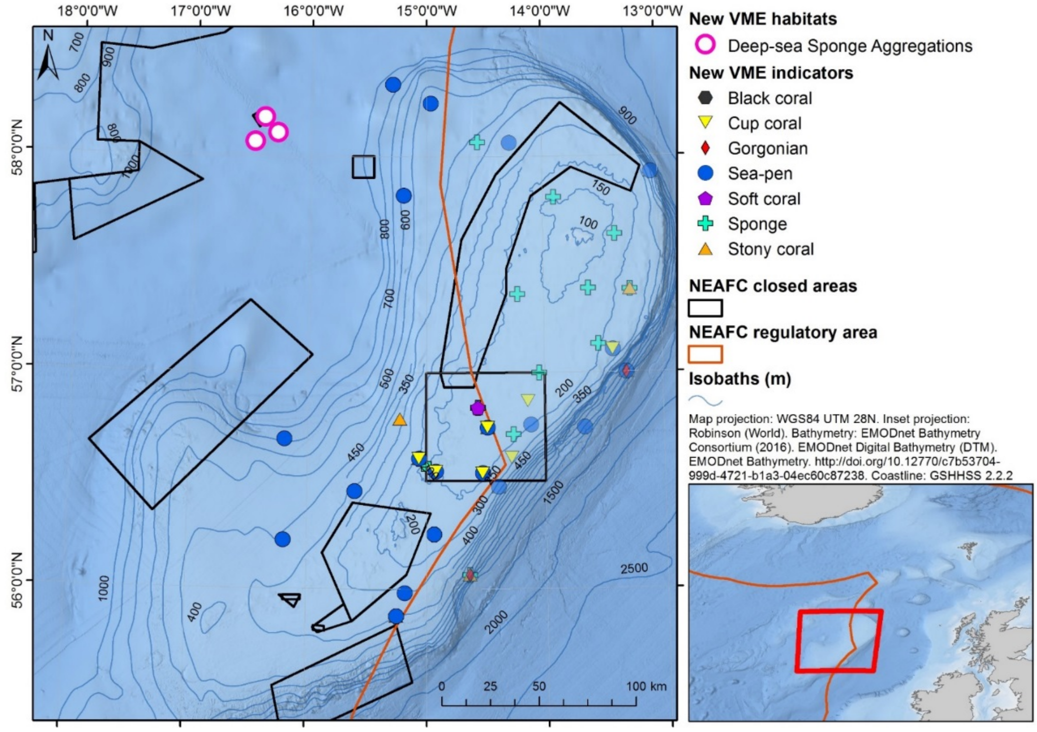

Figure 3.1. New VME indicator and VME habitat records submitted through the 2017 ICES VME data call for the Rockall Bank area within the NEAFC Regulatory Area (RA). Records also supplied through the 2017 data call, but outside the NEAFC RA, are displayed as transparent.

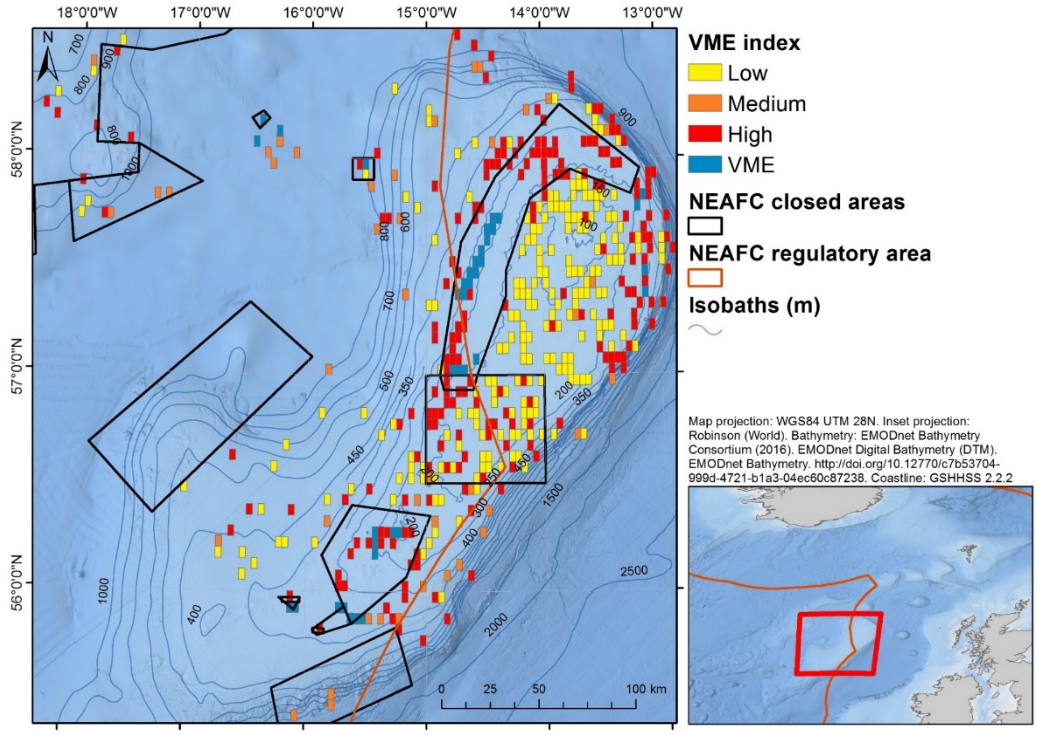

Figure 3.2. Output of the VME weighting algorithm for the Rockall Bank area, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

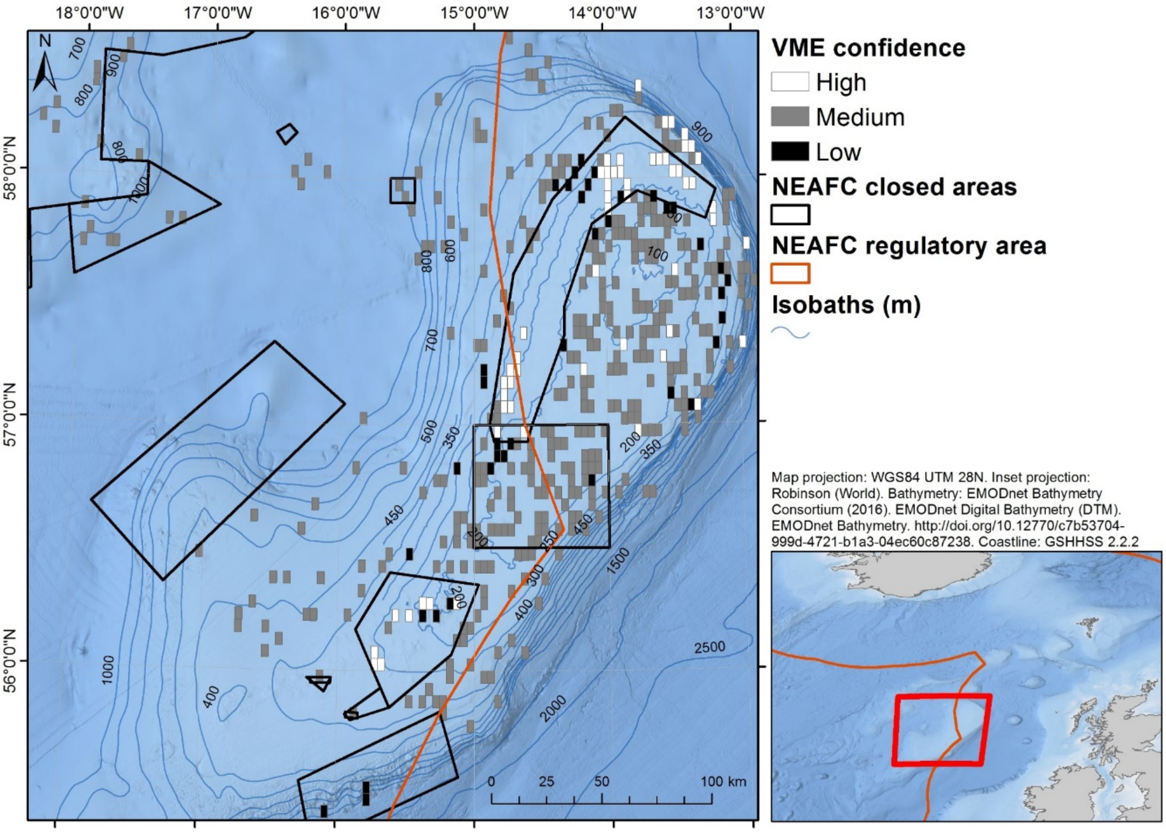

Figure 3.3. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.2). High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black. Note this includes all (not only 2017) records from the ICES VME database.

WGDEC recommendation summary: No change is necessary to the existing NEAFC bottom fishing closures on Rockall Bank, and no new bottom fishing closures are required on Rockall Bank.

3.4.1.2 Hatton-Rockall Basin

Hatton-Rockall Basin is located within the NEAFC Regulatory Area, between Rockall Bank and Hatton Bank. The basin has a wide, relatively flat base and there is evidence of polygonal faulting in the area which may be associated with hydrocarbon seeps (Berndt C. *et al.*, 2012).

Three new VME habitat records, in the form of soft-bottom deep-sea sponge aggregations, were recorded in the Hatton-Rockall Basin, at water depths of approximately 1200 m, on three, high resolution video, chariot tows conducted during Marine Scotland's 0915S survey (Figure 3.5). This included a mix of *Pheronema* spp. and *Hyalonema* spp. (stalked sponges) as well as unknown larger species (Figure 3.4). The deep-sea sponge aggregations were contiguous along the full length of the transects.

Figure 3.4. Observation (video freeze frame) of the deep-sea sponge aggregations in the Hatton-Rockall Basin. An unidentified large (estimated 30 cm) specimen of sponge (centre of image) among smaller species such as *Pheronema* spp. Red laser dot separation is 30 cm.

There is an existing NEAFC bottom fishing closure within the Hatton-Rockall Basin. However, this does not fully enclose the new records of VME (Figure 3.5). In light of these habitats being sensitive to the impacts of bottom fishing, WGDEC recommends that the current Hatton-Rockall Basin bottom fishing closure is extended to encompass the new records of VME. The boundary of the WGDEC recommendation was produced following the process outlined in ToR [c], and is summarised below:

1) New VME data and associated imagery was reviewed by WGDEC in plenary.

2) Consideration of additional layers such as bathymetry; location in a basin so no VME elements to consider.

3) Buffer zone applied around each video transect in line with ICES advice (ICES, 2013). These buffer zones considered two aspects:

   3.1) Positional accuracy of the record: the video chariot system used to identify the VME was towed approximately 1500 m behind the vessel.

   3.2) Warp length of bottom fishing vessels: ICES has previously advised that at depths greater than 500 m, a buffer of twice water depth should be used; the records were located in approximately 1200 m water depth.

4) Boundary drawn around the area of sensitive seabed habitat with a total buffer of 3900 m (1500 m + (2 x 1200 m)) (Figure 3.5). The coordinates for each vertex of the recommended closure are provided in Table 3.6.

Figure 3.6 shows the outputs of the VME weighting algorithm for Hatton-Rockall Basin; note that all records from the VME database are included here. This shows the likelihood of encountering a VME for each grid cell. Those grid cells containing *bona fide* records of VME habitat are shaded blue, and are excluded from the VME weighting algorithm. Figure 3.7 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.6. Medium confidence cells are shaded grey.

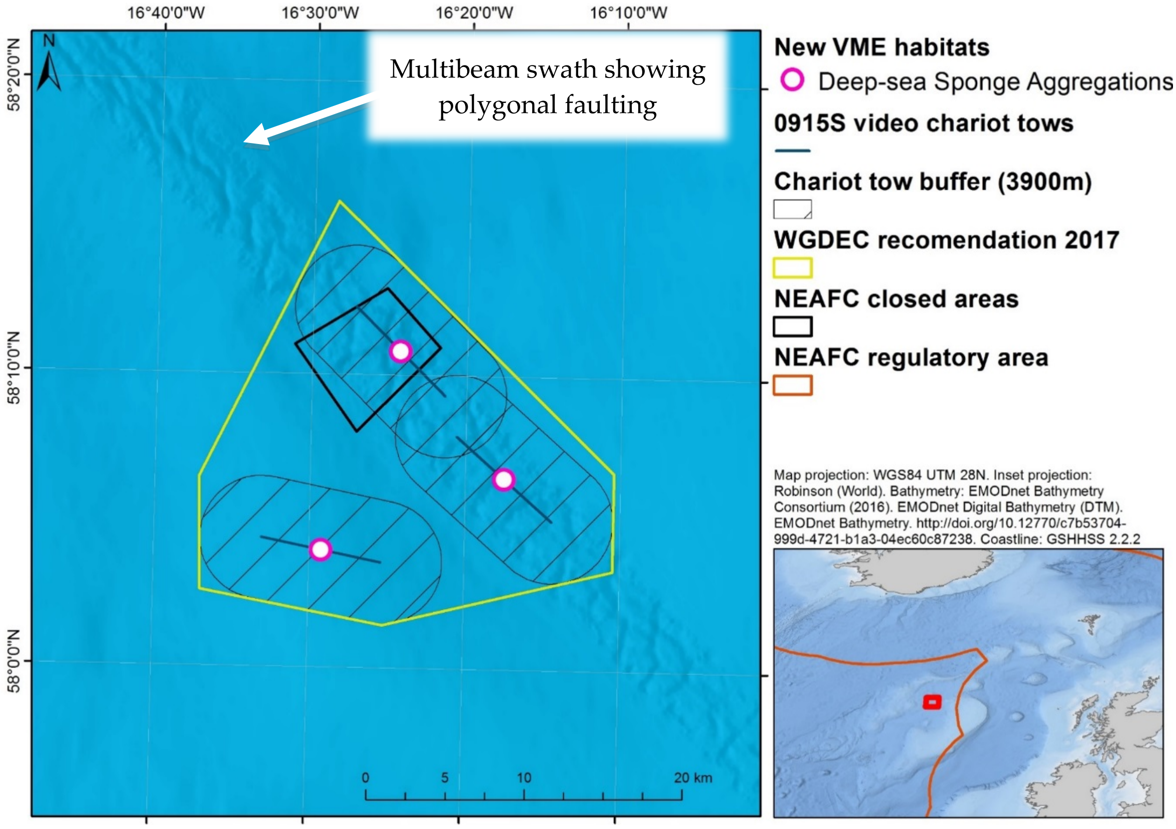

Figure 3.5. Location of new VME habitat records (deep-sea sponge aggregations), observed from underwater video transects. The existing Hatton-Rockall Basin closure is shown as black polygon. Grey lines show video transects. Yellow polygon is the WGDEC recommendation for extending the current closure to take account of new evidence of VME. Note the swathe of multibeam data in the base map, which shows evidence of polygonal faulting.

Table 3.6. The coordinates for each vertex of the proposed extended Hatton-Rockall Basin bottom fishing closure. Coordinates are shown in both decimal degrees (DD) and degrees, minutes and seconds (DMS).

Point	Latitude (DD)	Longitude (DD)	Latitude (DMS)	Longitude (DMS)
1	58.10772	-16.619213	58º 6' 27.792" N	16º 37' 9.167" W
2	58.265568	-16.474374	58º 15' 56.045" N	16º 28' 27.746" W
3	58.112869	-16.17333	58º 6' 46.328" N	16º 10' 23.988" W
4	58.05719	-16.173806	58º 3' 25.884" N	16º 10' 25.702" W
5	58.024825	-16.419742	58º 1' 29.370" N	16º 25' 11.071" W
6	58.043576	-16.615919	58º 2' 36.874" N	16º 36' 57.308" W

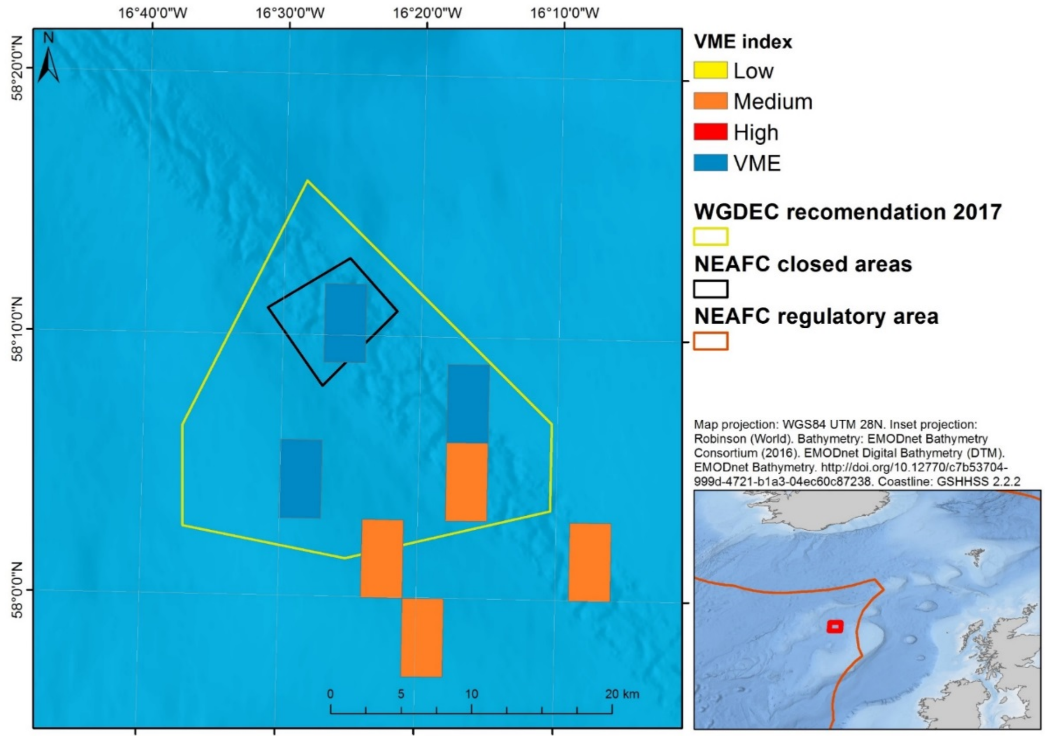

Figure 3.6. Output of the VME weighting algorithm for the Hatton-Rockall Basin area, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Blue cells indicate known VMEs. Note this includes all (not only 2017) records from the ICES VME database.

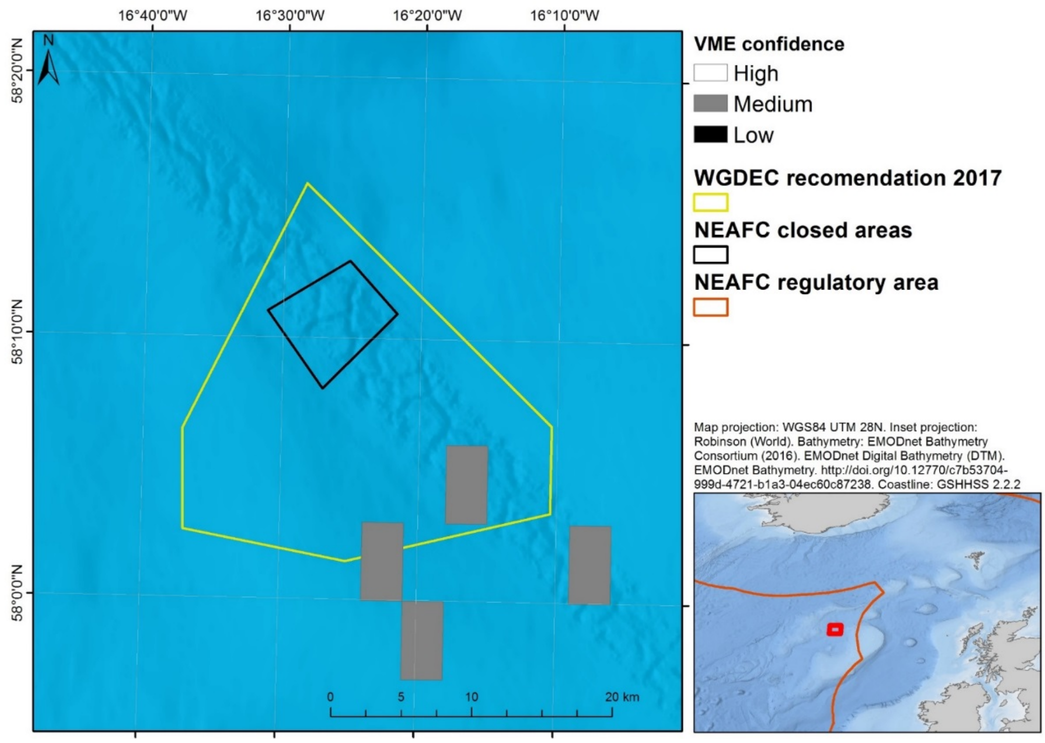

Figure 3.7. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.6). Medium confidence cells are shaded grey. Cells containing known VME fall outside the VME weighting algorithm, so are not assigned a confidence value.

WGDEC recommendation summary: An extension to the Hatton-Rockall Basin (Area l1) NEAFC closure to encompass new records of VME (deep-sea sponge aggregations).

3.4.2 Areas considered within the EEZs of various countries

3.4.2.1 Rockall Bank (UK and Ireland EEZ)

A total of 61 VME Indicator records were submitted, through the ICES VME data call, to WGDEC 2017 for the area of the Rockall Bank that sits within the EEZs of UK and Ireland (Figure 3.9). Additionally, one VME habitat record, a patchy *Solenosmilia variablis* cold-water coral reef was observed at a depth of 1500 m east of Rockall bank; it extended for 5 metres along-transect, and was located on a ridge feature, although it was not possible to estimate the cross-transect extent of the feature. From the field of view of the camera system, 10m^2 of reef feature was observed (Figure 3.8 and Figure 3.9). All the above VME indicator and habitat observations were made on Marine Scotland surveys (0416S, 1216S, 1316S).

15 of these new records, including the cold-water coral reef VME, are located within a draft fisheries management area around East Rockall Bank, which has been proposed by Scottish Government. This management area, shown as a purple polygon in Figure 3.9, would close the area to demersal fishing (Marine Scotland, 2017).

The outputs of the VME weighting algorithm for the Rockall Bank can be seen in Figure 3.10; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), from seabed imagery, are excluded from the VME weighting algorithm.

Figure 3.11 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.10. High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black.

Figure 3.8. Observation (video freeze frame) of a patchy *Solenosmilia variablis* reef at 1500 m east of Rockall Bank. Laser separation is 30 cm.

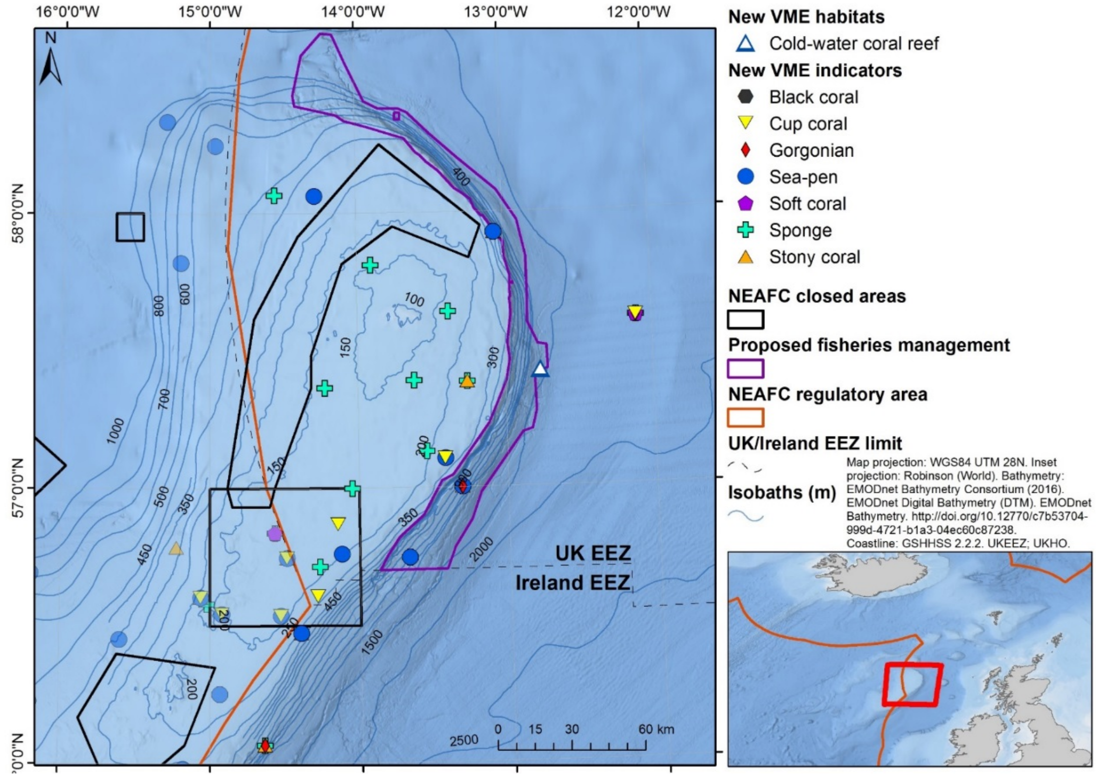

Figure 3.9. New VME indicator and VME habitat records submitted through the 2017 ICES VME data call for the Rockall Bank area within the EEZ's of the UK and Ireland. Records outside the EEZ of UK and Ireland are displayed as transparent.

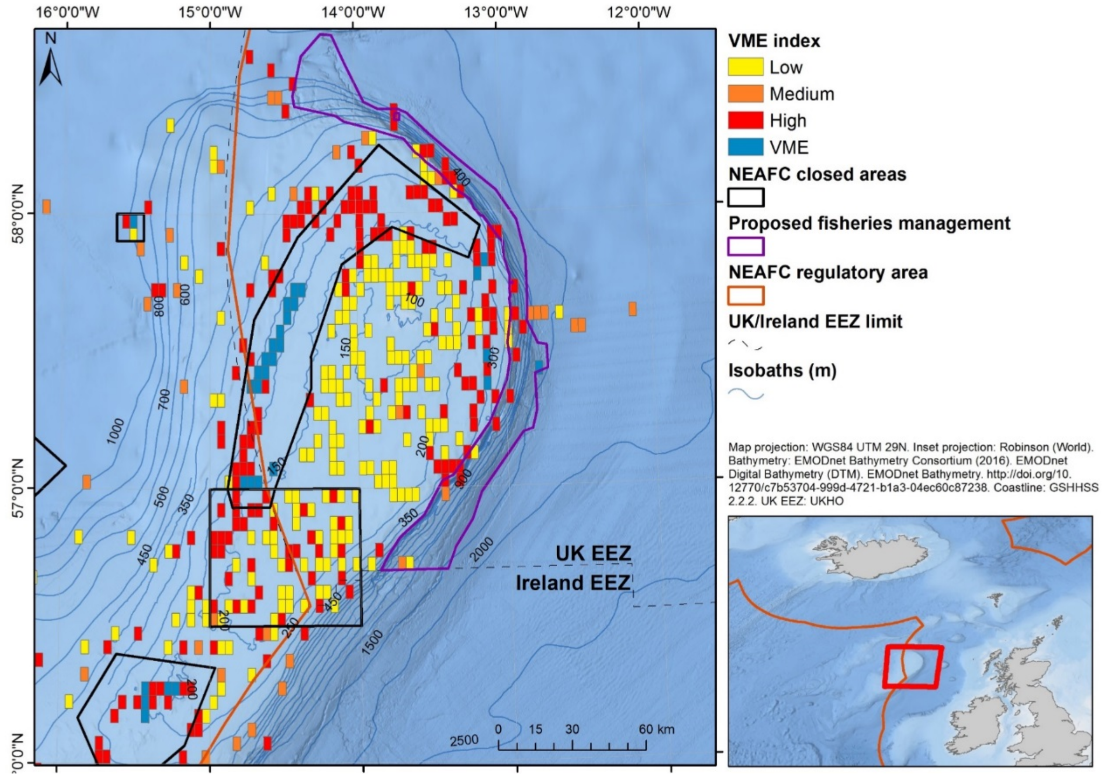

Figure 3.10. Output of the VME weighting algorithm for the Rockall Bank area, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

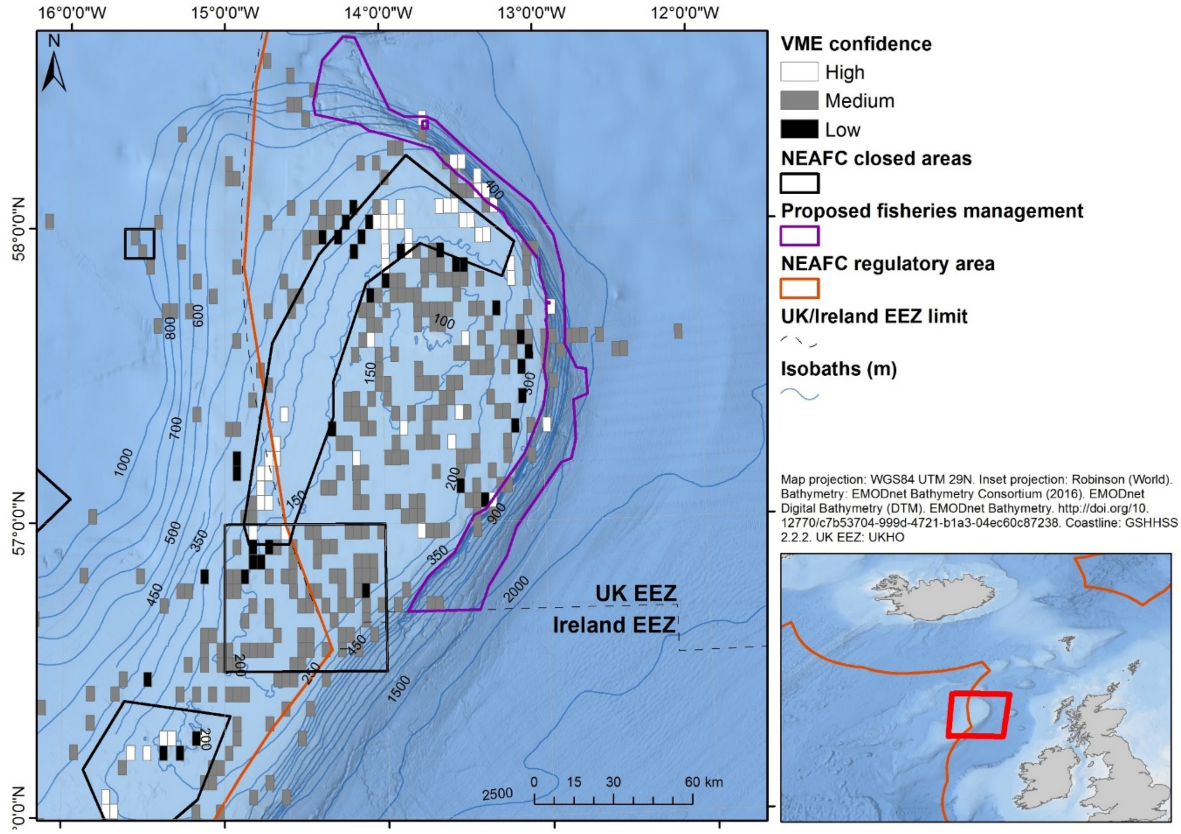

Figure 3.11. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.10) for the Rockall Bank area. High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black. Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.2 Ymir Ridge (UK)

The Ymir Ridge is located northwest of Scotland and spans the EEZ of two countries; the UK and the Faroe Islands (Denmark). However, all new records submitted to WGDEC in 2017 occur within the UK EEZ. Four new VME indicator records were submitted, from Marine Scotland's 0416S Anglerfish survey. In addition, a VME habitat (a hard bottom deep-sea sponge aggregation) was observed on a towed 'chariot' video transect, between depths of 800 m and 1100 m, during the 1316S Marine Scotland MOREDEEP II survey (Figure 3.12 and Figure 3.13).

The outputs of the VME weighting algorithm for the Ymir Ridge can be seen in Figure 3.14; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), from seabed imagery, are excluded from the VME weighting algorithm.

Figure 3.15 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.14. High confidence cells are shaded white and medium confidence cells are shaded grey.

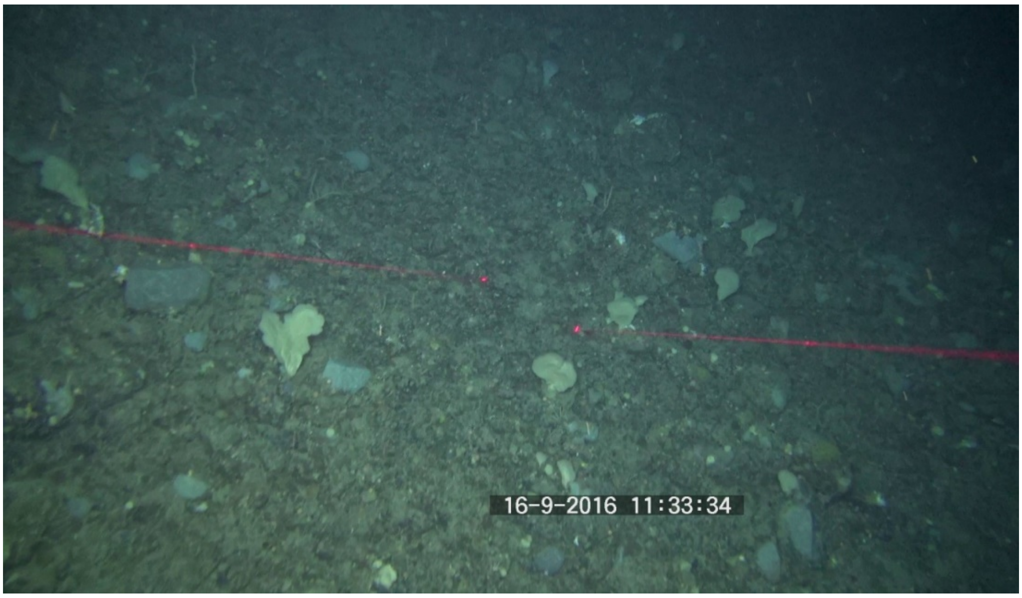

Figure 3.12. Observation (video freeze frame) of a VME (Hard bottom deep-sea sponge aggregations) from a towed video 'chariot' on the Ymir Ridge. Lasers are 30 cm apart.

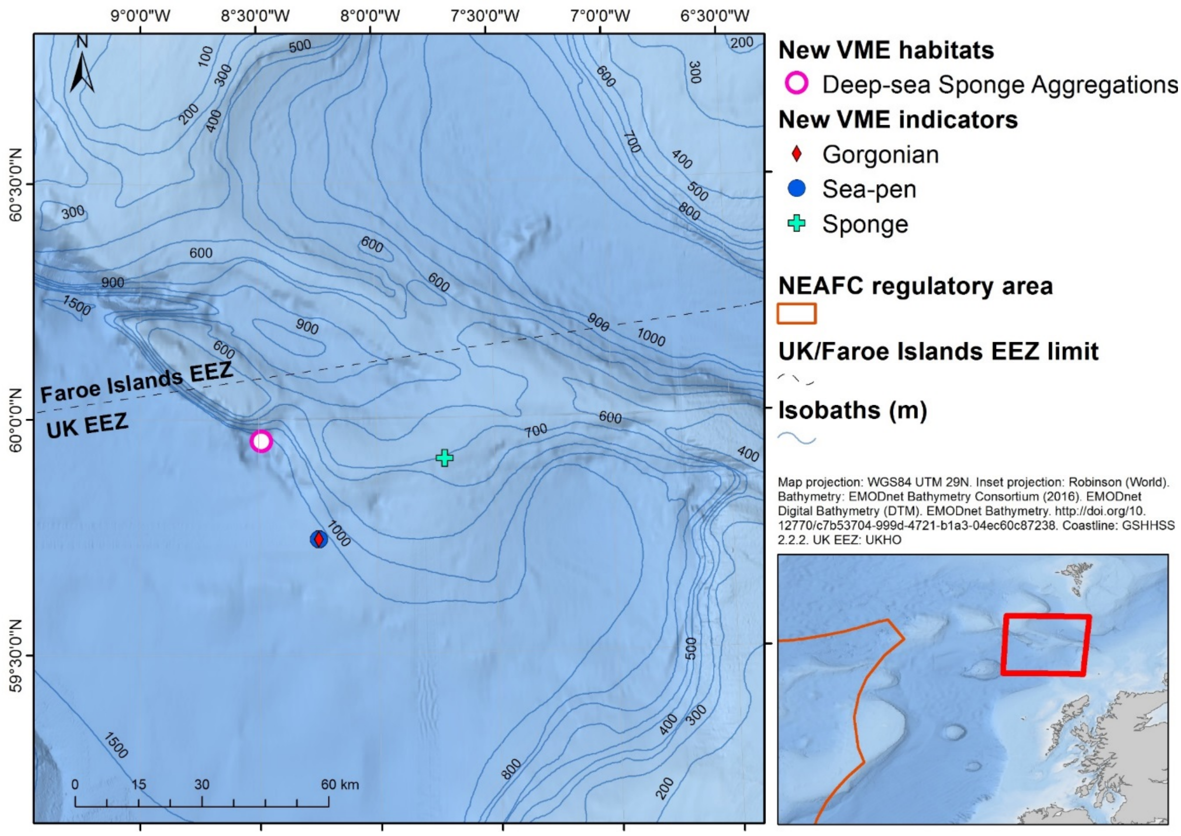

Figure 3.13. New VME indicator and VME habitat records submitted through the 2017 ICES VME data call for the Ymir Ridge, within the EEZ of the UK. Note that there are multiple (sponge, gorgonian and seapen) VME indicator records in one location on the map above, and only the latter two are visible (the sponge record is obscured).

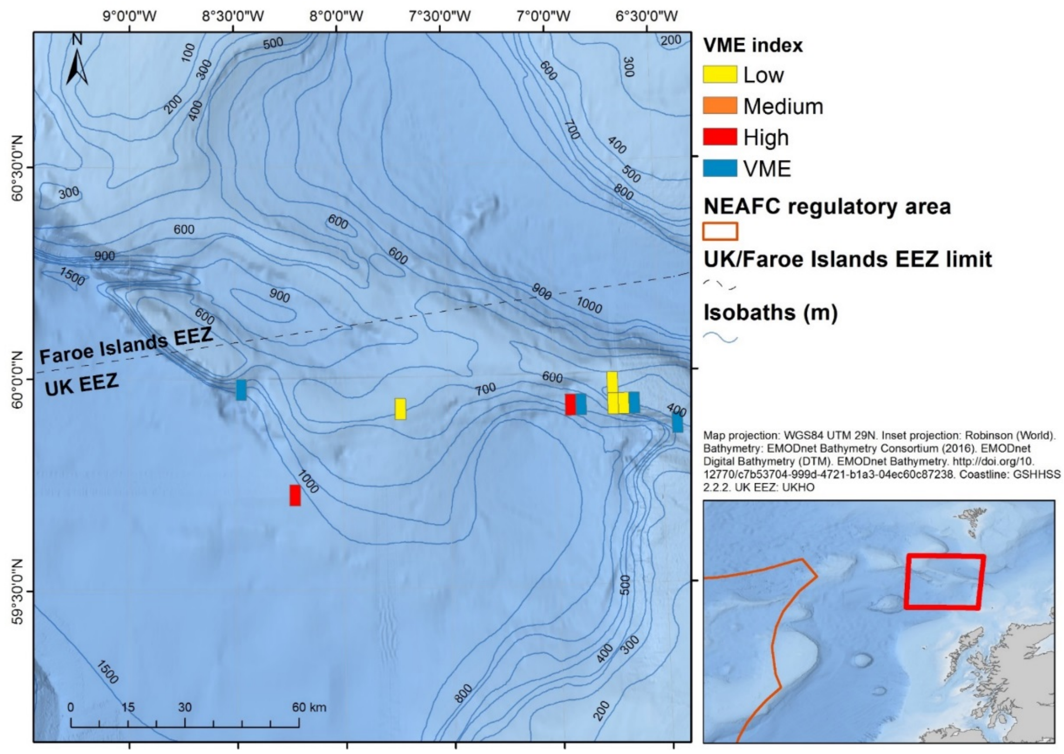

Figure 3.14. Output of the VME weighting algorithm for the Ymir Ridge area, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

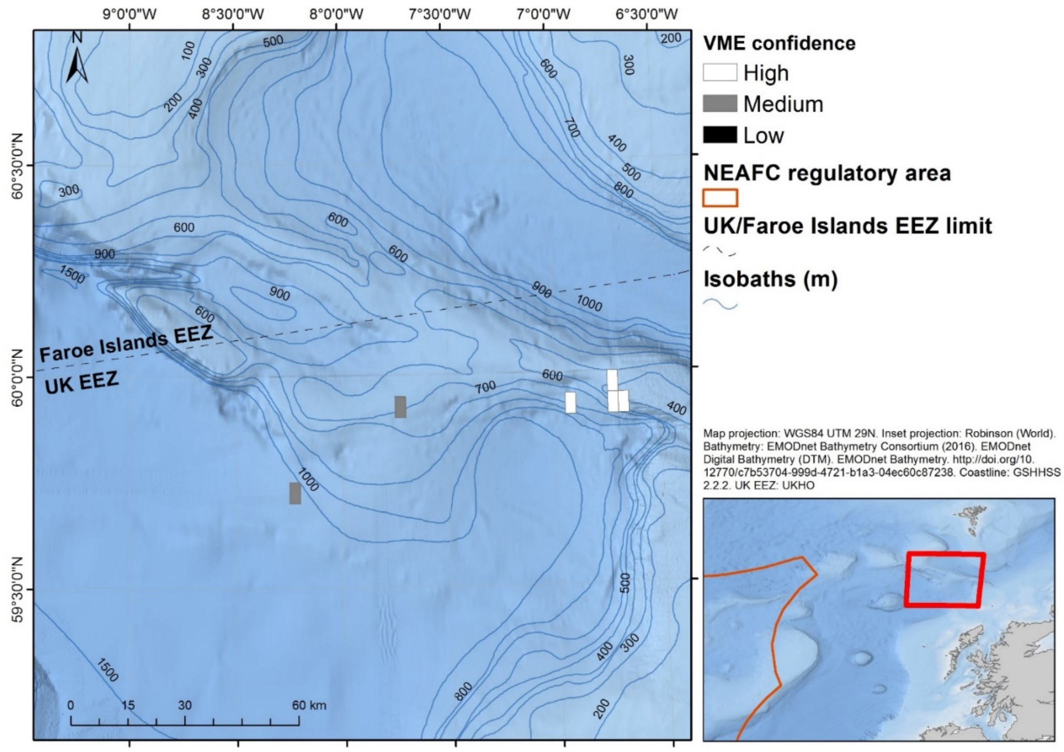

Figure 3.15. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.14) for the Ymir Ridge area. High confidence cells are shaded white and medium confidence cells are shaded grey. Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.3 Faroe-Shetland Channel (UK)

The Faroe-Shetland Channel is a deep channel located north of Scotland within the EEZ of two countries; UK and the Faroe Islands (Denmark). However, all new records submitted for this area occur within the UK EEZ. Six new VME indicators (a mix of sponge and soft coral) were submitted to WGDEC in 2017 for the Faroe-Shetland Channel (Figure 3.16). All six records were collected from the same single bottom trawl on the 1316S Marine Scotland MOREDEEP II survey.

The outputs of the VME weighting algorithm for the Faroe-Shetland Channel can be seen in Figure 3.17; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), are excluded from the VME weighting algorithm.

Figure 3.18 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.17. All cells shown are of medium confidence, and shaded grey.

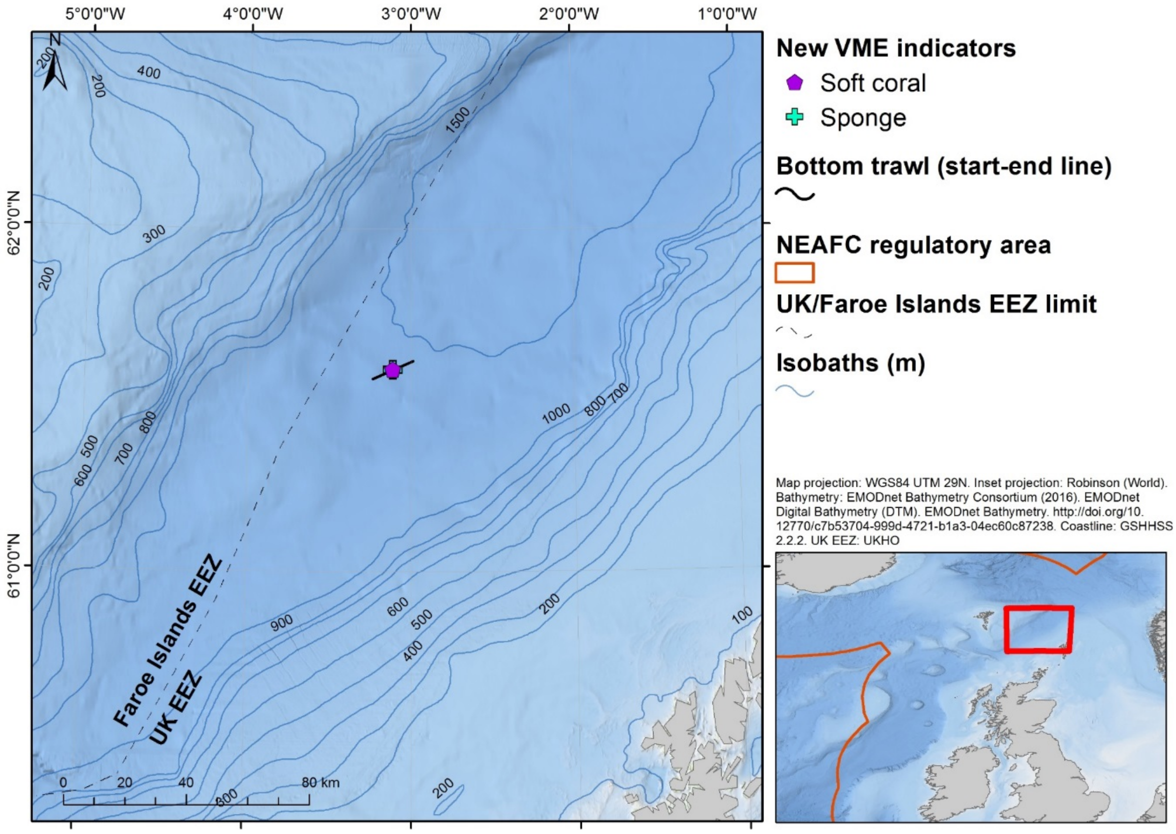

Figure 3.16. New VME indicator records submitted through the 2017 ICES VME data call for the Faroe-Shetland Channel area; a mix of soft coral and sponge VME indicator species. The short black line through the samples shows the trawl track.

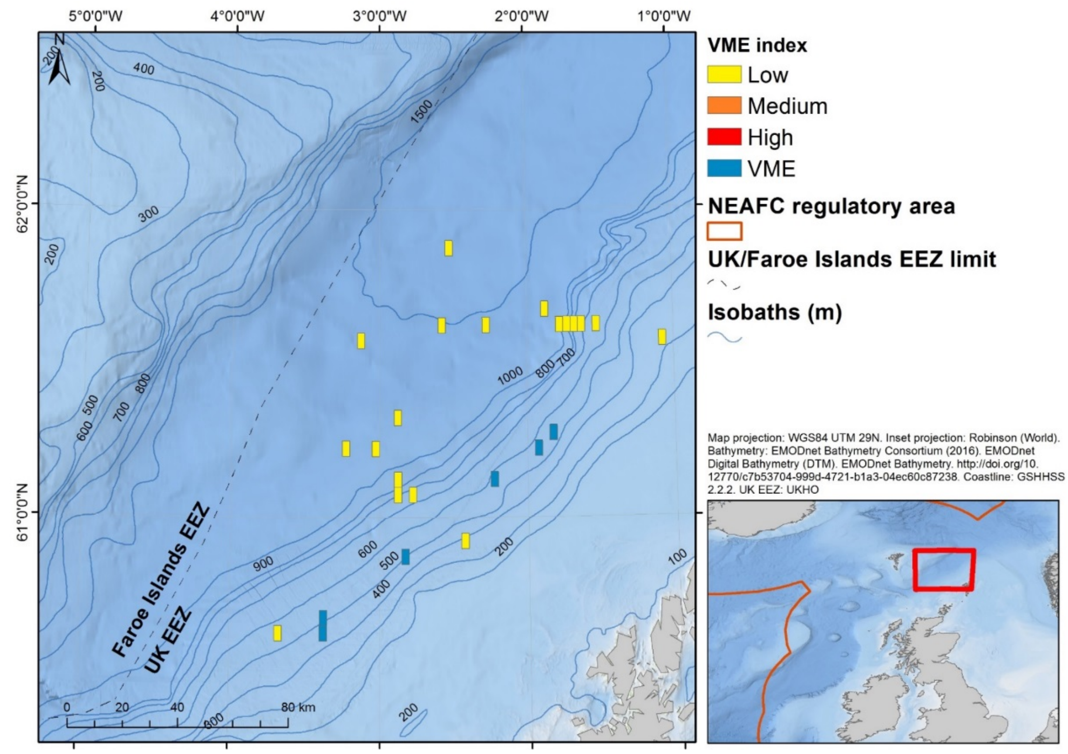

Figure 3.17. Output of the VME weighting algorithm for the Faroe-Shetland Channel area, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

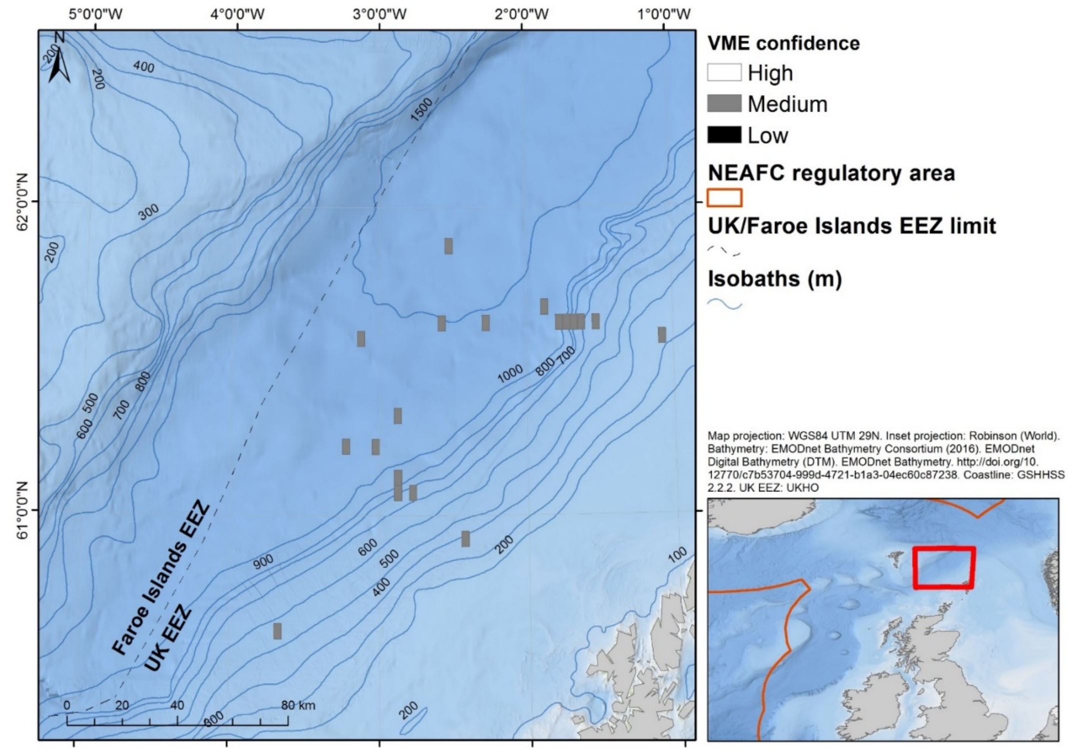

Figure 3.18. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.17) for the Faroe-Shetland Channel area. All cells shown are of medium confidence, and shaded grey. Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.4 George Bligh Bank (UK)

George Bligh Bank is located west of Scotland, within the UK's EEZ. One new VME habitat record (a coral garden) was submitted to WGDEC in 2017 for this area. The coral garden was observed associated with a steep slope on the flanks of George Bligh Bank at a depth of 1100 m, from high definition video footage captured using a remotely operated vehicle (ROV) on the RRS James Cook Deep Links (JC136) survey (Figure 3.19 and Figure 3.20). A variety of corals and sponges were observed at this site including the scleractinian *Solenosmilia variablis* and the bubble-gum coral *Paragorgia* spp. Analysis of these data are ongoing.

The outputs of the VME weighting algorithm for the George Bligh Bank can be seen in Figure 3.21; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), are excluded from the VME weighting algorithm.

Figure 3.22 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.21. Cells shown are either low confidence (shaded black) or medium confidence, and shaded grey.

Figure 3.19. Image from JC136 ROV Dive 292 at George Bligh Bank showing the VME, Hard-bottom coral garden, on rocky terrain with *Paragorgia* spp, dense patches of *Solenosmilia variabilis* and other coral and sponge species. © NERC funded Deep Links Project - Plymouth University, Oxford University, JNCC, BGS 2016.

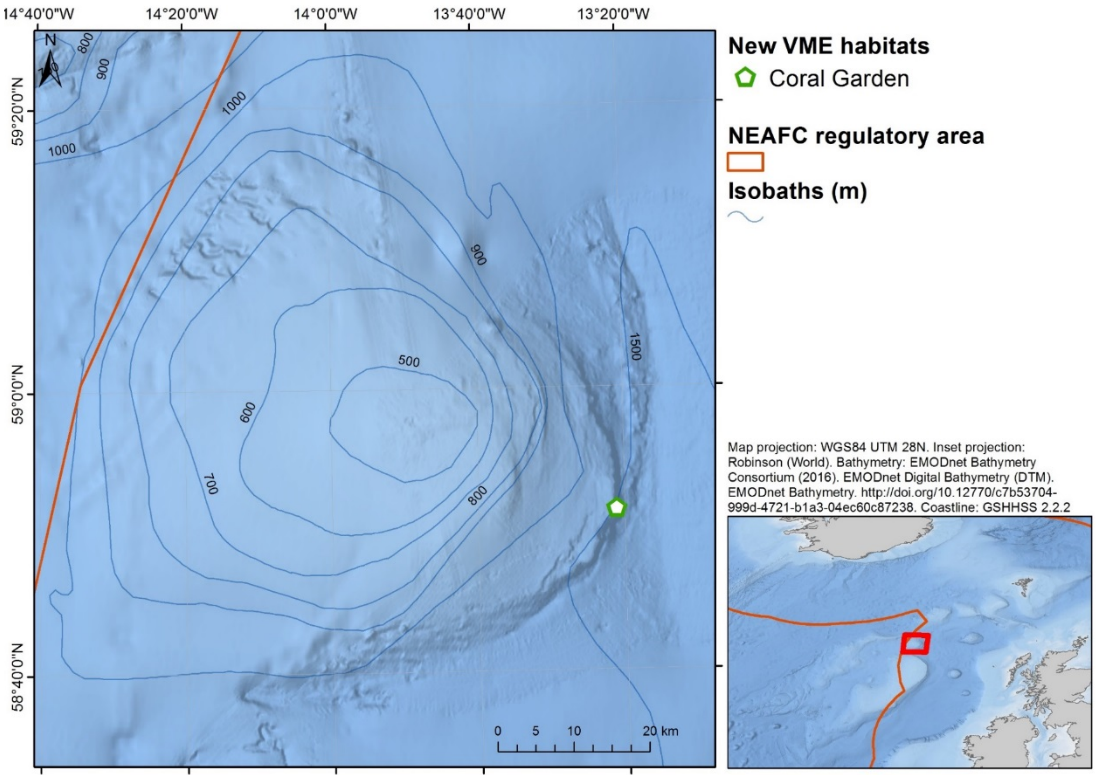

Figure 3.20. New VME habitat record (Hard-bottom coral garden) submitted through the 2017 ICES VME data call, for the George Bligh Bank area.

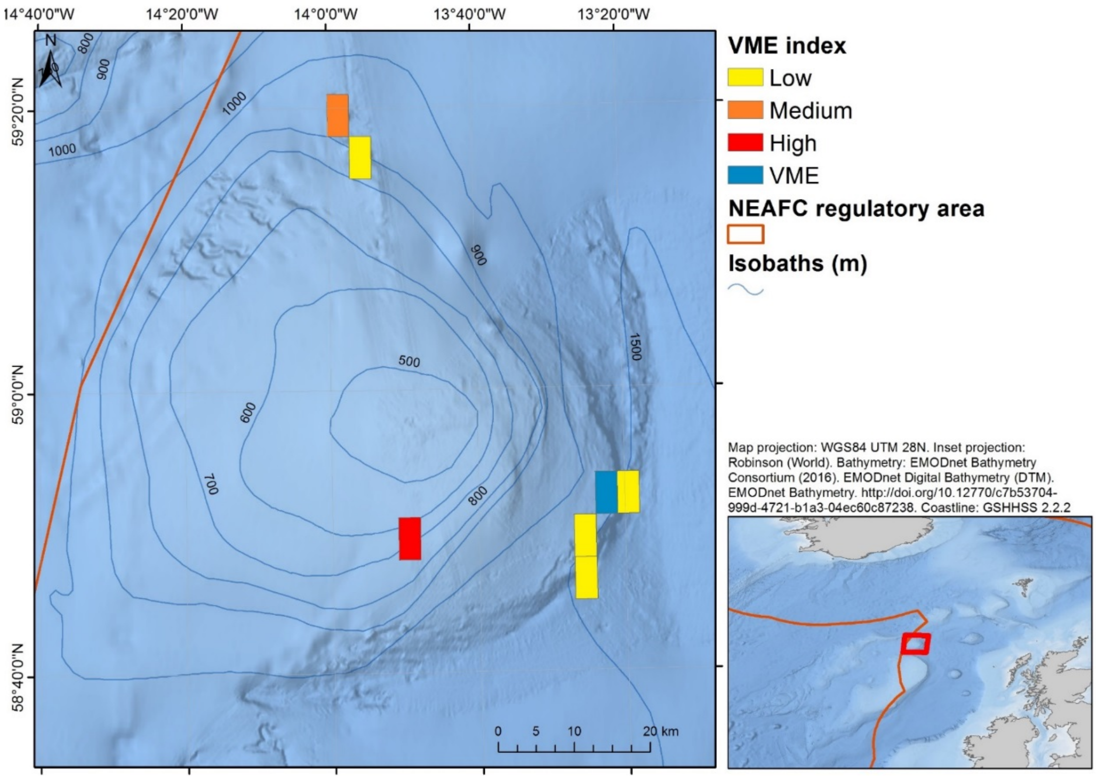

Figure 3.21. Output of the VME weighting algorithm for the George Bligh Bank area, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

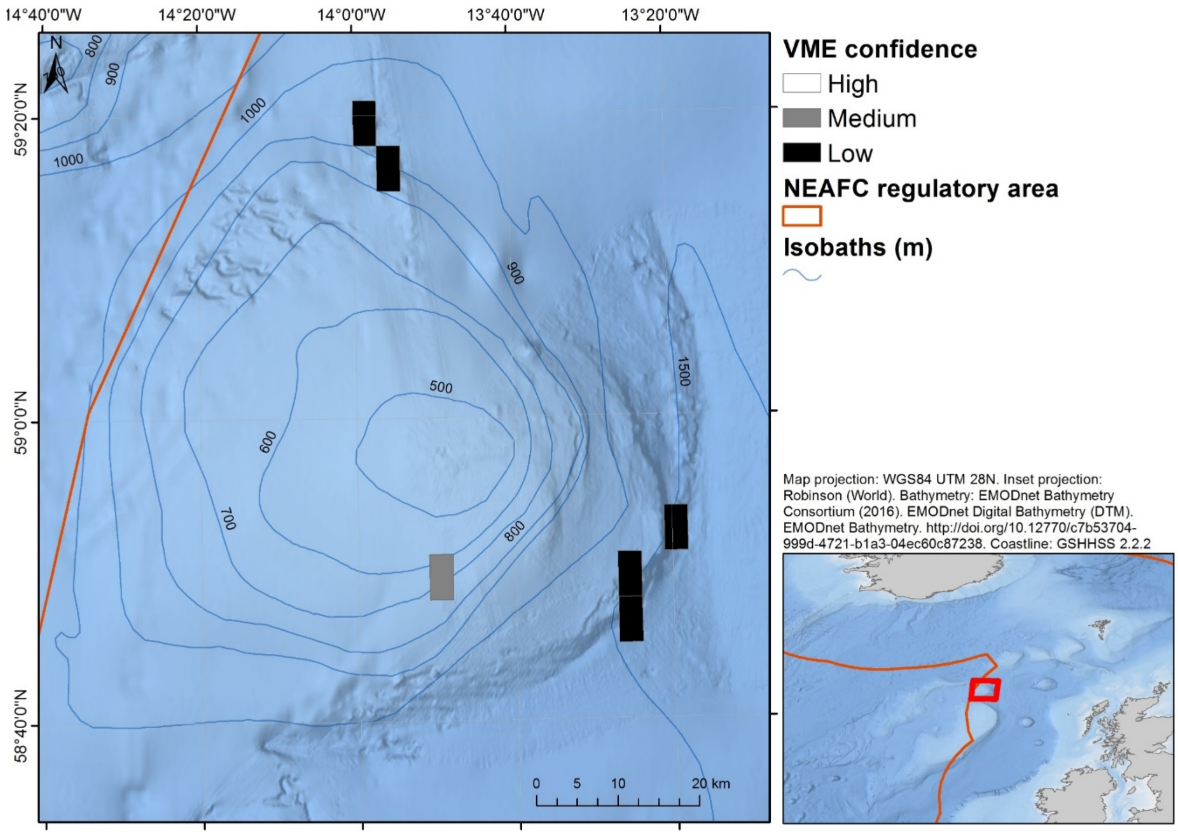

Figure 3.22. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.21) for the George Bligh Bank area. All cells shown are of medium confidence (shaded grey) or low confidence (shaded black). Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.5 Anton Dohrn Seamount (UK)

Anton Dohrn Seamount is located west of Scotland, within the UK's EEZ. A large *Lophelia pertusa* / *Madrepora oculata* cold-water coral reef was observed on the edge of Anton Dohrn Seamount summit, at 753 m water depth, using a remotely operated vehicle (ROV) capturing high definition video footage, deployed from the RRS James Cook on the Deep Links (JC136) research survey (Figure 3.23, Figure 3.24). Several mound features were visible on high resolution multibeam data, all of which were coral covered. In deeper water (1277 m water depth), a coral garden was also present on the flanks of the seamount. Analysis of these data are ongoing and more details of exact species composition will be provided in time.

These new records of VME on Anton Dohrn Seamount are located within a draft fisheries management area which has been proposed by Scottish Government (Marine Scotland, 2017, Figure 3.24).

The outputs of the VME weighting algorithm for Anton Dohrn Seamount can be seen in Figure 3.25; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), are excluded from the VME weighting algorithm.

Figure 3.26 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.25. Cells shown are either low confidence (shaded black) or medium confidence (shaded grey).

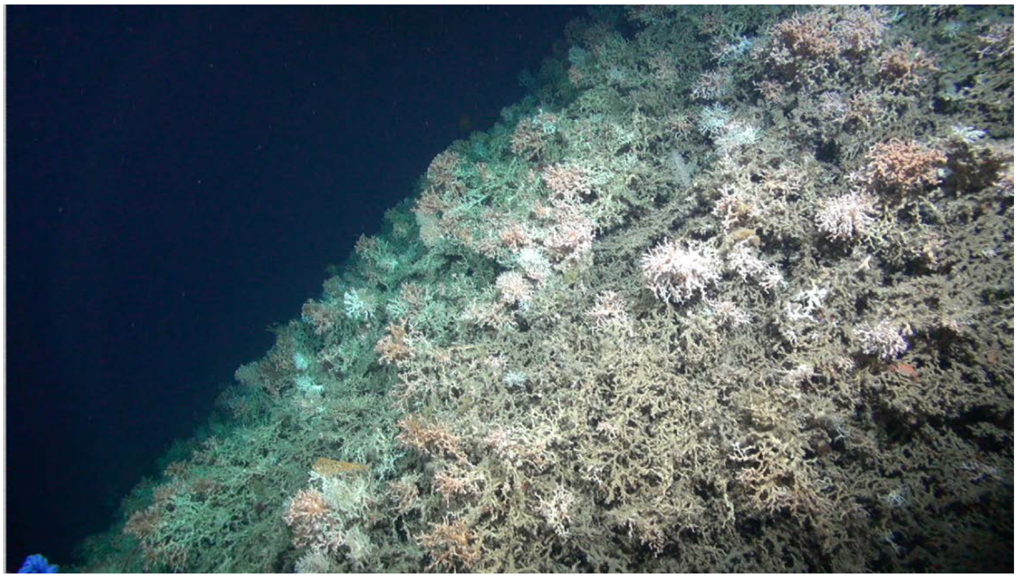

Figure 3.23. Image from JC136 dive 270 at Anton Dohrn Seamount, showing an extensive *Lophelia pertusa* / *Madrepora oculata* cold-water coral reef associated with mound structures visible on multibeam data. © NERC funded Deep Links Project - Plymouth University, Oxford University, JNCC, BGS 2016.

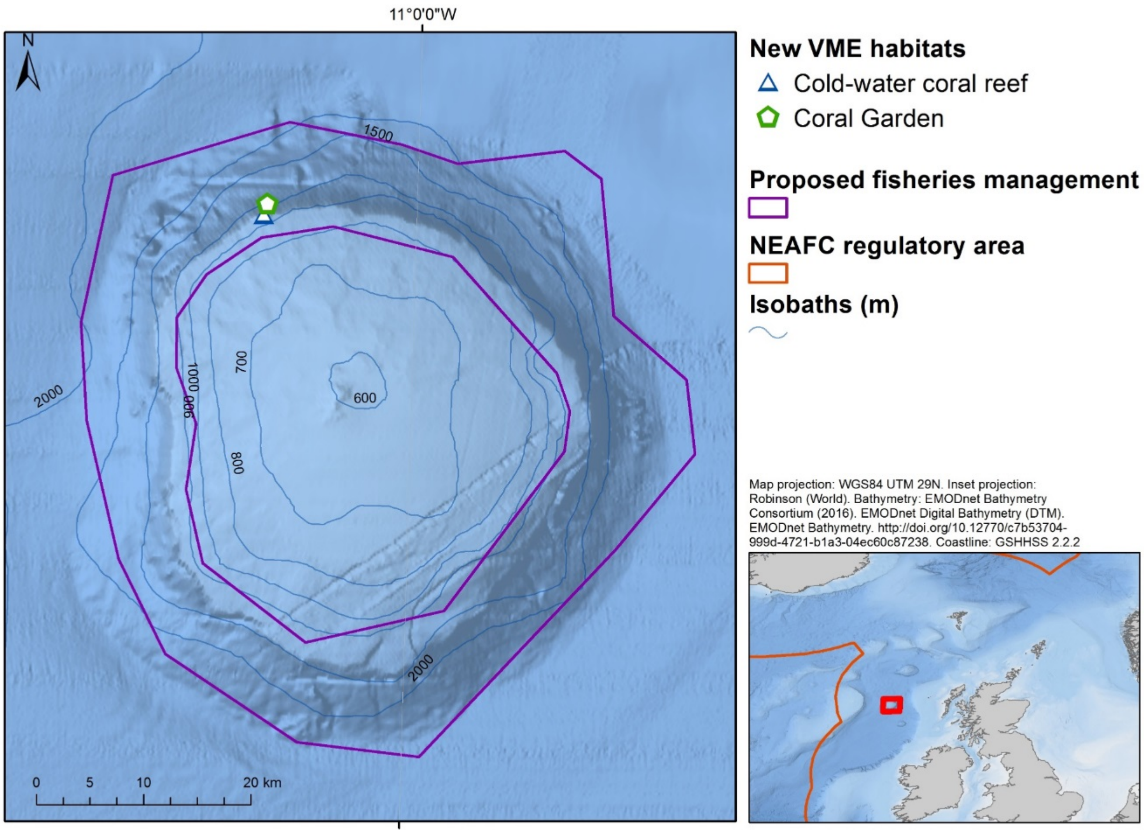

Figure 3.24. New VME habitat records (Cold-water coral reef and hard-bottom coral garden) submitted through the 2017 ICES VME data call for the Anton Dohrn Seamount.

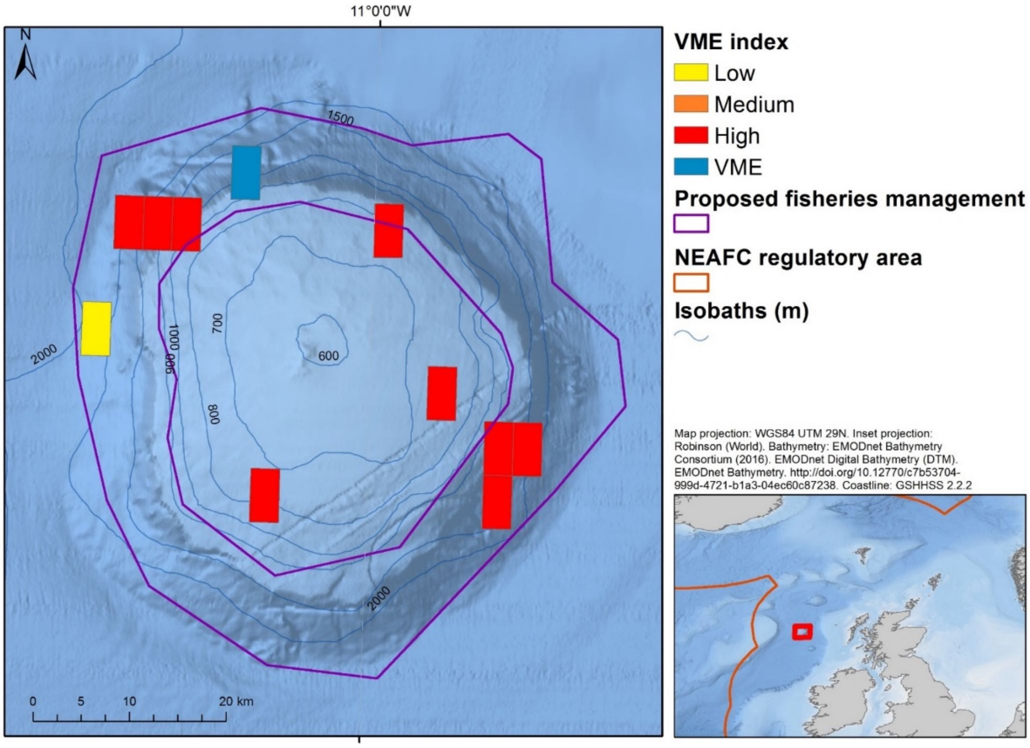

Figure 3.25. Output of the VME weighting algorithm for Anton Dohrn Seamount, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

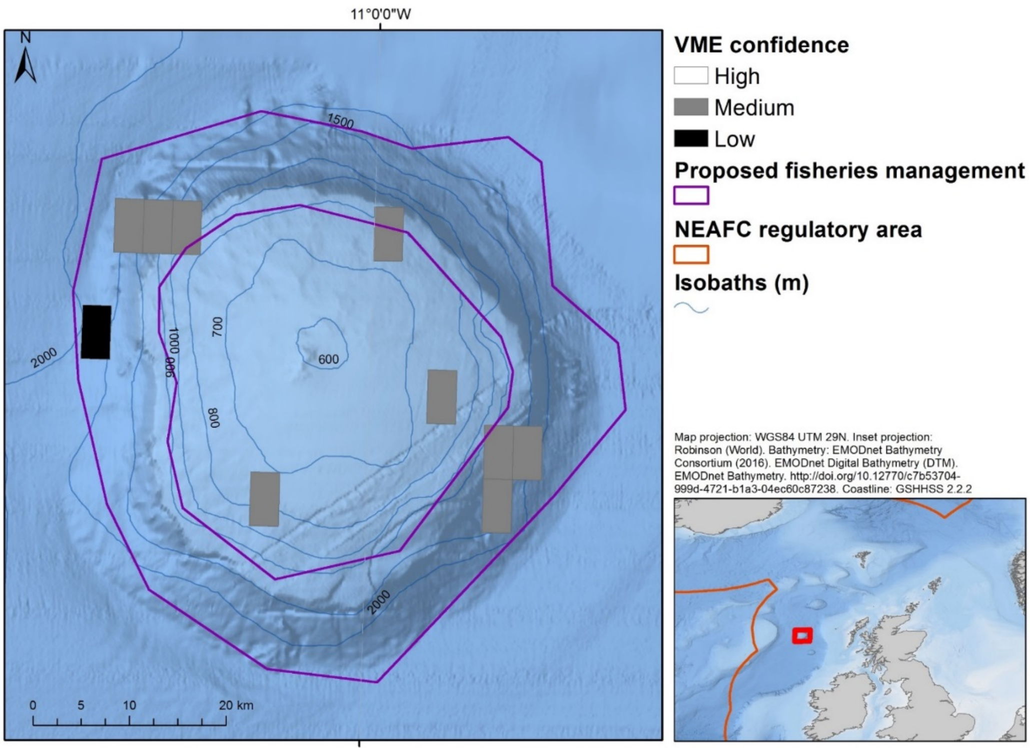

Figure 3.26. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.25) for Anton Dohrn Seamount. All cells shown are of medium confidence (shaded grey) or low confidence (shaded black). Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.6 Rosemary Bank (UK)

Rosemary Bank is located west of Scotland, within the UK's EEZ. 54 VME indicator records were submitted from Marine Scotland's 1316S research survey which visited Rosemary Bank in September 2016, as well as two observations of a VME habitat, extensive deep-sea sponge aggregations (Figure 3.27). The 54 VME indicators were collected from two types of trawl employed on the survey; a Jackson BT 184 bottom trawl with groundgear bag nets and an Agassiz benthic sampling trawl. The two observations of deep-sea sponge aggregation were at water depths of approximately 1300 m, using a towed 'chariot' high definition camera system.

The RRS James Cook (JC136) Deep Links research survey also visited Rosemary Bank in 2016. On this survey, observations were made of two new locations of VME habitats; a coral garden (Figure 3.28) and a cold-water coral reef (Figure 3.29). These were observations made using a remotely operated vehicle (ROV) capturing high definition video footage, on the flanks of Rosemary Bank at approximately 800 m.

All the above new records for Rosemary Bank are located within a fisheries management area which has been proposed by Scottish Government (Marine Scotland, 2017, Figure 3.30).

The outputs of the VME weighting algorithm for Rosemary Bank can be seen in Figure 3.31; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), are excluded from the VME weighting algorithm.

Figure 3.32 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.31. Cells shown are all medium confidence (shaded grey).

Figure 3.27. Observations of deep-sea sponge aggregations at Rosemary Bank showing examples of Geodia species that were estimated to be around 60 cm in diameter using a laser scaling device.

Figure 3.28. Image from JC136 Dive 289 at Rosemary Bank, showing a coral garden with the black coral *Leiopathes* spp, and coral rubble colonized by sponge and coral species including small colonies of *Lophelia pertusa* and *Madrepora oculata*. © NERC funded Deep Links Project - Plymouth University, Oxford University, JNCC, BGS 2016.

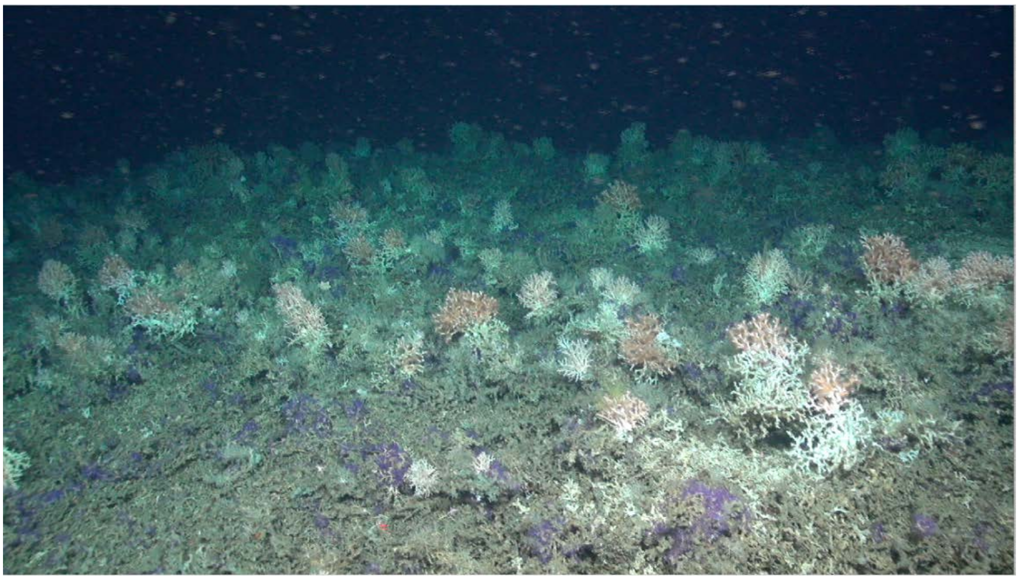

Figure 3.29. Image from JC136 Dive 287 at Rosemary Bank, showing an area of cold-water coral reef. © NERC funded Deep Links Project - Plymouth University, Oxford University, JNCC, BGS 2016.

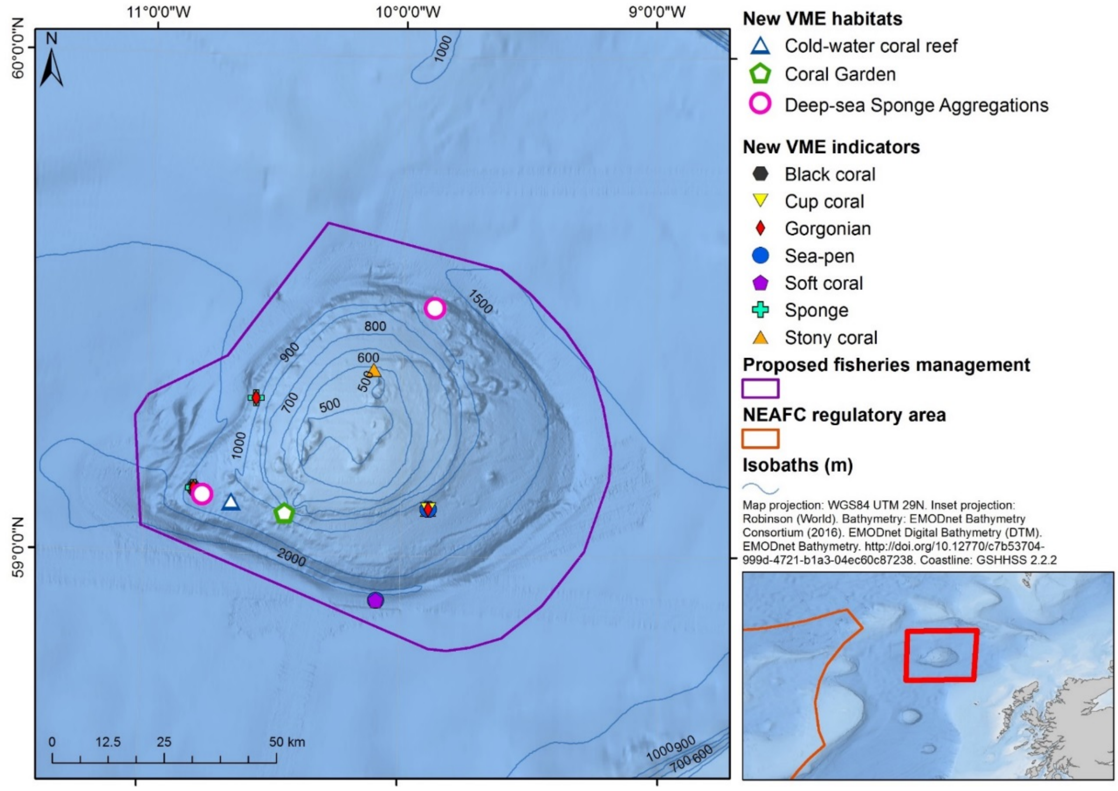

Figure 3.30. New VME indicator and VME habitat records submitted through the 2017 ICES VME data call for the Rosemary Bank area.

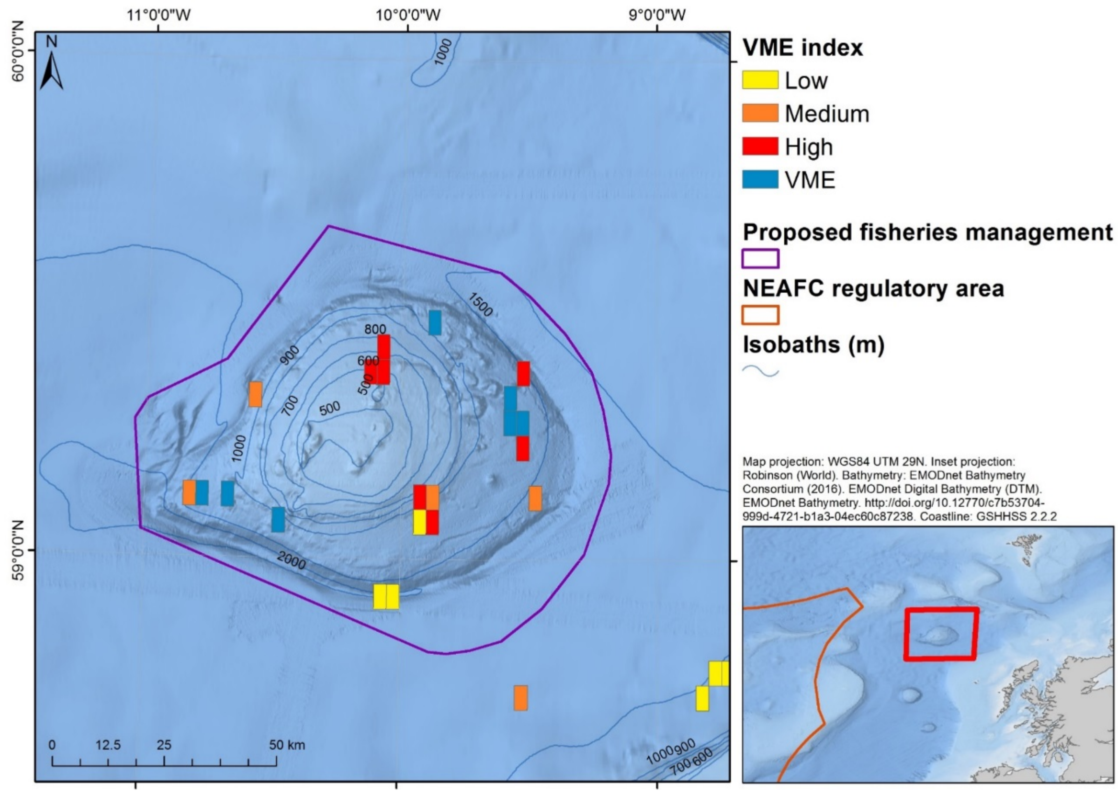

Figure 3.31. Output of the VME weighting algorithm for Rosemary Bank, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

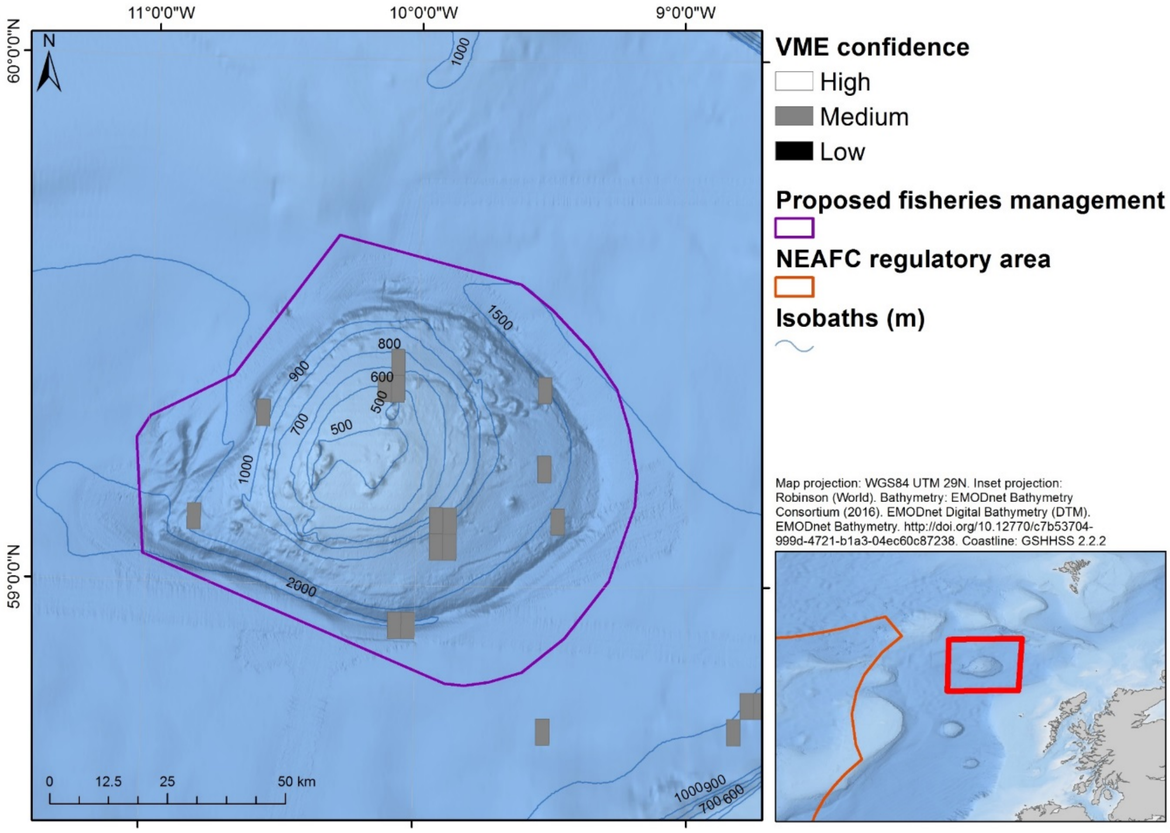

Figure 3.32. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.31) for Rosemary Bank. All cells shown are of medium confidence (shaded grey). Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.7 Irish continental shelf (Ireland)

For the continental shelf of Ireland, including Porcupine Bank, 66 new VME indicator records were submitted to the ICES VME database through the 2017 VME data call (Figure 3.33). Most records fall within Ireland's EEZ, although two records are just within the UK's EEZ. Full details of the survey methodologies used can be found in Section 3.3.3, earlier in this report.

The outputs of the VME weighting algorithm for Irish continental shelf area can be seen in Figure 3.34; note that all records from the VME database are included here. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red). Those grid cells containing *bona fide* records of VME habitat (shaded blue), are excluded from the VME weighting algorithm.

Figure 3.35 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.34. High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black.

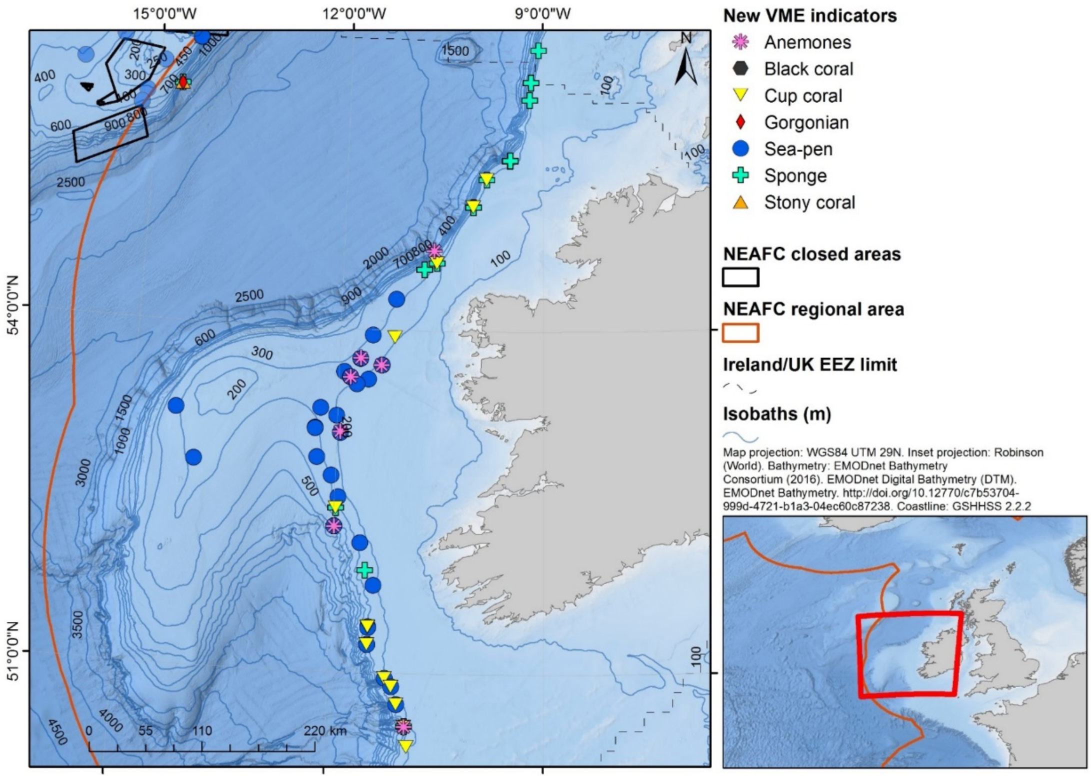

Figure 3.33. New VME indicator records submitted through the 2017 ICES VME data call for the Irish continental shelf area. Records within the NEAFC regional area are shown as transparent.

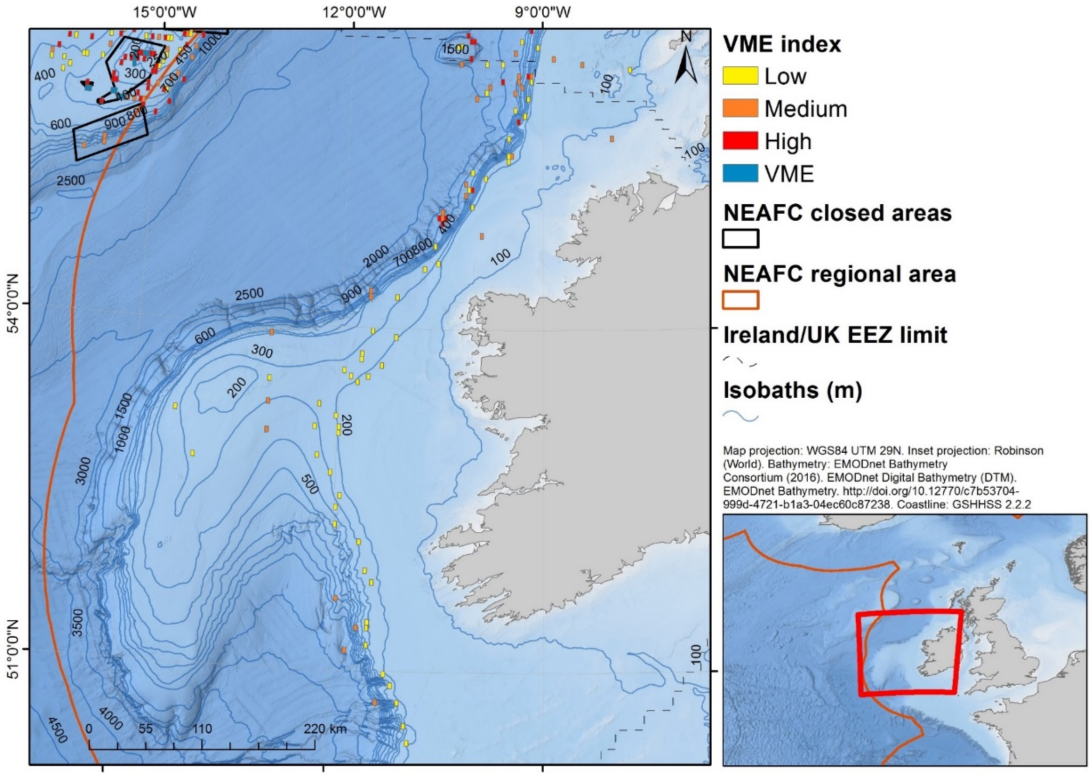

Figure 3.34. Output of the VME weighting algorithm for the Irish continental shelf area showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note this includes all (not only 2017) records from the ICES VME database.

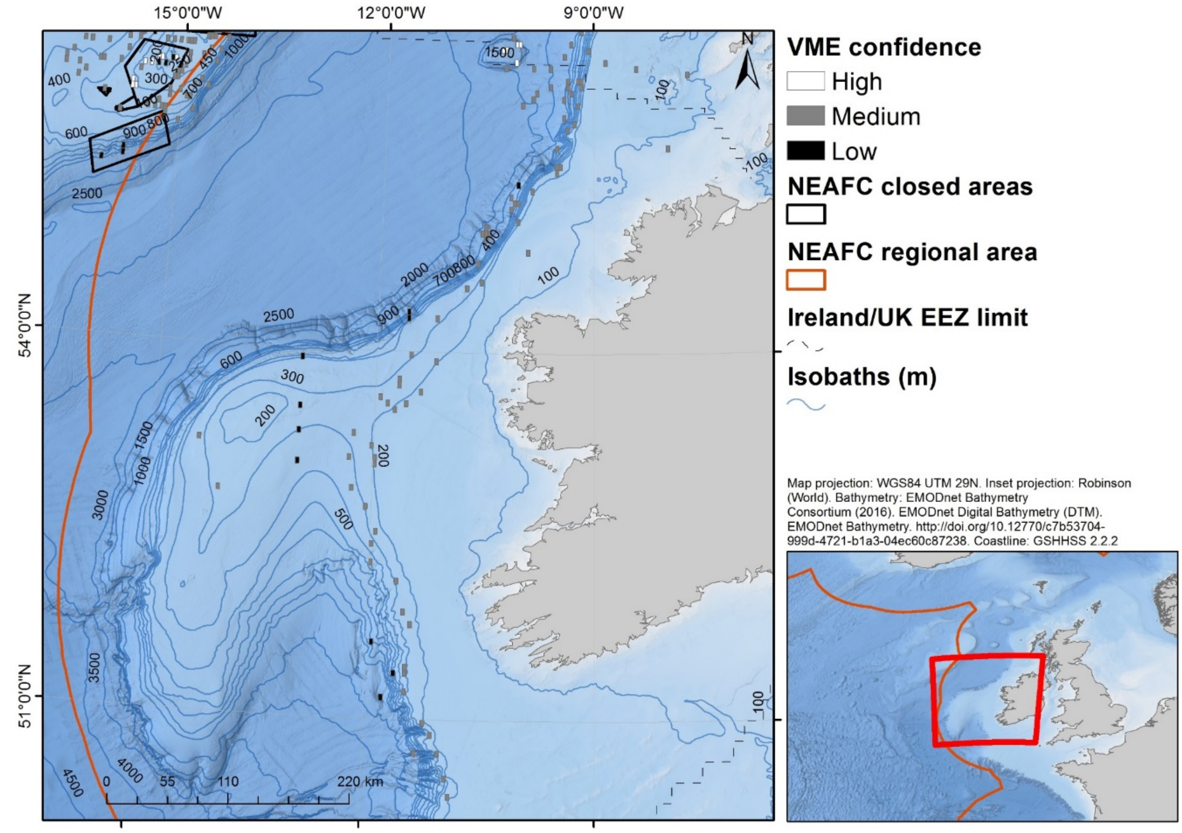

Figure 3.35. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.34) for the Irish continental shelf area. High confidence cells are shaded white, medium confidence cells are shaded grey whereas low confidence cells are shaded black. Note this includes all (not only 2017) records from the ICES VME database.

3.4.2.8 Icelandic continental shelf (Iceland)

New records of VME indicators were submitted for three areas on the Icelandic continental shelf as part of the 2017 ICES VME data call: Lónsdjúp, Öræfagrunn and Reynisdjúp.

3.4.2.8.1 Lónsdjúp

Lónsdjúp is a trough on the SE-shelf at 200–300 m depth. The VME indicator records submitted for this area were obtained during research survey B9-2010 from 18 seabed imagery (campod) transects. A total of 601 individuals belonging to seven VME indicator taxa were recorded (Figure 3.36 and Figure 3.37) and are listed in Table 3.7.

Table 3.7. New VME indicator species submitted for the Lónsdjúp area of the Icelandic shelf.

VME indicator species	Number of individuals
Kophobelemnon stelliferum	443
Lophelia pertusa	75
Madrepora oculata	37
Paragorgia arborea	1
Paramuricea spp	22
Pennatula phosphorea	13
Primnoa resedaeformis	10

These VME indicator records submitted (Table 3.7) originate from within a marine protected area closed to bottom fishing. (Figure 3.36). Further analysis of this imagery data will continue in order to determine the presence of VME habitats within this area (for example cold-water coral reefs), and future submissions by Iceland to the VME database will include these results.

The outputs of the VME weighting algorithm for the Lónsdjúp area can be seen in Figure 3.38. The gridded output layer shows the likelihood of encountering a VME for each grid cell; either low (shaded yellow), medium (shaded orange) or high (shaded red).

Figure 3.39 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.38. All cells are of medium confidence (shaded grey).

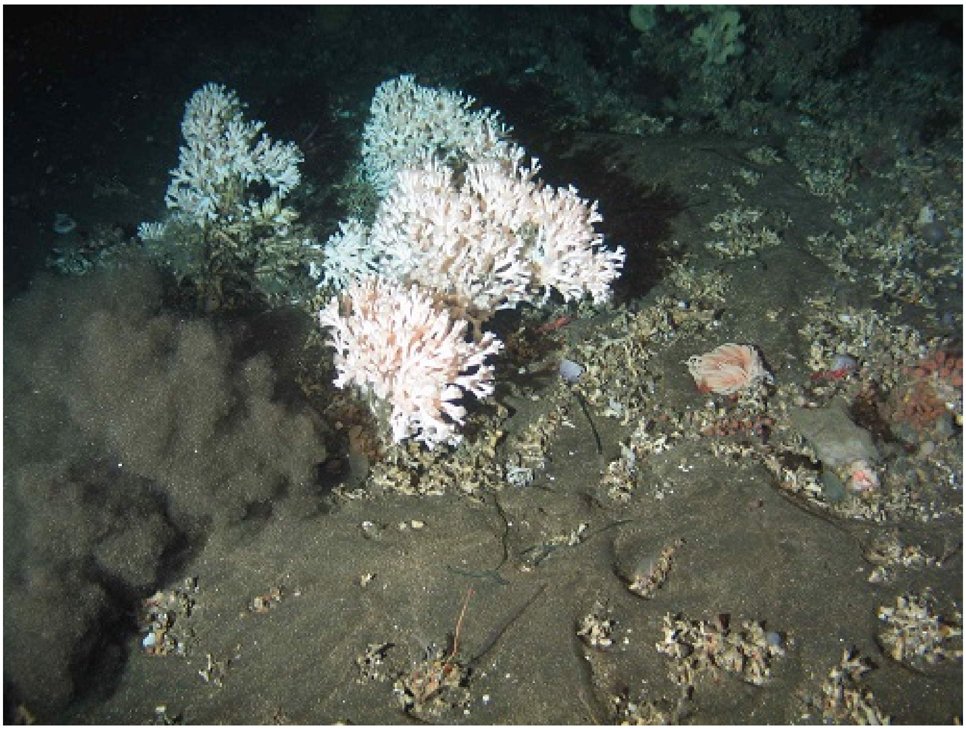

Figure 3.36. A *Lophelia pertusa* colony on sandy seabed in Lónsdjúp.

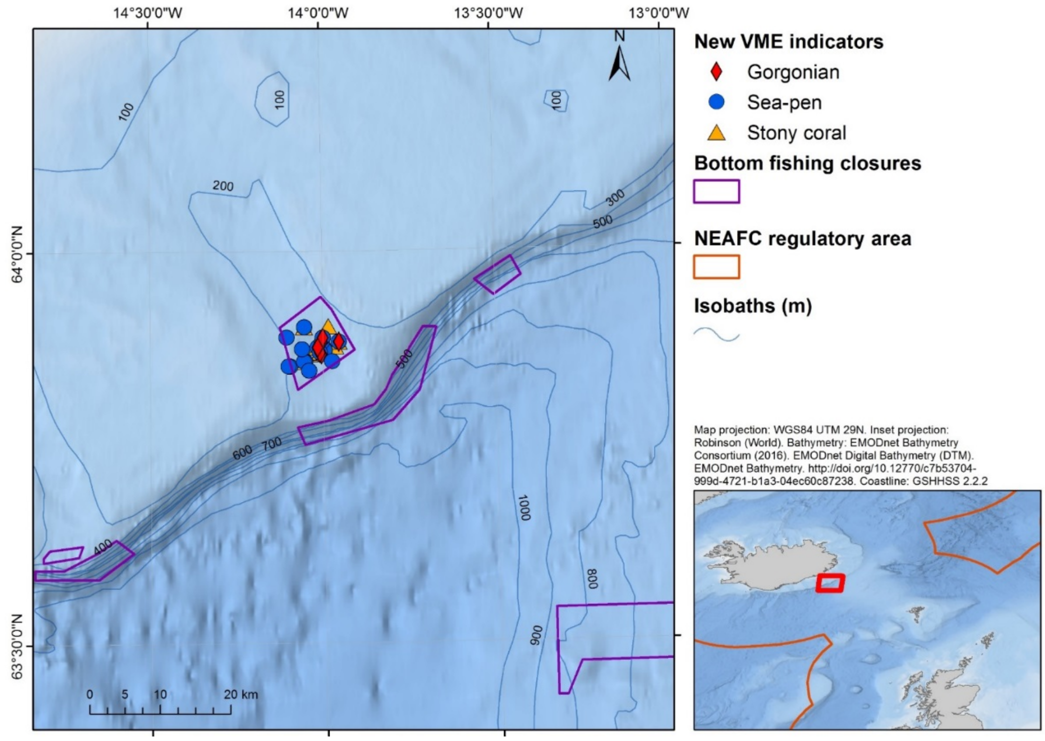

Figure 3.37. New VME indicator records submitted through the 2017 ICES VME data call for the Lónsdjúp area, Icelandic continental shelf. Also shown are marine protected areas (MPAs) within Iceland's EEZ (purple polygons) which are closed to bottom fishing.

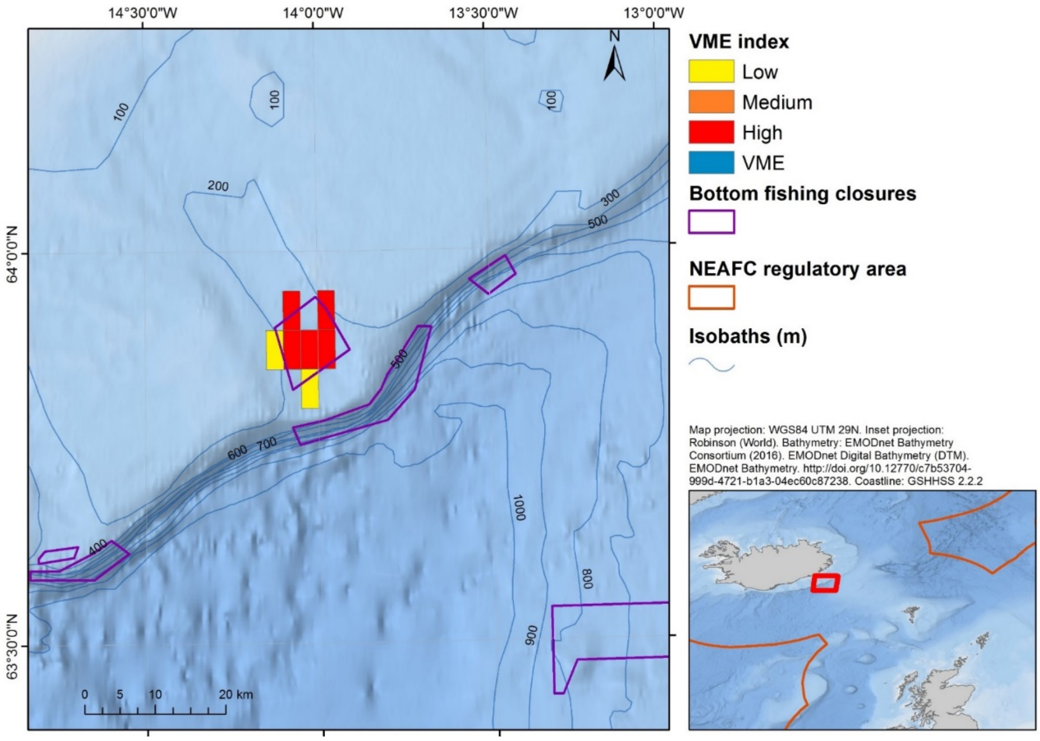

Figure 3.38. Output of the VME weighting algorithm for the Lónsdjúp area, Icelandic continental shelf, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Also shown are marine protected areas (MPAs) within Iceland's EEZ (purple polygons) which are closed to bottom fishing.

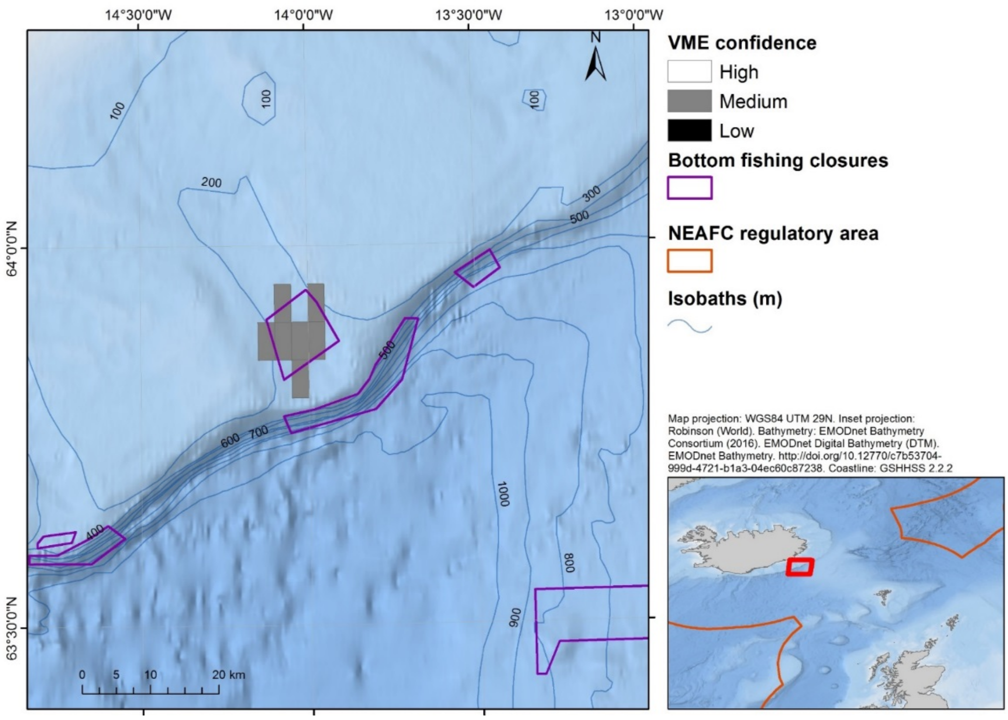

Figure 3.39. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.38) for the Lónsdjúp area, Icelandic continental shelf. All cells shown are of medium confidence, and shaded grey.

3.4.2.8.2 Öræfagrunn

The Öræfagrunn area is located on the southeast Icelandic continental shelf at depth of between 200–250 m. The VME indicator records submitted for this area were obtained during research survey B6-2004. A total of 347 individuals belonging to five VME indicator taxa were recorded from three remotely operated vehicle (ROV) transects (Figure 3.40) and are listed in Table 3.8.

Table 3.8. New VME indicator species submitted for the Öræfagrunn area of the Icelandic shelf.

VME INDICATOR SPECIES	NUMBER OF INDIVIDUALS
Kophobelemnon stelliferum	140
Halipteris spp.	197
Paramuricea spp	7
Acanella arbuscular	1
Lophelia pertusa	2

The outputs of the VME weighting algorithm for the Öræfagrunn area can be seen in Figure 3.41. The gridded output layer shows the likelihood of encountering a VME for each grid cell; all are shaded red (high likelihood). Figure 3.42 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.41. All cells are of low confidence (shaded black).

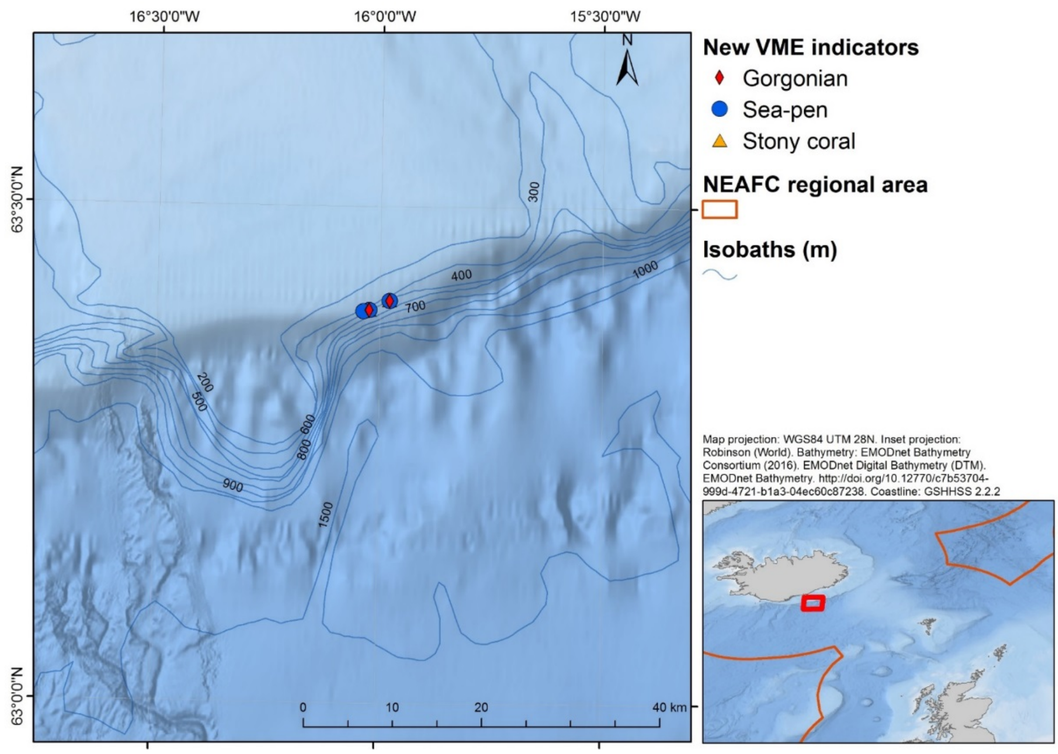

Figure 3.40. New VME indicator records submitted through the 2017 ICES VME data call for the Öræfagrunn area.

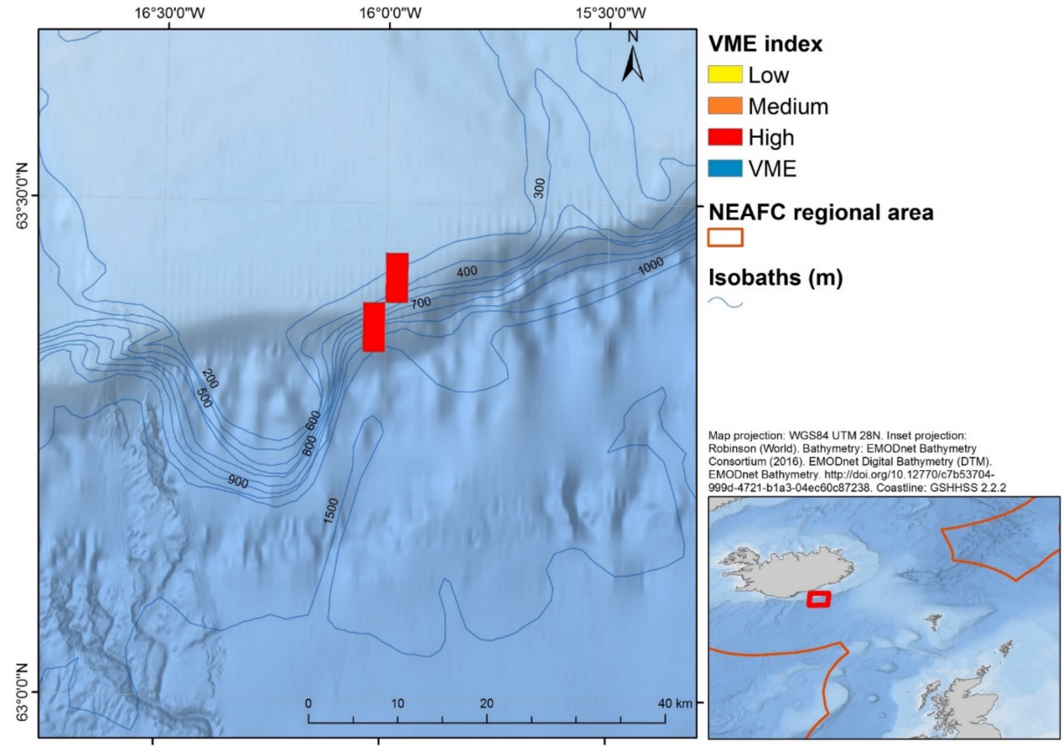

Figure 3.41. Output of the VME weighting algorithm for the Öræfagrunn area, Icelandic continental shelf, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high).

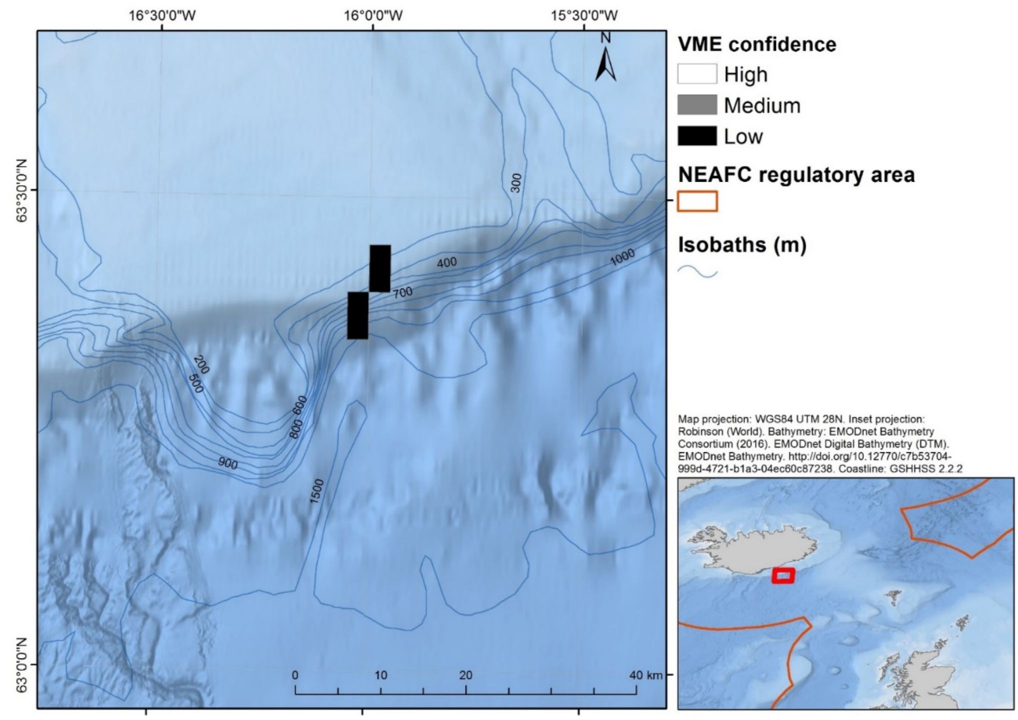

Figure 3.42. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.41) for the Öræfagrunn area, Icelandic continental shelf. All cells shown are of low confidence, and shaded black.

On the same research survey in the Öræfagrunn area (B6-2004), observations were made of several cold-water coral reefs at approximately 250 m water depth that showed evidence of the impact of anthropogenic activity (potentially caused by fishing pressure but further evidence would be required to confirm) (Figure 3.43).

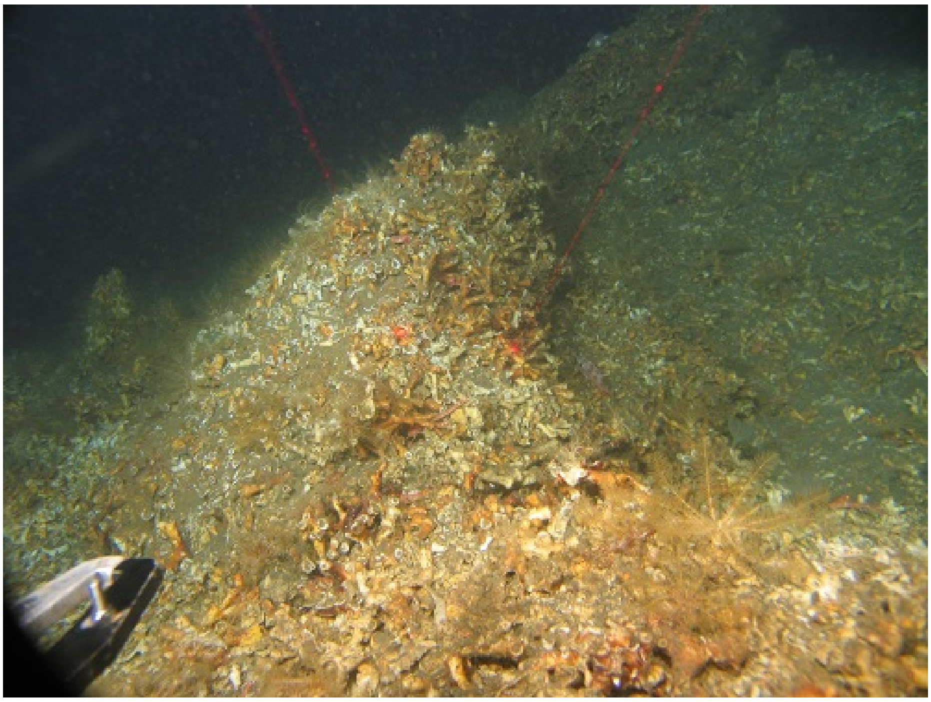

Figure 3.43. Evidence of anthropogenic impacts on a cold-water coral reef observed from an ROV on research survey (B6-2004).

3.4.2.8.3 Reynisdjúp

Reynisdjúp is an area on the slope of the Icelandic continental shelf break at 350–400 m water depth. A VME indicator record, submitted for this area, was recorded during research survey B6-2004. An observation of an octocoral (*Primnoa resedaeformis)* was made from a remotely operated vehicle (ROV) transect (Figure 3.44 and Figure 3.45).

The ROV transect was positioned on a vertical wall, where horizontal layers of soft and hard sediment were evident. High densities of the bivalve *Acesta excavata* were lined along the harder sediment layers. On top of this wall, high densities of crinoids were observed. Dead coral (*Lophelia pertusa*) was observed but not submitted as a record through the VME data call.

The outputs of the VME weighting algorithm for the Reynisdjúp area can be seen in Figure 3.46. The gridded output layer shows the likelihood of encountering a VME for each grid cell; all are shaded orange (medium likelihood). Figure 3.47 shows the confidence layer associated with the VME weighting algorithm's VME Index layer shown in Figure 3.46. All cells are of low confidence (shaded black).

Figure 3.44. *Primnoa resedaeformis*, crinoids and *Acesta excavata* in Reynisdjúp.

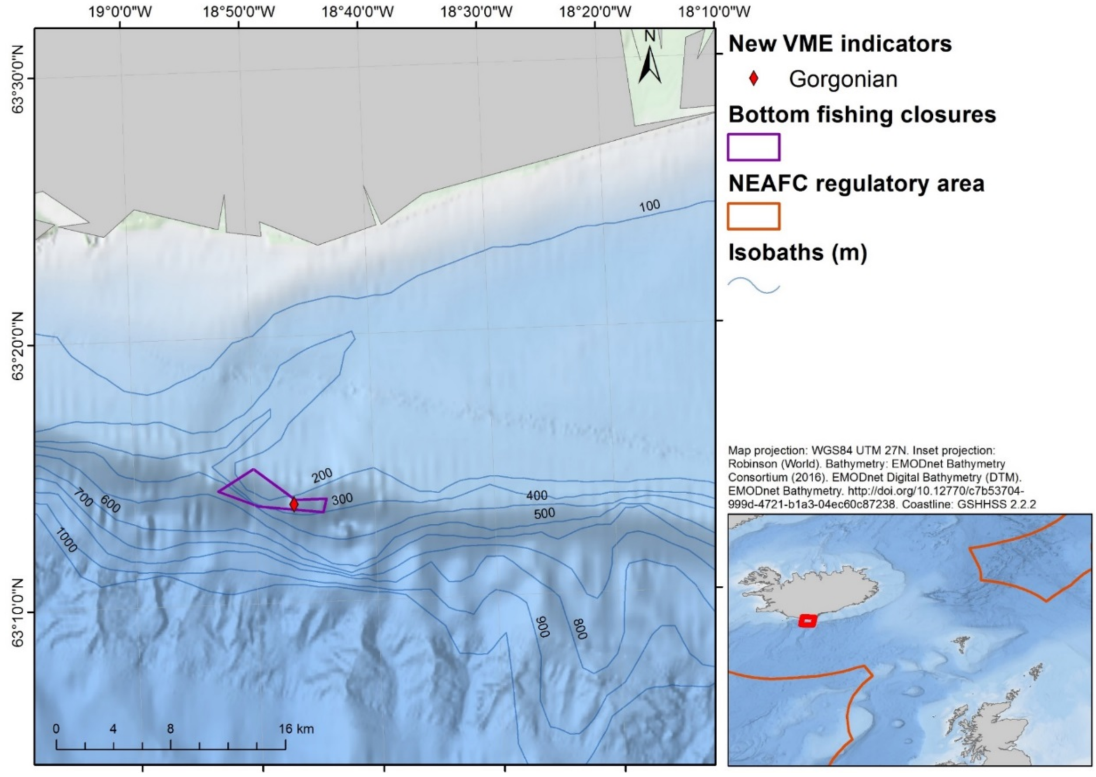

Figure 3.45. A new VME indicator record submitted in the 2017 ICES VME data call for the Reynisdjúp area. Also shown is a marine protected area (MPA) within Iceland's EEZ (purple polygon) which is closed to bottom fishing.

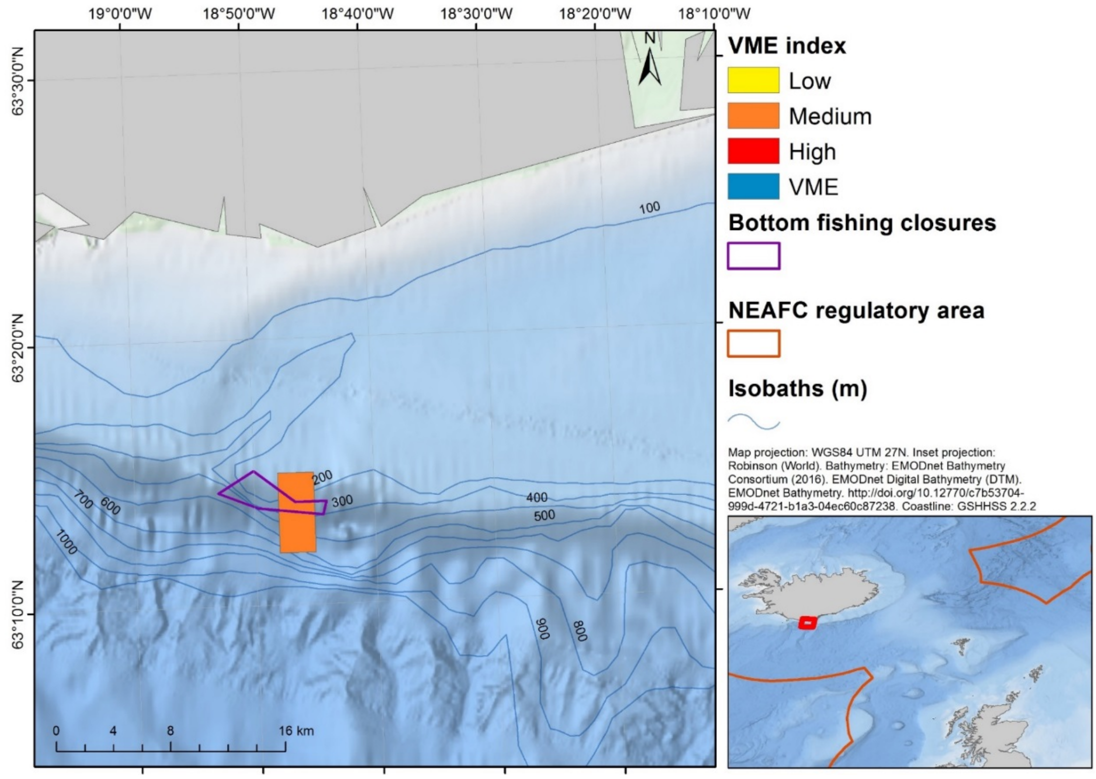

Figure 3.46. Output of the VME weighting algorithm for the Reynisdjúp area, Icelandic continental shelf, showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high).

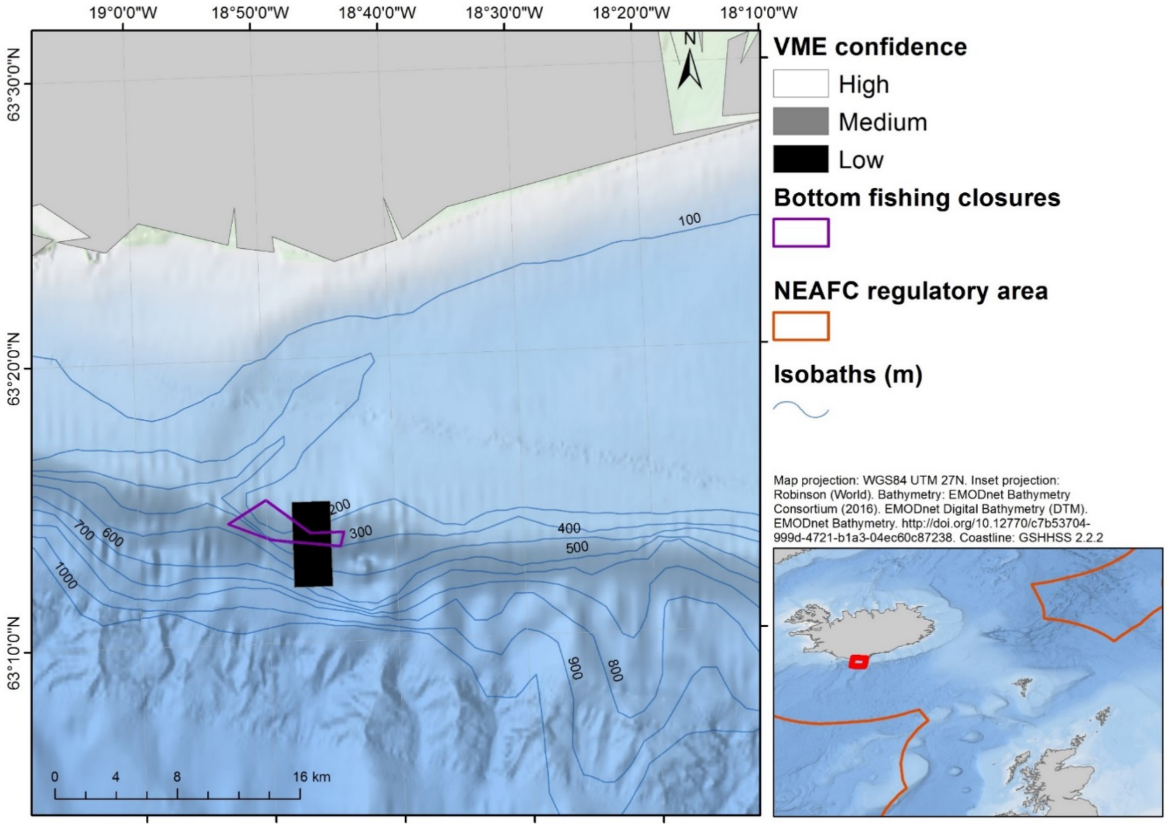

Figure 3.47. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 3.41) for the Reynisdjúp area, Icelandic continental shelf. All cells shown are of low confidence, and shaded black.

3.5 Analysis of the 2016 VMS submission from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs)

Vessel monitoring system (VMS) data were received from NEAFC, via the ICES Secretariat, along with catch information from logbooks, authorisation details, and vessel information from the NEAFC fleet registry. These tables were linked using a unique identifier (the "RID" field) which changes on a six-monthly basis to protect anonymity of vessels. As there is no date information in the catch records, catches can only be linked to vessels at this level of resolution, complicating the interpretation of results.

The VMS data were filtered in R[2] to exclude all duplicate reports, polls outside the year 2016, and messages denoting entry and exit to the NEAFC regulatory area ("ENT" and "EXT" positions). The time interval (difference) between consecutive pings for each vessel was calculated and assigned to each position. Any interval values greater than four hours were truncated to this duration, as this is the minimum reporting frequency specified in the Article 11 of the NEAFC Scheme of Control and Enforcement. Such a scenario could occur when a vessel leaves the NEAFC regulatory area, or has issues with its transmission system.

Examination of the speed field of the VMS data showed that there were issues with data quality. The "estimated speed" and "vessel speed" columns contained no values, and while the "SP" field did contain numeric values, they ranged from zero to 700, suggesting a problem with decimal places, however not in a consistent manner across the dataset (Figure 3.48a). As a means of avoiding this problem, a derived speed was calculated as the great-circle (orthodromic) distance[3] between consecutive points reported by a vessel, divided by the time difference between them. Fishing effort is inferred from VMS data on the basis of speed, with pings at slower speeds deemed to represent fishing activity, and those at faster speeds to represent steaming and/or searching. In this instance, a speed of 5 knots or lower has been used to demarcate fishing from non-fishing pings for all gears. Visual examination of speed profile histograms for vessels registered as using trawl gears suggests that this demarcation is appropriate (Figure 3.48b). For those vessels with no registered gear type, a histogram of derived speeds was also plotted (Figure 3.49).

Rasters of effort (time associated with pings at speeds of 0–5 knots) were prepared for the area from 39.5°N to 64°N and 42°W to 7°W (i.e. covering the area of the NEAFC regulatory area in which there are spatial measures for the protection of VMEs) for vessels registered as using mobile bottom contact gears (otter trawl - OTB, twin-rigged otter trawl - OTT, pair trawl - PTB and shrimp trawl - TBS). 12.5% of records in the VMS dataset come from vessels which do not have a registered gear type. To determine whether these vessels were fishing in a comparable manner to the bottom contacting gears, a raster was prepared in the same manner for vessels with "NIL" and "NULL" gear code entries. Visual inspection of their distribution suggested they followed a similar distribution to vessels registered with bottom contact gears. Rasters of effort have also been prepared for static gear (gear codes "LL", "LLS", "LLD",

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[2] https://www.r-project.org/

[3] The great-circle distance or orthodromic distance is the shortest distance between two points on the surface of a sphere, measured along the surface of the sphere (as opposed to a straight line through the sphere's interior).

"GND", "GNS" and "LNB"), again based on time associated with pings at speeds of 0–5 knots.

For vessels recorded as using mobile bottom contacting gears, consecutive pings at fishing speed (0–5 knots) were grouped into putative tows, to assist with interpretation of data and to serve as a quality check. These tow-lines were plotted in GIS and plotted as maps. Those vessels operating in waters greater than 1500 m or fishing in directions other than parallel with the prevailing isobaths direction can be considered as being miscoded and representing midwater trawling.

A set of four maps (bottom-trawl tow-lines, gridded effort for vessels registered as using bottom contact gear, gridded effort for vessels with no gear type registered and gridded effort for static gear) have been produced, in addition to depth profiles of VMS positions at fishing speeds of vessels registered as using bottom contact gears, for the following areas:

- Mid-Atlantic Ridge (Figure 3.50 and Figure 3.51);
- Reykjanes Ridge (Figure 3.52 and Figure 3.53);
- Southern Rockall Bank (Figure 3.54 and Figure 3.55);
- Hatton Bank (Figure 3.56 and Figure 3.57);
- East Rockall Bank (Figure 3.58 and Figure 3.59).

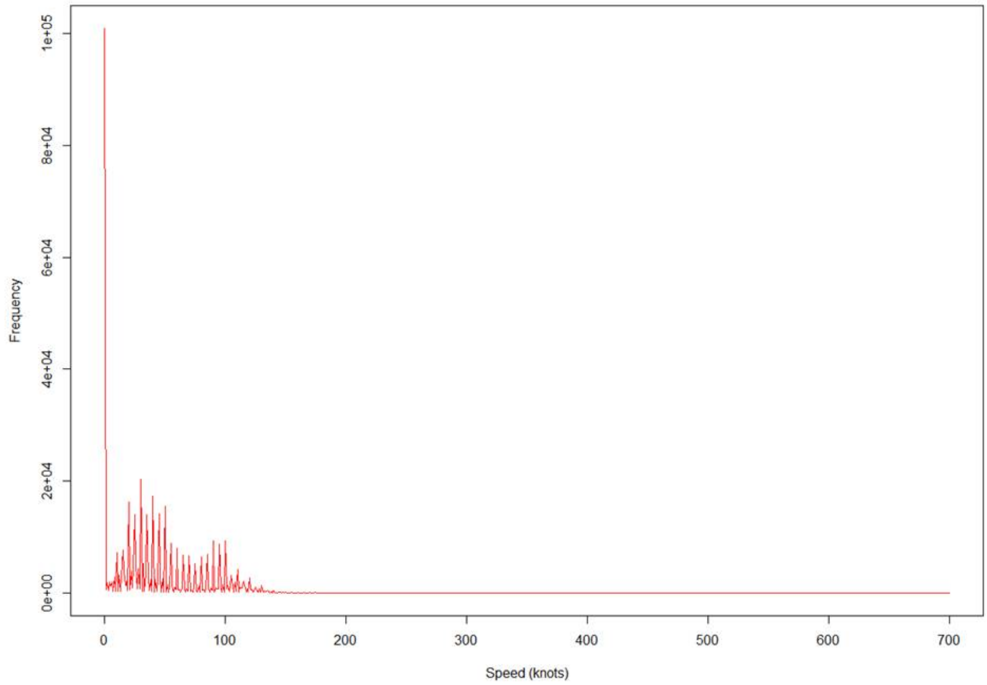

Figure 3.48a. This graph demonstrates the errors in the speed field from the NEAFC 2016 VMS data. Normally, you would expect a smooth curve. This necessitated speeds to be calculated using distance between positions and time.

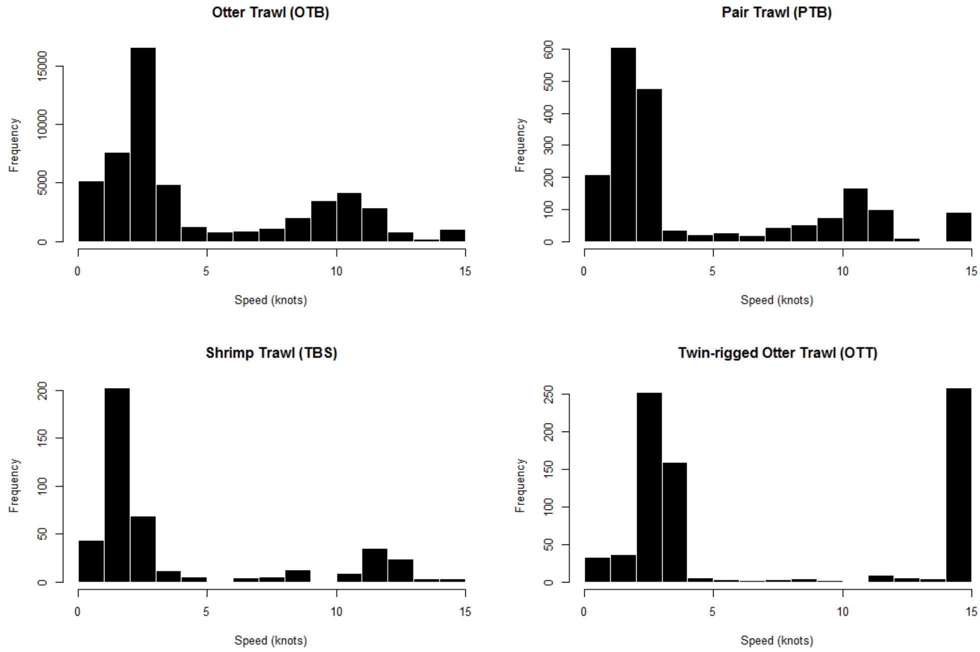

Figure 3.48b. Histograms of derived speed for vessels registered as using mobile bottom contacting gears to fish in the NEAFC regulatory area. Speeds equal or less than 5 knots are considered to represent fishing activity.

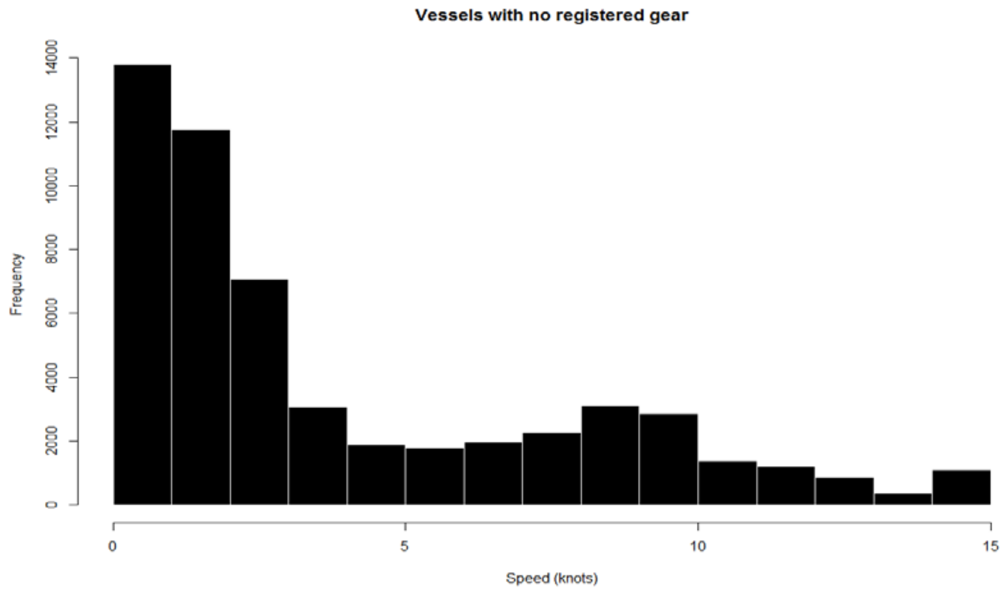

Figure 3.49. Histogram of derived speeds for vessels with no registered gear type.

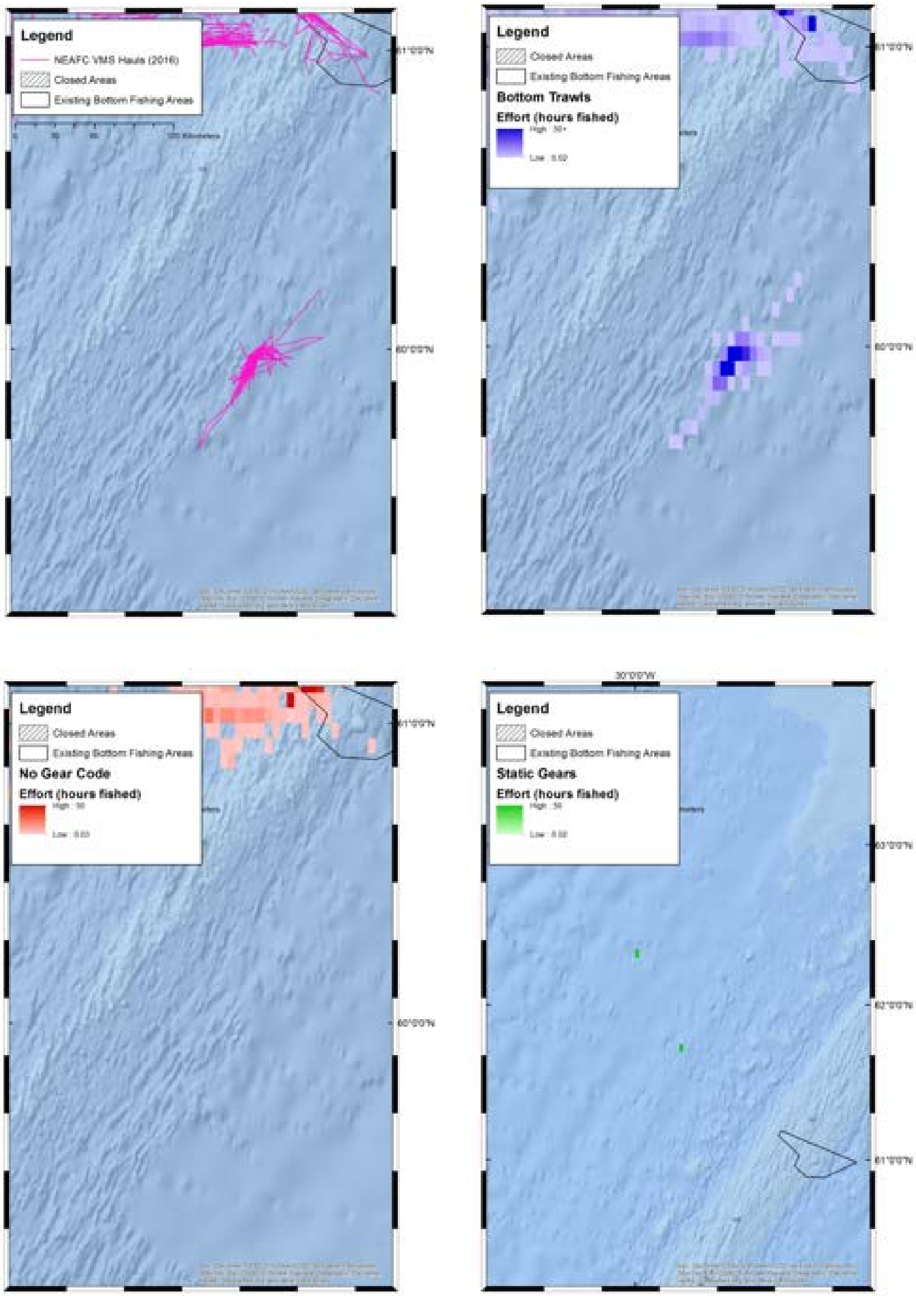

Figure 3.50. Bottom-trawl tows (top left), gridded effort for vessels registered as using bottom trawls (top right), no gear (bottom left), and static gears (bottom right) to the southeast of the Mid-Atlantic Ridge.

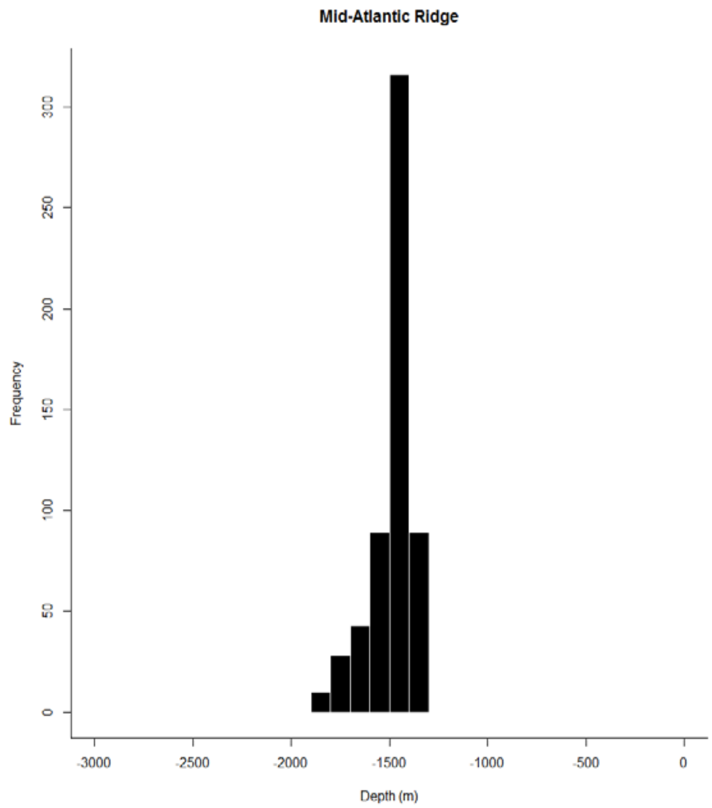

Figure 3.51. Depth profile of VMS positions at fishing speeds of vessels registered as using bottom-trawl gears to the southeast of the Mid-Atlantic Ridge.

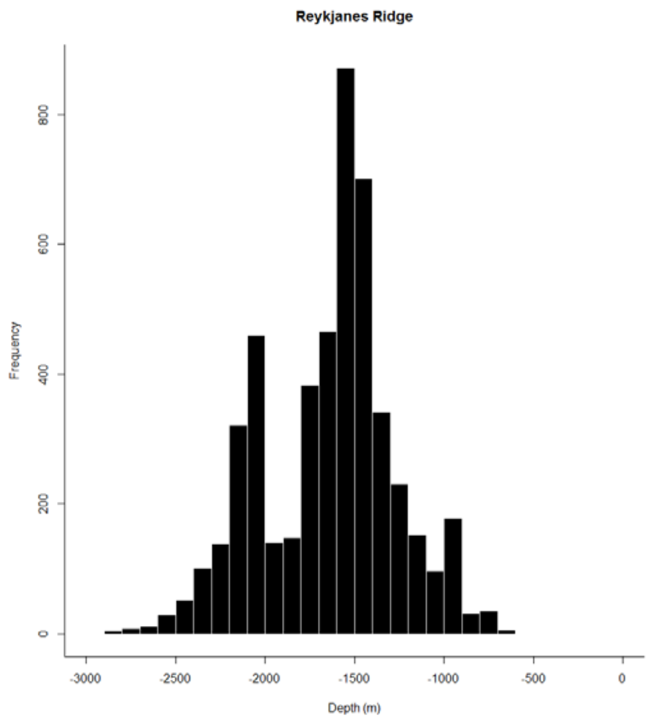

Figure 3.52. Depth profile of VMS positions at fishing speeds of vessels registered as using bottom-trawl gears over Reykjanes ridge.

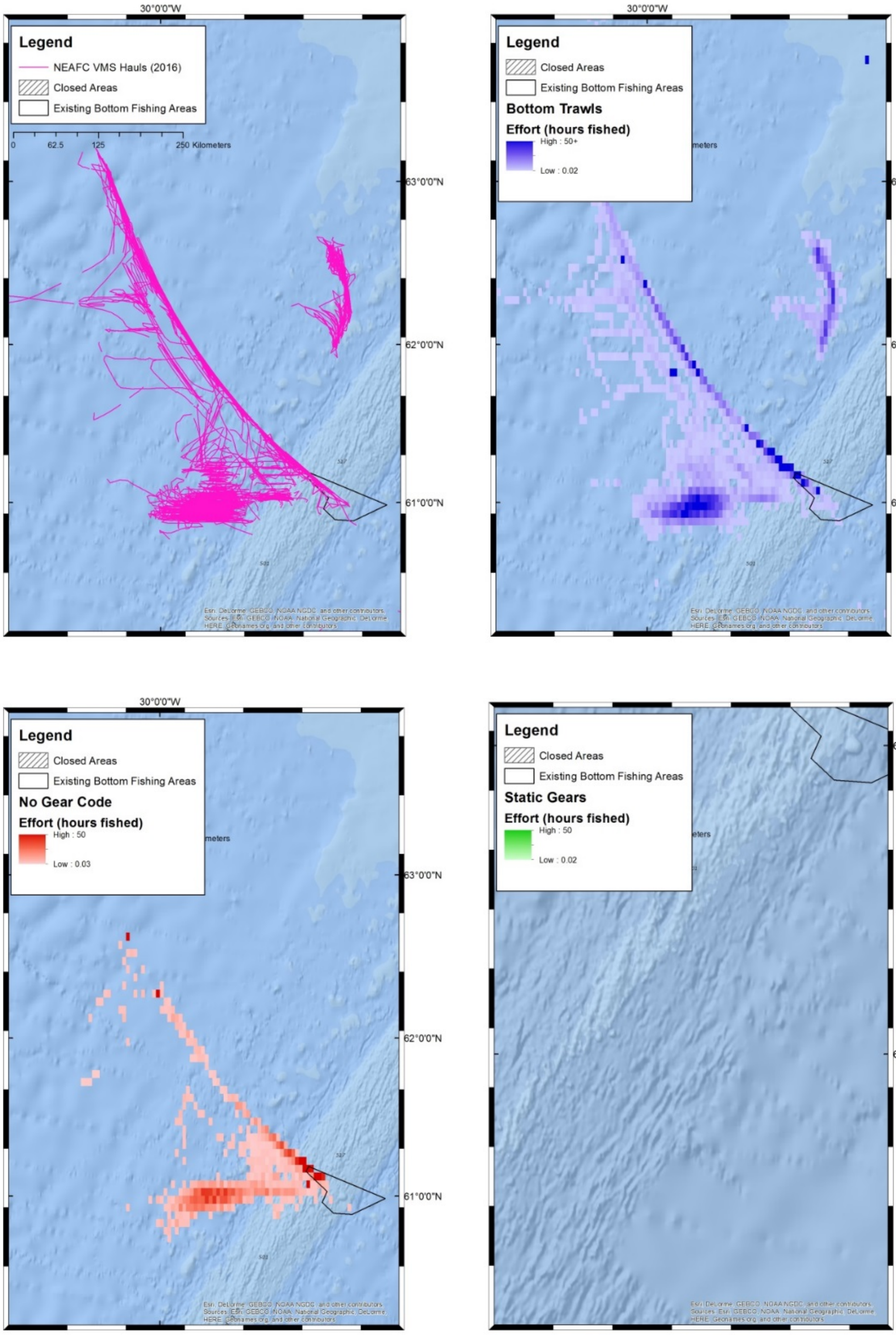

Figure 3.53. Bottom-trawl tows (top left), gridded effort for vessels registered as using bottom trawls (top right), no gear (bottom left), and static gears (bottom right) over Reykjanes Ridge.

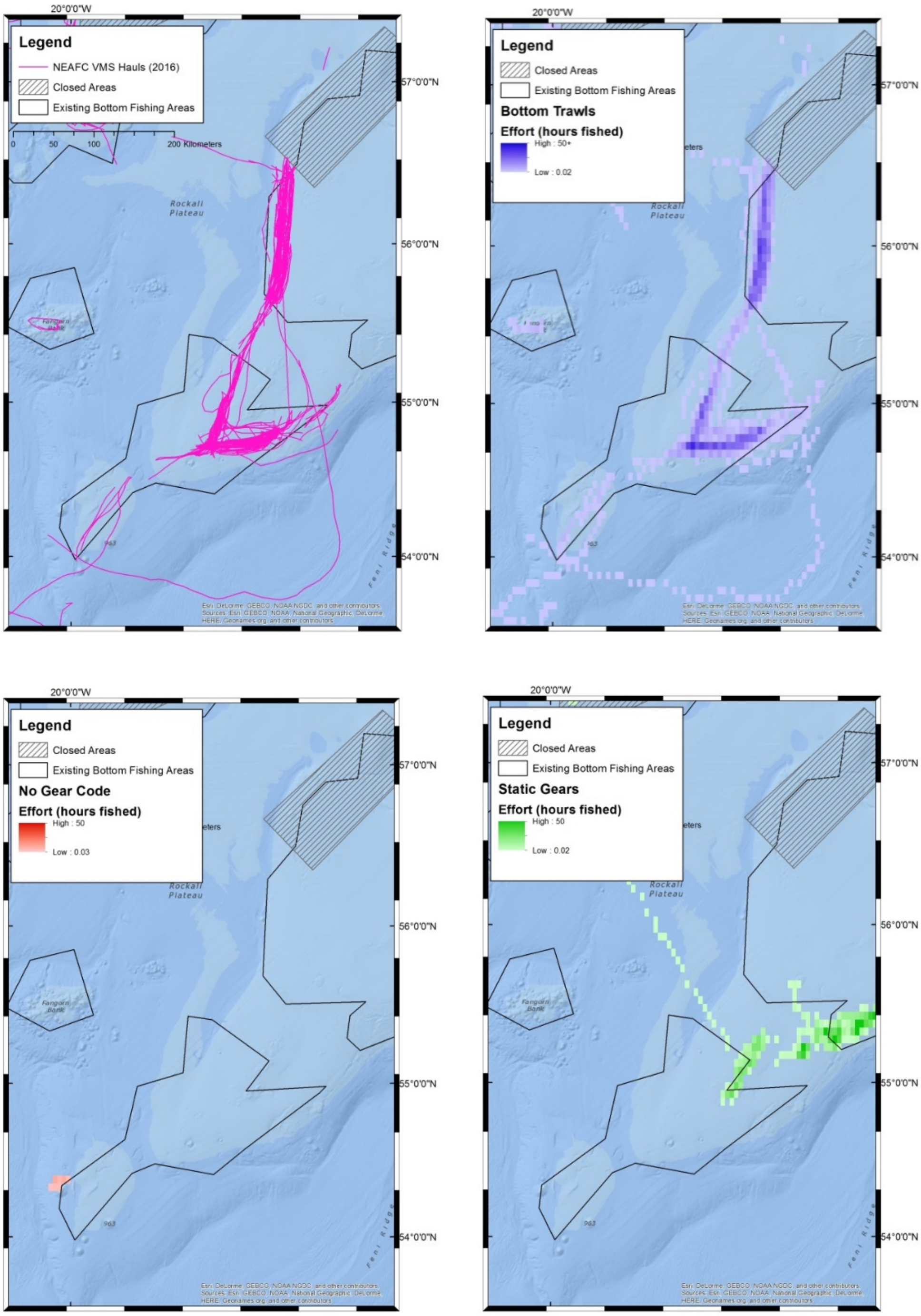

Figure 3.54. Bottom-trawl tows (top left), gridded effort for vessels registered as using bottom trawls (top right), no gear (bottom left), and static gears (bottom right) at the southern end of Rockall Bank.

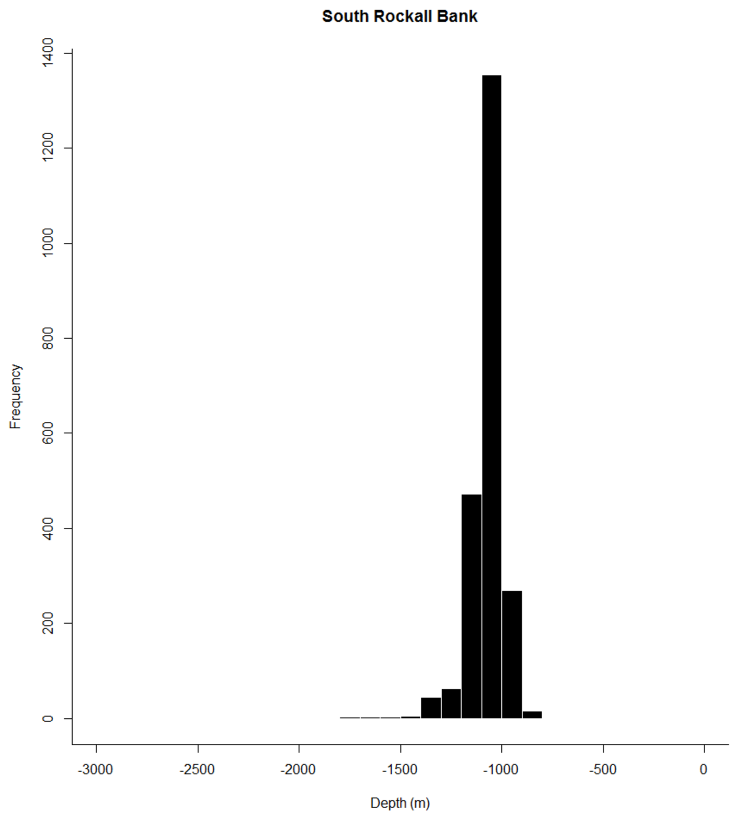

Figure 3.55. Depth profile of VMS positions at fishing speeds of vessels registered as using bottom-trawl gears at the southern end of Rockall Bank.

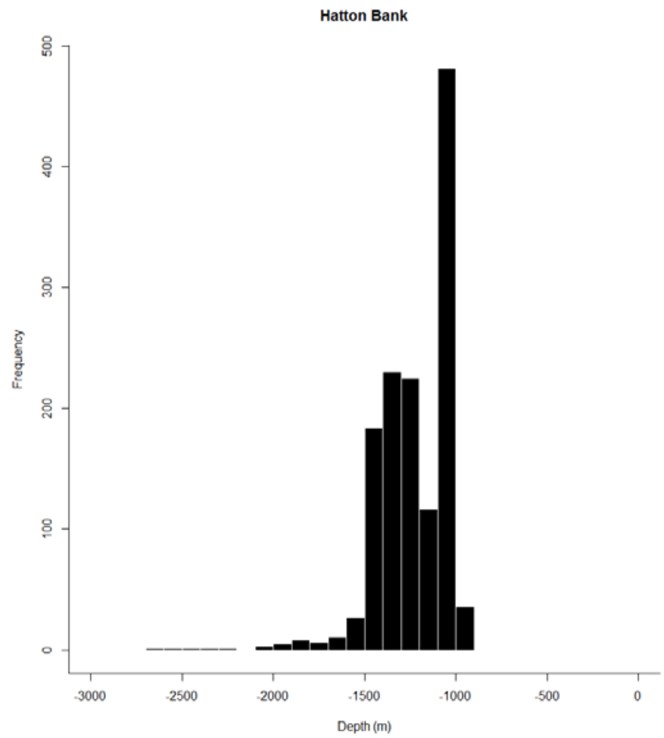

Figure 3.56. Depth profile of VMS positions at fishing speeds of vessels registered as using bottom-trawl gears at Hatton Bank.

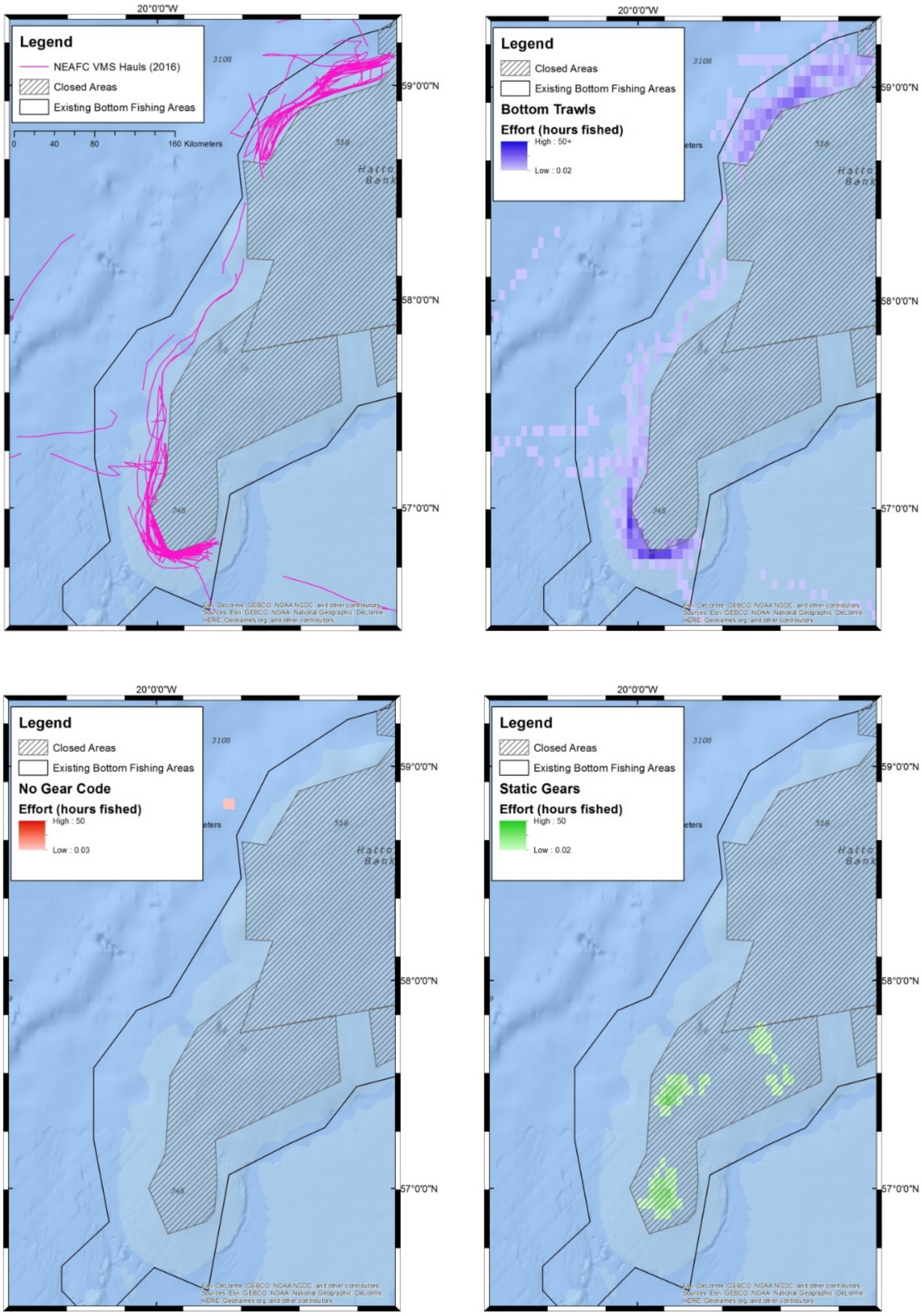

Figure 3.57. Bottom-trawl tows (top left), gridded effort for vessels registered as using bottom trawls (top right), no gear (bottom left), and static gears (bottom right) at Hatton Bank.

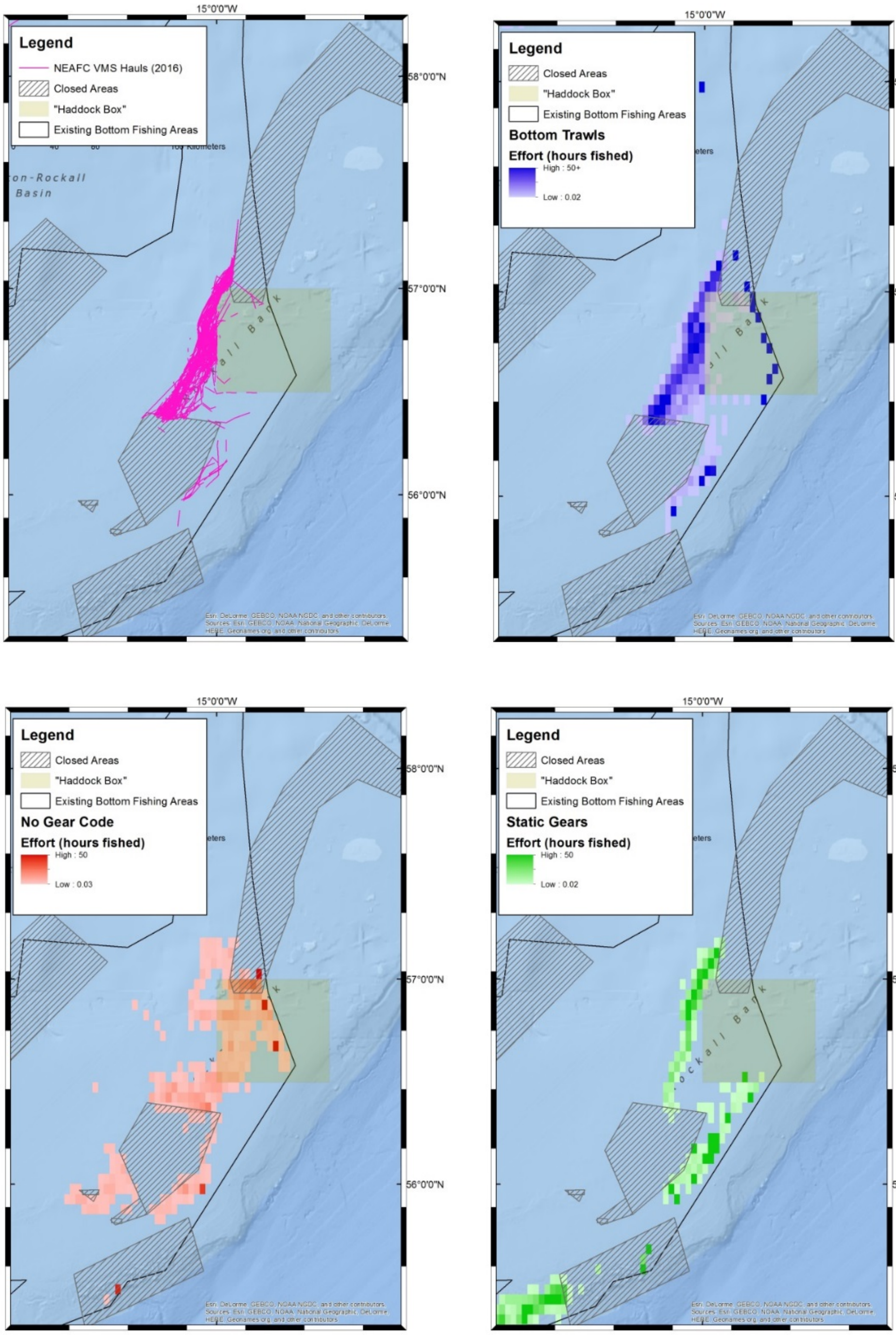

Figure 3.58. Bottom-trawl tows (top left), gridded effort for vessels registered as using bottom trawls (top right), no gear (bottom left), and static gears (bottom right) to the East of Rockall Bank.

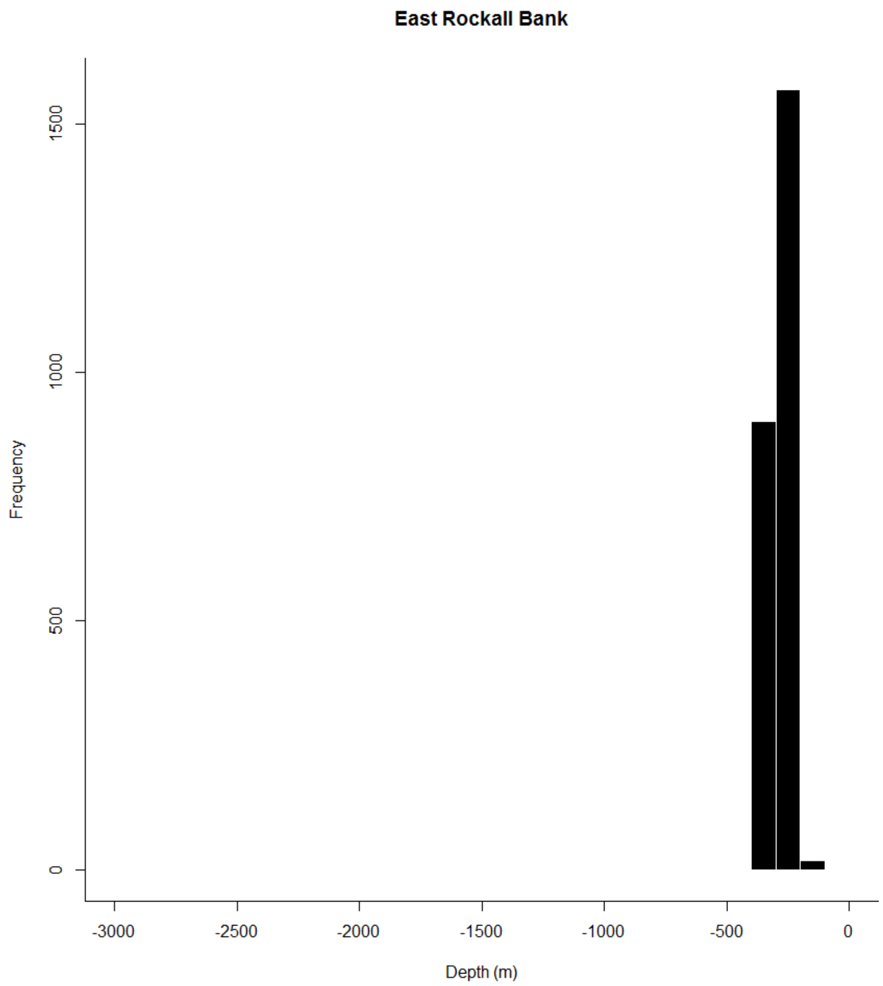

Figure 3.59. Depth profile of VMS positions at fishing speeds of vessels registered as using bottom-trawl gears to the East of Rockall Bank.

3.6 References

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4 Begin to explore how to best define Good Environmental Status (GES) for deep-sea habitats; in particular, commence a review on progress with indicator development for the deep sea - ToR [b]

4.1 Background

Understanding and defining Good Environmental Status is a core concept of the European Union (EU) Marine Strategy Framework Directive (MSFD). While much effort has been concentrated on shelf seas, including indicator development, further work on deep-sea ecosystems is required. In particular, this ToR will focus on reviewing the progress made to date with deep-sea indicator development; the focus of a number of European funded projects.

The EU Marine Strategy Framework Directive (MSFD) defines the marine environment as "a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing oceans which are clean, healthy and productive (EU Directive 2008/56/EC)." The MSFD requires member states to adopt an ecosystem approach to the management of human activities that puts emphasis on the health of the ecosystem alongside the sustainable use of marine goods and services. The Directive aims to achieve Good Environmental Status (GES) of most European marine waters by 2020. To help Member States (MS) interpret what GES means in practice, the Directive sets out, in Annex I, eleven qualitative descriptors which describe what the environment will look like when GES has been achieved.

Within this context, the European Commission has adopted criteria for assessing GES of marine waters (Commission Decision 2010/477/EU), in relation to the 11 descriptors of the MSFD. Although a great effort has been put into developing methodological standards for assessing GES in a coherent manner to support the ecosystem-based approach to management, there is still a substantial need to develop additional scientific understanding to determine appropriate ecosystem metrics, and in particular those that could be applied to the deep sea. The relationship between descriptors, criteria and potential indicators is summarised in Table 4.1.

The ICES scientific community and associated partners have worked towards providing scientific guidance to define GES indicators and standards. ICES and the Joint Research Centre (JRC) has established Task Groups for each of the qualitative Descriptors with the aim of developing criteria and methodological standards for each. A Management Group has been established to provide information on a number of issues that are common to all of the Descriptors (cf. Cardoso *et al*., 2010; also sections below for more recent information). More recently, ICES suggested some revisions to the MSFD to consider humans impacts on the functioning of ecosystems (ICES, 2015). The OSPAR Commission has also worked on developing methodologies and guidelines relevant to determining 'Good Environmental Status', in particularly for the descriptors addressing biodiversity, foodwebs, eutrophication, contaminants, litter and noise.

To further facilitate implementation, the European Union 7th Framework Programme (FP) project DEVOTES (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status) has built a catalogue of models and their derived indicators to assess which models provide information about indicators outlined in the MSFD, particularly for the biodiversity, foodweb, nonindigenous species and seabed integrity descriptors (Piroddi *et al*., 2015). Another important output from DEVOTES is the software package NEAT (The Nested Environmental status Assessment Tool), which has been developed to support the integrated assessment of the status of marine waters (Uusitalo *et al*., 2016). Other projects which address MSFD implementation include the IndiSeas project (funded by IOC/UNESCO, EUROCEANS), the FRB project EMIBIOS, and the 7th FP project MEECE. They have analysed indicators of the status of different ecosystems (Shin and Shannon, 2010).

To explore how best to define Good Environmental Status (GES) for deep-sea habitats, WGDEC 2017 undertook a review of progress with indicator development for the deep sea. A summary of the outcome of discussions made by the European Horizon 2020 project ATLAS towards these goals during its kick-off meeting in June 2016 is presented here.

Table 1. The relationship between descriptors, criteria and potential indicators.

DESCRIPTOR	CRITERIA	INDICATOR
1. Biological diversity	1.1. Species distribution	1.1.1. Distributional range 1.1.2. Distributional pattern within the latter 1.1.3. Area covered by the species (for sessile/benthic species)
	1.2. Population size	1.2.1. Population abundance and/or biomass
	1.3. Population condition	1.3.1. Population demographic characteristics 1.3.2. Population genetic structure
	1.4. Habitat distribution	1.4.1. Distributional range 1.4.2. Distributional pattern
	1.5. Habitat extent	1.5.1. Habitat area 1.5.2. Habitat volume, where relevant
	1.6. Habitat condition	1.6.1. Condition of the typical species and communities 1.6.2. Relative abundance and/or biomass, as appropriate 1.6.3. Physical, hydrological and chemical conditions
	1.7. Ecosystem structure	1.7.1. Composition and relative proportions of ecosystem components (habitats, species)
3. Exploited fish and shellfish	3.1. Level of pressure of the fishing activity	3.1.1. Fishing mortality (F) 3.1.2. Catch/biomass ratio
	3.2. Reproductive capacity of the stock	3.2.1. Spawning–Stock Biomass (SSB) 3.2.2. Biomass indices (if 3.2.1 not possible)
	3.3. Population age and size distribution	3.3.1. Proportion of fish larger than the mean size of first sexual maturation 3.3.2. Mean maximum length across all species found in research vessel surveys 3.3.3. 95% percentile of the fish length distribution observed in research vessel surveys 3.3.4. Size at first sexual maturation
4. Foodwebs	4.1. Productivity of key species or trophic groups	4.1.1. Performance of key predator species using their production per unit biomass

DESCRIPTOR	CRITERIA	INDICATOR
	4.2. Prop. of selected species at the top of foodweb	4.2.1. Large fish (by weight)
	4.3. Abundance/distribution of key trophic groups	4.3.1. Abundance trends of functionally important selected groups/species
5. Human-induced eutrophication	5.1. Nutrient levels	5.1.1. Nutrient concentration in the water column 5.1.2. Nutrient ratios (silica, nitrogen and phosphorus)
	5.2. Direct effects of nutrient enrichment	5.2.1. Chlorophyll concentration in the water column 5.2.2. Water transparency related to increase in suspended algae 5.2.3. Abundance of opportunistic macroalgae 5.2.4. Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms caused by human activities
	5.3. Indirect effects of nutrient enrichment	5.3.1. Abundance of perennial seaweeds and seagrasses impacted by decrease in water transparency 5.3.2. Dissolved oxygen changes and size of the area concerned
6. Seabed integrity	6.1. Physical damage, having regard to substrate characteristics	6.1.1. Type, abundance, biomass and areal extent of relevant biogenic substrate 6.1.2. Extent of the seabed significantly affected by human activities for the different substrate types
	6.2. Condition of benthic community	6.2.1. Presence of particularly sensitive and/or tolerant species 6.2.2. Multimetric indices assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species 6.2.3. Proportion of biomass or number of individuals in the macrobenthos above specified length/size 6.2.4. Parameters describing the characteristics of the size spectrum of the benthic community

4.2 Road map

Since evaluating GES for the deep sea has not been discussed in detail, it was agreed at WGDEC to start developing a road map to outline the process and explore the concepts necessary (Figure 4.1). As described in Prins *et al*. (2014), the first question that needs to be addressed is "What is the appropriate ecosystem component level (species, habitat and ecosystem) and spatial scales for the assessment of GES in the deep sea?" This topic needs thorough debate before moving on to discussing criteria and indicators. However during the ATLAS kick-off meeting (June 2016, Edinburgh), it was agreed that addressing GES for habitat and ecosystems (rather than species) would be more appropriate to the deep sea, due to sampling and taxonomic constrains.

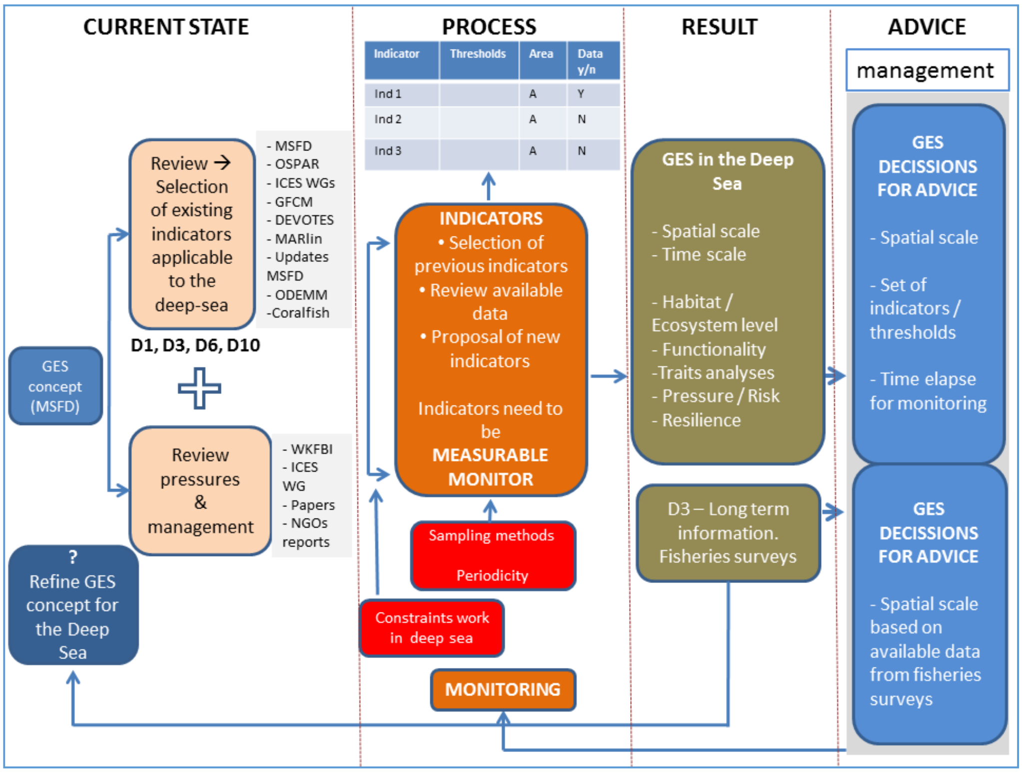

Figure 4.1. Preliminary concepts and road map to best address GES in the deep sea.

Current state of the assessment of GES in the deep sea

To appropriately address GES in the deep sea, a review of the work done previously on the development of indicators should be performed. A number of EU and national projects have been developing indicators to address GES in different ecosystems (e.g. DEVOTES, Options for Delivering Ecosystem-Based Marine Management (ODEMM) and MarLIN[4]) together with work done in ICES Working Groups (e.g. Working Group on Marine Habitat Mapping (WGMHM)). As most indicators have been developed for coastal and shallow-water ecosystems, it is necessary to review existing information and evaluate which indicators can be applied to assessing GES in the

[4] http://www.marlin.ac.uk/

deep sea. The descriptors considered useful to start the evaluation process of GES in the deep sea are:

Descriptor 1, Biodiversity

"Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions." Criteria used to evaluate Descriptor 1 should work on different ecosystem components (species, habitat and ecosystem) and at spatial scales. Due to the lack of information for most parts of the deep sea, evaluation of biological diversity indicators will likely remain at a habitat and ecosystem level and at a broad scale.

Descriptor 3, Commercial fish and shellfish

"Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock." Criteria for evaluating Descriptor 3 should be developed in collaboration with existing ICES working groups such as WGDEEP and may consider the level of pressure of the fishing activity, the life history of the considered species and the population structure of the fishing stocks.

Descriptor 6, Seabed integrity

"Seabed integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected." Criteria to evaluate Descriptor 6 should also be developed in collaboration with existing ICES working groups (e.g. WGMHM) or workshops such WKFBI or WKBENTH and may address both the level of physical damage to the seabed as well as the status, focusing mostly on the functionality of the benthic community.

Descriptor 10, Litter

"Properties and quantities of marine litter do not cause harm to the coastal and marine environment". A number of peer reviewed papers have begun to address litter in the deep sea (e.g. Ramirez-Llodra *et al.*, 2011; Pham *et al.*, 2014; van den Beld *et al.*, 2016).

Additionally, a further review of the past, current and future pressures in the deep sea as well as management measures is needed. Previous work on this subject should be included in the revision (e.g. reports from ICES WGs).

Process of developing indicators

After a careful and comprehensive review of the existing information, a selection of existing indicators should be conducted. Furthermore, a review of the available data to apply these indicators has to be performed. New indicators may also need to be proposed considering the specific constraints of working in the deep sea (e.g. remoteness, difficulties conducting scientific surveys and sampling in deep-sea areas, lack of baseline data) and the main characteristics of these ecosystems.

The selection of indicators should ensure they are SMART (**S**pecific, (Re-) **M**easurable, **A**ttainable, **R**ealistic and **T**imely). Furthermore, the selection of indicators for the deep sea needs to take into account:

- The sampling methods used in deep-sea scientific surveys (e.g. towed cameras, ROVs);
- The often low periodicity of the surveys (impacting opportunities for monitoring).

Once the indicator list exists, we suggest developing a matrix (see Table 4.1), for the different indicators, indicating applicable habitat type and area, thresholds indicating degraded habitat (whenever possible) and whether data are available or has to be collected. Indicators for Descriptor 3 may be straightforward to define as the information gathered from the fisheries surveys is standardised.

Table 4.1. Data matrix for indicators for GES in the deep sea (DS), habitat, area, thresholds, data available (yes/no).

INDICATOR	HABITAT TYPE	AREA	THRESHOLD	DATA (Y/N)
Ind 1	a	A		Y
Ind 2	b	A		N
Ind 3	c	A		Y
Ind 1	a	B		N
Ind 2	b	B		N
Ind 3	c	B		Y

Results of the application of GES deep-sea (DS) indicators

As a result of the selection and development of indicators, a set of GES-DS indicators will be applied to delineated areas, remembering that not all indicators will be applicable to all areas. Considering the spatial scale on which GES should be assessed is an important consideration in the deep sea. In Europe, the MSFD provides a means of setting boundaries for spatially managed areas. The FP7 project Monitoring and Evaluation of Spatially Managed Areas (MESMA) has developed a generic framework to facilitate marine spatial plans. The MESMA framework comprises a series of steps that can be completed, to a greater or lesser extent, to evaluate/propose an existing or new management plan for a given spatially managed area (Figure 4.2).

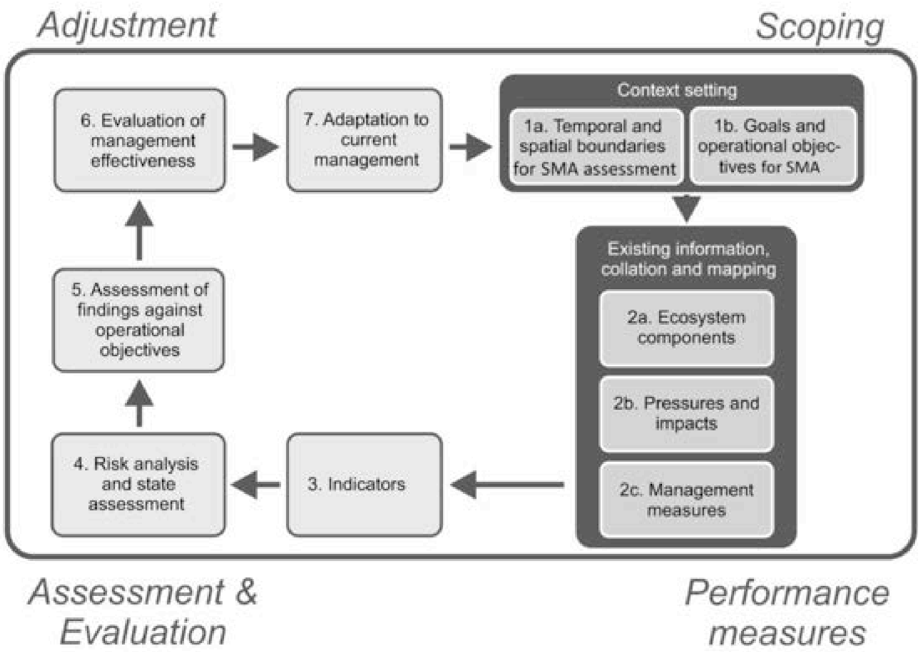

Figure 4.2. Proposed FP7 project *Monitoring and Evaluation of Spatially Managed Areas* (MESMA) framework to facilitate marine spatial planning.

Knowledge of the impact footprint of human activities operating in the deep sea will inform the extent of areas required to manage these activities. This will subsequently inform over what spatial scale GES should be evaluated. The ATLAS project will apply the MESMA framework to develop marine plans to support Blue Growth scenarios in 12 case studies located in different jurisdictions across the Atlantic.

Time-scale is another important issue, especially when thinking about monitoring. Ten years may be an appropriate time-scale, and also realistic, taking into account the probability that a scientific survey will revisit a specific site. This does not apply to Descriptor 3 as fisheries surveys take place at a higher frequency and hence more regular monitoring is expected.

Beside spatial and time-scales, some other aspects were identified during discussions by ATLAS partners and during this meeting of WGDEC. These include that:

- Biodiversity (D1) will generally be addressed at biotope/ habitat / ecosystem except where species determinations are unambiguous, e.g. *Lophelia pertusa*.
- The seabed integrity (D6) will focus on ecosystem functionality due to the lack of a baseline for other indicators and the difficulty of obtaining data in the deep sea for commonly used indicators such as abundance/biomass measurements.

Furthermore during this WGDEC meeting it was agreed to consider:

- Trait analyses;
- Pressure / risk assessment;
- Habitat / ecosystem resilience.

The results of the analyses, could be displayed in a table similar to Table 4.2 below, where the different habitats considered in an area as well as the different indicators will be displayed and the status presented in a general way using a simple traffic light system (red, amber, green). An easy-to-read table will be more useful (even it is of course a large simplification) for managers.

Table 4.2. Example of a potential way to display the environmental status evaluation of an area. Legend: red= good environmental status not achieved; yellow= good environmental status partially achieved; green= good environmental status achieved.

Area	Habitat 1	Habitat 2	Habitat 3	Habitat 4
Indicator 1				
Indicator 2				
Indicator 3				
Indicator 4				

For Descriptor 3, the indicators might be similar to the ones already being used in the assessment of GES of assessed stocks in coastal and shelf seas (ICES, 2012; e.g. Spawning–Stock Biomass (SSB), Fishing mortality consistent with achieving Maximum Sustainable Yield (F_{MSY}), Spawning–stock biomass (SSB) that results from fishing at F_{MSY} for a long time (B_{MSY}), fishing activity, the life history of target species, and the population structure of the fishing stocks). The spatial scale for D3 assessment might be limited to the existing fishing grounds, from where most fisheries surveys are conducted. However, D3 should also address non-assessed stocks with alternative techniques (e.g. ROV transects) and indicators, and also on non-fishing grounds. It should be noted that trawling impacts seabed integrity (D6) which may require a broader spatial assessment due to downstream effects of resuspended sediments. Time-scales for evaluating assessed stocks may be defined by fisheries survey periodicity. In the specific case of D3 the lack of baseline information (as it was the case for the benthic ecosystems) is not an issue for assessed stocks, since long-term dataseries may be available allowing to analyse the GES and trends over time. A potential easy-to-read table for summarizing D3 is shown in Table 4.3. Such a table may be prepared for each spatial area including the different analysed fish stocks and a GES status will be added into the table for each analysed indicator.

Table 4.3. Example of a potential way to display the environmental status evaluation of the fish stock in an area. Legend: red= good environmental status not achieved; yellow= good environmental status partially achieved; green= good environmental status achieved.

Area	Fish stock1	Fish stock2	Fish stock3	Fish stock4
Indicator 1				
Indicator 2				
Indicator 3				
Indicator 4				

Advice

Combined analyses of multiple GES descriptors in a spatially managed area should help to identify areas where accumulated impacts of overlapping activity footprints have the potential to lead to environmental degradation, such that GES will no longer be achieved. Mitigation actions will then need to be proposed. A better understanding of the factors leading to accumulated impacts will also be important in this regard.

4.3 Conclusions

The temporal and spatial scale on which GES should be assessed in the deep sea is an important aspect to be considered and which will need further discussion. Due to the data limited situation and challenges posed for monitoring, it may well be the case that GES will have to be assessed at large spatial and temporal scales when compared to the shallower waters of the European Seas. For similar reasons, the type of indicators to be used may have to be simplified and likely be based on high level analyses related to traits, pressures/risks, and habitat /ecosystem resilience. Ultimately, the results of the combined analyse of GES descriptors may lead to a potential refining or redefinition of the GES concept for the deep sea.

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5 Develop a flow chart capturing how and when different information layers (including but not exclusively geomorphology, bathymetry, VME indicator/habitat layers and buffer zones) are used in order to delineate bottom fishing closures used to manage impacts of fisheries on sensitive areas – ToR [c]

5.1 Background

The process used by WGDEC to identify sensitive areas of the seabed, and subsequent recommend bottom fishing closures, has evolved over many years. This evolution has particularly accelerated in recent years with the development of the VME Indicator weighting process (ICES, 2016). At the request of the ICES Advice Drafting Group on Vulnerable Marine Ecosystems (ADGVME), WGDEC have outlined a flowchart (Figure 5.1) capturing how different data sources and layers are used when considering new VME Indicator/Habitat records presented to the group. A text summary is also provided below.

WGDEC also note that while this flowchart captures the current practice used by the group as of 2017; this may evolve further in future. Future changes to the process are likely, for example, following a re-design of the database which has made submitting VME indicator absence records easier. Although there are currently no absence records in the database, in future, this information will further aid the identification of boundaries around sensitive areas of seabed.

WGDEC request that ADGVME provide comment on the outlined process, in order for any updates to be made by WGDEC, ahead of disseminating wider.

5.2 Process to identify sensitive areas of the seabed

The follow text summarises the process shown in Figure 5.1 for considering new data on VME indicators/habitats.

1) New VME data are reviewed by the group and added to the VME database according to points 2 and 3 below.

2) If the record is a VME habitat (a *bona fide* record of a VME, such as an ROV video transect showing a cold-water coral reef), then it is stored in the database as a VME Habitat record.

3) If a record is a VME indicator (e.g. species record from bycatch), then it is stored in the database as such, and then fed through the VME Indicator weighting algorithm. The weighting algorithm outputs are a gridded VME index layer and an associated gridded confidence score layer.

4) VME habitats (vector) and VME index (grid) data are considered together in a Geographic Information System (GIS) alongside other data layers including bathymetry (depth data). If these new data highlight new sensitive areas (either VME habitat records or grid cells with a High VME Index and High confidence), then these are looked at in closer detail. Likewise, any new information which suggest changes to existing boundaries around known sensitive areas will also be closely studied.

5) When considering sensitive areas, records of VME habitat would be considered in preference over the VME Index. In the absence of VME habitat

records, grid cells which scored a High VME Index and High confidence will be considered.

6) If a VME Element can be identified from bathymetry data (such as a bank, seamount or knoll), then this will also be considered alongside the VME habitat/VME index layer. The scale of the VME element is important in deciding whether or not to use its entire extent. For example a relatively discrete VME element, such as an isolated seamount or knoll, may be considered for its entire area. However large areas such as the continental slope in the Bay of Biscay should only be considered in part.

7) If no VME element is identified, then the VME record or area of index grid is considered as a sensitive area.

8) In all cases a buffer zone is applied to the sensitive area following advice provided by ICES (ICES, 2013).

9) A boundary is then drawn around the buffered sensitive area, maintaining a simple shape with as few vertices as possible.

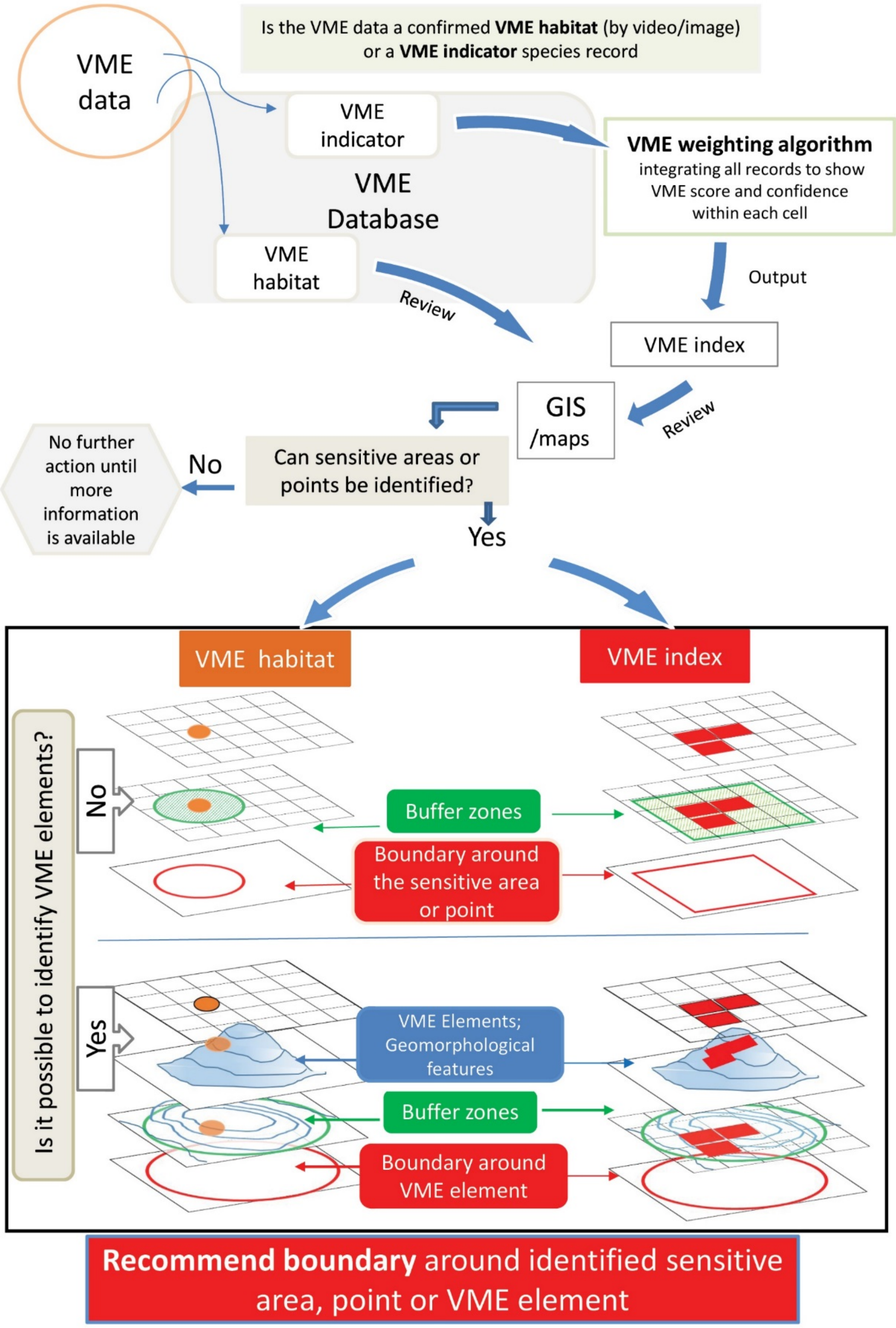

Figure 5.1. Process used by WGDEC (as of 2017) to delineate boundaries around sensitive areas of seabed.

5.3 References

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6 Explore the development of the ICES VME Database in order to better capture 'survey effort', particularly from those trawl records where no VME indicators were recorded (absence records) – ToR [d]

6.1 Background

In 2012, the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC) developed a VME database to provide a central storage system for data on VME habitats and indicators. Data were submitted via an Excel spreadsheet template, with datasets being collated into the central database by the ICES Data Centre.

During the WKVME workshop in 2015, the group further developed the data submission format, in particular to address inconsistencies in the list of VME indicators and VME habitat types to ensure only bona fide records, mainly identified using imagery or acoustic data, were recorded as VME habitats, with other records submitted as VME indicators (ICES, 2016). A new field was also added called 'VME key' to allow data providers to link multiple records of VME indicators to a VME habitat type where relevant, by using the same VME key, and to record separate patches of VME habitats from the same transect or tow using sequential VME keys. WKVME also reviewed existing records of VME data previously submitted to the database, and updated them to the new data format to ensure there was consistency within the database.

Following these changes to the database, the group felt there was also a need to improve the submission process. As such, the ICES Data Centre and WGDEC experts have started to develop a mechanism to supply data online. In support of automated data submissions, the data submission format was additionally modified to standardise data input and remove redundant and duplicate metadata information. The data submission template with incorporated vocabularies and xml export function, together with data submission guidance document, were developed to support an improved data flow. Data are now submitted to the database in four structured record types: File information; VME cruise; VME sample, and VME data record (see Figure 6.1). The new data flow allows the incorporation of data quality checks that would ensure all records meet the relevant quality control (QC) criteria. Development of relevant quality checks is still in progress, and will require input from both ICES Data Centre and WGDEC experts.

6.2 Absence data

The new data submission format now provides a clearer process to report absence data to the database. Absence data has sometimes been submitted in the past to WGDEC (e.g. Russian trawl bycatch data), but often wasn't due to uncertainties in what and how to submit these data. Regardless, the database structure at the time prevented this type of data being stored centrally within the VME database. The new database structure now allows submission of 'absence' data via completion of the "VME cruise" tab, with details of each survey of relevance, and the "VME sample" tab, with details of the sampling events. If no VMEs are found in these sampling events, this is all that is needed (i.e. no information is needed under 'VME data record') and absence is therefore recorded.

On review of the new submission process, and discussion of the types of data that may be submitted as absence data, WGDEC agreed that absence data should currently only be submitted in the following cases:

- For scientific trawl surveys only (both current and older/historical records);
- Where presence of VMEs have been recorded on the same survey (i.e. if no VMEs seen throughout the survey, do not record absences).

In addition, a couple of guiding points were made:

- Each tow should either be presence OR absence, it should not combine both. If VMEs are present in part of the tow, this is recorded as presence data;
- If presence data are recorded for some VME indicators, absence of others can be assumed and does not need to be recorded separately.

These guidelines aim to ensure that only validated absence data are recorded. The group chose to initially look at trawl survey data as the spatial scale of the information can be very useful for habitat modelling and similar studies. It was recognised that trawls may not sample all VME indicators but if trawl gear does pass through an actual VME on the seabed, then some evidence of this would be expected to be recorded in the trawl dataset. Experience elsewhere has shown this to be the case. Video data will record presence and absence over very fine spatial scales and likely at a resolution that cannot be readily handled by the grid size of the VME mapping portal. This type of data will require more thought as to how to incorporate absences and will be considered in future. Additionally, it was felt that absence data from commercial fishing trawl surveys using observers should not yet be submitted due to difficulties in knowing if observers are recording the full suite of VME indicators during these surveys or just a 'subset'.

The group agreed that a trial of VME absence data submission following the above guidelines could be undertaken for the WGDEC 2018 data call, and further consideration of these guidelines could then be made following these submissions.

6.3 Data submission and Quality Control

Formalization of the data submission format enables a variety of data quality checks to be undertaken that increase the value of the dataset by excluding inconsistency in data entries. However, input from experts to develop the proper data quality checks is essential. For example, these may be logical, conditional, vocabulary, or range checks.

Submissions for the 2017 VME data call were supported by an excel data submission template, an XML Schema Definition (*.xsd) template and a guidance document. The latest version of the data submission template is available to download from the ICES webpage: http://www.ices.dk/marine-

data/Documents/VME/VME_Reporting_Format_Template.xlsm. Data files, prepared according to the guidelines, can then be uploaded via the VME data portal: http://vme.ices.dk/. Before uploading, datasets have to pass the data screening utility. Data screening allows data submitters to screen and verify their files, where data are checked against quality control rules and errors in the data are flagged. If no critical errors are found, data submission can continue. For the 2017 VME data call, data submissions were manually registered by the ICES Data Centre, and then uploaded to the central database. In future, this step will become automated.

In some circumstances, older data within the database will need to be reviewed and updated; in these cases the ICES member/data managers for the ICES country will need to prepare the revised data in the new data submission template, paying particular attention to ensuring the following fields match that of previously submitted data:

- Country
- Responsible Organisation
- Cruise ID
- StartDate
- EndDate

The ICES DataCentre will use these key fields to develop a data overwriting procedure, where the old data records will be replaced with the new submitted data. Data delivered to the VME database prior to the WGDEC Data Call 2017, cannot be automatically overwritten as they are stored in slightly different format. If any resubmissions are made for these datasets, submitters need to contact ICES DataCentre for assistance at accessions@ices.dk .

These changes to the data submission process are a first attempt at developing an online submission system and as such there are still improvements to be made in order to streamline the screening and submission process. The next steps for this work are laid out within the proposed Terms of Reference for WGDEC 2018 at the end of this report.

6.4 Future development

Online data downloads and viewing of gridded VME data on the VME Data Portal have not changed since last year, but we anticipate some minor work improving ways to view the data in the coming year. During WGDEC 2017, the group agreed that in the longer term it would also be beneficial to allow submission of more complex spatial data, such as complex video transect lines from ROV surveys, in the form of geographic information system (GIS) data such as ESRI polyline shapefiles (.shp). Support from scientific experts and the ICES DataCentre is key to the successful development and implementation of these new features.

The group also discussed the links between the ICES VME database and the Ocean Biogeographic Information System (OBIS) database, where deep-sea data can also be submitted. It was suggested that in future it would be useful for OBIS to harvest data directly from the VME database to support alignment of the two, similar to the approach taken for other ICES managed databases.

Finally, the VME database currently contains some records from the NAFO area. However, there are large areas of the North Atlantic where VME data exist but have not been submitted to the database. The Joint ICES/NAFO Working Group agreed to bring this fact to the attention of the NAFO Scientific Council. Many benefits would be realized through incorporating data from the NW Atlantic. Bringing all the ICES and NAFO data together in a central repository would allow our Joint ICES/NAFO Working Group, as well as NAFO's Working Group on Ecosystem Science Assessment (WGESA), consider Terms of Reference applicable across the entire North Atlantic, such as questions at ocean basin scales like deep-sea connectivity. A proposal to incorporate these data has been prepared by WGDEC for the attention of the NAFO Scientific Council (see Annex 4).

6.5 References

ICES. 2016. Report of the Workshop on the Vulnerable Marine Systems Database (WKVME), 10–11 December 2015, Peterborough, UK. ICES CM 2015/ACOM:62. 36 pp.

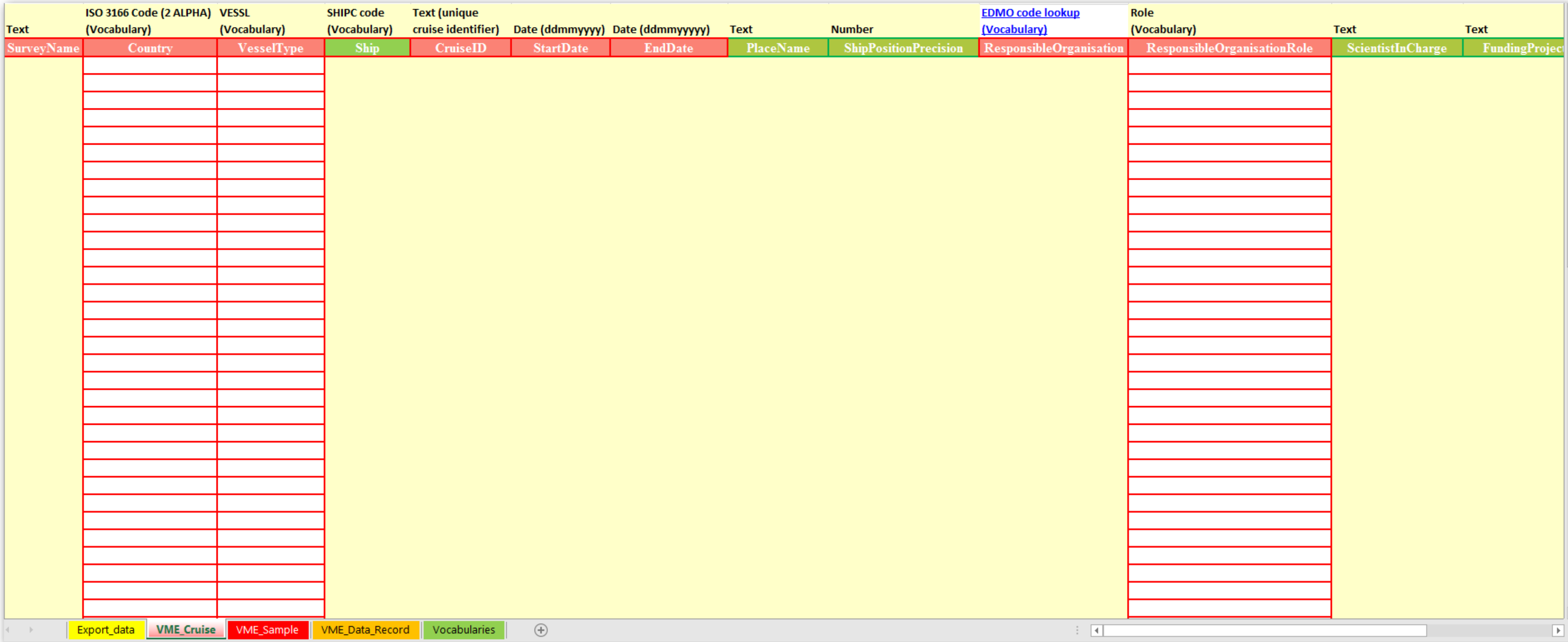

Figure 6.1. Example fields for the "VME Cruise" sheet in the revised reporting format for 2017.

7 Review our current understanding and knowledge of the connectivity of deep-sea populations, with a view to the management of deep-sea ecosystems - ToR [e]

7.1 What is connectivity, why is it important, and how can we measure it?

Connectivity is typically defined as the exchange of particles, energy or materials among entities (Cowen *et al.*, 2007). In the case of marine protection, connectivity is typically considered in the spatial domain and the connections can be achieved by the exchange of individuals, genes, species, as well as energy and materials. Temporal connectivity is receiving increased attention, particularly considering the potential influence of climate change on rates of these exchanges.

Connectivity links fragmented populations, species within and among populations and energy and materials within and across ecosystems. Those links ensure the delivery of ecosystem functions, as well as insurance against population extirpation. In fact, connectivity can significantly influence resilience to disturbance and enhance recovery of a population through the supply of new individuals from an external source. For this reason, connectivity should be explicitly addressed when assessing viability of populations, communities and ecosystems experiencing any form of natural or anthropogenic disturbances and it should be integrated in decisions about management practices as they relate to anthropogenic impacts.

The Convention on Biological Diversity (CBD, 1992) recognized the importance of connectivity in the design of Marine Protected Areas (MPAs). Aichi Target 11 states that "By 2020, at least ….10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and *well-connected* systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape". In 2003 at the Oslo and Paris Commissions (OSPAR) Ministerial Meeting, recommendation 2003/03 on a network of MPAs was adopted, with the purpose of establishing an ecologically coherent network of MPAs in the Northeast Atlantic that is well managed by 2016 (OSPAR, 2003).

The Marine Protected Areas Federal Advisory Committee (USA) recently provided a scientific synthesis and action agenda through the document "Harnessing ecological spatial connectivity for effective Marine Protected Areas and resilient marine ecosystems" (NOAA, 2017). In that document, they provided definitions that describe four different types of ecological spatial connectivity:

Population connectivity results from the movement of individuals of a single species among patchily distributed "local" or "sub-" populations. **Genetic connectivity** (also called "gene flow") is the movement of genes among distinct populations of a single species and results from the movement of organisms -whether spores of marine algae or the larvae, juveniles or adults of marine animals -among these populations. **Community connectivity** results from the movement of multiple different species among distinct ecological communities. **Ecosystem connectivity** results from the movement of multiple species among distinct ecological communities, along with the movement of chemicals (e.g. nutrients and pollutants), energy (in the form of organisms), and materials (e.g. sediments and debris).

Each type of connectivity is estimated with different tools.

Population (demographic) connectivity: For benthic invertebrates, movement of individuals is achieved only by the larval stage since the juveniles and adults are sessile or near-sessile. Larvae are poor swimmers and are transported by currents for the duration of this life-history stage, known as planktonic larval duration (PLD). PLD can range from hours to years depending on the species. Knowledge of the circulation patterns and the length of the PLD can allow the generation of larval trajectories of dispersal. Probability densities of connections between points in space (i.e. populations, habitats, etc.) can then be constructed based on these trajectories. These metrics apply to ecological time-scales of single generations.

Genetic connectivity: Genetic connectivity incorporates outcomes of the many processes that occur over the entire life history and over many generations, such as larval dispersal, settlement, recruitment and reproduction. It provides the ultimate outcome of whether a gene from one population will survive in another, but it cannot address the relative importance of different processes. For example, availability of suitable habitat will influence settlement and survival to reproduction but not necessarily dispersal distance. In contrast, alterations in currents due to climate change will only affect dispersal. Genetic connectivity is measured using molecular tools (e.g. isolation by distance, assignment or parental tests), and the technology is rapidly advancing.

Community and Ecosystem Connectivity: The complexity in estimating these two types relative to the first two described above is much higher because many species and processes (e.g. trophic interactions, energy transfer within and across ecosystems) need to be considered at the same time. Species and ecosystem distributions need to be combined with known linkages (e.g. benthic pelagic coupling, migration across different feeding grounds, movement from nursery areas to adult habitats, detrital exports, etc.). For most communities, it is almost unfeasible to identify all member species and their interactions. Similarly, for most ecosystems, the rates of all relevant fluxes are difficult to measure. One feasible approach is to use traits rather than species as the units, as has been suggested for population connectivity (Burt *et al*., 2014). Ecologists are currently determining the best approaches to measure these two types of connectivity, and are likely to be able to provide some advice to managers within the next two to four years.

This review will be limited to consideration of population demographic and genetic connectivity of benthic invertebrate species. Other working groups may be better placed to advise on highly mobile and pelagic fauna. We are also only concerned with deep-sea species defined as those living predominantly below 200 m water depth.

7.2 What do we know about deep-sea connectivity?

7.2.1 Genetic connectivity

Much of our understanding of deep-sea connectivity is derived from population genetic research. Successful genetic connectivity requires dispersal, survival and continued gene flow (Shank, 2010; Hedgecock *et al*., 2007). Deep-sea fauna exhibit broad geographic ranges with many species having a cosmopolitan distribution (McClain and Hardy, 2010). Such broad geographic ranges coupled with a relatively stable environment suggest that deep-sea populations may be ‘open’ and hence lacking in spatial genetic structuring. Evidence from early molecular studies in general supports this theory, suggesting that gene flow is maintained over considerable horizontal distances (Bucklin *et al*., 1987; France *et al*., 1992; France, 1994; Howell *et al*., 2004). However, more recent research using higher resolution markers has suggested that although gene flow does occur over basin scales, it may occur in a stepping-stone like manner (Etter *et al*., 2011).

Patterns of gene flow (and thus connectivity) are likely to be influenced by reproductive strategy. Brooding species are considered the least capable of distant dispersal (Gage and Tyler, 1991) while those with planktonic larval forms have a much larger capacity for dispersal, due to their potential for hydrographic transport (Thorson, 1950; Vance, 1973). Molecular studies have provided some evidence of differences in genetic structuring that corresponds to reproductive strategy. Samadi *et al*. (2006) examined genetic structuring among two species of Galatheids, two species of Chirostylids and two species of gastropod between seamounts on the Norfolk Ridge, western Pacific Ocean. Population structure was observed only in the non-planktotrophic gastropod which in contrast to the other species studied had limited larvae dispersal ability (short planktonic development phase). Cho and Shank (2010) found incongruent patterns of genetic connectivity among four species of ophiuroid that corresponded to their host coral specificity and their reproductive mode. The different strategies of dispersal; 'broadcast spawners' vs. 'brooders' in the examined ophiuroids corresponded directly with the observed asymmetrical gene flow between the New England and Corner Rise Seamounts. More recent studies on specific deep-sea species in the Pacific (*Primnoa* and *Swiftia*) have found genetic differentiation corresponding to differences in reproductive strategy.

Baco *et al*. (2016), recently summarised genetic divergence data from 51 studies on population genetics of deep-sea species. These authors analysed so-called Isolation-by-Distance slopes (I-B-D slope) to estimate average dispersal distances of invertebrate and non-invertebrate species. Estimates of dispersal distance ranged from 0.24 km to 2028 km with a geometric mean of 33.2 km and differed in relation to taxonomic and life-history factors as well as several study parameters. As perhaps expected, fish species had the largest dispersal distances with invertebrates being much lower. Importantly these authors found that contrary to the widely held (but untested) paradigm that deep-sea taxa can disperse much greater distances than shallow water taxa, overall dispersal distances, although greater, were not large (0.3–0.6 orders of magnitude between means). These authors suggest that scales of dispersal and connectivity for reserve design in the deep sea might be comparable to or only slightly larger than those in shallow water.

It is important to note that there is strong evidence to suggest that gene flow is poor across the depth gradient, with increasing evidence of bathymetric reproductive isolation and speciation among species of a variety of continental slope taxa [Crustacea (Bucklin *et al*., 1987; France and Kocher, 1996); Mollusca (Chase *et al*., 1998; Etter *et al*., 1999; Quattro *et al*., 2001 ; Zardus *et al*., 2006); Echinodermata (Howell *et al*., 2004, Cho and Shank, 2010), and Cnidaria (Miller *et al*., 2011)]. The likely explanation for this is genetic structuring along those environmental gradients that vary with depth. But this has important implications for conservation and management of deep-sea fauna.

While measures of gene flow offer evolutionary insights into successful dispersal events they reveal little in terms of demographic larval flux beyond the identification of barriers to dispersal and perhaps the direction of gene flow (Bohonak, 1999; Wilson and Rannala, 2003; Hellberg, 2009). They are generally able to convey longer term 'evolutionary' connectivity, as opposed to short-term 'ecological' connectivity, which is more relevant to conservation and management of populations. However, the development of new techniques such as next generation sequencing may significantly improve our ability to determine ecological connectivity.

7.2.2 Population (demographic) connectivity

Application of biophysical models at their most fundamental requires knowledge of the planktonic larval duration (PLD) and current speed. PLD has been estimated for only 21 true deep-sea species over a variety of taxa, 93 if you include eurybathic species (mostly echinoderms) (Hilário *et al*., 2015). McClain and Hardy (2010) reviewed the known PLD of deep-sea species and calculated potential larval dispersal distances for these species based on two different current speeds using a simple speed x time = distance calculation. Estimates ranged from <100 km in a current of 0.1 m^{-2} to >100 000 km at 5 m^{-2}. These null models are known to overestimate larval dispersal (Shanks, 2009). More recently Hilário *et al*. (2015) demonstrated that PLDs representative of 50% and 75% of deep-sea species for which PLD are known were 35 days and 69 days respectively. Using these PLD estimates, Ross *et al*. (submitted) modelled passive larval dispersal from several sites in the NE Atlantic using two different oceanographic models, and found that for both PLDs and models, larvae dispersed >10 km but <200 km.

Most species-specific deep-sea studies that employ larval dispersal modelling techniques have been focused on vent and seep fauna (Marsh *et al*., 2001; Mullineaux *et al*., 2002; Bailly-Bechet *et al*., 2008; Young *et al*., 2012). There have only been five deep-sea studies to date simulating the dispersal of non-vent species with species-specific parameters. Yearsly and Sigwart (2011) modelled the dispersal of deep-sea wood obligate Polyplacophorans and provided estimates of dispersal distances of between 48 km and 565 km. Young *et al*. (2012), along with some vent species, modelled the dispersal potential for two sedimented slope echinoids (*Cidaris blakei* and *Stylocidaris lineata*) providing estimates of 160–1570 km dispersal distance. Etter and Bower (2015) recently modelled the dispersal of protobranch bivalves in an area of the NW Atlantic with known genetic structuring amongst depths. Their data suggest at PLDs of 30, 180 and 360 days, mean dispersal distances of <60, <300, and <500 km respectively. Most recently both Ross (2016) and Fox *et al*. (2016) specifically modelled connectivity of Neil, I agree with Kerry that we do not want to get into the shallow water species.

Lophelia pertusa populations within an MPA network in the NE Atlantic. For one MPA Ross (2016) reported trimodal peaks in dispersal distances reflecting three potential pathways open to larvae. These peaks were at 150, 350 and 700–800 km distance from the release location for actively dispersing larvae. Fox *et al*. (2016) provided mean dispersal distances for *L. pertusa* from MPA clusters of 97–190 km for actively dispersing larvae, and 158–309 km for 'long-lived' actively dispersing larvae where PLD was doubled.

7.3 How has connectivity been used in spatial management?

Incorporating connectivity into the design of MPA networks is a challenge. There are several examples from shallow water where this has been done by applying 'rules of thumb' about the size and spacing of MPAs based on current scientific understanding of both genetic connectivity and larval dispersal of shallow water species (Botsford *et al*., 2001; Botsford *et al*., 2003; Shanks *et al*., 2003; Palumbi, 2004; Hastings and Botsford, 2006; Mora *et al*., 2006; Botsford *et al*., 2009; Gaines *et al*., 2010; Pelc *et al*., 2010). Several national reviews (for example Roberts *et al*., 2010 (UK); Burt *et al*., 2014 (Canada)) have dealt with the development of general management principles on size and spacing of MPAs that are applicable across a broad spectrum of marine life for the region in question, and these general management principles have then been applied to that nations MPA network design.

In establishing a representative no-take area network in the Great Barrier Reef Marine Park, a minimum size for no-take areas of at least 10 or 20 km was used as a guiding principle, derived from ecological theory of population maintenance (Fernandes *et al*., 2005). Within the UK Marine Conservation Zones project connectivity was considered in the design principles with the following guidance provided: In the absence of species-specific information on connectivity MPAs of similar habitat should be separated by no more than 40–80 km between individual MPA boundaries (Natural England & the Joint Nature Conservation Committee, 2010). The California Marine Life Protection Act states that based on currently known scales of larval dispersal, MPAs should be placed within 50 to 100 km of each other (California Department of Fish and Game, 2008). While in Canada the current process to establish an MPA network in British Colombia have suggested that both small ~10 km^2 and large 100–1000 km^2 MPAs may be required, that are spaced within 20–100 km (or closer) to each other.

7.4 Can we apply this approach to the deep sea?

When considering potential general management principles for size and spacing of deep-sea protected areas, data from both molecular (Baco *et al*., 2016) and larval dispersal modelling (Hilário *et al*., 2015; Ross *et al*., submitted) suggest a size in the region of 35–100 km in the smallest dimension would be appropriate, but recognising that longer dispersers may require a significantly larger size. For MPA spacing, and from the small number of studies available (highlighted above), it appears most estimates of distance travelled from larval dispersal modelling studies are <1000 km, and many <500 km. Larval dispersal modelling is however, fraught with potential error, not least of which is the ability to accurately represent oceanography over large areas, but at scales relevant to larvae. Estimates from molecular data suggest that scales of dispersal and connectivity for reserve design in the deep sea may be slightly larger than for shallow water but not by much (Baco *et al*., 2016). Therefore spacing at the upper end of shallow water guidance (100 km) but less than 500 km would seem a good initial guideline.

Because deep-sea ecosystems often occur beyond the continental shelves and well beyond a single country's economic zones, connectivity will most often link populations across national borders and areas beyond national jurisdiction (ABNJ). For example, the main source of new individuals for a deep-water closure may be across the border and under a different national jurisdiction than the closure. This is a different case than the current experience with conservation in shallow waters and requires the development of new transboundary approaches and legal instruments than the ones we are familiar with. In addition, considering the potential impacts of climate change on deep-sea connectivity is at present almost impossible since we have very little understanding of the likely impacts of climate change on deep-sea hydrography.

7.5 References

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8 Review and report on the distribution of VMEs (VME Indicators and Habitats) within the Rockall Bank Haddock Box – ToR [f]

8.1 Background

In 2001 NEAFC closed an area on the Rockall Bank for the purposes of protecting juvenile haddock that were thought to be especially abundant within the area. The 'Haddock Box' closure lay partially in the areas beyond national jurisdiction (ABNJ) and partially within the EEZs of the UK and Republic of Ireland. It was respected by the fishing industry and it became an area with no bottom-trawl impacts for over a decade. Because the area had been closed to bottom fishing and thus was largely protected from benthic impact, little focus had been given to whether the area contained VMEs. In 2015 VMS data provided by NEAFC suggested bottom fishing activity occurred inside the closure which could potentially impact VMEs.

The ICES VME database contains information on VME indicator species in this area that are derived from a range of sources including records of coral bycatch from the fishing industry, records of bycatch from research vessel surveys and some scientific visual transects. There are no verified recent records of VME habitat in the closed area, however, there are 390 VME indicator records located within the bounds of the Haddock Box (Table 8.1). The OSPAR 2015 database contains 15 records of OSPAR habitats from within the Haddock Box, 12 of which are *Lophelia pertusa* reefs and three of which are deep-sea sponge aggregations. All except two of these records are 'uncertain' suggesting that these records may have been bycatch records of *Lophelia pertusa* and deep-sea sponge species, similar to VME indicators, rather than *bona fide* records of VME habitats. The two certain records are both of *Lophelia pertusa* reef, but are taken from data collected in 1973. As such, the confidence in these records still occurring in these locations, and thus being VME habitat records, is reduced due to the age of the records.

There is also high resolution multibeam data (Irish National Seabed Survey) for the southern two-thirds of the Haddock box, which was examined. Note that these multibeam data have been incorporated into the EMODNET Bathymetry[5] layer which is used in the base map for Figure 8.1. The multibeam data suggest an area of complex seabed topography in the west of the area and a flatter, deeper and possibly more sedimentary area in the east of the area. All VME related data, plotted against a background of EMODNET Bathymetry data, are shown in Figure 8.1.

[5] http://www.emodnet-bathymetry.eu/

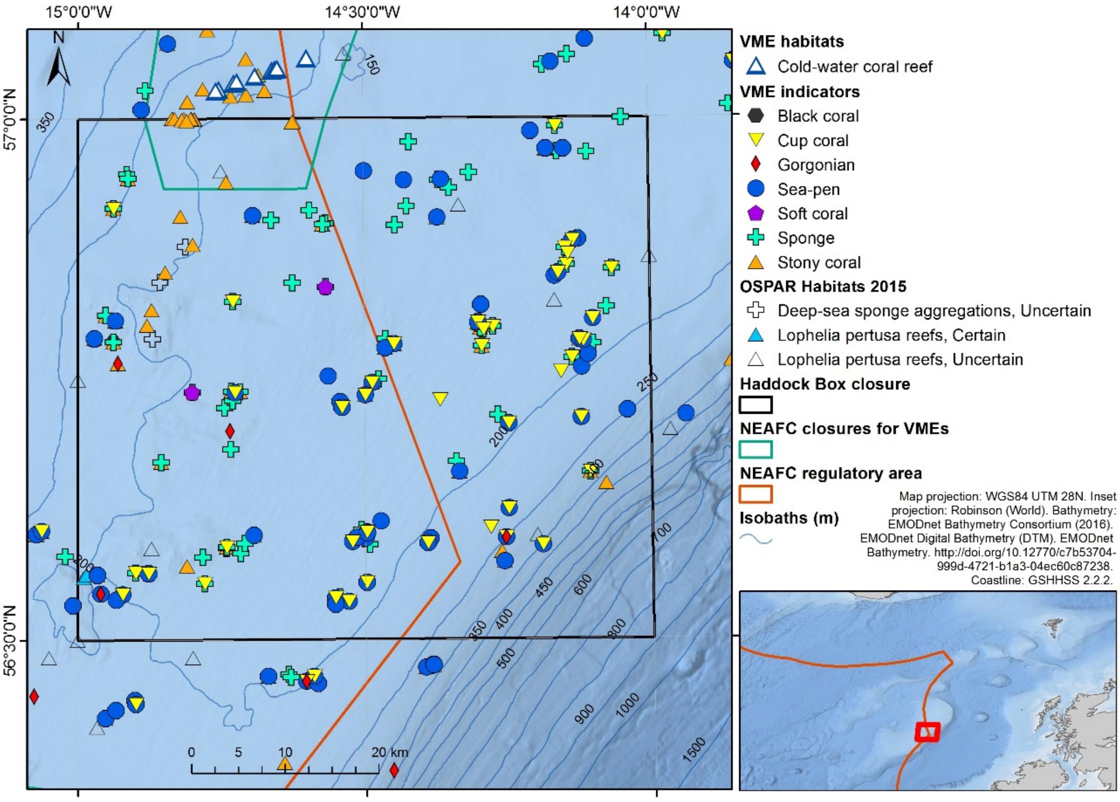

Figure 8.1. The Haddock Box and all records from the VME database and the OSPAR 2015 database (including the 390 VME indicator records and 15 OSPAR records within the Haddock box). The base map from EMODNET Bathymetry incorporates high resolution multibeam from the Irish National Seabed Survey[6].

Table 8.1. Number of records for each VME indicator from the ICES VME database (March 2017 version).

VME Indicator	Number of records
Black coral	2
Cup coral	49
Gorgonian	4
Seapen	73
Soft coral	5
Sponge	202
Stony coral	55
Total	390

[6] https://www.gsi.ie/Programmes/INFOMAR+Marine+Survey/

The ICES VME weighting algorithm allows all these VME indicator records (shown in Table 8.1) to be considered simultaneously to assess the likelihood of VME within the closed area. The output of the VME weighting algorithm (Figure 8.2) shows an area in the NW of the Haddock Box with a high concentration of c-squares with a 'high' VME Index; that is, there is a high likelihood of encountering a VME within these cells. However, only two of these c-squares were assigned a high confidence score (Figure 8.3) and notably, both these were the same c-squares that fall within the NW Rockall NEAFC bottom fishing closure where it overlaps with the Haddock Box. Throughout the rest of the Haddock box, there were several other c-squares with high VME Index scores (Figure 8.2). However, these all have either medium or low confidence scores associated with them (Figure 8.3).

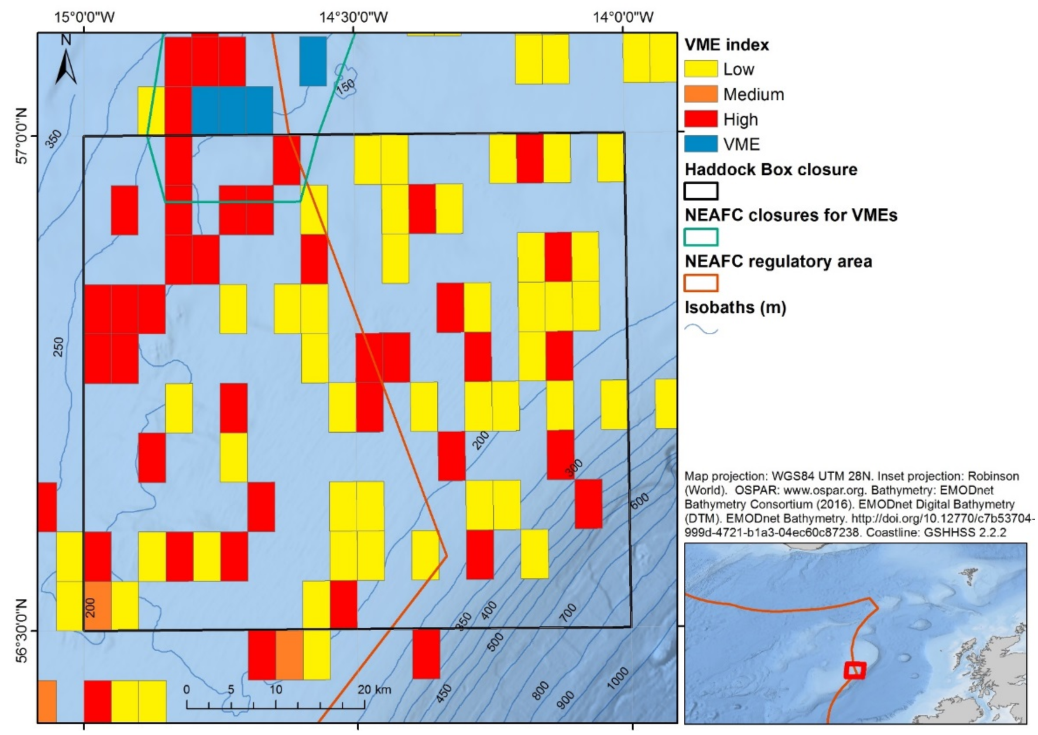

Figure 8.2. Outputs of the ICES VME Indicator weighting algorithm for records from the ICES VME Database (March 2017 version). The Haddock box is delineated by the black line. Note the concentration of c-squares in the NW corner with a high VME Index. These results should be interpreted in association with the VME Index confidence layer shown below in Figure 8.3.

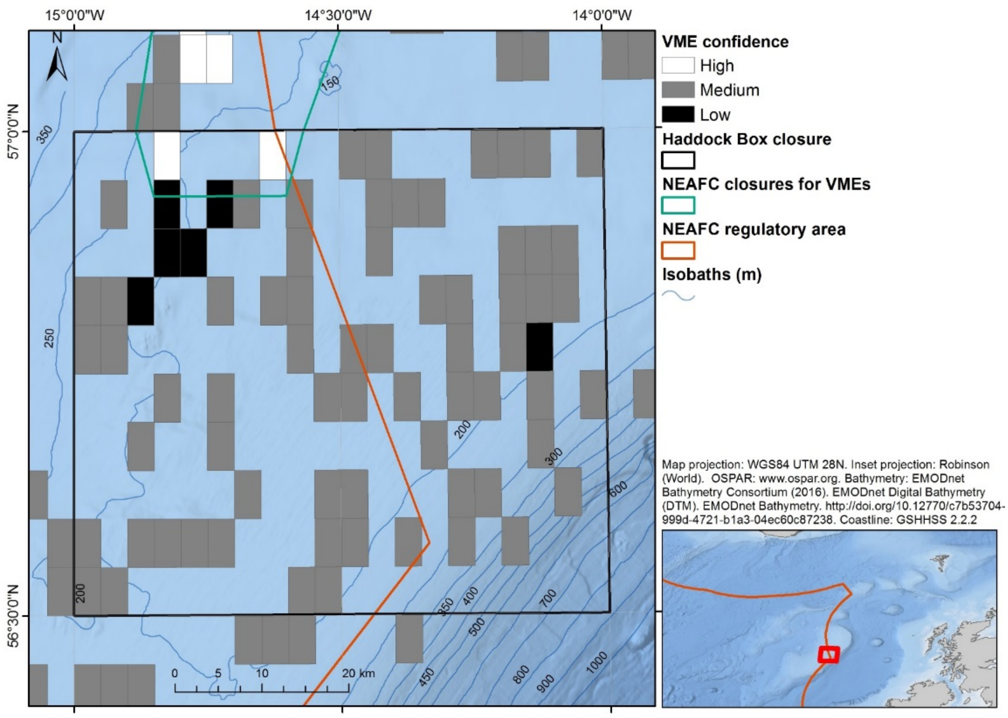

Figure 8.3. The VME index confidence layer, associated with the outputs from the ICES VME Indicator weighting algorithm, for records from the ICES VME Database (March 2017 version).

8.2 Details of VME indicator taxa from records within the Haddock Box closure

There were two survey bycatch records of the black coral, *Parantipathes* spp; both were very small specimens (<10 grammes weight). These were found in the NW corner of the Haddock Box. 49 records of cup-corals, all of the species *Caryophyllia smithii*, were widely distributed, most abundantly in the SE half of the closure. Four specimens of gorgonian were recorded, all of which were the genus *Placogorgia* and all very small specimens (<50 grammes). They were located primarily in the western half of the closure in the area of complex seabed topography. 73 records of seapens (from survey bycatch) were located inside the Haddock Box. They were distributed throughout the area, although more frequently encountered in the SE half of the closure, especially in the deeper water. Some of the catches of *Funiculina quadrangularis* were significant (>100 individuals), potentially indicative of seapen fields. Also of note were specimens of a *Pennatula* species that is currently undescribed for this region. Soft corals were recorded on five occasions; all were small specimens of the species *Duva florida* and in all cases, were found in the NW half of the closure. Sponges were the most commonly encountered VME indicator in this area (202 records), however, these were not the large aggregation forming species such as *Geodia*, but included species such as *Phakellia ventilabrum*, *Suberites pagurorum* and Axinellidae spp. There were three records of deep-sea sponge aggregations from the OSPAR habitats database (all 'uncertain') from a video transect in the NW of the area. Records of stony corals (*Lophelia pertusa* in this case) were scattered across the area. These records are both from commercial bycatch records and research vessel surveys. Many are old, historic records, notably those from OSPAR (1973), including the only two 'certain' records. No recent (since 1973) *bona fide* coral reef habitat is recorded in the area. Records since 2005 have all been in small quantities (maximum 11 kg).

There appears to be a concentration of records in the NW corner and a video transect along the edge of the Haddock Box in 2012 (ICES, 2012) revealed living *Lophelia* reefs. This is, however, within the NW Rockall closure.

8.3 Overall assessment

It is proposed that the part of Rockall bank within the Haddock Box is divided into two main ecotypes; the northwest and western half of the 'Box', which has a complex seabed topography (possibly indicative of a hard, rocky seabed) transitioning to the southeast half of the 'Box', where the seabed appears flatter (until the edge of Rockall Bank in the far SE corner), less complex, and typical of a soft-bottom, sedimentary seabed.

8.3.1 The NW section of the Haddock Box (NEAFC RA)

The NW half of the Haddock Box shows clear evidence of once having stony coral reefs, although the only recent evidence is now in the far north (currently also within the NW Rockall bottom fishing closure). This NW area is also where occasional black corals, gorgonians and soft corals were recorded. While this area supports various VME indicator species, and the high VME Index c-squares show there is a high likelihood of encountering a VME within these cells, all (apart from two cells within the NW Rockall closure) have low or medium confidence assessments. Therefore, excluding the area within the NW Rockall closure, there is no strong evidence of *bona fide* VME. Recent video footage (from Marine Scotland survey 1011S) shows this NW half of the 'Box' to have isolated records of large sponges, but no sign of the historical coral records reported by fishermen. The weight of observed VME indicators were below the NEAFC threshold, suggesting that no VME had been detected to date in this part of the Haddock Box, located in the NEAFC regulatory area.

8.3.2 The SE section of the Haddock Box (UK and Ireland EEZ)

There was no evidence of VME, e.g. cold-water coral reef or deep-sea sponge aggregations, despite numerous records of small pieces of *Lophelia pertusa* and small sponges. The main VME indicator species from this area were seapens and cup-corals, of which only seapens were found in quantities that may be of concern. Although WGDEC does not have a weight threshold for seapen that would qualify as VME, in some places the seapen counts per trawl exceeded 100 individuals which may be indicative of seapen fields.

8.4 References

ICES. 2012. Standing NEAFC request on vulnerable deep-water habitats in the NEAFC Regulatory Area. Report of the ICES Advisory Committee 2012. ICES Advice, 2012. Book 1. 156 pp.

9 Review the appropriateness of NEAFC bottom fishing closures as defined in Annex 2 of NEAFC Recommendation 19:2014, and whether significant adverse impacts on VME are still considered likely in these areas – ToR [g]

9.1 Background

WGDEC has approached this Term of Reference by considering each area in turn in relation to what the scientific basis of the closure was, whether new information has become available since the closure and whether this new information suggests the closure remains appropriate to protecting Vulnerable Marine Ecosystems (VMEs). If no new information has come to light since closure disputing the presence of VME, it is assumed that VMEs still occur, or are likely to occur in the area and require protection. WGDEC has produced a table (Table 9.1) summarising the current situation for each VME closure. WGDEC is of the view that all closures should remain as is and are appropriate, but stresses that this may be subject to change as new information comes to light in future. Closure names and codes are as listed in NEAFC (2015).

9.2 Mid-Atlantic Ridge (MAR): Areas (a), (b) and (c)

In general, for these areas and the MAR as a whole, very limited areas have been studied and mapped with sufficient spatial resolution to assess the distribution of VMEs. The decision to close certain areas was therefore based more on general information on seabed topography (VME elements: geomorphological features likely to contain VMEs), biogeography and ecology, and the general spatial distribution patterns of VME indicator species. The only detailed information is from a few sites within the closures that were explored during the Mid-Atlantic Ridge Ecosystem project (MAR-ECO) and Ecosystems of the Mid-Atlantic Ridge project (ECOMAR). These studies confirmed the presence of VMEs (Mortensen *et al.*, 2008) on the MAR. The closures aimed to protect a representative selection of VMEs within the faunal provinces north and south of the Subpolar Front, and each closure contained VME elements such as pinnacles, knolls, ridges, and troughs likely to contain VMEs. The precise boundaries and sizes of the closures were not considered critical as long as they contained a range of VME elements and covered a swathe extending to around 3000–3500 m water depth on either side of the ridge axis. As representative portions of the Mid-Atlantic Ridge ecosystem, these areas are likely to contain VMEs and therefore the closures remain appropriate and should be maintained.

9.3 The Altair and Antialtair Seamounts: Areas (d) and (e)

Although there are no VME records from these two seamounts, they are considered as VME elements (ICES, 2013a), are likely to contain seamount communities and thus VMEs. ICES WGDEC is not aware of new data indicating presence of VMEs within the closed area. As representative seamounts to the east and west of the Mid-Atlantic Ridge ecosystem that are likely to contain VMEs, the closure remains appropriate and should be maintained.

9.4 Hatton Bank and Hatton Bank 2: Area (f) and (m: m1 & m2)

The Hatton Bank closures were drawn up on the basis of high quality scientific data consisting of multibeam data, research survey samples and samples obtained by observers working on fishing vessels (Howell *et al.*, 2007; Duran *et al.*, 2009). VMS data were also a key element in designing the closure boundaries. There have been no further scientific investigations of the Hatton Bank and thus the current boundaries are considered appropriate.

9.5 Rockall Bank

9.5.1 Northwest Rockall: Area (g)

This closure was drawn up on the basis of numerous records of *Lophelia* reefs from scientific investigations (Wilson 1979; Howell *et al.*, 2009; Long *et al.*, 2010), information from fishermen on where they had encountered coral in the past and patterns of fishing activity based on vessel plotter data and VMS data. Several recent investigations have taken place within or adjacent to the closure boundary using visual survey methods such towed cameras and remotely operated vehicles (ROVs) fitted with high resolution seabed imagery equipment. These surveys confirm the presence of VMEs (cold-water coral reefs) inside but also outside the current closure. Overall the closure offers protection to VMEs, but could be extended to further reduce the risk of VMEs being impacted. Following new evidence on VMEs presented to WGDEC in 2011 and 2012, ICES advised a change to the fishing closure boundary in 2011 and reiterated this advice in 2012 (ICES, 2011 and ICES, 2012).

9.5.2 Southwest Rockall (Empress of Britain Bank): Area (g1)

This closure was drawn up on the basis of numerous records of *Lophelia* reefs from scientific investigations, information from fishermen on where they had encountered coral in the past and patterns of fishing activity based on vessel plotter data and VMS data. A towed camera investigation took place within and adjacent to the closure boundary (ICES, 2011). It revealed significant areas of *Lophelia* reef in the centre of the closure. The current boundary of the closure protects the main locations of coral adequately and so remains appropriate.

9.5.3 Southwest Rockall: Area (k1) and (k2)

These two small areas were closed in 2013 following reports of large bycatches of *Lophelia* by research surveys in 2011 (ICES, 2012). No new data are available and thus the boundaries are considered appropriate.

9.6 Logachev Mounds: Area (h)

This area is a deep-water site closed on the basis of scientific evidence of carbonate mounds and cold-water coral reefs. Some new explorations confirm presence of VMEs within the closure (van Haren *et al.*, 2014; Roberts *et al.*, 2013; Kazanidis and Witte, 2016). The closure thus remains appropriate.

9.7 West Rockall Mounds: Area (i)

This area is a deep-water site closed on the basis of scientific evidence of carbonate mounds and cold-water coral reefs. No further evidence to the contrary has been received by WGDEC, so the group considers that the closure remains appropriate.

9.8 Edora's Bank: Area (j)

This area was closed on the basis of several longline bycatch records of corals and gorgonians alongside new high resolution multibeam bathymetry indicating the presence of a VME element (ICES 2012); the boundary was delineated based on the topographic feature which makes up Edora's Bank, recognising it as a VME element (ICES, 2013a) and assuming VMEs to be present across the bank. No new data are available. The closure is therefore considered appropriate.

9.9 Hatton–Rockall Basin (cold seep): Area (l1)

This area was originally closed on the basis of evidence of bycatch of chemosynthetic bivalve species in 2012 (ICES, 2013b). Since 2012 there has been visual confirmation of a cold-seep ecosystem (ICES, 2016b). The closure is therefore considered appropriate.

9.10 Hatton–Rockall Basin (Sponge area): Area (l2)

This area was closed on the basis of towed seabed video and remotely operated vehicle (ROV) seabed video evidence of deep-sea sponge aggregations in the area (Jacobs and Howell, 2006; Howell *et al.*, 2013). The closure remains appropriate. However, note that ToR (a) includes a new recommendation for extending the current fishing closure following new evidence of VME presented to WGDEC 2017.

WGDEC recommendation summary: WGDEC is of the view that all closures remain appropriate, but stress that this may be subject to change as new information on VME distribution comes to light in future.

Table 9.1. Summary of the review of NEAFC VME closures under Recommendation 19 2014, as amended by Recommendation 09:2015.

Area	Year closed	Basis for closure	New evidence on presence of VME	New evidence on absence of VME	Closure considered appropriate
Northern Mid-Atlantic Ridge (MAR) – Area (a)	2005	VME Element (Ridge feature)	No	No	Yes
Middle Mid-Atlantic Ridge (MAR) – Area (b)	2005	VME Element (Ridge feature) & VME Indicators	Yes	No	Yes
Southern Mid-Atlantic Ridge (MAR) – Area (c)	2005	VME Element (Ridge feature) & VME Indicators	No	No	Yes
Altair Seamount – Area (d)	2005	VME Element (Seamount)	No	No	Yes
Antialtair Seamount – Area (e)	2005	VME Element (Seamount)	No	No	Yes
Hatton Bank – Area (f) & (m1 & m2)	2007–2015	VME Element (Bank feature), VME Indicators	Yes	No	Yes
Northwest Rockall – Area (g)	2007	VME Habitats & VME Indicators	Yes	No	Yes[7]
Southwest Rockall (Empress of Britain Bank) – Area (g1)	2008	VME Habitats & VME Indicators	Yes	No	Yes
Southwest Rockall – Area (k1) and (k2)	2013	VME Indicators	Yes	No	Yes
Logachev Mounds – Area (h)	2007	VME Habitats & VME Indicators	Yes	No	Yes
West Rockall Mounds – Area (i)	2007	VME Indicators	No	No	Yes

[7] Overall the closure offers protection to VMEs, but could be extended to further reduce the risk of VMEs being impacted, in line with ICES advice in 2011 and 2012 (ICES, 2011 and ICES, 2012).

Area	Year closed	Basis for closure	New evidence on presence of VME	New evidence on absence of VME	Closure considered appropriate
Edora's Bank – Area (j)	2013	VME Element (Bank feature) & VME Indicator	No	No	Yes
Hatton Rockall Basin (cold seep) – Area (l1)	2015	VME Habitats & VME Indicators	Yes	No	Yes
Hatton Rockall Basin (sponge area) – Area (l2)	2015	VME Habitats & VME Indicators	Yes	No	Yes

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10 Evidence of damage to a vulnerable marine ecosystem (cold-water coral mound) on Rockall Bank

10.1 Background

Neil Golding (UK) presented a summary of the findings from a briefing document drafted by JNCC for Marine Scotland (Last, 2016). The briefing document examined the preliminary findings from a recent collaborative survey (JC136) in 2016 (Howell *et al.,* 2016) when a remotely operated vehicle (ROV) transect was undertaken over Rockall Bank at the location of a formerly identified coral mound feature. This video transect imaged the same area surveyed in 2011 (JC060) by ROV (Huvenne, 2011). On the same 2011 survey, high resolution side-scan data have also been collected by Autonomous Underwater Vehicle (AUV) (see Figure 10.1) in addition to ROV imagery (Figure 10.3), verifying the presence of a coral mound.

The 2016 survey recorded notable quantities of coral rubble from this coral mound location (Figure 10.4). A subsequent comparison between the 2011 and 2016 ROV imagery data showed key differences in the condition of the coral mound feature.

This coral mound is situated in Scottish offshore waters within the UK's Exclusive Economic Zone. It is located within the NW Rockall candidate Special Area of Conservation (cSAC) and Site of Community Importance (SCI), but is located outside the current bottom fishing closure (Regulation (EU) No 227/2013). ICES advised in 2011 (ICES, 2011a) that this bottom fishing closure be modified, encompassing the location where this coral mound was found, based on data presented at WGDEC 2011 (ICES, 2011b). This advice was reiterated in 2012 (ICES, 2012) when new data from JC060 were presented showing evidence of cold-water coral reefs outside the current fishing closure area.

10.2 Spatial extent of change to cold-water coral mound

Underwater video footage from the JC060 (2011) ROV transect shows elevated cold-water coral reef in a distinct circular shape. The mound feature is visible on the sidescan sonar data (Figure 10.1), showing an indicative diameter of 10 m. There are extensive areas of live (white-coloured) coral (Figure 10.3). There were no areas of coral rubble visible in the ROV imagery.

The ROV imagery from JC136 (2016) (Figure 10.4) showed the same cold-water coral feature, but with a reduced elevation. Elevation of reef was estimated at <50 cm across much of the feature with occasional patches reaching approximately one metre high. The JC136 ROV imagery also showed coral rubble dispersed up to approximately 180 m away from the edge of the cold-water coral mound, mapped in 2011. The frequency and size of the coral rubble fragments increased along the length of the tow, right up to the location of the mapped coral mound.

Locations of the example images taken from the ROV footage in 2011 and 2016 are mapped in Figure 10.2, along with buffers showing positional accuracy. The apparent positional discrepancies are likely to be due to the combination of difference datasets and the different systems used for data collection. In addition, an offset (north:south) error of 12 m was noted during the processing of the sidescan sonar mosaic, which also contributes to the apparent mismatch between ROV positions and the side-scan data. Furthermore, the sidescan sonar imagery distinctly shows the coral mound feature, on an otherwise featureless seabed, and the distance to the next nearest coral mound is ~65 m. Consequently, there is high confidence that the images from 2011 and 2016 surveys do represent the same feature.

Metadata from the images shown in Figure 10.3, Figure 10.4 and Figure 10.5 are presented in Table 10.1.

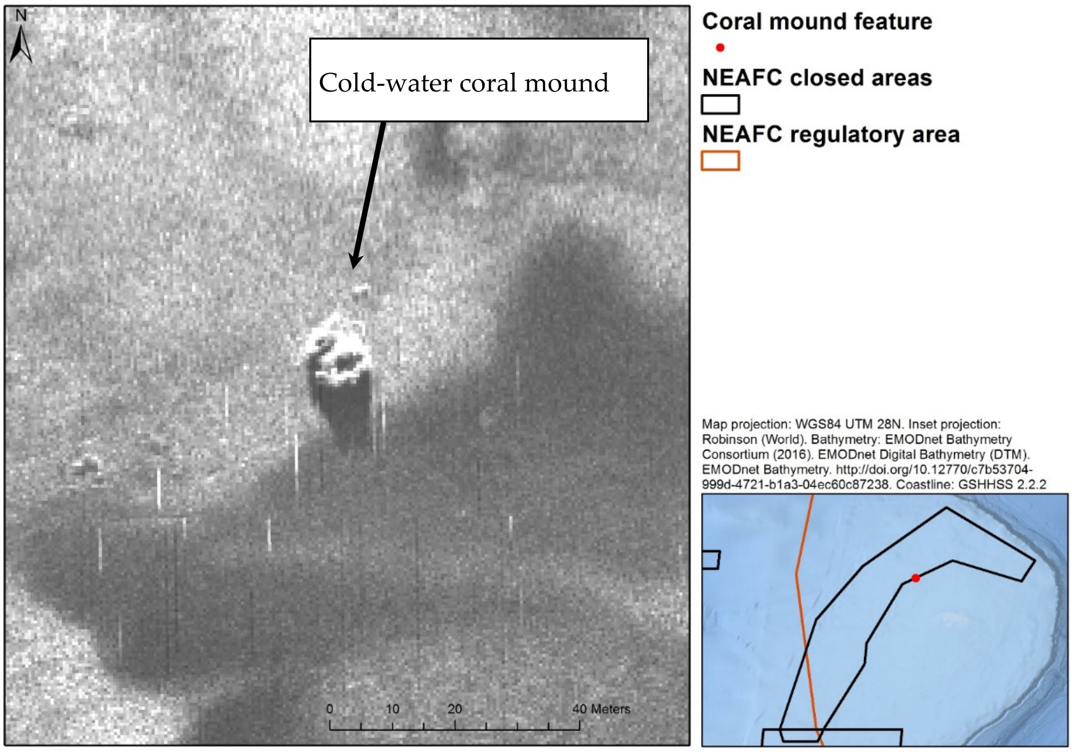


Figure 10.1. Main map shows the sidescan sonar data collected during JC060 (2011) and the coral mound feature in the centre of the image. Inset map shows where this feature is located on the edge (and just outside) of the Northwest Rockall Bank bottom fishing closure area (main black outline). Sidescan sonar data © NOC, 2011.

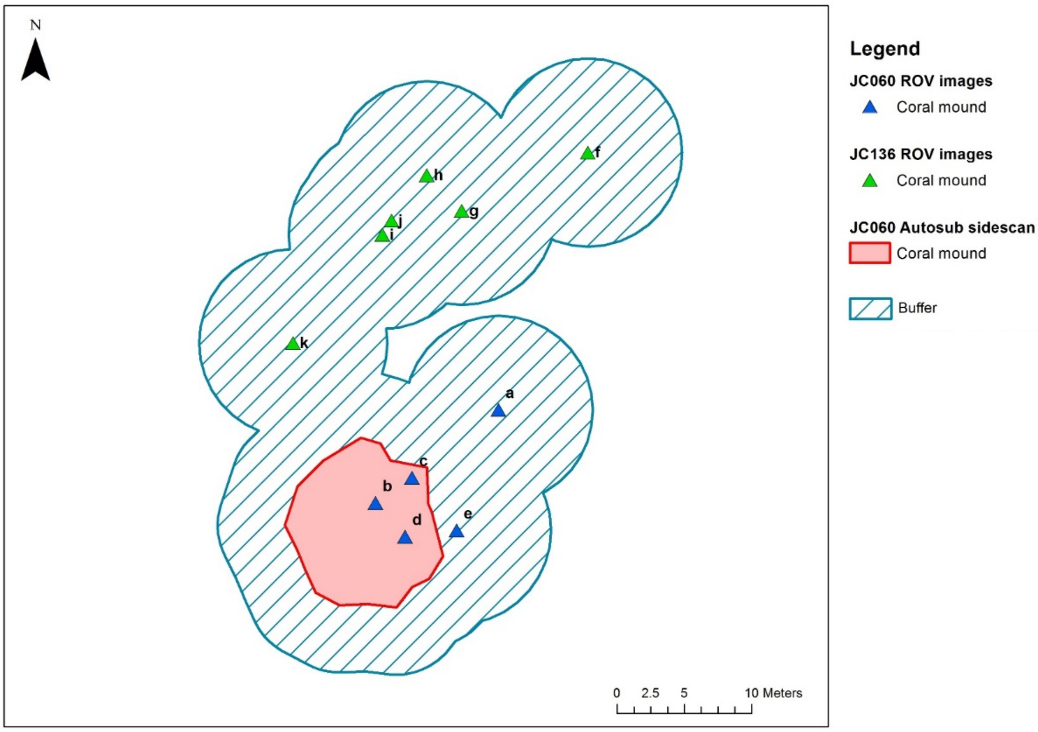


Figure 10.2. Main map shows the locations of the ROV images from JC060 (2011) and JC136 (2016) shown in Figure 10.3 and Figure 10.4 respectively. The coral mound feature has been digitised from the JC060 AutoSub sidescan data © NOC, 2011. A buffer of 7 meters around the coral mound data points and a buffer of 5 meters around the JC060 AutoSub sidescan data has been applied to show the possible positional error, as described in Section 10.1 above.

10.3 Possible cause(s) of change to cold-water coral mound extent

The coral mound feature occurs at a depth of ~190 m (see Table 10.1). The disturbance effects of storm events diminish with depth, and at 190 m water depth, the coral mound is likely below the storm wave-base depth (Bridge and Demicco, 2008). Therefore, it is unlikely that the damage to the coral mound feature between 2011 and 2016 is associated with any natural storm event, and is more likely caused by mechanical damage from anthropogenic activity.

Clear linear scars in the seabed, with scattered coral rubble, were observed near the coral mound on JC136 ROV imagery in 2016 (Figure 10.5), between 7 and 168 m away from the mound; the coral rubble appeared to become more dispersed further away from the feature. These linear scars are consistent with marks made on the seabed by trawl doors; examination of VMS data showed that there had been some fishing activity in the area, but it is not possible to conclusively say what kind of activity these scars relate to.

10.4 Next steps

In light of the evidence (in the form of ROV seabed imagery) gathered on survey JC136 in 2016, the Scottish Government is intending to seek emergency measures through the European Commission to extend the current bottom fishing closure on NW Rockall Bank within the UK EEZ, in order to align it with current ICES advice (Figure 10.6).

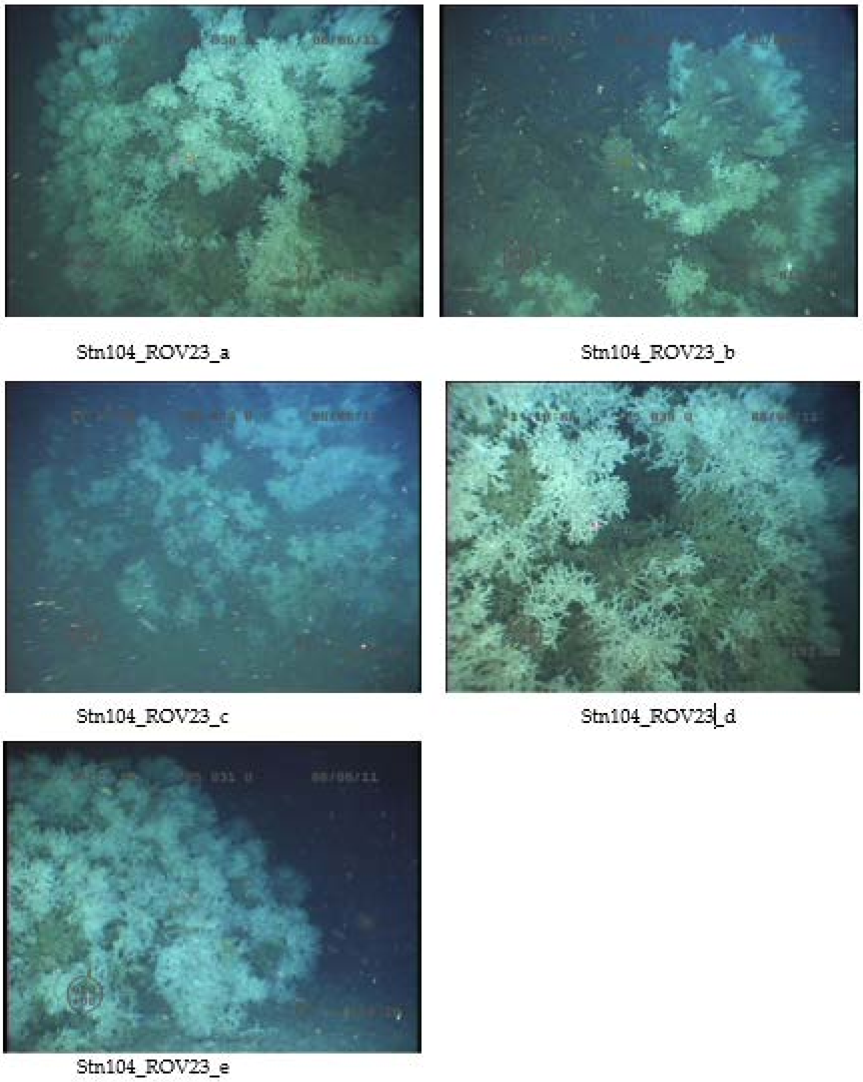
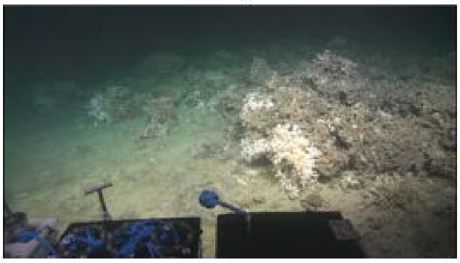


Figure 10.3. A selection of representative images from the ROV videos recorded during JC060 (Huvenne, 2011) © NOC, 2011. The location of the images can be seen in Figure 4. The metadata for each of the photos can be found in Table 10.1. The two red laser dots represent a 10 cm scale.

Stn16_ROV274_f

Stn16_ROV274_g

Stn16_ROV274_h

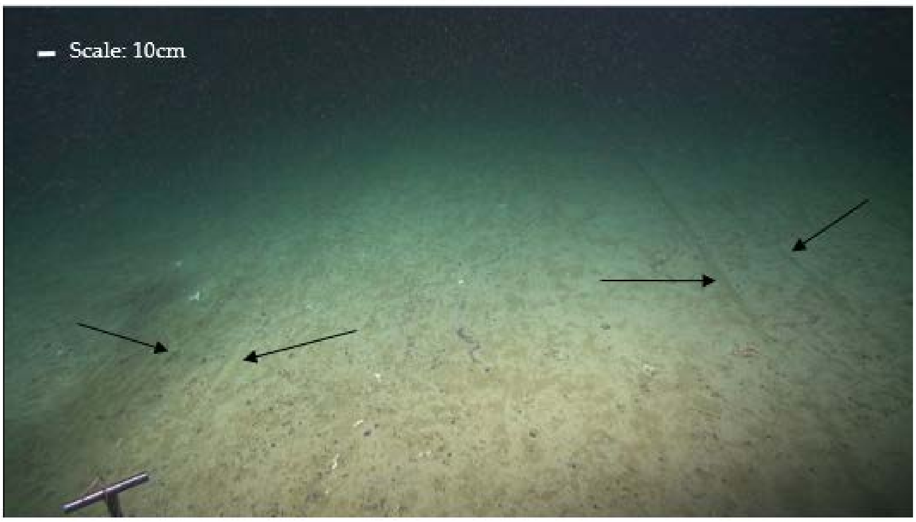


Stn16_ROV274_i

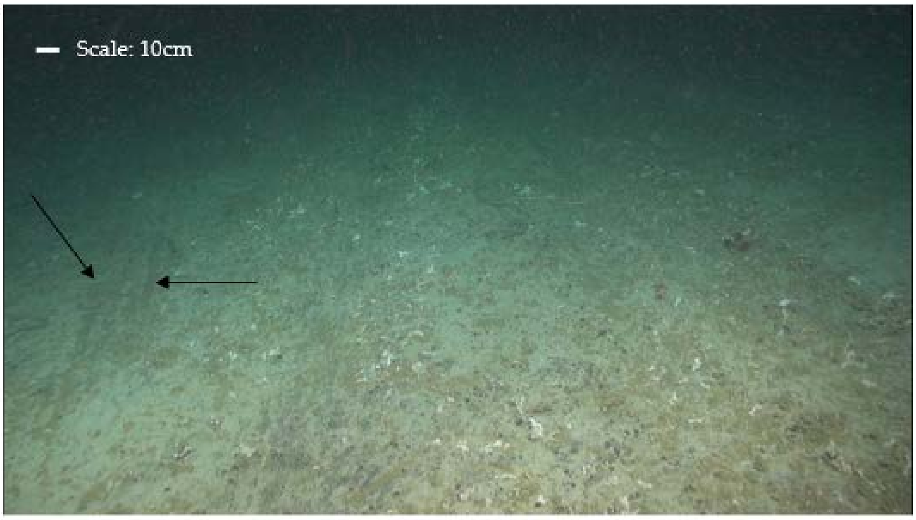
Stn16_ROV274_j

Stn16_ROV274_k

Figure 10.4. A selection of representative images from the ROV videos recorded during JC136 (Howell *et al.*, 2016) © NERC funded Deep Links Project - Plymouth University, Oxford University, JNCC, 2016. The location of the images can be seen in Figure 4. The metadata for each of the photos can be found in Table 10.1. The two red laser dots represent a 10 cm scale, but they are only present on image Stn16_ROV274_f.



Stn16_ROV274_l



Stn16_ROV274_m

Figure 10.5. Linear scars on the seabed observed during JC136 (2016) ROV dive 274, station 16, on sandy seabed with dispersed coral rubble visible. The top image (Stn16_ROV274_l) is at a distance of 168 m from the coral mound feature, while the bottom image (Stn16_ROV274_m) is 7 m away from the coral mound. Metadata for the images can be found in Table 10.1. The two dot red lasers represent a 10 cm scale (also represented by white scale bar). Both images ©NERC funded Deep Links Project - Plymouth University, Oxford University, JNCC, 2016.

Table 10.1. Metadata for the JC060 (Huvenne, 2011) and JC136 (Howell *et al.*, 2016) images in Figure 10.3, Figure 10.4 and Figure 10.5. JC136 and JC060 depths were recorded using CTD. The locations have been plotted in Figure 10.2.

SURVEY	IMAGE	LOCATION		TIME		CTD DEPTH (M)	USBL DEPTH (M)
		Latitude	Longitude				
JC060 (2011)	Stn104_ROV23_a	57.8480	-14.0051	14:06:56		-191.5	-187.1
	Stn104_ROV23_b	57.8477	-14.0054	14:09:14*		-189.6	-190
	Stn104_ROV23_c	57.8479	-14.0052	14:17:40		-190.1	-186.6
	Stn104_ROV23_d	57.8479	-14.0052	14:18:06		-188.4	-185
	Stn104_ROV23_e	57.8478	-14.0052	14:24:07**		NA	-188.9
JC136 (2016)				Video time	Real time		
	Stn16_ROV274_f	57.8482	-14.005	00:39:57	10:26:26	-191.3	NA
	Stn16_ROV274_g	57.8481	-14.0052	00:50:50	10:37:21	-191.6	NA
	Stn16_ROV274_h	57.8481	-14.0052	01:00:46	10:47:18	-191.6	NA
	Stn16_ROV274_i	57.8481	-14.0053	01:08:04	10:54:37	-191.3	NA
	Stn16_ROV274_j	57.8481	-14.0053	01:16:40	11:03:14	-191.4	NA
	Stn16_ROV274_k	57.8480	-14.0054	01:21:08	11:07:42	-190.0	NA
	Stn16_ROV274_l	57.8491	-14.0029	00:07:40	09:54:05	- 192.1	NA
	Stn16_ROV274_m	57.8482	-14.0049	00:38:35	10:25:04	-191.3	NA

*** USBL error so next closest fix used (14:09:21).**

**** USBL error so next closest fix used (14:24:14).**

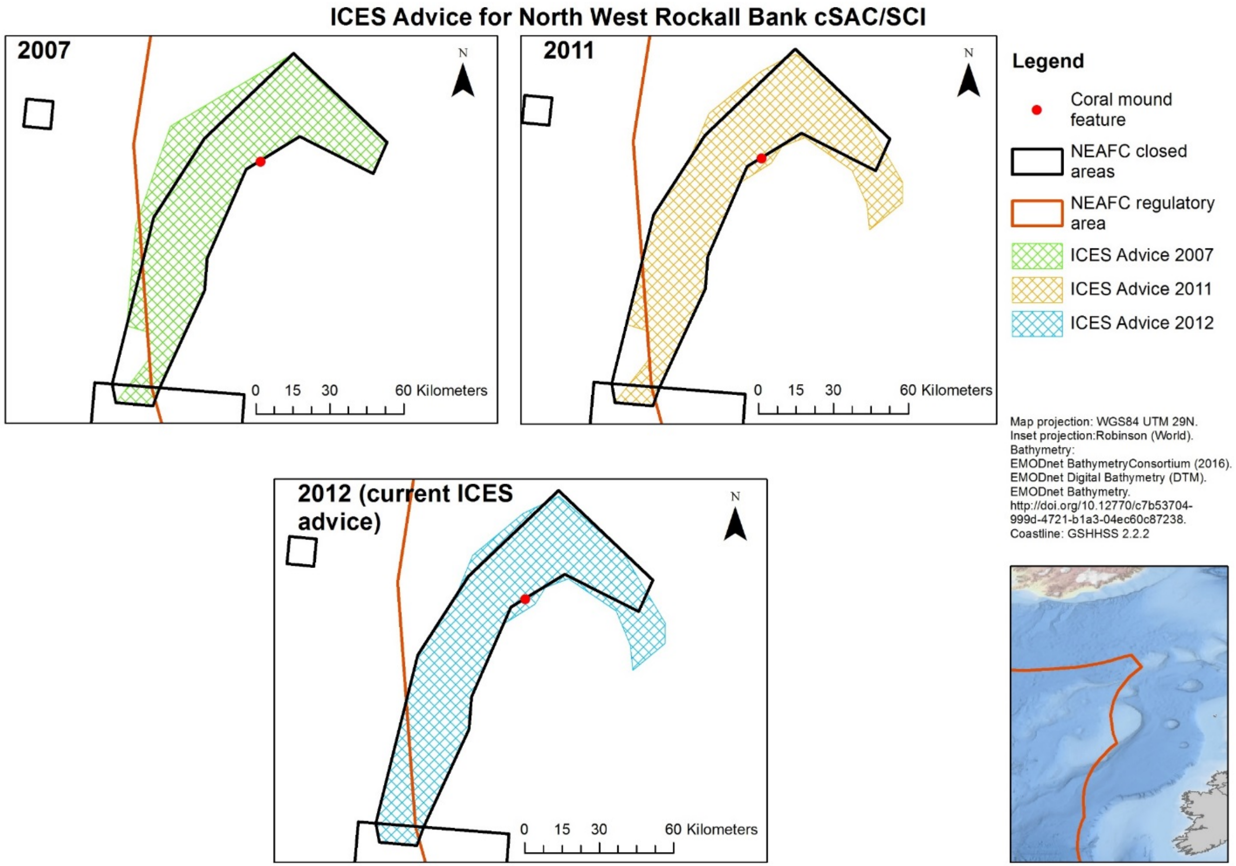


Figure 10.6. Evolving ICES advice for bottom fishing closure areas on Rockall Bank from 2007, 2011, 2012 (current ICES advice).

10.5 References

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Regulation (EU) No 227/2013 of the European Parliament and of the Council of 13 March 2013 amending Council Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms and Council Regulation (EC) No 1434/98 specifying conditions under which herring may be landed for industrial purposes other than direct human consumption. http://data.europa.eu/eli/reg/2013/227/oj

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Annex 2: WGDEC terms of reference for the next meeting

The Joint ICES/NAFO **Working Group on Deep-water Ecology (WGDEC)**, chaired by Neil Golding, UK, will meet at (TBC) in (TBC) 2018 to:

a) Collate new information on the distribution of vulnerable habitats as well as important benthic species and communities in the North Atlantic and adjacent waters, and archive appropriately using the ICES VME Database for dissemination via the Working Group report and ICES VME Data Portal;

b) Provide all available new information on the distribution of vulnerable habitats (VMEs) in the NEAFC Convention Area and fisheries activities in the vicinity of such habitats, with a view to identifying potential new closures, or revision of existing closures to bottom fisheries in the NEAFC Regulatory Area. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters;

c) Continue reviewing how to best define Good Environmental Status (GES) for deep-sea habitats. In particular, continuing a review on spatial and temporal scales and progress with indicator development for the deep-sea;

d) Summarize existing knowledge of ecosystem functioning of deep-sea benthic communities and habitats and the ecosystem roles of chemical/physical structures such as vents, seeps, seamounts, canyons, etc.;

e) Review how vulnerable marine ecosystems (VMEs) have been defined previously (e.g. from other RFMOs or States) and through the use of case studies for specific VMEs (e.g. seapen fields and cold-water coral reefs), suggest a procedure and consider approaches relevant to the available data and species of the NE Atlantic for developing a biological basis for defining how VMEs are identified, which will allow us in future to have an ecological basis for determining when a VME indicator record (or group of) transitions into a VME;

f) Propose parameters for use within the VME database that would serve to remove the effect of the passage of time in the evaluation of confidence in the weighting system, associated with each data entry. In addition, consider anthropogenic impacts that might be used to reintroduce uncertainty in such records.

WGDEC will report by 28th May 2018 to the attention of the ACOM Committee.

Supporting Information

Priority	The current activities of this Group will enable ICES to respond to advice requests from a number of clients (NEAFC/EC). Consequently, these activities are considered to have a high priority.
Scientific justification	ToR [a] The Joint ICES/NAFO Working Group on Deep-water Ecology undertake a range of Terms of Reference each year; the scope of these cover the entire North Atlantic, and include aspects such as ocean basin processes. Therefore, collating information on vulnerable habitats (including important benthic species and communities) across this wide geographic area (and adjacent waters) is essential. To this end, a VME data call will be run from September to December 2017, facilitated by the ICES Data Centre. Data will be quality checked/prepared one month in advance of WGDEC 2018. New data will be incorporated into the ICES VME Database and ICES VME Data Portal. This ToR includes any development work on the ICES VME Database and Data Portal, as identified by WGDEC, with support from the ICES Data Centre. ToR [b] This information and associated maps are required to meet 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, and provide advice relevant to the Regulatory Area….." as well as part of the European Commission MoU request to "provide any new information regarding the impact of fisheries on. sensitive habitats". The location of newly discovered/mapped sensitive habitats is critical to these requests. ToR [c] Understanding, defining, and measuring Good Environmental Status is a core concept of the EU Marine Strategy Framework Directive. Further work on deep-sea ecosystems is still required. In particular, this ToR will focus on continuing the progress made at WGDEC 2017, to review the progress made to date with deep-sea spatial and temporal scale definition and indicator development – the focus of a number of European funded projects. ToR [d] In the past five years there have been new insights into the role of benthic species in deep-sea ecosystems. Examples include the filtration capacity of deep-sea sponges, the draw-down of surface production by *Lophelia* reefs and the microbial loop associated with deep-sea sponges. Collating this information will provide greater insight into functioning of these ecosystems, identify knowledge gaps and inspire research to fill those gaps. This information can be used to describe ecosystem services and assess anthropogenic impacts on these areas. ToR [e] With WGDEC now considering records of *bona fide* VME from Remotely Operated Vehicle (ROV) or towed video observations, there is a need to better define VMEs using quantitative approaches linked to the biology. This is needed to ensure we are consistent in how we interpret new evidence of VME brought to the group, as well as to identify if/when we can consider groups of VME indicator records as VME, and can be done through reviewing existing definitions and quantitative approaches used by existing RFMOs and States. ToR [f] When the VME Database was first developed there was a need to give a lower confidence in the weighting system to some of the historical data for which there was no expert available to validate the records. As data has been collected more recently, WGDEC feel the data are robust, yet they still reduce in confidence with the passage of time, due to criteria in the VME weighting algorithm. This ToR will allow those records to stand equal with newer records, which is appropriate given the biology of the VME species, unless certain anthropogenic events intervene to change the value of the record.

Resource requirements	Some support will be required from the ICES Secretariat
Participants	The Group is normally attended by some 15–20 members and guests.
Secretariat facilities	None, apart from WebEx provision and SharePoint site
Financial	No financial implications.
Linkages to advisory committees	ACOM is the parent committee. Links to work undertaken by WGSFD and to WGDEEP (although no explicit overlap with the latter this year).
Linkages to other committees or groups	No direct linkages, but better links in 2018 to WGMHM and BEWG will be explored
Linkages to other organizations	As a Joint ICES/NAFO group, the work of this group links to work being undertaken by Working Groups under the NAFO Scientific Council, such as WGESA

Annex 3: Recommendations

RECOMMENDATION	ADRESSED TO
WGDEC recommends that a VME data call is undertaken in Autumn 2017. The Data Call will invite ICES Member Countries to submit new data on occurrences of VME indicators or *bona fide* VME. The Data Call will be managed by the ICES Data Centre. It is important that the geographic scope of the data call is revised to include all of the North Atlantic, in line with ToR [a] proposed for WGDEC 2018.	ICES Data Centre
WGDEC recommends that the ICES Data Centre continue to assist in development of the ICES online VME Database Portal and online VME data submission process. This year was a first attempt at developing the online submission system, and following feedback, improvements have been identified to expedite the process of screening and submitting. Feedback has also been received on recommended updates for the VME Data Portal. In addition, support will be required to assist in the expansion of the VME database to capture newly submitted 'absence' records.	ICES Data Centre
WGDEC recommends that 2017 VMS data for the NEAFC Regulatory Area are provided to ICES in advance of the 2018 WGDEC meeting. These VMS data should include information on fishing gear type (e.g. bottom trawl), and should be resolved to the finest possible temporal and spatial scales (not aggregated).	NEAFC & EC
WGDEC recommends that a backup copy (snapshot) of the ICES VME database is stored after each WGDEC meeting, ensuring that its is possible to revert back to the database finalised at the end of the last WGDEC meeting if necessary.	ICES Data Centre
WGDEC recommends that the ICES Data Centre faciliate the resubmission of VME data; allowing older records in the old VME format to be overwritten with resubmitted data in the new format. This will, through necessity, be more onerous than the automated submission of new data, and will require some technical support from the ICES Data Centre. However, this is an essential process in order to raise the quality of records within the current database.	ICES Data Centre
WGDEC recommends that WGSFD continue to provide support in analysing the 2017 NEAFC VMS data at WGDEC 2018, in order for ICES to answer the standing request from NEAFC to provide information on fisheries activities in and in the vicinity of VME areas.	WGSFD

Annex 4: Proposal to incorporate VME data used by the NAFO Working Group on Ecosystem Science Assessment (WGESA) into the ICES VME Database

The Working Group on Deep-water Ecology (WGDEC) is a joint ICES/NAFO expert group that deals with the biology and conservation of deep-sea habitats in the North Atlantic. WGDEC experts are comprised of taxonomic specialists, deep-sea survey scientists, GIS analysts, fisheries scientists, database experts, benthic ecologists, and fish biologists. Under a terms of reference formulated by ICES, they meet annually to compile and analyse relevant data and to provide the foundation of ICES response to requests for information and advice from clients. The ToR Item [a] requests the Working Group to "Provide all available new information on distribution on Vulnerable Marine Ecosystems (VMEs) in the North Atlantic….". The expectation is thus that the group should consider the entire North Atlantic. In order to carry out this task, provision of data from the entire North Atlantic is essential. Data are provided to ICES from member states and incorporated in the ICES VME database.

By undertaking a number of ICES Data Calls[8] over subsequent years, the assumption had been that ICES Member Countries would populate this database. However, this has not been the case and there are large areas of the North Atlantic where VME data exists, but has not been submitted to the database. The Joint ICES/NAFO working group wish to bring this fact to the attention of the NAFO Scientific Council.

In recognition of this fact, WGDEC propose that data on the distribution of Vulnerable Marine Ecosystems (VMEs), used by the NAFO Working Group on Ecosystem Science Assessment (WGESA), are incorporated into the VME database and portal developed by WGDEC. WGDEC recognises that data provision is a responsibility of individual member states, but hopes that the NAFO Scientific Council can motivate such submissions.

It should be noted that the ICES VME database and portal[9] has been through a period of significant development, and now incorporates an online data visualisation portal and an online submission system for new records. The database is used by WGDEC to fulfil various terms of reference each year. The database holds restricted as well as public records; the latter is available for download. All data are displayed as a 0.05 x 0.05 degree grid on the VME Data Portal.

Many benefits would be realised through incorporating data from the Northwest Atlantic. Bringing all the NAFO and ICES data together in a central repository would allow the joint ICES/NAFO group, as well as WGESA, to consider Terms of Reference applicable across the entire North Atlantic at an ocean-basin scale. For example, this may be required for considering large-scale concepts such as population connectivity. NAFO would benefit from having data used as part of the Scientific Councils work stored securely and available for use by the NAFO scientific community.

ICES would retain the overall lead for the VME database, using WGDEC as the main channel for governance and prioritization of developments. We would hope that this

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[8] See the latest call here http://ices.dk/marine-data/Documents/Data_calls/20161212_VME_Datacall.pdf

[9] http://ices.dk/marine-data/data-portals/Pages/vulnerable-marine-ecosystems.aspx

process could be complete within two years. New data would be submitted by member states using the newly developed online submission process during a dedicated North Atlantic VME data call run by ICES Data Centre each year.

Annex 5: Review Group for the ICES /NAFO Joint Working Group on Deep-Water Ecology (WGDEC)

- Reviewers: Emanuela Fanelli, Fernando Nieto (Chair)
- Secretariat: Sebastian Valanko, Michala Ovens
- Review period: 15–30 May 2017
- Review Group of ICES /NAFO Joint Working Group on Deep Water Ecology (WGDEC)

The review group worked by correspondence (mail, skype) during the period indicated. One teleconference took play in order to agree on the approach of the review, request any additional information/documentation we may need from the ICES Secretariat and tasks assignments. Else it made possible to check ICES SharePoint operability and final composition of the review group. Once uploaded WGDEC report contribution was compiled and used to accomplish this report.

Review introduction

The review group reviewed the report provided by the working group, containing work in response to the advice request from NEAFC and EU requests related to 1) update on impact of fisheries on the ecosystem and location of VMEs, 2) update on distribution of vulnerable habitats in the NEAFC Convention area and fisheries activities in and in the vicinity of such habitats, 3) review the appropriateness of NEAFC bottom fishing closures, and whether significant adverse impacts on VME are still considered likely in these areas. This corresponds to the parts of the report pertaining to the advice request, so ToR "a", "f" and "g"

a) Provide all available new information on distribution of VMEs in the North Atlantic with a view to identifying potential new closures to bot-tom fisheries or revision of existing closures to bottom fisheries. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters;

f) Review and report on the distribution of VMEs (VME Indicators and Habitats) within the Rockall Bank Haddock Box;

g) Review the appropriateness of NEAFC bottom fishing closures as defined in Annex 2 of NEAFC Recommendation 19:2014, and whether significant adverse impacts on VME are still considered likely in these areas.

General statement

The review may be published as an Annex to the WGDEC 2017 report. For the review group, the science/work done by WGDEC is sufficient for ICES to base their advice on.

General Comments

Maps illustrating new VME indicator records in the NEAFC RA, EU and National waters are quite self-explanatory, where the use of transparent display is considered very useful. Similarly, keeping the historical records in the maps illustrating the outcome of VME weighting algorithms complete the descriptions and discussions.

The review group noted that within the EEZs of countries, WGDEC does not recommend management areas/closures although VME indicator and habitat records have been submitted. WGDEC also describes when a National Authority has proposed a specific area as a candidate management area. These all is in line with ToR "a", where the scope of the request is limited to NEAFC RA, providing "new information on location of habitats sensitive to particular fishing activities".

WGDEC responses beyond ToR "f", proposing that the Haddock Box is split into "two main ecotypes", according to the differences in topography complexity obtained by high resolution multibeam devices (Irish National Seabed Survey). Though, the reviewers find relevant the WGDEC proposal in the context of the report, namely as a basis for discussion in a later stage (policy-making and implementation).

The variety of the basis for closure of the geographical areas under ToR "g" makes very pertinent the information summarised by WGDEC in table format. Else the absence of further scientific investigations as the more relevant aspect to judge appropriateness of the closures is also welcome.

However, and taking into account that WGDEC recognises the added value of counting on VMS data as "a key element in designing the closure boundaries', this subject seems to be not sufficiently discussed in the report, despite the existence of a dedicated chapter 3.5 "Analysis of the 2016 VMS submissions from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs)" more focused on data quality affairs.

The review group thinks that VMS data deserve special attention and should have been highlighted, in particular as to the availability of VMS datasets during the life of the closures as a basis for an accurate assessment. Moreover, from the reading of the report as it stands, the reader could conclude that VMS data availability is not, any longer, an issue in this context compared to other recent ICES Data Calls (for instance WGSFD 2016).

Specific comments

Executive summary

It seems that the number of new records of VME indicator species and VME habitats is not correct: in the second paragraph, instead of 1150 should be 1149 in.

Adoption of the Agenda. Supporting information

"Linkages to other organisations" is the last section of the table called "Supporting information". The review group considers that the General Fisheries Commission for the Mediterranean (GFCM) should come up as a third organisation to link to WGDEC in future.

Rational. A newly established GFCM Working group on Vulnerable Marine Ecosystems (WGVME) met -for the second time from 3–5 April 2017 at Malaga, Spain. The meeting was sponsored by the International Union for Conservation of Nature–Mediterranean and Oceana. The meeting reviewed the current GFCM management measures specific to deep-sea fisheries and biodiversity protection in High Seas context. In light of the productive discussions and results achieved, the experts of the WGVME expressed their will to continue meeting on a regular basis and to discuss and propose new relevant measures for deep-sea fisheries and VMEs. Thus, it is deemed convenient to follow up the discussions in ICES context.

Icelandic continental shelf (Iceland). Lónsdjúp

WGDEC responded that the Marine and Freshwater Research Institute of Iceland submitted new records of VME indicators records via the ICES VME Data Call. The review group proposes small changes in the text: i) In Lónsdjúp with data obtained from imagery (campod) transects "A total of 601 individuals belonging to six VME indicator species (plus *Paramuricea* spp.) were recorded…" ii) In Öræfagrunn, with data obtained by remotely operated vehicle (ROV) "A total of 347 individuals belonging to five VME indicator taxa were recorded…"

Analysis of the 2016 VMS submissions from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs)

WGDEC recalls the issue of linking catch records with vessels' trip records, due to lack of consistency with the level of aggregation of both variables. However the report does not indicate that this is not a legal issue but technical, as the NEAFC Recommendation 14: 2017 lay down the instruction for the Secretariat to provide with "VMS and catch data" without accuracy requirements. The review group thinks that the legal scope abovementioned is certainly improvable, encourages to discuss a revision of the NEAFC VMS agreement with ICES, and proposes small changes in the text: "According to the NEAFC Recommendation 14:2017, vessel monitoring system (VMS) data were received from NEAFC, via the ICES Secretariat, along with catch information…"