

ICES/NAFO JOINT WORKING GROUP ON DEEP-WATER ECOLOGY (WGDEC)

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Contents

i	Executive summary	1
ii	Expert group information	2
1	Opening of the meeting	3
2	Adoption of the agenda.....	4
	WGDEC – ICES/NAFO Joint Working Group on Deep-water Ecology.....	4
3	Collation of new data on vulnerable habitats, species and communities in the ICES VME database – ToR [a].....	6
	3.1 Vulnerable Marine Ecosystem (VME) terminology used by WGDEC.....	6
	3.2 Background	7
	3.3 Data providers for ToR [a].....	7
	3.3.1 United Kingdom (Marine Scotland)	7
	3.3.2 Canada (Department of Fisheries and Oceans Canada)	8
	3.3.3 Norway (Institute of Marine Research)	10
	3.3.4 Ireland (Marine Institute)	11
	3.3.5 Spain (Spanish Institute of Oceanography).....	14
	3.3.6 Iceland (Marine and Freshwater Research Institute)	16
	3.3.7 Russia	17
	3.3.8 Data resubmissions – United Kingdom (Joint Nature Conservation Committee).....	18
	3.4 Results of studies with no VME records (absence data).....	18
	3.5 OSPAR habitats database records.....	19
	3.6 References	20
4	Provision of new information on VMEs in the NEAFC Convention Area and EU waters, review of fishing activity in NEAFC waters and drafts of NEAFC and EU VME advice - ToR [b]	21
	4.1 Areas with new, historical or resubmitted VME data	21
	4.2 Areas considered within the NEAFC Regulatory Area.....	22
	4.2.1 Rockall Bank	22
	4.2.2 Hatton Bank	24
	4.2.3 North East Barents Sea	26
	4.3 Areas considered within the EEZs of various countries	28
	4.3.1 Faroe-Shetland Channel.....	28
	4.3.2 Rockall Bank	30
	4.3.3 Rosemary Bank Seamount and Wyville-Thomson Ridge	32
	4.3.4 Irish continental shelf	34
	4.3.5 Spanish continental shelf (Gulf of Cadiz)	37
	4.3.6 Formigas Seamount	39
	4.3.7 Mid-Norwegian continental shelf	41
	4.3.8 Central and South West Barents Sea (Tromsø Flaket).....	45
	4.3.9 North West Barents Sea (Svalbard)	46
	4.3.10 Iceland.....	50
	4.3.11 Eastern Scotian Slope, Canada.....	53
	4.4 Analysis of the 2018 VMS submission from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs).....	55
	4.4.1 Results.....	57
	4.4.1.1 Hatton Bank	57
	4.4.1.2 Rockall Bank	59
	4.4.1.3 South of Iceland	59
	4.4.1.4 Mid Atlantic Ridge Seamounts.....	60
	4.4.1.5 Barents Sea	61

	4.4.1.6 West of the Bay of Biscay.....	62
	4.5 References	63
5	Reviewing how to best define Good Environmental Status (GES) for deep-sea habitats – ToR [c].....	64
	5.1 Summary	64
	5.2 Summary framework generated by ICES for assessing the seafloor (D1, D6) and its potential application to deep-sea ecosystems.....	65
	5.3 Summary on the work conducted by ATLAS and IDEM on how to best define GES in the deep-sea.	67
	5.4 The challenge of assessing the environmental status of the deep-sea. Potential collaborative work between WGDEC and WGFBIT to address GES in the deep- sea	68
	5.5 References	71
6	Review of current, and proposal of revised, threshold for VME indicators within the VME weighting algorithm - ToR [d].....	74
	6.1 Background to the Term of Reference.....	74
	6.2 Change to the Term of Reference aims	75
	6.3 Review of methods to identify areas of VME likelihood.....	75
	6.4 Application of kernel density estimation to VME data from the ICES VME database.....	76
	6.5 Conclusions and limitations	83
	6.6 References	83
7	Work jointly with the Working Group on Marine Habitat Mapping to identify and trial approaches for VME modelling in the North Atlantic – ToR [e].....	85
	7.1 Background to the Term of Reference.....	85
	7.2 Prior consideration of modelling at WGDEC.....	85
	7.3 Availability and resolution of existing models	86
	7.4 Next steps for model use by WGDEC	87
	7.5 References:	87
8	Request from the European Commission to provide updates on representative taxa for 2 VME habitats, and advice on additional VME indicators to be included in Annex III of the EU deep-sea access regulations	89
	8.1 Background – the existing VME habitat list for NEAFC and EU waters.....	89
	8.2 European Commission request to ICES.....	89
	8.3 Representative taxa for hydrothermal vents/fields and cold seeps	90
	8.4 Additional VME indicators and representative taxa for VME habitat types	92
	8.4.1 Deep-sea sponge aggregations.....	92
	8.4.2 Coral gardens	95
	8.4.3 Mud and sand emergent fauna	95
	8.4.4 Tube-dwelling anemone patches.....	96
	8.4.5 Proposed changes to the VME sub-types and indicators for Annex III of the deep-sea access regulations	96
	8.5 References	98
9	Update on links between the Joint ICES/NAFO Working Group on Deep-water Ecology and the General Fisheries Commission for the Mediterranean (GFCM) Working Group on Marine Protected Areas and Working Group on Vulnerable Marine Ecosystems	99
	9.1 References	101
Annex 1:	List of participants.....	102
Annex 2:	Resolutions	104
Annex 3:	Catches of cold-water corals and sponges in the North Atlantic as reported in observations obtained by Russian fishing vessels in 2018.....	107
Annex 4:	ATLAS work conducted to assess GES in specific Case Study areas (NE Atlantic).....	111
Annex 5:	Technical minutes from the Vulnerable Marine Ecosystems Review Group	116

i Executive summary

The joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC) collates new information on the distribution of Vulnerable Marine Ecosystems (VMEs) for use in annual ICES advisory processes and the development of new methods/techniques to further our understanding of deep-sea ecosystems, and further suggests novel management tools to ensure human activities do not adversely affect them.

This year, a total of 26 379 new presence records were submitted through the ICES VME data call in 2018/19 and included within the ICES VME database, plus 314 absence records. This information was prepared by WGDEC for ICES to be able to provide advice on the distribution of VMEs in the North Atlantic. All presence 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.

Further to this work, the group's additional objectives in 2019 were to continue to review how to best define Good Environmental Status (GES) for deep-sea habitats; to investigate methods to further develop the VME weighting algorithm; and to review options for the use of predictive modelling techniques to provide wider coverage of potential VME distribution, in collaboration with the Working Group on Marine Habitat Mapping (WGMHM) who met jointly with WGDEC this year.

To these goals, WGDEC reviewed work conducted by the ICES Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT) on the evaluation of benthic impacts from fisheries at a regional scale, and further reviewed progress assessing GES in deep-sea areas within the projects ATLAS (Horizon 2020) and IDEM (DG Environment). It was identified that testing the approach developed by WGFBIT, building upon the ICES 2017 indicators and assessment framework, for deep-sea habitats would be beneficial, initially using case study examples from the ATLAS project, and outputs would be further reviewed at WGDEC 2020.

One of the key tools developed by WGDEC over the last 4 years is the VME weighting algorithm which aims to show the known and likely distribution of VMEs, based on underlying VME habitat and indicator data from the VME database. There have been some concerns raised about the method underlying the weighting algorithm, and as such WGDEC explored two supplementary methods this year. The first method was kernel density estimation (KDE), a method adopted by the Northwest Atlantic Fisheries Organization (NAFO). This was tested on trawl data from the VME database for 1) all VME indicators and 2) only for sea-pens. Whilst the first trial tended to reflect sampling effort over VME hotspots, the second trial for sea-pens was more successful. There are, however, limitations with the approach and it was agreed that further work could be explored to standardise the data to optimise the application of these tools to data in the ICES VME database. The second method reviewed the use of predictive modelling techniques to support understanding of area of likely VME distribution. Modelling methods were not tested this year, but a series of considerations for model creation and criteria for model use were identified, to be trialled at WGDEC 2020.

Finally, to support advice to the European Commission for application of the EU deep-sea access regulations, WGDEC reviewed the list of VME indicators in Annex III of the regulations and proposed additional VME habitat sub-types and representative taxa for certain habitats. Additional changes to representative taxa will be discussed through an intersessional sub-group, to ensure agreement by taxa specialists, for submission to ICES by September 2019

ii Expert group information

Expert group name	Working Group on Deep Water Ecology (WGDEC)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Laura Robson, United Kingdom
Meeting venue(s) and dates	3–7 June 2019, Esporles, Mallorca, Spain (21 participants)



Participants of the Working Group on Deep-water Ecology and Working Group on Marine Habitat Mapping

1 Opening of the meeting

The Working Group on Deep-water Ecology (WGDEC) commenced in plenary at 10:00 on Monday 3rd June 2019 at the Mediterranean Institute for Advanced Studies (IMEDEA), Esporles, Mallorca. The leads for each Term of Reference (ToR) were appointed, and are outlined below:

- ToR [a] lead: James Albrecht
- ToR [b] lead: Laura Robson and David Stirling
- ToR [c] leads: Cova Orejas and Anthony Grehan
- ToR [d] leads: Lindsay Beazley
- ToR [e] leads: James Strong (WGMHM) and Kerry Howell

The meeting was joined by the Working Group on Marine Habitat Mapping (WGMHM), chaired by James Strong (UK) for the week. Joint plenary sessions were arranged for Monday 3rd June and Tuesday 4th June, with further work on ToR [e] undertaken by experts from WGDEC in collaboration with the WGMHM on Tuesday 4th and Wednesday 5th.

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 throughout the week; these were via WebEx allowing remote participants to join. 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 12:30 on Friday 7th June 2019 by the Chair.

2 Adoption of the agenda

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

2018/2/ACOM:26 The Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), chaired by Laura Robson, UK, will meet 3rd to 7th June 2019 in Mallorca 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, archive appropriately using the ICES VME Database, and disseminate 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. Using the most recent NEAFC spatial layers of fishing activity analysed by WGSFD, produce a first draft of the annual NEAFC VME advice for further consideration by a review group (RGVME) and advisory committees advice drafting group (ADGVME). In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters; and produce a first draft of the annual EU VME advice for further consideration by a review group (RGVME) and advisory committees advice drafting group (ADGVME);
- 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) Considering work undertaken at WGDEC 2012 to examine NEAFC encounter thresholds as well as criteria used by other RFMOs (such as South Pacific Regional Fisheries Management Organization - SPRFMO) to trigger “move-on” rules, review current and propose revised thresholds appropriate to each VME indicator type considered in the WGDEC VME weighting algorithm;
- e) To further develop the use of the VME weighting algorithm outputs within ICES advice, work jointly with the ICES Working Group on Marine Habitat Mapping (WGMHM) to review the availability and quality of VME data and physico-chemical predictor variables across the North Atlantic and identify and trial potential approaches to model the distribution of VMEs in the North Atlantic.

The deadline for ToR [b] is June 21, 2019 (for submission to review by RGVME)

WGDEC will report by July 15 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	<p>ToR [a]</p> <p>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 2018, facilitated by the ICES Data Centre. Data will be quality checked/prepared one month in advance of WGDEC 2019. 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.</p> <p>ToR [b]</p> <p>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” 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.</p> <p>ToR [c]</p> <p>Understanding, defining, and measuring Good Environmental Status is a core concept of the EU Marine Strategy Framework Directive. Work was started on GES at WGDEC 2017 and further work on deep-sea ecosystems is still required. In particular, this ToR will focus on continuing the review of progress made to date with deep-sea spatial and temporal scale definition and indicator development – the focus of a number of European funded projects.</p> <p>ToR [d]</p> <p>Currently, the VME abundance thresholds used within the VME weighting algorithm are based on the NEAFC VME encounter thresholds for corals (30 kg) and half the encounter threshold for sponges (200 kg). These thresholds were based on work undertaken in WGDEC 2012/2013, and were selected during the early developmental stages of the weighting algorithm. However, they only specifically examined cold water corals and deep-sea sponge aggregations. Since this time, new information on the life histories and vulnerability/sensitivities of other VME are available, and should be considered in order to develop specific and appropriate thresholds for each VME indicator. As part of this ToR, work undertaken developing VME encounter thresholds for NEAFC in 2012/2013 will be considered alongside work undertaken by other RFMO on criteria, such as the SPRFMO.</p>
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 and SharePoint site provision.
Financial	No financial implications.
Linkages to advisory committees	ACOM is the parent committee and specific ToRs from WGDEC provide information for the Advice Committee to respond to specific requests from clients.
Linkages to other committees or groups	While there are currently no direct linkages to other groups, WGDEC should develop stronger links (ideally through the establishment of joint Terms of Reference) with WGSFD, WGMHM and WGDEEP.
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; specifically WGESA.

3 Collation of new data on vulnerable habitats, species and communities in the ICES VME database – ToR [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, archive appropriately using the ICES VME database, and disseminate via the Working Group report and ICES VME Data Portal – ToR [a]

3.1 Vulnerable Marine Ecosystem (VME) terminology used by WGDEC

Vulnerable Marine Ecosystems (VMEs) are defined within the Food and Agriculture Organisation of the United Nations' (FAO) International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO, 2009) using five criteria:

1. Uniqueness or rarity
2. Functional significance of the habitat
3. Fragility
4. Life-history traits of component species that make recovery difficult
5. Structural complexity

Further to this, NEAFC recommendation 19:2014¹ on the protection of VMEs in the NEAFC Regulatory Area lists seven VME habitat types as well as physical elements (referred to as "VME elements") and refers to "VME indicators" as the taxa most likely to be found in these habitats. This recommendation also details the encounter thresholds where move-on rules are applied for encounters with VMEs from fishing gears in the NEAFC RA. Under Article 9, an encounter with a possible VME is defined as follows:

- a) for a trawl tow, and other fishing gear than longlines: the presence of more than 30 kg of live coral and/or 400 kg of live sponge of VME indicators; and
- b) for a longline set: the presence of VME indicators on 10 hooks per caught per 1000 hook segment or per 1200 m section of long line, whichever is the shorter.

The inclusion of data on VMEs in the ICES VME database required some informal definitions to be created by WGDEC to enable users to include data on VME elements, habitats and indicators, based on different collection methods. As a result, WGDEC considers information relating to VMEs in three ways:

1. 'VME habitat' records are generally 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, 2016).
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, 2016).

¹ http://neafc.org/system/files/Rec19-Protection-of-VMEs_0.pdf

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, 2013).

3.2 Background

The ICES VME data call in January 2019, requested ICES member states to submit data to the ICES VME database. All data submitted to the database since the previous WGDEC meeting in March 2018 is considered new data for WGDEC 2019.

The database stores records of VMEs, VME indicators and the locations of where neither of these have been observed (absence data), as described by the database schema. The records in the ICES VME database can therefore be split into two broad categories;

1. Presence records are samples where a VME and/or a VME indicator have been identified
2. Absence records are samples where neither a VME or a VME indicator has been identified

26 379 new presence records have been submitted to the ICES VME database since March 2018, which increases the total number of presence records in the database to 41 989.

Of the 26 379 newly submitted presence records, 93 are within the NEAFC Regulatory Area, and the remaining 26 286 are within the Exclusive Economic Zones of North Atlantic ICES/NAFO member states.

As part of the 2019 data call, 314 absence records were submitted. These, along with absence records submitted in previous years, are summarised in section 3.4.

The new data has been submitted by data providers from six ICES member countries.

3.3 Data providers for ToR [a]

New records of VME indicators and habitats were submitted to the ICES VME database by the following ICES Member Countries (organisations/affiliations in brackets)

3.3.1 United Kingdom (Marine Scotland)

Marine Scotland submitted information on new VME indicator records to ICES as part of the VME data call for 2019. These records arose from scientific bottom trawl surveys undertaken during the 1218S² (21 August–15 September 2018) and 1318S³ (19 September–1 October 2018) fisheries research surveys, which used Jackson BT 184 and BT 137 bottom trawls respectively, with groundgear bag nets attached. Trawls were undertaken in the Faroe-Shetland Channel, on the Wyville-Thomson Ridge and on Rosemary Bank Seamount during the 1218S survey and on top of Rockall Bank during the 1318S survey.

From the fisheries research trawl surveys, 283 VME indicator records were submitted to ICES (Table 3.1). Additionally, 19 trawls where no VME indicators were identified have been submitted as absence records.

² https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/17134/

³ https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/17139/

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

VME indicator	Number of records
Cup coral	15
Gorgonian	4
Sea-pen	23
Soft coral	14
Sponge	212
Stony coral	14
Stylasterids	1

3.3.2 Canada (Department of Fisheries and Oceans Canada)

For the 2019 data call, the Department of Fisheries and Oceans (DFO) Canada submitted 21 353 VME indicator records, including gorgonians, sea pens, and sponges to the ICES VME database (Table 3.2). These records were from annotations of benthic imagery data collected during an oceanographic research mission onboard the Canadian Coast Guard Ship *Hudson* to the Eastern Scotian Slope, located off Banquereau Bank, Nova Scotia, in June 2018. The purpose of data collection in this area was to validate a large gorgonian coral Significant Benthic Area (SBA) identified through kernel density estimation and species distribution modelling techniques, and to collect data to inform the boundaries of a proposed conservation area⁴.

Video data was collected using the drift camera system “Campod”, and benthic photographs using the “4K Camera” drop camera system. A total of 24 taxa and 43 620 individuals were annotated and grouped into functional groups (sponges, N=16 602; sea pens, N=6661; large gorgonian corals, N=8338; small gorgonian corals, N=1363). Additionally, data on the occurrence of the tube-dwelling anemone *Pachycerianthus borealis* (N=10 656), which is recognized as a VME indicator species by NAFO (NAFO, 2019) were also submitted. These data and their analyses are summarized in a DFO technical report (Beazley *et al.*, 2019). Figure 3.1 and Figure 3.2 show example images of VME indicators from the survey.

Table 3.2. Summary of VME indicator records submitted by DFO Canada

VME indicator	Number of records
Anemones	1729
Gorgonian	5234
Sea-pen	5621
Sponge	8769

⁴ <https://www.canada.ca/en/fisheries-oceans/news/2018/03/three-new-potential-marine-conservation-measures-announced-off-the-coast-of-nova-scotia.html>



Figure 3.1 Image of *Pachycerianthus borealis*, a tube dwelling anemone VME indicator, from the Eastern Scotian Slope in Canada, identified during the DFO survey in 2018 at 189 m depth. © Department of Fisheries and Oceans Canada

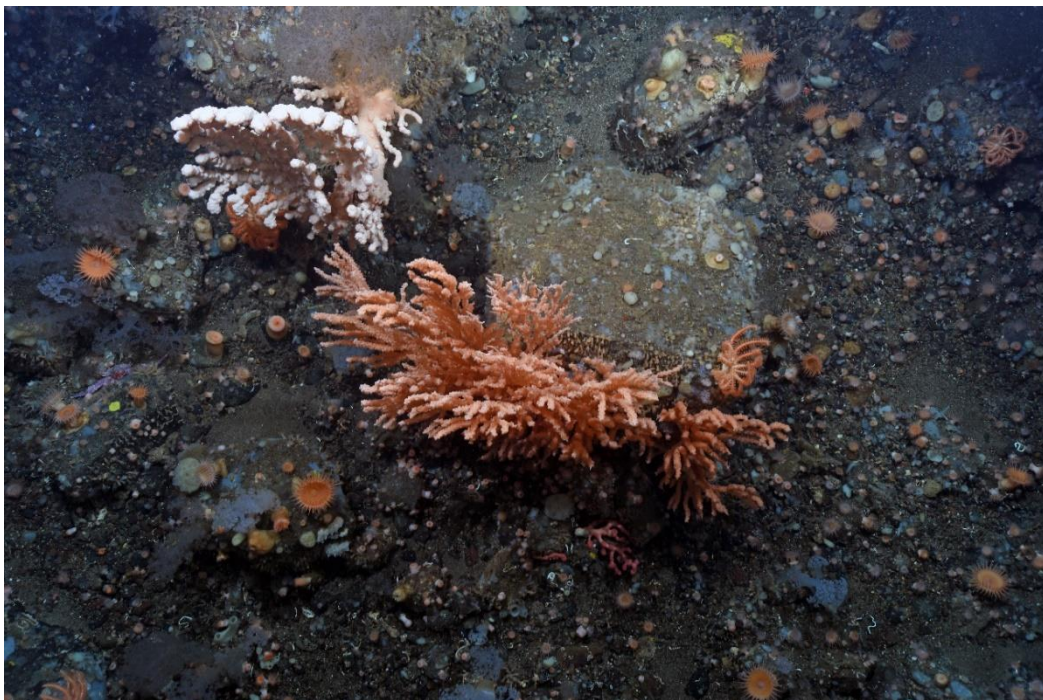


Figure 3.2 Image of *Primnoa resedaeformis* and *Paragorgia arborea*, gorgonian VME indicators, from the Eastern Scotian Slope in Canada, identified during the DFO survey in 2018 at 276 m depth. © Department of Fisheries and Oceans Canada

3.3.3 Norway (Institute of Marine Research)

Two different datasets were submitted to the ICES VME database by the Institute of Marine Research (IMR), Norway, in 2018 (after the VME data call for 2017/18) and for the 2019 VME data call.

Data on VME occurrence were submitted from 21 cruises which took place from 2006 to 2016, as part of the Norwegian National mapping programme MAREANO⁵. The data consisted of 995 records of VME habitats, covering eight habitat sub-types (Table 3.3), from 639 video samples (covering 200 m long distances along the seafloor). The positions provided to the database are mid points from each video tow and depths represent mean depths from each video tow. Figure 3.3 and Figure 3.4 show example images of VME habitats from the cruises.

Table 3.3. Summary of VME habitat records submitted by IMR Norway

VME Habitat Type	Number of records
Anemone aggregations	3
Cold-water coral reef	530
Coral Garden	100
Deep-sea Sponge Aggregations	283
Seapen fields	79

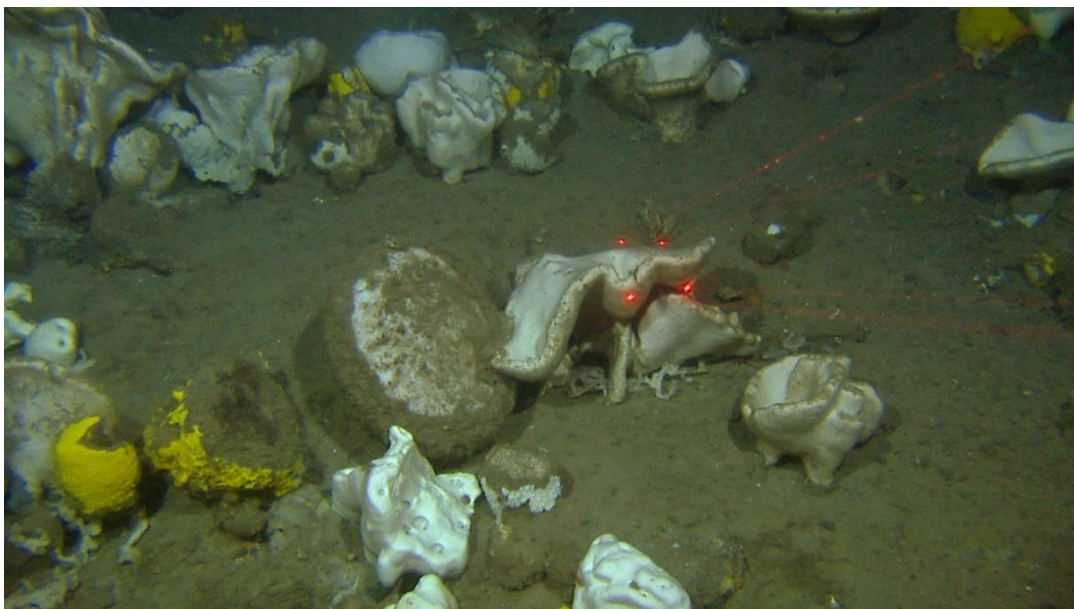


Figure 3.3 Example of deep-sea sponge aggregation VME habitat from the MAREANO programme. © MAREANO, Institute of Marine Research, Norway

⁵ www.mareano.no

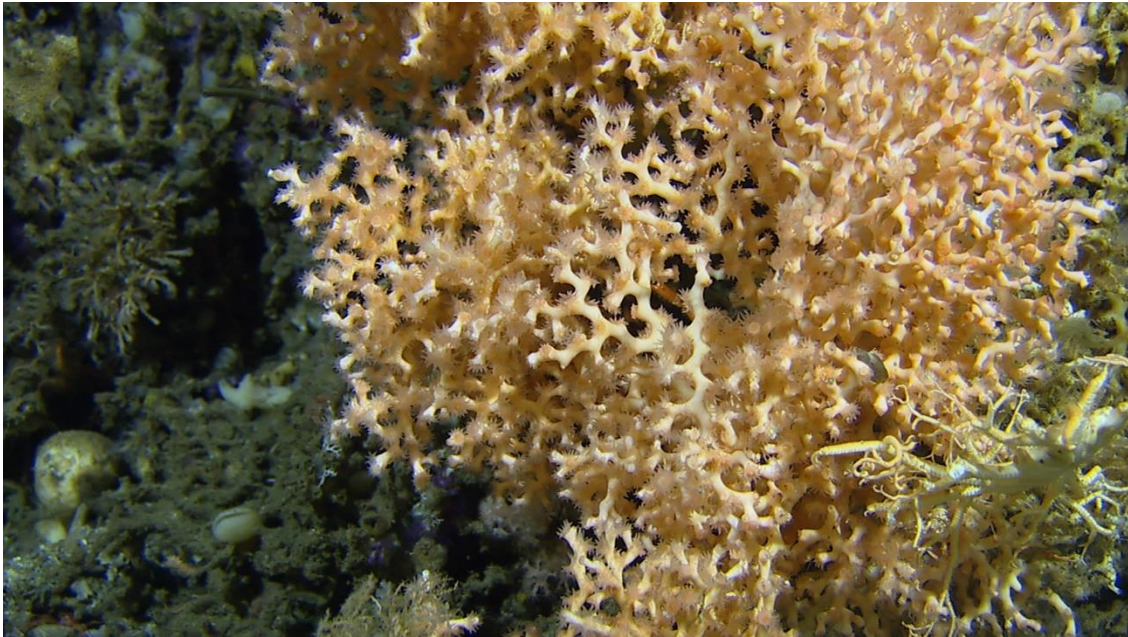


Figure 3.4 Example of cold-water coral reef VME habitat, from the MAREANO programme. © MAREANO, Institute of Marine Research, Norway

For the 2019 VME data call, Norway also contributed records of sponge by-catch data from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS)⁶. These data provide timeseries of sponges recorded in the Barents Sea from 2006 to 2018 by bottom trawl sampling. The sampling is based on a regular grid and provide habitat mapping with a comprehensive spatial coverage of the seafloor. This dataset represents the first records in the ICES VME database for the Barents Sea. In total, 2291 new presence records were submitted (Table 3.4), comprising 27 different taxa of sponges which have been identified as sponge indicators. Additionally, 288 records of trawls where no VME indicators were identified have been submitted as absence data.

Table 3.4. Summary of VME indicator records submitted by IMR Norway

VME indicator	Number of records
Sponge	2291

3.3.4 Ireland (Marine Institute)

An extensive survey of Ireland's EEZ was funded by the European Maritime and Fisheries Fund (EMFF) in 2017, which was coordinated and led by Ireland's Marine Institute and INFOMAR (Integrated Mapping for the Sustainable Development of Ireland's Marine Resources).

The survey, commissioned by the National Parks and Wildlife Service (NPWS), conducted Remotely Operated Vehicle (ROV) dives along the Irish Northwest Continental margin to monitor the abundance and distribution of offshore cold-water reef habitat. These data are the first of a three-year assessment of sensitive habitats in Irish waters.

132 new records of VME habitats including cold-water coral reef, coral gardens and sea-pen fields were submitted to the database for the 2019 data call (Table 3.5). Additionally, 7 ROV dives

⁶ https://www.imr.no/tokt/okosystemtokt_i_barentshavet/survey_reports/survey_report_2018/nb-no

from which no VME habitats were identified have been submitted as absence data. Figure 3.5, Figure 3.6 and Figure 3.7 show example images of VME habitats from the survey.

Table 3.5. Summary of VME habitat records submitted by the Marine Institute Ireland

VME Habitat Type	Number of records
Anemone aggregations	3
Cold-water coral reef	15
Cold seeps	2
Coral Garden	67
Deep-sea Sponge Aggregations	6
Mud and sand emergent fauna	25
Seapen fields	14

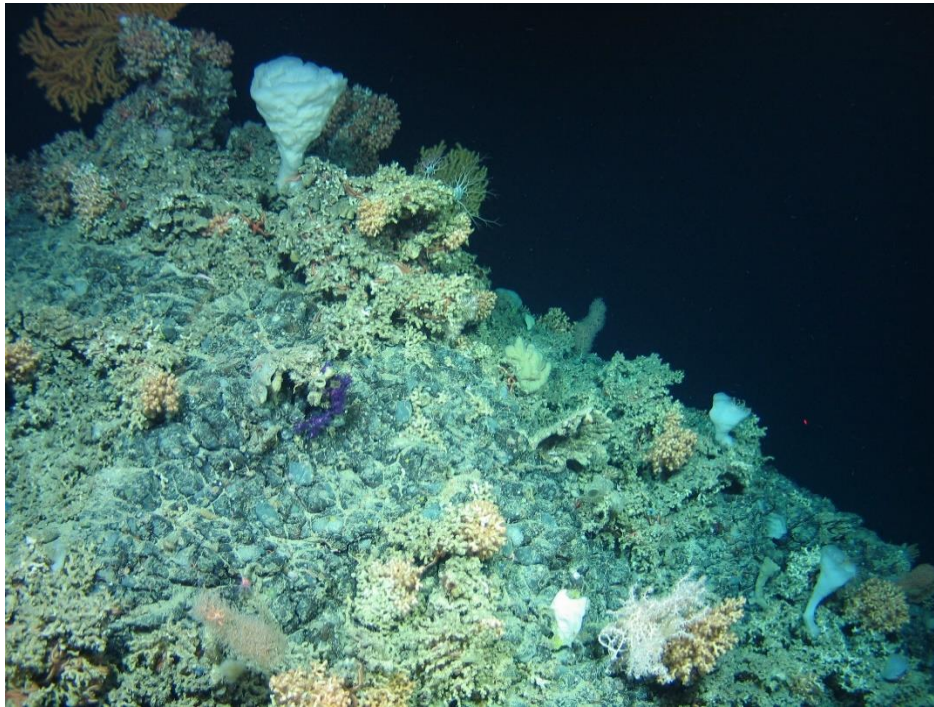


Figure 3.5 Example of cold-water coral reef VME habitat from the Irish Continental Shelf identified during the SeaRover 2017 survey © SeaRover survey / Ireland Department of Agriculture, Food and Marine / EU European Maritime and Fisheries Fund / INFOMAR

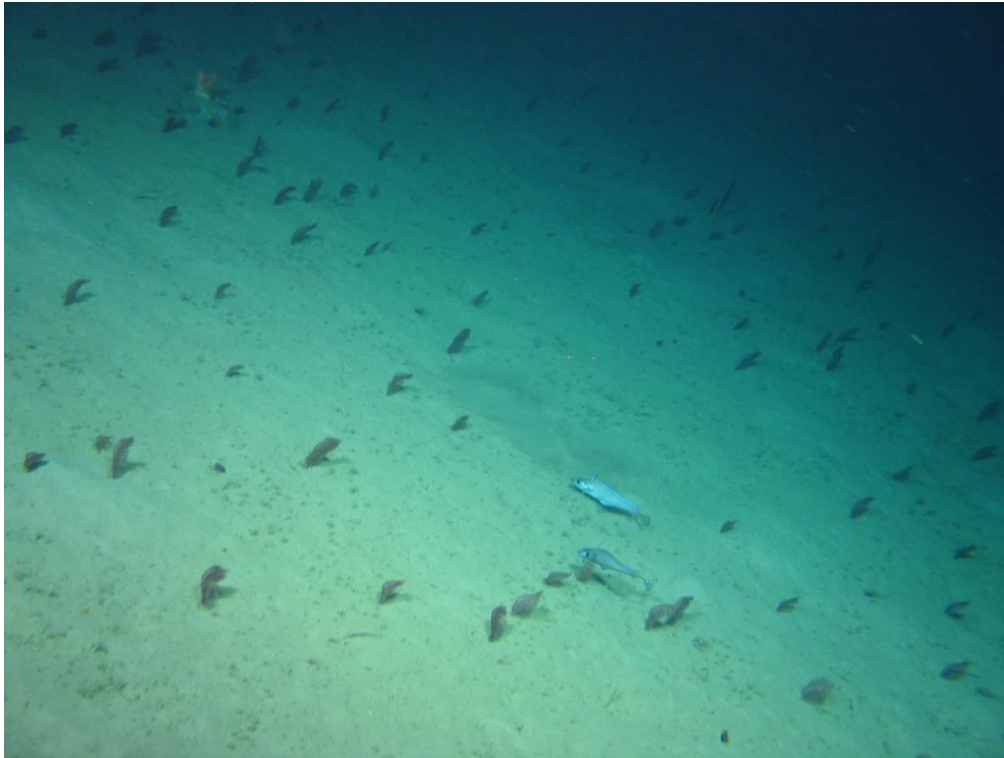


Figure 3.6. Example of a sea-pen field VME habitat from the Irish Continental Shelf identified during the SeaRover 2017 survey © SeaRover survey / Ireland Department of Agriculture, Food and Marine / EU European Maritime and Fisheries Fund / INFOMAR

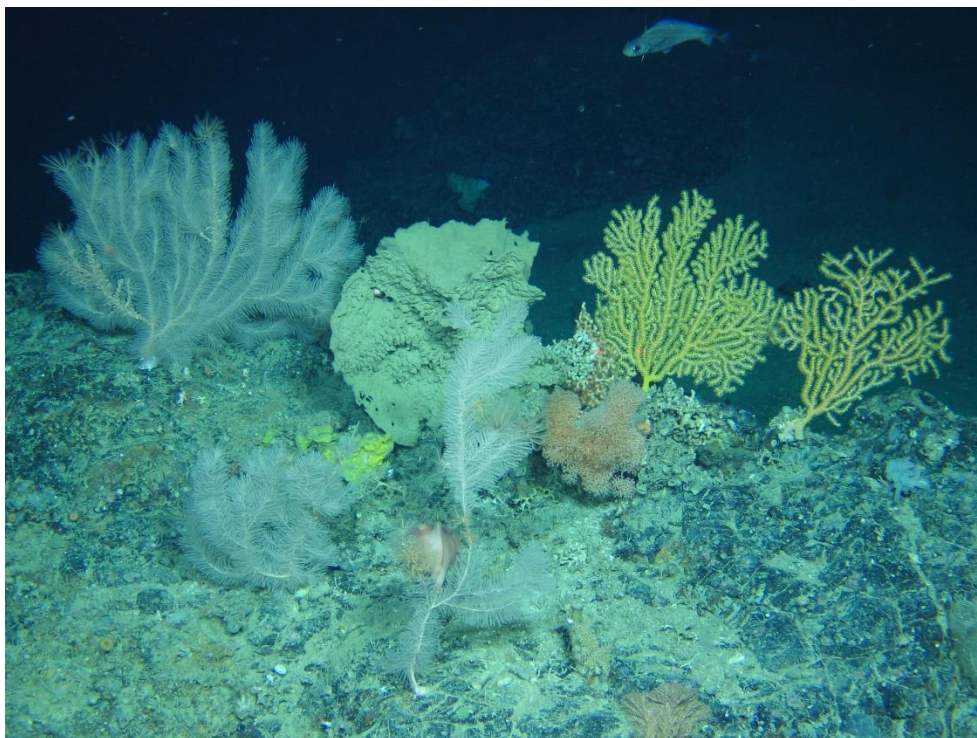


Figure 3.7 Example of a coral garden VME habitat from the Irish Continental Shelf identified during the SeaRover 2017 survey © SeaRover survey / Ireland Department of Agriculture, Food and Marine / EU European Maritime and Fisheries Fund / INFOMAR

3.3.5 Spain (Spanish Institute of Oceanography)

Spain submitted a VME dataset originating from the research cruise “Mediterranean Out flow Water and Vulnerable Ecosystems” (MEDWAVES) (Orejas *et al.*, 2017) on the Research Vessel *Sarmiento de Gamboa* (CSIC). The cruise was conducted by the Spanish Institute of Oceanography (IEO) within the framework of the Horizon 2020 European project ATLAS⁷. The data were submitted from ROV surveys at the Gazul Mud Volcano (Gulf of Cadiz, Spain), and the Formigas Seamount (Azores). The VME habitat records submitted from both these are summarised in Table 3.6.

Two ROV transects were conducted covering a depth range from 386 to 473 m, through which 18 records of VME habitats were identified from the Gazul Mud Volcano. In addition, 18 records of VME habitats were identified from Formigas Seamount. Figure 3.8, Figure 3.9 and Figure 3.10 show example images of VME habitats from the survey.

Table 3.6. Summary of VME habitat records submitted by IEO Spain

VME Habitat Type	Number of records
Cold-water coral reef	1
Coral Garden	22
Deep-sea Sponge Aggregations	9
Mud and sand emergent fauna	4

⁷ <https://www.eu-atlas.org/>



Figure 3.8 *Callogorgia verticillata*, part of a coral garden VME habitat at the Gazul Mud Volcano, identified during the MEDWAVES cruise in 2016 © Spanish Institute of Oceanography

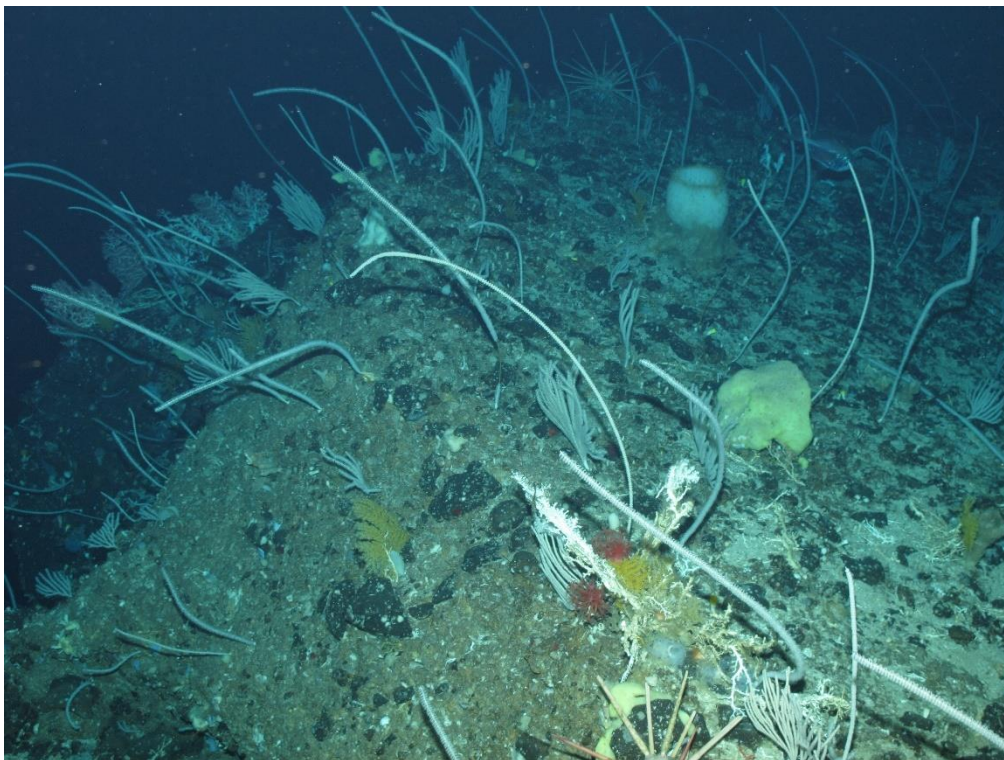


Figure 3.9 Example of a coral garden VME habitat from Formigas Seamount, identified during the MEDWAVES cruise in 2016 © Spanish Institute of Oceanography

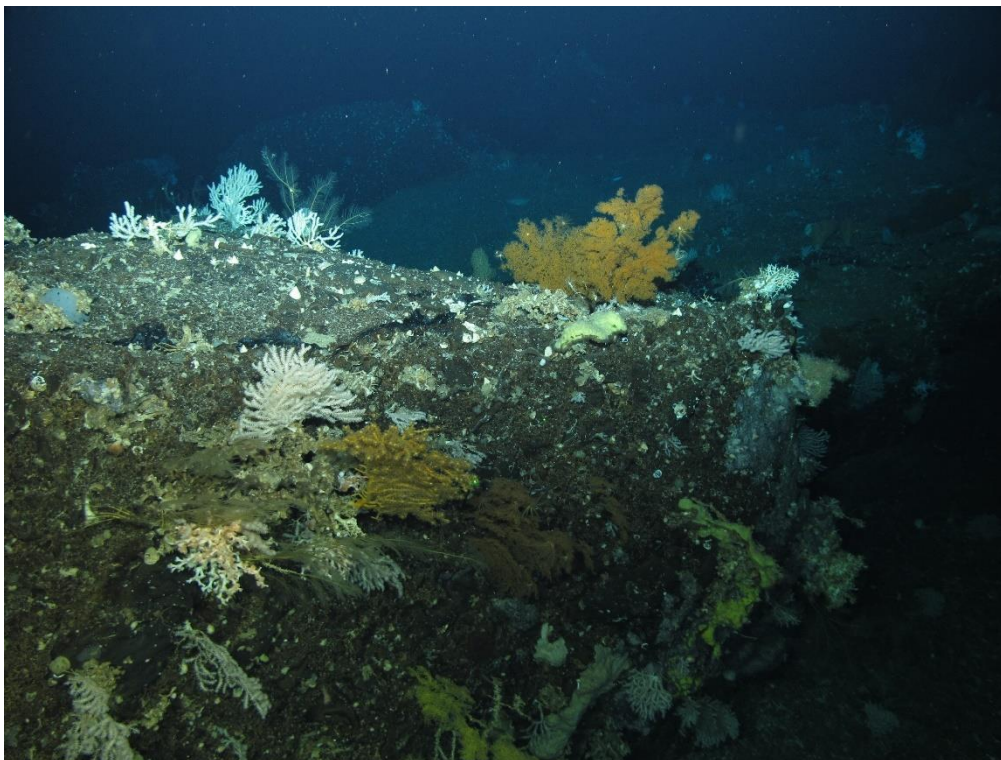


Figure 3.10 Further example of a coral garden VME habitat at Formigas Seamount from the MEDWAVES cruise in 2016 © Spanish Institute of Oceanography

3.3.6 Iceland (Marine and Freshwater Research Institute)

A total of 1279 records of new VME habitats and indicators were submitted by the Marine and Freshwater Research Institute (MFRI) of Iceland through the ICES VME data call for several locations along Iceland's southern shelf. The data were obtained during a survey carried out in 2004 by the Marine and Freshwater Research Institute on board the R/V *Bjarni Sæmundsson* to locate and map cold-water coral reefs and other VME areas within Iceland's EEZ.

The data provided observations from 14 ROV transects carried out within the Skaftárdjúp, Skeiðarárdjúp, and Reynisdjúp troughs, on the Öraefagrunn bank, and on the Reykjanes Ridge. Records of VME indicators included anemones, gorgonians and sponges (Table 3.7). The data also include observations of cold-water coral reef habitats (Table 3.8). Figure 3.11 shows an example image of a VME habitat from the survey.

Table 3.7. Summary of VME indicator records submitted by MFRI Iceland

VME indicator	Number of records
Anemones	294
Gorgonian	144
Sea-pen	275
Sponge	427
Stony coral	134
Stylasterids	5

Table 3.8. Summary of VME habitat records submitted by MFRI Iceland

VME Habitat Type	Number of records
Cold-water coral reef	134

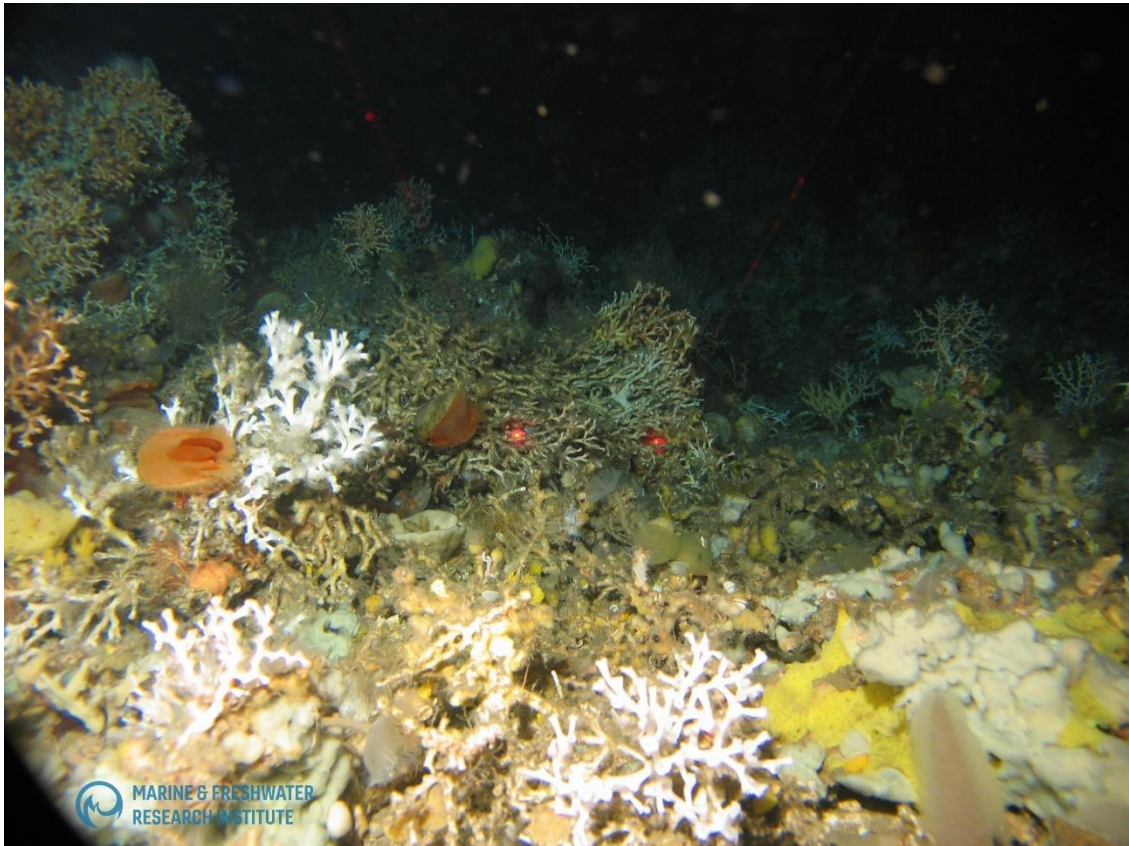


Figure 3.11 Example of a cold-water coral reef VME habitat from the Southern shelf of Iceland, identified during the MFRI 2004 survey © Marine Freshwater Research Institute

3.3.7 Russia

VME data were collated by Russia from April-May 2018 from fishing trawl bycatch records. Data were collected from fisheries observers on one fishing vessel cruise to the Grand Bank of Newfoundland and the Flemish Cap (NAFO divisions 3LM). In the NAFO Regulatory Area (RA), cold-water corals were recorded in the waters of the Flemish Cap, the Flemish Pass and the Grand Banks of Newfoundland. VME indicators included soft and dendriform corals, sea-pens and deep-sea sponges. The amount of VME indicator species caught throughout the NAFO RA did not exceed 1 kg per haul. These data were not submitted to ICES for inclusion in the VME database in time for consideration at WGDEC 2019, but will be submitted in 2020 for further consideration at WGDEC 2020. A working paper submitted by Russia detailing the records discussed above is included in Catches of cold-water corals and sponges in the North Atlantic as reported in observations obtained by Russian fishing vessels in 2018.

3.3.8 Data resubmissions – United Kingdom (Joint Nature Conservation Committee)

The Joint Nature Conservation Committee (JNCC) submitted 10 VME indicator records of stony corals (*Lophelia pertusa*) from Hatton Bank to the ICES VME database as part of the 2019 data call (Table 3.9). These are historic records from the scientific literature and have previously been considered by the group during WGDEC 2005 (ICES, 2005). However, these records had not yet been submitted to the database.

Location and metadata of these records was gathered from Frederiksen *et al* (1992). The samples were collected in 1987 using a rock dredge and include 6 records of living coral and 4 records of dead coral.

Table 3.9. Summary of VME indicator records submitted by the JNCC

VME indicator	Number of records
Stony coral	10

3.4 Results of studies with no VME records (absence data)

A summary of the survey data where no VMEs were recorded, i.e. ‘absence data’, currently held in the VME database was presented to the group. As of WGDEC 2019, there are 433 records of proposed absence data collected between 2006 and 2018 (Absence data originates from both trawls and ROVs, however these methods record absence at different spatial scales. Additionally, trawling has a low VME catchability, which hinders its usefulness as an indicator of absence. Both of these caveats would need to be considered carefully if WGDEC was to report on the absence of VMEs.

Due to these outstanding questions on the use of the absence data in the ICES VME database, it was decided that absence records would not be considered as part of ToR [b] during WGDEC 2019. Instead a ToR focused on developing standards for provision of absence data has been proposed for WGDEC 2020.

Table 3.10). These records are spread across the NEAFC Regulatory Area (Rockall Bank and the Barents Sea), the UK’s EEZ, Ireland’s EEZ, Norway’s EEZ, and Russia’s EEZ.

Absence data originates from both trawls and ROVs, however these methods record absence at different spatial scales. Additionally, trawling has a low VME catchability, which hinders its usefulness as an indicator of absence. Both of these caveats would need to be considered carefully if WGDEC was to report on the absence of VMEs.

Due to these outstanding questions on the use of the absence data in the ICES VME database, it was decided that absence records would not be considered as part of ToR [b] during WGDEC 2019. Instead a ToR focused on developing standards for provision of absence data has been proposed for WGDEC 2020.

Table 3.10. Absence record observations from different survey methods (bottom trawl, ROV, or not reported) per year

Observation year	Trawl	ROV	Not reported	Total per year
2018	19	-	-	19
2017	48	7	-	55
2016	47	-	53	100
2015	12	-	-	12
2014	30	-	-	30
2013	62	-	-	62
2012	52	-	-	52
2011	31	1	-	32
2010	18	-	4	22
2009	39	-	-	39
2008	-	-	-	-
2007	3	-	-	3
2006	7	-	-	7
Total per survey method	368	8	57	433

3.5 OSPAR habitats database records

The OSPAR database⁸ is updated annually and provides data on habitats listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR Agreement 2008-06). Not all habitats would be considered VMEs and records are included across all depths in the OSPAR region, however there are six deep-sea habitats of relevance: *Lophelia pertusa* reefs; Coral gardens; Deep-sea sponge aggregations; Oceanic Ridges with Hydrothermal Vents; Seamounts; and Sea-pen and burrowing megafauna communities. However, these OSPAR records are managed and administered independently of ICES and the ICES VME database.

Historically, records from the OSPAR database have been considered (and reported) by WGDEC when undertaking Terms of Reference in relation to the distribution of VME habitats. For example, at WGDEC 2018, this was achieved by considering relevant records from the OSPAR 2015 database. During WGDEC 2018, it was noted that some records of VME habitats had been submitted by some ICES member states to the OSPAR habitats database, but not the ICES VME database. It was therefore agreed that in future, these data should be included within the ICES VME database wherever possible, being mindful to avoid duplicate records.

To support this, work took place intersessionally after WGDEC 2018, to explore the possibility of automating the inclusion of OSPAR records into the VME database using a data script developed in R. This required the matching of fields between the OSPAR and ICES VME data proformas, and determination of mandatory fields in the ICES VME database that would need to be

⁸ <https://odims.ospar.org/>

completed using the OSPAR datasets before cross-population of data could begin. Further development of this work was discussed during WGDEC 2019, and a number of issues need to be addressed before this workflow can be finalised:

- Completion of all mandatory fields in the ICES VME database using the OSPAR metadata where possible;
- Determination of the appropriate survey data collection method, noting that the OSPAR database enables multiple methods to be assigned for the survey whereas the ICES database allows only one;
- Screening of OSPAR data points for areas $\geq 200\text{m}$ only, using an appropriate bathymetry dataset;
- Ensuring only 'certain' records from the OSPAR database are included, rather than both 'certain' and 'uncertain' records;
- Consideration of the quality of validation for OSPAR habitats vs that of VME habitats from data suppliers, as not all OSPAR habitat records may be confirmed VME habitat types;
- Consideration and agreement of OSPAR habitats vs VME habitats in terms of definition (e.g. OSPAR 'Seapens and burrowing megafauna community' vs VME 'Seapen field')
- Removal of records already submitted to both the OSPAR and the ICES VME database, to ensure no duplication, including those submitted with coordinates of different precision (e.g. 2 decimal places vs 5 decimal places).

Further work will take place intersessionally before submission of OSPAR database records to the ICES VME database. It was agreed that a quality control exercise should be undertaken before submission to ensure data suppliers are confident that the records are accurate and do not duplicate existing records. The final discussion point around coordinate precision is particularly prudent as there is a high risk of duplicate records if this is not carefully implemented.

3.6 References

- Beazley, L., Lirette, C., and Guijarro, J. 2019. Characterization of the corals and sponges of the Eastern Scotian Slope from a benthic imagery survey. Can. Tech. Rep. Fish. Aquat. Sci. 3302: vi + 83 p.
- FAO. 2009. International Guidelines for the Management of Deep-sea Fisheries in the High Seas. FAO, Rome. 73 p
- Frederiksen, R., Jensen, A., and Westerberg, H. 1992. The distribution of the scleractinian coral *Lophelia pertusa* around the Faroe islands and the relation to internal tidal mixing, *Sarsia*, 77:2, 157-171, DOI: 10.1080/00364827.1992.10413502
- ICES. 2005. Report of the Working Group on Deep-water Ecology (WGDEC), 8-11 March 2005, ICES Headquarters, Copenhagen. ICES CM 2005/ACE:02. 76 pp.
- ICES. 2013. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). ICES CM 2013/ACOM: 28.
- ICES. 2016. Report of the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), 15-19 February 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:28. 82 pp.
- NAFO. 2019. NAFO Conservation and Enforcement Measures. NAFO/COM Doc.19-01, Serial No. N6901. 181 pp.

4 Provision of new information on VMEs in the NEAFC Convention Area and EU waters, review of fishing activity in NEAFC waters and drafts of NEAFC and EU VME advice - ToR [b]

Provide all available new information on the distribution of vulnerable habitats (VMEs) in the NEAFC Convention Area. Using the most recent NEAFC spatial layers of fishing activity analysed by WGSFD, produce a first draft of the annual NEAFC VME advice for further consideration by a review group (RGVME) and advisory committees advice drafting group (ADGVME). In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters; and produce a first draft of the annual EU VME advice for further consideration by a review group (RGVME) and advisory committees advice drafting group (ADGVME) – ToR [b]

4.1 Areas with new, historical or resubmitted VME data

This chapter is split according to areas within the NEAFC Regulatory Area and those areas within the EEZs of EU countries and wider. No new VME submissions were received for areas within the NAFO Regulatory Area.

Areas considered within the NEAFC Regulatory Area:

- Rockall Bank
- Hatton Bank
- North East Barents Sea

Areas considered within the EEZs of various countries:

- Faroe-Shetland Channel
- Rockall Bank
- Rosemary Bank Seamount
- Wyville-Thomson Ridge
- Irish continental shelf
- Spanish continental shelf (Gulf of Cadiz)
- Formigas Seamount
- Mid-Norwegian continental shelf
- Central Barents Sea and South West Barents Sea (Tromsø Flaket)
- North West Barents Sea (Svalbard)

For each area, maps are shown of the new VME indicator and/or habitat records, the outputs of the VME likelihood index based on the VME weighting algorithm, and the associated VME index confidence layer. Details of the method for the VME weighting algorithm are reported in Section 7 of the WGDEC 2018 report (ICES, 2018).

4.2 Areas considered within the NEAFC Regulatory Area

4.2.1 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 Regulatory Area whereas the steeper, eastern side of the bank is located within the EEZ of both the UK and Ireland.

New VME indicator data within the NEAFC Regulatory Area on Rockall Bank were submitted by the UK (Figure 4.1). Records came from a Marine Scotland Science scientific bottom trawl survey (1318S) on the RV *Scotia*, as detailed in Section 3.3.1.

These new data have contributed to updated outputs from the VME weighting algorithm. The updated VME index for Rockall Bank (within NEAFC waters) is shown in Figure 4.2. The algorithm has a gridded output layer, which shows the likelihood of encountering a VME for each grid cell; either low (yellow), medium (orange) or high (red). Those grid cells containing bona fide records of VME habitat are shown in blue and were excluded from the VME weighting algorithm and confidence layer.

The confidence layer associated with the VME weighting algorithm's VME Index layer is shown in Figure 4.3. High confidence cells are shaded black, medium confidence cells are shaded grey and low confidence cells are shaded white.

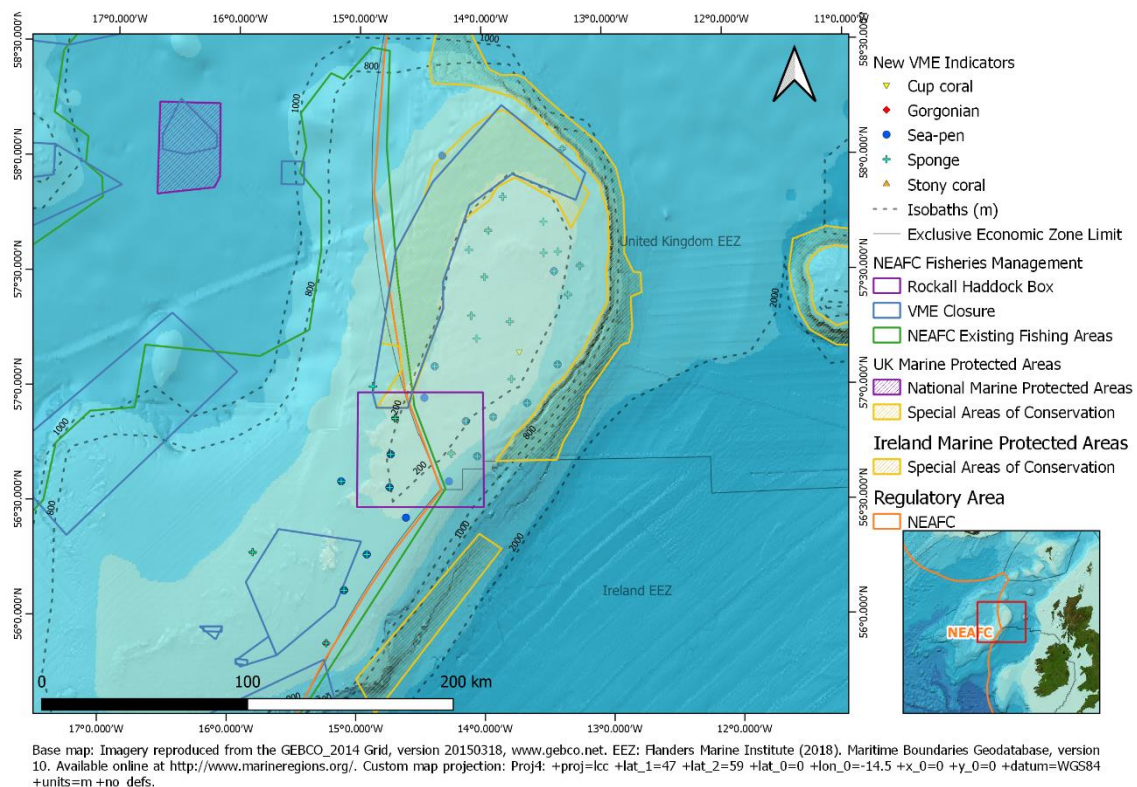


Figure 4.1. New VME records submitted in 2019 for Rockall Bank within the NEAFC Regulatory Area (new records outside the NEAFC Regulatory Area are displayed as transparent). Note, other (historic) VME records from the VME database for this area are not displayed.

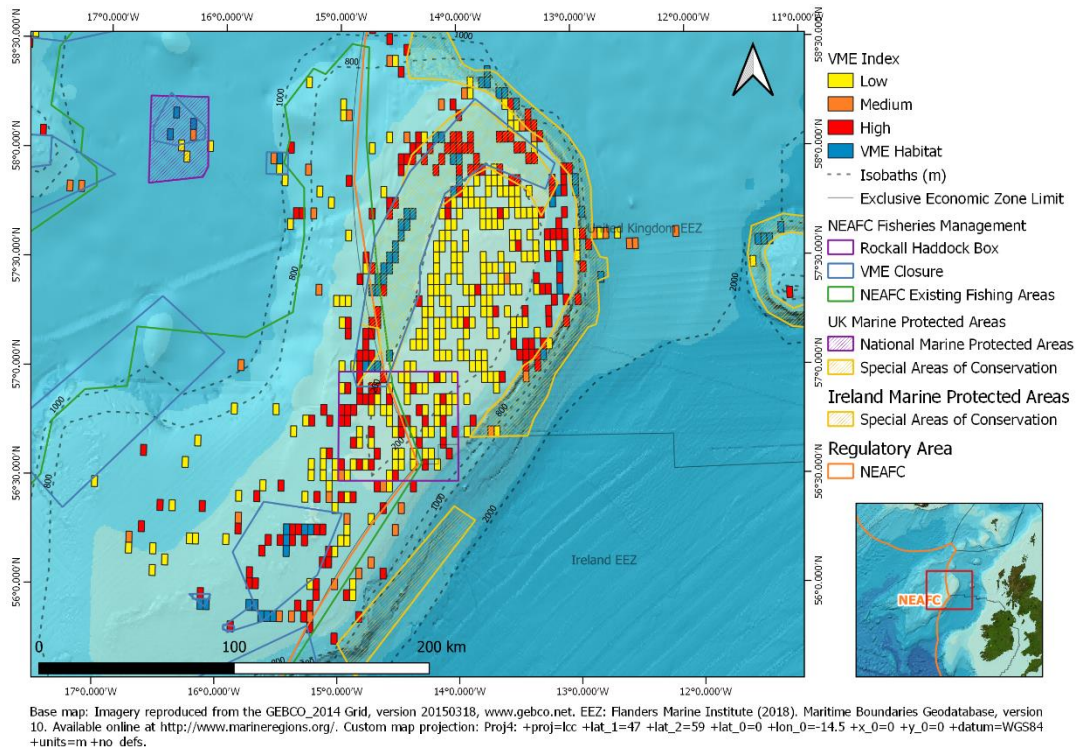


Figure 4.2. Output of the VME weighting algorithm for the area shown in Figure 4.1 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

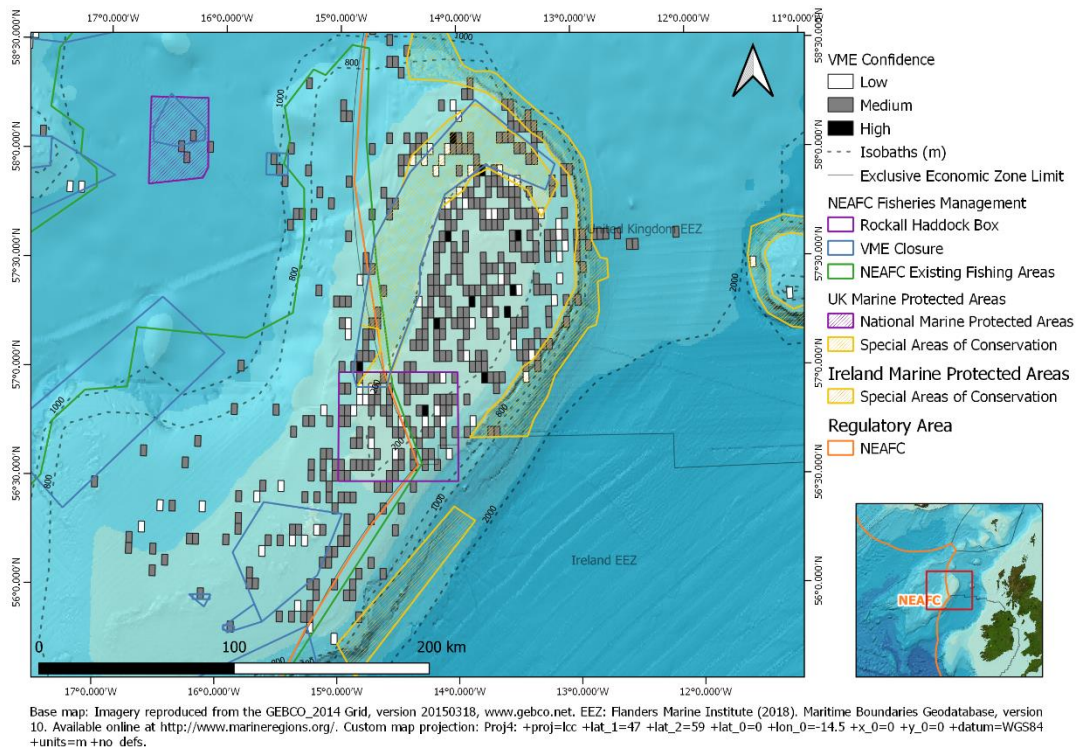


Figure 4.3. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.2). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2019) records from the ICES VME database.

4.2.2 Hatton Bank

Hatton Bank is a large volcanic bank, situated in the Atlantic Northwest Approaches, towards the western extent of the UK continental shelf. It is an elongate, arc-shaped bank, stretching nearly 500 km in length and rising up to 1 km above the surrounding seabed.

As noted in Section 3.3.8, records for Hatton Bank were re-submitted in 2019, following a review of data noted in previous WGDEC reports that did not appear in the ICES VME database. These data (Figure 4.4) were submitted by the UK for the 2019 data call from literature (Frederiksen *et al.*, 1992).

The weighting algorithm has been re-run to include these VME records, and the output is shown in Figure 4.5. The confidence layer for the VME index for Hatton Bank is shown in Figure 4.6.

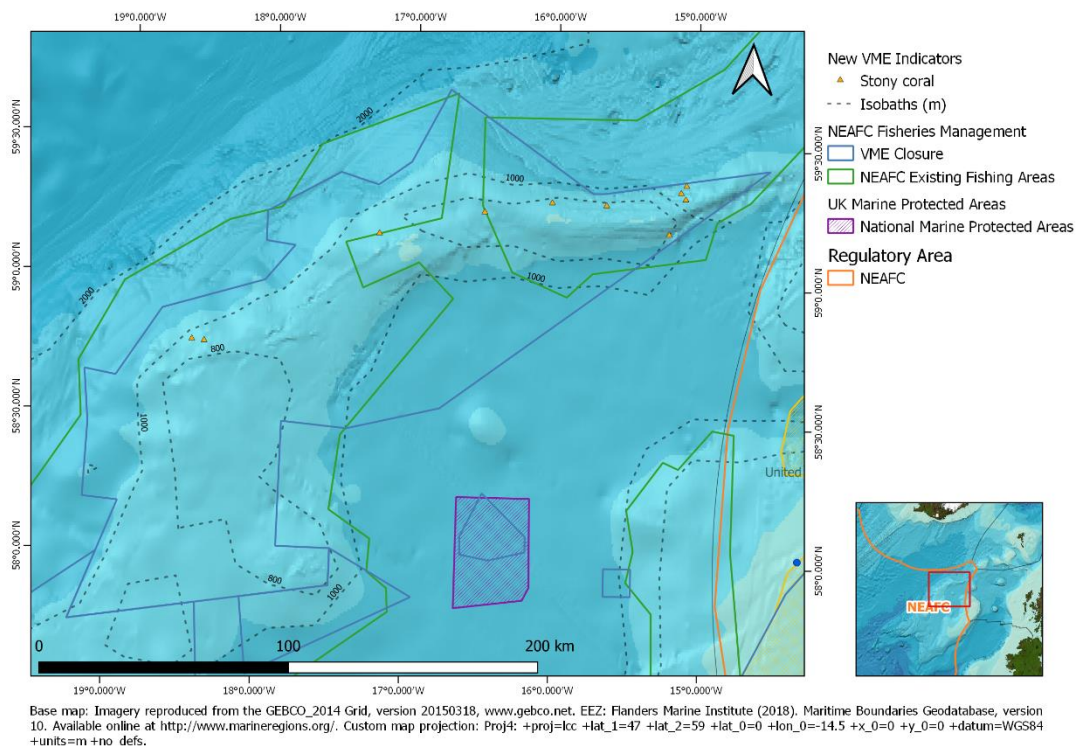


Figure 4.4 New VME records re-submitted to the VME database in 2019 for Hatton Bank within the NEAFC Regulatory Area. Note, other VME records from the VME database for this area are not displayed.

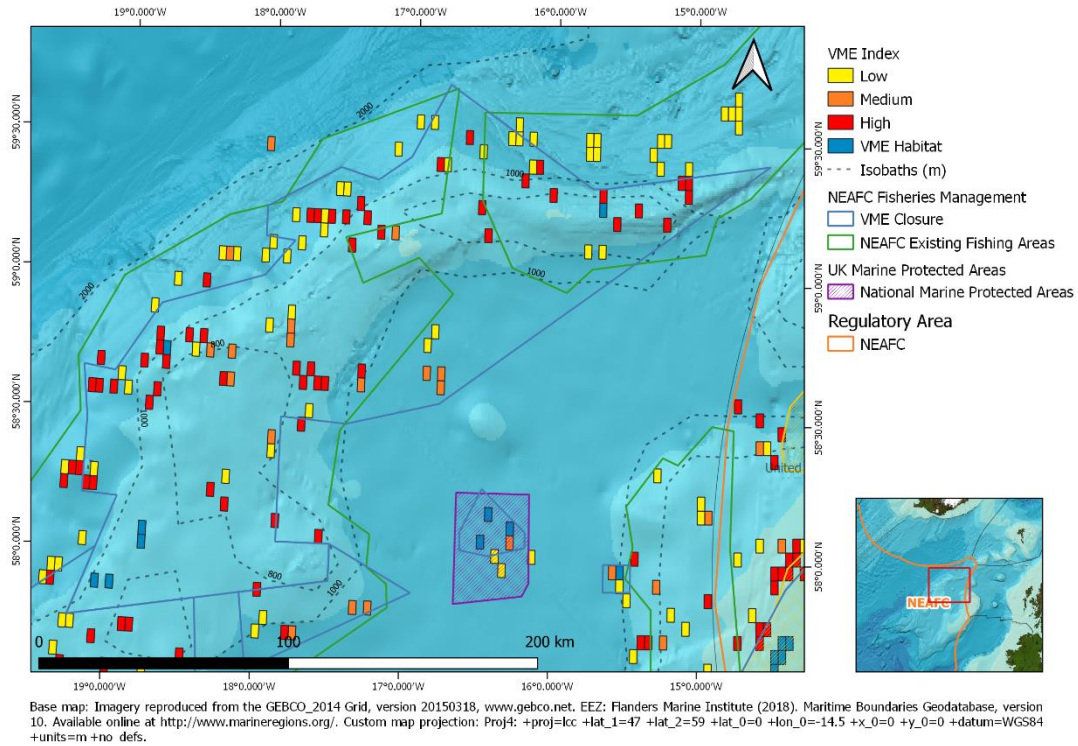


Figure 4.5 Output of the VME weighting algorithm for the area shown in Figure 4.4 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

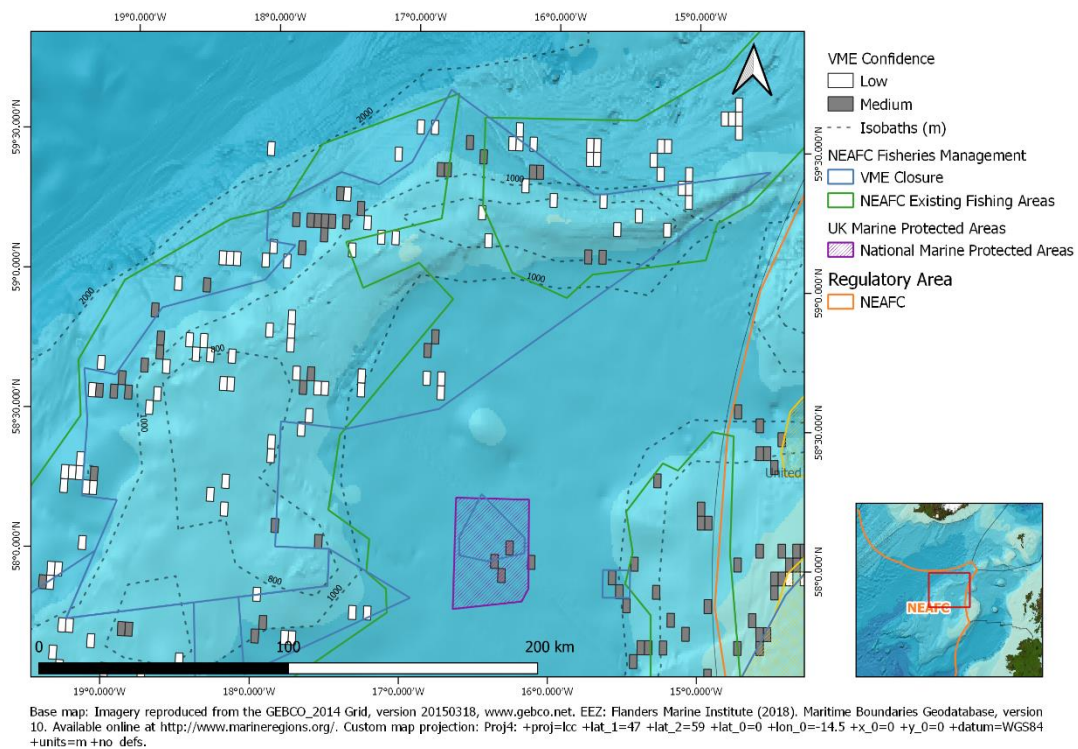


Figure 4.6 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.5). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2019) records from the ICES VME database.

4.2.3 North East Barents Sea

New VME indicator data were submitted by Norway for the North East Barents Sea within the NEAFC Regulatory Area (Figure 4.7). Data were from bottom trawls from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS) as detailed in Section 3.3.3.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.8, and the confidence layer for the VME index is shown in Figure 4.9.

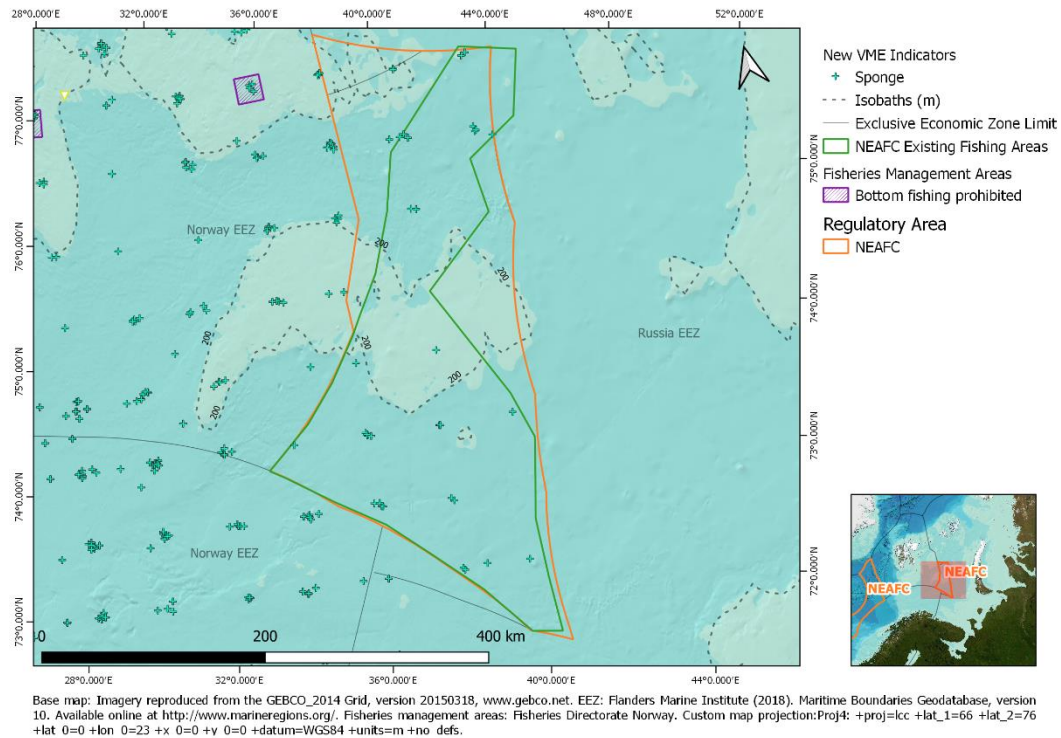


Figure 4.7. New VME indicator records (green crosses) submitted to the VME database in 2019 for the Central Barents Sea. The NEAFC Regulatory Area is shown as an orange line.

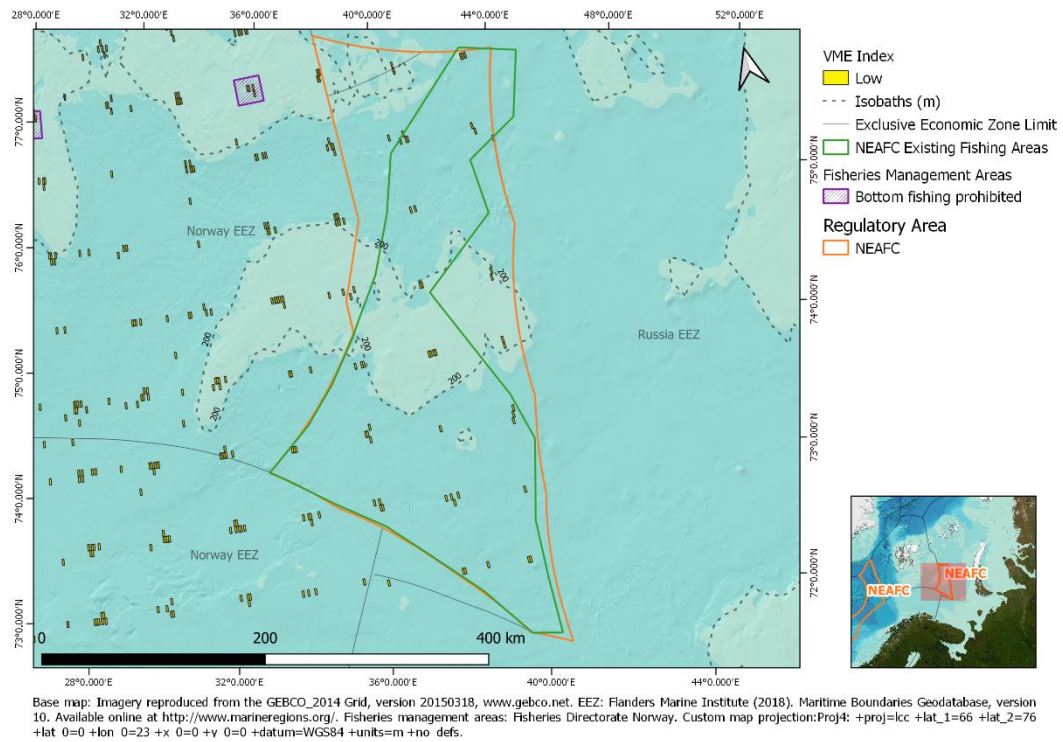


Figure 4.8. Output of the VME weighting algorithm for the area shown in Figure 4.7. Showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

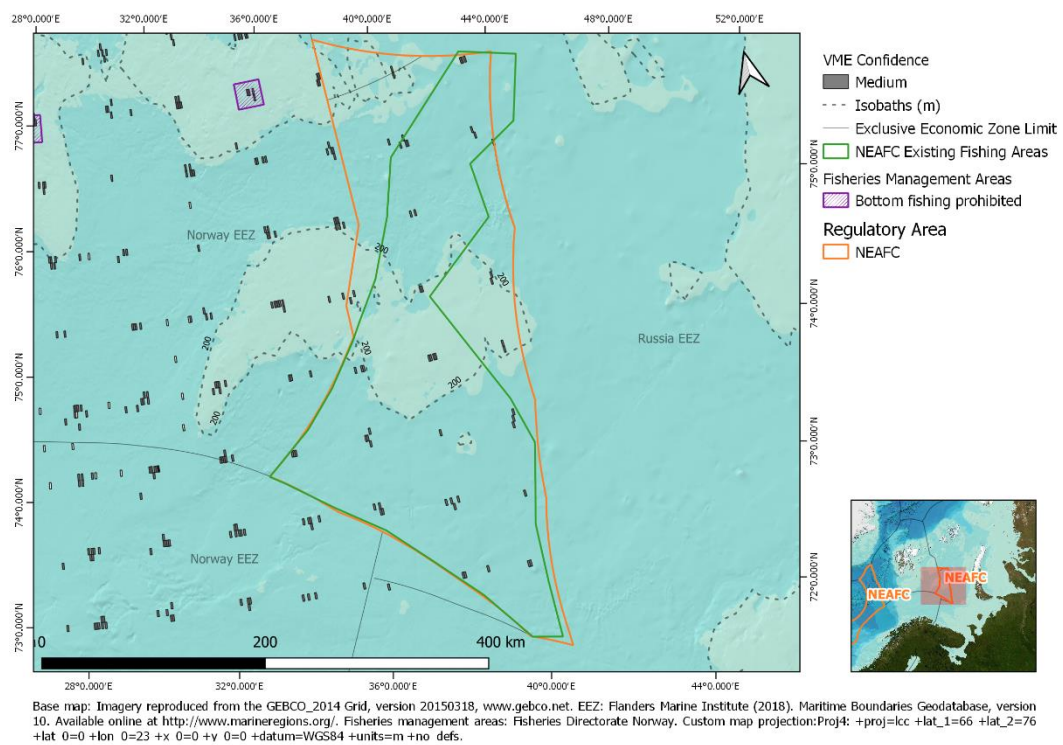


Figure 4.9. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.8). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating.

4.3 Areas considered within the EEZs of various countries

4.3.1 Faroe-Shetland Channel

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 (Figure 4.10). New VME indicator data submitted include sponges, soft corals, sea-pens and gorgonians, from a Marine Scotland Science scientific bottom trawl survey (1218S), as detailed in Section 3.3.1.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.11, and the confidence layer for the VME index is shown in Figure 4.12.

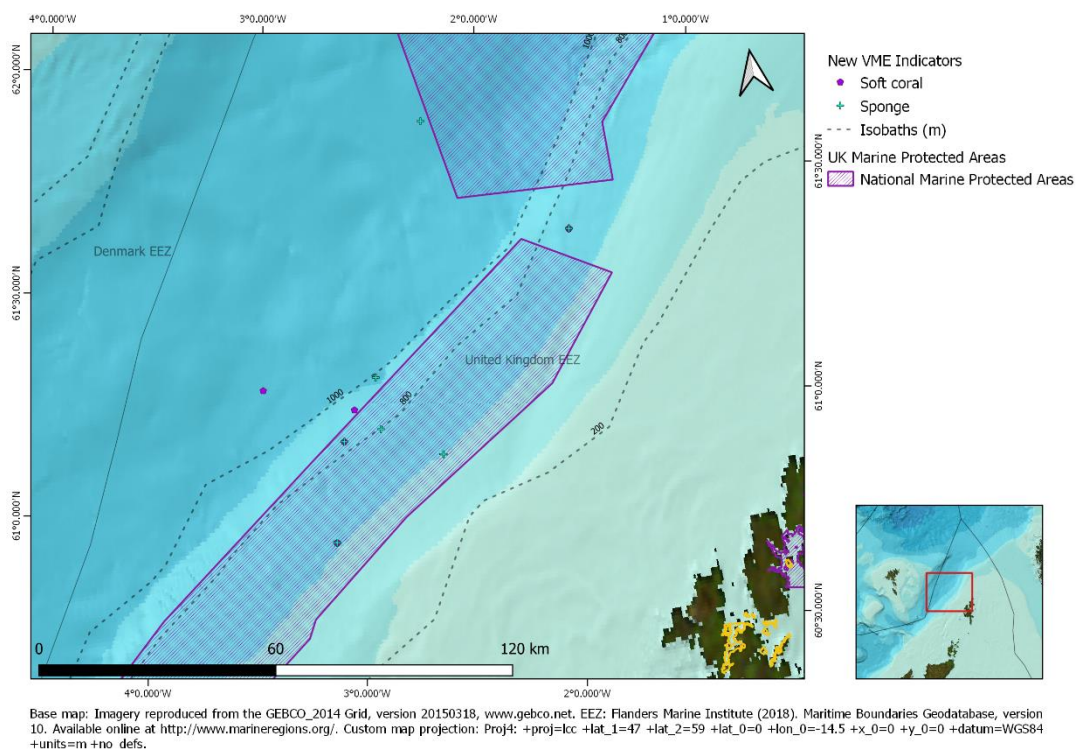


Figure 4.10. New VME records submitted to the VME database in 2019 for the Faroe Shetland Channel within EU waters. Note, other VME records from the VME database for this area are not displayed.

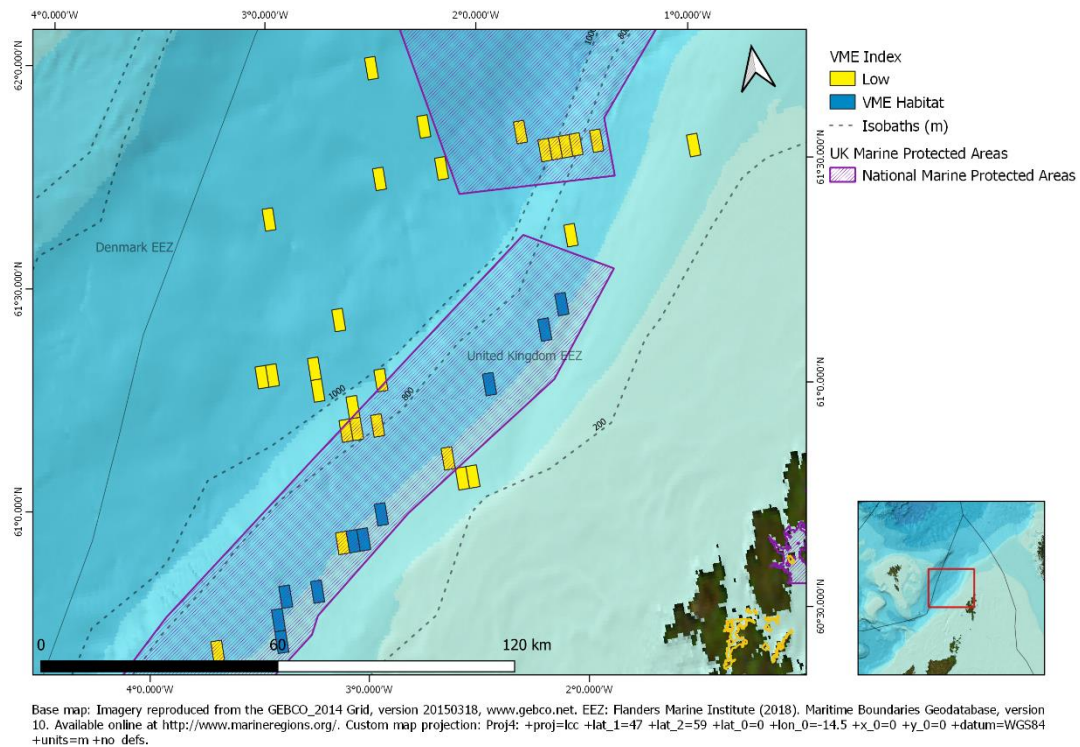


Figure 4.11. Output of the VME weighting algorithm for the area shown in Figure 4.10 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

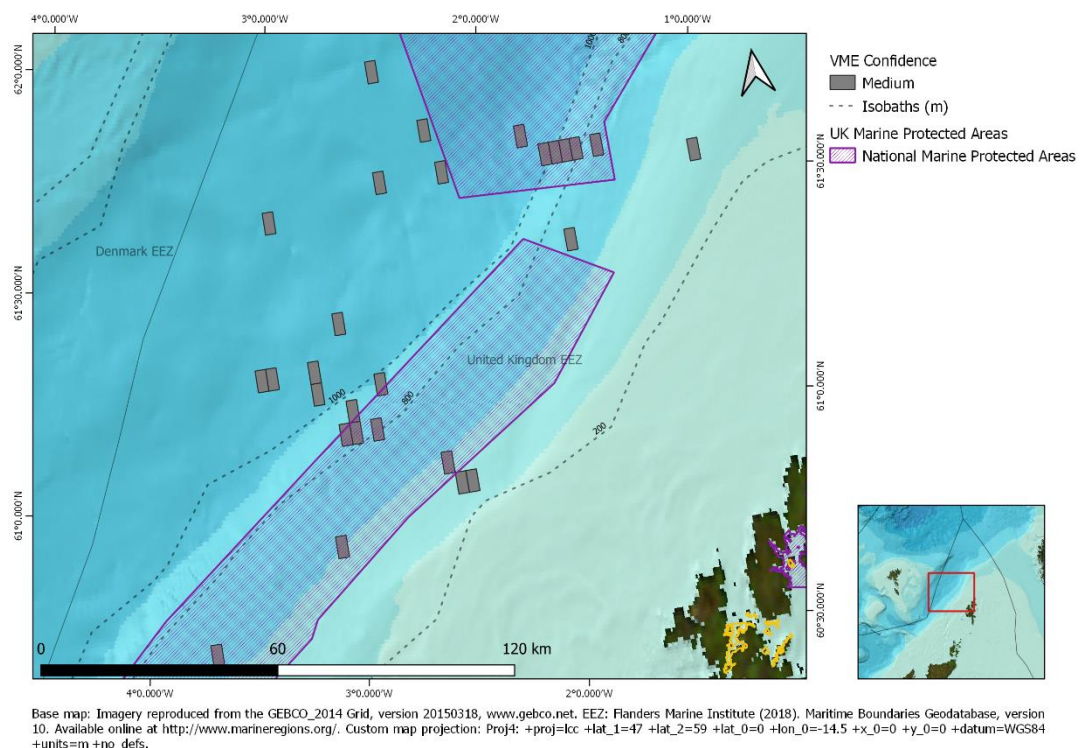


Figure 4.12. The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.11). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.2 Rockall Bank

New VME indicator data was submitted during the 2019 data call for the area of Rockall Bank within the UK and Ireland's EEZ. Data was from a Marine Scotland Science survey (1318S) as detailed in Section 3.3.1.

New records of cup corals, gorgonians, sea-pens, sponges and stony corals were collected from scientific bottom trawl surveys on the North East of Rockall Bank outside of the VME closure area and within the Haddock Box closure (Figure 4.13).

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.14, and the confidence layer for the VME index is shown in Figure 4.15.

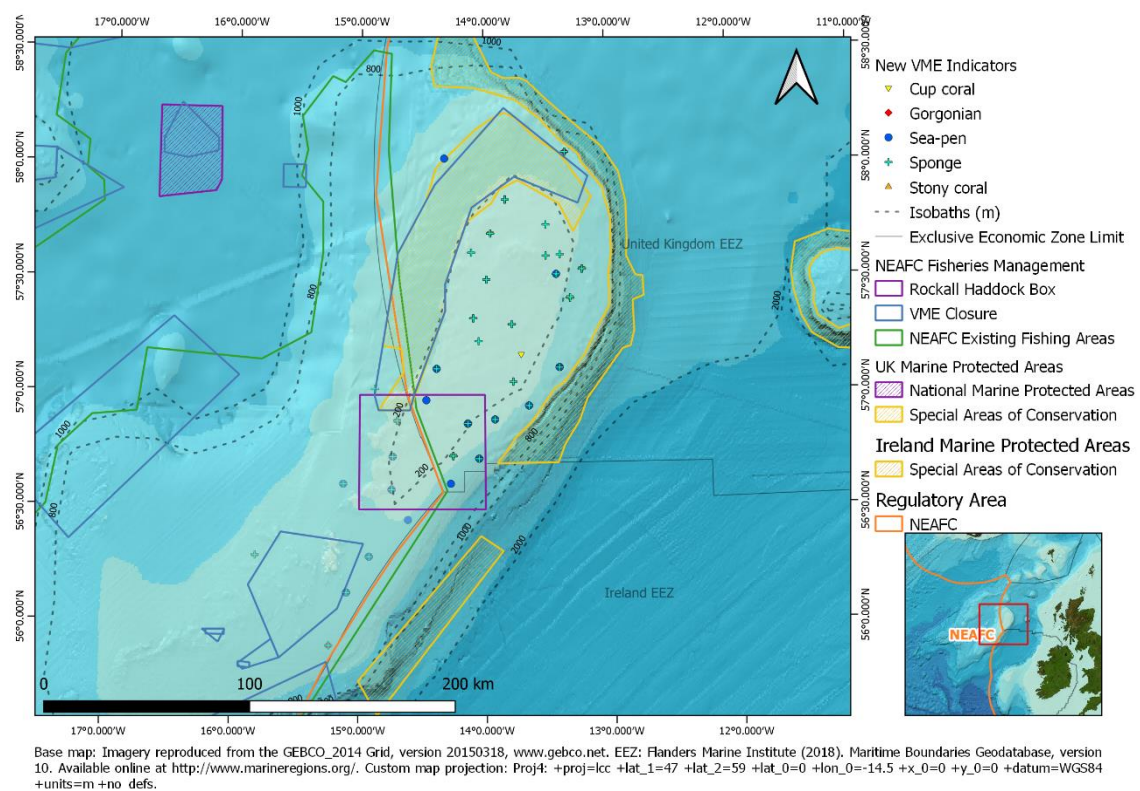


Figure 4.13. New VME records submitted to the VME database in 2019 for Rockall Bank within EU waters. Area (new records outside EU waters are displayed as transparent). Note, other VME records from the VME database for this area are not displayed.

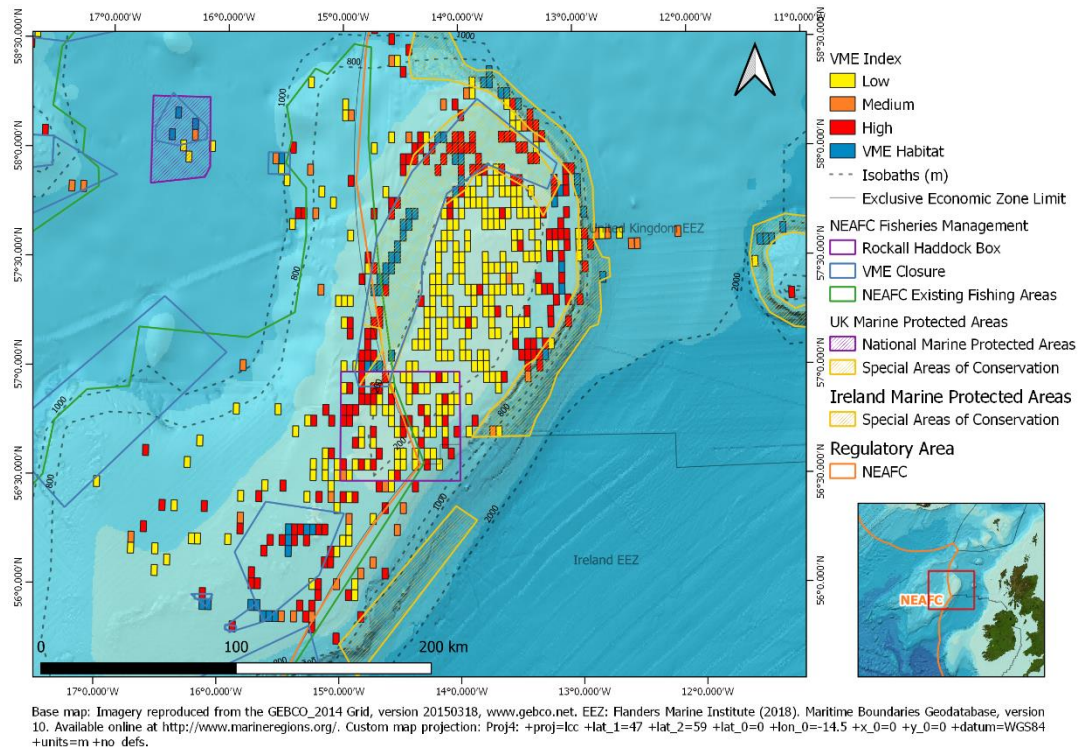


Figure 4.14. Output of the VME weighting algorithm for the area shown in Figure 4.13 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

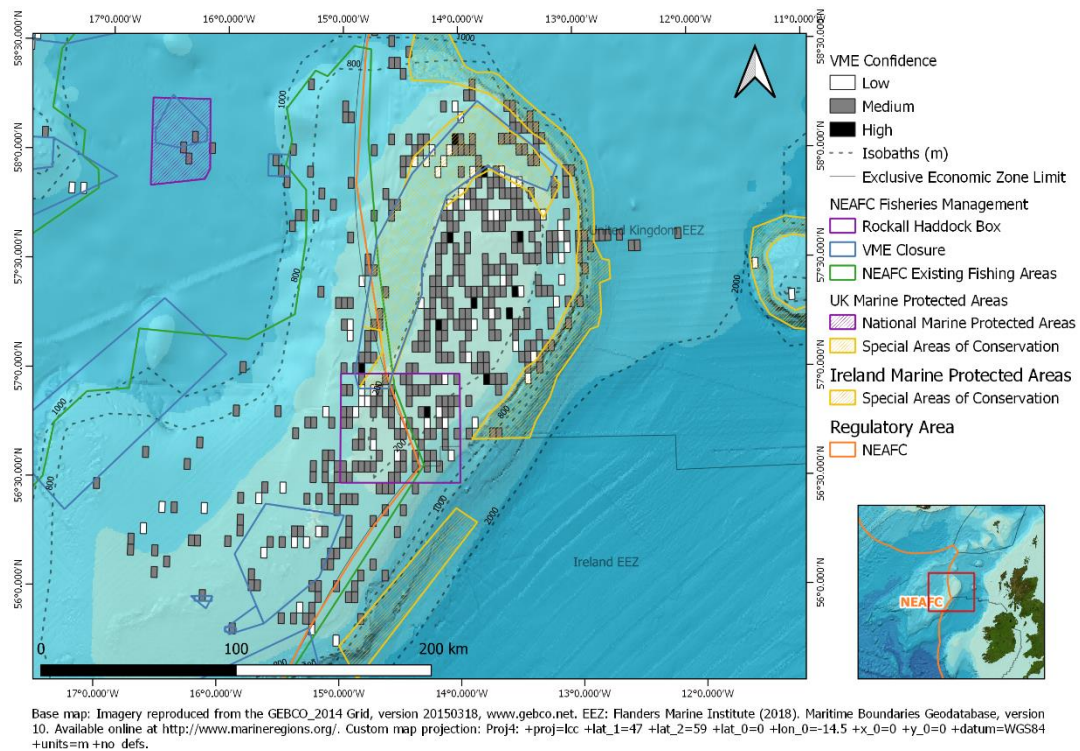


Figure 4.15. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.14). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.3 Rosemary Bank Seamount and Wyville-Thomson Ridge

New VME indicator data were submitted by the UK for Rosemary Bank Seamount and the Wyville-Thomson Ridge, located to the northwest of Scotland within the UK EEZ. Additional records were submitted for an area to the northwest of Wyville-Thomson Ridge within the Faroese EEZ (Figure 4.16). New VME indicator data were submitted from a Marine Scotland Science scientific bottom trawl survey (1218S), as detailed in Section 3.3.1.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.17, 4.17 and the confidence layer for the VME index is shown in Figure 4.18.

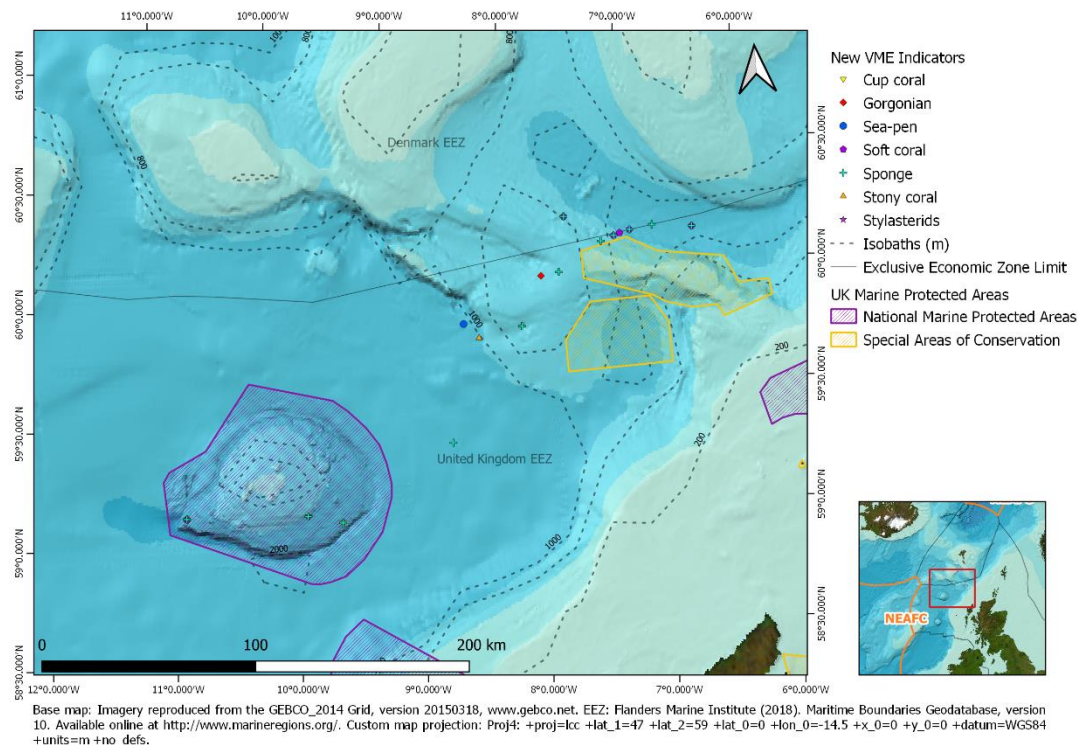


Figure 4.16. New VME records submitted to the VME database in 2019 for Rosemary Bank Seamount and Wyville Thomson Ridge within EU waters, and the Faroese EEZ. Note, other VME records from the VME database for this area are not displayed.

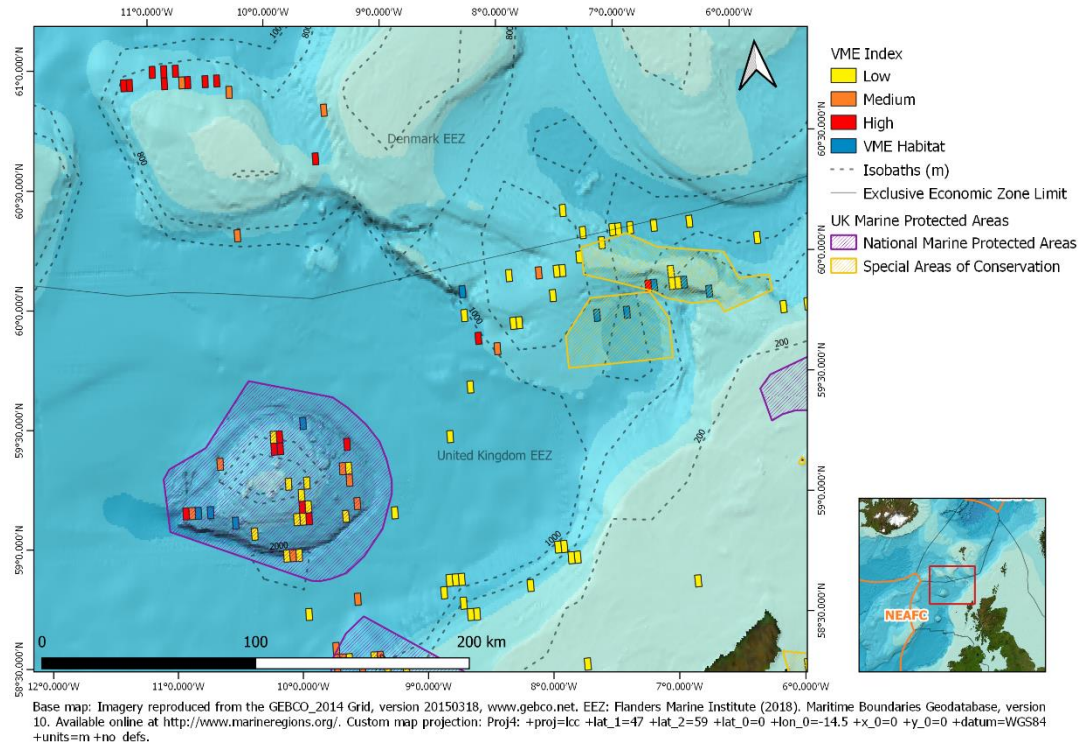


Figure 4.17. Output of the VME weighting algorithm for the area shown in Figure 4.16 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

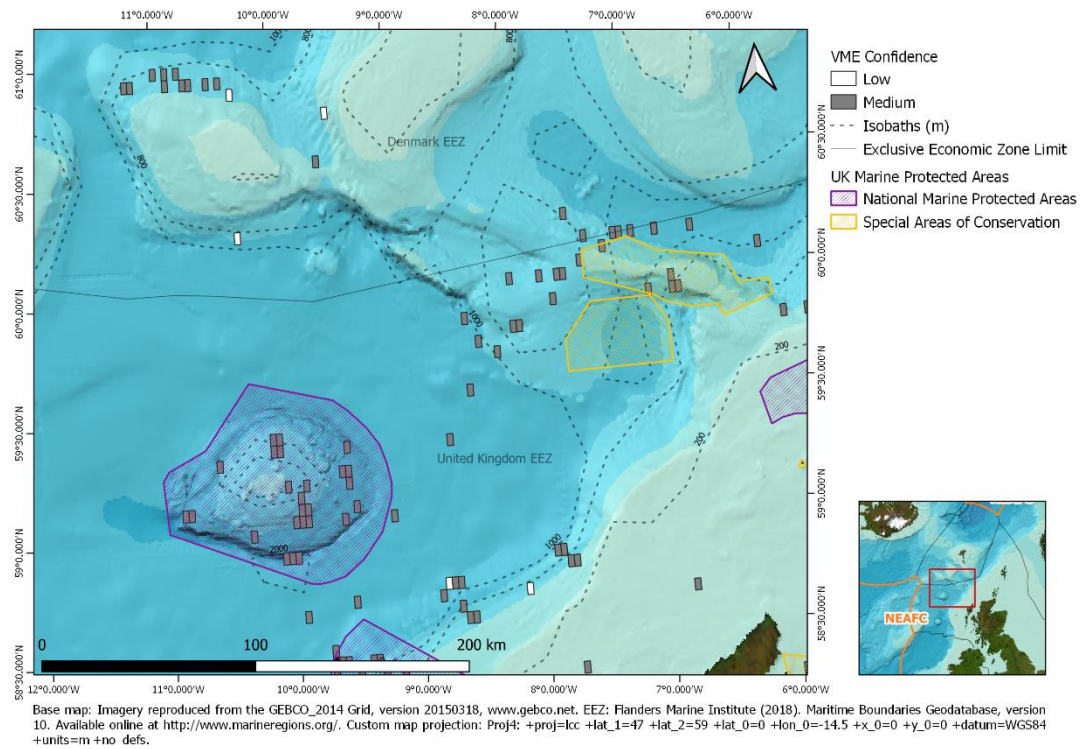


Figure 4.18. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.17). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.4 Irish continental shelf

New records of VME habitats were submitted for the Irish/Scottish Continental Shelf by Ireland's Marine Institute from the Marine Institute and INFOMAR 2017 SeaRover survey. These data were collected by ROV dives along the Irish Continental margin, see Section 3.3.4 and are shown in Figure 4.19 and Figure 4.22.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.20 and Figure 4.23, and the confidence layer for the VME index is shown in Figure 4.21 and Figure 4.24.

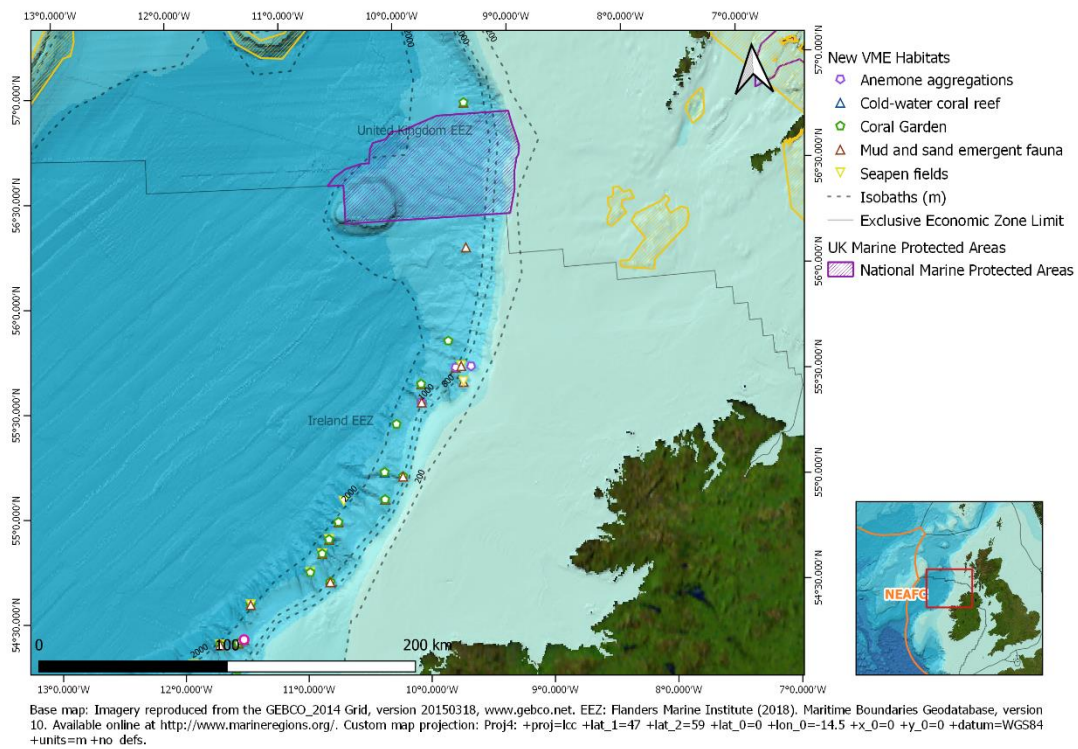


Figure 4.19. New VME records submitted to the VME database in 2019 for the Irish/Scottish Continental Shelf within EU waters (see also Figure 4.22)

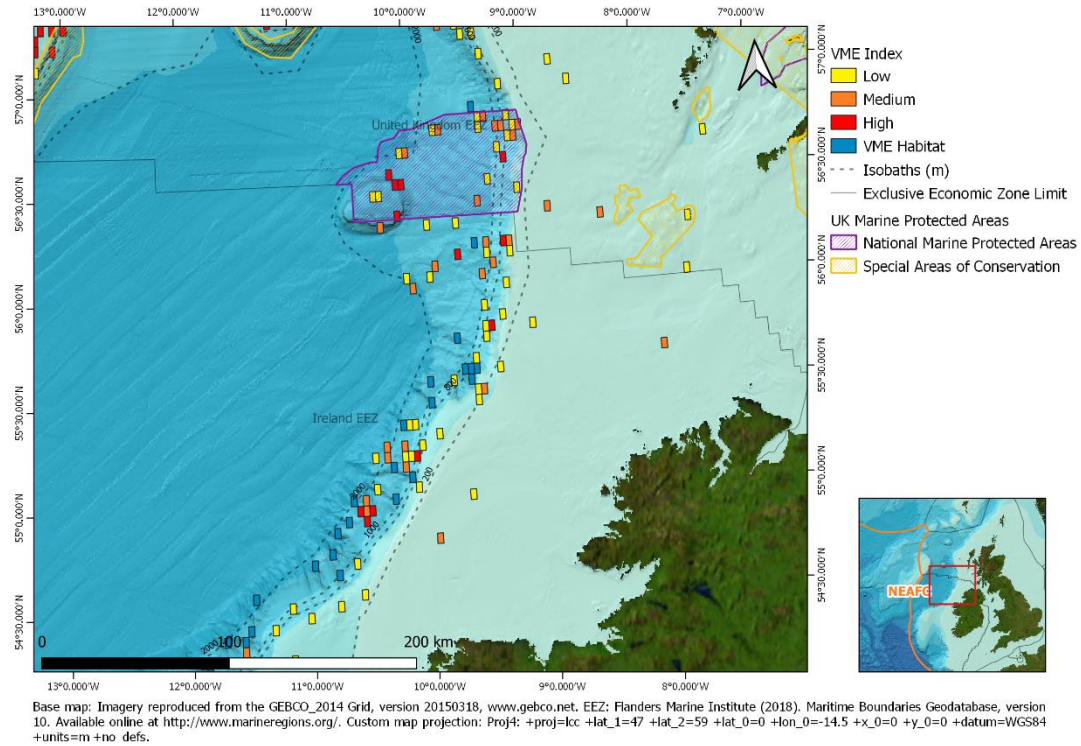


Figure 4.20. Output of the VME weighting algorithm for the area shown in Figure 4.19 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

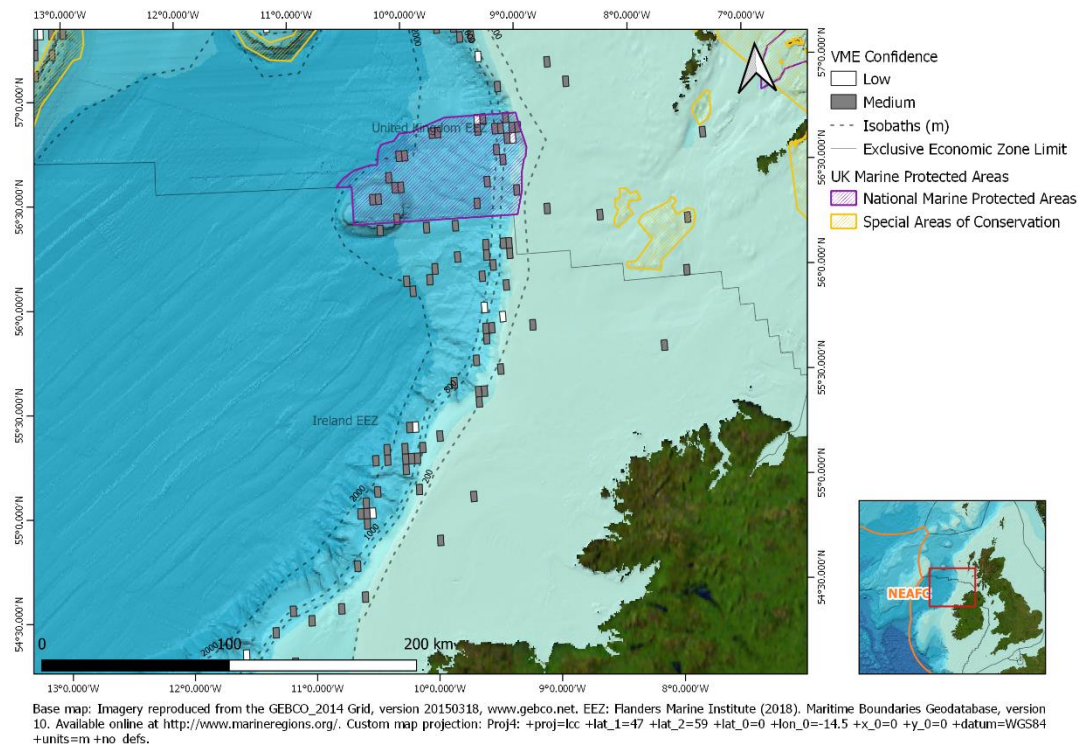


Figure 4.21. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.20). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating.

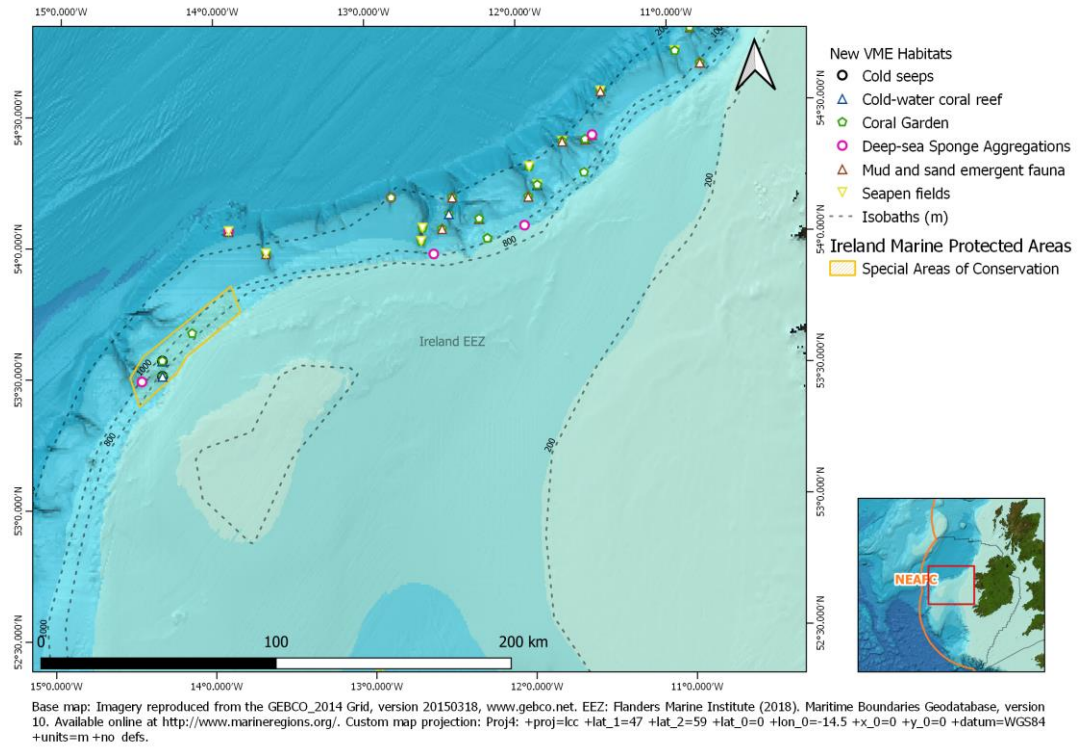


Figure 4.22. New VME records submitted to the VME database in 2019 for the Irish Continental Shelf within EU waters (see also Figure 4.19).

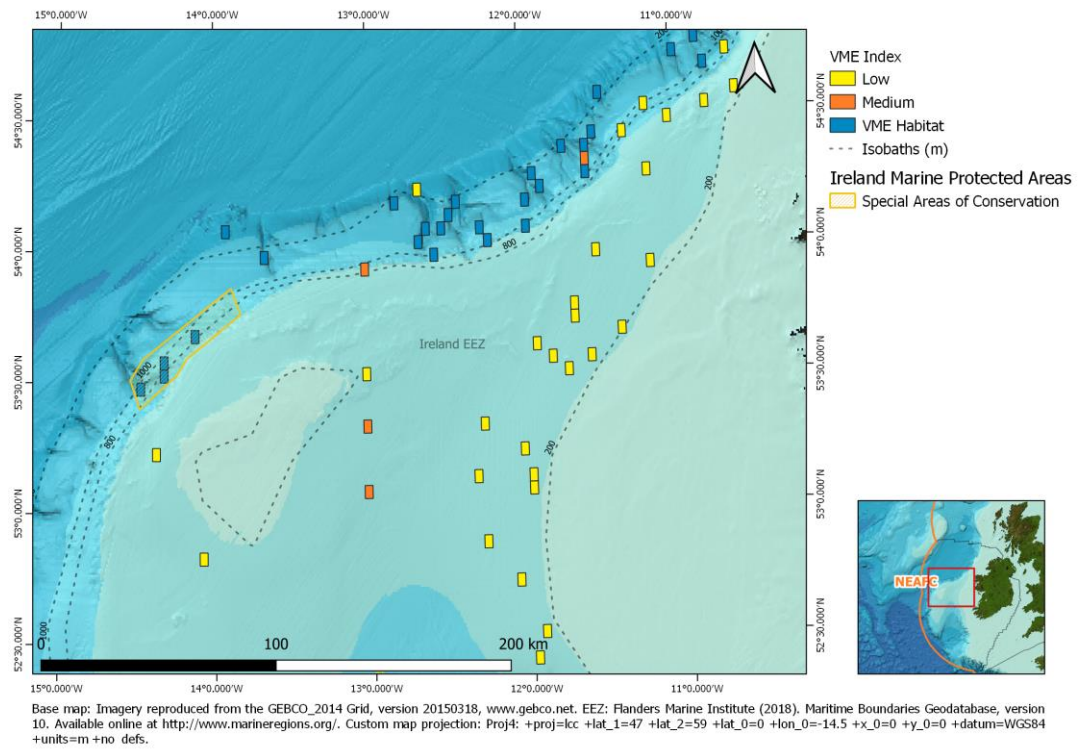


Figure 4.23. Output of the VME weighting algorithm for the area shown in Figure 4.22 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

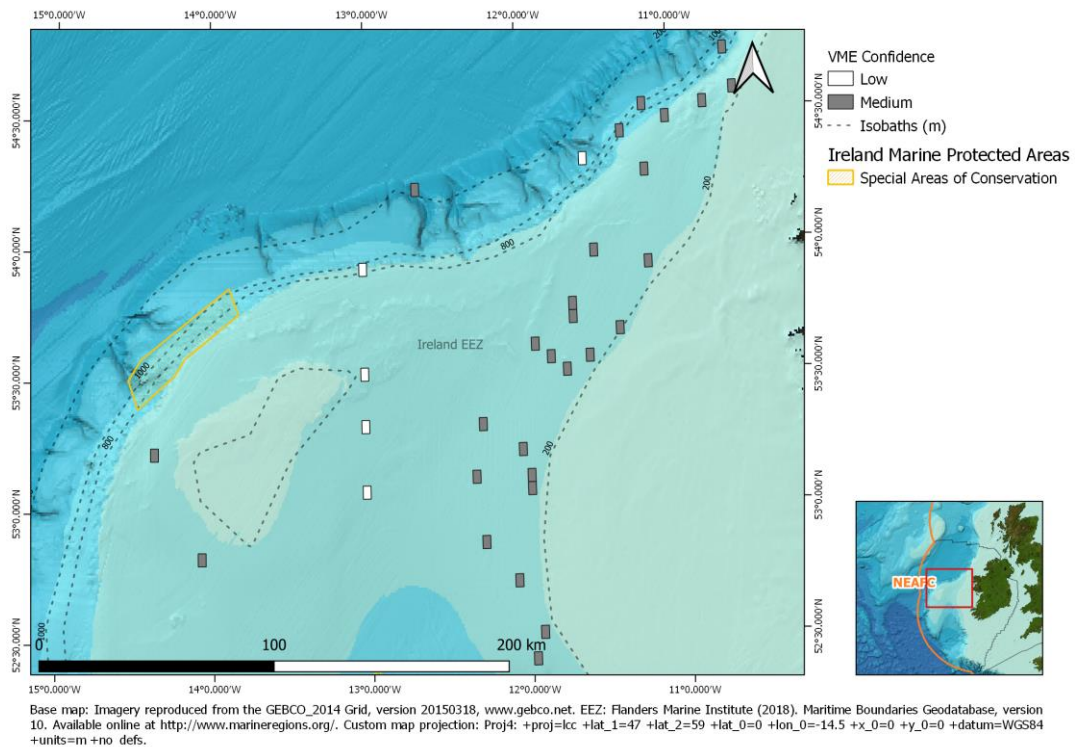


Figure 4.24. The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.23). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating.

4.3.5 Spanish continental shelf (Gulf of Cadiz)

Gazul is a Mud Volcano located in the Gulf of Cádiz, approx. 33 nautical miles (nm) away from the city of Cádiz. The Gazul Mud Volcano shape is sculpted by the Mediterranean Outflow Water (MOW).

New VME habitat records for the Spanish Continental Shelf in the Gulf of Cadiz, were submitted to the VME database from the Spanish Institute of Oceanography’s “Mediterranean out flow water and vulnerable ecosystems” (MEDWAVES) research cruise, see section 3.3.5. These data were from ROV footage at the Gazul Mud Volcano and included records of coral gardens, deep-sea sponge aggregations and a coral reef record (Figure 4.25).

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.26, and the confidence layer for the VME index is shown in Figure 4.27.

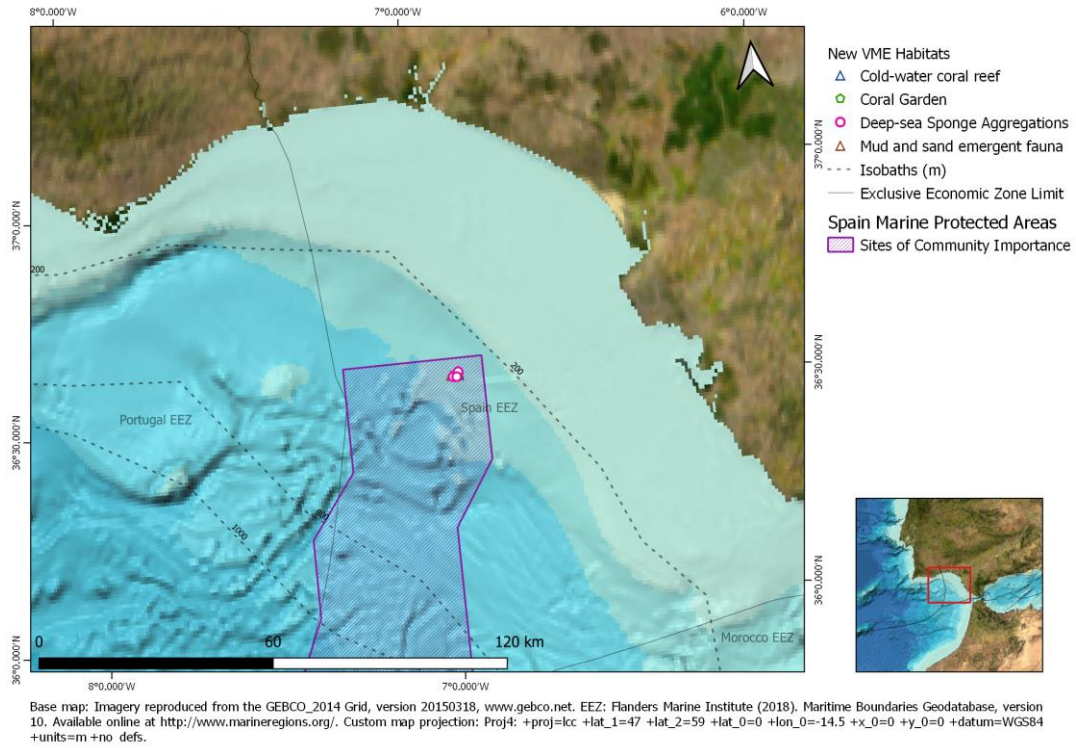


Figure 4.25. New VME records submitted to the VME database in 2019 for the Spanish continental shelf (Gulf of Cadiz) within EU waters. Note, other VME records from the VME database for this area are not displayed.

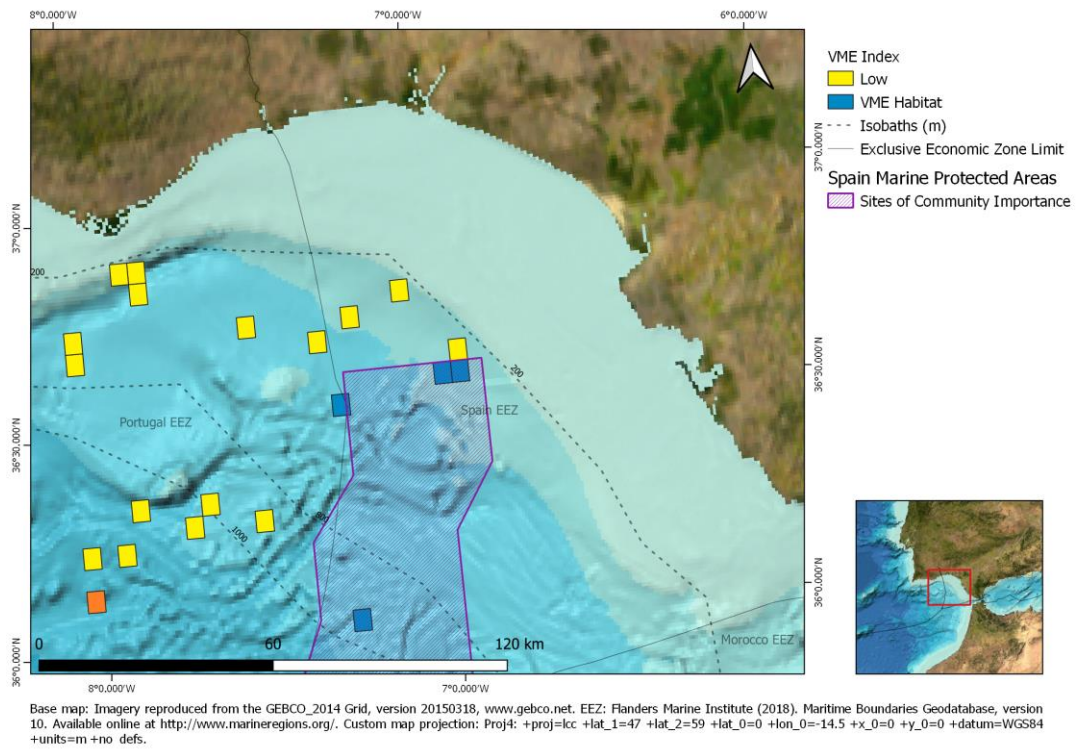


Figure 4.26. Output of the VME weighting algorithm for the area shown in Figure 4.25 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

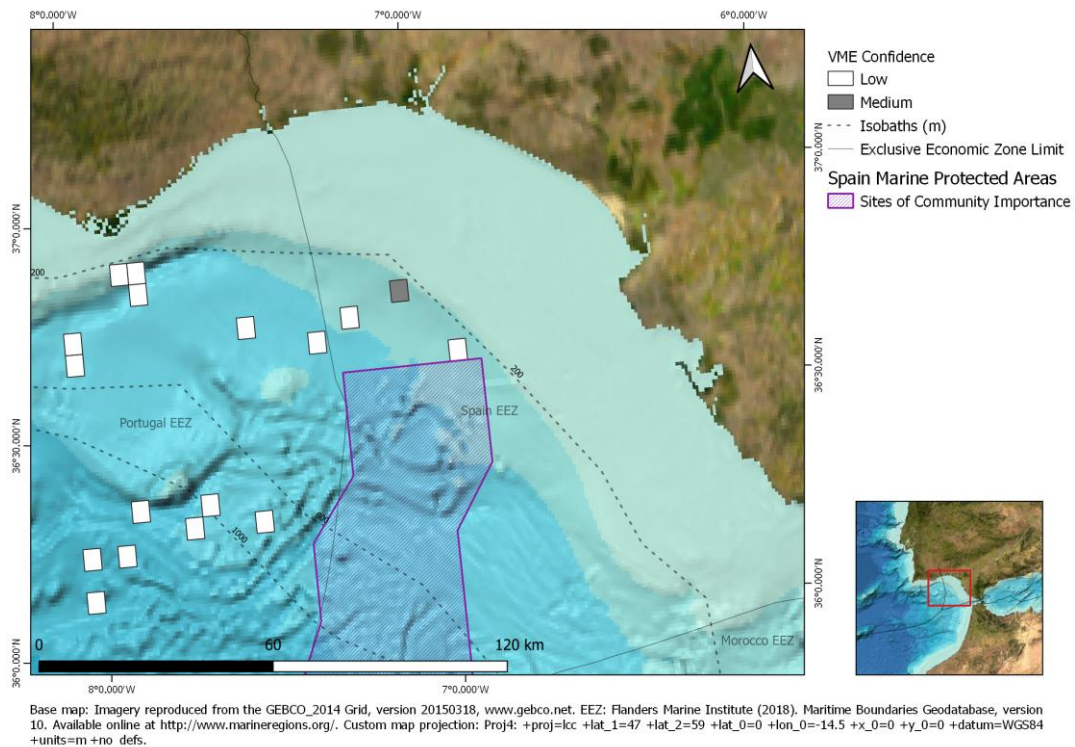


Figure 4.27. The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.26). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.6 Formigas Seamount

The Formigas Islets are part of a promontory named Formigas Bank. This promontory is located next to the junction of East Atlantic Fracture Zone (EAFZ) and Terceira Rift. On the western sector a 1800 m depth flat abyssal plain extends. At the northeastern side of the surveyed area at least twenty knolls are spread on an area of 130 km².

New VME habitat records for the Formigas Seamount in the Azores, were submitted to the VME database from the Spanish Institute of Oceanography’s “Mediterranean out flow water and vulnerable ecosystems” (MEDWAVES) research cruise, see section 3.3.5. These data were from ROV footage and included coral gardens and deep-sea sponge aggregations (Figure 4.28).

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.29, and the confidence layer for the VME index is shown in Figure 4.30.

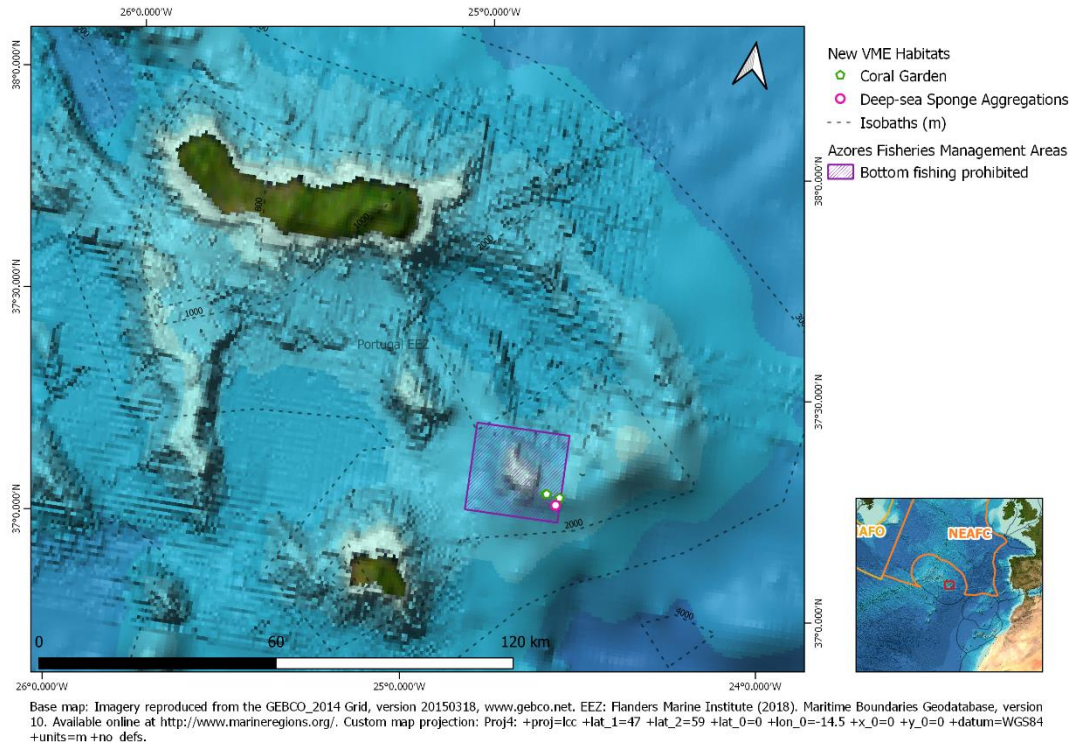


Figure 4.28. New VME records submitted to the VME database in 2019 for Formigas Seamount within EU waters. Note, other VME records from the VME database for this area are not displayed.

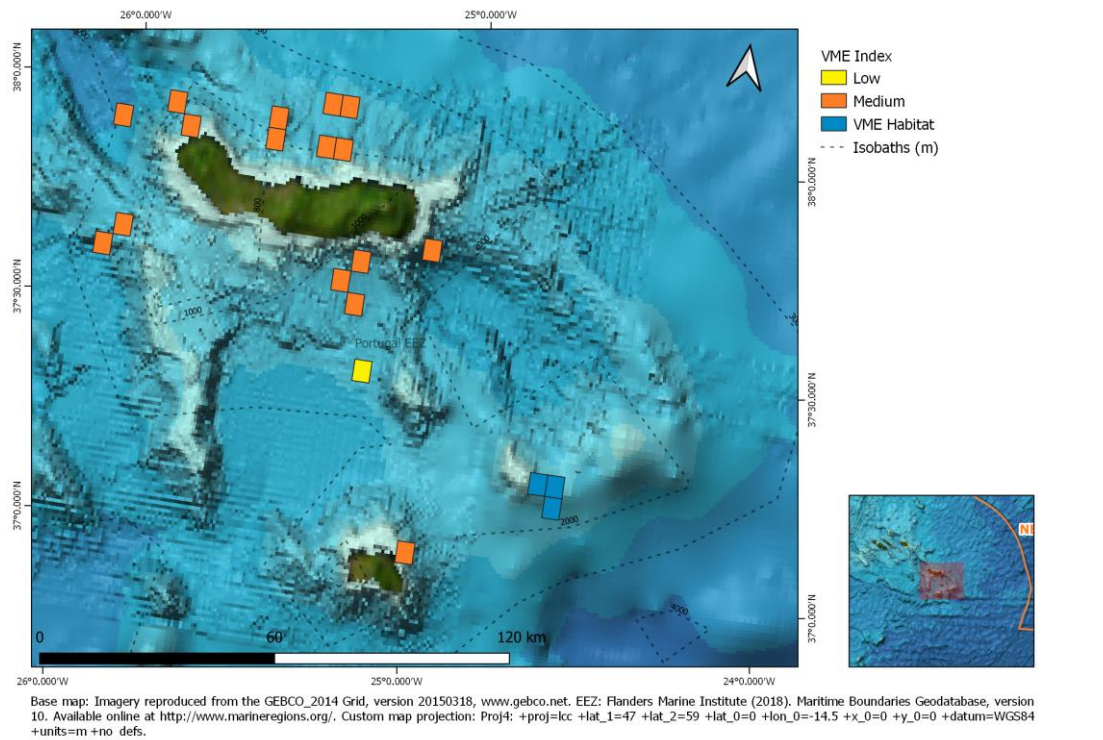


Figure 4.29. Output of the VME weighting algorithm for the area shown in Figure 4.28 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

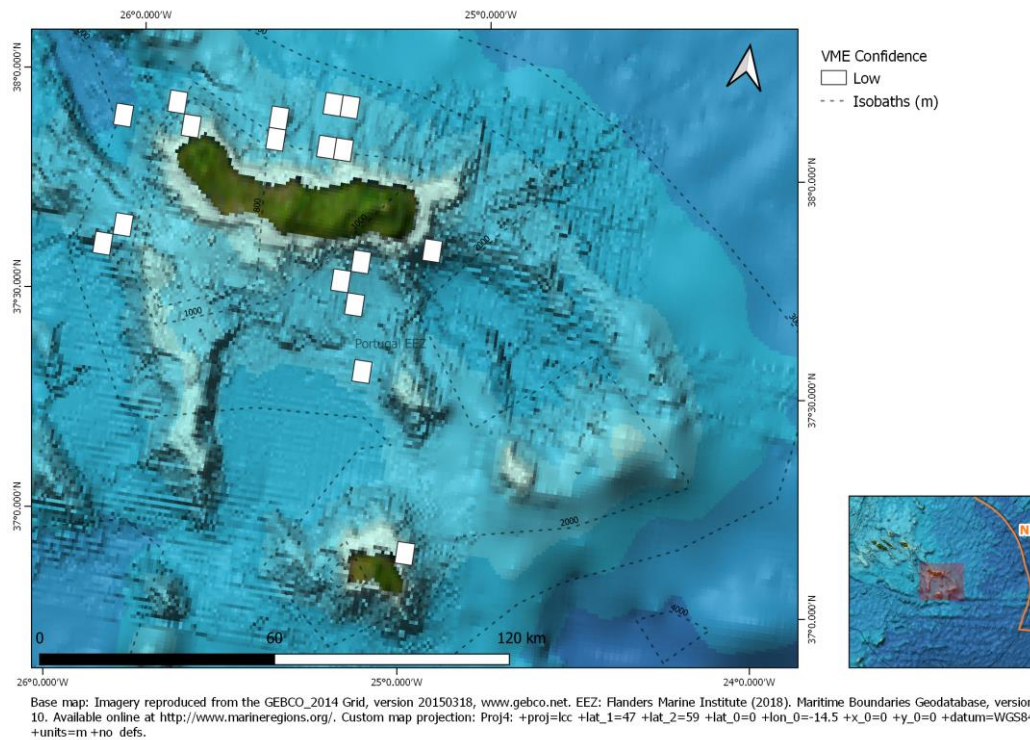


Figure 4.30. The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.29). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.7 Mid-Norwegian continental shelf

New VME data from the Mid-Norwegian continental shelf were submitted to the ICES VME database from the Norwegian National mapping programme MAREANO by the Institute of Marine Research (Figure 4.31 and Figure 4.34).

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.32 and Figure 4.35, and the confidence layer for the VME index is shown in Figure 4.33 and Figure 4.36.

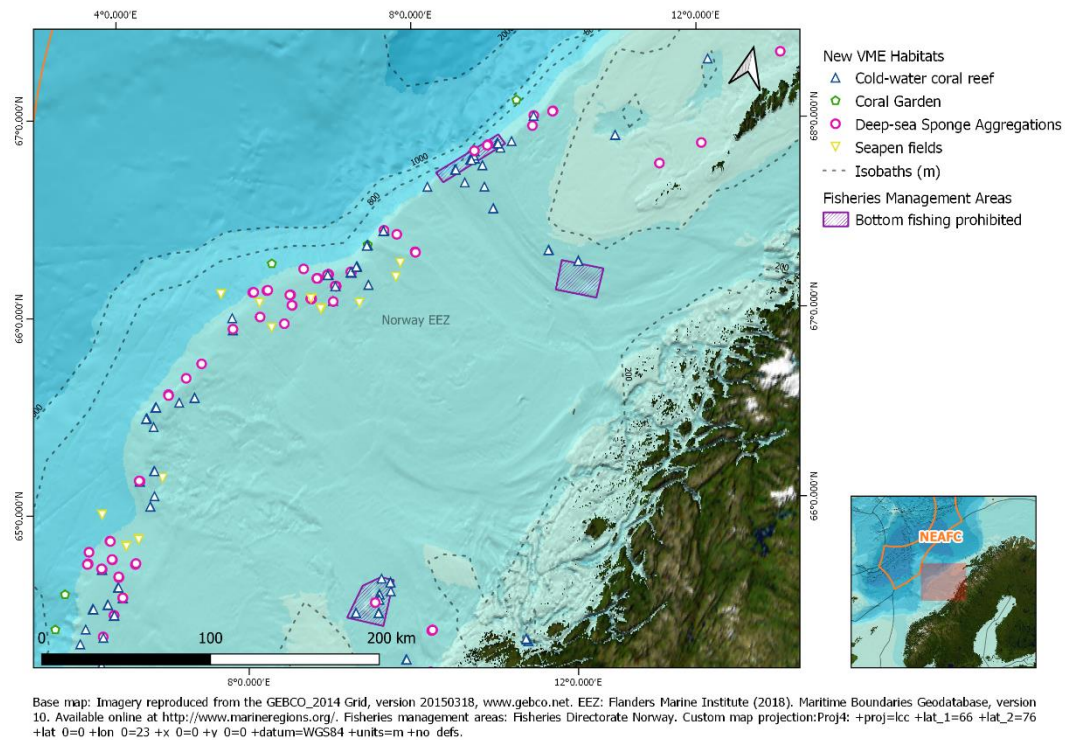


Figure 4.31. New VME records submitted to the VME database in 2019 for the Mid-Norwegian continental shelf within the Norwegian EEZ. Note, other VME records from the VME database for this area are not displayed. See Figure 4.34 for additional records in this area.

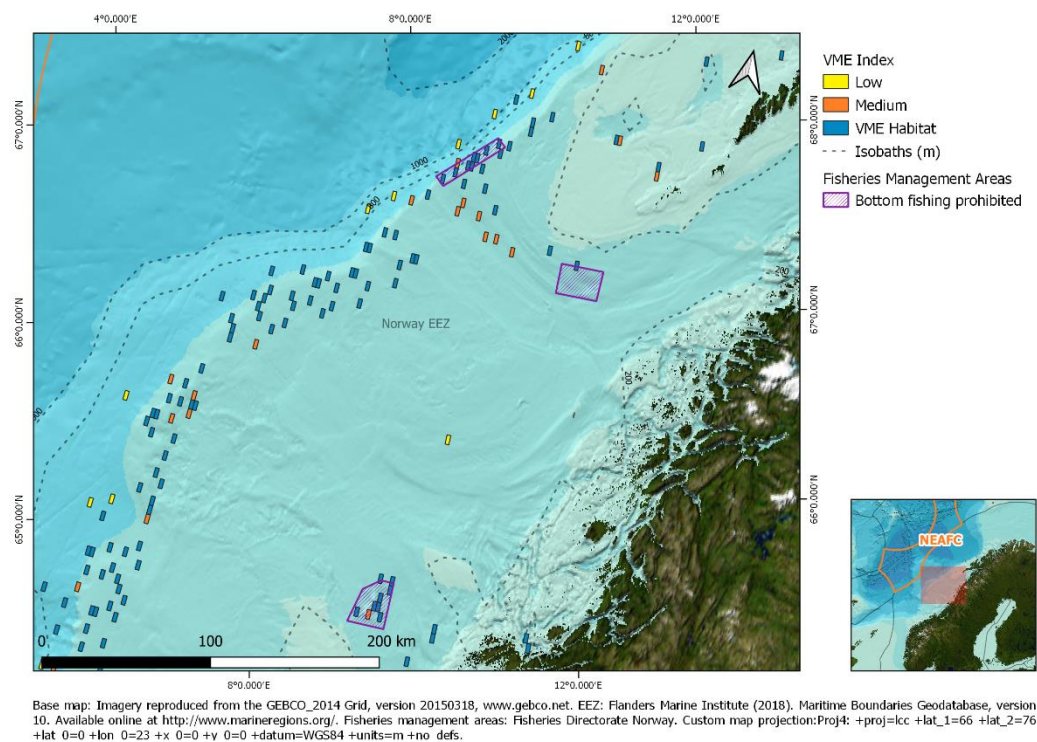


Figure 4.32. Output of the VME weighting algorithm for the area shown in Figure 4.31 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

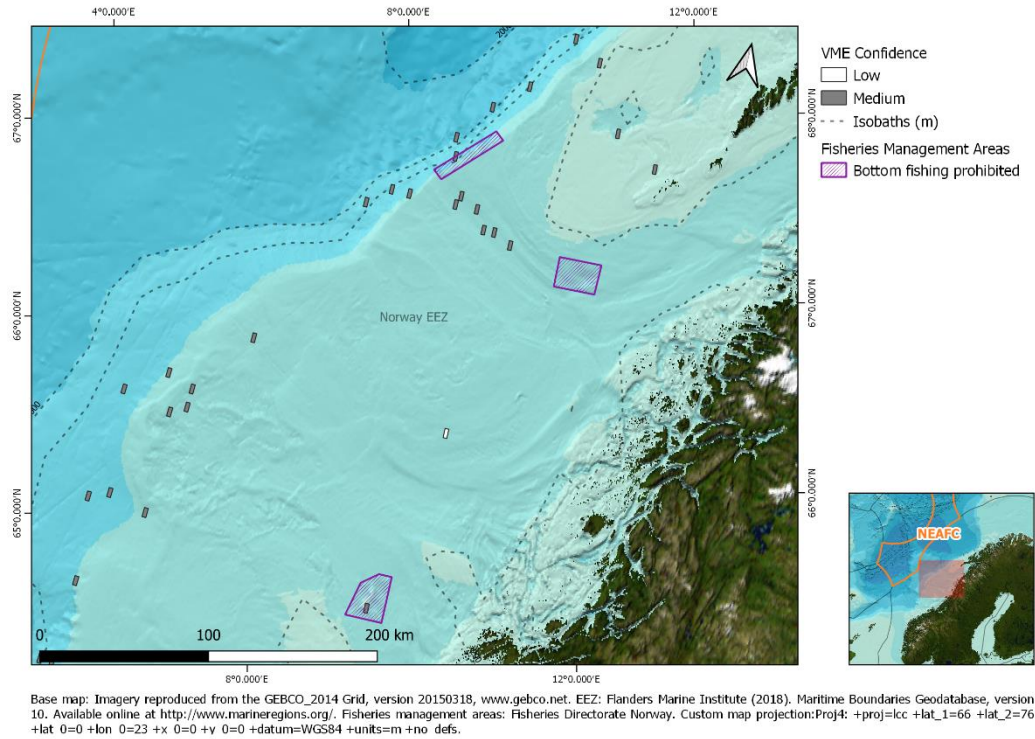


Figure 4.33. The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.32). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

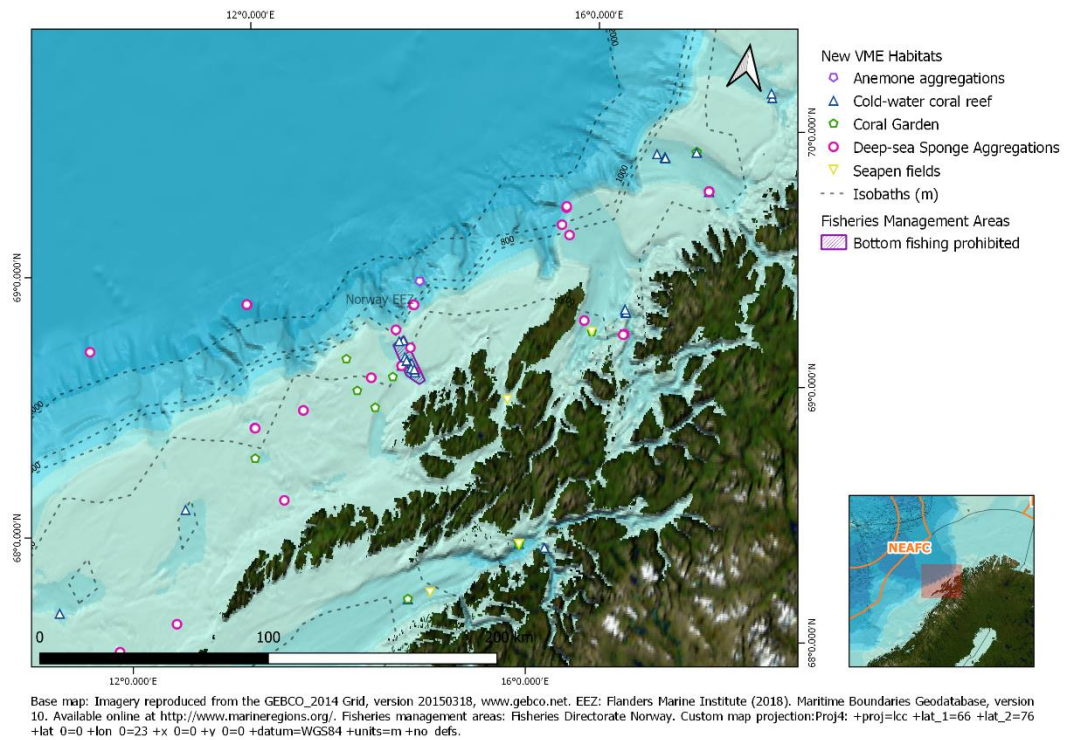


Figure 4.34 New VME records submitted to the VME database in 2019 for the Mid-Norwegian continental shelf within the Norwegian EEZ. Note, other VME records from the VME database for this area are not displayed. See Figure 4.31 for additional records in this area.

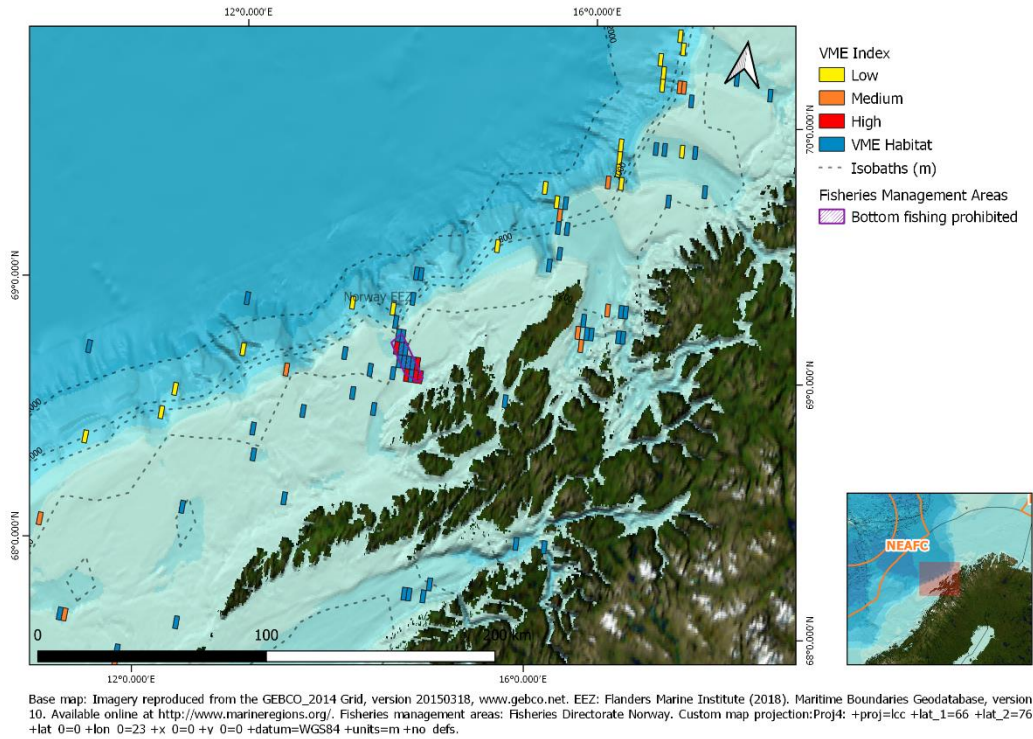


Figure 4.35 Output of the VME weighting algorithm for the area shown in Figure 4.34 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

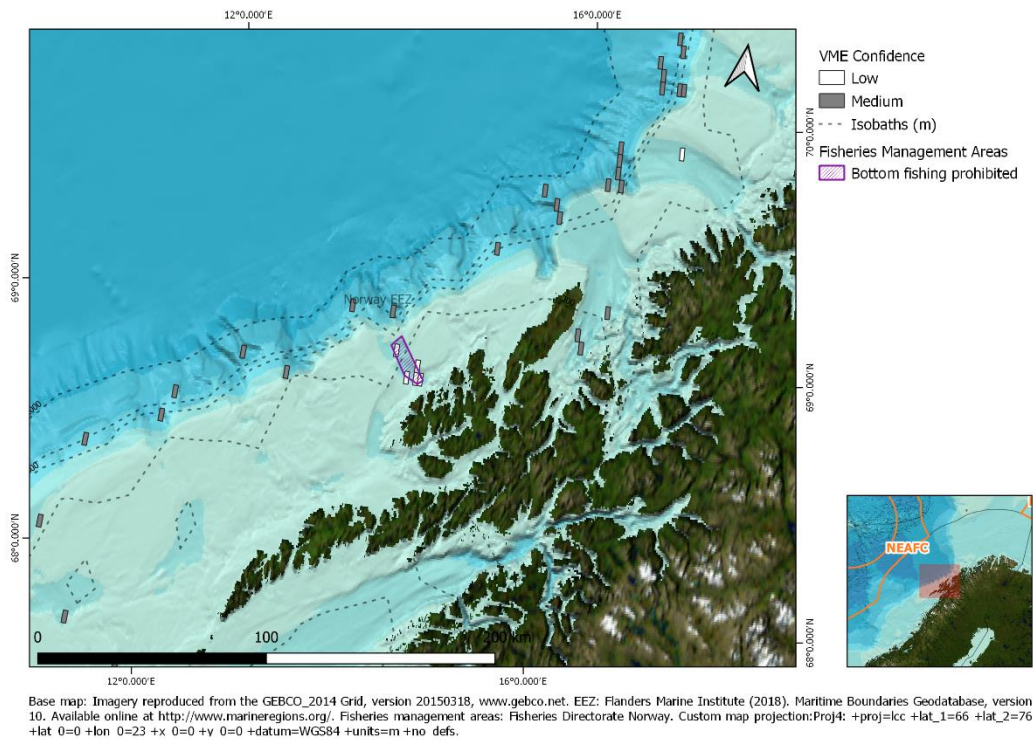


Figure 4.36 The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.32). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.8 Central and South West Barents Sea (Tromsø Flaket)

New VME indicator data were submitted by Norway for the Central and South West Barents Sea (around Tromsø Flaket). Data were from the Institute of Marine Research bottom trawl surveys from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS) (Figure 4.37 and Figure 4.38)

Outputs of the weighting algorithm and confidence layer with these new VME data are not presented due to the large number of new records making the scale of view too small. However, these can be viewed on the ICES VME data portal⁹.

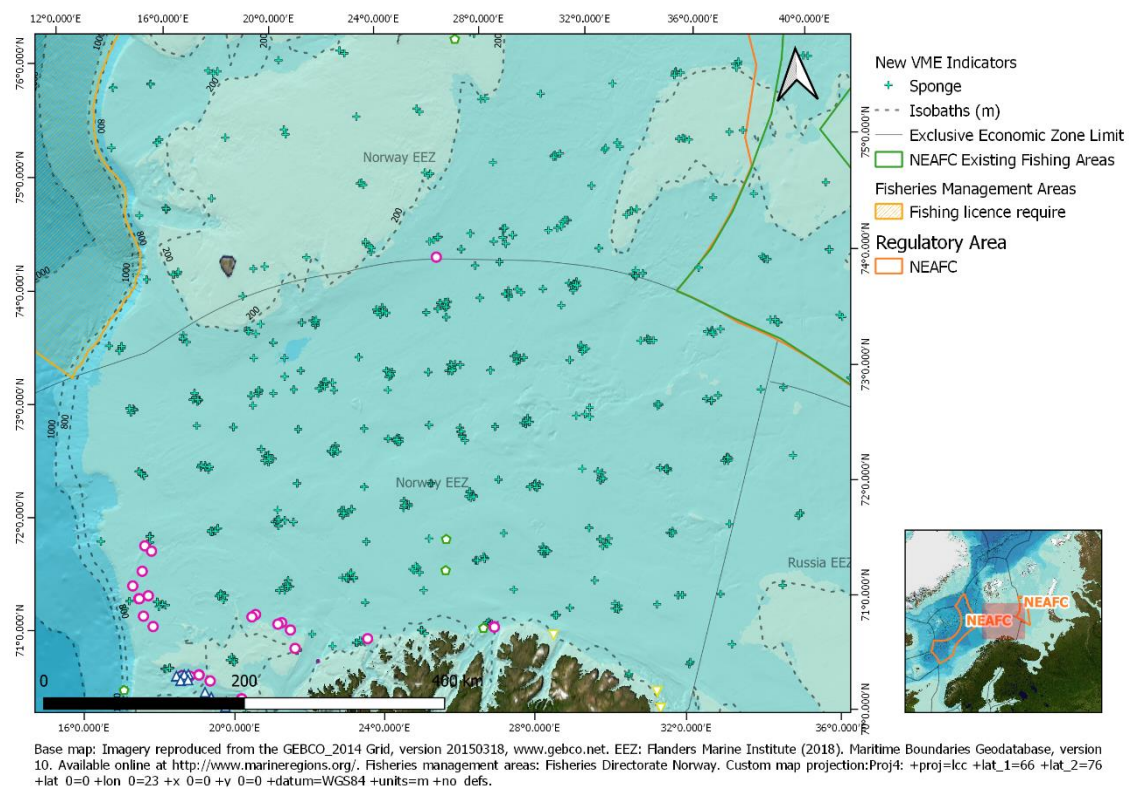


Figure 4.37. New VME indicator records (green crosses) submitted to the VME database in 2019 for the Central and South West Barents Sea. Note, records shown as a pink circles and blue triangles represent new records of deep-sea sponge aggregations and cold-water coral reefs from the Institute of Marine Research’s MAREANO project (see section 4.3.7)

⁹ <http://vme.ices.dk/map.aspx>

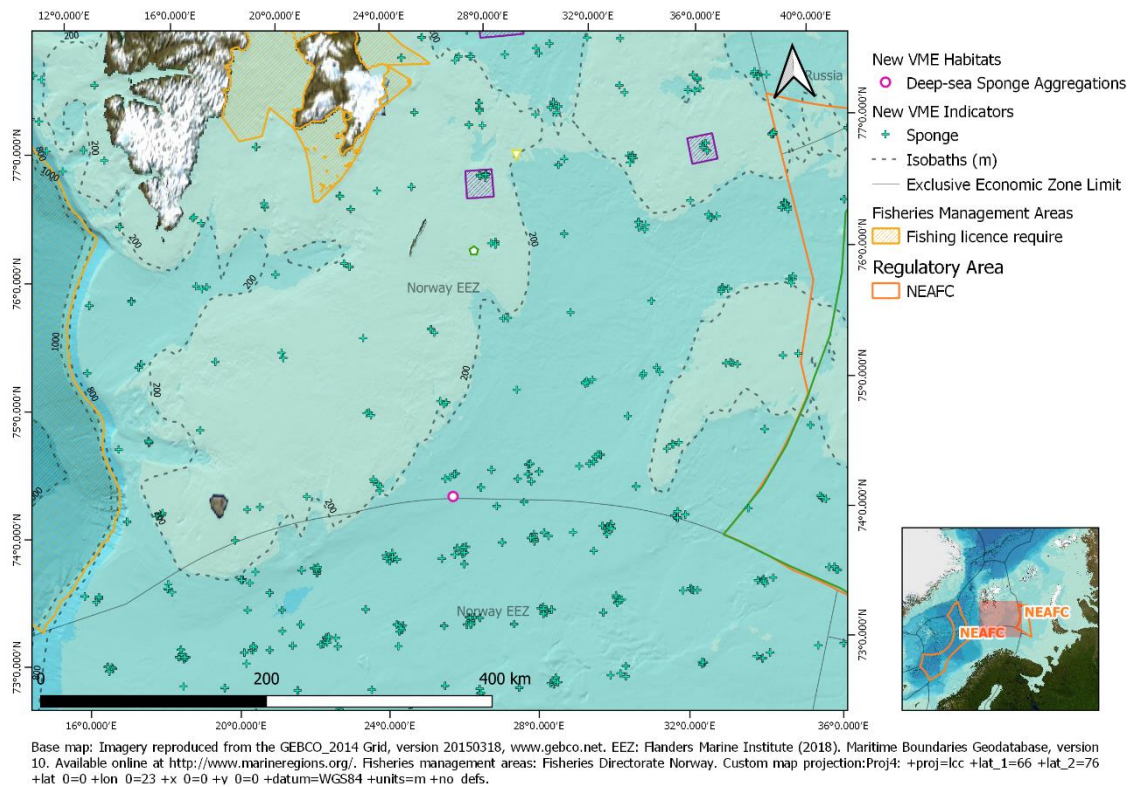


Figure 4.38 New VME indicator records (green crosses) submitted to the VME database in 2019 for the Central Western Barents Sea. Note, records shown as a pink circles represent new records of deep-sea sponge aggregations from the Institute of Marine Research's MAREANO project (see section 4.3.7)

4.3.9 North West Barents Sea (Svalbard)

New VME indicator data were submitted by Norway for the North West Barents Sea (Svalbard). Data were from the Institute of Marine Research bottom trawl surveys from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS) (Figure 4.39 to Figure 4.42).

Outputs of the weighting algorithm and confidence layer with these new VME data are not presented due to the large number of new records making the scale of view too small. However, these can be viewed on the ICES VME data portal¹⁰.

New legislation regarding closure of current fishing areas will take action July 1, 2019 to further protect vulnerable species and seabed habitats in the Barents Sea, specifically in waters around Svalbard. The closures have been designated based on evidence from the joint Norwegian-Russian Barents Sea ecosystem survey. There will be three types of closure;

1. 10 new areas completely closed for bottom trawling, including any fishing gear likely to be in contact with the seafloor;
2. Waters around Svalbard are divided into new and existing fishing areas, areas below 800 meter in depth are considered a new fishing area;
3. Where bottom trawling requires special license from the Directorate of Fisheries.

¹⁰ <http://vme.ices.dk/map.aspx>

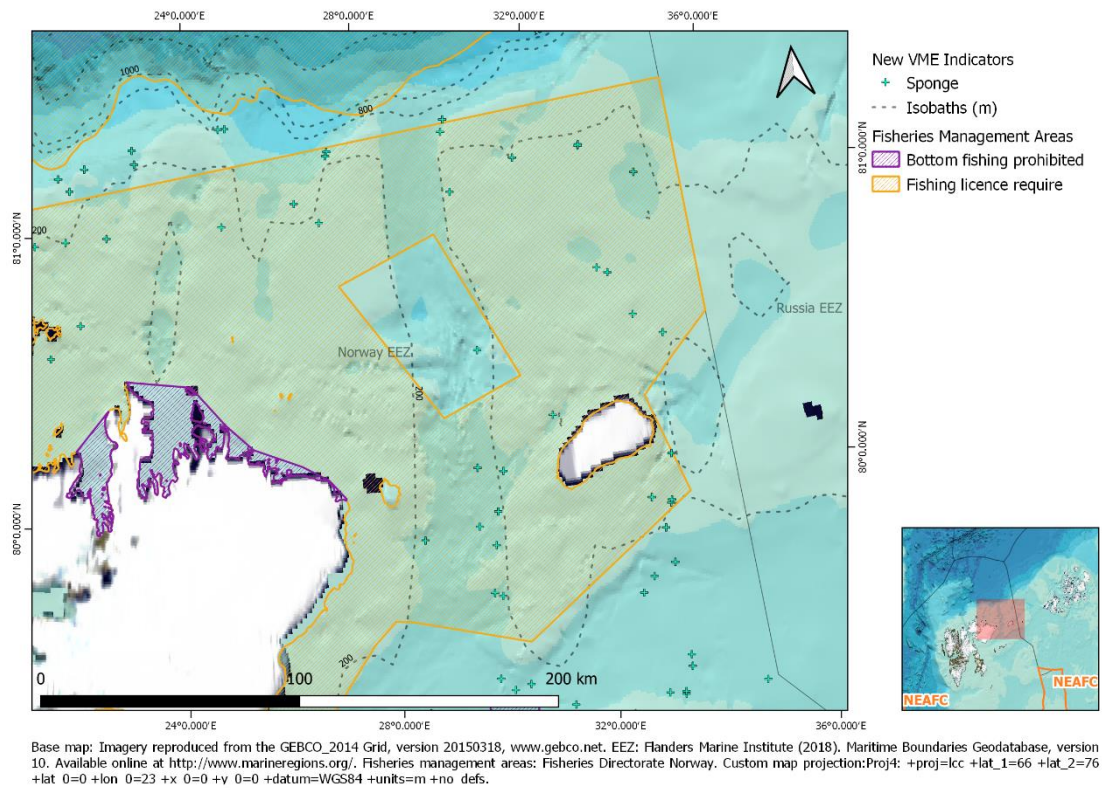


Figure 4.39 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Northeast of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.

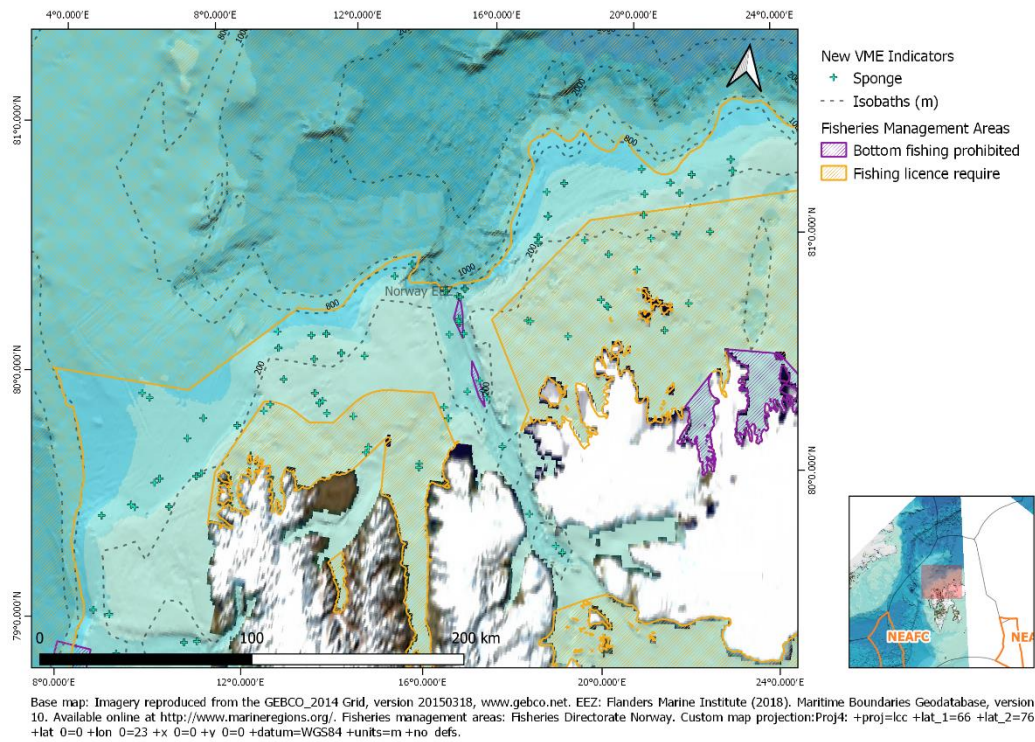


Figure 4.40 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Northwest of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.

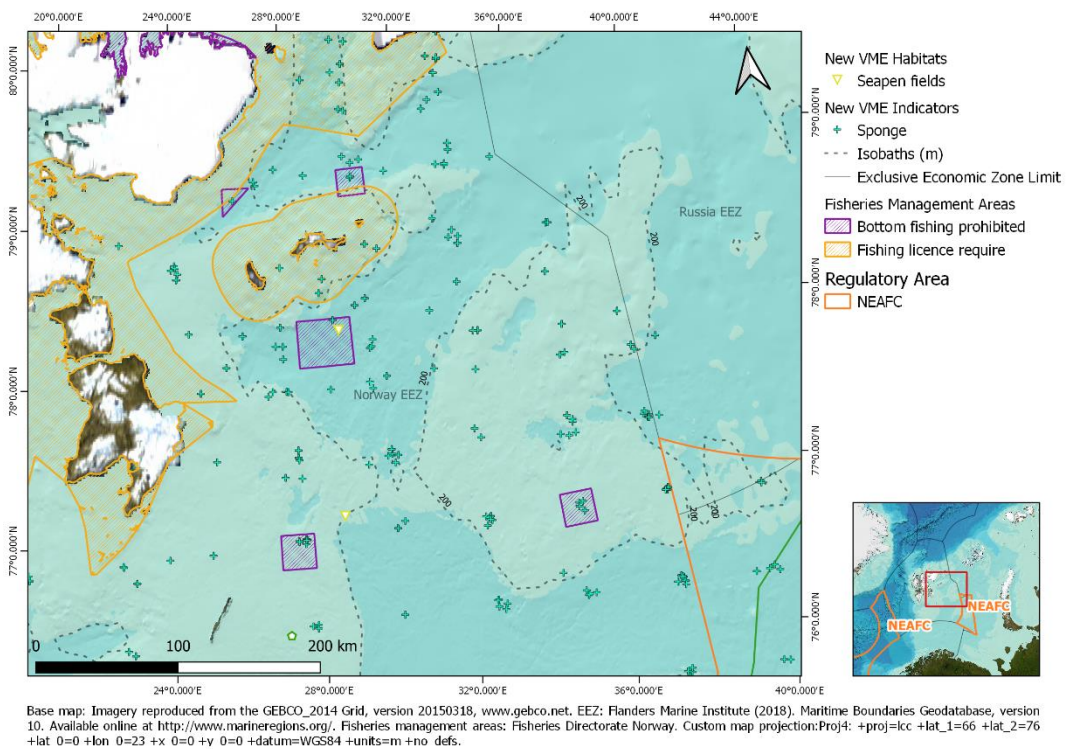


Figure 4.41 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Southeast of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.

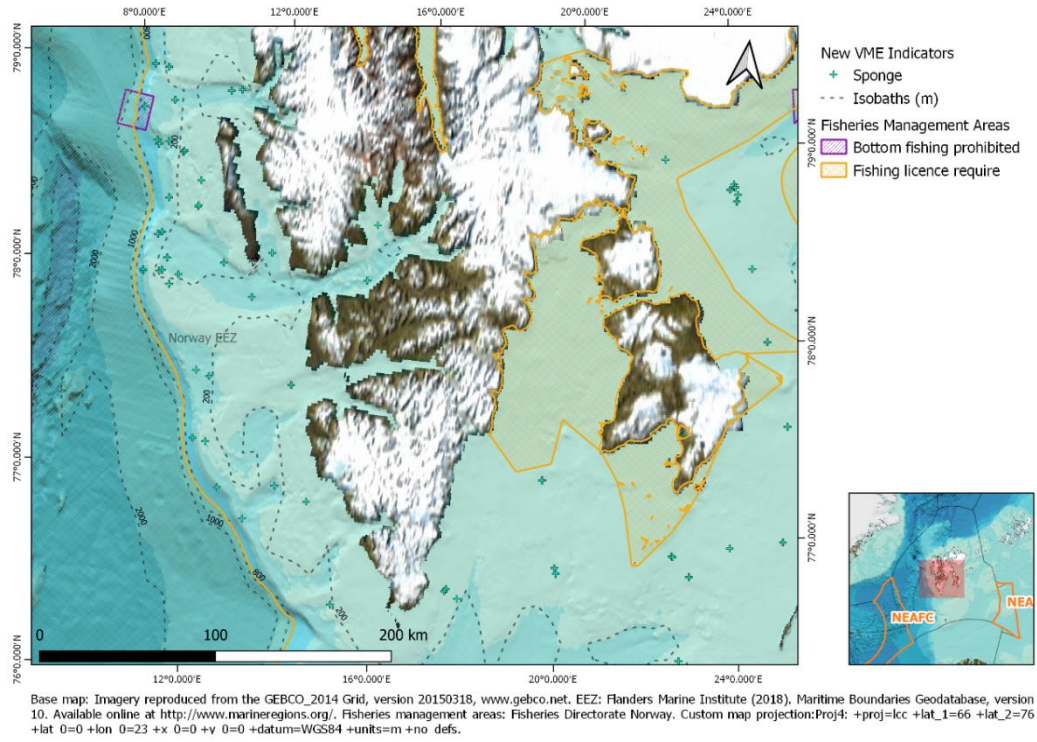


Figure 4.42 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Southwest of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.

4.3.10 Iceland

New VME data from Iceland were submitted from along Iceland's southern shelf (Figure 4.43 and Figure 4.46). The data were from a 2004 survey by the Marine and Freshwater Research Institute, as detailed in section 3.3.6.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.44 and Figure 4.47, and the confidence layer for the VME index is shown in Figure 4.45 and Figure 4.48. **Error! Reference source not found..**

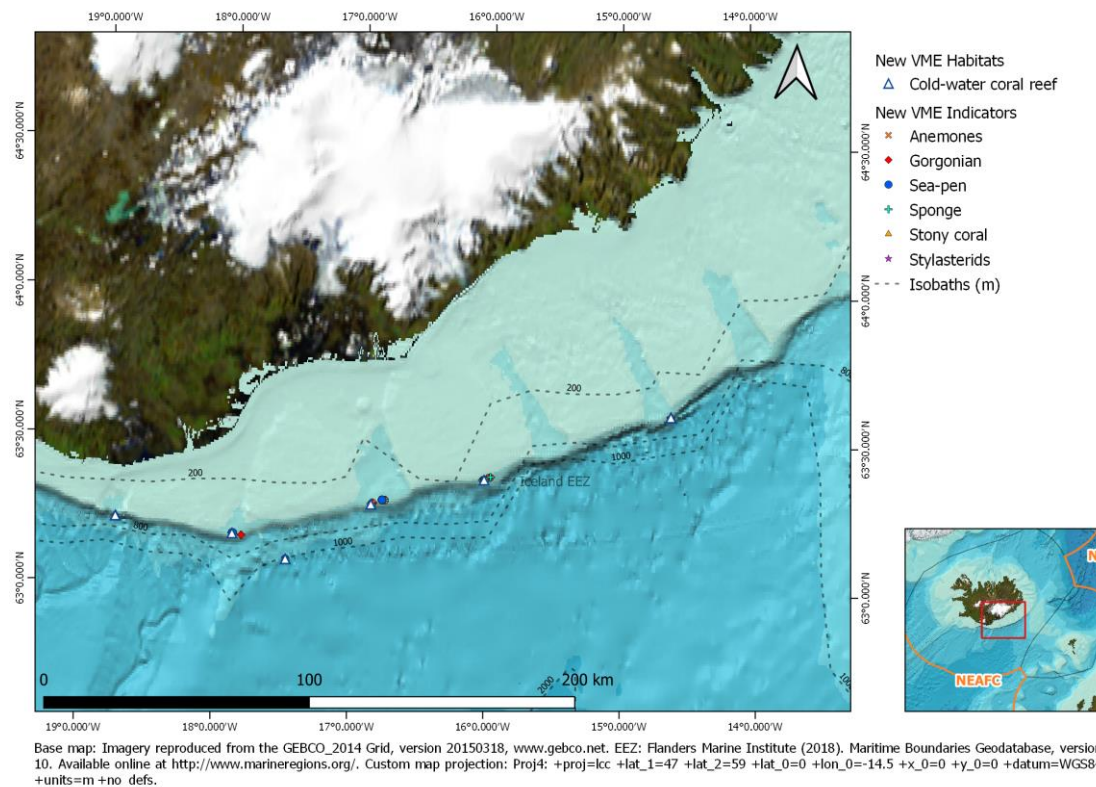


Figure 4.43 New VME records submitted to the VME database in 2019 for the Southeast of Iceland within the Iceland EEZ. **Note, other VME records from the VME database for this area are not displayed. See also Figure 4.46.**

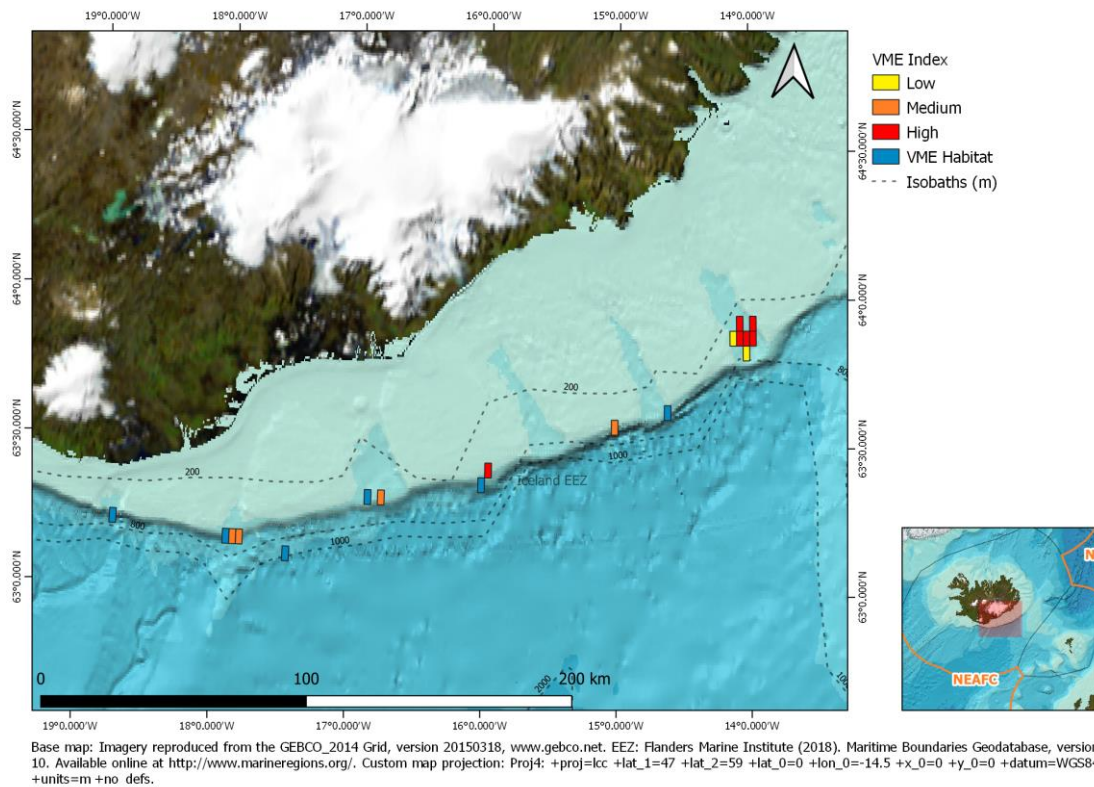


Figure 4.44 Output of the VME weighting algorithm for the area shown in Figure 4.43 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

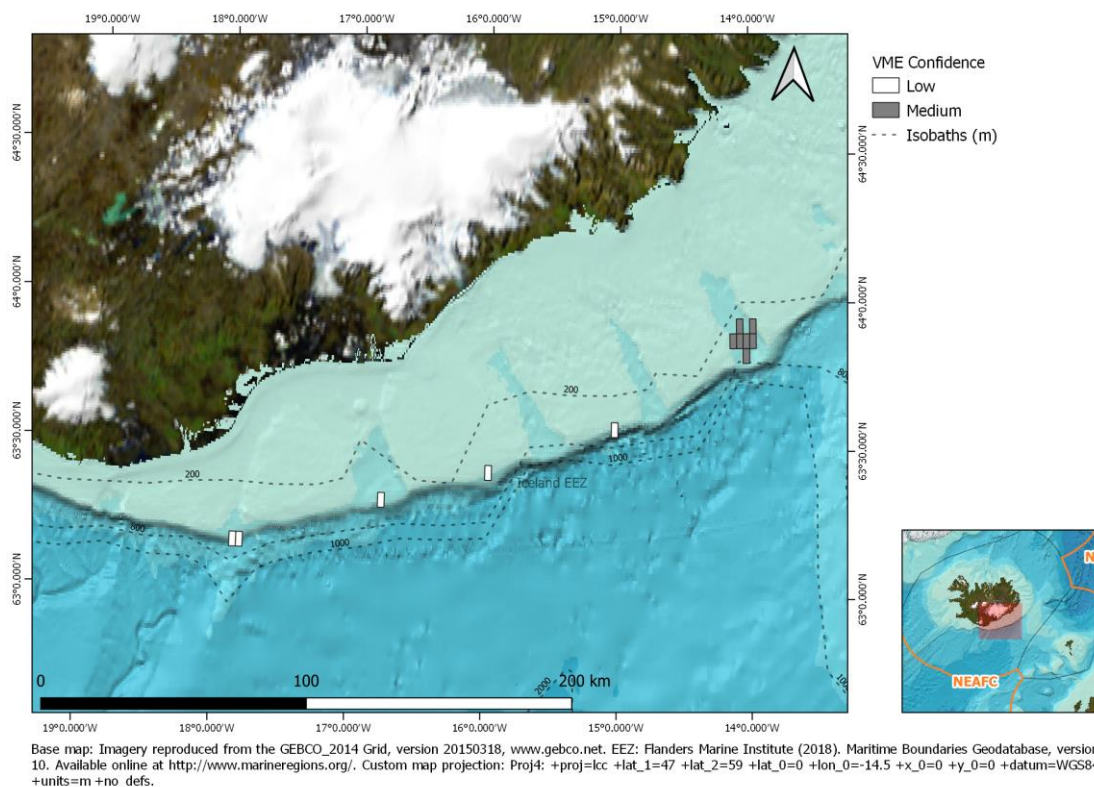


Figure 4.45 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.44). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

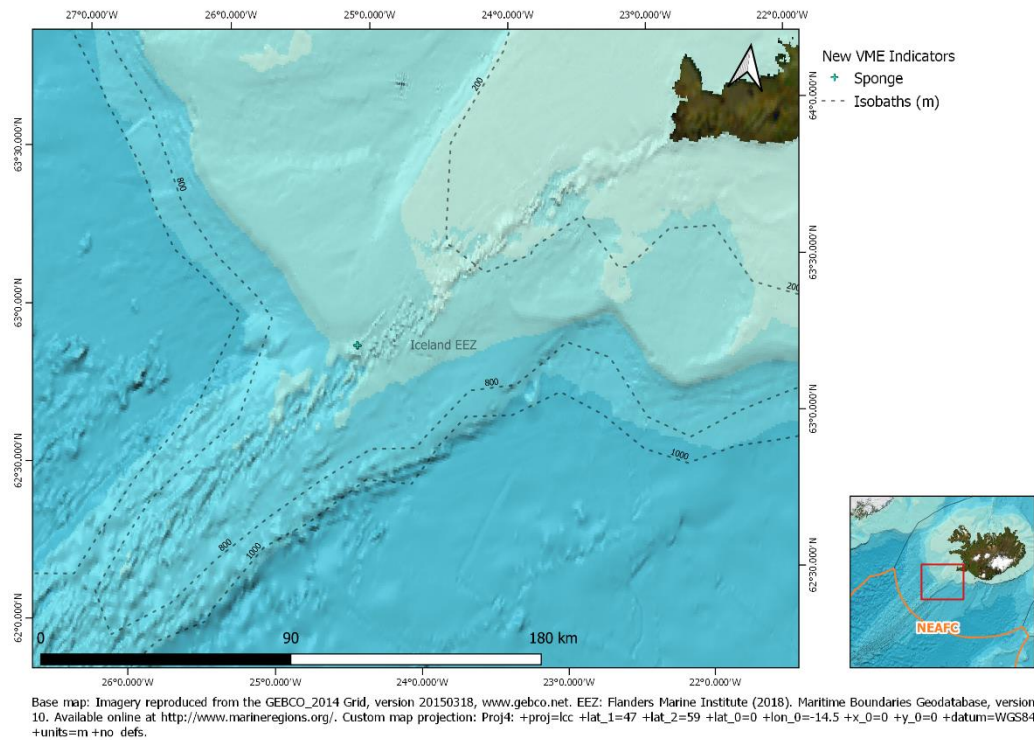


Figure 4.46. New VME records submitted to the VME database in 2019 for the Southwest of Iceland within the Iceland EEZ. Note, other VME records from the VME database for this area are not displayed. See also Figure 4.43.

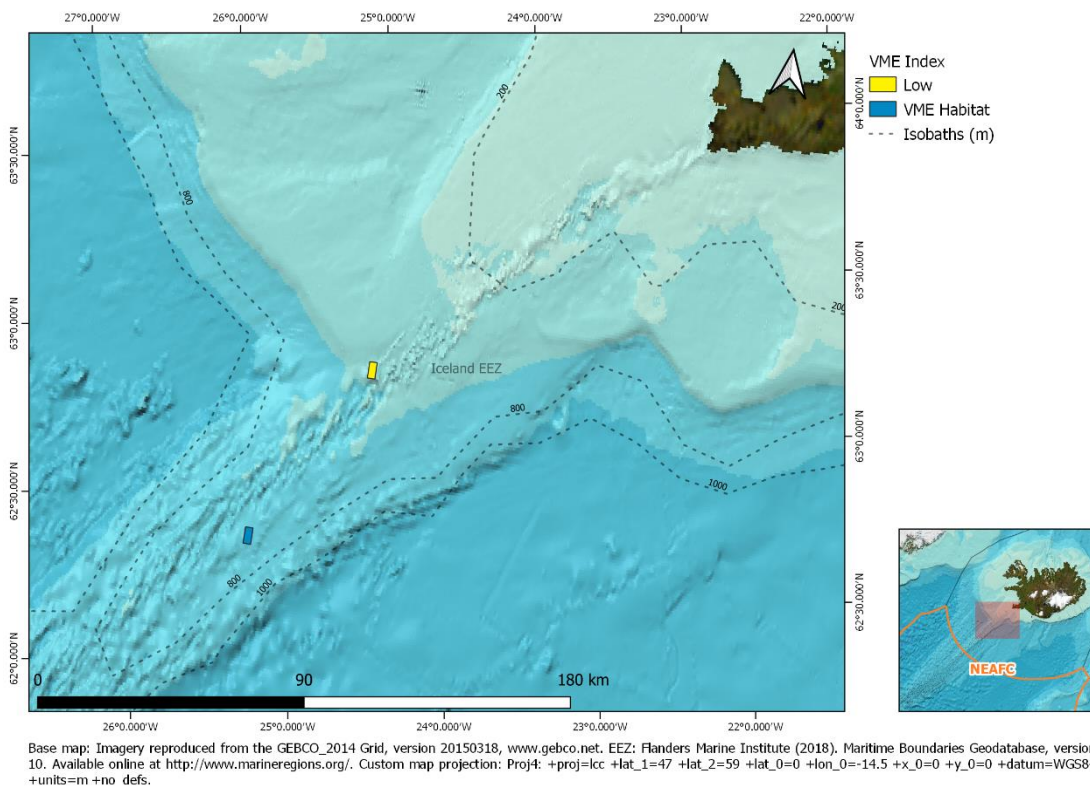


Figure 4.47 Output of the VME weighting algorithm for the area shown in Figure 4.46 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database

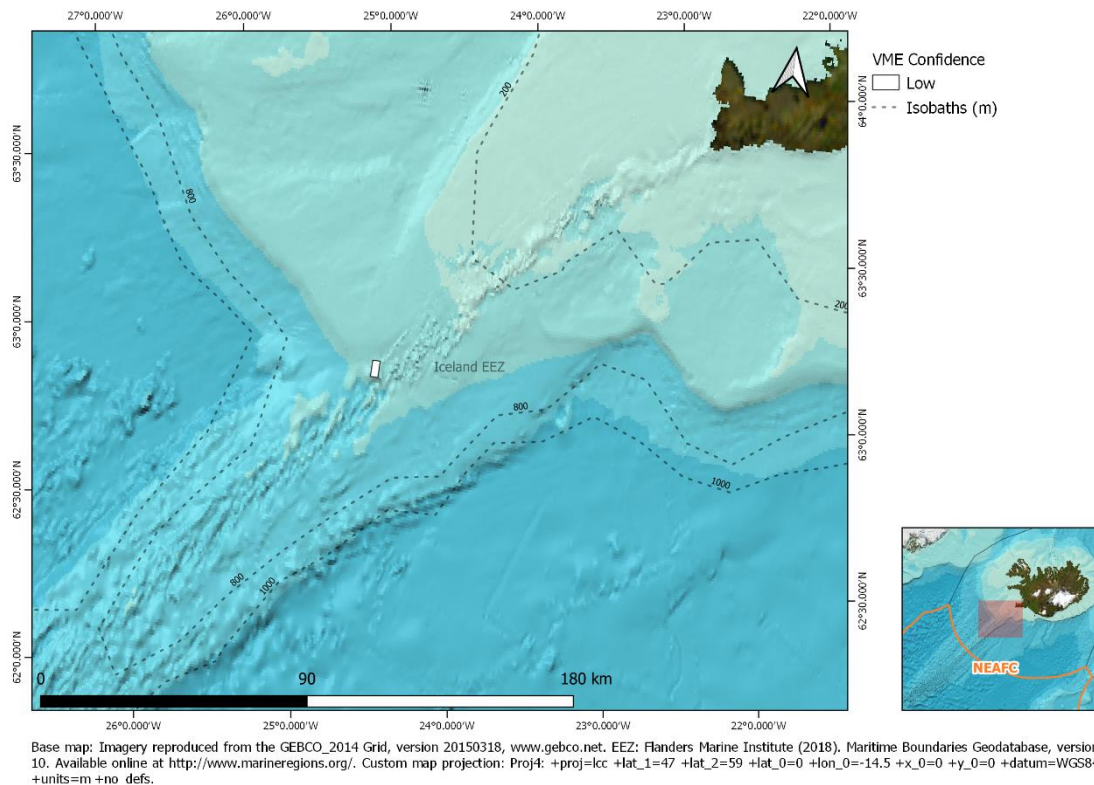


Figure 4.48 The confidence layer associated with the VME weighting algorithm’s VME Index layer (Figure 4.47Error! Reference source not found.). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.11 Eastern Scotian Slope, Canada

A total of 21 353 records of VME indicators and habitats were submitted by Canada from a research survey on the Canadian Coast Guard Ship *Hudson*. These data were from the Eastern Scotian Slope, within the Canadian EEZ, see 3.3.2 for more details. These provide a significant number of new VMEs to the VME database, in addition to the 13 745 submitted in 2018. New VME indicator records included gorgonians, sea pens, and sponges.

The area where new data have been collected (Figure 4.49) has been announced as a proposed "Other Effective Area-Based Conservation Measure" called the "Eastern Canyons Proposed Conservation Area"¹¹.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.50 and the confidence layer for the VME index is shown in Figure 4.51.

¹¹ <https://www.canada.ca/en/fisheries-oceans/news/2018/03/three-new-potential-marine-conservation-measures-announced-off-the-coast-of-nova-scotia.html>

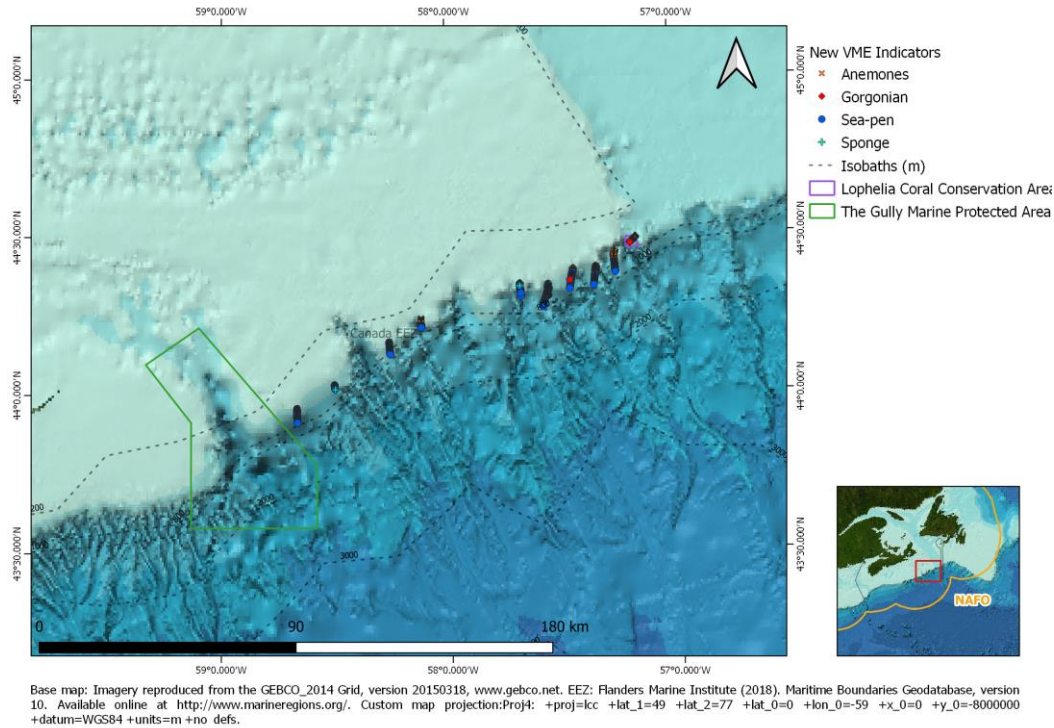


Figure 4.49. New VME records submitted to the VME database in 2019 within the Canadian EEZ. Note, other VME records from the VME database for this area are not displayed.

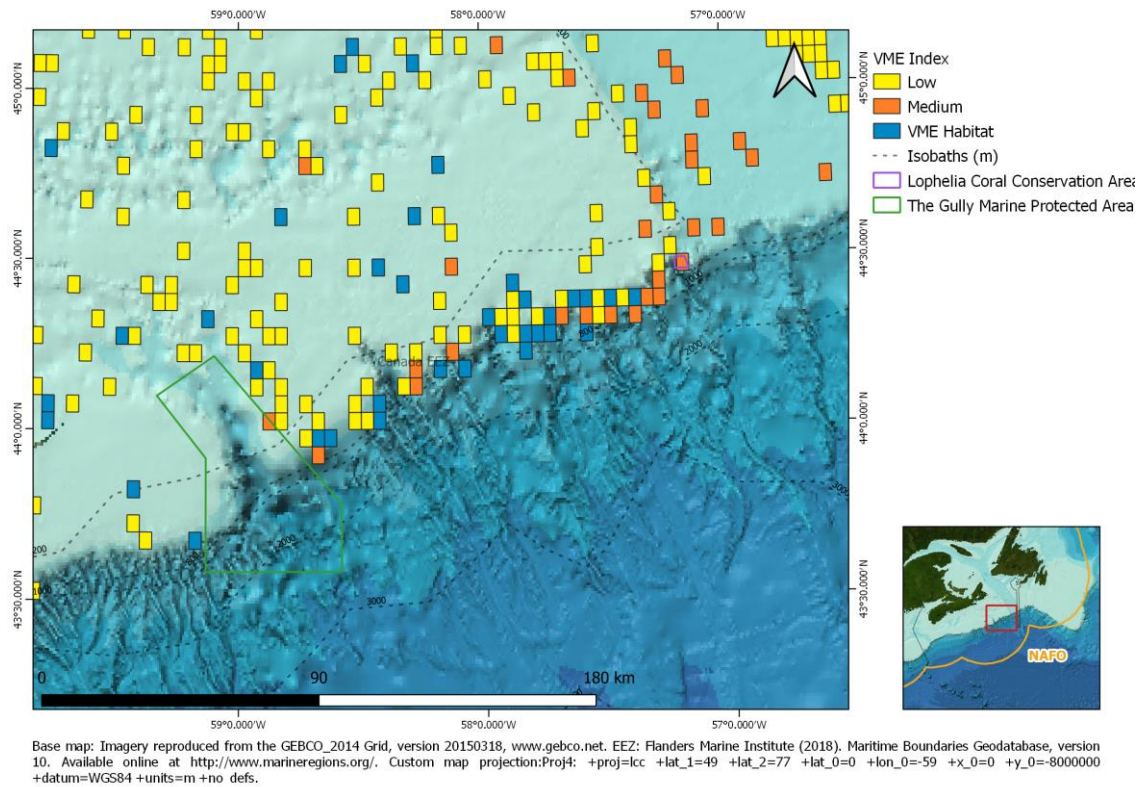


Figure 4.50. Output of the VME weighting algorithm for the area shown in Figure 4.49 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.

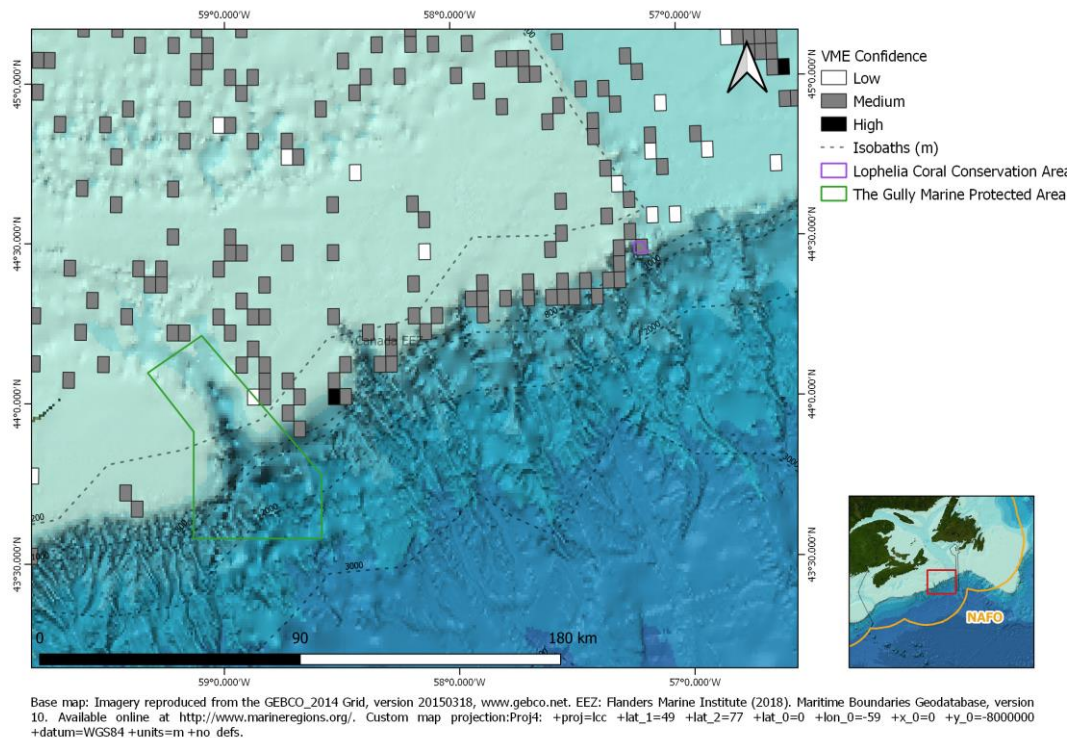


Figure 4.51. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.50). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.4 Analysis of the 2018 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 data were analysed by the Working Group on Spatial Fisheries Data (WGSFD), in advance of the WGDEC meeting, to support the NEAFC request to ICES to provide information on the distribution of fisheries activities in and in the vicinity of VME habitats. These tables were linked using a unique identifier (the "RID" field) which changes on a yearly basis to protect anonymity of vessels. This year, ICES received information on the catch date and the catches were linked to vessels on the date of operation.

The VMS data were filtered in R by WGSFD to exclude all duplicate reports, polls outside the year 2018, and messages denoting entry and exit to the NEAFC regulatory area ("ENT" and "EXT" reports). 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 again with quality of speed data. The "estimated speed" and "vessel speed" columns contained no values, and whilst the "SP" field did contain numeric values, they ranged from zero to 500, suggesting a problem with decimal places, however not in a consistent manner across the dataset. As a means

of avoiding this problem, a derived speed was calculated as the great-circle (orthodromic) distance 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 4.52).

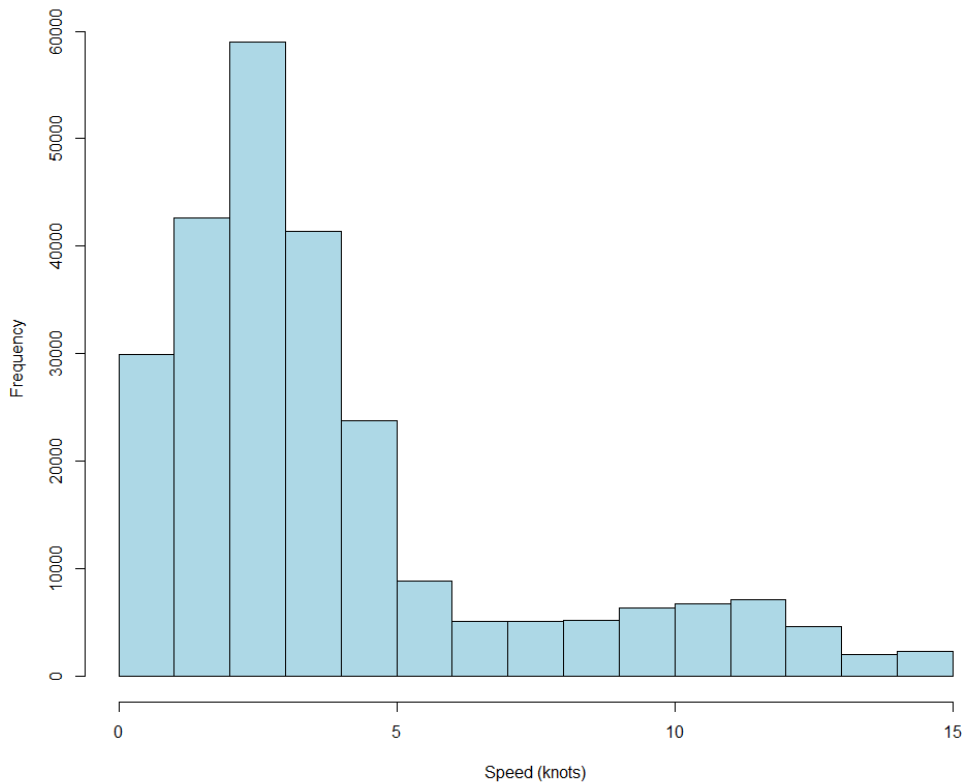


Figure 4.52 Histogram of derived speeds for all gears, based on position and time, conforms to expected distribution.

The speed filtered pings (0–5 knots) are represented as points on the map, as this was considered the best option for display purposes. These are given for vessels registered as using mobile bottom contact gears (otter trawl – OTB and shrimp trawl - TBS), static gear (gear codes "LL" and "LLS"), and for vessels for which no gear code was available ("NIL"). This year, a large proportion of the vessels had no gear specified and the number of gear types reported was very low compared to previous years (Table 4.1).

Table 4.1 Number of pings (N) registered against each fishing gear type (Gear) in the speed filtered (0-5 knots) NEAFC VMS data. Gear codes: Pots (FPO), longlines (not specified) (LL), set longlines (LLS), no gear code (NIL), bottom otter trawls (OTB), midwater otter trawls (OTM), purse seines (PS), bottom shrimp trawls (TBS).

Gear	N
FPO	1282
LL	31
LLS	831
NIL	25364
OTB	38649
OTM	128252
PS	264
TBS	2056

4.4.1 Results

The VMS ping data was mapped together with the VME Index outputs, showing likelihood of VME presence based on the VME weighting algorithm, by WGDEC to assess whether fishing activity was occurring in the vicinity of VMEs in the NEAFC Convention Area. Results of this analysis are shown for Hatton Bank, Rockall Bank, Iceland, the Mid Atlantic Ridge, the Barents Sea and to the west of the Bay of Biscay (Josephine Seamount).

4.4.1.1 Hatton Bank

The closures to the northern side of Hatton Bank are generally well observed (Figure 4.53). A small number of bottom trawl tows appear to extend into the closed area at the easternmost part and along the northernmost part of the existing bottom fishing area, however, these incursions are limited. The highest levels of fishing are closely associated with the boundary of the closed areas. There was little evidence of vessels using static bottom contact gears, or activity of vessels without a registered gear type, in this area. Closures on the western side of the bank are also well observed (Figure 4.54).

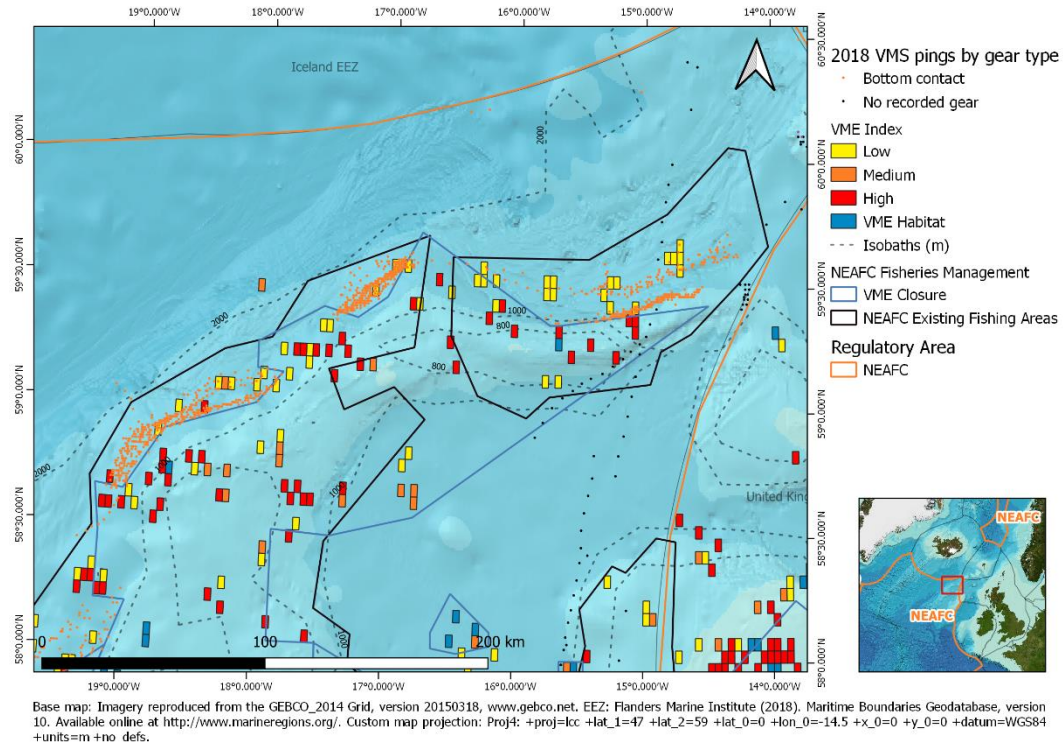


Figure 4.53. VMS pings for bottom contact gears (orange) and no recorded gear (black) to the north of Hatton Bank, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

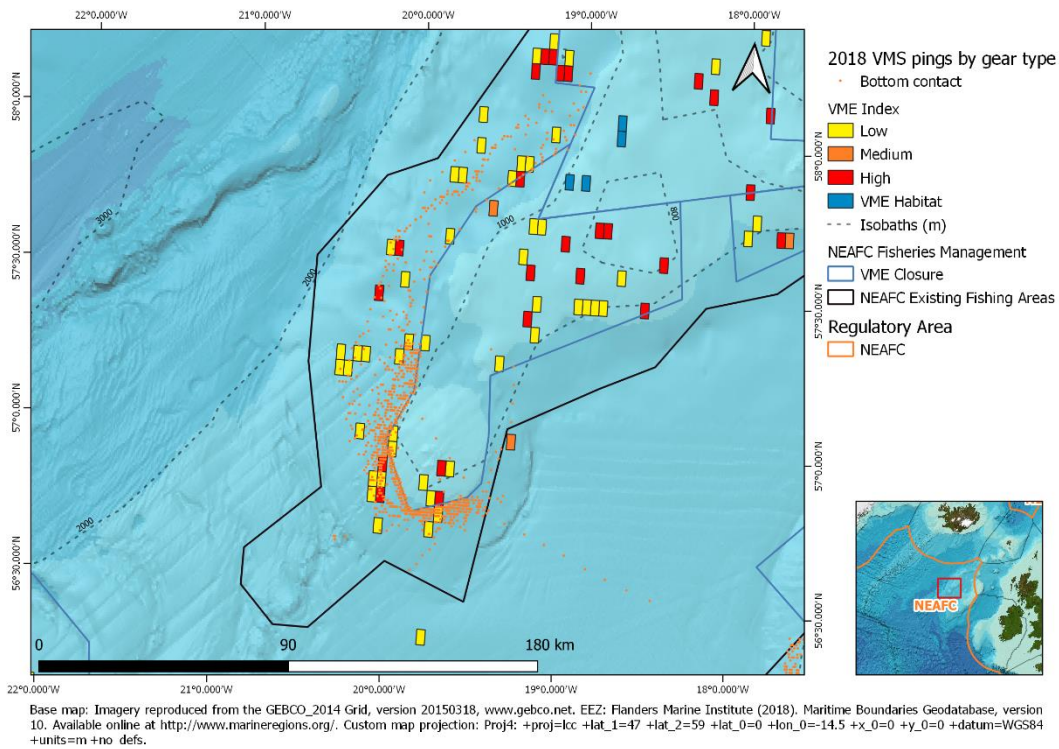


Figure 4.54 VMS pings for bottom contact gears (orange) to the west of Hatton Bank, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

4.4.1.2 Rockall Bank

The VME closures on the eastern side of Rockall Bank are also generally well observed, although there is some suggestion of vessels with no registered gear type operating within the Haddock Box, particularly in the northwest quadrant (Figure 4.55). Vessels registered as using static gears work outside this area. To the south of Rockall Bank, trawling continues to be better confined to the “existing bottom fishing area” (Figure 4.55). Static gears appear to be absent from the small areas at the southerly end of the bank in which they were observed last year.

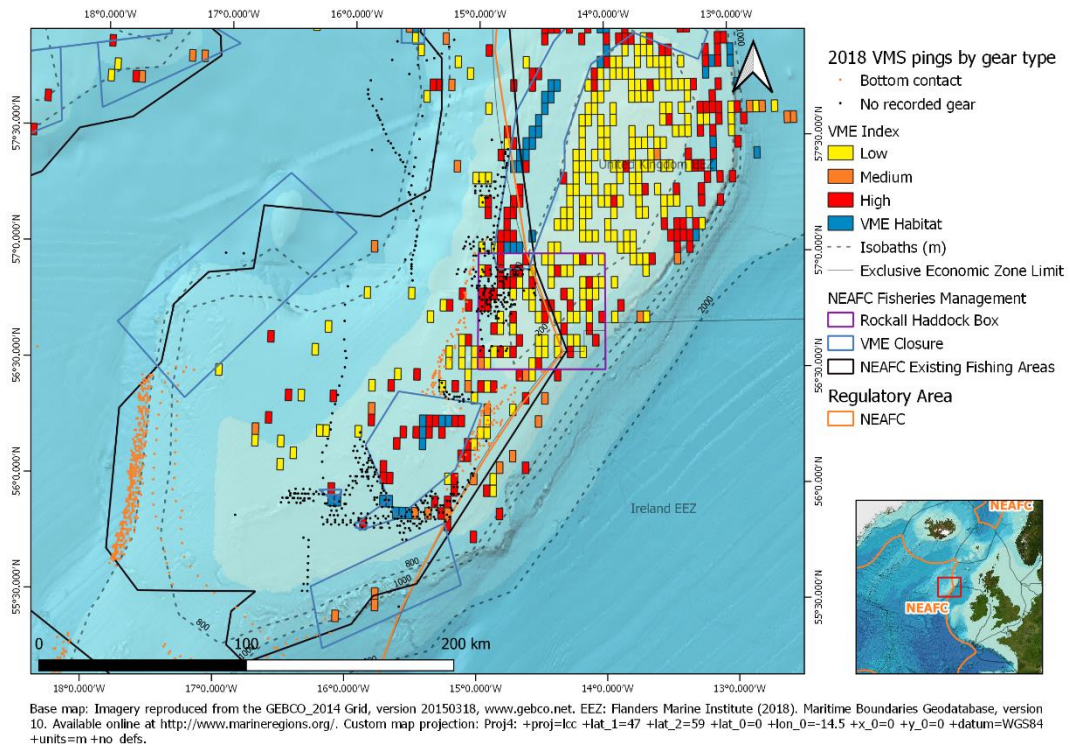


Figure 4.55. VMS pings for bottom contact gears (orange) and no recorded gear (black) for the Rockall Bank, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

4.4.1.3 South of Iceland

As in previous years, the pattern of activity around the Reykjanes Ridge is somewhat confused (Figure 4.56). A high proportion of this activity takes place in waters over 3000m in depth – too deep to represent bottom fishing activity – and is believed to be vessels targeting mid-water redfish being miscoded in the database. One potential area of actual bottom fishing is still seen to the southeast of the mid-Atlantic ridge. The seabed in this area is at around 1300 – 1500m.

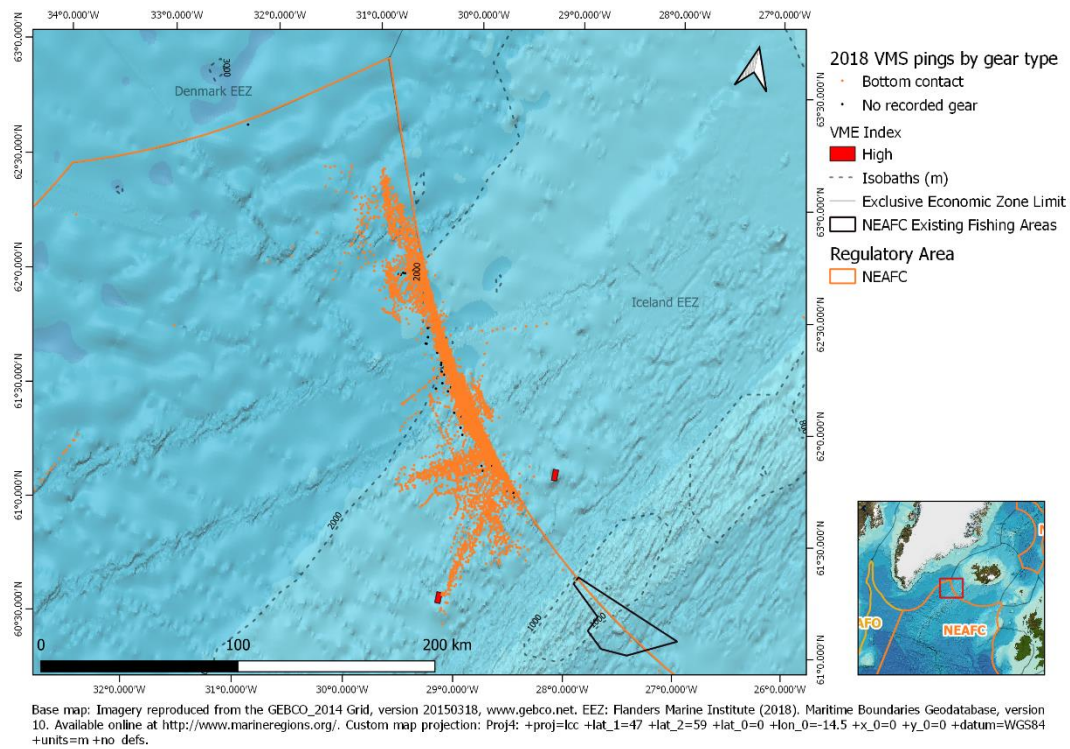


Figure 4.56. VMS pings for bottom contact gears (orange) and no recorded gear (black) to the South of Iceland.

4.4.1.4 Mid Atlantic Ridge Seamounts

As seen in the previous two years, bottom trawling activity appears to be taking place on an unnamed seamount to the south of the Mid Atlantic Ridge (MAR) closure, outside the existing bottom fishing area (Figure 4.57). Slightly further south, bottom trawling takes place inside the existing bottom fishing area, as well as on a seamount to the west of the Olympus knoll. The fishing observed last year on the Chaucer seamounts to the south, including within the Southern MAR (C) closure area, is not evident this year.

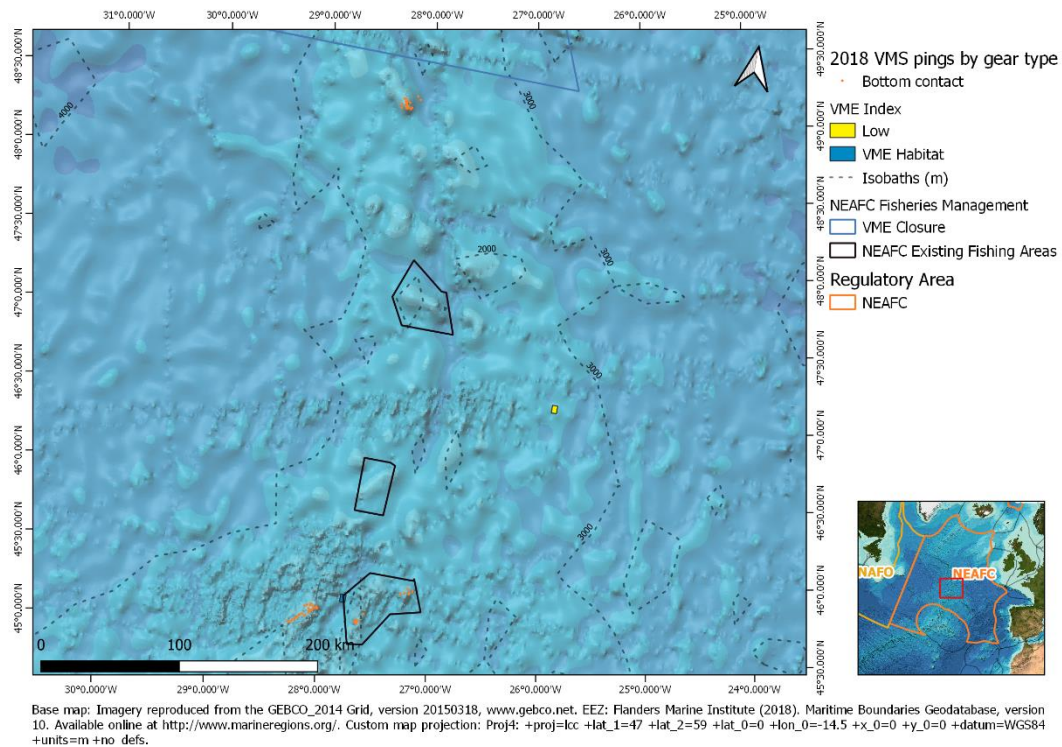


Figure 4.57. VMS pings for bottom contact gears (orange) on the Mid Atlantic Ridge

4.4.1.5 Barents Sea

Activity within the Barents Sea is being reported this year due to the submission of new VME records. Fishing activity is most intense in the north and east of this area for both bottom trawling and where no gears were reported (Figure 4.58). To the north of the NEAFC area there is some suggestion that activity is expanding beyond the existing fishing area, particularly to the west for vessels with no reported gear type. Static gears appear not to be used in this area.

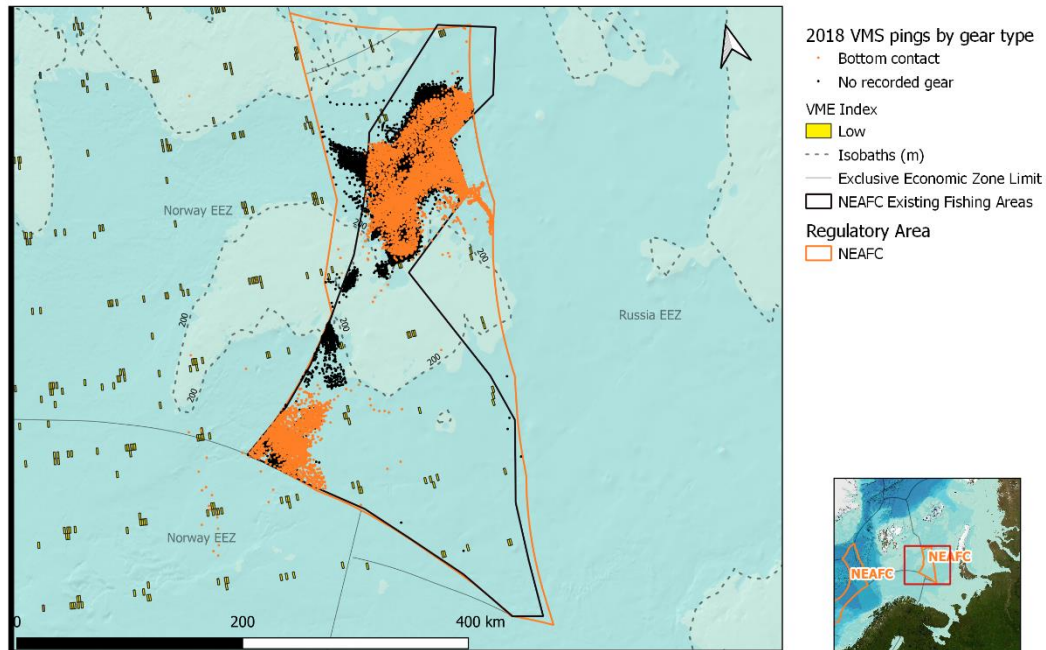


Figure 4.58 VMS pings for bottom contact gears (orange) and no recorded gear (black) for the Barents Sea NEAFC regulatory area, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high).

4.4.1.6 West of the Bay of Biscay

Examination of VMS data revealed areas of activity to the west of the Bay of Biscay. Within the Josephine seamount (JOS1 area) and to the west of this area there is extensive activity of static gears (Figure 4.59). A small area, further west still, also shows some fishing activity from unreported gear types.

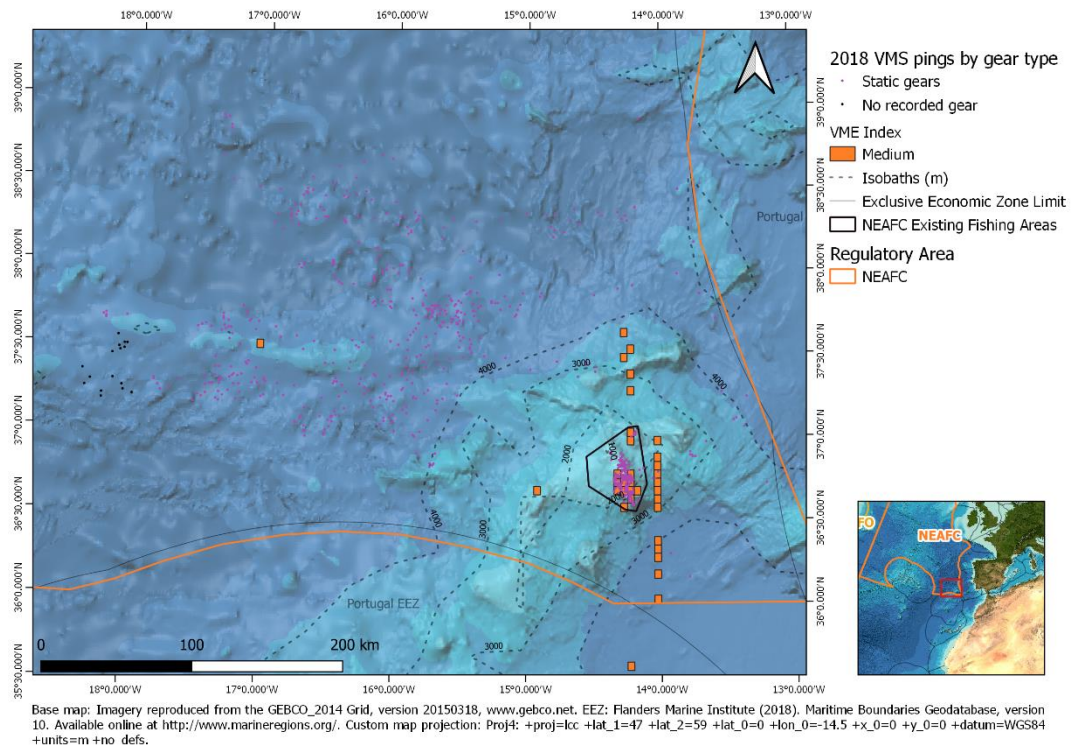


Figure 4.59. VMS pings for static gears (purple) and unreported gears (black) to the west of the Bay of Biscay and within Josephine Seamount, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high).

4.5 References

- Frederiksen, R., Jensen, A., and Westerberg, H. 1992. The distribution of the scleractinian coral *Lophelia per-tusa* around the Faroe islands and the relation to internal tidal mixing, *Sarsia*, 77:2, 157-171, DOI: 10.1080/00364827.1992.10413502
- ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 126 pp.

5 Reviewing how to best define Good Environmental Status (GES) for deep-sea habitats – ToR [c]

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

5.1 Summary

Work towards the next Marine Strategy Framework Directive (MSFD) policy cycle has begun and ICES is assisting Member States, through appropriate platforms and processes, in progressing the assessment of descriptors D1 (Biodiversity), D3 (commercial fish), D6 (seafloor integrity) and aspects of D7 (hydrography) relating to D6. To date, most ICES work on D6 has focused on the development of operational methodologies to assess the seafloor of shallow (< 200m) water areas. The deep sea, however, is generally under-sampled, and data appropriate for the assessment of MSFD Good Environmental Status (GES) is more limited (ICES, 2017a).

The ICES Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), is developing methods and performing assessments to evaluate benthic impact from fisheries at a regional scale, while also considering fisheries and seabed impact trade-offs. WGFBIT has built upon the ICES 2017 indicators and assessment framework (e.g. MSFD, D6) (ICES, 2017b). The assessment framework consists of three main components: fishing pressure (footprint), benthic habitat sensitivity and the resulting benthic impact. The framework is used to estimate trade-offs relating to the distribution of impact with other factors important for management (e.g. fisheries economics).

Furthermore, two European Commission projects, ATLAS (A Trans-Atlantic Assessment and deep-water ecosystem-based Spatial management plan for Europe) and IDEM (Implementation of the MSFD to the Deep Mediterranean Sea), have been funded/part funded, to progress work through the development of environmental targets and associated indicators/criteria, that can be used to extend the concept of Good Environmental Status (GES) to the deep sea.

For WGDEC 2019, this ToR aimed to continue to review advances in the assessment of the environmental status of the deep sea, taking into consideration the work conducted by the ICES WGFBIT included in their last report (ICES, 2019a), as well as the progress on assessing GES in deep sea areas within the projects ATLAS (Horizon 2020) and the IDEM approach (DG Environment).

During the WGDEC 2019 meeting, different approaches that could be used to address this work were discussed in an attempt to define the next steps considered necessary to improve the assessment of the deep-sea environmental status and support MSFD requirements.

5.2 Summary framework generated by ICES for assessing the seafloor (D1, D6) and its potential application to deep-sea ecosystems

In 2016, ICES advised that the assessment of the seafloor should be undertaken using a mechanistic, quantitative approach based on biological principles, to assess the sensitivity of habitats to fishing pressures (ICES, 2016a¹², see also WKGMSDD6 2015 (ICES, 2015), WKFB1 2016 (ICES, 2016b) and WKBENTH 2017 (ICES, 2017b)). The basis for the ICES assessment of the seafloor is available in the Working Group on Fisheries Benthic Impact and Trade-offs' (WGFBIT) report of their November 2018 meeting (ICES, 2019a) within [Annex 4: "Technical guidelines document for assessing fishing impact from mobile bottom-contacting fishing gears"](#). Furthermore, ad-hoc ICES workshops have been organised in recent years to produce guidance on how to assess pressures from human activities that result in either habitat loss ([WKBEDLOSS](#): ICES, 2019b) and/or physical disturbance ([WKBEDPRES1](#): ICES, 2018) to the seafloor.

Based on ICES advice in 2016 (ICES, 2016a) and 2017 (ICES, 2017c¹³), for which the North Sea was the focus, recent ICES work now applies the same assessment framework and indicators across the Celtic Sea and the Baltic Sea areas. This work builds on the old Data Collection Framework (DCF) Annex XII indicators 5, 6, and 7 (ICES, 2015b¹⁴), but now also includes benthic impact estimate indicators, e.g. biomass relative to carrying capacity.

ICES has established a set of indicators to assess seafloor integrity, in terms of the spatial extent and distribution of pressures classed under the assessment criteria of the MSFD (physical loss - D6C1 and physical disturbance - D6C2) and their impact for each broad scale habitat type (based on EUNIS Level 3 habitats of the 2004 version of EUNIS (ICES, 2017b)), within each ecoregion and subdivision. WGFBIT is working towards fully operationalizing the suggested seafloor assessment framework during 2018-2020 (Figure 5.1) to enable indicator estimations across the whole EU and ICES areas. To date, the development of this assessment framework has mainly been used for shallow water ecosystems (< 200 metres depth). However, during the WGDEC 2019 meeting, the group discussed the possibility of applying the ICES framework for the assessment of D1 and D6 in the deep sea, integrating information on deep-sea GES collated by the EU H2020 ATLAS project (see section 5.4). To that end, it was proposed that some WGDEC members should try to attend the next WGFBIT meeting (7-11 October 2019).

¹²

[https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special Requests/EU guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed.pdf](https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special%20Requests/EU_guidance_on_how_pressur_e_maps_of_fishing_intensity_contribute_to_an_assessment_of_the_state_of_seabed.pdf)

¹³ [https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special requests/eu.2017.13.pdf](https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special%20requests/eu.2017.13.pdf)

¹⁴ [http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/2015/DCF indicators_567.pdf](http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/2015/DCF_indicators_567.pdf)

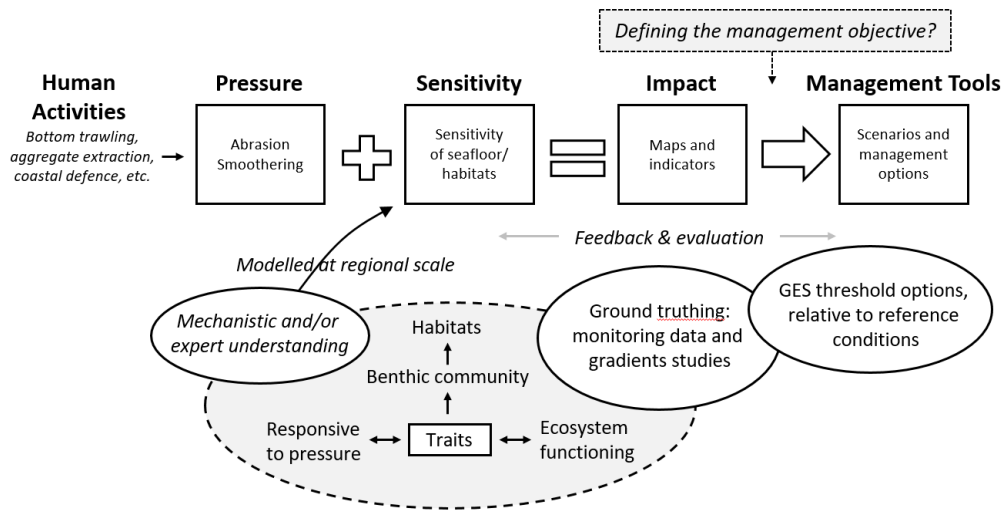


Figure 5.1 Conceptual diagram of the steps taken in developing management tools for assessing pressure and impact on the seafloor (WGFBIT 2019)

WGFBIT considered that a good indicator to assess MSFD GES D6 should take into account the biodiversity, structure and function of the benthic community (ICES 2016a; ICES, 2017c). The method that WGFBIT is taking forward is based on an approach that combines information on total benthic invertebrate biomass (which is linked to the overall functioning of the ecosystem, see ICES, 2019a) with the relative abundance of different longevity classes (that in turn relates to the structure and biodiversity). This assessment method has been considered by ICES to be the most suitable to assess seabed status at a European scale because of its mechanistic nature, which means that it will be applicable outside the specific region it was developed in.

In their report, WGFBIT also recommended the integration of benthic datasets that are linked to specific functional traits (e.g. longevity/biomass) of the species. These data are required not only for a wider range of taxa, but also across a specific range of habitats within, for example, the Barents Sea, Celtic Sea, Baltic Sea, Norwegian Shelf and the Mediterranean Sea (amongst others). Where data does not exist, targeted pressure gradient studies – rather than traditional monitoring - will be required. Some data do exist via the European Marine Observation and Data Network (EMODnet) biology data portal, but this needs to be greatly expanded. With this in mind, there may be a need in the near future to establish new initiatives and/or projects to target some of the identified gaps. Considering the limitations in data available for the deep sea, this approach could be challenging as data on total community benthic biomass, community functionality, species longevity, structure and biodiversity are scarce and when available, are spatially very localised.

WGDEC also reviewed the list of WGFBIT achievements arising from their 2018 meeting. Of interest and requiring further consideration by WGDEC are:

- Reporting data using c-squares of $0.05^\circ \times 0.05^\circ$ and the potential need to move to $0.01^\circ \times 0.01^\circ$ to better describe habitat heterogeneity. In the deep sea, ATLAS, for example, reports regionally using a slightly coarser 10×10 km grid and at basin scale using a 100×100 km grid.
- Moving to habitat proportionality rather than centroid point habitat types, when reporting habitat type. Further consideration of how VMEs are delineated is required in the deep-sea.
- Use of R code to promote transparency. The ATLAS project also used R code to promote transparency.

- Addressing sediment resuspension and smothering pressures. This is particularly relevant in the deep sea where examples of this have been described in the Mediterranean (Puig *et al.*, 2012) and the Atlantic (Wilson *et al.*, 2015; Daly *et al.*, 2018). Smothering of coral polyps by increased sedimentation can lead to a decline in overall health or mortality.
- The need to include a parameter of uncertainty. This is particularly relevant in the deep sea where modelled habitat/species distribution maps could be used to address data gaps.

Besides the need for biological data¹⁵ a recent ICES workshop in October 2018 ([WKBEDPRES1](#): ICES, 2018) also identified the benthic physical disturbance (D6C2) pressure layers available within ICES and the European and wider marine community across four EU regions – including the mapping of pertinent data flows and the establishment of criteria needed to ensure the practical use of the data in assessing benthic impact. Preliminary analysis indicated that the key human activities that resulted in physical disturbance on the seabed are very similar for the 4 EU regions examined (Baltic Sea, North East Atlantic, Mediterranean and Black Sea). Fishing was found to be the most extensive cause of physical abrasion, with aggregate extraction and dredging also of relevance in most regions, but much less extensive.

Data flows and quantitative methodologies for the processing of maps of physical disturbance from bottom fishing currently exist within ICES and were considered appropriate for the EU, e.g. for MSFD purposes for assessing the seafloor. These methods are in line with previous ICES advice on indicators (ICES 2016a; ICES, 2017c). In addition to physical disturbance pressures data, ICES has recently run a similar workshop ([WKBEDLOSS](#): ICES, 2019b) to identify data flows for activities resulting in physical loss (D6C1, D6C4) pressures, i.e. permanent alteration of the habitat from which recovery is impossible, such as construction activities (e.g. offshore windfarms).

5.3 Summary on the work conducted by ATLAS and IDEM on how to best define GES in the deep-sea.

In the North Atlantic, the Horizon 2020 project ATLAS¹⁶, due to finish at the end of March 2020, has completed work on a first assessment of GES in the deep sea across a range of case studies. This assessment focused on four descriptors: D1 – biological diversity; D3 – populations of commercial fish; D6 - seafloor integrity and D10 – marine litter.

In 2017, WGDEC explored how to best define Good Environmental Status (GES) for deep-sea habitats and undertook a review of progress with indicator development for the deep sea. A summary of the discussions towards these goals from the ATLAS kick-off meeting in June 2016, was presented and discussed in relation to the ICES work conducted on Descriptors 1, 3 and 6 (ICES, 2017a).

Over the last three years, ATLAS has been working on the challenge of how to best define GES in the deep sea and how to assess the environmental status of the deep sea. To support this work, ATLAS considered 4 Descriptors (D1, D3, D6 and D10) out of the 11 included in the MSFD and

¹⁵ ICES has received a number of EU advice requests to map out the data needs necessary to the seafloor assessment framework and to demonstrate its operationality. This work has already highlighted some specific data needs to service the underlying methods of the indicators. If these data needs are met, this would ensure the overall assessment of the seafloor (impact and pressure) can be featured in the future iterations of, for example, the ICES Fisheries Overviews and Ecosystem Overviews for each ecoregion (e.g. in 2020).

¹⁶ www.eu-atlas.org

applied the Nested Environmental Assessment Tool (NEAT), developed within the European Union 7th Framework Programme (FP) project DEVOTES (DEVELOPMENT OF innovative TOOLS for understanding marine biodiversity and assessing good Environmental Status). NEAT has been developed to support the integrated assessment of the status of marine waters (e.g. Uusitalo *et al.*, 2016, Nemati *et al.*, 2017, 2018, Pavlidou *et al.*, 2019, Borja *et al.*, 2019). More details on the work conducted in ATLAS to address GES can be found in ATLAS work conducted to assess GES in specific Case Study areas (NE Atlantic).

The results of NEAT analyses suggested that the selection of scientific indicators, boundary values, the specific regional dimension, habitats and ecosystem components, have a significant impact on the NEAT evaluation, as well as in the GES value reported by NEAT. The constraints of deep-sea environmental analysis, such as data limitations, lack of baselines, or the difficulties in establishing monitoring programmes, make the assessment of GES more likely to be developed at broader habitat and ecosystem levels (rather than species level), and at larger spatial and temporal scales. For similar reasons, the types of scientific indicators to be used need to be simplified and based on high-level analyses related to traits, pressures/risks and habitat/ecosystem resilience.

Contemporary to ATLAS, the two-year project IDEM¹⁷, funded by DG Environment that finished earlier this year (March 2019), has attempted to develop a regionally coherent, coordinated and consistent initial environmental assessment and determination of GES for the Mediterranean deep sea (> 200 m depth). This study aimed to increase knowledge on the quantification of drivers, anthropogenic pressures and impacts, and current knowledge and spatial coverage of data regarding the MSFD indicators in the Mediterranean deep sea. IDEM has developed a set of selection criteria for assessing indicators for MSFD descriptors/criteria. The project analysed data gaps, as well as how to define GES with associated thresholds. For D6, IDEM showcased how bottom fishing activity off the Mediterranean coast of Spain and France not only disturbs the seafloor, but can result in a loss of habitat, and how peaks in trawling can have large scale ecosystem effects (beyond D6) via the resuspension of sediment, as already documented by Pusceddu *et al.* (2010, 2014) and Puig *et al.* (2012).

5.4 The challenge of assessing the environmental status of the deep-sea. Potential collaborative work between WGDEC and WGFBIT to address GES in the deep-sea

The WGFBIT report (ICES, 2019a) noted that, in relation to MSFD D1 and D6, there are two broad management objectives associated with the state of seabed habitats:

1. The protection and conservation of particularly valued and sensitive habitats and communities in shallow and deep waters, including VMEs;
2. The state of more widespread habitats and communities that are not covered by the category of particularly valued and sensitive habitats and communities. These habitats may be less sensitive, but they are important for the ecosystem functionality, as well as the services they provide, and are required under the MSFD to maintain biodiversity and sea-floor integrity.

The approaches suggested by WGFBIT were discussed during the WGDEC 2019 meeting within a deep-sea context. There was general consensus with the two-step approach for the two main categories of benthic habitats identified in the WGFBIT report (ICES, 2019a), i.e. a) VME species

and habitats and b) more common and widespread habitats. The vulnerability of VMEs to physical disturbance, their age composition and recovery potential is sufficiently different from more common and widespread habitats to warrant separate treatment. The sensitivity of VMEs to impact requires that appropriate control measures are applied to fisheries (e.g. bottom fishing closures, move on rules etc.), and the main focus for ICES advice to the European Commission and the North East Atlantic Fisheries Commission (NEAFC) is to locate and map VMEs (e.g. ToR [b] of WGDEC 2019). The general view is that VME status under D1 and D6 would need to be assessed in an approach specifically designed for VMEs, in accordance with the need to protect these habitats from any form of fishing activity.

In addition to mapping, GES descriptors D1 and D6 should be assessed through specifically adapted indicators or tools for VMEs. Some of these indicators have been applied through the NEAT analyses conducted through ATLAS, for example the density of biogenic reef forming species (type, abundance, biomass and areal extent of relevant biogenic substratum per habitat type, see Table A4.1, ATLAS work conducted to assess GES in specific Case Study areas (NE Atlantic)), but others, for instance based around the morphological complexity of benthic communities, could be explored in the future (e.g. the fractal structure of surface irregularity).

The principal current human activity resulting in physical disturbance spatially in the deep sea is fishing, in particular bottom trawling (Benn *et al.*, 2010), but also long-lining (Pham *et al.*, 2014). There are also other pressures related to non-renewable resource extraction occurring in the deep sea (e.g. oil and gas exploitation and potentially deep-sea mining in the future, Ragnarsson *et al.*, 2017). The framework developed by WGFBIT to assess GES could be challenging for VMEs considering the currently available information, since, for instance, data on longevity for the VME structuring organisms are scarce and biomass calculations would need to be based on imagery data which is the type of information gathered on VMEs. However, research teams are working on new approaches to overcome this lack of information, considering, for instance, thresholds related to the Swept Area Ratio and methods to assess species longevity for high-sensitivity and long-lived biota (Jan Hiddink, *pers. comm.*). Therefore, it is worthy to further jointly explore the framework generated by WGFBIT and potential future applications to assess GES in deep-sea VMEs.

With respect to deep sea habitats that do not contain VMEs, and where fishing may have less impact, the assessment approach developed by WGFBIT to manage fishing effort levels so that risk of impact remains below the threshold for D1 and D6, may be feasible. However, the main problem for VME and non-VME areas, highlighted by ATLAS work, is the scarcity of data for these areas to parameterize and apply the framework generated by WGFBIT. The potential application of models to aid assessment of the GES status of the deep sea, is similarly compromised by lack of data on biomass and biodiversity (see also section 7 of this report).

An exception may be areas with dedicated bottom trawl surveys (e.g. Rockall Bank, the Barents Sea, perhaps Iceland), or better yet, areas with good coverage of underwater video surveys. Even if biomass cannot be evaluated directly from video, a better description of the biodiversity can be obtained from imagery data allowing estimates of density or coverage that could be used as alternative proxies for benthic community functioning. Further, it may also be possible to produce direct models of biodiversity as a function of environmental parameters for these areas. Nevertheless, a serious limitation is the paucity of longevity data, in particular for non-VME species on which the WGFBIT approach is predicated.

Deep sea research and surveys have mainly focused on areas of high biogenic complexity and, to date, little research has been directed to the more common and widespread habitat types that may or may not sustain some fishing effort (but see work conducted in the Mediterranean: Puscchedu *et al.*, 2010, 2014, as well as surveys carried out by the MAREANO programme in Norway,

and by MFRI in Iceland). An important recent improvement is that the ICES VME database already includes not only presence records of VMEs but also absence observations. Absence data may be used to improve species distribution models in due course when sufficient consideration is given to how to use these data consistently (cf. Kenchington *et al.*, 2019). A review of published literature, as well as an examination of available databases for deep-sea “non VME areas” (e.g. regular trawl surveys conducted in European waters), should be conducted. It is, however, unlikely that such a review will be useful in relating pressure to state as benthic studies across fishing pressure gradients in the deep sea are likely to be rare; therefore to properly assess GES in the deep sea, the overlapping of VME distribution maps and fishing pressure (trawling) maps is crucial.

Data collection in the deep sea is often based on scientific surveys that normally apply non-invasive methods and supply visual observations made by underwater cameras and/or Remotely Operated Vehicles (ROVs), therefore it may be difficult at this stage to work with community biomass indicators as suggested in the framework proposed in the WGFBIT 2018 report (ICES, 2019a) and further opportunities need to be jointly explored by WGDEC and WGFBIT. Datasets that are available on larger spatial scales for the deep sea tend to be bycatch data from trawl surveys. WGFBIT already used these types of data in application of their framework in shallower areas, as it is the case of the Barents Sea (Jørgensen *et al.*, 2019). Furthermore, most of the data provided by Canada on VME records also originated from trawl surveys.

There are also specific aspects to be considered in the deep-sea approach. For instance, the secondary effects of sedimentation from fishing on deep-sea organisms/habitats, considering VMEs, but also the general functionality of the ecosystem. The effects of bottom trawling on ecosystem function have been documented in the Mediterranean deep sea (Puscchedu *et al.*, 2014), and also for seafloor morphology (Puig *et al.*, 2012).

Overall, the group felt that it would be good to explore these aspects together with WGFBIT members during the next WGFBIT meeting in Ancona Italy (7-11 October 2019). In preparation for this meeting the group suggested to explore with key WGFBIT members, the use of the suggested WGFBIT approach/framework in some of the ATLAS case studies that may contain more usable data and also highlight potential data gaps. In ATLAS, two case studies, Rockall Bank and the Porcupine Sea Bight, have essentially followed the pressure assessment methodology developed by WGFBIT. Applying the PD (Population Dynamic) method and/or the LL2 (longevity) method does not appear feasible at the moment due to lack of data. Indeed, we note that in 2016 when WGECO reviewed the work done by WKBENTH (Annex in WKBENTH report (ICES, 2017b)) they supported the recommendation that quantitative methods should be used whenever sufficient data are available. However, the expert judgement-based method for the OSPAR indicator ‘BH3’ - Extent of Physical Damage to Predominant and Special Habitats¹⁸ - can be applied in data-poor situations or for those habitats (e.g. VMEs) where the parameters required to apply the quantitative methods are lacking. This approach has also been followed in the ATLAS NEAT assessment where expert judgement has also been taken into account. The ATLAS project is currently assessing the BH3 approach to develop a deep-sea habitat sensitivity scoring matrix as a precursor to assessing impact. To further improve on this work, there is a need to improve seafloor substrate maps – EMODnet Geology can potentially help here and the newly funded H2020 project iAtlantic also aims to generate new seafloor maps. We note that in 2019, WGFBIT is looking to apply, as a starting point for data poor regions (i.e. Black Sea and Mediterranean), a more generic longevity-biomass relationship at the broad habitat scale. Once the framework is

¹⁸ <https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/extent-physical-damage-predominant-and-special-habitats/>

set up and further data becomes available, this relationship can be refined similarly to what is available for the North Sea. A similar approach could be looked at for the deep sea.

The suggested next steps to continue exploring the collaborative work between WGDEC and WGFBIT are:

- ATLAS Rockall and Porcupine case study leads could present the outputs of their initial swept area ratio pressure assessments at the next WGFBIT meeting 7-11 October 2019 in Ancona, Italy. This would provide an opportunity to explore the potential to further adopt/adapt the WGFBIT framework for deep-sea assessments.
- ATLAS is currently working on mapping ecosystem goods and services valuations for deep-sea habitats. Assigning monetary values to seafloor habitats is fraught and economists tend to shy away from providing actual values. Nevertheless, ATLAS could provide a useful deep-sea counterpoint for deliberations during the upcoming workshop (at ICES WKTRADE2, 4-6 September 2019).
- WGDEC/WGMHM could link with WGFBIT in future by undertaking fishing pressure assessments using VMS data from WGSFD for deep waters to provide advice to the EC in relation to the deep-sea access regulations¹⁹. Fisheries economic data could also be mapped to facilitate testing of trade off scenarios. Adding an economist to the group membership would be useful for this work. To support this work, we propose to expand the MSFD ToR to include Marine Spatial Planning in the deep sea at WGDEC 2020.
- Further links between WGDEC and WGFBIT will benefit both groups' work towards jointly developing an ICES approach to assess GES that covers both shallow and deep-sea areas. Such an assessment will be well suited for future iterations of the ICES Ecosystem Overviews advice²⁰. Work towards this could include consideration of the current state of play, the specific characteristics of both realms, as well as drawing on approaches developed in targeted projects (i.e. ATLAS and IDEM) for assessing GES in the deep-sea, and any forthcoming assessment methods (Jan Hiddink, *pers. comms.*).

5.5 References

- Benn, A.R., Weaver, P.P., Billet, D.S., van den Hove, S., Murdock, A.P., Doneghan, G.B. & Le Bas, T. 2010. Human activities on the deep seafloor in the North East Atlantic: an assessment of spatial extent. *PLoS One*, 5, e12730, <http://doi.org/10.1371/journal.pone.0012730>.
- Borja, A., Garmendia, J.M., Menchaca, I., Uriarte, A., and Sagarminaga, Y. 2019. Yes, We Can! Large-Scale Integrative Assessment of European Regional Seas, Using Open Access Databases. *Frontiers in Marine Science*, 6, 19 pp.
- Buhl-Mortensen, L., JM Burgos, P Steingrund, P Buhl-Mortensen, SH Ólafsdóttir, SÁ Ragnarsson. 2019. Vulnerable marine ecosystems (VME): Coral and sponge VMEs in Arctic and sub-Arctic waters - Distribution and threats. The Nordic Council of Ministers Report, 1-145pp. <http://dx.doi.org/10.6027/TN2019-519>
- Daly, E., Johnson, M.P., Wilson, A.M., Gerritsen, H.D., Kiriakoulakis, K., Allcock, A.L. & White, M. 2018. Bottom trawling at Whittard Canyon: Evidence for seabed modification, trawl plumes and food source heterogeneity. *Progress in Oceanography*, 169, 227-240, <http://doi.org/10.1016/j.pocean.2017.12.010>.
- ICES. 2015a. Report of the Workshop on guidance for the review of MSFD decision descriptor 6 – seafloor integrity II (WKGMSFDD6-II), 16-19 February 2015, ICES Headquarters, Denmark. ICES CM 2015\ACOM:50. 133 pp.

¹⁹ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R2336>

²⁰ <https://www.ices.dk/community/advisory-process/Pages/Ecosystem-overviews.aspx>

- ICES. 2015b. Indicators 5, 6 and 7 of DCF Annex XII. ICES Advice, Northeast Atlantic Ecoregion. Published 17 December 2015.
- ICES. 2016a. EU request for guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats. ICES Special Request Advice. Published 04 July 2016.
- ICES. 2016b. Report of the Workshop on guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats (WKFBI), 31 May–1 June 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:46. 109 pp.
- ICES. 2017a. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 20–24 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:25. 121 pp.
- ICES. 2017b. Report of the Workshop to evaluate regional benthic pressure and impact indicator(s) from bottom fishing (WKBENTH), 28 February–3 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:40. 233 pp
- ICES. 2017c. EU request on indicators of the pressure and impact of bottom-contacting fishing gear on the seabed, and of trade-offs in the catch and the value of landings. ICES Special Request Advice 2017.13, ICES, Copenhagen, 27pp.
- ICES. 2018. Workshop on scoping for benthic pressure layers D6C2 - from methods to operational data product (WKBEDPRES1), 24–26 October 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:59. 62 pp
- ICES. 2019a. Interim Report of the Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), 12–16 November 2018, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/HAPISG:21. 74 pp.
- ICES. 2019b. Workshop on scoping of physical pressure layers causing loss of benthic habitats D6C1– methods to operational data products (WKBEDLOSS). ICES Scientific Reports. 1:15. 37 pp.
- Jørgensen, L.L., Primicerio, R., Ingvaldsen, R.B., Fossheim, M., Strelkova, N., Thangstad, T.H., Manushin, I., Zakharov, D. 2019. Impact of multiple stressors on sea bed fauna in a warming Arctic. *Marine Ecology Progress Series*, 608: 1-12. <https://doi.org/10.3354/meps12803>
- Kennington, E., Callery, O., Davidson, F., Grehan, A., Morato, T., Appiott, J., Davis, A., Dunstan, P., Du Preez, C., Finney, J., González-Irusta, J.M., Howell, K., Knudby, A., Lacharité, M., Lee, J., Murillo, F.J., Beazley, L., Roberts, J.M., Roberts, M., Rooper, C., Rowden, A., Rubidge, E., Stanley, R., Stirling, D., Tanaka, K.R., Vanhatalo, J., Weigel, B., Woolley, S. and Yesson, C. 2019. Use of Species Distribution Modeling in the Deep Sea. *Canadian Technical Report of Fisheries and Aquatic Sciences*, 3296, 76pp.
- Nemati, H., Shokri, M.R., Ramezanpour, Z., Ebrahimi Pour, G.H., Muxika, I., and Borja, Á. 2017. Using multiple indicators to assess the environmental status in impacted and non-impacted bathing waters in the Iranian Caspian Sea. *Ecological Indicators*, 82, 175-182.
- Nemati, H., Shokri, M.R., Ramezanpour, Z., Ebrahimi Pour, G.H., Muxika, I., and Borja, A. 2018. Sensitivity of indicators matters when using aggregation methods to assess marine environmental status. *Marine Pollution Bulletin*, 128, 234-239.
- Orejas *et al.* 2018. ATLAS Deliverable 3.1 Good Environmental Status and Biodiversity Assessments. 170 pp
- OSPAR. 2012. MSFD Advice Manual and Background Document on Biodiversity. 141 pp
- Pavlidou, A., Simboura, N., Pagou, K., Assimakopoulou, G., Gerakaris, V., Hatzianestis, I., Panayotidis, P., Pantazi, M., Papadopoulou, N., Reizopoulou, S., *et al.* 2019. Using a holistic ecosystem-integrated approach to assess the environmental status of Saronikos Gulf, Eastern Mediterranean. *Ecological Indicators* 96, 336-350
- Pham, C.K., Diogo, H., Menezes, G., Porteiro, F., Braga-Henriques, A., Vandeperre, F. & Morato, T. 2014. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. *Sci Rep*, 4, 4837, <http://doi.org/10.1038/srep04837>.
- Puig P., Canals M., Martín J., Amblas D., Lastras G., Palanques A., Calafat A.M. 2012. Ploughing the deep-sea floor. *Nature*, 489, 286-289.

- Pusceddu, A., Bianchelli, S., Canals, M., Sanchez-Vidal, A., De Madron, X.D., Heussner, S., Lykousis, V., de Stigter, H., Trincardi, F., and Danovaro, R. 2010. Organic matter in sediments of canyons and open slopes of the Portuguese, Catalan, Southern Adriatic and Cretan Sea margins. *Deep Sea Research Part I: Oceanographic Research Papers*, 57, 441-457.
- Pusceddu, A., Bianchelli, S., Martín, J., Puig, P., Palanques, A., Masqué, P., and Danovaro, R. 2014. Chronic and intensive bottom trawling impairs deep-sea biodiversity and ecosystem functioning. *Proceedings of the National Academy of Sciences*, 201405454. www.pnas.org/cgi/doi/10.1073/pnas.1405454111
- Ragnarsson, S.A., Burgos, J.M., Kutti, T., van den Beld, I., Egilsdóttir, H., Arnaud-Haond, S. And Grehan, A. 2017. The Impact of Anthropogenic Activity on Cold-Water Corals. *In Marine Animal Forests: The Ecology of Benthic Biodiversity Hotspots*. Rossi, S., Bramanti, L., Gori, A. and Orejas, C., eds.
- Uusitalo, L., Blanchet, H., Andersen, J.H., Beauchard, O., Berg, T., Bianchelli, S., Cantafaro, A., Carstensen, J., Carugati, L., Cochrane, S., *et al.* 2016. Indicator-Based Assessment of Marine Biological Diversity—Lessons from 10 Case Studies across the European Seas. *Frontiers in Marine Science*, 3.
- Wilson, A.M., Kiriakoulakis, K., Raine, R., Gerritsen, H.D., Blackbird, S., Allcock, A.L. & White, M. 2015. Anthropogenic influence on sediment transport in the Whittard Canyon, NE Atlantic. *Marine Pollution Bulletin*, 101, 320-329, <http://doi.org/10.1016/j.marpolbul.2015.10.067>.

6 Review of current, and proposal of revised, threshold for VME indicators within the VME weighting algorithm - ToR [d]

Considering work undertaken at WGDEC 2012 to examine NEAFC encounter thresholds as well as criteria used by other RFMOs (such as the South Pacific Regional Fisheries Management Organization - SPRFMO) to trigger “move-on” rules, review current and propose revised thresholds appropriate to each VME indicator type considered in the WGDEC VME weighting algorithm – ToR [d]

6.1 Background to the Term of Reference

The VME weighting algorithm was developed during the WGDEC 2015 and 2016 meetings, to provide a tool to assess the likelihood of an area containing an actual VME, based on underlying data from the ICES VME database. Many data records in the VME database are of VME indicators rather than bona fide VME habitats, so the index method aimed to make best use of these data to support ongoing advice to the European Commission (EC) and the North East Atlantic Fisheries Commission (NEAFC), on the distribution and location of VMEs in European Union and NEAFC waters.

In brief, the VME weighting algorithm considers two key components:

1. The ranked vulnerability of each VME indicator type, based on expert judgment; and
2. The abundance of VME indicator data records, evaluated against the NEAFC VME encounter thresholds for bottom trawls, for corals (30kg) and half the encounter threshold for sponges (200kg).

Once VME indicator data are scored against these two components, the VME index is produced as follows: $VME\ index = VME\ indicator\ score * 0.9 + abundance\ score * 0.1$.

To map the VME likelihood, the VME index scores for each VME indicator are aggregated per c-square (0.05 dd) grid cell, and the maximum VME index score is used as the overall value for that cell. In addition, the VME score is complemented by a confidence index to account for data uncertainty such as data quality issues and the varying degree of knowledge regarding each cell (e.g. how well it has been surveyed).

A full summary of the method behind the VME weighting algorithm can be found in Section 7 of the WGDEC 2018 report (ICES, 2018).

For the second component of the VME index, the VME abundance thresholds are based on the NEAFC VME encounter thresholds for bottom trawls, for corals (30kg) and half the encounter threshold for sponges (200kg) (Article 9, NEAFC Recommendation 19:2014²¹). All VME indicators, except for sponges, are considered against the coral threshold of 30 kg. These thresholds were based on work undertaken during WGDEC 2012 (ICES, 2012) and 2013 (ICES, 2013), and were selected for use during the early developmental stages of the weighting algorithm, for the purpose of trialling the system. However, during WGDEC 2018, the group reported that these thresholds may not be appropriate for use in the VME weighting algorithm, as this is not what the thresholds were designed for. They also suggested that the 30 kg threshold for all other VME

²¹ https://www.neafc.org/system/files/Rec.19-2014_as_amended_by_09_2015_and_10_2018_fulltext-and-map.pdf

indicators was felt to be too high. In addition, the Review Group on VME noted some concern over the abundance scoring, stating that without consistent and considered thresholds, supported by field observations, it was felt that this information currently offered little additional value.

To address these concerns, it was agreed at WGDEC 2018 that this should be reviewed at WGDEC 2019 to try to implement more appropriate thresholds per VME indicator, based on current knowledge of these species. Additional information could, in future, also be used to reconsider the VME encounter thresholds to provide further advice to NEAFC, although the values for the weighing algorithm and the encounter thresholds may not necessarily be the same.

As such, a new Term of Reference was developed for WGDEC 2019 to review new information on the life histories and vulnerabilities/sensitivities of other VME, to help develop specific and appropriate thresholds for each VME indicator. This aimed to consider work undertaken to develop the VME encounter thresholds for NEAFC in 2012/2013, as well as work undertaken by other RFMOs on such criteria.

6.2 Change to the Term of Reference aims

Since the development of the VME weighting algorithm in 2015/16 there have been a number of concerns and issues raised with the components of the VME weighting algorithm, many of which were reported in the WGDEC 2018 report (ICES, 2018) and through the Review Group on VME.

During WGDEC 2019, it was noted that the VME index was originally developed to make use of a wide range of VME data, collected from a range of surveys using different methods over a large temporal scale, which has resulted in different standards of metadata available. Whilst the WKVME 2015 workshop (ICES, 2016) aimed to improve the standardisation of VME metadata in the database moving forwards, there are a range of older data for which this was not possible (e.g. data from literature). As such, the aim of the VME weighting algorithm was to make use of all available data and create a set of transparent steps to determine likelihood of VME presence, together with a confidence score acknowledging the limitations in the data. It was also noted that the abundance scores used in the VME weighting algorithm do not have a very high weighting in the index (only 10% of the final score) because at the time of development, there were very few records of VME indicators with actual biomass values (15% of the records). As a result, the VME indicator vulnerability ranking is a bigger driver in the overall VME index score than the abundance score, and there was some question as to whether updates to the VME abundance component would make any fundamental difference to the final outputs.

On further deliberation, the group decided that alternatives to the weighting system might warrant investigation given that any weighting system would be subjective. In light of the abundance of a particular VME indicator only accounting for 10% of the final VME index, and the amount of new, more standardised, VME indicator data available in the ICES VME database, following the WKVME (ICES, 2016), the group suggested that there may now be more powerful methods to identify significant concentrations of VME, if sufficient data could be collated from the database. As such, the group agreed that a change to the ToR would be appropriate, with the aim of reviewing the application of other methods to identify areas of VME likelihood.

6.3 Review of methods to identify areas of VME likelihood

During plenary, the WGDEC and WGMHM deliberated on other methods that could be applied to the data in the VME ICES database in order to identify areas important for VME indicator species and potential boundaries for conservation management purposes. One tool that was discussed was kernel density estimation, or KDE, which is the main tool adopted by the Northwest

Atlantic Fisheries Organization (NAFO) to identify significant concentrations of VME indicator species, which they equate to VME. Kernel density estimation is a non-parametric, neighbour-based smoothing function that is typically applied in an ecological setting to identify hotspots in either biomass or abundance data. Both NAFO and Fisheries and Oceans Canada (DFO) have applied KDE to biomass data collected from depth stratified random trawl surveys and used an associated areal expansion method to identify weight thresholds that define significant concentrations of indicator taxa (Kenchington *et al.*, 2014). Species distribution models were then developed to identify areas of suitable habitat based on species-environment relationships and were used to refine the KDE-derived significant concentration polygons (DFO, 2017). To date, neither body has investigated the application of KDE to abundance data, or to occurrence datasets collected from a variety of collection methods and gear types.

Other alternative applications of KDE in the marine environment have included the calculation of Gaussian curves to identify modes, and their location, in body size spectra for several macrofauna taxonomic groups (Dolbeth *et al.*, 2014), to estimate structural complexity in coral reef rugosity indices (BOEM, 2016), and identify the spatial distribution and home range sizes of large motile megafauna (Makowski *et al.*, 2006; Aerts *et al.*, 2013). In a terrestrial setting, both KDE and ecological niche modelling (ENM) were recently applied to paedomorphic newt abundance data to identify spatial conservation targets (Denoël and Ficetola, 2015). The authors found that while KDE was valuable in identifying discrete boundaries and quantitative spatial conservation targets, the best performance was achieved through the combination of both KDE and ENM, where the latter could identify suitable environments within the boundaries of the KDE polygons.

6.4 Application of kernel density estimation to VME data from the ICES VME database

During the WGDEC 2019 meeting, the application of KDE to data from the ICES VME database was trialled to determine the feasibility of this method for inclusion in WGDEC's toolbox for advice provision to the EC and NEAFC on areas of importance for benthic VME indicators.

Initial trials were generated on the number of VME indicator records per ~3 km grid cell, which generated kernel density surfaces of the number of VME records/km². To some extent, the results of this analysis reflects sampling effort over VME hotspots, although some densely sampled areas did not appear as hotspots (see Figure 6.1). The areas delineated by 10 or more VME indicators may reflect areas of high diversity (if the indicators are of different taxa) or of dense aggregations of the same or similar indicator taxa. In order to disentangle the contributions of VME indicator type and data collection method to the KDE surface, a second iteration was run on a dataset from stratified random (by depth) trawl surveys, and based on a single VME indicator group, sea pens.

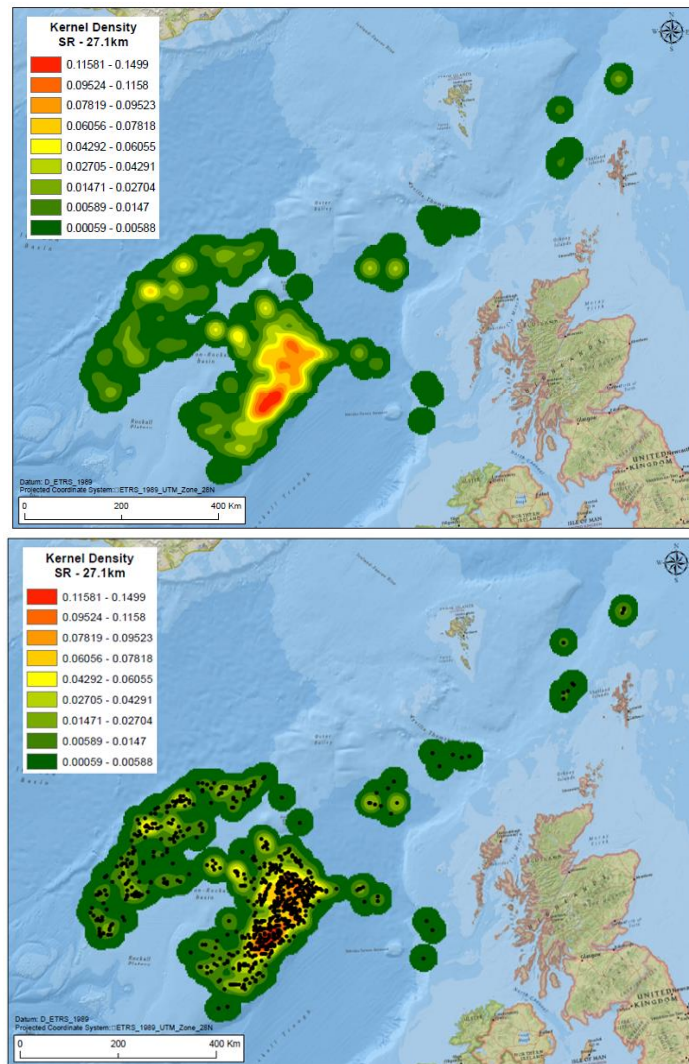


Figure 6.1 Kernel density surface (upper) and the same layer showing the number of VME indicator records per km² with raw data used in the analysis overlain (lower). Data come from a variety of sources based on the VME database.

The data downloaded from the ICES VME database for use in the second trial consisted of abundances of sea pen VME indicator taxa from Rockall Bank, collected in stratified random (by depth) research science trawl surveys conducted by Marine Scotland Science (Figure 6.2). The fishing gear types (SurveyMethod field in database) were GOV (GOV trawl), BOT (bottom trawl), and ROT (rock hopper otter trawl). Records from longline (LL) were excluded. A total of 287 records of sea pen VME indicators were extracted, consisting of 31 270 individuals from 14 sea pen taxa, of which 204 trawl sets (locations) had abundance data (see Table 6.1). Biomass was not associated with all entries; therefore, a direct comparative analysis applied to biomass was not done at this time with a smaller data set.

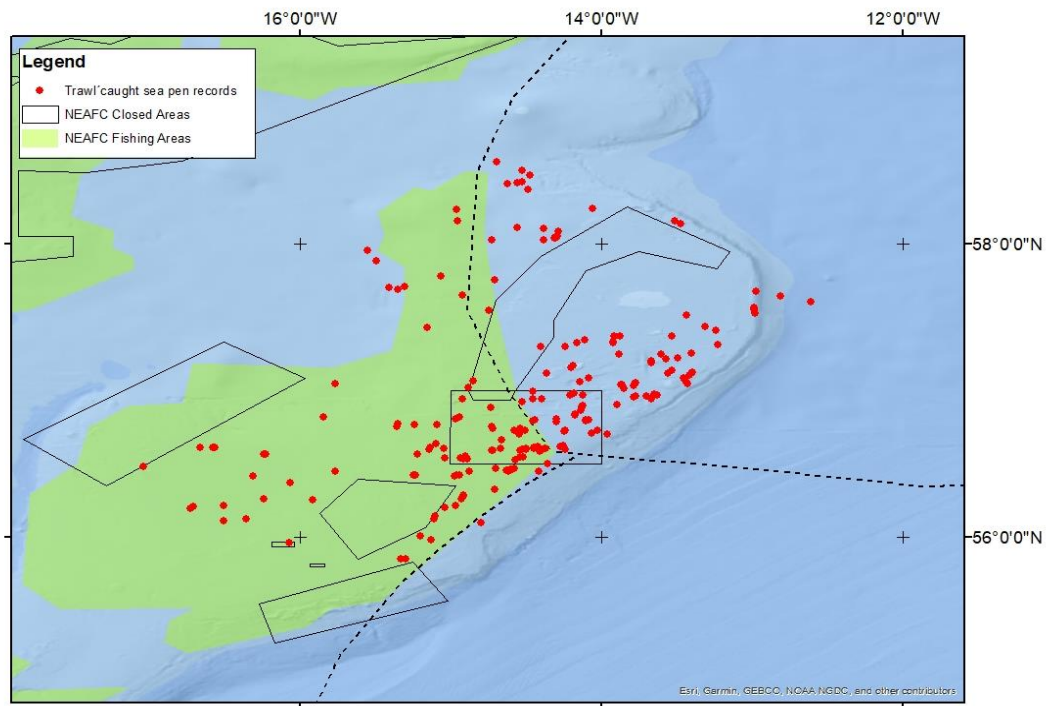


Figure 6.2. Location of sea pen abundance data from research vessel trawl surveys conducted by Marine Scotland Science between 2005 to 2018.

Table 6.1 Total number of sea pen individuals extracted from research vessel trawl survey data submitted to the ICES VME database for Rockall Bank.

Taxa	Total Number of Individuals
<i>Anthoptilum grandiflorum</i>	13
<i>Funiculina</i>	2
<i>Funiculina quadrangularis</i>	16413
<i>Halipterus</i>	11
<i>Halipterus finmarchica</i>	5
<i>Kophobelemnon</i>	1
<i>Kophobelemnon stelliferum</i>	69
<i>Pennatula</i>	128
<i>Pennatula aculeata</i>	12135
<i>Pennatula grandis</i>	45
<i>Protoptilum</i>	28
<i>Ptilella</i>	21
<i>Umbellula huxleyi</i>	98

NULL (Identified as sea-pen VME indicator)

2301

The trawl tow start position was used to represent each trawl set. The abundance for all sea pen taxa was summed for each trawl start location to give an abundance of sea pens per trawl record. The default search radius was 10.1 km, which was used to generate the kernel density surface. This surface resulted in many isolated catches and discontinuous habitat. Therefore, a search radius of 15 km was then applied and resulted in a smoother surface with connectedness between locations with higher abundances (Figure 6.3), but resulted in larger areas of interpolated abundance. The cell size of this trial was 1500 m.

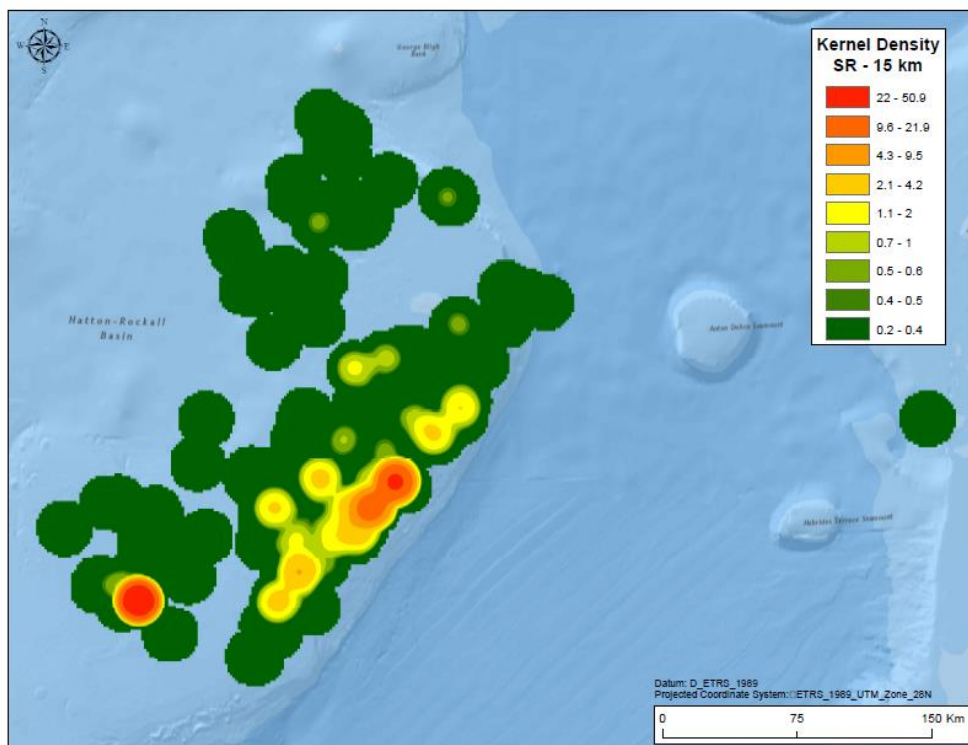


Figure 6.3. KDE surface of trawl-caught sea pen abundance calculated using a search radius of 15 km and cell size of 1500

After the initial mapping of the habitat and overlaying of closely spaced polygons, those polygons encompassing catches with 100 sea pens or more showed the greatest percent change in area between successive abundance intervals (133.1% between abundance interval 100 and 50; see Table 6.2 and Figure 6.4), and this was chosen as the abundance threshold defining the habitat occupied by sea pens on Rockall Bank as sampled by research vessel trawls. This large change in area is illustrated in Figure 6.5.

Figure 6.6 shows the polygons encompassing catches with 100 or more sea pens per trawl set (blue) and with more than 50 sea pens (brown). Black points show the number of points used to increase the area (See Table 6.2). The final significant area polygons are shown in Figure 6.7 in black outline, with the significant catches and non-significant catches identified.

Table 6.2. Results of aerial expansion around sea pen abundance thresholds overlain on the KDE surface. The threshold corresponding to the habitat delineation is indicated by shading.

Number of Points in Polygon	Area km ²	Interval	Percent Change in Area
19	1364.5	200	115.5
35	2940.2	100	133.1
49	6854.1	50	23.0
63	8431.3	30	13.3
82	9549.8	15	34.2
95	12820.2	10	9.6
104	14053.8	7	16.1
116	16314.9	5	28.4
138	20946.6	3	0.4
160	21024.3	2	0.0
196	21024.3	1	

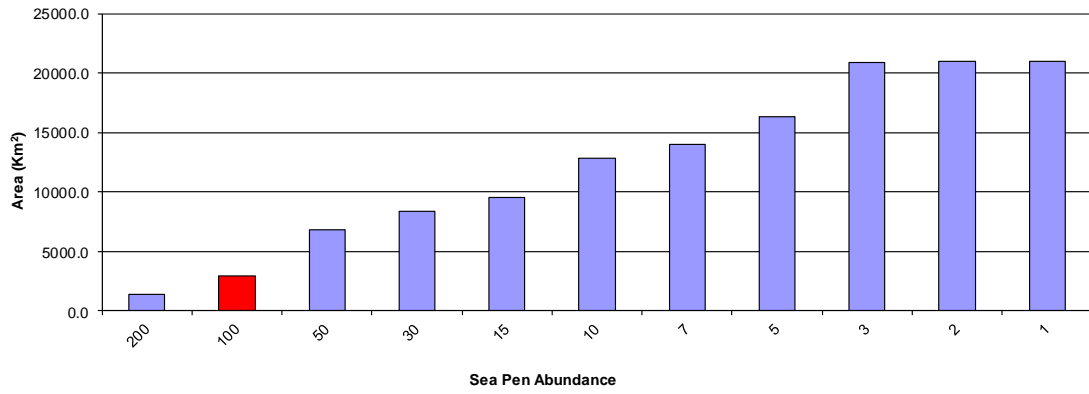


Figure 6.4 Histogram of area occupied by successive sea pen catch abundance thresholds.

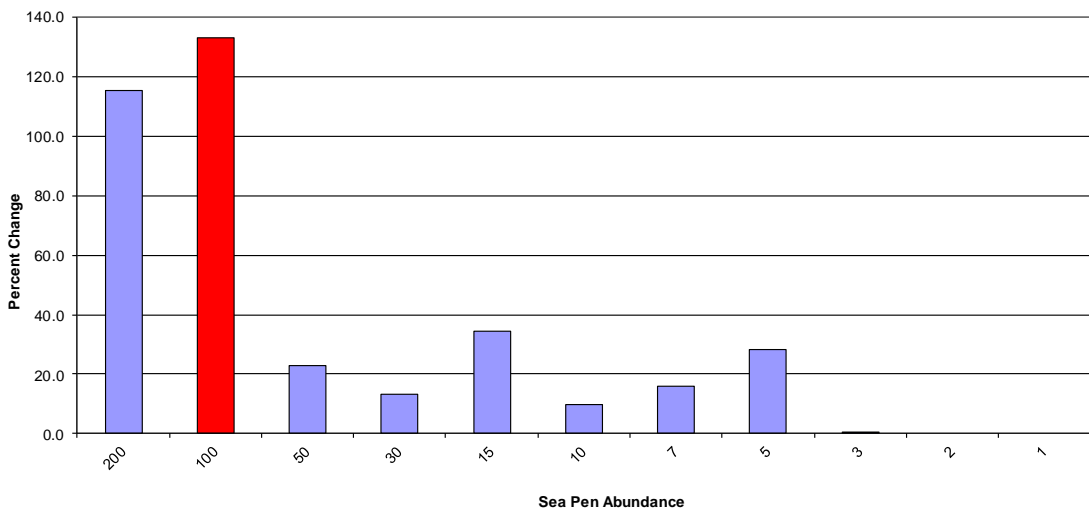


Figure 6.5 Histogram of change in area created by successive sea pen catch abundance thresholds.

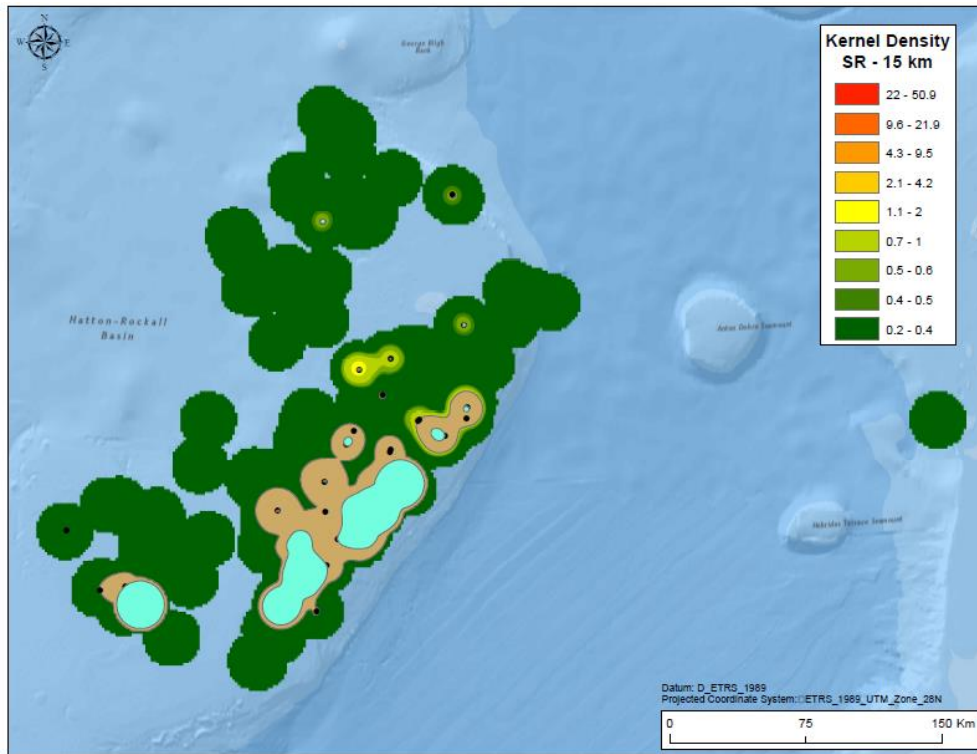


Figure 6.6 KDE surface of trawl-caught sea pen abundance calculated using a search radius of 15 km and cell size of 1500 m showing the area occupied by catches with 100 or more sea pens (blue) and with more than 50 sea pens (brown). Black points show the number of points used to increase the area (See Table 6.2).

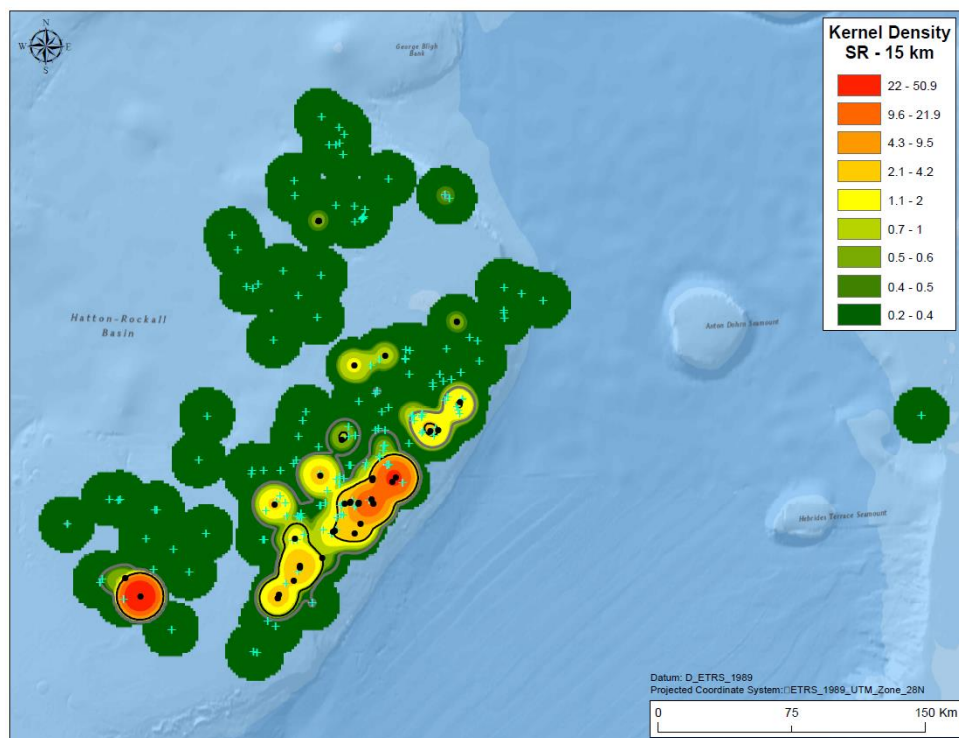


Figure 6.7. KDE surface of trawl-caught sea pen abundance calculated using a search radius of 15 km and cell size of 1500 m showing the area occupied by catches with 100 or more sea pens (black bold outline). Catches above and below the significant threshold are represented by black circles and turquoise crosses, respectively.

6.5 Conclusions and limitations

Although there is minimal interpolation to unsampled areas with this method (compared to species distribution modelling), the boundaries and extent of the polygons are influenced by the search radius and the spatial distribution of the data (NAFO, 2015). The use of a search radius less than 15 km, as applied in this example, would reduce the level of interpolation around a single datum. However, it would break up the continuity of the surface; a balance is needed between creation of an effective KDE surface and the minimisation of interpolation, which is greatest around single isolated data points. In this instance, species distribution models that model the species-environment relationship may be useful in clipping or refining the significant area polygons, as done by NAFO (NAFO, 2014) and DFO (Kenchington *et al.*, 2016).

Similarly, the application of KDE to abundance data collected using different trawl gears with varying levels of “catchability” is also a source of uncertainty. In this trial, data was standardised by using only one source of data (e.g. those from research science trawl surveys conducted by Marine Scotland Science). However, currently, the ICES VME database contains a range of data types, many from opportunistic surveys using drop-down cameras, ROVs, etc. with varying levels of associated data (e.g. effort or abundance/biomass). Further work could be done to standardise the data in order to optimise the application of these tools to the data in the ICES VME database.

6.6 References

- Aerts, L.A.M., McFarland, A.E., Watts, B.H., Lomac-MacNair, K.S., Seiser, P.E., Wisdom, S.S., Kirk, A.V., Schudel, C.A. 2013. Marine mammal distribution and abundance in an offshore sub-region of the northeastern Chukchi Sea during the open-water season. *Cont. Shelf. Res.* 67: 116-126.
- U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM). Benthic Habitat Mapping and Assessment in the Wilmington-East Wind Energy Call Area. Taylor, J.C., Paxton, A.B., Voss, C.M., Sumners, B., Buckel, C.A., Vander Pluym, J., Ebert, E.B., Viehman, T.S., Fegley, S.R., Pickering, E.A., Adler, A.M., Freeman, C. and Peterson, C.H. Atlantic OCS Region, Sterling, VA. OCS Study BOEM 2016-003 and NOAA Technical Memorandum 196.
- Denoël, M., and Ficetola, G.F. 2015. Using kernel and ecological niche modeling to delineate conservation areas in an endangered patch-breeding phenotype. *Ecol. Appl.* 25(7): 1922-1931.
- DFO. 2017. Delineation of Significant Areas of Coldwater Corals and Sponge-Dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters and their Overlap with Fishing Activity. DFO Canadian Science Advisory Secretariat Science Advisory Report 2017/007. 45 p.
- Dolbeth, M., Raffaelli, D., and Pardal, M.Â. 2014. Patterns in estuarine macrofauna body size distributions: The role of habitat and disturbance impact. *J. Sea. Res.* 85: 404-412.
- ICES. 2012. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 26–30 March 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:29. 120pp
- ICES. 2013. Report of the ICES\NAFO Joint Working Group on Deep-water Ecology (WGDEC), 11–15 March 2013, Floedevigen, Norway. ICES CM 2013/ACOM:28. 95 pp.
- ICES. 2016. Report of the Workshop on Vulnerable Marine Ecosystem Database (WKVME), 10–11 December 2015, Peterborough, UK. ICES CM 2015/ACOM:62. 42 pp
- ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 126 pp.
- Kenchington, E., Beazley, L., Lirette, C., Murillo, F.J., Guijarro, J., Wareham, V., Gilkinson, K., Koen-Alonso, M., Benoît, H., Bourdages, H., Sainte-Marie, B., Treble, M. and Siferd, T. 2016. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada Using Kernel Density Analyses and Species Distribution Models. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/093. vi + 178p.

- Kenchington, E., Murillo, F.J., Lirette, C., Sacau, M., Koen-Alonso, M., Kenny, A., Ollerhead, N., Wareham, V., and Beazley, L. 2014. Kernel Density Surface Modelling as a Means to Identify Significant Concentrations of Vulnerable Marine Ecosystem Indicators. *PLoS ONE* 10(1): e0117752. doi:10.1371/journal.pone.0117752.
- Makowski C., Seminoff, J.A., and Salmon, M. 2006. Home range and habitat use of juvenile Atlantic green turtles (*Chelonia mydas* L.) on shallow reef habitats in Palm Beach, Florida, USA. *Mar. Biol.* 148: 1167-1179.
- NAFO. 2014. Report of the 7th Meeting of the NAFO Scientific Council Working Group on Eco-system Science and Assessment (WGESA). NAFO Scientific Council Summary Document 13/024, Serial No. N6277, 207 pp.
- NAFO. 2015. Report of the 8th Meeting of the NAFO Scientific Council Working Group on Eco-system Science and Assessment (WGESA). NAFO Scientific Council Summary Document 13/024, Serial No. N6277, 207 pp.

7 Work jointly with the Working Group on Marine Habitat Mapping to identify and trial approaches for VME modelling in the North Atlantic – ToR [e]

To further develop the use of the VME weighting algorithm outputs within ICES advice, work jointly with the ICES Working Group on Marine Habitat Mapping (WGMHM) to review the availability and quality of VME data and physico-chemical predictor variables across the North Atlantic and identify and trial potential approaches to model the distribution of VMEs in the North Atlantic

7.1 Background to the Term of Reference

In 2018, WGDEC was requested to prepare spatial layers and a list of areas where VMEs occur, or are likely to occur, in the Northeast Atlantic to support ICES advice to the European Commission with respect to implementation of the EU deep-sea access regulations²². To implement this, WGDEC produced maps of known VME occurrence using data from the ICES VME database, supplemented with data from peer reviewed literature and the OSPAR 2015 database. To identify areas where VMEs are likely to occur, WGDEC used the outputs of the VME weighting algorithm to infer VME likelihood of occurrence, according to the VME index (ICES, 2018).

Following this work, the Review Group on Vulnerable Marine Ecosystems (RGVME) noted that the VME index and habitat observations within the maps presented by WGDEC were very scattered and sparse, meaning an overlap with the fisheries footprint data would be challenging. The RGVME recommended that statistical modelling techniques that produce predicted probability surfaces for VMEs (e.g. Howell *et al.*, 2016) were investigated in future by WGDEC, and this should ideally be facilitated by increased submission of absence data to the ICES VME database. Furthermore, the RGVME proposed that predictive modelling techniques could also be used to provide a fuller representation of 'suitable habitat' or potential VME distribution in EU waters, to support the European Commission request to provide new data on habitats sensitive to particular fishing activities within EU waters.

To meet these recommendations, WGDEC 2019 was organised as a joint meeting with the Working Group on Marine Habitat Mapping which has expertise additional to WGDEC on modelling techniques, to support habitat mapping and modelling work.

7.2 Prior consideration of modelling at WGDEC

The potential use of Species Distribution Modelling (SDM) and Habitat Suitability Modelling (HSM) as a tool to identify areas where VME are likely to occur, has arisen several times over the last ten years in WGDEC. In their 2009 report, WGDEC made a recommendation that, in the absence of reliable widespread biological sampling to approximate species distributions, the use of predictive habitat models (HSM and SDM) should be seriously explored. However, the group

²² REGULATION (EU) 2016/2336 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2016 establishing specific conditions for fishing for deep-sea stocks in the Northeast Atlantic and provisions for fishing in international waters of the Northeast Atlantic and repealing Council Regulation (EC) No 2347/2002.

stopped short of adopting use of these models in their recommendations to ICES to support provision of draft ICES advice. In 2014, WGDEC revisited this subject, and reviewed the state-of-the-art in high resolution 'terrain-based models' for predicting VME distribution. The working group report concluded the following:

1. Published (and therefore peer reviewed) predictive models of the distribution of VMEs or VME indicator species should be taken into consideration in management decisions regarding human use of the deep-sea ecosystem.
2. Predictive models based on high resolution multibeam bathymetry data offer finer resolution predictive models (maps of VME suitable areas) at higher resolution, which can be used to inform the provision of advice on spatial use of the deep-sea ecosystem.
3. In regions where published predictive models indicate a high likelihood of VME presence, we suggest survey effort is required to discount presence in order to implement a bottom contact fishery.

Despite these conclusions, to date, WGDEC have not used predictive habitat models (SDM and HSM) in recommendations to ICES to support draft ICES advice. At WGDEC 2019, the group discussed how HSM might be brought into the decision-making process and documented considerations around this.

7.3 Availability and resolution of existing models

Global / basin scale HSM models, by necessity, use environmental predictors that are themselves the outputs of models. They tend to make use of global bathymetry models (Becker *et al.*, 2009; Weatherall *et al.*, 2015) for deriving depth and topographic variables such as slope, rugosity, and bathymetric position index; and until recently (Tozer *et al.* 2018), this has limited the resolution of the HSM to 30 arc seconds. Oceanographic data used in these basin-scale models are generally only available from models at coarser resolution than the bathymetry models. The resolution of these global / basin-scale HSM models is unlikely to become substantially better until higher resolution environmental data become available. However, a number of global and basin scale models for VME distribution have already been published (e.g. Davies and Guinotte 2011; Yesson *et al.*, 2012; Howell *et al.*, 2016) and some are available through the European Marine Observation and Data Network (EMODnet) and could be used by WGDEC.

While basin-scale models are the only means by which to provide continuous surfaces of prediction, regionally and nationally higher resolution models of VME distribution have been published (e.g. Bryan and Metaxas, 2007; Guinan *et al.*, 2009; Rengstorf *et al.*, 2013; Ross and Howell, 2013; Rooper *et al.*, 2014; Ross *et al.*, 2015; Piechaud *et al.*, 2015; Kenchington *et al.*, 2016) and in some cases are used in national spatial management decisions. In Canada for example, a number of marine refugia²³ were delineated, in part, from outputs of kernel density estimation (KDE) and/or SDMs of cold-water corals and sponges (DFO, 2017). In the Scotian Shelf Bioregion off Nova Scotia, Canada, Significant Benthic Areas (Canada's equivalent to VME under their domestic policy) of corals, sponges, and other biogenic habitat-forming taxa identified from KDE and/or SDMs were assigned conservation targets and used in the conservation planning tool, MARXAN, to identify a draft network of marine protected areas (DFO, 2018). Such efforts have directly contributed towards Canada's commitment to the Convention on Biological Diversity (CBD) Strategic Plan 2011-2020 to protect 10% of coastal and marine areas by 2020 (SCBD, 2010).

These higher resolution regional and national models tend to make use of multibeam data to derive terrain variables, but may also access a much wider range of potential environmental

²³ <http://www.dfo-mpo.gc.ca/oceans/oeabcm-amcepz/refuges/index-eng.html>

drivers of species distributions, and therefore tend to produce more accurate models. Although these models have limited spatial coverage, they are particularly useful for spatially constrained areas where there is a need to understand VME distribution (e.g. individual nation's EEZs or individual seafloor features such as seamounts).

The resolution of published models is varied but tends to be < 200 m grid cell size. As a result of the smaller grid cell size in these models versus basin-scale / global models, the estimates of area of predicted suitable habitat for VME derived from such models tends to be much smaller, and this may be an important consideration when considering spatial closures.

7.4 Next steps for model use by WGDEC

For these models to take their place in the toolbox used by WGDEC in recommendations to ICES to support provision of draft ICES advice for NEAFC and the European Commission for the identification of areas where VME are likely to occur, it is important for the group to consider and agree how these models can be used, and what criteria for use must be met.

Specifically, the working group needs to consider the following issues around model creation:

1. Whether only published peer reviewed models can be used, or whether models constructed by ICES working group experts for the purposes of the working group meeting may also be used.
2. How best to advise end users on the level of validation of the model undertaken (e.g. validated internally and / or with independent data).
3. The levels of model performance at which use is acceptable, and / or how best to advise end users on the level of performance (e.g. ability to predict presence, ability to predict absence, percent of test data correctly predicted, etc.).
4. How best to communicate model variability / uncertainty to end users.
5. How best to communicate challenges with model resolution.
6. Whether applying thresholds to models is required, and whether any technique for thresholds applied is appropriate for the proposed end use.

Further considerations around the use of models include:

1. Should different resolution models be used in different ways? For example, is it appropriate to recommend area closures on the basis of basin scale models?
2. Under what conditions might area closures be recommended on the basis of models? (for example, single model, multiple models, need for ground truthing, temporary closures pending ground truthing in line with the precautionary principle, etc.).
3. Should the way in which models are used differ depending on the setting, for example, in data-poor regions of ABNJ vs European EEZ.

These questions could be used to form the basis for discussions at the next working group meeting in 2020. Using a case study area, WGDEC and WGMHM could jointly work through an example to provide recommendations for developing draft advice on area closures on the basis of HSM model output (both low-resolution and high-resolution models), documenting the process, decisions taken, and issues considered.

7.5 References:

Becker, J.J., Sandwell, D.T., Smith, W.H.F., Braud, J., Binder, B., Depner, J.L., Fabre, D., Factor, J., Ingalls, S., Kim, S.H. and Ladner, R. 2009. Global bathymetry and elevation data at 30 arc seconds resolution: SRTM30_PLUS. *Marine Geodesy*, 32(4), pp.355-371.

- Bryan, T.L. and Metaxas, A. 2007. Predicting suitable habitat for deep-water gorgonian corals on the Atlantic and Pacific Continental Margins of North America. *Marine Ecology Progress Series*, 330, pp.113-126.
- Davies, A.J. and Guinotte, J.M. 2011. Global habitat suitability for framework-forming cold-water corals. *PloS one*, 6(4), p.e18483.
- Guinan, J., Brown, C., Dolan, M.F. and Grehan, A.J. 2009. Ecological niche modelling of the distribution of cold-water coral habitat using underwater remote sensing data. *Ecological Informatics*, 4(2), pp.83-92.
- Howell, K.L., Piechaud, N., Downie, A.L. and Kenny, A. 2016. The distribution of deep-sea sponge aggregations in the North Atlantic and implications for their effective spatial management. *Deep Sea Research Part I: Oceanographic Research Papers*, 115, pp.309-320.
- ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 126 pp.
- Kenchington, E., Beazley, L., Lirette, C., Murillo, F.J., Guijarro, J., Wareham, V., Gilkinson, K., Koen-Alonso, M., Benoît, H., Bourdages, H. and Sainte-Marie, B. 2016. Delineation of coral and sponge significant benthic areas in Eastern Canada using Kernel Density Analyses and Species Distribution Models. *Canadian Science Advisory Secretariat*.
- Piechaud, N., Downie, A., Stewart, H.A. and Howell, K.L. 2015. The impact of modelling method selection on predicted extent and distribution of deep-sea benthic assemblages. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*, 105(4), pp.251-261.
- Rengstorf, A.M., Yesson, C., Brown, C. and Grehan, A.J. 2013. High-resolution habitat suitability modelling can improve conservation of vulnerable marine ecosystems in the deep sea. *Journal of Biogeography*, 40(9), pp.1702-1714.
- Rooper, C.N., Zimmermann, M., Prescott, M.M. and Hermann, A.J. 2014. Predictive models of coral and sponge distribution, abundance and diversity in bottom trawl surveys of the Aleutian Islands, Alaska. *Marine Ecology Progress Series*, 503, pp.157-176.
- Ross, R.E. and Howell, K.L. 2013. Use of predictive habitat modelling to assess the distribution and extent of the current protection of 'listed' deep-sea habitats. *Diversity and Distributions*, 19(4), pp.433-445.
- Ross, L.K., Ross, R.E., Stewart, H.A. and Howell, K.L. 2015. The influence of data resolution on predicted distribution and estimates of extent of current protection of three 'listed' deep-sea habitats. *PloS one*, 10(10), p.e0140061.
- Tozer, B., Sandwell, D.T., Becker, J.J., Tea, B., Freund, Y., Harper, H., Beale, J., Wessel, P. and Smith, W.H. 2018. Global bathymetry at 15 arc seconds resolution with implications for the isostatic compensation of geological features in the MH370 survey area. In *AGU Fall Meeting Abstracts*.
- Weatherall, P., Marks, K.M., Jakobsson, M., Schmitt, T., Tani, S., Arndt, J.E., Rovere, M., Chayes, D., Ferrini, V. and Wigley, R. 2015. A new digital bathymetric model of the world's oceans. *Earth and Space Science*, 2(8), pp.331-345.
- Yesson, C., Taylor, M.L., Tittensor, D.P., Davies, A.J., Guinotte, J., Baco, A., Black, J., Hall-Spencer, J.M. and Rogers, A.D. 2012. Global habitat suitability of cold-water octocorals. *Journal of Biogeography*, 39(7), pp.1278-1292.

8 Request from the European Commission to provide updates on representative taxa for 2 VME habitats, and advice on additional VME indicators to be included in Annex III of the EU deep-sea access regulations

8.1 Background – the existing VME habitat list for NEAFC and EU waters

In 2013, ICES was requested by the North East Atlantic Fisheries Commission (NEAFC) to assess whether the list of VME indicator species was exhaustive, to suggest possible additions to that list based on the FAO guidelines for VME, and to consider harmonization with the Northwest Atlantic Fisheries Organisation (NAFO) list. WGDEC 2013 therefore reviewed the NAFO Scientific Council's list of VME taxa for the NW Atlantic, and concluded that this should be harmonized into a more general list of VME types for the NEAFC Regulatory Area, rather than listing all the likely species that would be indicators of VMEs. There were a few discrepancies with the NAFO list due to geographic differences, and uncertainty as to whether certain species could be considered a VME indicator, e.g. cup corals, soft-corals and xenophyophores (ICES, 2013a). A final list was provided as formal ICES advice to NEAFC (ICES, 2013b).

Following this, in 2015, a workshop on VME (WKVME) was held by WGDEC to review the ICES VME database, with a particular focus on the existing list of VME indicators/habitats and the associated lists of representative taxa. The group agreed a set of modifications for the database, including a series of changes to the VME indicator, habitat and sub-type lists. However, these changes were not formally proposed to NEAFC through ICES advice. A summary of changes to VME indicators, habitats and sub-types is provided in the WKVME report (ICES, 2016).

8.2 European Commission request to ICES

In 2018, utilising work undertaken by WGDEC, ICES responded to a request from the European Commission to advise on a list of areas where VMEs are likely to occur and should be closed off from bottom fishing, in relation to the EU deep-sea access regulations (EU 2016/2336²⁴). In addition, ICES noted the ability, provided under Article 9 of the Regulation, to review and amend the list of VME indicators in Annex III, and suggested that the Commission add the following two VME habitats to Annex III, which are included on the FAO vulnerable habitat list and occur in EU waters:

- Hydrothermal vents/fields with typical species including *Alvinocaris* spp., *Munidopsis* spp. and *Thyasira* spp.
- Cold seeps with the same typical species groups.

Following the submission of this advice, in 2019, the European Commission requested ICES to:

²⁴ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R2336>

- Provide a full list of representative taxa and an indication of the classification under the VME Habitat type, as per table in Annex III of the regulation, for hydrothermal vents/fields and cold seeps, and;
- Provide advice on additional VME indicators to be included in Annex III of the regulation, together with a full list of representative taxa for each of the new VME indicators and an indication of the classification under the VME Habitat type as per table in Annex III

The information for this request is provided in sections 8.3 and 8.4. The geographic scope of the deep-sea access regulations, as stated in Article 2, is Union waters of the North Sea, of the north-western waters and of the south-western waters as well as Union waters of ICES zone IIa; and international waters of CECAF areas 34.1.1, 34.1.2 and 34.2. However, WGDEC considered this request in relation to the whole ICES area, including both the NEAFC Regulatory Area and those areas within the EEZ of member state countries, since this is where the majority of data in the VME database is available from.

8.3 Representative taxa for hydrothermal vents/fields and cold seeps

The ICES Workshop on VME (WKVME) proposed a series of representative taxa of relevance to hydrothermal vents/fields and cold seep habitats (see Annex 6 of ICES, 2016). This was used as the basis of discussions to respond to the EC request for these habitat types.

Initially, some questions were raised about whether representative taxa could be provided for these VME habitats, on the recognition that the presence of a certain species (e.g. *Munidopsis* spp.) would not necessarily mean the presence of the VME habitat, but equally, the absence of a representative species would not mean that a VME was not present. It was also noted that representative taxa for these VME habitat types will vary from ocean basin to basin, and thus the geographic remit of ICES (North Atlantic) would influence which species could be listed. As such, it was agreed that any representative taxa listed should be considered as example species only and not as a comprehensive list.

Further discussion was also had on the sub-types of these habitats where different species may be found, for example active chimneys/black smokers, areas of diffuse flow or inactive chimneys. Chimney-like structures can also be indicators of either active or inactive vents and, when relying on seafloor observations, these can be visually or chemically identified by the presence (or absence) of hydrothermal fluid flow. Therefore, it was proposed that the VME habitat, hydrothermal vents/fields, was split into two habitat sub-types: active and inactive vents. It was agreed that the list of representative taxa for hydrothermal vents would be specific to active vents. Inactive vents will generally be colonised by sponges or corals, so representative taxa would be similar to those for coral garden and deep-sea sponge aggregation VMEs.

Experts from the WGDEC meeting therefore developed a list of example representative taxa for the North Atlantic for active vents and for cold seeps which are provided in Table 8.1.

Table 8.1 Proposed VME habitat subtypes and representative taxa for hydrothermal vent/fields and cold seeps

VME Habitat type	Proposed VME habitat subtype	Representative Taxa
Hydrothermal vents/fields	Active vents	Anthozoa: Kadosactinidae <i>Maractis rimicarivora</i> Bivalvia: Mytilidae <i>Bathymodiolus</i> sp. <i>Bathymodiolus azoricu</i> Gastropoda Turridae <i>Phymorynchus</i> sp. Crustacea Alvinocaridae <i>Rimicaris exoculata</i> <i>Chorocaris chacei</i> <i>Mirocaris fortunata</i> Crustacea, Bythograeidae <i>Segonzacia mesatlantica</i> Ophidiiformes Bythitidae <i>Cataetyx laticeps</i> Perciformes Zoarcidae <i>Pachycara</i> sp.
	Inactive vents	Generally colonized by sponges and corals, some identified as VME indicators species under ‘coral gardens’ and ‘deep-sea sponge aggregations’
Cold Seeps		Bivalvia Lucinidae <i>Lucinoma</i> sp. Bivalvia Thyasiridae <i>Thyasira</i> sp. Mytilidae <i>Bathymodiolus</i> sp. Solemydae <i>Acharax</i> sp. Polychaeta

VME Habitat type	Proposed VME habitat subtype	Representative Taxa
		Siboglinidae
		<i>Siboglinum</i> sp.
		<i>Polybrachia</i> sp.
		<i>Spirobrachia</i> sp.
		<i>Bobmarleya</i> sp.
		<i>Lamellisabella</i> sp.
		<i>Sclerolinum</i> sp. <i>Oligobrachia</i> sp.
		Perciformes
		Zoarcidae
		<i>Lycodes squamiventer</i>

8.4 Additional VME indicators and representative taxa for VME habitat types

WGDEC 2019 also discussed the full list of VME habitats, with associated sub-types, and representative taxa from Annex III of the EU deep-sea access regulations, to consider any proposed changes. The group agreed that the list developed by WKVME in 2015 for the VME database should also be used as a starting point to respond to this request, as many of these changes had already been considered during the workshop.

Most of the changes proposed through WKVME for VME habitat sub-types were transferred to this work directly (see section 8.4.5), however a small number of additional changes were proposed for deep-sea sponge aggregations (section 8.4.1), coral gardens (section 8.4.2), mud and sand emergent fauna (section 8.4.3) and tube-dwelling anemone patches (section 8.4.4). It was also noted that any significant changes to the sub-type list would impact the ICES VME database (since old and new data would then be submitted against different VME sub-type names) and therefore needed to be considered carefully before proposing these to the European Commission as a formal change. As such, only minor changes, such as additions of VME habitat sub-types or changes to match the WKVME list, have been proposed at this stage.

Regarding the representative taxa, the group considered these for the deep-sea sponge aggregations VME habitat, using expertise from the Horizon 2020 SponGES project. During this process, it became clear that there were differences in opinion on how to define representative taxa, and that the current list needed specific expertise from appropriate taxa specialists to refine. It was therefore agreed that changes would be reported for deep-sea sponge aggregations, as specialist expertise was available during the meeting, but further changes to the representative taxa for other habitat types would be discussed through an intersessional sub-group and would be provided to ICES by September 2019.

8.4.1 Deep-sea sponge aggregations

The 2013 VME list (ICES, 2013b) detailed three sub-types for deep-sea sponge aggregations: Ostur sponge aggregations; Hard-bottom sponge gardens; and Glass sponge communities,

which have been transferred directly to Annex III of the EU deep-sea access regulations²⁵. The WKVME agreed to change these into two sub-types: Soft bottom sponge aggregations and Hard-bottom sponge aggregations, because glass sponge communities are found on both soft and hard substrates and could therefore be submitted to the ICES VME database as either 'Hard bottom sponge aggregations' or 'Glass sponge communities' which could cause inconsistencies in data submissions. On discussion at WGDEC 2019, it was agreed these two sub-types would be a more straightforward way of splitting the deep-sea sponge aggregations VME habitat, so this change was proposed.

A list of representative taxa for the two deep-sea sponge aggregation sub-types were prepared by experts from the H2020 SponGES project and are detailed in Table 8.2, together with the justification for any changes and additional comments.

For future updates, it is suggested that the list is aligned with ongoing efforts to define and characterise the different types and sub-types of VMEs through, for example, the H2020 SponGES project. Furthermore, consistency between the list of representative taxa and the identification guides available on deep-sea sponges should be considered. Such guides exist for the NAFO area (Best *et al.*, 2010, Kenchington *et al.*, 2015) and for the Mediterranean (Xavier & Bo, 2017), and a guide that will cover both the North Atlantic and Mediterranean is also in preparation through the H2020 SponGES project.

²⁵ An error was noted where Annex III of the deep-sea access regulations currently includes 'Other sponge aggregations' instead of 'Ostur sponge aggregations'

Table 8.2 Proposed changes to representative taxa for deep-sea sponge aggregations (split by soft bottom and hard bottom sub-types). Revisions are denoted in red.

VME habitat sub-type	Proposed changes to representative taxa	Justification for changes/remarks
Soft bottom sponge aggregations	GEODIIDAE	¹ <i>Geodia phlegraei</i> is another geodiid very typical of the boreal grounds.
	<i>Geodia barretti</i>	
	<i>Geodia macandrewi</i>	² The <i>Stryphnus</i> species commonly found on boreal grounds has been mistakenly called <i>S. ponderosus</i> for many years (Cárdenas & Rapp, 2015). This needs to be corrected.
	<i>Geodia atlantica</i>	
	¹ <i>Geodia phlegraei</i> – new addition	³ The species present on the soft bottom boreal grounds is <i>S. normani</i> , whereas in the hard bottom cold-water grounds is <i>S. raphidiophora</i> .
	ANCORINIDAE	
	² <i>Stryphnus fortis</i> – change in species name	⁴ <i>Caulophacus arcticus</i> is found in various seabed types, but always attached to hard substrate such as pebbles
	³ <i>Stelletta normani</i> – change in taxonomic level	⁵ <i>Pheronema carpenteri</i> is found in both soft and hard substrates
	PACHASTRELLIDAE	
	<i>Thenea</i> spp.	
ROSELLIDAE		
⁴ <i>Caulophacus arcticus</i>		
PHERONEMATIDAE		
⁵ <i>Pheronema carpenteri</i>		
Hard bottom sponge aggregations	GEODIIDAE	^{6-8, 11-14} Species marked with* are characteristic of the “cold-water Ostur” (Roberts <i>et al.</i> , 2018, Meyer <i>et al.</i> , in review). In some areas they are found over a spicule mat several cm in thickness (i.e. not always on hard-bottoms).
	⁶ <i>Geodia hentscheli</i> * – new addition	
	⁷ <i>Geodia parva</i> * – new addition	⁹ <i>Axinella</i> spp. – species within this genus are difficult to identify even for experts and through molecular analyses we are finding that some species hybridize. As such a change of taxonomic level is proposed.
	ANCORINIDAE	
	⁸ <i>Stelletta raphidiophora</i> * – new addition	¹⁰ Aggregations of <i>A. setubalense</i> are known to occur off Portugal, in the Cantabrian Sea and on islands and seamounts (sub-areas 8, 9 and CECAF 34.1.2)
	AXINELLIDAE	
	⁹ <i>Axinella</i> spp. – change in taxonomic level	¹⁵ The glass sponge <i>Poliopogon amadou</i> is known to form dense aggregations on seamount slopes in Areas Beyond National Jurisdiction (Xavier <i>et al.</i> 2015; Ramiro-Sanchez <i>et al.</i> 2019) but in very deep areas (below 2000 m depth). This VME indicator may be not so relevant to the deep-sea access regulations given the bottom trawl ban at depths > 800 m. However, it has been included on the list for completeness.
	<i>Phakellia</i> spp.	
	MYCALIDAE	
	<i>Mycale lingua</i> - new addition	
	POLYMASTIIDAE	
	<i>Polymastia</i> spp.	
	TETILLIDAE	
	ROSELLIDAE	
	<i>Caulophacus arcticus</i>	
¹⁰ <i>Asconema setubalense</i> - new addition		
¹¹ <i>Asconema foliatum</i> * - new addition		

VME habitat sub-type	Proposed changes to representative taxa	Justification for changes/remarks
	¹² <i>Schaudinnia rosea</i> * - new addition	
	¹³ <i>Scyphidium septentrionale</i> * - new addition	
	¹⁴ <i>Trichasterina borealis</i> * - new addition	
	PHERONEMATIDAE	
	<i>Pheronema carpenteri</i>	
	¹⁵ <i>Poliopogon amadou</i> – new addition	

8.4.2 Coral gardens

For coral gardens, the list currently includes soft-bottom coral gardens: cup-coral fields, but not hard-bottom cup coral fields. Examples of this habitat type have recently been reported from the South Atlantic where hard-bottom cup coral fields of densities up to 1,150 m⁻² were observed in images collected on a survey in 2018 to the UK Overseas Territory (UKOT), Tristan da Cunha, at a depth of 288 m (Bridges *et al.*, in prep). This was discussed at the WGDEC 2019 meeting to establish if any examples of this habitat had been found in the North East Atlantic, and examples were available, such as one from UK waters at the Wyville-Thomson Ridge (see Figure 8.1). As such it was agreed to propose this as a new sub-type of the VME habitat Coral Gardens.

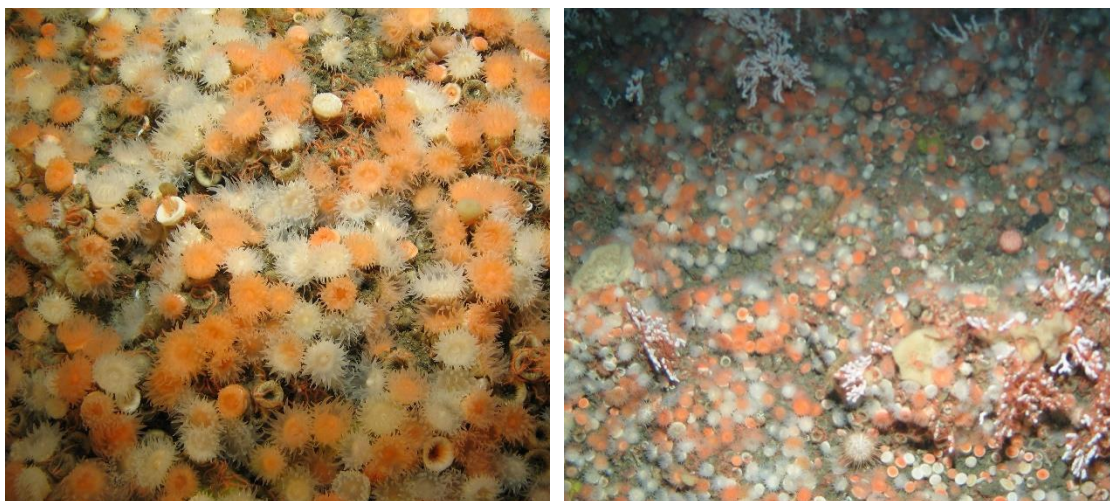


Figure 8.1 Hard bottom cup coral field seen at the Wyville-Thomson Ridge in UK waters. Images from tow WTR_4, from the Department of Trade and Industry (DTI) SEA_SAC 2006 survey ©DTI

8.4.3 Mud and sand emergent fauna

On review of the VME habitat type ‘Mud and sand emergent fauna’, it was agreed that the VME indicators were representative of different sub-types of this habitat, and as such would be better split into 3 VME sub-types: Stalked crinoid aggregations; Xenophyophore aggregations; and Stalked sponge aggregations. These changes would allow more definition than the broader habitat type, for VME data submissions.

8.4.4 Tube-dwelling anemone patches

The VME habitat 'Tube-dwelling anemone patches' currently has two representative taxa: Cerianthidae and Zoantharia. At the WKVME meeting, the group changed this habitat to 'Anemone aggregations' to incorporate the Zoantharia taxa. However, on discussion at WGDEC 2019 it was agreed that the broader use of 'anemone' in the habitat type may cause confusion to those using the VME list, particularly for data submissions to the VME database, as not all anemones are considered by the group to be VMEs as defined by the five FAO criteria (FAO, 2009). In addition, for other regional VME lists (e.g. the NAFO VME list²⁶) tube-dwelling anemones such as Cerianthidae are generally the only type of anemones listed. As such, a change was proposed for this habitat to 'tube-dwelling anemone aggregations'.

8.4.5 Proposed changes to the VME sub-types and indicators for Annex III of the deep-sea access regulations

The final changes proposed by the group were as follows, and are shown in Table 8.3 (revisions are denoted in red text):

- The cold-water coral reef VME habitat subtype *Lophelia pertusa* expanded to include *Madrepora oculata* reef to match the WKVME 2015 list.
- An additional VME habitat subtype to be added for coral gardens: Hard-bottom coral garden: Stylasterid corals on hard substrata, to match the WKVME 2015 list.
- A new VME habitat subtype to be added for coral gardens: Hard-bottom coral garden: cup coral fields.
- Changes of the three deep-sea sponge aggregations sub-types to two: Soft-bottom sponge aggregations and Hard-bottom sponge aggregations, to match the WKVME 2015 list.
- Change of the representative taxa for deep-sea sponge aggregations (see Table 8.2)
- Addition of three VME sub-types for the VME habitat type 'Mud and sand emergent fauna', based on the associated VME indicators: Stalked crinoid aggregations; Xenophophore aggregations; and Stalked sponge aggregations
- Change of tube-dwelling anemone patches to 'tube-dwelling anemone aggregations'.
- Addition of hydrothermal vents and cold seeps as VME habitat types (see Section 8.3).

²⁶ See Annex VI of <https://www.nafo.int/Portals/0/PDFs/COM/2019/comdoc19-01.pdf>

Table 8.3 Proposed changes to VME habitat types and sub-types to be included in Annex III of the EU deep-sea access regulations. Revisions are denoted in red. Representative taxa are not provided as further work on these is needed.

Proposed VME Habitat type	Proposed VME habitat subtype
Cold-water coral reef	<i>Lophelia pertusa/Madrepora oculata reef</i>
	<i>Solenosmilia variabilis reef</i>
Coral garden	Hard-bottom coral garden
	Hard-bottom coral garden: Hard-bottom gorgonian ²⁷ and black coral gardens
	Hard-bottom coral garden: Colonial scleractinians on rocky outcrops
	Hard-bottom coral garden: Non-reefal scleractinian aggregations
	Hard-bottom coral garden: Stylasterid corals on hard substrata
	Hard-bottom coral garden: Cup coral fields
	Soft-bottom coral garden: Soft-bottom gorgonian ¹ and black coral gardens
	Soft-bottom coral garden: Cup coral fields
Deep-sea sponge aggregations	Soft-bottom sponge aggregations
	Hard-bottom sponge aggregations
Sea-pen fields	Tube-dwelling anemone aggregations
Mud and sand emergent fauna	Stalked crinoid aggregations
	Xenophyophore aggregations
	Stalked sponge aggregations
Bryozoan patches	Hydrothermal vents/fields
	Cold seeps

²⁷ GORGONIAN IS NOW NOT A RECOGNISED TAXONOMIC TERM. HOWEVER, AS MANY DEEP-SEA BIOLOGISTS ARE FAMILIAR WITH THIS TERM, THIS VME INDICATOR WAS RETAINED.

8.5 References

- Best, M., Kenchington, E., MacIsaac, K., Wareham, V.E., Fuller, S.D. and Thompson, A.B. 2010. Sponge Identification Guide NAFO Area. NAFO Scientific Council Studies, 43. 50pp.
- Bridges *et al.*, *in prep.* Depth and latitudinal gradients in seamount benthic communities of the South Atlantic.
- Cárdenas, P. and Rapp, H.T. 2015. Demosponges from the Northern Mid-Atlantic Ridge shed more light on the diversity and biogeography of North Atlantic deep-sea sponges. *Journal of the Marine Biological Association of the United Kingdom* 95(7), 1475-1516.
- FAO. 2009. International Guidelines for the Management of Deep-sea Fisheries in the High Seas. FAO, Rome. 73 p
- ICES. 2013a. Report of the ICES\NAFO Joint Working Group on Deep-water Ecology (WGDEC), 11–15 March 2013, Floedevigen, Norway. ICES CM 2013/ACOM:28. 95 pp
- ICES. 2013b. General Advice. Assessment of the list of VME indicator species and elements. Special request Advice, June 2013.
- ICES. 2016. Report of the Workshop on Vulnerable Marine Ecosystem Database (WKVME), 10–11 December 2015, Peterborough, UK. ICES CM 2015/ACOM:62. 42 pp
- ICES. 2018. Advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011. ICES Special Request Advice North Atlantic Ecoregion. Published 28 June 2018 sr.2018.10.
- Kenchington, E., Beazley, L., Murillo, F.J., Tompkins MacDonald, G. and Baker, E. 2015. Coral, Sponge, and Other Vulnerable Marine Ecosystem Indicator Identification Guide, NAFO Area. NAFO Scientific Council Studies, 47. 74pp.
- Meyer, H.K., Roberts, E.M., Rapp, H.T. and Davies, A.J. (in review) Spatial patterns of arctic sponge ground fauna and demersal fish are detectable in autonomous underwater vehicle (AUV) imagery.
- Ramiro-Sánchez, B., González-Irusta, J.M., Henry, L-A, Cleland, J., Yeo, I., Xavier, J.R., Carreiro-Silva, M., Sampaio, Í., Spearman, J., Victorero, L., Messing, C.G., Kazanidis, G., Roberts, J.M. and Murton, B. 2019. Characterization and mapping of a deep-Sea sponge ground on the Tropic seamount (Northeast tropical Atlantic): implications for spatial management in the High Seas. *Frontiers in Marine Sciences* 6, 278.
- Roberts, E.M., Mienis, F., Rapp, H.T., Hanz, U., Meyer, H.K. and Davies, A.J. 2018. Oceanographic setting and short-timescale environmental variability at an Arctic seamount sponge ground. *Deep-Sea Research Part I* 138, 98–113.
- Xavier, J.R. and Bo, M. 2017. Deep-sea sponges of the Mediterranean Sea. <http://www.fao.org/3/a-i6945e.pdf>
- Xavier, J.R., Tojeira, I. and Van Soest, R.W.M. 2015. On a hexactinellid sponge aggregation at the Great Meteor seamount (North-east Atlantic). *Journal of the Marine Biological Association of the United Kingdom* 95(7), 1389-1394.

9 Update on links between the Joint ICES/NAFO Working Group on Deep-water Ecology and the General Fisheries Commission for the Mediterranean (GFCM) Working Group on Marine Protected Areas and Working Group on Vulnerable Marine Ecosystems

During WGDEC 2018, the group was updated on developments being undertaken through the General Fisheries Commission for the Mediterranean (GFCM) Working Group on VME (WGVME). At the 2018 WGVME meeting, a recommendation was made to create a GFCM VME database, containing information on VME indicator species and habitats, along the lines of that developed by WGDEC with the ICES Data Centre. It was therefore agreed that further knowledge sharing between WGDEC and WGVME would be beneficial, due to similarities in parts of the work being undertaken and the benefits of sharing knowledge of WGDEC and the ICES Data Centre's experience with the ICES VME database and VME data portal.

As a result, the GFCM secretariat invited the chair of WGDEC, Laura Robson, to attend their February 2019 meeting of the Working Group on Marine Protected Areas (WGMPA)²⁸ to share experience and help build more collaboration between the groups. The WGMPA Terms of Reference include:

1. Review the state of Fisheries Restricted Areas (FRAs) in the Mediterranean Sea, including an assessment of the state of the ecosystem and human dimension and assess the benefits of FRAs for protection and recovery of endangered /overexploited stocks in the GFCM area.
2. Identify potential areas for the establishment of new FRAs, including both ecosystem and socioeconomic analysis and identification of needs for a formal protection proposal.
3. Review of the state of implementation of Resolution GFCM/41/2017/5 on a network of Essential Fish Habitats (EFH), including advances on the implementation of the roadmap proposed by the Scientific Advisory Committee on Fisheries (SAC).
4. Advise the SAC on any EFH/VME related matters, including on potential management measures.

At the WGMPA 2019 meeting, an update was provided on progress on the management of VMEs and deep-sea fisheries in the Mediterranean, amongst other topics. It was raised that establishing a comprehensive picture of the distribution of VME indicator species across the Mediterranean from any survey type was important, and a discussion was held on the potential development of a GFCM interactive geodatabase to collate and display VME data, as advised by the WGVME in 2017 and 2018 (GFCM, 2019). The group agreed that developing such a database was necessary, starting with data from scientific surveys and publications. Additionally, it was agreed that an annual data call should be made in advance of relevant expert meetings to integrate new data.

As a result, a sub-group was formed to develop a proposed format for the database. Further work on this was completed intersessionally from February to April 2019, by experts including

²⁸ Note, since 2018, the WGVME has been subsumed into the remit of the WGMPA. The group will likely change name next year to include these two aspects (VMEs and MPAs)

two attendees from WGDEC (Covadonga Orejas and Laura Robson), with input from the GFCM to adapt the template. The sub-group based the format on the ICES VME data submission template, and revised fields to ensure relevance to Mediterranean data types for both scientific survey and commercial fisheries, and alignment with the GFCM VME Encounter Protocol where possible. The aim for the database was that data received would be presented to GFCM relevant technical meetings and presented to the Scientific Advisory Committee (SAC) annually for validation.

Following final agreement on the proposed template with the GFCM secretariat, initial data on *Isidella elongata* (Figure 9.1), a species known to be in decline in the Mediterranean due to fisheries impacts and thus listed under Annex II of the Barcelona Convention (UNEP/MAP, 2018) and listed as critically endangered on the IUCN Mediterranean Red List, were submitted to GFCM to be presented at the SAC in June 2019.



Figure 9.1 *Isidella elongata*, listed as critically endangered on the IUCN Mediterranean Red List, and listed under Annex II of the Barcelona Convention. © Oceana

At WGDEC 2019, the group were updated on developments with the GFCM VME database, and some discussion was had about future collaborative efforts between the groups. It was agreed that it would be beneficial for WGDEC to maintain collaboration with the GFCM WGMPA and contribute to the group, considering the previous experience of WGDEC, i.e. involving experts from different countries and, together with the ICES Data Centre, establishing an operational VME database with annual data calls to update it with new data, forming a solid foundation for the ICES Advisory Committee's (ACOM) advice process to inform NEAFC and EU. This ICES process might be a useful source of information for GFCM WGMPA to further refine their database and subsequent assessments. This could also serve to harmonize respective ICES and GFCM approaches for any potential joint work/assessments involving respective WGDEC and WGMPA groups. WGDEC, however, noted that there would first need to be a formal request from the GFCM side to involve ICES for such work/assistance, with subsequent planning and resources allocated accordingly. Such an initial agreement could, for example, be included within the cooperation agreement between ICES and GFCM. It was suggested that joint project funding, involving the ICES Data Centre, could also be an option to further such work if agreed by GFCM and ICES.

9.1 References

GFCM. 2019. Report of the third meeting of the Working Group on Marine Protected Areas (WGMMPA), FAO HQ, Italy, 18-21 February 2019

UNEP/MAP-SPA/RAC. 2018. SAP/RAC: SPA-BD Protocol - Annex II: List of endangered or threatened species. http://www.rac-spa.org/sites/default/files/annex/annex_2_en_20182.pdf

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Annex 2: Resolutions

The Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), chaired by Laura Robson, UK, will meet [TBC] 2020 in [TBC] 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, archive appropriately using the ICES VME Database, and disseminate 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. In addition, provide new information on the location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters;
- c) Develop standards for the provision of absence data and OSPAR habitat data to the ICES VME database, and utilise VME indicator data records to further develop and test kernel density estimation methods to assess VME likelihood;
- d) Building on work initiated in 2019, work jointly with the WGMHM to undertake case studies for VME data-rich and data-poor areas, to test the use of habitat suitability models for the provision of recommendations to the ICES advisory committee (ACOM) on how to incorporate such information when suggesting VME closures through draft ICES advice;
- e) Continue work started in 2019 to build links between the WGFBIT and WGDEC to explore the potential to further adopt/adapt the WGFBIT framework for deep-sea assessments and its use for marine spatial planning, taking into account work developed through ToR [d] on modelling methods to support VME distribution mapping.

WGDEC will report by [date TBC] to the attention of ACOM.

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	<p>ToR [a]</p> <p>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 January to March 2020, facilitated by the ICES Data Centre. Data will be quality checked/prepared one month in advance of WGDEC 2020. New data will be incorporated into the ICES VME database and 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.</p> <p>ToR [b]</p> <p>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” 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.</p> <p>ToR [c]</p> <p>The VME weighting algorithm was developed in 2015/2016 to utilise data in the ICES VME database from a range of survey types, to determine likelihood of VME presence and associated confidence. In 2019, new methods of determining VME likelihood were explored via kernel density estimation (KDE). This ToR will further this work and look to address limitations in the use of KDE on datasets from the VME database, to optimise its use for assessing VME likelihood. The inclusion of absence data, and additional presence records from the OSPAR database, to the VME database would further enhance any assessment of VME likelihood, therefore this ToR will also identify standards to include these data types.</p> <p>ToR [d]</p> <p>The potential use of Species Distribution Modelling (SDM) and Habitat Suitability Modelling (HSM) as a tool to identify areas where VME are likely to occur, has arisen several times over the last ten years in WGDEC. However it has not yet been used to provide recommendations to ACOM on how to incorporate such information when suggesting VME closures through draft ICES advice. This ToR will utilise the considerations for model creation and criteria for model use developed at WGDEC 2019, to test the use of HSM for two case study areas: one data-rich and one data-poor, and document the methods, decisions taken, and issues encountered.</p> <p>ToR [e]</p> <p>ICES is assisting Member States in progressing assessments for key descriptors of the Marine Strategy Framework Directive (MSFD) to support assessment of Good Environmental Status (GES). WGDEC 2019 reviewed the applicability of assessment approaches for fisheries benthic impacts (Descriptor 6: seafloor integrity), developed through the ICES Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), to deep-sea habitats including VME. However, application of this method in light of limitations in data availability for the deep sea needs further consideration. This ToR will explore the potential to further adopt/adapt the WGFBIT framework for deep-sea assessments, taking into account modelling methods being developed through ToR [d] which could support VME distribution mapping, and look to determine its use for Marine Spatial Planning.</p>
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 and SharePoint site provision.
Financial	No financial implications.
Linkages to advisory committees	ACOM is the parent committee and specific ToRs from WGDEC provide information for the Advice Committee to respond to specific requests from clients.
Linkages to other committees or groups	While there are currently no direct linkages to other groups, WGDEC should develop stronger links (ideally through the establishment of joint Terms of Reference) with WGSFD, WGMHM, WGDEEP and WGFBIT.
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; specifically, WGESA.

Annex 3: Catches of cold-water corals and sponges in the North Atlantic as reported in observations obtained by Russian fishing vessels in 2018

Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC) 2019

Working Document

V. Khlivnoi

Polar Branch of FSBSI «VNIRO» («PINRO» named after N.M. Knipovich)

Introduction

Targeted research of vulnerable marine ecosystems (VMEs) in the North Atlantic conducted by Russian fishing vessels was started in 2007-2008 (Vinnichenko *et al.*, 2009). Afterward, the research was continued on regular basis (Vinnichenko, 2010; Vinnichenko *et al.*, 2011; Vinnichenko and Sukhangulova, 2012; Vinnichenko and Kanishchev, 2013; Vinnichenko, Kanishchev and Fomin, 2014; Vinnichenko and Kanishchev, 2015; Kanishchev and Zavoloka, 2016; Fomin, 2018).

The objective of this Annex is to submit information on the results of Russian studies of VMEs conducted in the North Atlantic in 2018 to ICES and NAFO.

Materials and methods

Data on VMEs was collected by observers during one fishing vessel cruise on the Grand Bank of Newfoundland and the Flemish Cap (NAFO divisions 3LM) in April-May 2018 (Table A3.1). The observations included:

- records of VME indicator species in catches;
- taxonomic identification of corals and sponges using relevant NAFO indicators (Kenchington *et al.*, 2009, Best *et al.*, 2010, Kenchington *et al.*, 2015);
- photographing of corals and sponges for their identification ashore;
- registration of catch locations of corals and sponges using the GPS system.

Results

In 2018, in the NAFO Regulatory Area (RA), cold-water corals were recorded in the waters of the Flemish Cap, the Flemish Pass and the Grand Banks of Newfoundland between 48°08'5 – 48°40'0 N, 45°35'8 – 47°42'7 W over the depth range from 950 to 1250 m (Table A3.1).

The representatives of two orders occurred in the catches: Alcyonacea (soft and dendriform corals), with the genus *Anthoptilum* predominating, and Pennatulacea (sea pens). Three cases of sponge catch were recorded: representatives of the genus *Geodia* were caught twice and there was one case of *Vasella pourtalesi* catch (Table A3.2).

The amount of caught VME indicator species everywhere did not exceed 1 kg per haul.

Discussion and conclusion

The data on VME indicator species has been regularly collected by the Russian fishing vessels in the NAFO RA for eleven years. Observations covered an extensive area of bottom fisheries in the open part of the Newfoundland area, however there was no evidence of coral and sponge aggregations. Data collected in 2018 has reaffirmed the results of the previous research. In traditional fishing grounds, catches of cold-water corals and sponges were significantly below the threshold level established by the NAFO Fisheries Commission. Thus, the results of long-term Russian research suggest the absence of VMEs in traditional bottom fishing areas in the Newfoundland area of the NAFO Regulatory Area.

Table A3.1 Areas of North Atlantic VMEs research covered by Russian fishing vessels in 2018

Area	Coordinates		Depths, m	Target species	Number of hauls
	Northern latitude	Western longitude			
Newfoundland area	48°08'5 - 48°40'0	45°35'8 - 47°42'7	950-1250	Greenland halibut	60

Table A3.2 Composition and amount of coldwater corals and sponges caught by Russian trawlers in NAFO RA in 2018

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Weight, kg
Set of gear		Sampling						
N	W	N	W					
48°52'9	45°03'6	48°40'0	45°35'8	1260-1140	<i>Duva florida</i>	2	3-5	10
48°52'9	45°03'6	48°40'0	45°35'8	1260-1140	<i>Funiculina quadrangularis</i>	2	5-10	10
48°19'8	46°26'3	48°31'8	45°57'5	980-1080	<i>Duva florida</i>	3	3-5	15
48°19'8	46°26'3	48°31'8	45°57'5	980-1080	<i>Anthoptilum</i> spp.	2	10	15
48°20'4	46°23'0	48°12'4	46°52'5	960-1020	<i>Acanella</i> sp.	1	5	5
48°20'4	46°23'0	48°12'4	46°52'5	960-1020	<i>Geodia</i> spp.	2	10-12	840
48°18'0	46°29'7	48°09'7	46°59'8	950-970	<i>Funiculina quadrangularis</i>	7	3-5	18
48°18'0	46°29'7	48°09'7	46°59'8	950-970	<i>Geodia</i> spp.	3	8-12	690
48°18'0	46°29'7	48°09'7	46°59'8	950-970	<i>Vasella pourtalesi</i>	4	10-15	300
48°08'2	47°10'2	48°08'5	47°42'7	950-1000	<i>Funiculina quadrangularis</i>	4-10	5-10	15
48°08'8	47°40'6	48°08'8	47°08'1	1020-1000	<i>Funiculina quadrangularis</i>	5	3-10	10

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Weight, kg
Set of gear		Sampling						
N	W	N	W					
48°09'2	47°28'3	48°09'2	47°07'0	1120-1070	<i>Anthoptilum</i> spp.	4-7	5-10	15
48°09'8	47°12'7	48°09'8	47°41'6	1150-1250	<i>Anthoptilum</i> spp.	4-7	5-10	15
48°10'2	47°37'4	48°10'2	47°05'0	1200-1250	<i>Anthoptilum</i> spp.	4-7	5-10	15
48°09'0	47°12'0	48°09'2	47°40'8	1030-1180	<i>Acanella</i> sp.	1	7	10
48°09'2	47°10'9	48°09'2	47°40'0	1050-1180	<i>Anthoptilum</i> spp.	4-6	5-10	15
48°09'2	47°10'9	48°09'2	47°40'0	1050-1180	<i>Funiculina quadrangularis</i>	4-8	5-10	20

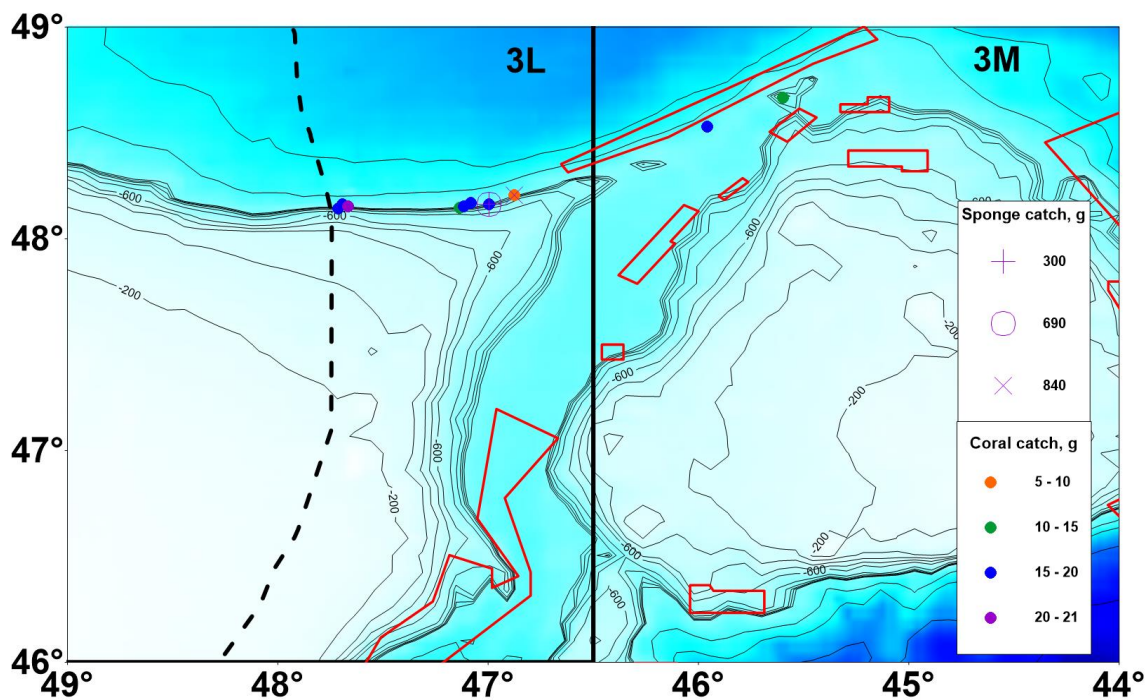


Figure A3.1 Occurrence of cold-water corals and sponges in the NAFO Regulatory Area in 2018

References

Best, M., E. Kenchington, K. MacIsaac, V.E. Wareham, S.D. Fuller & A.B. Thompson. 2010. Sponge Identification Guide: NAFO Area. NAFO Scientific Council Studies, 43:1-49. doi:10.2960/S.v43.m1.

Fomin, K.Yu. Catches of coldwater corals and sponges in the North Atlantic as reported in observations obtained by Russian fishing vessels in 2016-2017. Working Document to the ICES/NAFO WGDEC 2018. Dartmouth, Canada, 2018.

- Kanishchev A.A. and Zavoloka P.A. Russian catches of coldwater corals and sponges in the North Atlantic based on the data of observations by fishing vessels in 2015. Working Document to the ICES/NAFO WGDEC 2016. Copenhagen, Denmark, 2016.
- Kenchington, E., M. Best, A. Cogswell, K. MacIsaac, J. Murillo-Perez, B. MacDonald, V. Wareham, S. D. Fuller, H. I. Ø. Jørgensbye, V. Sklyar & A. B. Thompson. 2009. Coral Identification Guide NAFO Area. Scientific Council Studies, 42: 1-23. doi:10.2960/S.v42.m1.
- Kenchington, E., L. Beazley, F. J. Murillo, G. Tompkins MacDonald, E. Baker. 2015. Coral, Sponge, and Other Vulnerable Marine Ecosystem Indicator Identification Guide, NAFO Area. NAFO Sci. Coun. Studies, 47: 1-74. doi:10.2960/S.v47.m1.
- Vinnichenko V.I., Sklyar V.V., Zhivov B.D. and Mashkov V.N. 2009. Encounter of coldwater corals in the Iceland and Faeroe Islands areas (by the results on Russian researches in 2007-2008). Working Document to the ICES WGDEC 2009 Copenhagen, Denmark, 9-13 March 2009.
- Vinnichenko V.I. 2010. Russian investigations of Vulnerable Marine Ecosystems in the Newfoundland area. Unreviewed Working Document to the ICES WGDEC 2010. Copenhagen, Denmark, 22-26 March 2010.
- Vinnichenko V.I., V.N. Zelinsky, K. Yu. Fomin. 2011. Russian catches of coldwater corals and sponges in the Northwest Atlantic in 2010. Working Document to the ICES/NAFO WGDEC 2011. Copenhagen, Denmark, 28 February- 4 March 2011.
- Vinnichenko V.I. and K.O. Sukhagulova. 2012. Russian catches of coldwater corals and sponges in the North Atlantic based on the data of observations by fishing vessels in 2011. Working Document to the ICES/NAFO WGDEC 2012. Copenhagen, Denmark, 2012.
- Vinnichenko V.I. and A.A. Kanishchev. Russian catches of coldwater corals and sponges in the North Atlantic based on the data of observations by fishing vessels in 2012. Working Document to the ICES/NAFO WGDEC 2013. Floedevigen, Norway, 2013.
- Vinnichenko V.I., A.A. Kanishchev, K.Yu. Fomin. Russian catches of coldwater corals and sponges in the North Atlantic based on the data of observations by fishing vessels in 2013. Working Document to the ICES/NAFO WGDEC 2014. Copenhagen, Denmark, 2014.
- Vinnichenko V.I. and A.A. Kanishchev. Russian catches of coldwater corals and sponges in the North Atlantic based on the data of observations by fishing vessels in 2014. Working Document to the ICES/NAFO WGDEC 2015. Horta, the Azores, 2015.

Annex 4: ATLAS work conducted to assess GES in specific Case Study areas (NE Atlantic)

The academic exercise on addressing the issue “GES assessment in the deep sea” using the software NEAT, was carried out in 9²⁹ of the 12 ATLAS European case studies (not all of them subject to MSFD) across the North Atlantic (Figure A4.1) to showcase how existing data could be integrated into regional GES assessments and to identify constraints on this approach.

To evaluate the four MSFD descriptors detailed in Section Summary 5.3, a selection from the 500 scientific indicators included in NEAT was conducted. In addition, new scientific indicators were proposed by ATLAS experts, considering the specific constraints of working in the deep sea (e.g. remoteness, difficulties in conducting scientific surveys and sampling, lack of baseline data and long-term monitoring) and the main characteristics of these ecosystems (Table A4.1). GES boundary values were also defined for each scientific indicator. In most cases, this was a difficult task because of the lack of pre-impacted or historical information to use as baseline or reference condition information, together with the limited knowledge on many aspects of deep-sea ecosystems. To help with this challenging task, a comprehensive literature review was performed collecting quantitative data of different taxa (e.g. D6, indicator: % covered by *Lophelia pertusa*) to facilitate the task of setting-up threshold values. Experts from ATLAS highlighted constraints around baseline data availability for all descriptors. The work conducted through ATLAS to assess GES highlighted important aspects to be considered when addressing GES in the deep sea (Table A4.2). The ATLAS work conducted in the GES assessment in the deep sea also included a comprehensive review of the results of the MSFD initial assessments by Member State countries as well as reports produced by the different task groups and scientific literature. The ATLAS work on GES is summarized in a Deliverable report which is currently under review.

Work is continuing in ATLAS with a risk analysis based on comparison of the degree of overlap between fishing activity/ trawl swept area, derived from open access Automatic Identification System (AIS) data, and the predicted distribution of Vulnerable Marine Ecosystem (VME) indicator taxa and selected deep-sea fish. The approach is similar to that adopted by Buhl-Mortensen *et al.* (2019), assessing coral and sponge VME distribution and threats in the Arctic and sub-Arctic waters. The VME indicator taxa selected included three scleractinian corals (*Lophelia pertusa*, *Madrepora oculata*, and *Desmophyllum dianthus*), and three gorgonians (*Acanella arbuscula*, *Acanthogorgia armata*, and *Paragorgia arborea*). The six deep-sea fish species selected were the roundnose grenadier (*Coryphaenoides rupestris*), Atlantic cod (*Gadus morhua*), bluemouth rockfish (*Helicolenus dactylopterus*), American plaice (*Hippoglossoides platessoides*), Greenland halibut (*Reinhardtius hippoglossoides*), and beaked redfish (*Sebastes mentella*). Transparent assessment is facilitated through the development of open access R scripts. The outputs of this work will be available to WGDEC 2020.

²⁹ The exercise has been conducted in 6 countries that are full members of European Union (France, Ireland, Portugal, Spain, The Netherlands, United Kingdom) and two non-members (Norway and Iceland), however considering the interest to perform this exercise in all European case studies the assessment was also performed for the case study 1 (Love Observatory, Norway) and case study 9 (Reykjanes Ridge, Iceland)

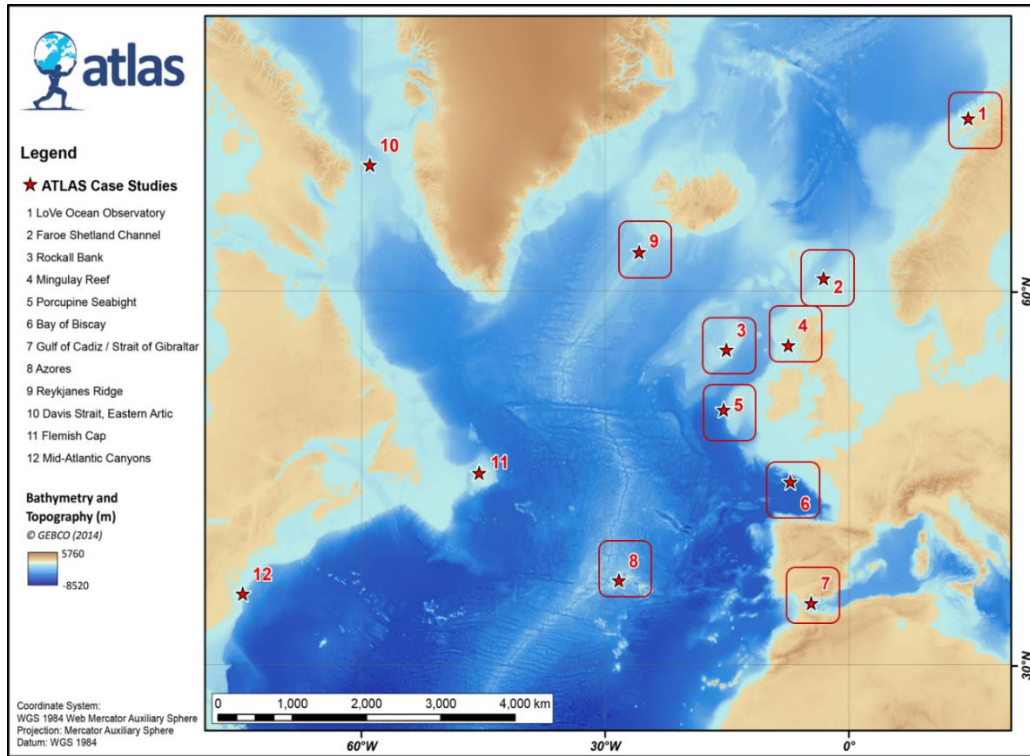


Figure A4.1. ATLAS case study areas are highlighted with red stars. Good Environmental Status has been addressed in the case studies 1 to 9, highlighted with the red squares. The legend in the left of the image indicates the names of each case study (Source: GEBCO. Image provided by British Geological Survey)

Table A4.1 Scientific indicators agreed by case study leads in the ATLAS project, to assess GES using NEAT. Scientific indicators denoted in orange were the new indicators added to the already existing NEAT scientific indicators (source: Deliverable 3.1 ATLAS project).

Indicators												
D1	Distributional range and patterns of selected (sensitive) non-commercial demersal fish	Species richness of non-commercial fish	Abundance of non-commercial demersal fish and cephalopods	Abundance of non-commercial functional groups of fish	Species Diversity (Shannon Index) of non-commercial species							
D6	Abundance of coral colonies alive	Areal extent of biogenic / vulnerable habitats (type, abundance, biomass, condition and areal extent of relevant biogenic substrata)	Areal extent of human affected area	Areal extent of protected sea areas	Density of biogenic reef forming species (type, abundance, biomass and areal extent of relevant biogenic substratum per habitat type)	Distribution and condition of habitat forming species	Areal extent of sedimentary seafloor / vulnerable habitats (type, abundance, biomass, condition and areal extent of relevant sedimentary communities)	Abundance and composition of functional groups in selected habitats	Species richness of corals	Ratio of life versus dead/overgrown coral cover	VMEs and VME indicator taxa (status, areal extent, size frequency distribution)	Structural complexity

Table A4.2 Important considerations in the assessments of GES in the deep sea identified by the ATLAS project

Scientific knowledge	Biology and ecology. Ecosystem functioning	<ul style="list-style-type: none"> - Identify ecological structures and functions of particular importance in deep-sea ecosystems - Use of trends with respect to a reference level when no reference values are available - Identify natural disturbances on the seafloor, resilience and recovery potential - Assess functionality and resilience, information on sensitivity and pressures needs to be considered together to evaluate overall impact - Use of results from aquaria experiments to define tipping points, establish baselines and target values - Perform Species Distribution Models and Habitat Suitability Models as they can provide useful information to assess GES in current and future scenarios - Identify source and sink populations to select key areas for geographical connectivity and establish priorities to assess GES
	Environmental data	<ul style="list-style-type: none"> - Consider environmental drivers and interannual variability and seasonal effects - Consider environmental features from the water column in GES assessment - Consider environmental features from the seafloor in GES assessment
	Spatial and temporal scales	<ul style="list-style-type: none"> - Consider temporal and spatial scales depending on the indicator addressed - Integrate results from local scales to sub regional and regional scales
Pressures and impacts	Human pressures	<ul style="list-style-type: none"> - Identify the human pressures known or likely to reach levels that degrade environmental status - Analyse pressure maps together with NEAT results to better interpret the data to disentangle anthropogenic and natural effects
	Physical damage	<ul style="list-style-type: none"> - Identify physical damage in substrate characteristics - Identify physical damage regarding climate change effects
Methodologies	Underwater technology and data processing	<ul style="list-style-type: none"> - Adapt existing methodologies (e.g. Side Scan Sonar, AUVs, machine learning...) for better and more effective deep-sea mapping
	Data access	<ul style="list-style-type: none"> - Access to VMS (Vessel Monitoring System) data and AIS data (Automatic Identification System) - Deposition of collected data in online data bases (e.g. https://www.pangaea.de/)
	Standardisation	<ul style="list-style-type: none"> - Need for data and protocol standardisation (e.g. video and photo data)

Monitoring	Spatial and temporal scales	<ul style="list-style-type: none"> - Select areas considered of special relevance (e.g. ecological relevance, relevance for fisheries or other anthropogenic activities) to conduct monitoring programs - Select appropriate monitoring scales (spatial and temporal) considering scientific Indicators and pressures - Ten years have been considered as an adequate time frame for GES monitoring in the deep sea - Set-up and monitor reference areas (e.g. MPAS) as baselines/reference for GES assessment
	Technical requirements	- Asses the financial and technical requirements needed for the pursuing of the suggested monitoring programmes. This will also guide further the establishment of priorities in terms of areas and indicators to be monitored.
	Science-Industry interface	- Establish pathways for collaboration between industry and academia

Annex 5: Technical minutes from the Vulnerable Marine Ecosystems Review Group

- RGVME
- By correspondence August 2019
- Participants: Emanuela Fanelli (Chair), Rabea Diekmann, Miriam Tuaty Guerra and Sebastian Valanko (ICES Secretariat)
- Working Group: WGDEC and WGSFD

1. Overview

In response to the two advice requests (EU, NEAFC), this report reviews (i) the spatial data, historical and new information, provided by the Working Group on Deep-water Ecology (WGDEC) and the Working Group on Spatial Fisheries Data (WGSFD), on the distribution, vulnerability and abundance (VME index) of VMEs in the Northeast Atlantic, and (ii) the occurrence of fisheries activities in the vicinity of VMEs in the NEAFC convention area.

The review group worked by correspondence during the period indicated (from 1st to 16th August 2019). A first email exchange among the participants took place at the beginning of July in order to agree on the review approach. Participants decided to work simultaneously, providing separate reviews and then the chair organized a teleconference on 9th August 2019, to identify the main advice points for the report.

Then the RG worked by correspondence and all members considered there was no need for a further teleconference. They agreed by correspondence on 16th August 2019 on the final advice provided in this report.

The review document is structured according to some general remarks and the two requests.

2. General remarks:

Three areas were considered in the NEAFC Regulatory Area (Hatton Bank, Rockall Bank, and the North East Barents Sea) and ten areas within the EEZs of EU countries and wider.

For each area, the report provides maps with the new VME indicator and/or habitat records, the outputs of the VME likelihood index based on the VME weighting algorithm, and the associated VME index confidence layer. The method used for the calculation of the VME index had been described in Section 7 of the WGDEC 2018 report (ICES, 2018).

- a) The RG is highly pleased about the extensive dataset (indicator and habitat records) that was collected as response to the ICES data call in 2019 and that was analysed by WGDEC. In total, 26 379 new presence records were received, some of them had been considered in previous WGDEC reports, but were not yet included in the ICES database (JNCC re-submission). Of all new records, 93 were located within the NEAFC Regulatory Area, and the remaining 26 286 were found within the Exclusive Economic Zones of North Atlantic ICES/NAFO member states. Of these records, 21 353 were provided by the Department of Fisheries and Oceans (DFO) of Canada. No new VME submissions were received for areas within the NAFO Regulatory Area.

This large amount of data likely increases the confidence in the identification of VME habitats. It also demonstrates a collaborative commitment by all countries and a valuable approach by ICES, which could be of inspiration also for other RFMOs and International commissions.

- b) According to the request of the Review Group in 2018, also absence data were reported, with a total of 433 records collected between 2006 and 2018 and 314 records as part of 2019 data call, spread across the NEAFC Regulatory Area (Rockall Bank and the Barents Sea), the UK's EEZ, Ireland's EEZ, Norway's EEZ, and Russia's EEZ, which may aid in the interpretation of the VME presence records. WGDEC mentioned doubts about the usefulness of absence data, as data from ROV and trawling provide absence records at different spatial scales. Additionally, data from trawling are not fully reliable because trawling has a low VME catchability. As a consequence, WGDEC did not consider absence records as part of their ToRs but proposed a specific ToR for 2020. The Review Group recognises the caveats but supports WGDEC in analysing absence data in future meetings and further recommends to continue collecting absence data in future data calls. Additionally, as already highlighted by the RG 2018, having absence information will allow a broad array of geospatial modelling techniques to be used in the future.
 - c) Regarding point 3.3 "Data Providers for ToR [a]" the RG noted that in some sections the type of VME habitats or indicators is described, whereas in others only summary tables are provided. The RG recommends harmonization of descriptions.
 - d) The RG suggests that in data-rich areas, i.e. where regular surveys were carried out, it would be useful to present data additionally on a spatial-temporal scale in order to evaluate changes in VMEs distribution over time.
 - e) The RG considers for the next years that the WGDEC should focus on the definition of thresholds for the different VMEs (not only corals and sponges). The RG is aware that this could be a hard task but at the same time considers it could be an improvement in the VME weighting system.
 - f) As reviewed last year, the use of the VME vulnerability index (i.e. use of indicator species) with the associated confidence index provides useful supporting information for interpreting the distribution of VMEs. Still, considering the patchy distribution of the observations, the RGVME supports the use of predictive modelling techniques for providing a fuller representation of 'suitable habitat' or potential VME distribution.
 - g) The RG fully supports the development of an automation process for the inclusion of OSPAR records into the ICES VME database using a data script in R, as mentioned in the Report.
 - h) RGVME 2018 had mentioned that some details about how the VME likelihood index was calculated remained unclear. Unfortunately, this was not clarified in this year's report (e.g. concerning multiple indicator observations in one grid cell). RGVME thus asks WGDEC to outline the method again in the following year report and address the concerns mentioned by RGVME in 2018.
3. **EU request –"As part of the MoU with the European Commission, ICES is requested to: Provide any new information regarding the impact of fisheries on other components of the ecosystem including small cetaceans and other marine mammals, seabirds and habitats. This should include any new information on the location of habitats sensitive to particular fishing activities".**

Altogether, ten areas were considered within the EEZs of EU countries and wider (Faroe-Shetland Channel, Rockall Bank, Rosemary Bank Seamount, Wyville-Thomson Ridge, Irish continental shelf, Spanish continental shelf (Gulf of Cadiz), Formigas Seamount (Azores, Portugal), Mid-Norwegian continental shelf, Central Barents Sea and South West Barents Sea (Tromsø Flaket), and North West Barents Sea (Svalbard)).

The report stated that e.g. Norway provided 995 records of VME habitats from 2006-2016 and data from 2006 to 2018 for sponges (2291 new presence records). The RG considers that in case of data-rich areas, where regular surveys have been carried out, it would be useful to present data additionally on a spatial-temporal scale, in order to assess if VMEs have been impacted by fisheries throughout the reported period (e.g., if a decrease in the number of records was observed).

Concerning Iceland, the 1279 new records reported, were obtained from a survey carried out in 2004, which means 15 years ago. The RGVME considers that, although this information is rather old, in case of new surveys, it could provide a georeferenced base against which to compare new data and assess the VMEs status.

Spain submitted new VME records for Spanish and Portuguese waters as well. However, the origin of the latter is not appropriately specified, neither in the text, nor in the Table. The RGVME considers that both the origin and the new VME types must be clearly specified, as from the Gazul Mud Volcano (Gulf of Cadiz, Spain) or from the Formigas Seamount (Azores, Portugal). Such practice should apply both to the current and future reports.

4. NEAFC requests ICES 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 and the above mentioned objectives.

Three areas were considered in the NEAFC Regulatory Area: Hatton Bank, Rockall Bank, and the North East Barents Sea.

Considering the new records observed on Rockall Bank (Figure 4.2), just in the central area of the bank, the RGVME wondered about the low likelihood of encountering VMEs. The same consideration can be applied for data from North East Barents Sea (Figure 4.8). The RG is aware that the weighting algorithm takes into account abundance data, but also considers that thresholds are established only for some groups of species, i.e. corals and sponges, and this could affect the output of the analysis when such index is applied to other species.

The RGVME was additionally asked to review information about the fisheries footprint in relation to VMEs. VMS data from 2018 were received from NEAFC via the ICES Secretariat, along with catch information from logbooks, authorization details, and vessel information from the NEAFC fleet registry. Data were analysed by the WGSFD, to support the NEAFC request to ICES to provide information on the distribution of fisheries activities in and in the vicinity of VME habitats.

Similar to ICES (2018) the report mentions problems with the quality of the VMS speed data in 2018. The polling frequency was still low (4h), which is however beyond the influence of WGSFD. Further, speed information was largely missing and therefore vessel speeds had to be calculated as the great-circle (orthodromic) distance between consecutive points reported by a vessel, divided by the time difference between them. The group used a speed of 5 knots to demarcate fishing from non-fishing pings for all gears. The presented speed profile indicates that this is a reasonable threshold, at least for mobile bottom contacting gears. It would be however useful to exclude static gears from the speed histogram in the future, as fishing activity of the latter is likely related to lower vessel speeds.

Generally, RGVME evaluates that the currently available information on the intensity of fishing with bottom contacting and static gears was analyzed adequately and thus allowed an overlay with VME layers. Further, RGVME considers the representation of speed filtered pings as points on maps with VME records as best display option.

The maps in the report (Figs. 4.53 to 4.59) illustrate that trawling often concentrates along the border of closed areas; vessels usually comply with measures. However, as point data VMS pings on the maps are small, RGVME recommends that in the future the number of pings (identified as fishing) within closed areas should be given as well. Although misinterpretations due to the speed-filtering algorithm are possible, it would give further information about fishermen's compliance with measures.

Based on this review, RGVME is content that the VME vulnerability index and habitat observations represent the best available evidence of representing the likely distribution of VMEs, and are a suitable evidence base for ICES to provide the requested advice to the EU and NEAFC. RGVME further evaluates that VMS data, despite all data problems, were analysed adequately and the output of the analyses was sufficient to indicate the intensity and distribution of fishing activities within NEAFC regulatory areas.

References

ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 123 pp.