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

VOLUME 2 | ISSUE 62

ICES SCIENTIFIC REPORTS

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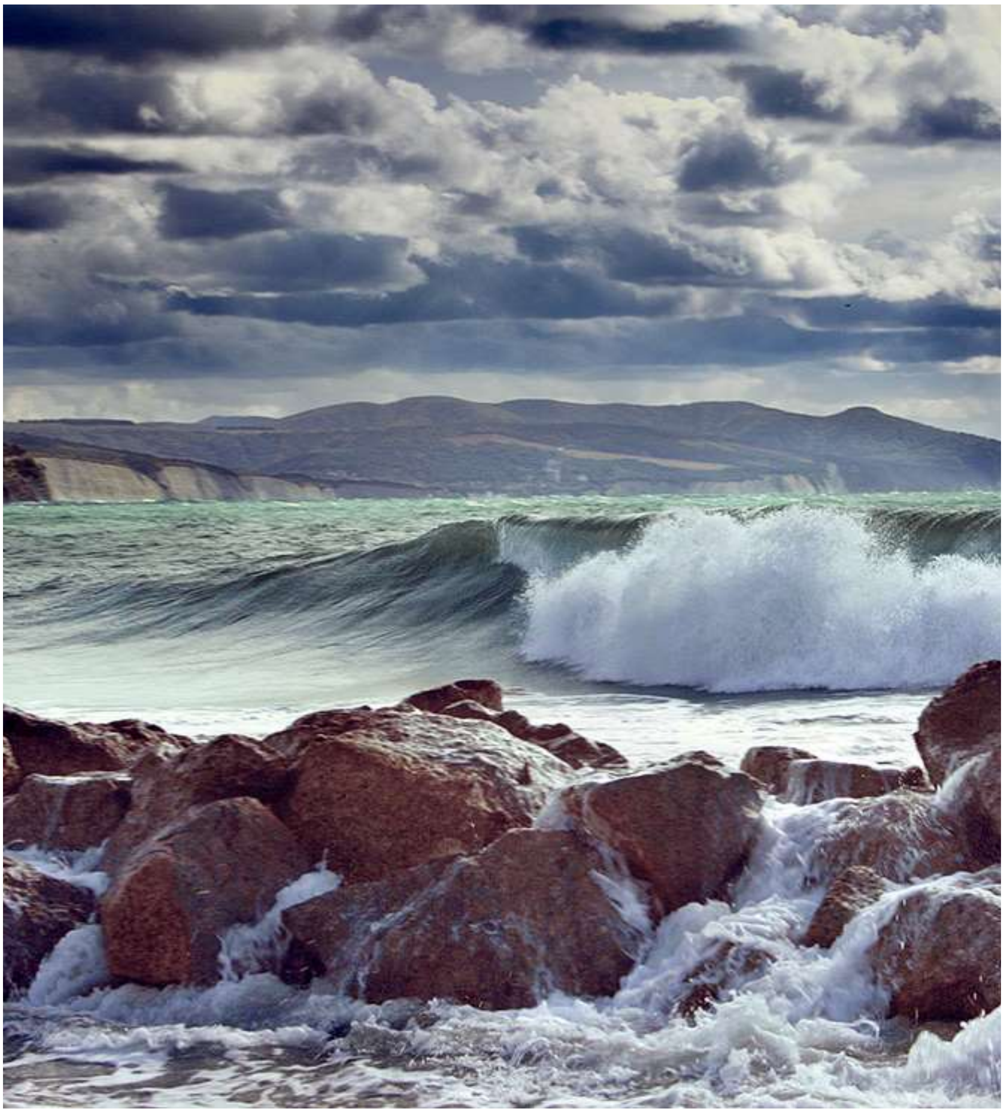

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
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ISSN number: 2618-1371 I

ICES Scientific Reports

Volume 2 | Issue 62

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

Recommended format for purpose of citation:

ICES. 2020. ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC).
ICES Scientific Reports. 2:62. 171 pp. http://doi.org/10.17895/ices.pub.6095

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Contents

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 4609 new presence records and 181 absence records, were submitted through the ICES VME data call in 2020 and were included within the ICES VME database. This information was collated and mapped by WGDEC, to support ICES in providing 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. VMS data from NEAFC was analysed by the Working Group on Spatial Fisheries Data (WGSFD), and outputs were used by WGDEC to assess whether fishing activity was occurring in the vicinity of VMEs in the NEAFC Convention Area, to support ICES advice.

Another objective this year was to further develop approaches for the inclusion of absence data and data from the OSPAR habitats database, into the ICES VME database. Absence data would add value to development of predictive habitat models for VMEs. However, some challenges with collection of absence data include the survey method used and associated spatial scales, where different approaches would mean data were not comparable. Furthermore, absence data should not be confused with ‘missing data’, which is particularly prudent for the deep sea where limited surveys have taken place. A series of criteria to be fulfilled for any submissions of VME absence data to the VME database were identified by the group.

Methods to bring OSPAR records into the ICES VME database have been developed. However, the need to quality assure OSPAR data before it is transferred to the database is vital to avoid duplication of records already in the VME database. Additionally, further work needs to be done to encourage data providers to submit records to both the ICES VME and OSPAR databases to avoid the need for annual exchanges of data between the two.

Due to restrictions of working remotely this year, further testing on the use of predictive habitat models for the provision of information on potential VME presence was not undertaken. However, WGDEC agreed that an intersessional benchmark workshop prior to WGDEC 2021 would provide a more effective forum to complete this work, with the aim of developing a set of criteria, against which new and existing models will be reviewed to determine appropriate standards for their use for future ICES advice.

A final objective this year was to finalise the proposed changes to the list of VME habitats and representative taxa, for submission to the European Commission. Work undertaken during WGDEC 2019 and an intersessional sub-group was built upon, and proposed taxa were evaluated against the FAO criteria for the prevention of significant adverse impacts on VMEs and protection of the marine biodiversity. Proposals were drafted for hydrothermal vents and cold seeps, cold-water coral reefs, coral gardens, deep-sea sponge aggregations and sea pen fields. This list will be finalised intersessionally to include tube-dwelling anemone aggregations, stalked crinoid aggregations, xenophyophore aggregations and bryozoan patches.

ii Expert group information

Expert group name	ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair	Laura Robson, United Kingdom
Meeting venue(s) and dates	4-8 May 2020, By correspondence (25 participants)

Ole Secher Tendal

It was with great sadness that WGDEC learned of the recent passing of our friend and colleague Ole Tendal, a valued member of WGDEC from its early days through to 2014. Ole had profound knowledge of deep-sea invertebrate fauna and of the xenophyophores, sponges and octocorals of the North Atlantic and Arctic in particular, which he was always willing to share with others. He was instrumental in providing the detailed explanation for why sponge grounds qualified as vulnerable marine ecosystems for WGDEC which has led to their widespread conservation around the globe, including the Polar seas, where some WGDEC members had the opportunity to join him in a Polarstern expedition in 1996 to Antarctica. For early career scientists it was an honour to share two months on board with scientists such as Ole, who transmitted to the students his fascination of the large sponge fields of the Weddell Sea. In his retirement he continued to work as an Emeritus Associate Professor at the Zoological Museum at the University of Copenhagen. His many contributions have been recognized by his colleagues who named a genus of xenophyophore, *Tendalia,* and three species of sponge, *Lycopodina tendali*, *Clathrina tendali* and *Hymedesmia (Hymedesmia) tendali,* in his honour; something that Ole was deeply proud of.

On the personal side, Ole was always happy and proud to share his Danish heritage. When the meetings were held in Copenhagen, some WGDEC members were able to partake of a Danish lunch, being led by Ole to a little sandwich shop on Langebro St. for open Danish sandwiches, after which the group would retire to the Langebro café and bar to wash the sandwich down with a local brew. He was very generous, and probably the gentlest, person that most of us had ever known.

We dedicate the 2020 report of WGDEC to Ole and will miss his wisdom and guidance.

1 Opening of the meeting

In consultation with the ICES Secretariat and ACOM Leadership, the physical meeting of the Working Group on Deep-water Ecology (WGDEC), scheduled to be held at ICES HQ, Copenhagen, Denmark, 4-8 May 2020, was moved to a WebEx meeting and work by correspondence due to travel restrictions in place as a result of the COVID19 outbreak. It was also agreed that WGDEC would focus its efforts this year on immediate advisory related TORs (a, b and e) and reduce the scope of the other TORs (c and d).

The meeting was run in parallel with the Working Group on Marine Habitat Mapping (WGMHM), chaired by James Strong (UK), for the week. Joint plenary sessions were arranged for Monday 4 May and Wednesday 6 May.

WGDEC commenced in plenary at 10:30 am BST on Monday 4 May 2020. Following confirmation of no conflicts of interest from the group, the leads for each Term of Reference (ToR) were appointed, and are outlined below:

- ToR [a] lead: Laura Robson
- ToR [b] lead: Laura Robson and David Stirling
- ToR [c] lead: James Albrecht
- ToR [d] lead: James Strong (WGMHM)
- ToR [e] lead: Marina Carreiro Silva and Ana Colaço

Following the review and adoption of the agenda, WGDEC began working through the Terms of Reference. A short presentation for each ToR was provided by the chair, ToR leads and data suppliers. The group then agreed how they would tackle each ToR, and the group was split into small groups to work on each ToR remotely. Smaller sub-groups were identified for ToR e to work on separate habitat types.

Dedicated plenary sessions were held throughout the week via WebEx. During these plenary sessions, ToR leads updated the group with progress and issues were discussed. Participants joining through correspondence only could comment on working documents via the WGDEC SharePoint site. At the end of the week, the Working Group was formally closed at 5:15 pm on Thursday 7 May 2020 by the Chair. Work continued on Friday 8 May by correspondence only.

2 Adoption of the agenda

The Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), chaired by Laura Robson, UK, will meet by correspondence, 4–8 May 2020 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. This should also include information on the distribution of vulnerable habitats in subareas of the Regulatory Area that are closed to fishing for other purposes than VME protection, e.g. the haddock box at Rockall Bank. In addition, provide new information on 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 test the use of habitat suitability models for mapping VME presence, to assess how such information could be incorporated when, for example, recommending proposals for VME closures

e) Provide recommendations on additional VME indicators to be included in Annex III of the EU deep-sea access regulations, 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 the table in Annex III.

WGDEC will report on TOR a, b and e by 22 May 2020 and all TORs by 15 June 2020 to the attention of the Advisory Committee.

Supporting Information

Priority	The current activities of this Group will enable ICES to respond to advice requests from a number of clients (NEAFC/EC). Consequently, these activities are considered to have a high priority.
Scientific justification	ToR [a] The Joint ICES/NAFO Working Group on Deep-water Ecology undertake a range of Terms of Reference each year; the scope of these cover the entire North Atlantic, and include aspects such as ocean basin processes. Therefore, collating information on vulnerable habitats (including important benthic species and communities) across this wide geographic area (and adjacent waters) is essential. To this end, a VME data call will be run from 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. ToR [b] Collation of information and associated maps (using TOR a) are required to meet the annual NEAFC and EU requests. ICES provides advice, via its working groups and its advisory committee (ACOM), "to continue to provide all available new information on the distribution of vulnerable habitats in the NEAFC Convention Area", which includes "information on the distribution of vulnerable habitats in subareas of the Regulatory Area that are closed to fishing for other purposes than VME protection, e.g. the haddock box

	at Rockall Bank". This information is also used in combination with NEAFC VMS data (analysed by WGSFD) to advise on "fisheries activities in and in the vicinity of such habitats". This ICES advice supports the objective of NEAFC recommendation 19:2014 to "ensure the implementation by NEAFC of effective measures to prevent significant adverse impacts of bottom fishing activities on vulnerable marine ecosystems known to occur or likely to occur in the NEAFC Regulatory Area based on the best available scientific information provided or endorsed by the ICES". Furthermore, ICES provides advice, via its working groups and its advisory committee (ACOM), to support the European Commission request to provide "new information on the impact of fisheries on sensitive habitats. This should include new information on the location of habitats sensitive to particular fishing activities". The location of newly discovered/mapped sensitive habitats (i.e. vulnerable marine ecosystems, VMEs) is critical to these NEAFC and EU requests. ToR [c] 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. ToR [d] 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 assessing VME likelihood, and document the methods, decisions taken, and issues encountered. ToR [e] For the ongoing request work for the EU with regard to the deep sea access regulation (ref. (EU)2016/2336), ICES have been asked to provide scientific input on the list of VME indicators to be included in Annex III of the EU deep-sea access regulations. This input should include 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 the table in Annex III.
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.

3 Collate new information on the distribution of vulnerable habitats and 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

The inclusion of data on VMEs in the ICES VME database has 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. 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, 2016a).
2. 'VME indicator' refers to records of VME indicator species from data sources for which there is a degree of uncertainty that a VME is, or was, present. Typical examples are trawl-survey or static longline bycatch records (ICES, 2016a).
3. 'VME element' refers to seabed topographic features, readily identified using high resolution multibeam data, and with which VMEs are often associated. Examples include seamounts, ridges, canyons (ICES, 2013).

3.2 Background

The ICES VME data call in January 2020 requested ICES member states to submit data to the ICES VME database. All data submitted to the database since the previous WGDEC meeting in June 2019 is considered new data for WGDEC 2020.

The database stores records of VME habitats, 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;

- Presence records are samples where a VME habitat and/or a VME indicator have been identified
- Absence records are samples where neither a VME habitat, nor a VME indicator, have been identified

Presence records can include mixed (mosaic) habitats, where more than one habitat type and/or sub-type occur together in the same location (for example, two sub-types of coral garden or a cold-water coral reef and coral garden). They can also include species lists from data analyses that, combined, form a community which comprise a VME habitat. The mosaic habitats and species lists are input to the database as separate records but are linked together by a 'VME Key' indicating that they occur in the same patch of habitat. Therefore, some VME locations will be represented in the database by multiple records with the same coordinates. These records provide information on the species communities and habitat (sub)types that make up that VME.

4609 new presence records have been submitted to the ICES VME database since June 2019, which increases the total number of presence records in the database to 61 200. This count consists of all individual records in the database, and it should be noted that some VMEs will be represented by more than one record, as detailed above.

Of the newly submitted presence records, 21 are within the NEAFC Regulatory Area, 5 are within the NAFO Regulatory Area, and the remaining 4583 are within the Exclusive Economic Zones of North Atlantic ICES/NAFO member states. In addition, 181 absence records were submitted. For more information on absence data, see Section 5.

The new data has been submitted by data providers from five ICES member countries (UK, Ireland, Sweden, Iceland and Estonia) and one Non-Governmental Organisation (Oceana).

3.3 Quality assurance of new VME data submissions

Since its founding in 1902, ICES has developed a strong reputation in delivering robust scientific advice to governments and regional fisheries management organisations. Data calls, such as the request for new information on VMEs, are an essential mechanism for WGDEC to widen its knowledge, and supplement its central database, holding information on the distribution and abundance of habitats and species considered to be indicators of VMEs across the North Atlantic.

Data providers should note that data of relevance to WGDEC may also be submitted by Contracting Parties, including WGDEC members, through the OSPAR threatened and/or declining habitats database[1], specifically for cold water coral reefs, coral gardens and deep-sea sponge aggregations.

ICES uses the VME database to provide scientifically-robust advice on the distribution of VMEs and recommendations for management solutions. Therefore, to maintain the integrity of its advice, it is essential that any data submitted through the VME data call has been subjected to an appropriate level of quality assurance during its collection and interpretation. WGDEC have therefore identified some initial guidelines for data providers who are submitting new data records to the VME database and have proposed a new intersessional WGDEC data call subgroup to quality control data submissions.

3.3.1 Guidelines for VME data providers

By submitting data to ICES through the VME data call process, data providers are confirming that they have followed national and international best practice guidelines in the quality assurance of their data. Best practice in the quality assurance of VME data will vary according to data type (e.g. Batley, 1999; Rumohr, 2009; Howell *et al*, 2014; Turner *et al*, 2016).

Of particular relevance to data providers is the understanding of the difference between VME habitats, VME indicators and absence records (ICES, 2016). In light of the significance of new VME habitat records (Section 3.1), evidence of each new VME record could also be submitted through the data call; this evidence could take the form of peer reviewed published literature

[1] https://odims.ospar.org/search/?limit=100&offset=0&datastream=habitats

reporting on the record(s), grey literature in the form of cruise reports, and/or imagery (photographs/video clips) of the habitat(s). There are data fields within the VME Cruise record where a reference for the data source can be provided.

WGDEC therefore recommend that data suppliers provide supporting evidence for VME Database submissions wherever possible.

3.3.2 Quality control processes by the ICES data centre and WGDEC

To maintain the high quality of the final advice, each national data submission shall be quality assured/quality checked by the ICES Data Centre and a newly created formal intersessional WGDEC VME data call subgroup.

A series of automated quality control (QC) checks for new data submissions are already in existence, generated by the ICES Data Centre. These flag initial problems to the data provider that need addressing before the data can be formally accepted to the database. QC checks include, for example, warnings for invalid habitat sub-types for specific VME habitat types; incorrect coordinates (e.g. if the data point appears on land); and ensuring only the VME indicator **or** habitat field is filled in, to avoid a mix of data types for one record. Any issues are flagged to the data provider during the submission process for checking (and potentially correcting) before resubmission. Support is available via the ICES Data Centre for any queries over these errors.

This year, a number of further data issues were identified by the ICES Data Centre and WGDEC members. As a result, the group agreed that an intersessional WGDEC VME data call subgroup would be beneficial to quality assure all new data submissions in advance of the WGDEC meetings. This group will therefore review and map new data submissions, and check for any problems that cannot be caught by automated QC checks. For example, additional errors/queries during the WGDEC 2020 data call included misidentification of VME species from trawl data; submission of data from regions on the continental shelf of the UK EEZ < 200 m considered to be outside the remit of the WGDEC group; and verification of the analytical methods used to identify VME habitats from imagery data.

An audit trail of the data quality checks will be tabulated and will be produced as an Annex to each WGDEC report.

WGDEC has therefore developed the following recommendations:

Recommendation 1: The annual VME data call should detail the need for data suppliers to follow national and international best practice guidelines in the quality assurance of their data, and that supporting evidence for new VME records should ideally be included as part of the VME data submission.

Recommendation 2: A new formal intersessional subgroup of WGDEC will be created, charged with quality assuring/quality checking new VME presence and absence data submissions prior to the annual WGDEC meeting.

3.4 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):

3.4.1 United Kingdom (Joint Nature Conservation Committee)

3.4.1.1 Institute of Oceanographic Sciences (Rice *et al.*, 1990)

The Joint Nature Conservation Committee (JNCC) submitted historical data records from literature, from the Institute of Oceanographic Sciences (IOS), Deacon Laboratory (Rice *et al*., 1990). Data were collected on annual and bi-annual cruises to the Porcupine Seabight, between 1979 and 1985. Three survey methods were used – IOS epibenthic sledge, Granton trawl and semi-balloon otter trawl. All records were of *Pheronema carpenteri*, representing sponge VME indicators (Table 3.1).

Table 3.1 Summary of VME indicator records submitted by JNCC from literature (Rice *et al.*, 1990).

VME Indicator Type	No. of indicator records
Sponge	22
Total	**22**

3.4.1.2 James Cook survey JC136: Deeplinks

JNCC, on behalf of the NERC funded DeepLinks project partners (University of Plymouth, University of Oxford, JNCC and British Geological Survey), submitted new VME habitat records from the JC136 "DeepLinks" cruise in 2016. Records came from analysis of remotely operated vehicle (ROV) footage collected on the survey from Anton Dohrn Seamount, North Rockall Bank and George Bligh Bank.

A total of 68 records of VME habitats were submitted, including cold water coral reefs, coral gardens and deep-sea sponge aggregations (Table 3.2 and Figure 3.1, Figure 3.2 and Figure 3.3). The coral garden records included the habitat sub-types: Hard-bottom coral garden: colonial scleractinians on rocky outcrops; Hard-bottom coral garden: hard-bottom gorgonian and black coral gardens, and; Soft bottom coral gardens, some of which occurred as mosaic habitats.

Previous data from this survey had been submitted to WGDEC in 2017, but these represent additional data records for these areas.

Table 3.2 Summary of VME habitat records submitted by the JNCC on behalf of DeepLinks project partners.

VME Habitat Type	No. of habitat records
Cold water coral reef	5
Coral garden	62
Deep sea sponge aggregation	1
Total	**68**

Figure 3.1 VME coral garden habitat from dive 269 at Anton Dohrn Seamount provided by JNCC from the JC136 DeepLinks survey. Image source: NERC funded DeepLinks project - University of Plymouth, University of Oxford, JNCC and BGS (2016).

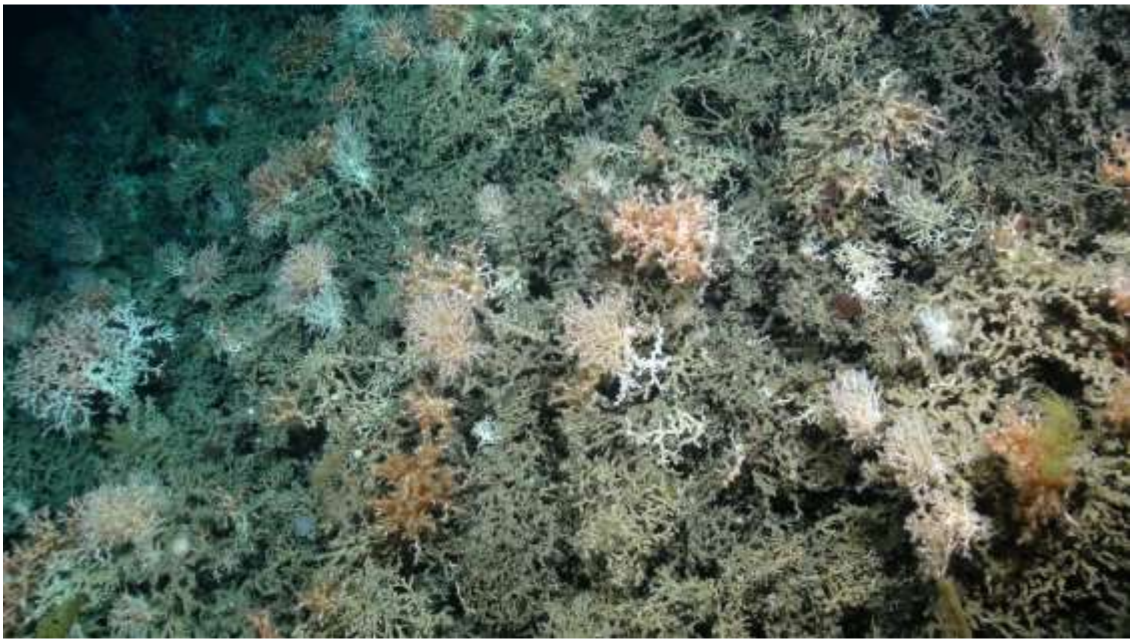

Figure 3.2 VME cold-water coral reef habitat, from dive 270 at Anton Dohrn Seamount provided by JNCC from the JC136 DeepLinks survey. Image source: NERC funded DeepLinks project - University of Plymouth, University of Oxford, JNCC and BGS (2016).

Figure 3.3 VME coral garden habitat from dive 292 at George Bligh Bank provided by JNCC from the JC136 DeepLinks survey. Image source: NERC funded DeepLinks project - University of Plymouth, University of Oxford, JNCC and BGS (2016).

3.4.2 United Kingdom (Marine Scotland Science)

3.4.2.1 Scotia Survey 1341S: MOREDEEP

New VME data records were submitted by the University of Edinburgh and the Horizon 2020 ATLAS project, collected on the Marine Scotland Science 1341S 'MOREDEEP' survey which took place between 8–19 September 2014. The survey took place in the Faroe Shetland Channel Nature Conservation Marine Protected Area (NCMPA), where records of VME habitats, specifically deep-sea sponge aggregations, were collected using towed-camera surveys (Table 3.3 and Figure 3.4 and Figure 3.5). Sponge aggregations occurred between 450 and 530 m in depth.

Table 3.3 Summary of VME habitat records submitted by the University of Edinburgh from the 1314S MOREDEEP survey.

VME Habitat Type	No. of habitat records
Deep sea sponge aggregations	442
Total	**442**

Figure 3.4 Fan-shaped sponge aggregations (possibly *Phakellia* sp.) within the Faroe-Shetland Channel Nature Conservation MPA. Depth 498.5 m. Image collected on 11/09/2014 during the MoreDeep_1314S research expedition. Image source: Marine Scotland Science.

Figure 3.5 Massive (possibly *Geodia* sp.) and fan-shaped sponge aggregations (possibly *Phakellia* sp.) within the Faroe-Shetland Channel Nature Conservation MPA. Depth 492 m. Image collected on 11/09/2014 during the MoreDeep_1314S research expedition. Image source: Marine Scotland Science.

3.4.2.2 Scotia survey 1419S

Marine Scotland Science (MSS) submitted data on VME indicator taxa from the Deepwater Slope survey from 28 September to 11 October 2019 (survey code 1419S). A Jackson BT 184 bottom trawl with groundgear bag net was used to survey the demersal fish assemblages along the continental slope of Scottish and Irish offshore waters. A total of 64 VME indicator records were submitted from the bycatch of 25 hauls (Table 3.4). A further 11 hauls were recorded as absences as no VME indicator taxa were collected (Table 3.22).

Table 3.4 Summary of VME indicator records submitted by Marine Scotland Science from the 1419S survey.

VME Indicator Type	No. of indicator records
Black coral	2
Cup coral	6
Gorgonian	8
Sea pen	16
Soft coral	8
Sponge	24
Total	**64**

3.4.3 United Kingdom (National Oceanography Centre)

3.4.3.1 James Cook survey JC062

The benthos of the Porcupine Seabight was surveyed extensively in the 1980s, including an assessment of the mass occurrence of *Pheronema carpenteri* (Rice *et al*., 1990; Rice *et al*., 1991). Photographic transects at four sites in the northern Porcupine Seabight were also conducted in August 2011 through the RRS James Cook survey "JC062" (Ruhl, 2012). The aim of the transects was to assess the status of the same sponge aggregation sites identified by Rice *et al*. (1990, 1991) using comparable photographic survey methods (Vieira *et al*., 2020).

Transects were carried out using the National Oceanography Centre (NOC) Wide-Angle Seabed Photography (WASP) off-bottom, towed camera system. A vertically mounted stills camera was used and augmented with an obliquely mounted digital stills camera. A total of 1713 images were analysed. For each image, all invertebrate megafauna were identified to morphotype and counted. Geolocation and water depth data for the camera platform were derived from an ultra-short baseline navigation transponder attached directly to the WASP vehicle (Ruhl, 2012).

A total of 29 VME habitats and 26 VME indicator records were submitted to the ICES VME database from the JC062 survey, summarised in Table 3.5 and

Table 3.6. These included deep-sea sponge (Figure 3.6) and tube-dwelling anemone aggregations, soft-bottom cup coral gardens and sea pen fields, and the indicators; xenophyophores, sea pens, anemones and gorgonians.

Table 3.5 Summary of VME habitat records submitted by the National Oceanography Centre from JC062.

VME Habitat Type	No. of habitat records
Coral garden	6
Deep sea sponge aggregations	21
Sea pen fields	1
Tube-dwelling anemone aggregations	1
Total	**29**

Table 3.6 Summary of VME indicator records submitted by the National Oceanography Centre from JC062.

VME Indicator Type	No. of indicator records
Anemones	11
Gorgonians	6
Sea pen	4
Xenophyophores	5
Total	**26**

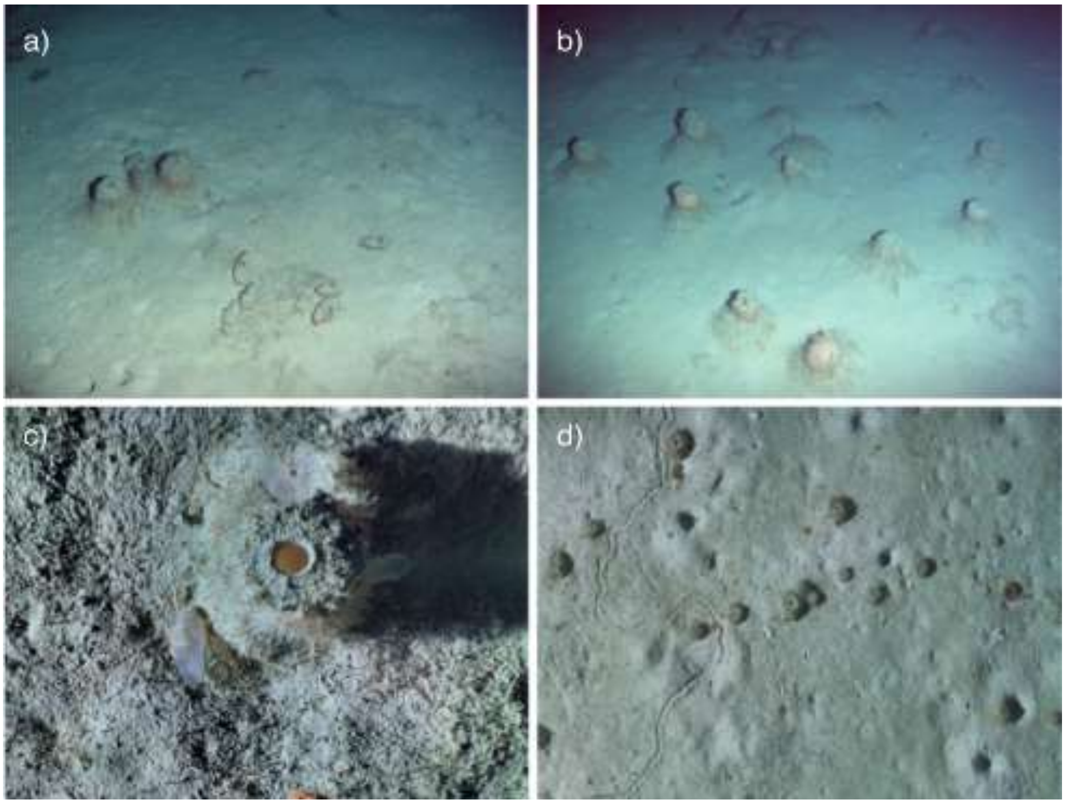

Figure 3.6 Examples of deep-sea sponge aggregations (*Pheronema carpenteri*) as observed in oblique (a, b), and vertical (c, d) photographs in the northern Porcupine Seabight. Image source: National Oceanography Centre, UK.

3.4.3.2 Discovery survey DY108

In 2019, the RRS Discovery (DY)108 cruise from 6 September to 2 October 2019, funded by NERC through the CLASS (Climate-Linked Atlantic Sector Science) programme, investigated the Darwin Mounds area in search of signs of recovery of the benthic community after trawling was banned in 2003.

The Darwin Mounds are small geological features up to 70 m across and up to 5 metres high, located south-west of the Wyville-Thomson Ridge, within the EEZ of the United Kingdom. The region is a Special Area of Conservation (SAC EU Code: UK0030317).

The data, submitted by the NOC, included presence records of the VME habitat, xenophyophore aggregations, comprising the species *Syringammina fragilissima* (Table 3.7) and the VME indicator species: *Lophelia pertusa/Desmophylum pertusum* and *Madrepora oculata* (

Table 3.8 and Figure 3.7). Data were collected as image samples taken with the HyBis camera platform from the NOC, deployed from RRS Discovery. More information on collection and location of these samples is available in Huvenne and Thornton, 2020.

Table 3.7 Summary of VME habitat records submitted by the National Oceanography Centre from DY108.

VME Habitat Type	No. of habitat records
Xenophyophore aggregations	9
Total	**9**

Table 3.8 Summary of VME indicator records submitted by the National Oceanography Centre from DY108.

VME Indicator Type	No. of indicator records
Stony coral	18
Total	**18**

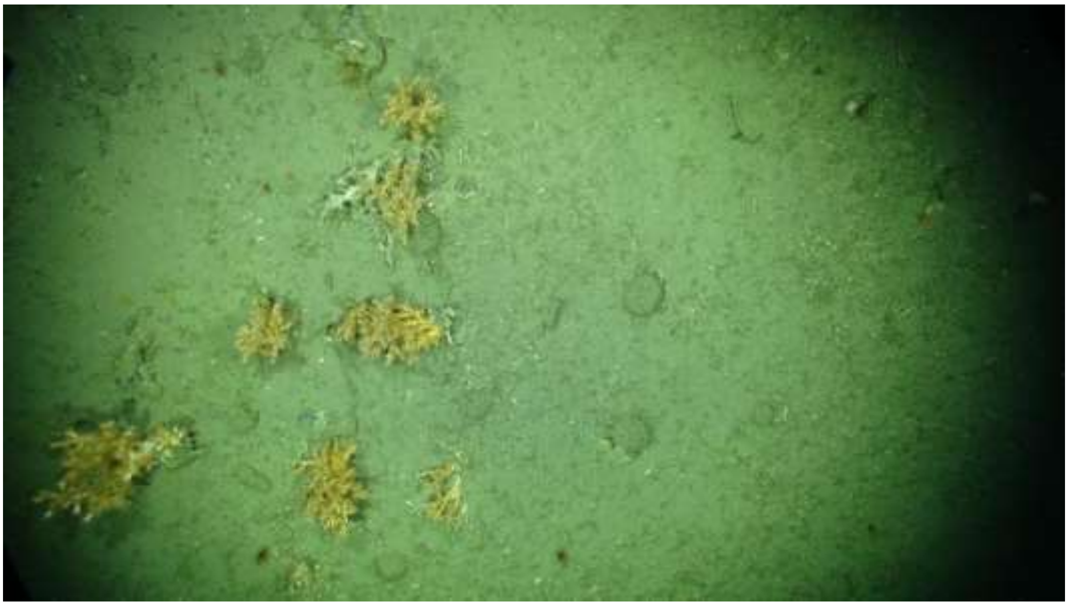

Figure 3.7 VME records of *Lophelia pertusa/Desmophylum pertusum* and *Syringammina fragilissima* from the DY108 survey. Image source: National Oceanography Centre, UK.

3.4.3.3 Discovery survey D248

Data were collected on the RRS Discovery (D)248 cruise in 2000, which aimed to carry out a multidisciplinary study of the environment and ecology of deep-water coral ecosystems and associated seabed features in the north-east Atlantic (Bett *et al.*, 2001). Three areas were surveyed: Darwin Mounds, northern Rockall Trough and the Porcupine Seabight. The survey took place over two legs, between 8 July to 10 August 2000. Various methods were used to collect data on both VME habitats and indicators, including box corers, Agassiz trawls and the Seabed High Resolution Imaging Platform (SHRIMP).

JNCC reviewed the Bett *et al.*, 2001 paper, where observations in the Darwin Mounds confirmed the common occurrence of deep-water corals in this area. Xenophyophores were observed in association with the mounds, however no live specimens were recovered. At the Porcupine Seabight, imagery of associated coral communities was obtained, from which biological samples were also recovered. Based on these records, together with records from trawl and box corer samples detailed in the report, VME habitats of cold-water coral reefs, coral gardens and xenophyophore aggregations and VME indicators of soft corals, sponges, stony corals and xenophyophores were submitted to the VME database by JNCC following QC by NOC (Table 3.9 and

Table 3.10).

Table 3.9 Summary of VME habitat records submitted by JNCC from the NOC's D248 cruise.

VME Habitat Type	No. of habitat records
Cold water coral reef	3
Coral garden	4
Xenophyophore aggregations	2
Total	**9**

Table 3.10 Summary of VME indicator records submitted by JNCC from the NOC's D248 cruise.

VME Indicator Type	No. of indicator records
Soft corals	1
Sponge	1
Stony coral	12
Xenophyophores	5
Total	**19**

3.4.4 Ireland (Marine Institute, Ireland)

3.4.4.1 SeaRover project

SeaRover (Sensitive Ecosystem Assessment and ROV Exploration of Reef Habitat) was a three-year project from 2017 to 2019 to collect data on VME habitats within Irish waters. The project aim was to carry out extensive mapping surveys of offshore reefs to evaluate status and introduce conservation and management measures in proportion to status and pressures from fishing. The survey used the ROV *Holland I* to search for vulnerable marine species and habitats along the slope and was funded by the Irish government and the European Maritime and Fisheries Fund (EMFF) through the Marine Institute and the Geographical Society of Ireland. It is planned that by 2021 all data and images will be made publicly available via a mapping portal.

VME habitat data from SeaRover 2017 and 2018 were submitted to the VME database in 2020, including records of cold-water coral reefs, coral gardens and deep-sea sponge aggregations (Figure 3.8). Data from SeaRover 2017 were previously submitted in 2019 and were re-submitted this year to correct some minor errors. A summary of the new and re-submissions is provided in Table 3.11. In addition, absence data was provided, see Table 3.22**Error! Reference source not found.**. These data provide substantial new records of VMEs within the Irish EEZ for the VME database.

Table 3.11 Summary of VME habitat records submitted by Marine Institute from the SeaRover project.

VME Habitat Type	No. of habitat records
Cold water coral reef	34
Coral garden	387
Deep sea sponge aggregation	115
Sea pen fields	89
Tube-dwelling anemone aggregations	56
Xenophyophore aggregations	30
Stalked crinoids	6
Total	**717**

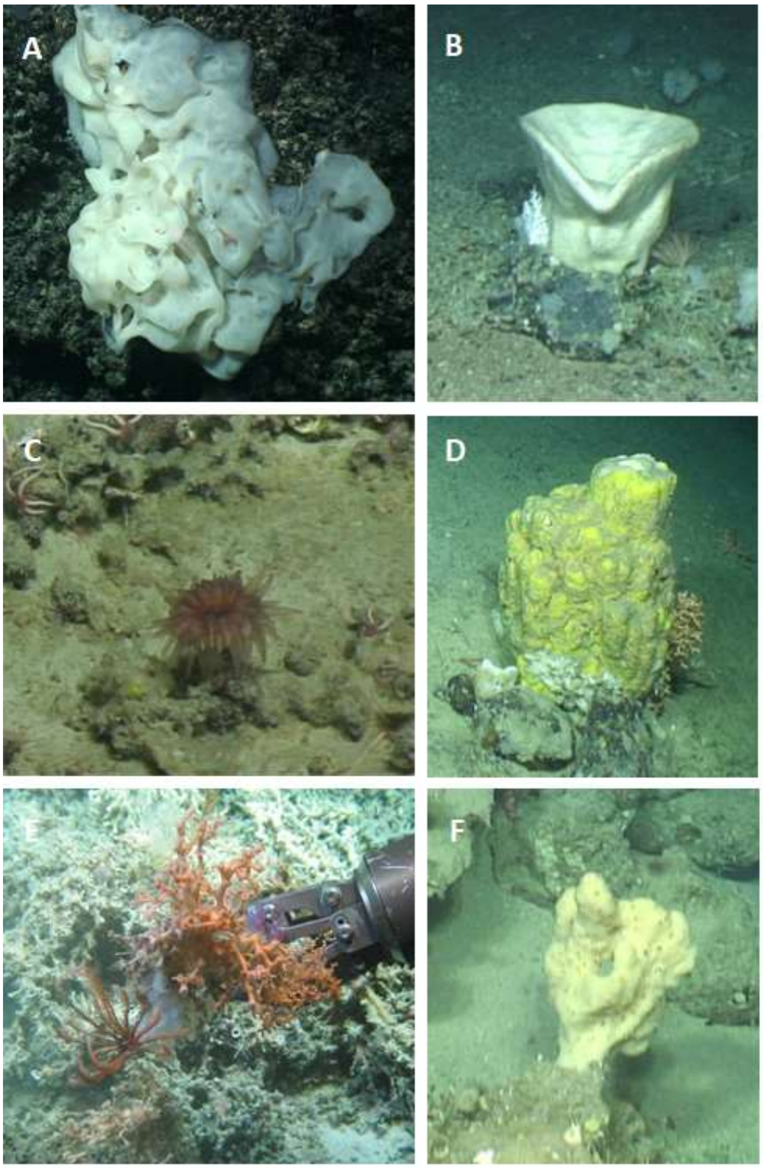

Figure 3.8. Images of sponge and coral VMEs identified during the SeaRover survey showing A) *Asconema* sp. (Porifera massive globular), B) *Geodia atlantica,* C) Caryophyllia sp., D) *Hexadella dedritifera,* E) *Lophelia pertusa/Desmophyllum pertusum,* and F) *Mycale lingua*. Image source: SeaRover survey/ Irish Government/ European Maritime and Fisheries Fund.

3.4.4.2 Irish Groundfish Surveys (IGFS)

Additional VME data was submitted by the Irish Marine Institute from the Irish Groundfish survey (IGFS). The IGFS is part of the ICES International Bottom Trawl Survey and its main aim is to collect data for fish stock assessments. Oceanographic, habitat, litter and non-fish data are also collected during the surveys. The IGFS covers Irish waters to 1500 m, although most stations are shallower than this. The survey uses a GOV trawl to survey fish and other species along 30 minute, randomly stratified tracks each year.

VME indicator records submitted to the database from the IGFS from 2017, 2018 and 2019 included anemones, cup corals, sea pens, soft corals and sponges (Table 3.12). The most abundant species in hauls were sea pens and anemones, with the largest haul comprising 4516 anemones

(Hexacorallia). Table 3.12 summarises the number of hauls with each type of VME indicator present. Abundance of indicator taxa is provided in the database, per record, where data was available. Two absence data records were also provided (Table 3.22).

Table 3.12 Summary of VME indicator records submitted by the Irish Marine Institute from the Irish Groundfish Surveys.

VME Indicator Type	No. of indicator records
Anemones	78
Cup coral	17
Sea pen	33
Soft coral	2
Sponges	12
Total	**142**

3.4.4.3 Underwater TV surveys (UWTV)

A series of underwater TV (UWTV) surveys are conducted annually by the Irish Marine Institute. This survey series uses a camera attached to a towed sled to count prawns, *Nephrops norvegicus,* and prawn burrows on commercially-fished prawn grounds around Ireland. The Porcupine Bank is the deepest area surveyed and the only relevant prawn ground for this Working Group. Sea pens were identified as presence/absence from survey data from 2012–2019 and provided to the VME database in 2020 (Table 3.13 and Table 3.22**Error! Reference source not found.**).

Table 3.13 Summary of VME indicator data submitted by the Irish Marine Institute from the Underwater TV survey series.

VME Indicators	No. of indicator records
Sea pens	502
Total	**502**

3.4.5 Sweden (Swedish University of Agricultural Sciences)

3.4.5.1 Bratten MPA

New data were submitted by the Swedish University of Agricultural Sciences, for VMEs within the Bratten Natura 2000 MPA. The Bratten MPA is located on the Swedish shelf slope, at depths from 100 to >500 m towards the Norwegian Deep in the East Skagerrak. It is a large Natura 2000 area that has been surveyed extensively. The area is cut by large canyons and has several pockmarks where hard bottoms are exposed. These habitats are surrounded by soft seafloor with sea pens. The Natura 2000 area has 14 zones with fishery closures for VME protection.

VME data records from a canyon area of the MPA were submitted to the VME database in 2020. Data came from a research cruise aboard the M/V Franklin in 2013 using a drop camera system (Kilnäs, 2013), and included 3 key habitat types: coral gardens, deep-sea sponge aggregations and sea pen fields, comprising multiple species records (Table 3.14). However, additional data from the area have been collected from other surveys, detailing multiple occurrences of these habitats which the MPA area protects. These data are not yet in the database.

Table 3.14 Summary of VME habitat data submitted by the Swedish University of Agricultural Sciences for the Bratten Natura 2000 MPA.

VME Habitat Type	No. of habitat records
Coral garden	3
Deep-sea sponge aggregations	5
Sea pen fields	4
Total	**12**

3.4.6 Estonia (Estonian Marine Institute)

3.4.6.1 Flemish Cap fisheries observer data

Data on VME indicators were submitted by the Estonian Marine Institute, University of Tartu from 2004 and 2005 surveys to the Flemish Cap, off Canada. The data were collected by scientific observers onboard fishing vessels operating in the NAFO area. Fishing operations were carried out using bottom trawls, with observers taking pictures of any invertebrates seen. These pictures were then later used for identification. VME indicator taxa identified included a large gorgonian coral (likely *Paragorgia* sp.), sea pens, soft corals and sponges (Table 3.15).

Table 3.15 Summary of VME indicator data submitted by the Estonian Marine Institute from fisheries observers.

VME Indicator Type	No. of indicator records
Gorgonian	1
Sea pen	1
Soft coral	1
Sponge	2
Total	**5**

3.4.7 Iceland (Marine and Freshwater Research Institute)

The Marine and Freshwater Research Institute (MFRI) is responsible for the submission of data from the Iceland EEZ and the Reykjanes Ridge.

3.4.7.1 BIOICE project

New VME indicator species records were compiled during the Benthic Invertebrates of Icelandic waters (BIOICE) project, which was conducted within the Icelandic EEZ from 1991–2004. This project was an initiative of the Icelandic Ministry for the Environment in collaboration with the MFRI, the Icelandic Institute of Natural History (IINH) and the University of Iceland Institute of Biology.

Data were sampled using a set of different gear types: Agassiz trawl, Rothlisberg and Pearcy (RP) sledge, Sneli sledge, triangle dredge and the grabs Shipek and Van Veen. Only data records collected at or below 200 m were submitted.

VME indicator species were collected in nineteen BIOICE cruises between 1991–2004 around Iceland (Steingrímsson *et al*. 2020). A total of 28 species, representing six VME indicator types, comprising gorgonians, sea pens, soft corals, stony corals, sponges and stylasterids (Table 3.16), were identified and submitted to the ICES VME database.

Table 3.16 Summary of VME indicator data submitted by the MFRI from the BIOICE project.

VME Indicator Type	No. of indicator records
Gorgonian	48
Sea pen	257
Soft coral	137
Stony coral	49
Sponge	23
Stylasterids	9
Total	**523**

3.4.7.2 Benthic habitat mapping project

The Icelandic data submission also included VME habitat data identified and collected by the MFRI during the Benthic habitat mapping project. Data was collected with a towed camera system called Campod and included both photos and video.

VME habitats and VME indicator species were identified in the Háfadjúp canyon, south of Iceland, during a single cruise of the benthic habitat mapping project in 2012 (Óðinsson *et al*. 2020). The transects were taken at a depth range of 200–730 m. Four types of VME habitats were identified: cold-water coral reefs, coral gardens, sea pen fields and deep-sea sponge aggregations (Table 3.17). In addition, a total of 23 taxa represented eight VME indicator types, comprising gorgonian, sea pens, soft corals, stony corals, black corals, cup corals, sponges and stylasterids (

Table 3.18 and Figure 3.9).

Table 3.17 Summary of VME habitat data submitted by the MFRI from the benthic habitat mapping project.

VME Habitat Type	No. of habitat records
Cold water coral reef	14
Coral garden	18
Deep sea sponge aggregation	14
Sea pen fields	55
Total	**101**

Table 3.18 Summary of VME indicator data submitted by the MFRI from the benthic habitat mapping project.

VME Indicator Type	No. of indicator records
Black coral	4
Cup coral	3
Gorgonian	75
Sea pen	226
Soft coral	10
Sponge	3
Stony coral	75
Stylasterids	12
Total	**408**

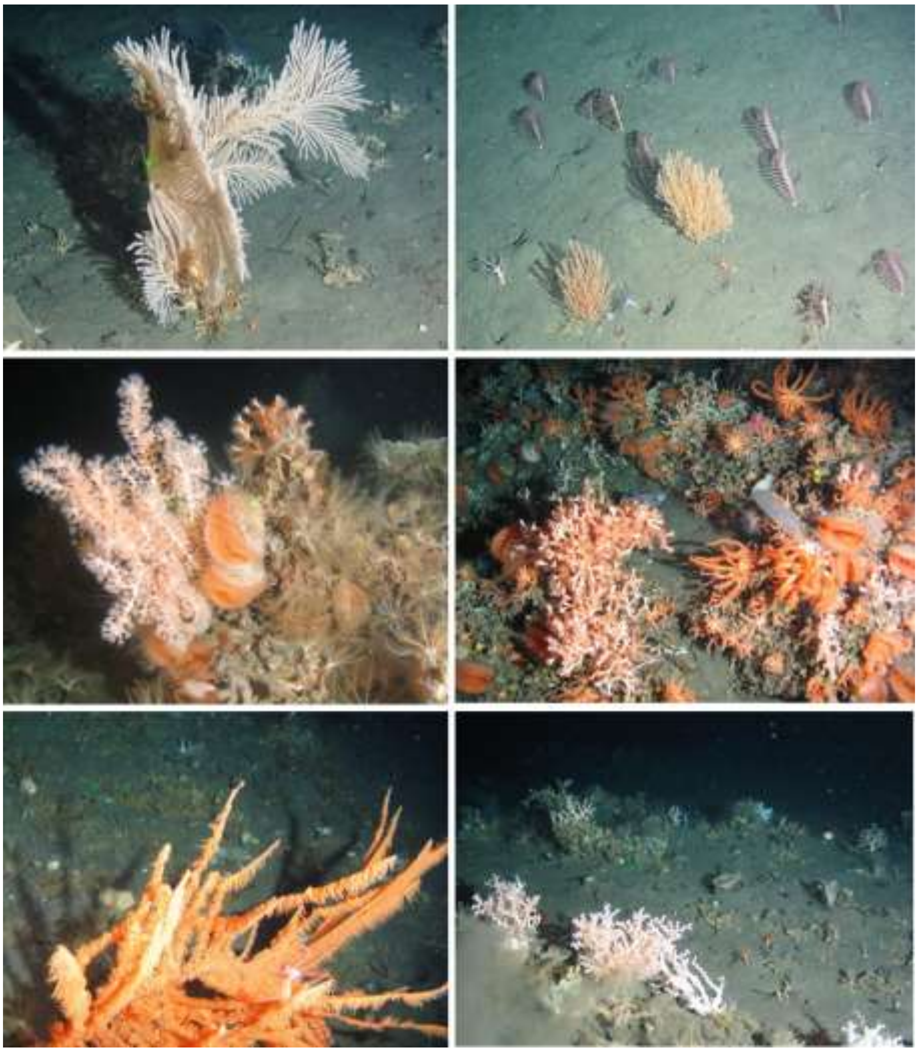

Figure 3.9 VME indicators and habitats located in the Háfadjúp canyon, south of Iceland. Top Left: Gorgonian cf. *Callogoria* sp.; Top Right: Sea pen field and Bamboo coral garden with *Acanella arbuscula*; Middle Left: Gorgonian cf. *Anthothelia grandiflora;* Middle Right: *Lophelia pertusa/Desmophyllum pertusum* cold-water coral reef; Bottom Left: Black coral cf. *Bathypathes* sp., Bottom Left: Stony coral *Madrepora oculate.* Image source: Marine and Freshwater Research Institute.

3.4.7.3 Icelandic marine Animals: Genetics and Ecology (IceAGE) project

Further VME data was submitted by the MFRI from the IceAGE project led by Saskia Brix in Senckenberg Research Institute, Germany. The survey was conducted on the Reykjanes Ridge, both within the Icelandic EEZ and in locations on the ridge south of the EEZ. Data was collected with an ROV system including seabed images and sample collection.

The VME habitats hydrothermal vents/fields and cold-water coral reef, subtype *Solenosmilia variabilis* reef, were identified during a survey of the IceAGE Reykjanes Ridge project in 2018 (Table 3.19). The hydrothermal vents (Figure 3.10) were in the known hydrothermal area called Steinahóll, located on the Reykjanes Ridge within the Icelandic EEZ. These data confirm that active hydrothermal chimneys are found in the Steinahóll area (Taylor *et al*. in prep.). The cold-water coral reef made by *Solenosmilia variabilis* was located on the Reykjanes Ridge (59.19, -30.33), at 1200 m south of the Icelandic EEZ (Devey *et al*., 2018).

Table 3.19 Summary of VME habitat data submitted by the MFRI from the IceAGE project.

VME Habitat Type	No. of habitat records
Cold water coral reef	1
Hydrothermal vents/fields	1
Total	**2**

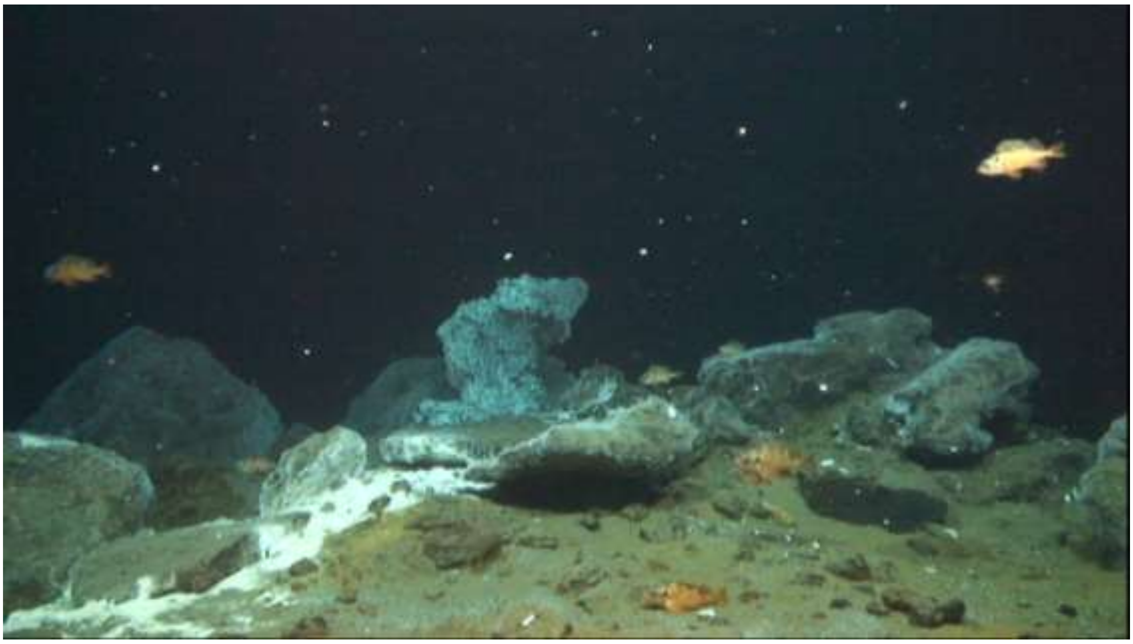

Figure 3.10 Hydrothermal chimneys in the Steinahóll area in Reykjanes Ridge. Image source: IceAGE_RR 2018 Seckenberg/GEOMAR.

3.4.8 Oceana

3.4.8.1 Norwegian Trench and Danish continental shelf

Oceana submitted new data in response to the 2020 VME data call for VME habitat types and indicators in the waters of Denmark and Norway. These data were collected during the North Sea expeditions that Oceana carried out in the years 2016 and 2017 on board the RV Neptune. These expeditions covered a range of survey areas in the North Sea, with the submitted data from the Norwegian Trench (Norwegian waters) and the Danish continental shelf.

A total of 1479 VME habitat type records were submitted. These data were obtained using a Saab Seaeye Falcon DR ROV, equipped with a high-definition video (HDV) camera. Images were recorded both in high definition (to film specific features of interest) and low definition (for the total duration of surveys), along with position, depth, course and time. Lasers on the ROV were used in order to estimate sizes and abundances.

An additional 12 VME indicator records submitted were derived from infaunal grab sampling, using a 12 L Van Veen grab sampler with a penetration capability of 20 cm and a sampling area of 0.1 m^2 per grab.

VME habitats included coral gardens, deep-sea sponge aggregations, sea pen fields and tube-dwelling anemone aggregations (Table 3.20). VME indicators comprised chemosynthetic species and sea pens (

Table 3.21). Images from the surveys are shown in Figure 3.11, Figure 3.12 and Figure 3.13.

As the governance group of ICES VME data, WGDEC QC'ed these data during the WGDEC 2020 meeting. The submitted data were confirmed to be representing VME habitats, based on expert knowledge from the group of the surveyed areas and review of images provided by Oceana.

Table 3.20 Summary of VME habitat data submitted by Oceana from the North Sea expeditions 2016 and 2017.

VME Habitat Type	No. of habitat records
Coral garden	130
Deep sea sponge aggregation	597
Sea pen fields	720
Tube dwelling anemone aggregations	32
Total	**1479**

Table 3.21 Summary of VME indicator data submitted by Oceana from the North Sea expeditions 2016 and 2017.

VME Indicator Type	No. of indicator records
Chemosynthetic species	11
Sea pen	1
Total	**12**

Figure 3.11 Deep-sea sponge aggregation VME habitat, comprising *Geodia* sp., from the Oceana North Sea expeditions. Image source: Oceana.

Figure 3.12 Sea pen field VME habitat, comprising *Funiculina quadrangularis*, from the Norwegian Trench. Image source: Oceana.

Figure 3.13 Sea pen field of *Funiculina quadrangularis*, and coral garden of the bamboo coral, Isididae, from the Norwegian Trench. Image source: Oceana.

3.4.9 Russia

3.4.9.1 NAFO Regulatory Area

VME data were collated by Russia from January–September 2019 from fishing trawl bycatch records. Data were collected from fisheries observers on six cruises to the Grand Bank of Newfoundland and the Flemish Cap (NAFO divisions 3LMNO). In the NAFO Regulatory Area (RA), VME indicators were recorded in the waters of the Flemish Cap, the Flemish Pass and the Grand Banks of Newfoundland. VME indicators included soft corals, sea pens and sponges.

3.4.9.2 Norwegian Sea

A single encounter of VME indicator species (sponges) occurred on 27 December 2019, in the Norwegian Sea.

These data were not ready to be uploaded to the ICES VME database for the 2020 VME data call but will be submitted in 2021 for consideration at WGDEC 2021. A working paper submitted by Russia detailing the records discussed above is included in Annex 3.

3.5 Absence data

In 2019, WGDEC discussed the inclusion of absence records in the VME database and decided not to consider these at the time for ToR [b] due to uncertainties on a range of issues related to inconsistencies in how absence data is collected through different methods. At WGDEC 2020, the group considered these issues further; more detail can be found in Section 5.

As a result of discussions on the use of absence data, new absence records were included within the VME database this year. These records were provided by data suppliers through the 2020 VME data call and comprised records from the Marine Scotland Science 1491S survey; the SeaRover 2017 and 2018 surveys; the Irish Groundfish Surveys; and the Irish Underwater TV surveys from a towed sled camera system (see Table 3.22).

Table 3.22 Absence records submitted to the ICES VME database in 2020.

Survey	Gear type	Absence records
Marine Scotland Science 1491S	Bottom trawl	11
SeaRover 2017 and 2018	ROV	8
Irish Groundfish Surveys	GOV trawl	2
Underwater TV surveys	Towed camera sled	160

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4 Provide all available new information on the distribution of vulnerable habitats (VMEs) in the NEAFC Convention Area. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters – ToR [b]

4.1 Areas with new, historical or resubmitted VME data

This chapter is split according to areas within the NEAFC and NAFO Regulatory Areas and those areas within the EEZs of EU countries and wider.

Areas considered within the NEAFC Regulatory Area:

- Rockall Bank
- Reykjanes Ridge

Areas considered within the NAFO Regulatory Area:

- Flemish Cap

Areas considered within the EEZs of various countries:

- Rockall Bank and George Bligh Bank
- Anton Dohrn Seamount
- Faroe Shetland Channel
- Darwin Mounds
- Hebridean Slope (Scotland)
- Scottish and Irish Continental Slopes
- Porcupine Bank and Seabight
- Icelandic Continental Slope and Reykjanes Ridge
- Norwegian Trench and Danish and Swedish Continental Slopes

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). It should be noted that the absence records described in Section 3.4.9 are not included in the VME weighting algorithm or the ToR [b] maps. More information on the use of absence data can be found in Section 5.

4.2 Areas considered within the NEAFC Regulatory Area

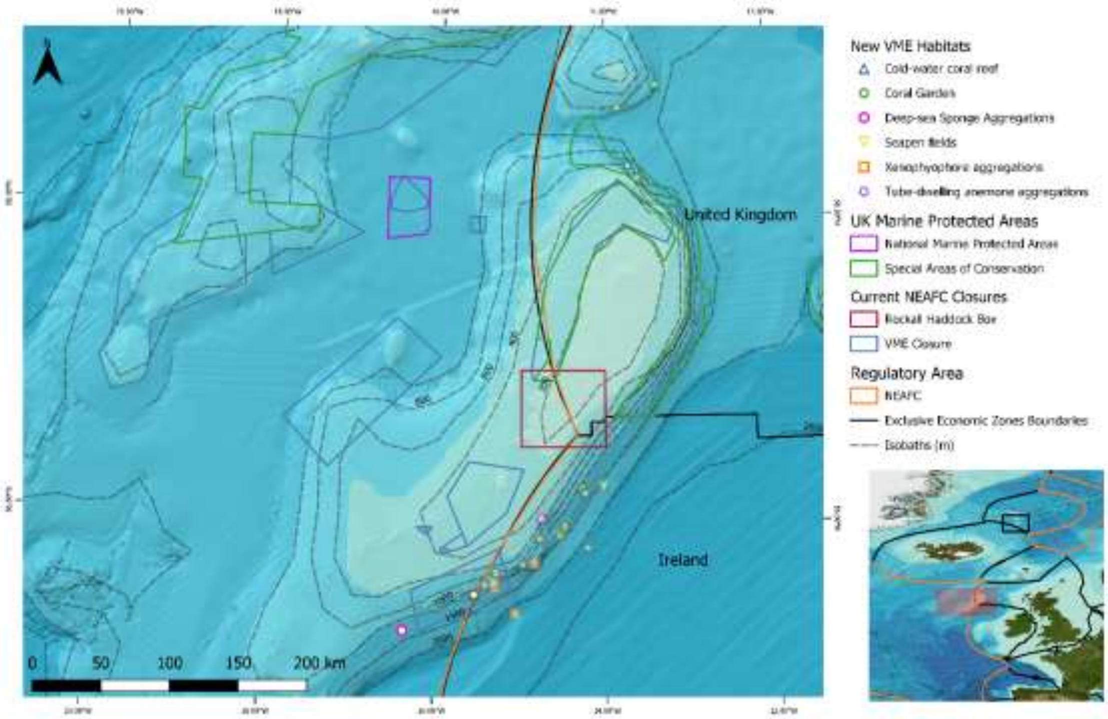
4.2.1 Rockall Bank

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 habitat data within the NEAFC Regulatory Area on Rockall Bank were submitted by Ireland (Figure 4.1). Records came from the Irish Marine Institute's SeaRover 2018 expedition (see Section 3.4.4.1).

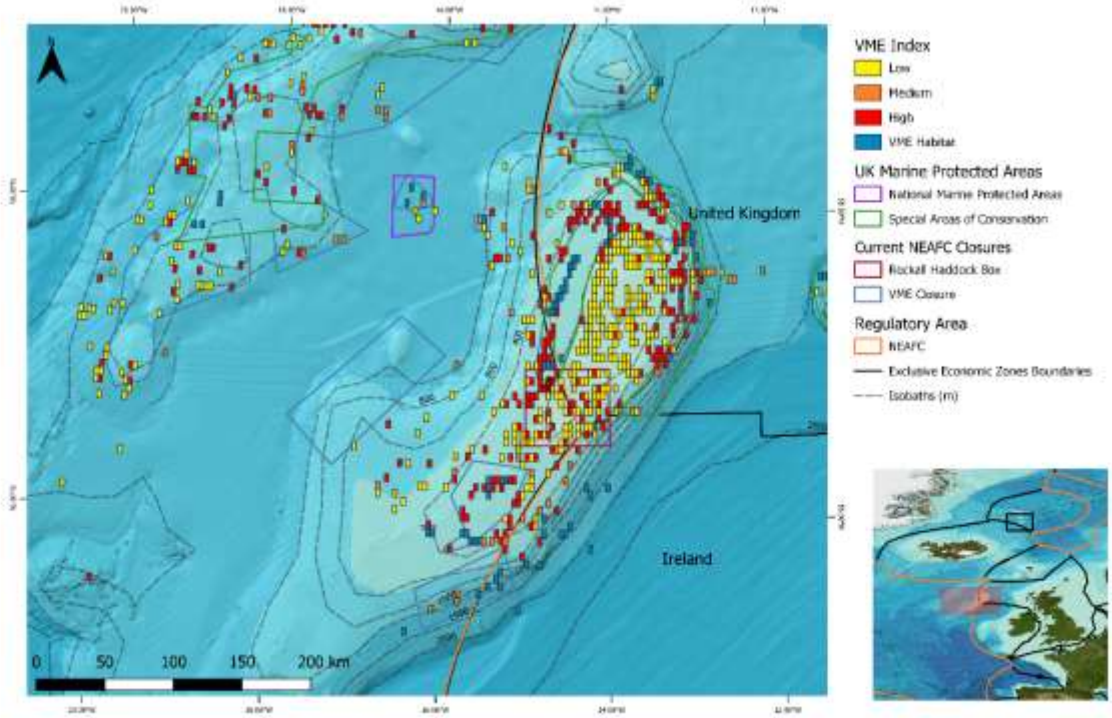
These new data have contributed to updated outputs from the VME weighting algorithm. The updated VME index for Rockall Bank (within NEAFC waters) is shown in Figure 4.2. The algorithm has a gridded output layer, which shows the likelihood of encountering a VME for each grid cell; either low (yellow), 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.



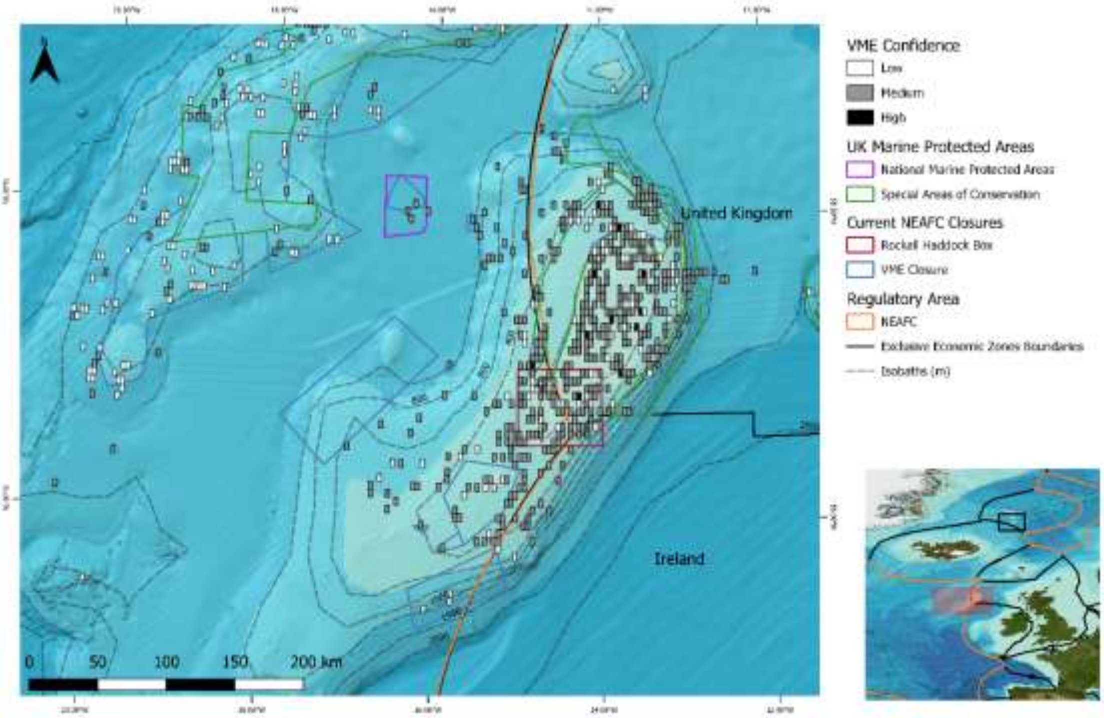
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.1 New VME records submitted in 2020 for Rockall Bank within the NEAFC Regulatory Area (new records outside the NEAFC Regulatory Area are displayed as transparent). Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.



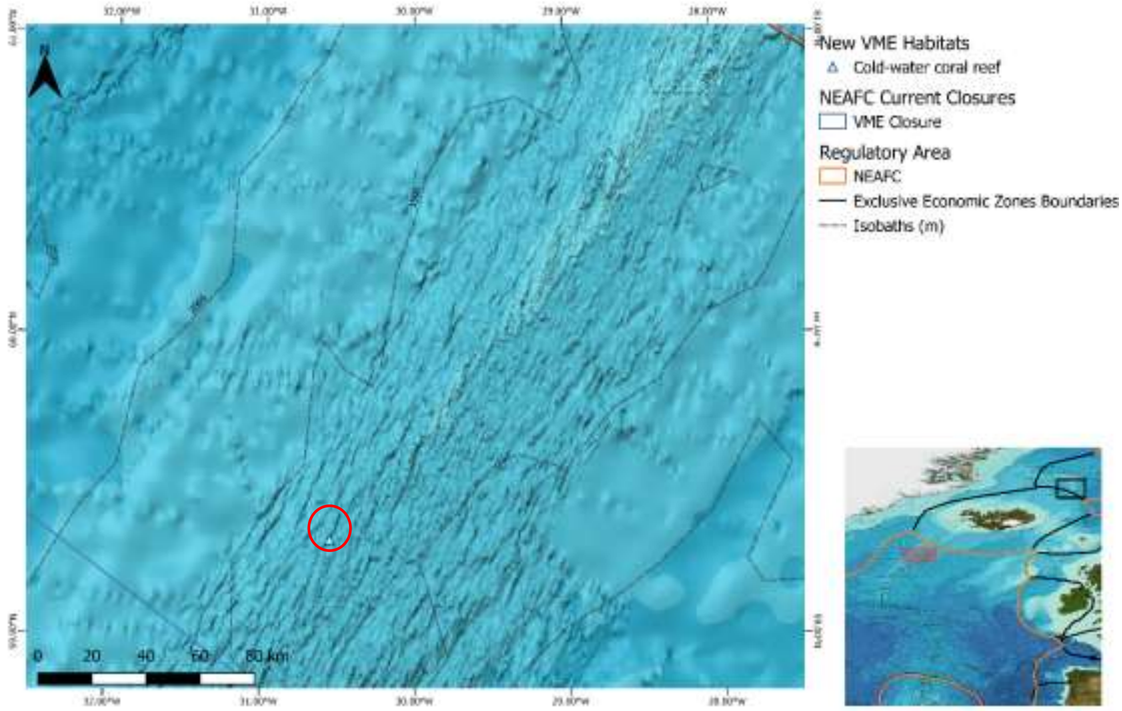
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.

4.2.2 Reykjanes Ridge

One new VME habitat record was also submitted by Iceland on the Reykjanes Ridge within the NEAFC Regulatory Area (Figure 4.4). Records came from the Icelandic marine Animals: Genetics and Ecology (IceAGE) project and detailed an area of *Solenosmilia variabilis* cold-water coral reef (see Section 0).

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.5, and the confidence layer for the VME index is shown in Figure 4.6.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Projection = WGS84

Figure 4.4 New VME record (highlighted with a red circle) submitted in 2020 for the Reykjanes Ridge within the NEAFC Regulatory Area. Note, other VME records from the VME database for this area are not displayed.

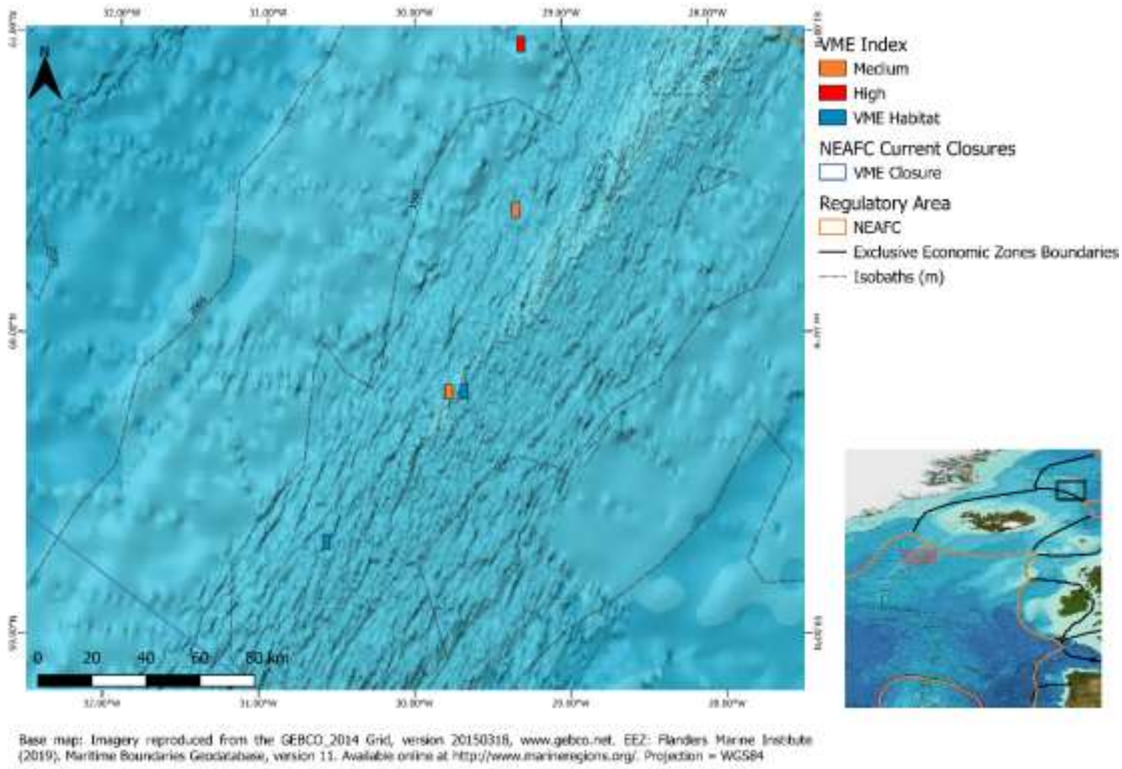


Figure 4.5 Output of the VME weighting algorithm for the area shown in Figure 4.4 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2020) records from the ICES VME database.

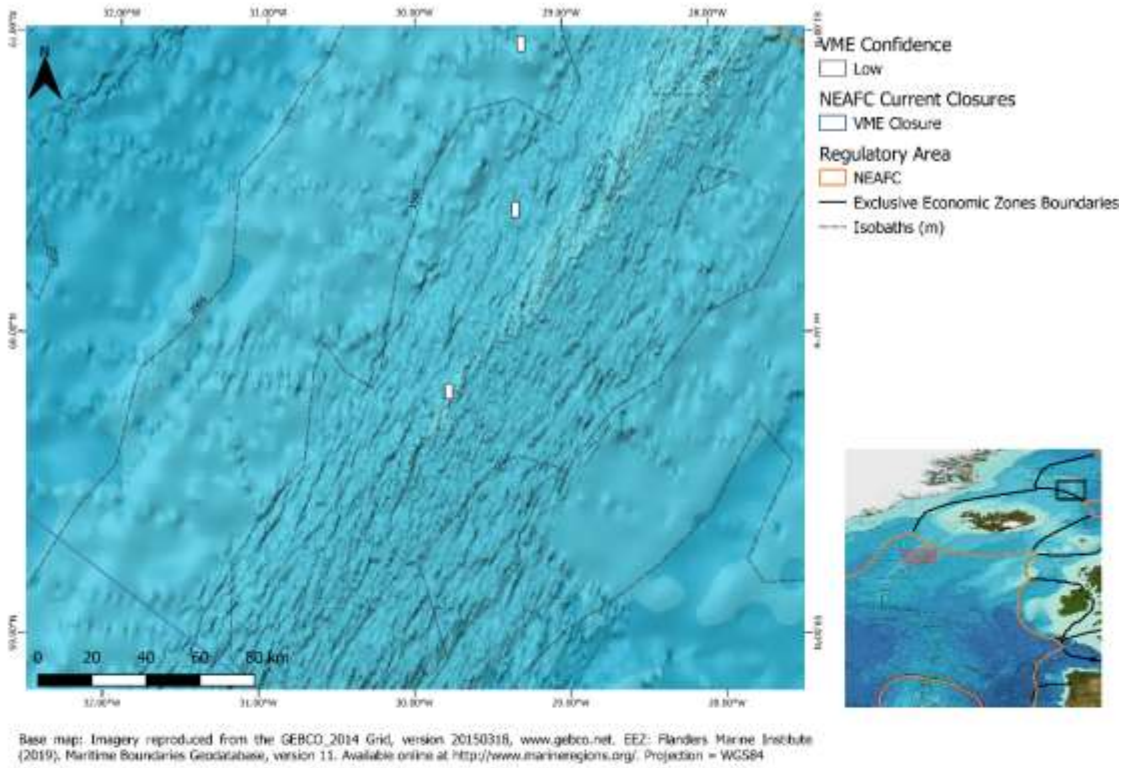


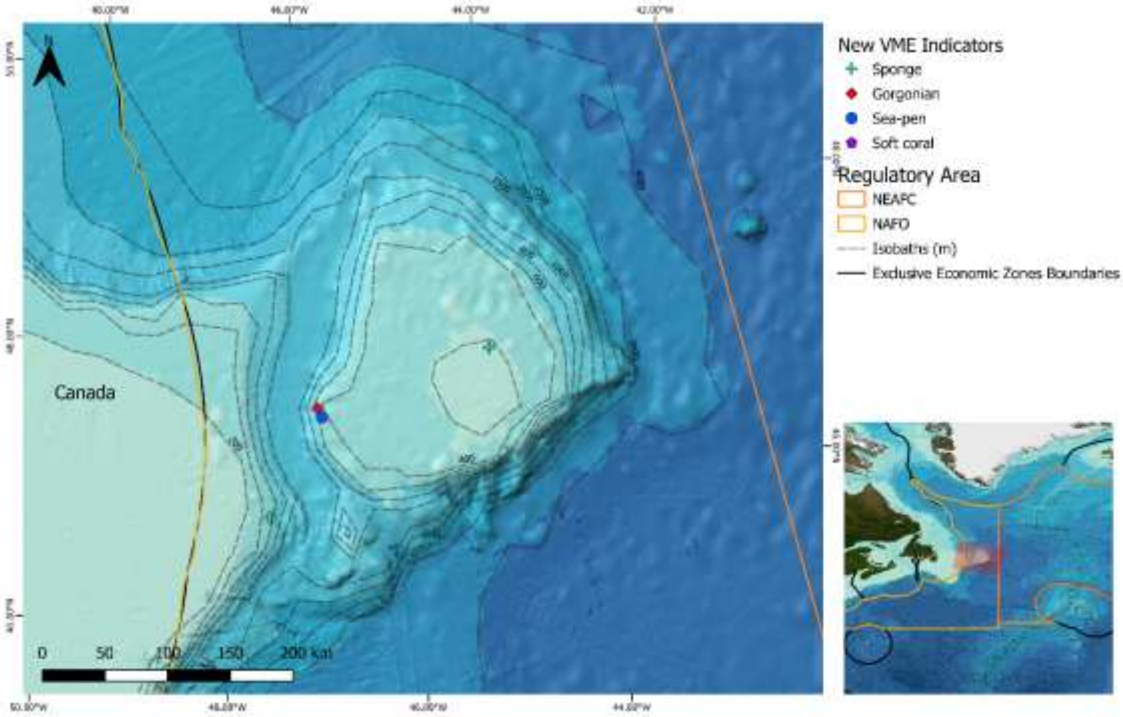
Figure 4.6 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.5). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.3 Areas considered within the NAFO Regulatory Area

4.3.1 Flemish Cap

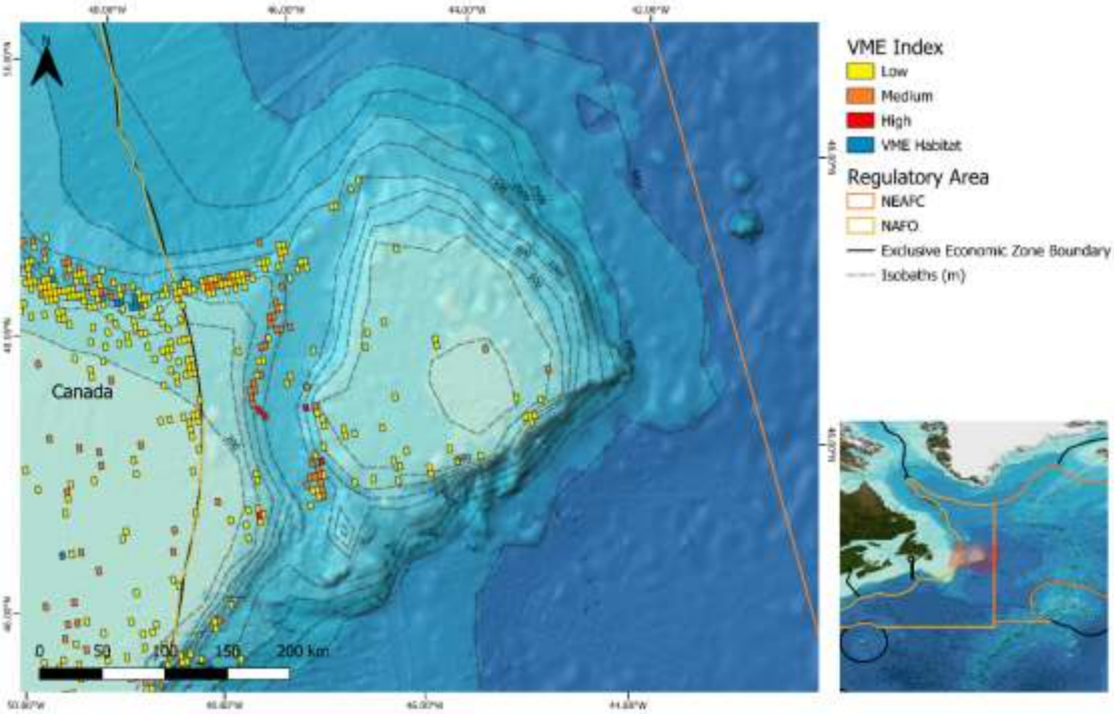
Small numbers of new VME indicator data within the NAFO Regulatory Area on the Flemish Cap off Canada were submitted by the Estonian Marine Institute, University of Tartu (Figure 4.7). Five VME indicators records, from scientific observers onboard fishing vessels, were provided (note some records overlap in location) (see Section 0).

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.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=49 +lat_2=77 +lat_0=0 +lon_0=-59 +x_0=0 +y_0=-8000000 +datum=WGS84 +units=m +no_defs.

Figure 4.7 New VME records submitted in 2020 for the Flemish Cap within the NAFO Regulatory Area. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=49 +lat_2=77 +lat_0=0 +lon_0=-59 +x_0=0 +y_0=-8000000 +datum=WGS84 +units=m +no_defs.

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. Note, this includes all (not only 2020) records from the ICES VME database.

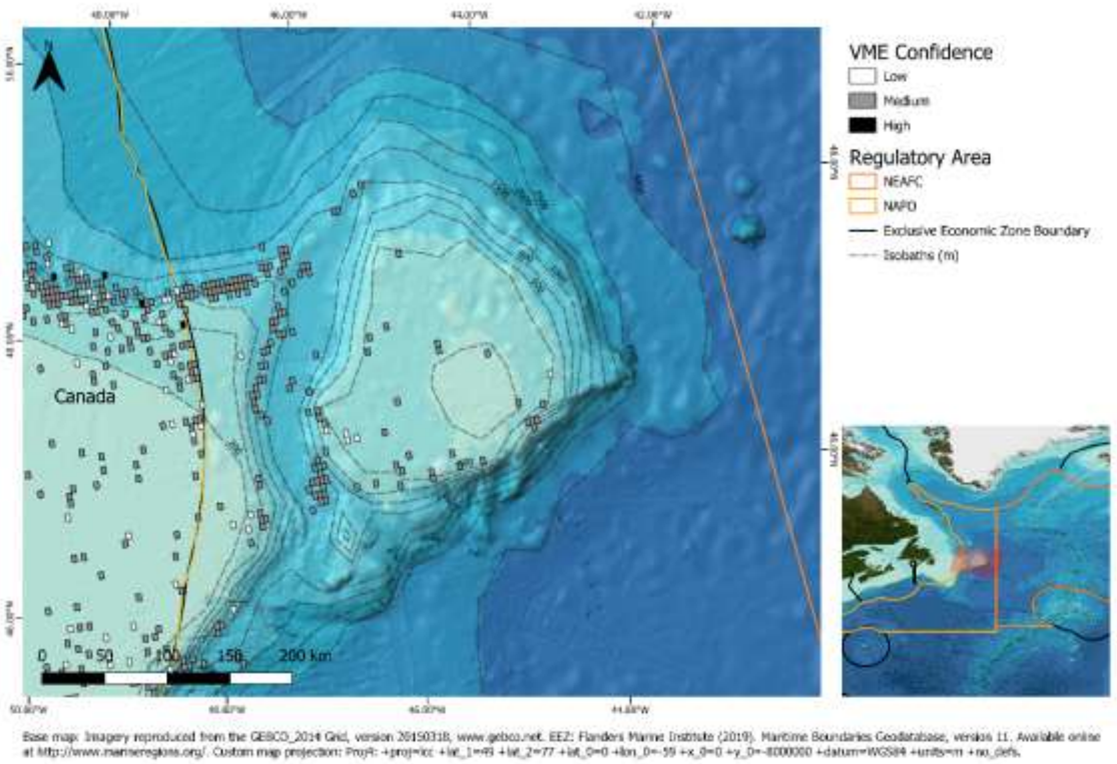


Figure 4.9 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.8). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4 Areas considered within the EEZs of various countries

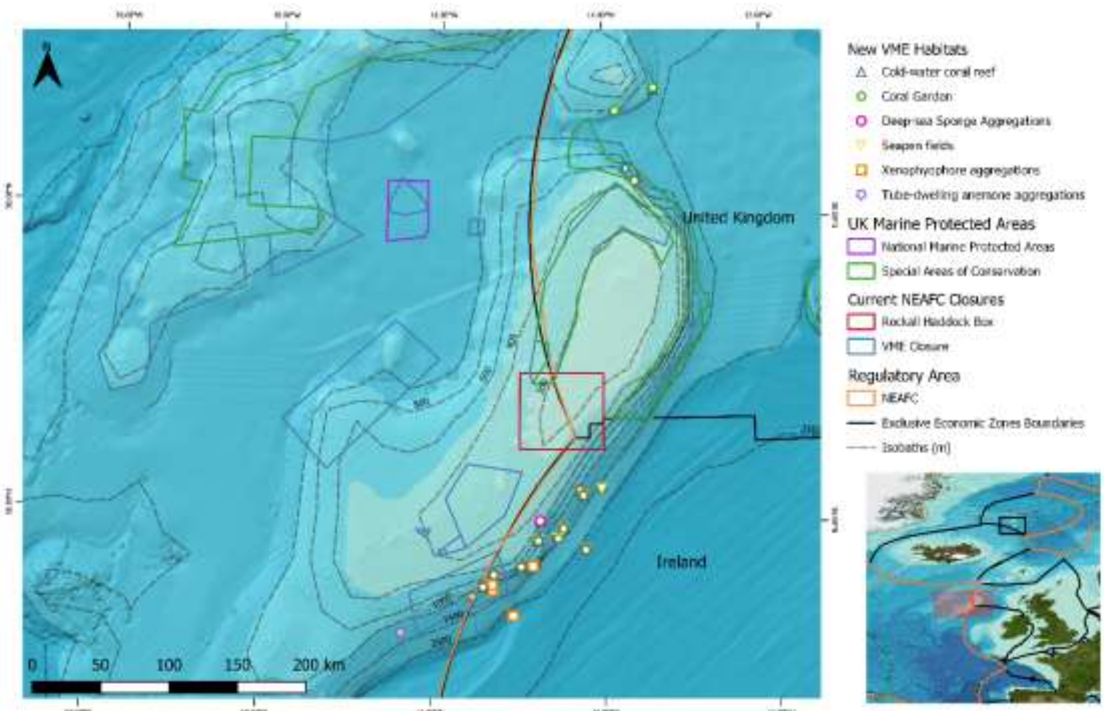
4.4.1 Rockall Bank and George Bligh Bank

New VME habitat data for Rockall Bank and George Bligh Bank were submitted by the UK and Ireland (Figure 4.10). George Bligh Bank is located at the north-eastern end of the Rockall Plateau.

New VME habitat records were located on the North Rockall Bank and George Bligh Bank within the UK's EEZ, collated from the JC136 'DeepLinks' survey in 2016 (see Section 0). Additional VME habitat records were located on the South East Rockall Bank, in the Irish EEZ, from the Irish Marine Institute's SeaRover 2018 survey (see Section 3.4.4.1).

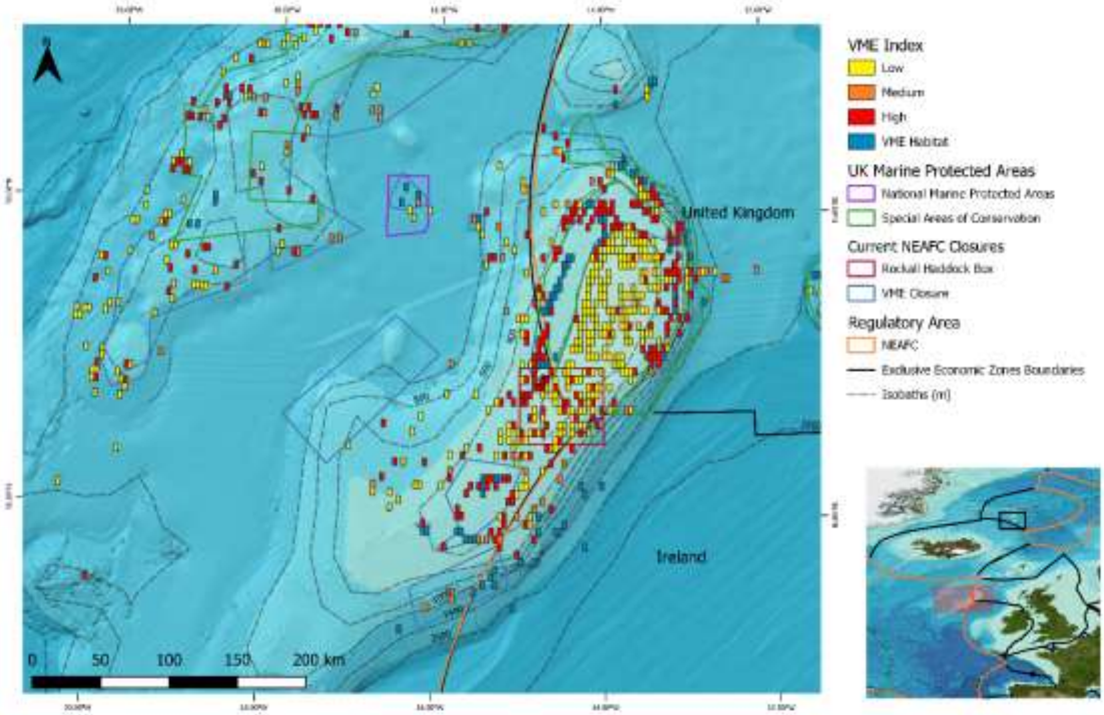
No new VME data were submitted this year for the 'Haddock Box' closure area on Rockall Bank. However, the closure remains an important area for VMEs, as indicated by the outputs of the VME weighting algorithm shown in Figure 4.11.

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



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.10 New VME records submitted in 2020 for the Rockall Bank and George Bligh Bank within EU waters (new records outside EU waters are displayed as transparent). Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.

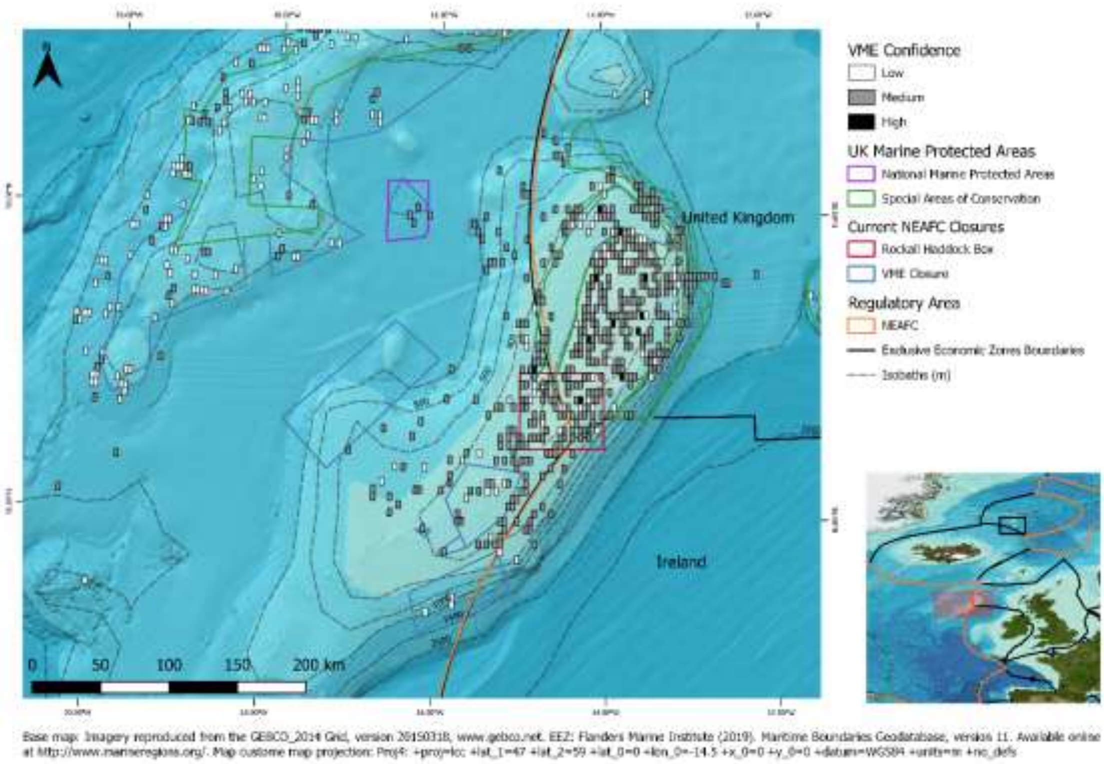


Figure 4.12 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.11). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.2 Anton Dohrn Seamount

Anton Dohrn Seamount is an extinct volcano located west of the Outer Hebrides, to the west of Scotland and occurs within the UK EEZ.

New VME habitat data for the Anton Dohrn Seamount were submitted by the UK (Figure 4.13). Data came from the JC136 'DeepLinks' survey in 2016 (see Section 0).

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

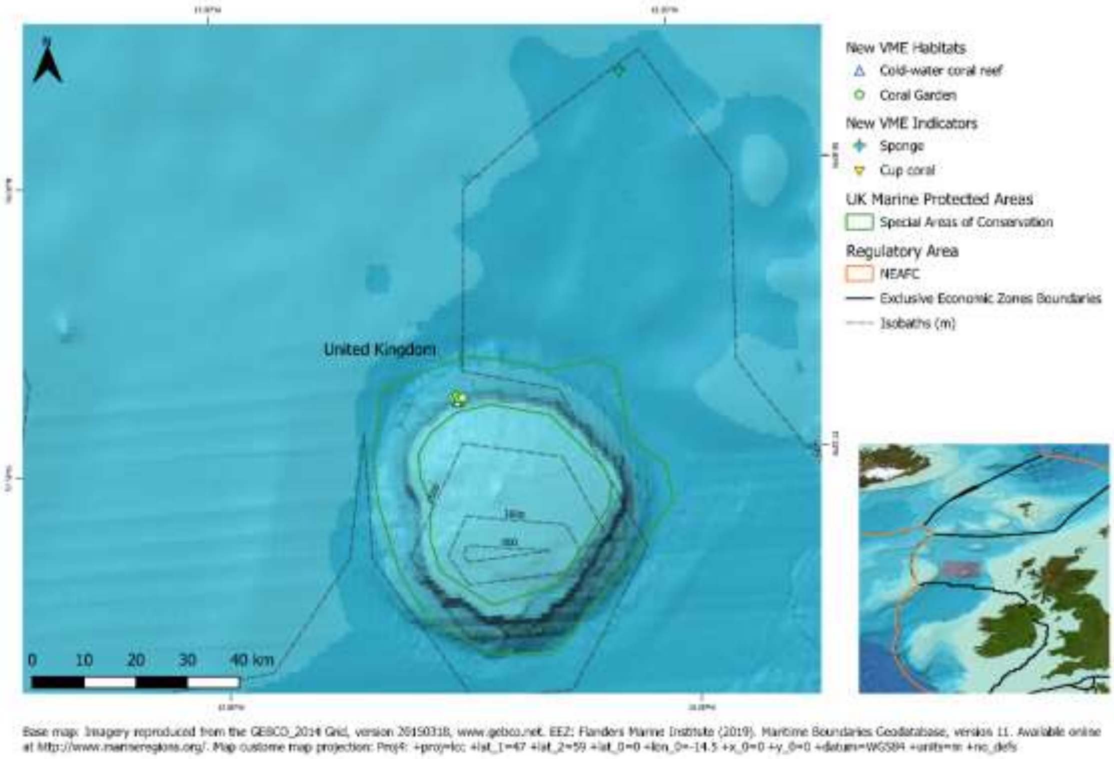
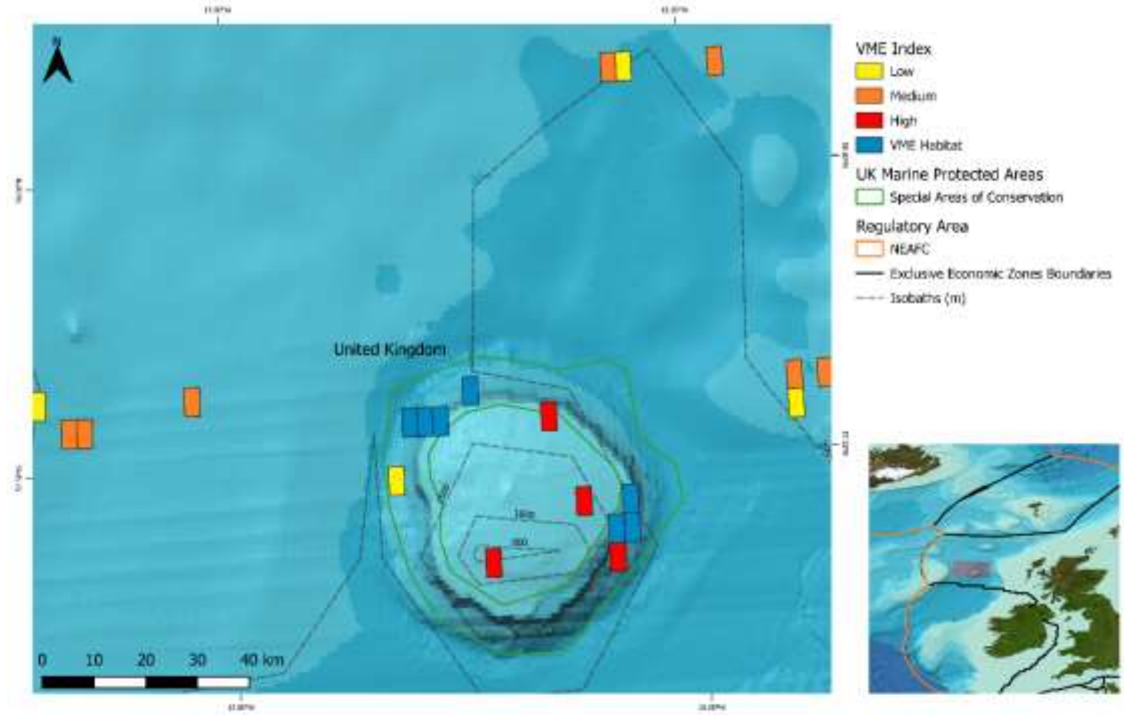


Figure 4.13 New VME records submitted in 2020 for the Anton Dohrn Seamount within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.

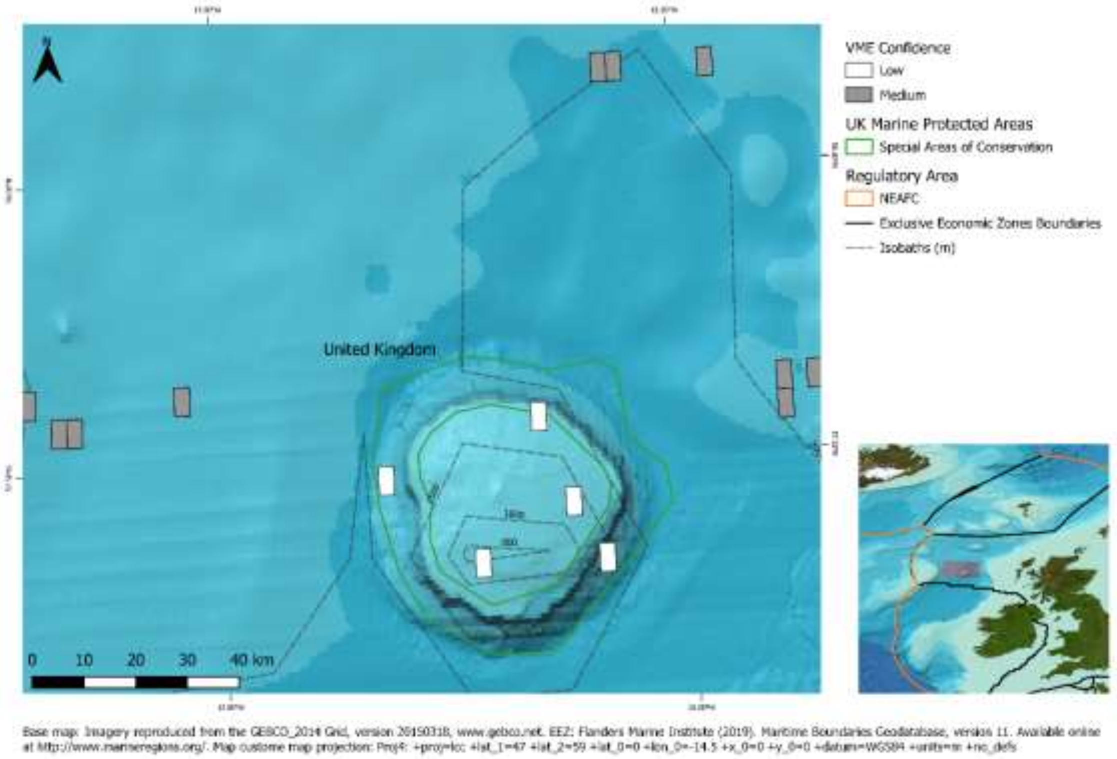


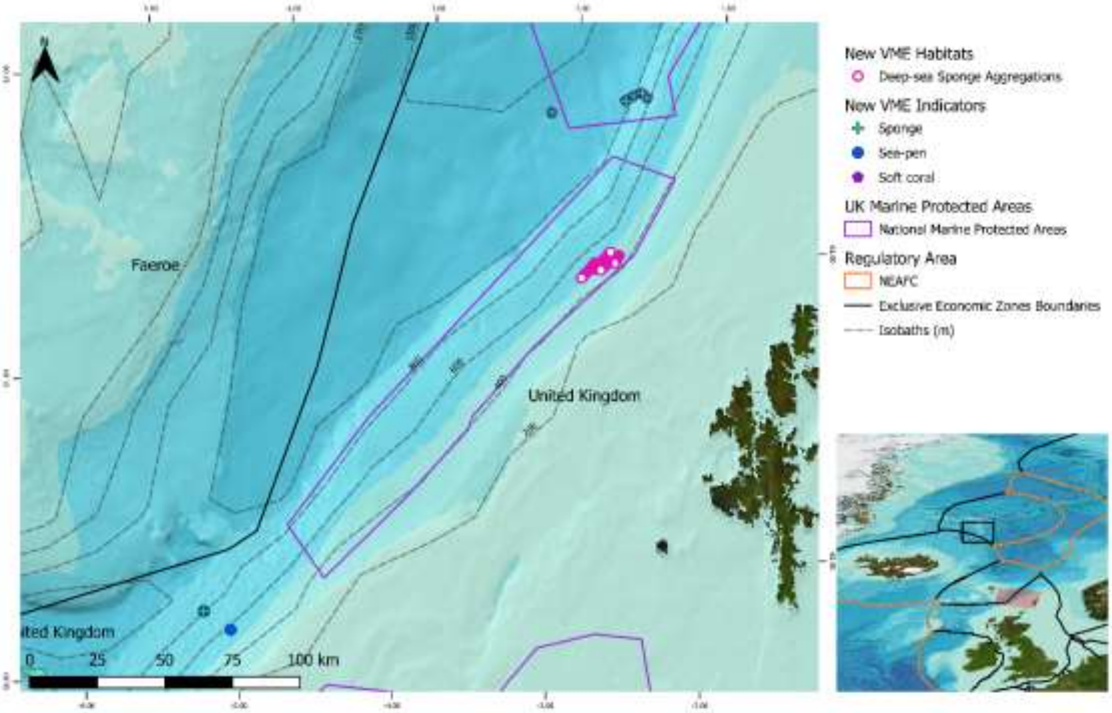
Figure 4.15 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.14). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.3 Faroe Shetland Channel

The Faroe-Shetland Channel is a deep channel located north of Scotland within the EEZ of two countries; the UK and the Faroe Islands (Denmark).

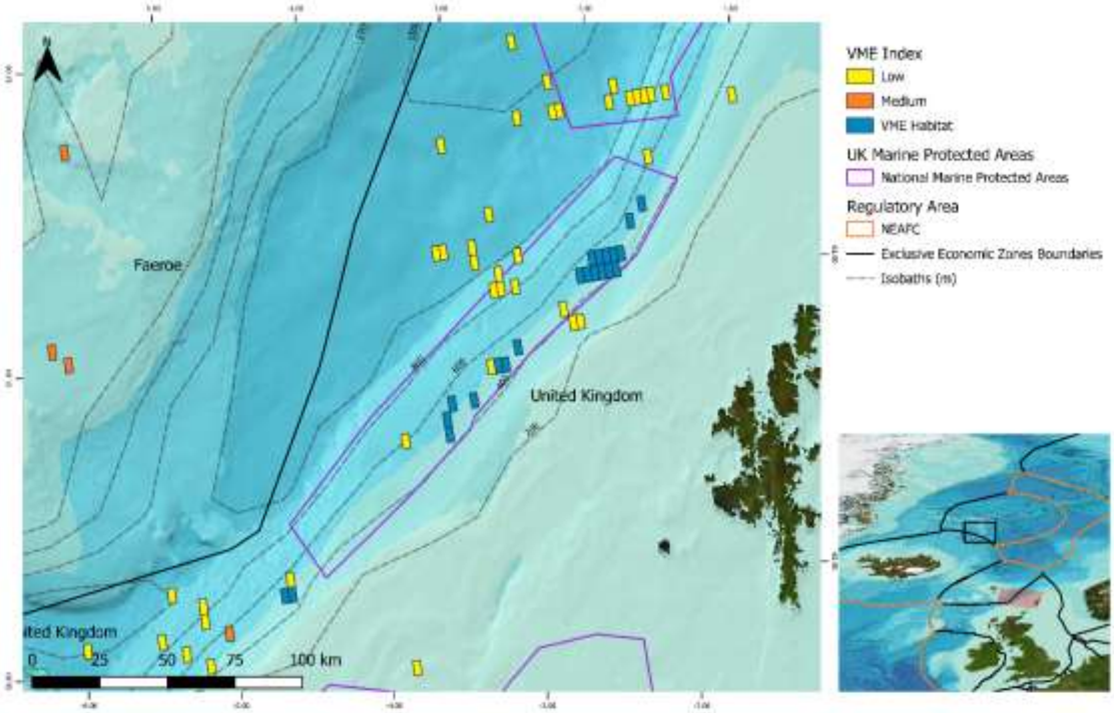
New VME habitat data with were submitted by the UK (Figure 4.16) from the Marine Scotland Science 1341S "MOREDEEP" cruise (see Section 3.4.2.1). VME indicator records for the region were also submitted from the Marine Scotland Science 1419S cruise (see Section 3.4.2.2).

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



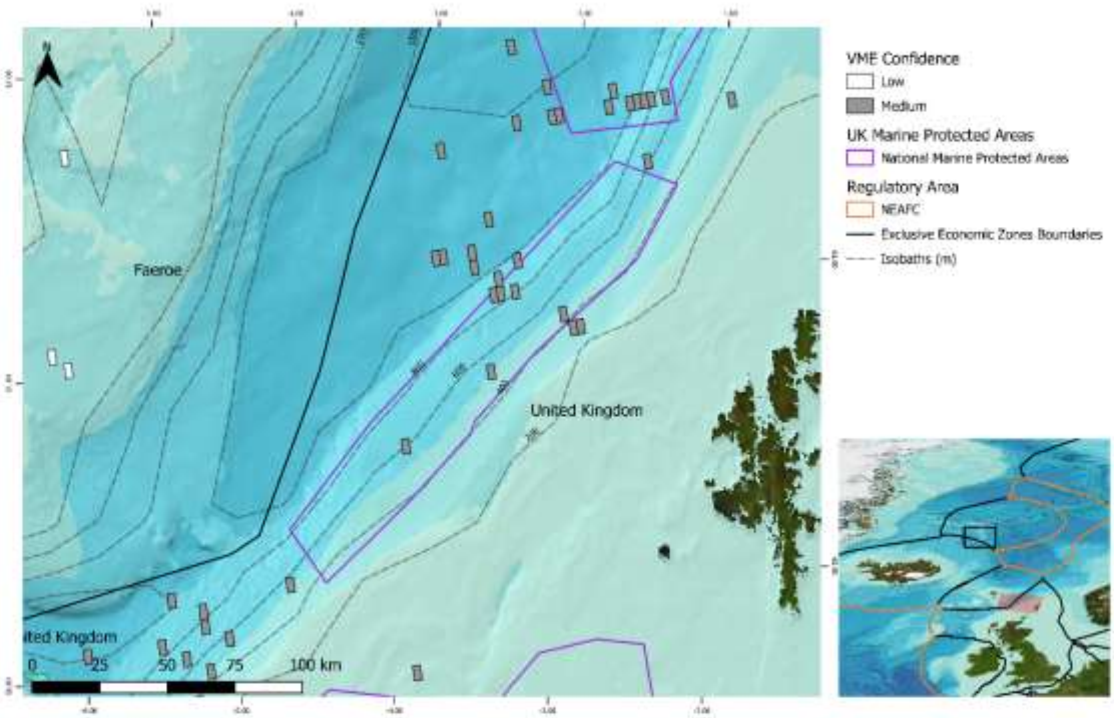
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.16 New VME records submitted in 2020 for the Faroe Shetland Channel within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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. This includes all (not only 2020) records from the ICES VME database.

4.4.4 Darwin Mounds

The Darwin Mounds are located at the north end of the Rockall Trough and are comprised of sandy mounds with cold-water coral thickets.

New VME habitat and indicator data for the Darwin Mounds were submitted by the UK (Figure 4.19), with historical data from the NOC Discovery 248 cruise (see Section 3.4.3.3) and more recent records from the NOC Discovery 108 Cruise (see 3.4.3.2).

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

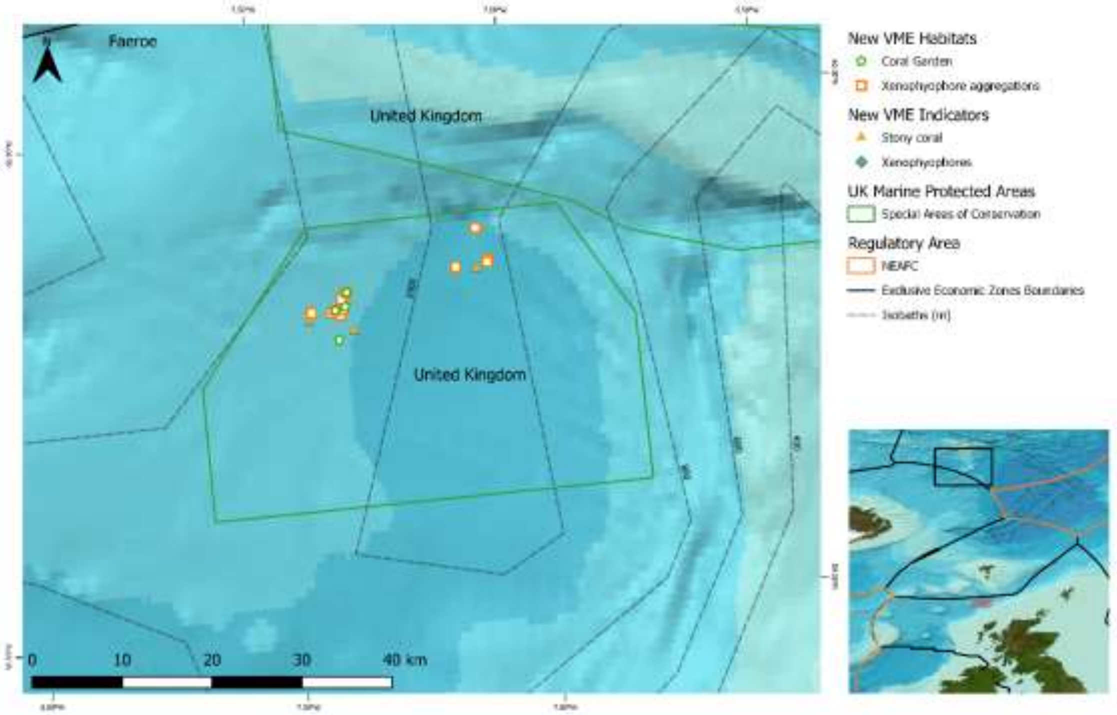


Figure 4.19 New VME records submitted in 2020 for the Darwin Mounds within EU waters. Note, other VME records from the VME database for this area are not displayed.

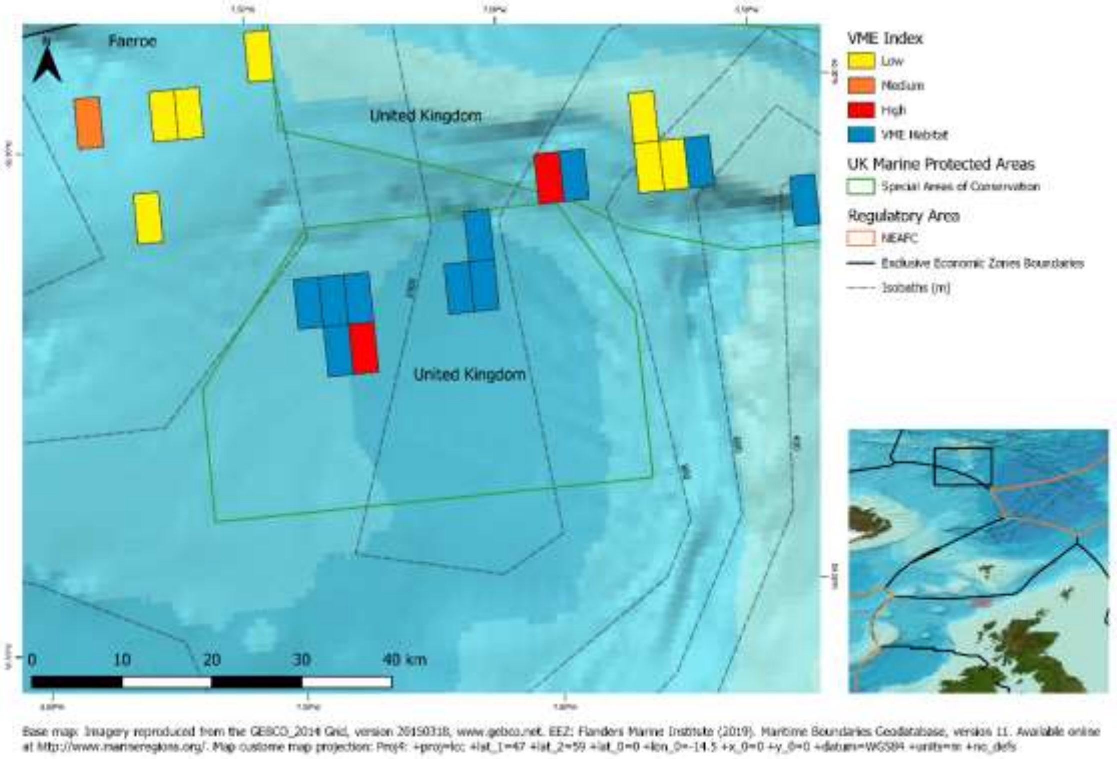


Figure 4.20 Output of the VME weighting algorithm for the area shown in Figure 4.19 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2020) records from the ICES VME database.

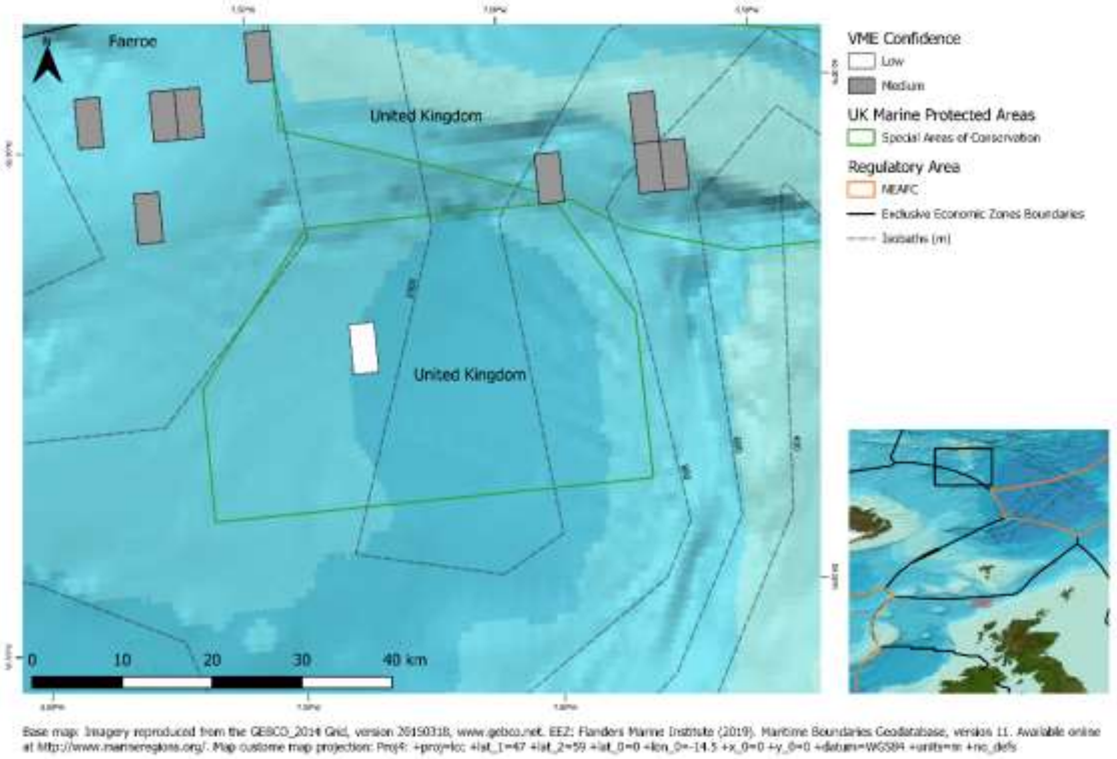
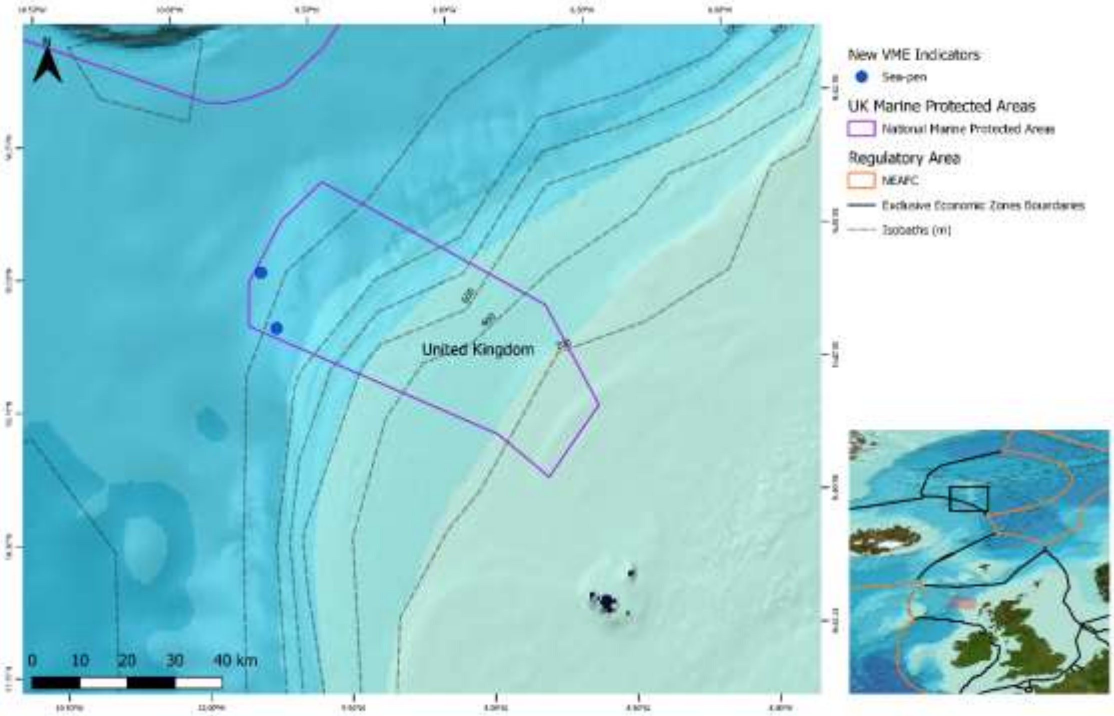


Figure 4.21 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.20). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.5 Hebridean Slope (Scotland)

New VME indicator records for the Hebridean Slope were submitted by the UK (Figure 4.22). Data came from the Marine Scotland Science 1419S survey (see Section 3.4.2.2) and detailed new records of sea pens.

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



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Map custome map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.22 New VME records submitted in 2020 for the Hebridean Slope within EU waters. Note, other VME records from the VME database for this area are not displayed.

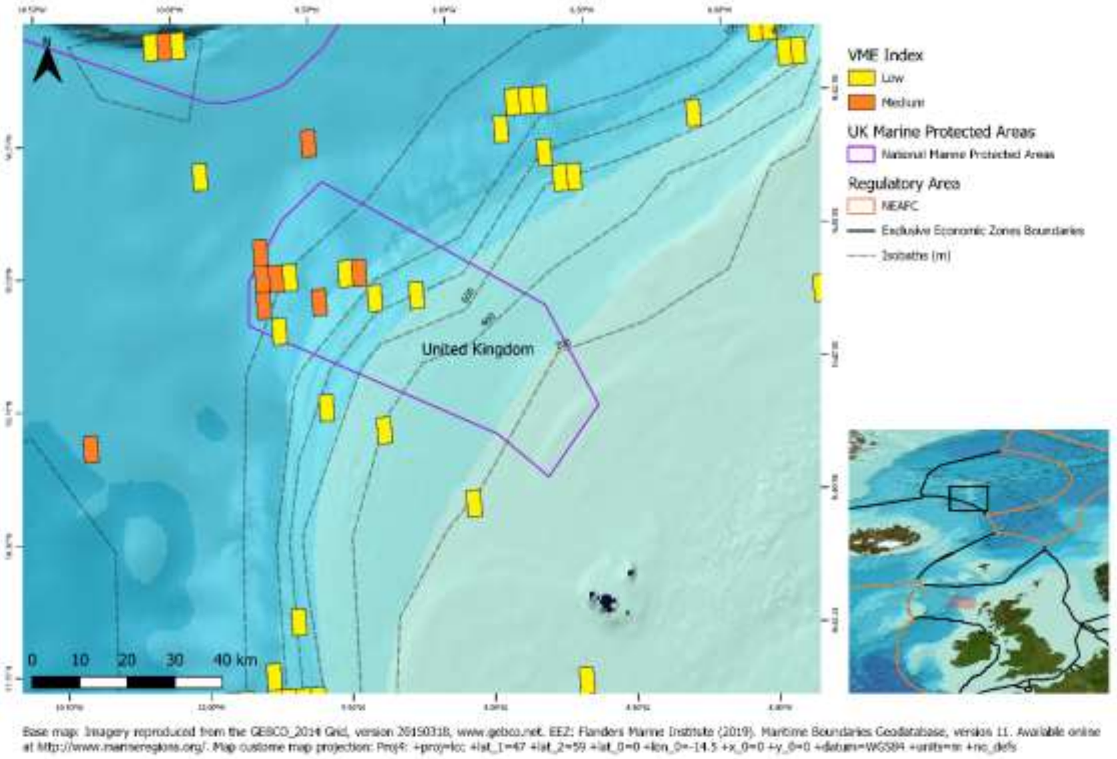


Figure 4.23 Output of the VME weighting algorithm for the area shown in Figure 4.22 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2020) records from the ICES VME database.

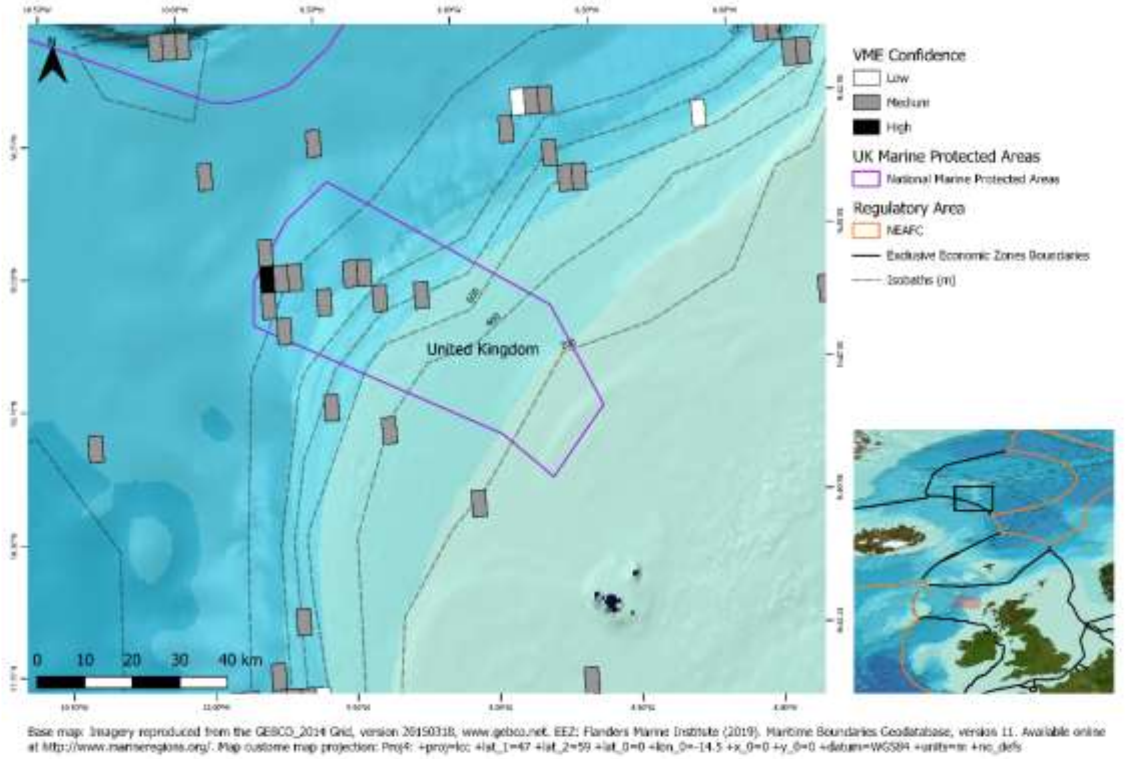


Figure 4.24 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.23). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.6 Scottish and Irish Continental Slope

New VME habitat and indicator records for the Scottish and Irish Continental Slope were submitted by the UK and Ireland (Figure 4.25). New VME indicators were submitted from the Marine Scotland Science 1419S Survey (see Section 3.4.2.2) and the Irish Groundfish surveys (IGFS) (see Section 3.4.4.2). New VME habitat records were submitted from the Irish SeaRover 2017 survey (see Section 3.4.4.1).

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

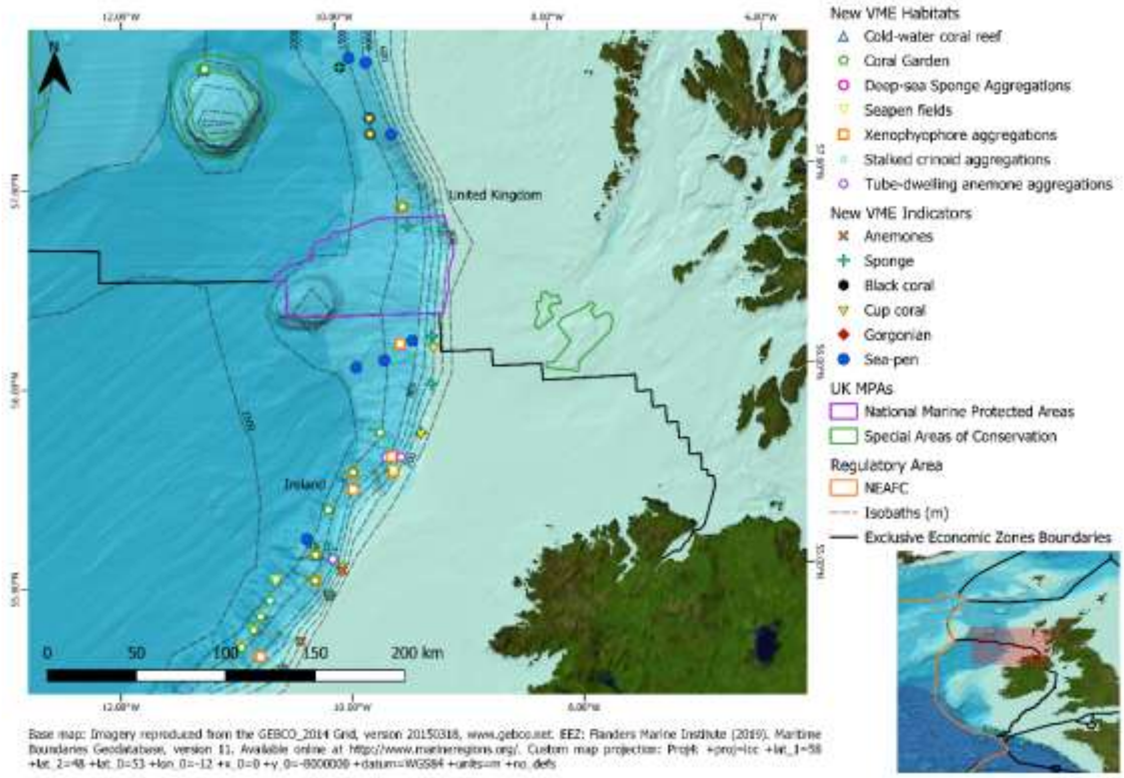
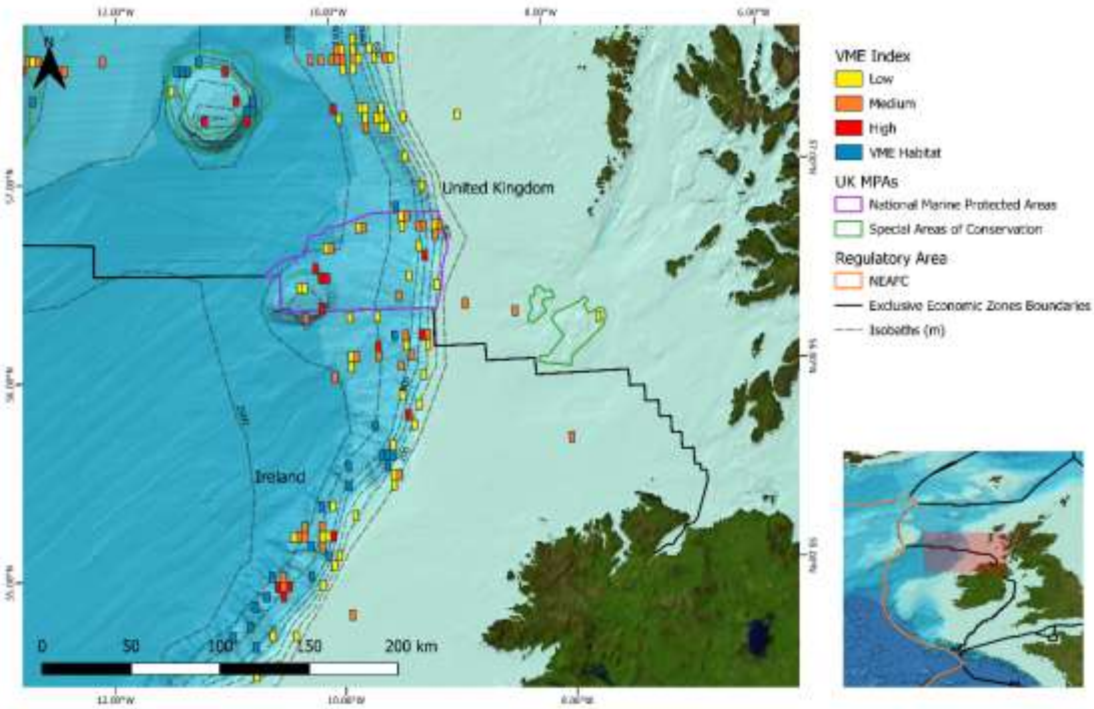


Figure 4.25 New VME records submitted in 2020 for the Scottish and Irish Continental Slope within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=50 +lat_2=48 +lat_0=53 +lon_0=-12 +x_0=0 +y_0=-8000000 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.

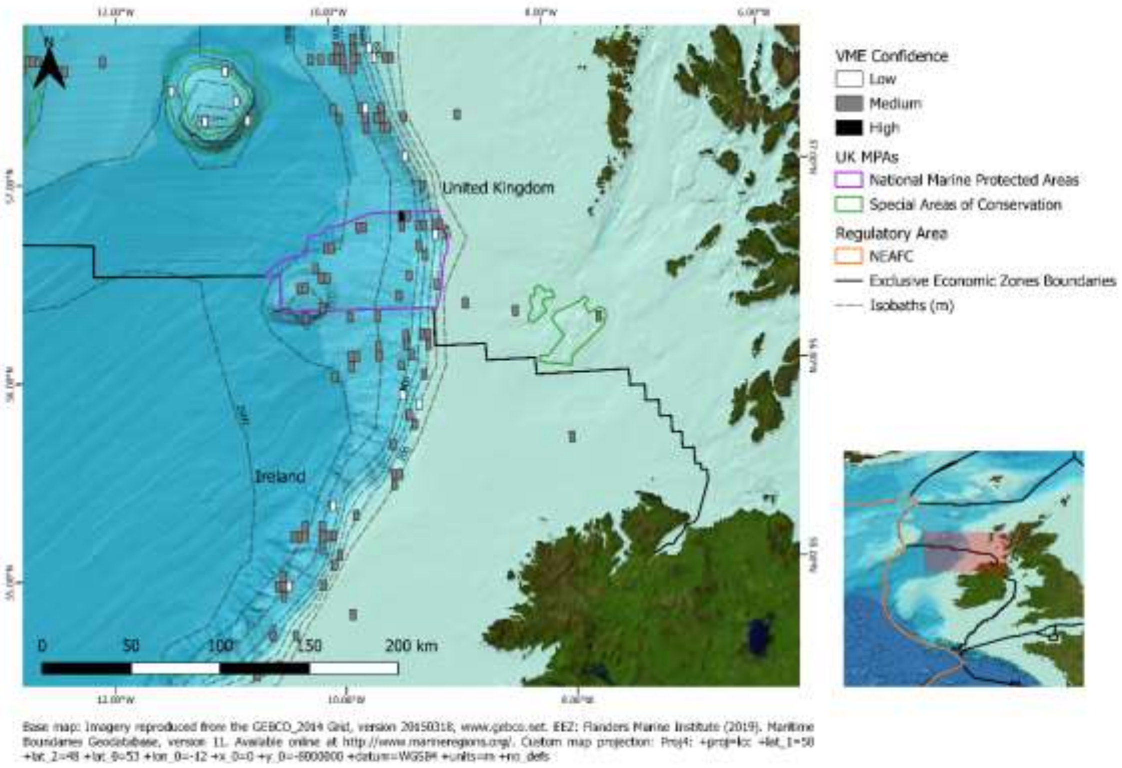


Figure 4.27 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.26). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.7 Porcupine Bank and Seabight

The Porcupine Bank is located west of Ireland, and is a plateau forming the north-western margin of the Porcupine Seabight Basin. To the north and west, the Porcupine Bank slopes steeply down a shelf break towards the Rockall Trough. To the south and southwest the bank slopes more gently to the Porcupine Seabight (Thébaudeau *et al.*, 2015).

A large number of new VME habitat and indicator data were submitted by the UK and Ireland to the database in 2020 for this region, in addition to absence records (Figure 4.28).

New VME indicator data were provided from a range of sources: historic records from the Institute of Oceanographic Sciences report (Rice *et al.*, 1990) (see Section 3.4.1.1); the NOC JC062 survey (see Section 3.4.3.1); the NOC D248 survey (see Section 3.4.3.3); the Irish Groundfish Surveys (see Section 3.4.4.2) and the Irish Underwater TV surveys (see Section 0).

VME habitat data were provided from the NOC JC062 survey (see Section 3.4.3.1); the SeaRover 2017 and 2018 surveys (see Section 3.4.4.1), and; the NOC D248 survey (see Section 3.4.3.3).

Absence data were provided from the Irish Underwater TV surveys.

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

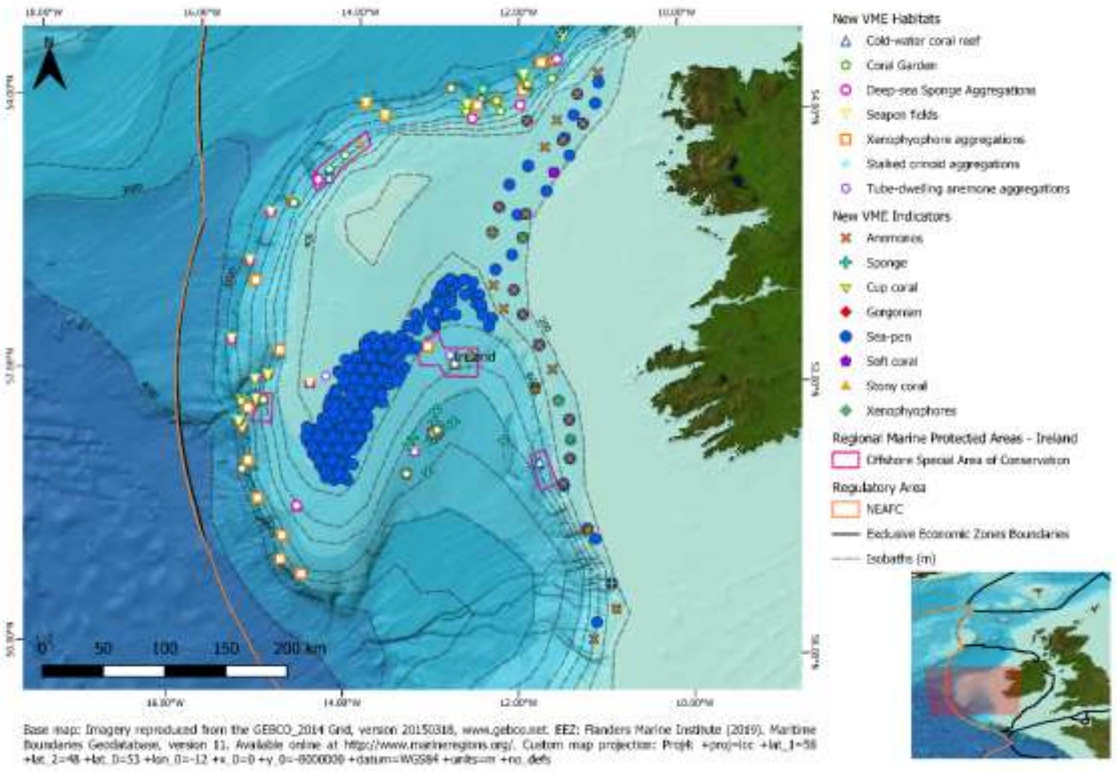


Figure 4.28 New VME records submitted in 2020 for the Porcupine Bank and Seabight within EU waters. Note, other VME records from the VME database for this area are not displayed.

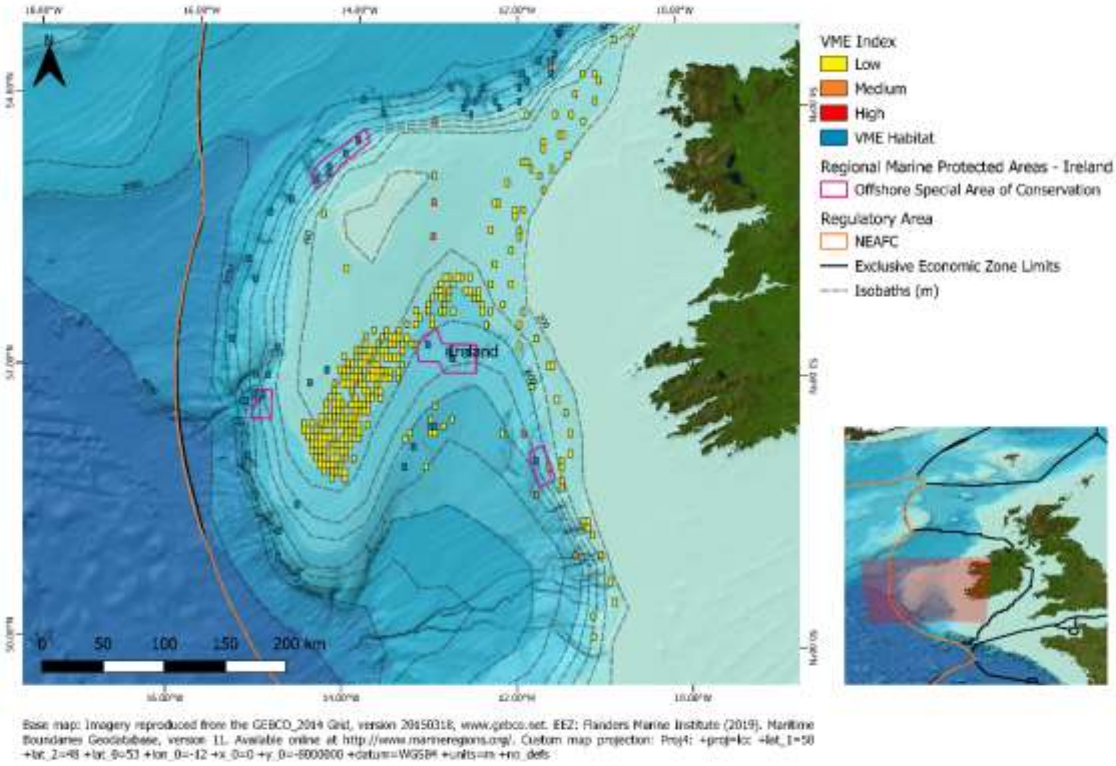


Figure 4.29 Output of the VME weighting algorithm for the area shown in Figure 4.28 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2020) records from the ICES VME database.

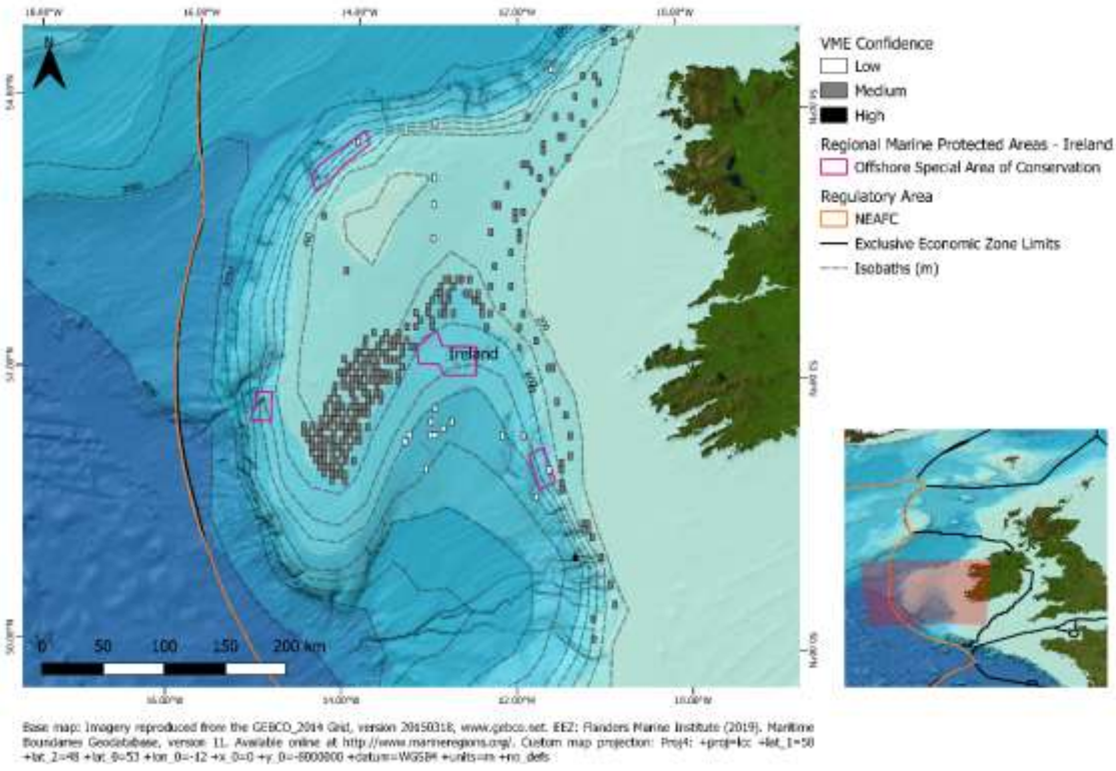
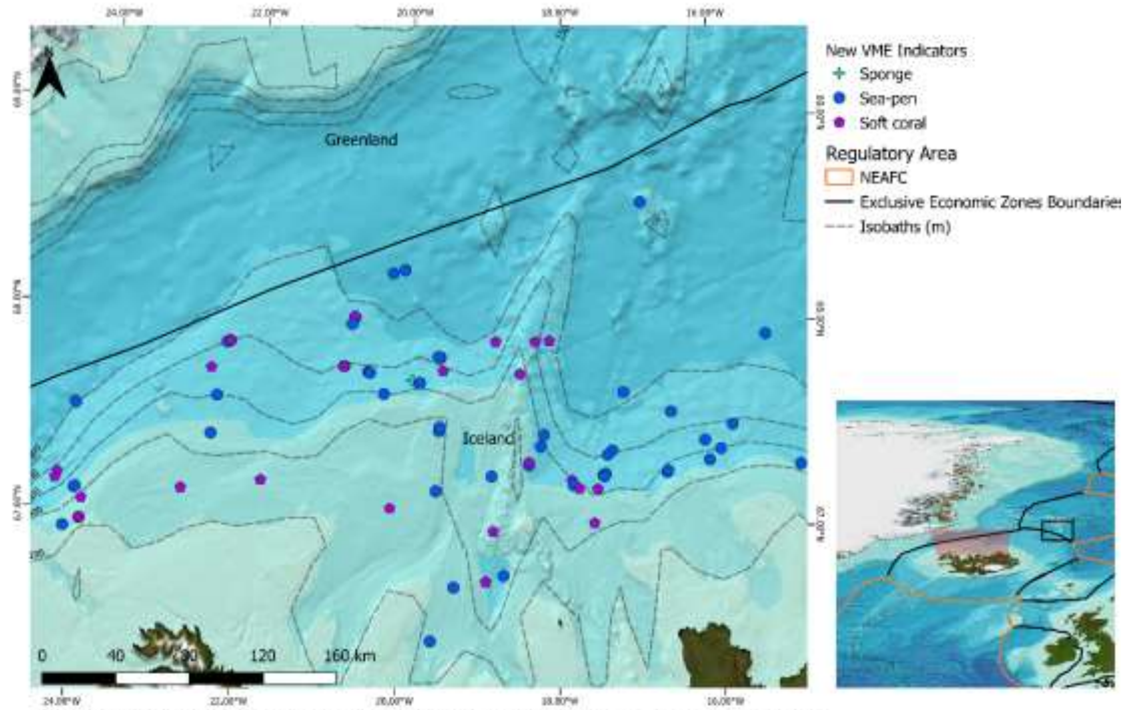


Figure 4.30 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.29). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.8 Icelandic Continental Slope

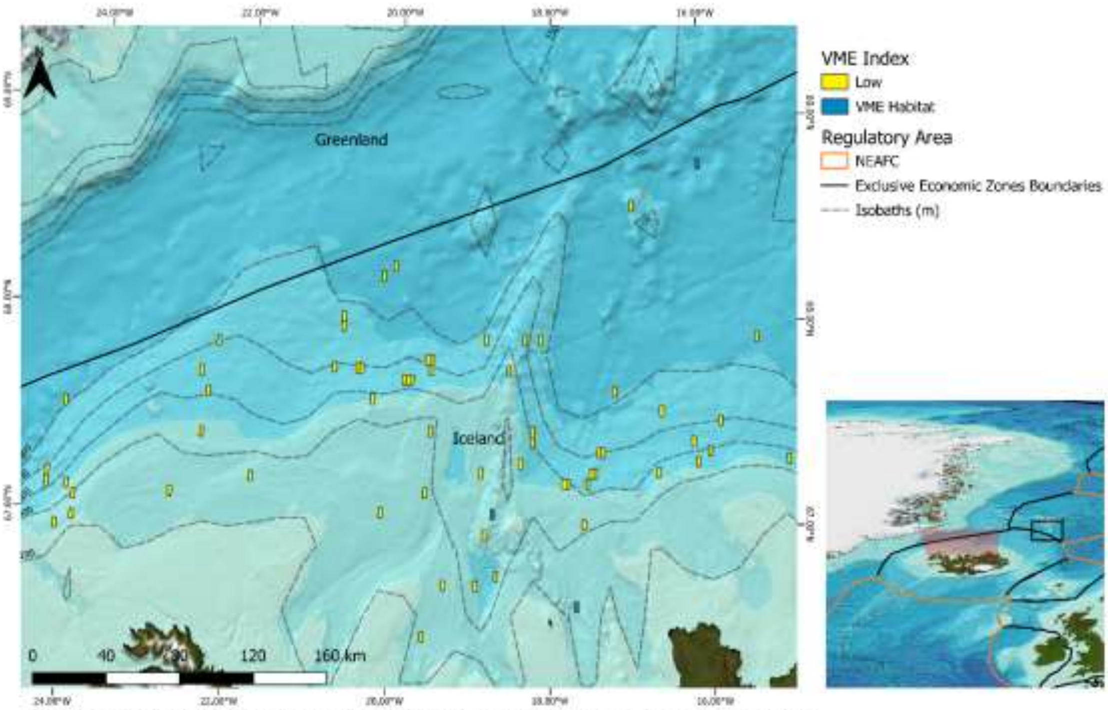
New VME habitat and indicator records were provided by Iceland for the Icelandic Continental Slope. New VME indicator data was provided from the Benthic Invertebrates of Icelandic waters (BIOICE) projects from 1991–2004 (see Section 3.4.7.1) and the Marine and Freshwater Research Institute's benthic habitat mapping project (see Section 0). New VME habitat data was also provided from the benthic habitat mapping project. An additional VME habitat record for a hydrothermal vent was submitted from the Icelandic marine Animals: Genetics and Ecology (ICEAGE) project (see Section 0).

Maps are split by North, East, South and West of Iceland to show the new records more clearly (Figure 4.31,Figure 4.34, Figure 4.37 and Figure 4.40). Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.32, Figure 4.35, Figure 4.39 and Figure 4.41), and the confidence layer for the VME index is shown in Figure 4.33, Figure 4.36, Figure 4.39 and Figure 4.42.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.31 New VME records submitted in 2020 for the North of Iceland within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

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 2020) records from the ICES VME database.

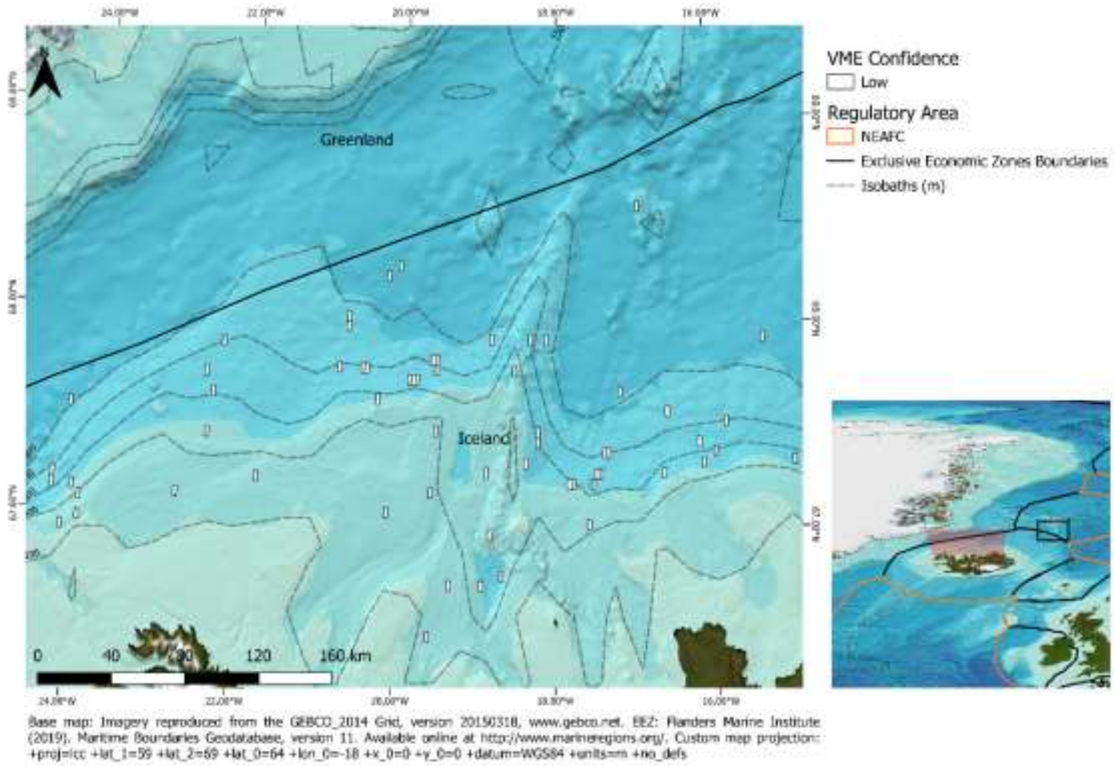
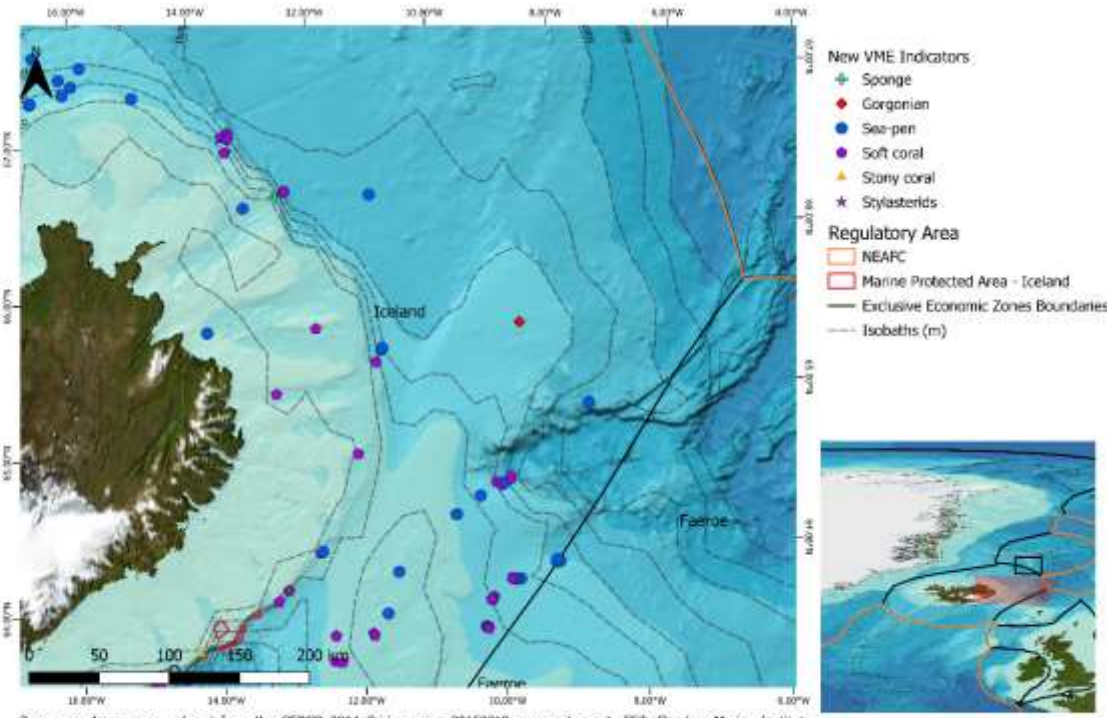


Figure 4.33 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.32). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.34 New VME records submitted in 2020 for East of Iceland within EU waters. Note, other VME records from the VME database for this area are not displayed.

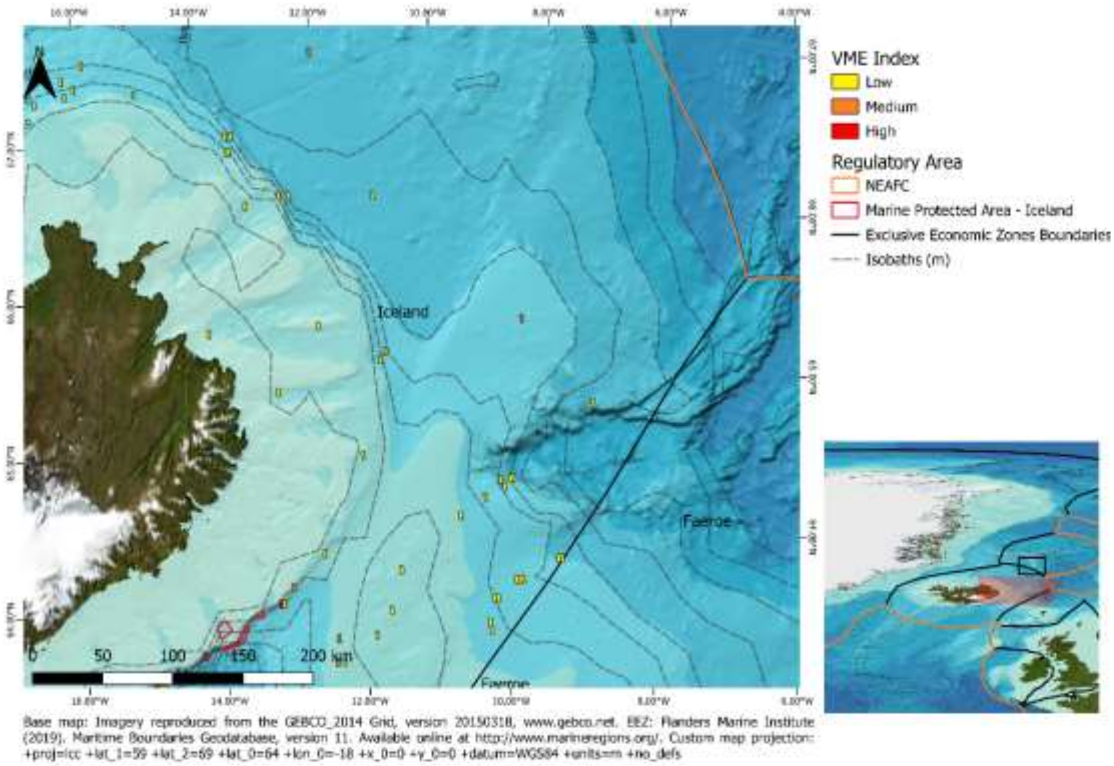
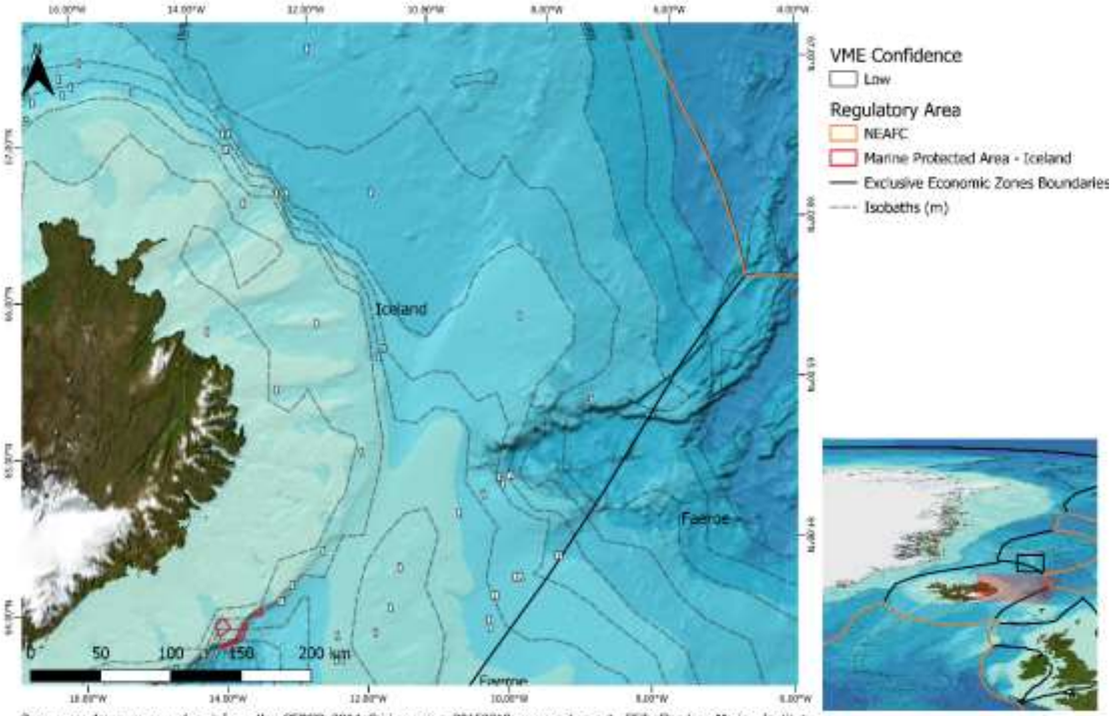
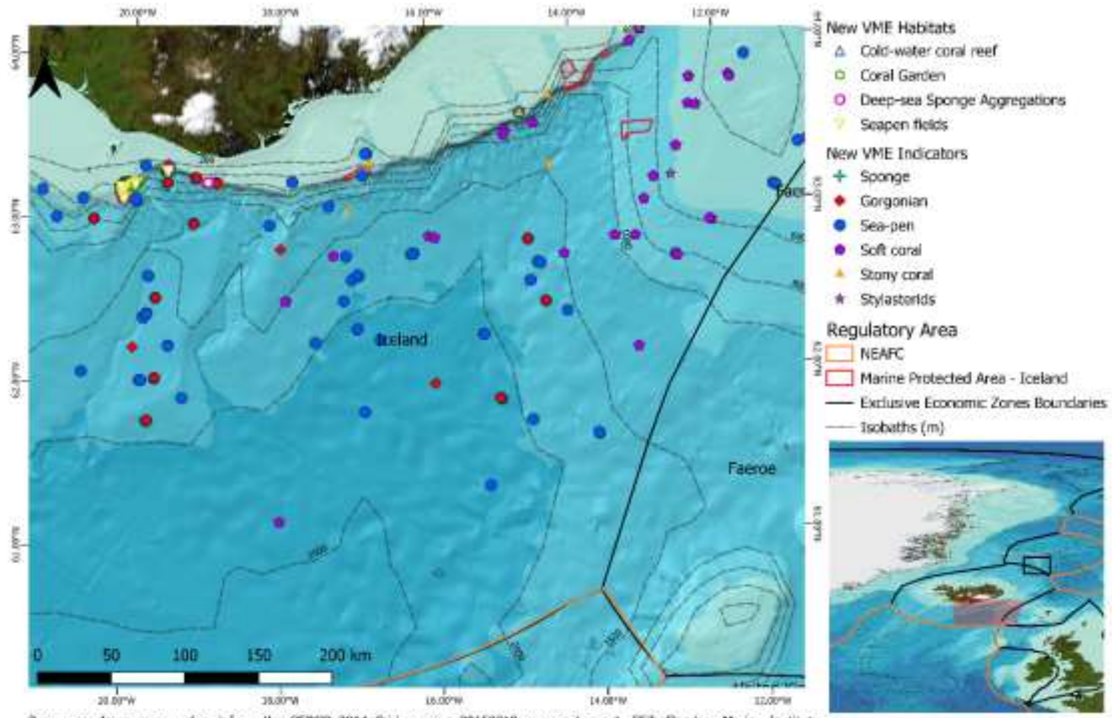


Figure 4.35 Output of the VME weighting algorithm for the area shown in Figure 4.34 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2020) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.36 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.35). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.37 New VME records submitted in 2020 for South of Iceland within EU waters. Note, other VME records from the VME database for this area are not displayed.

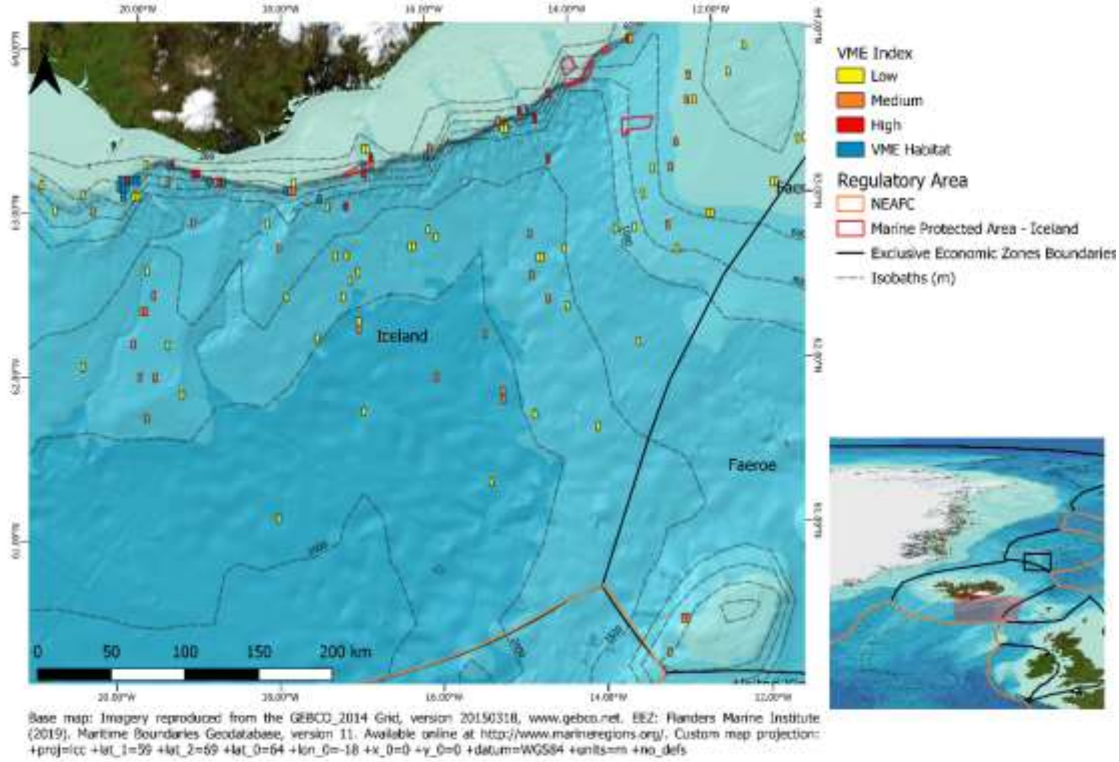
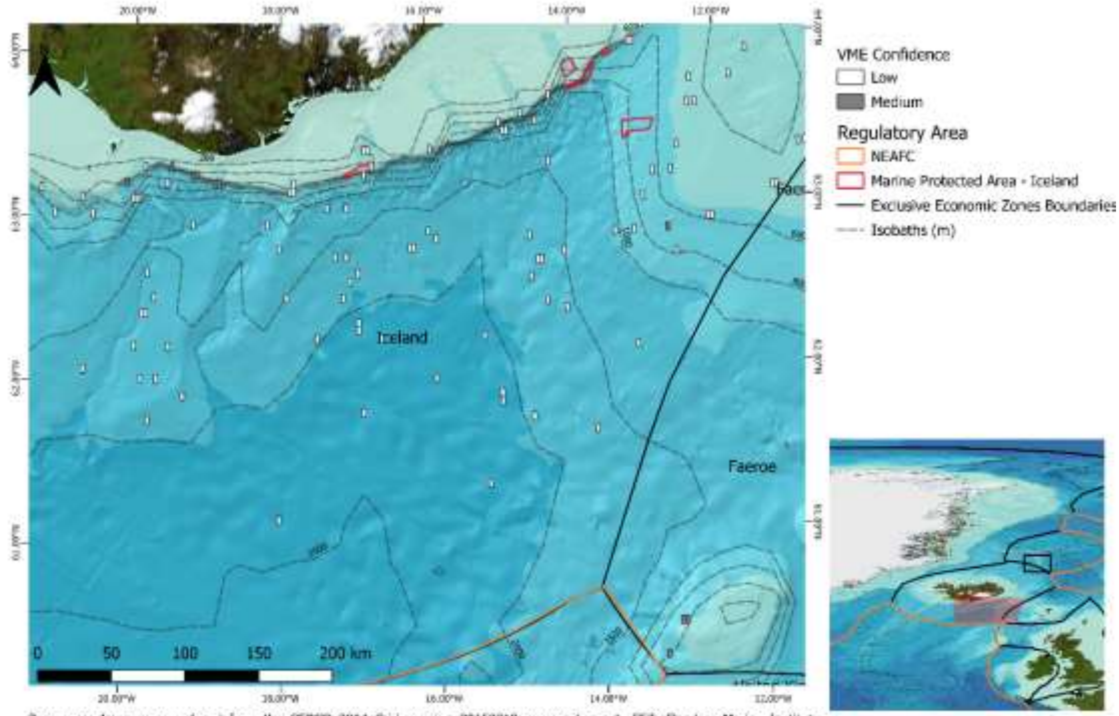
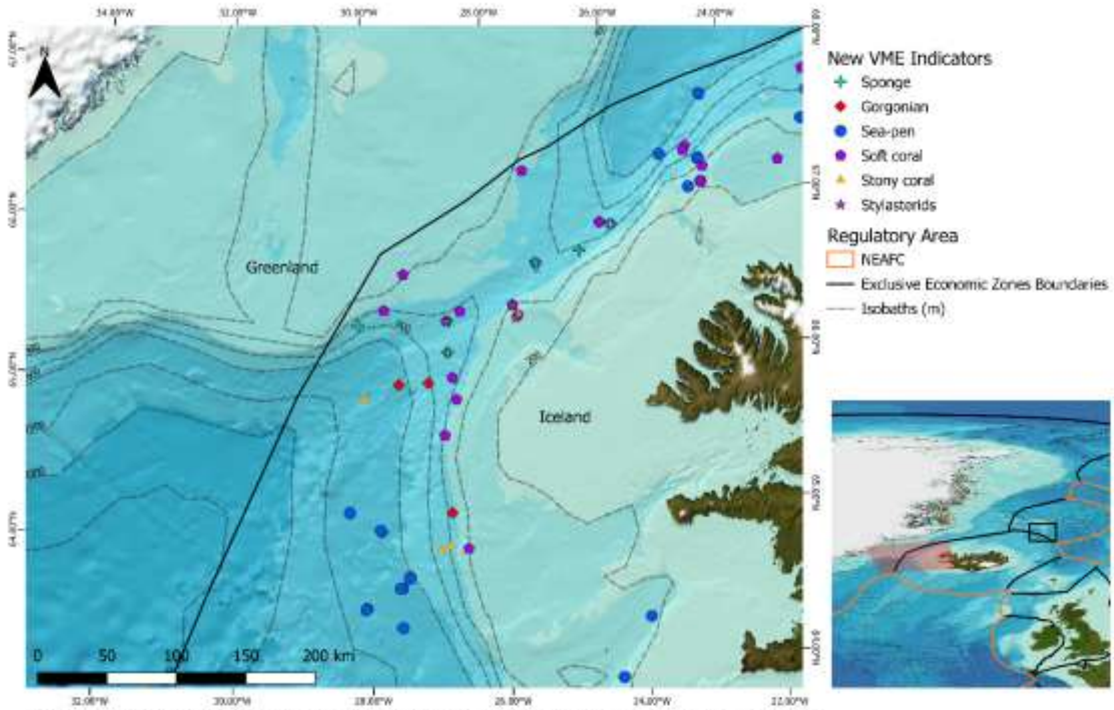


Figure 4.38 Output of the VME weighting algorithm for the area shown in Figure 4.37 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2020) records from the ICES VME database.



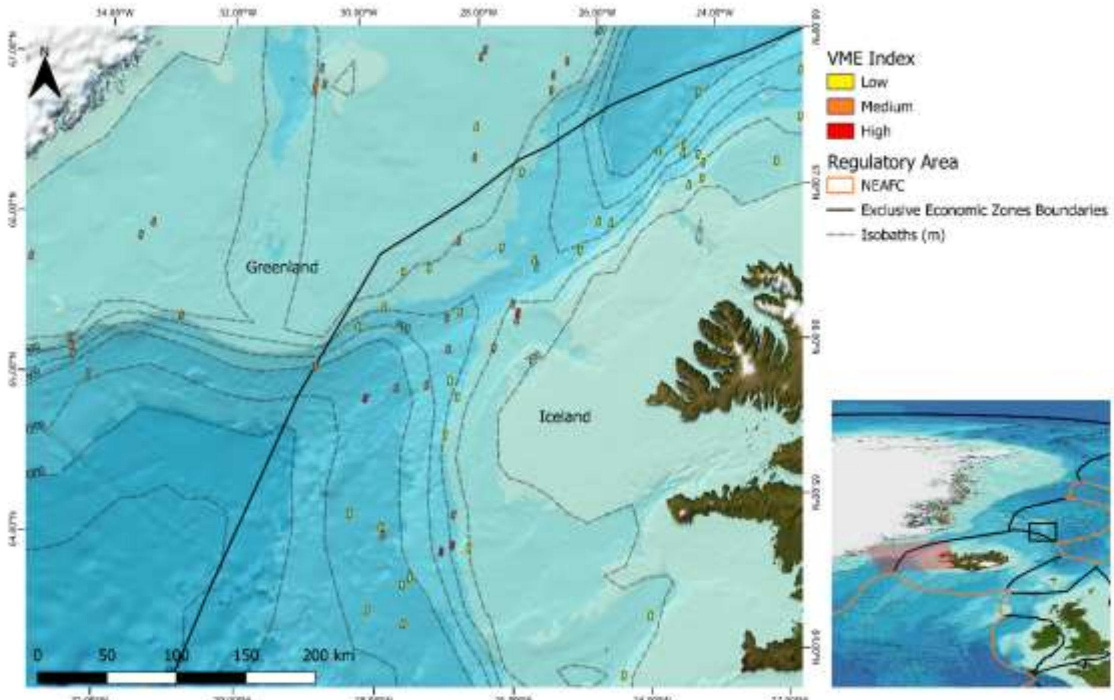
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.39 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.38). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.40 New VME records submitted in 2020 for West of Iceland within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: +proj=lcc +lat_1=59 +lat_2=69 +lat_0=64 +lon_0=-18 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs

Figure 4.41 Output of the VME weighting algorithm for the area shown in Figure 4.40 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 2020) records from the ICES VME database.

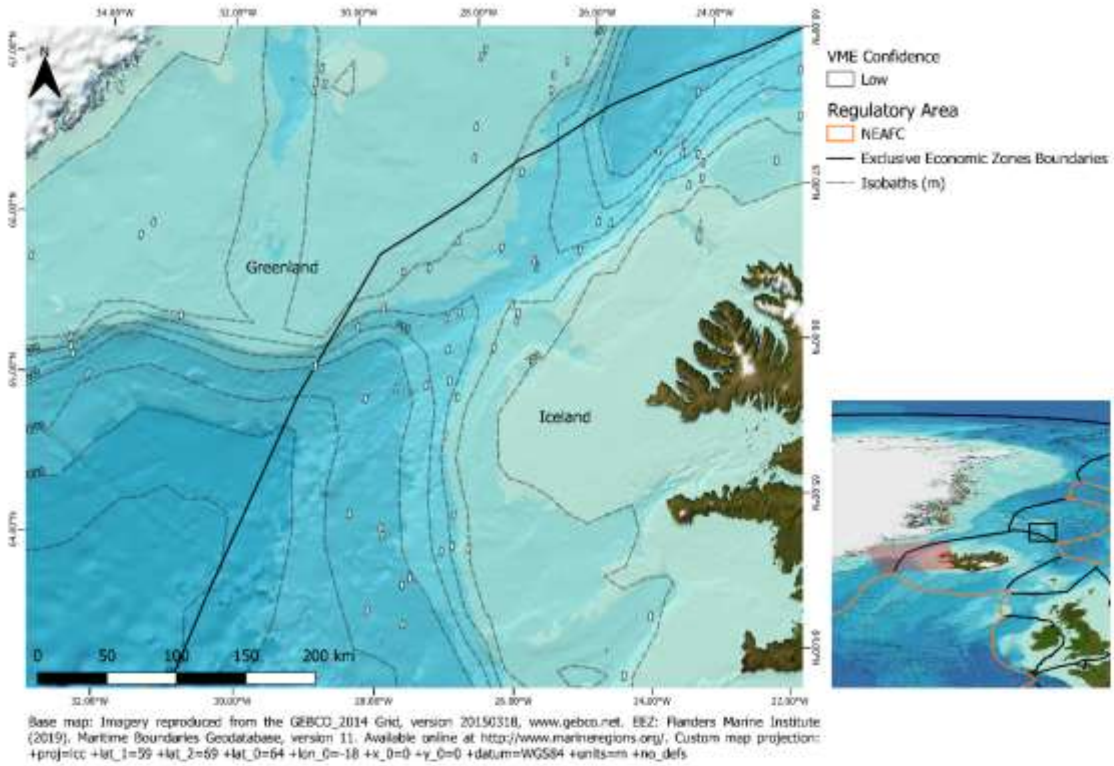
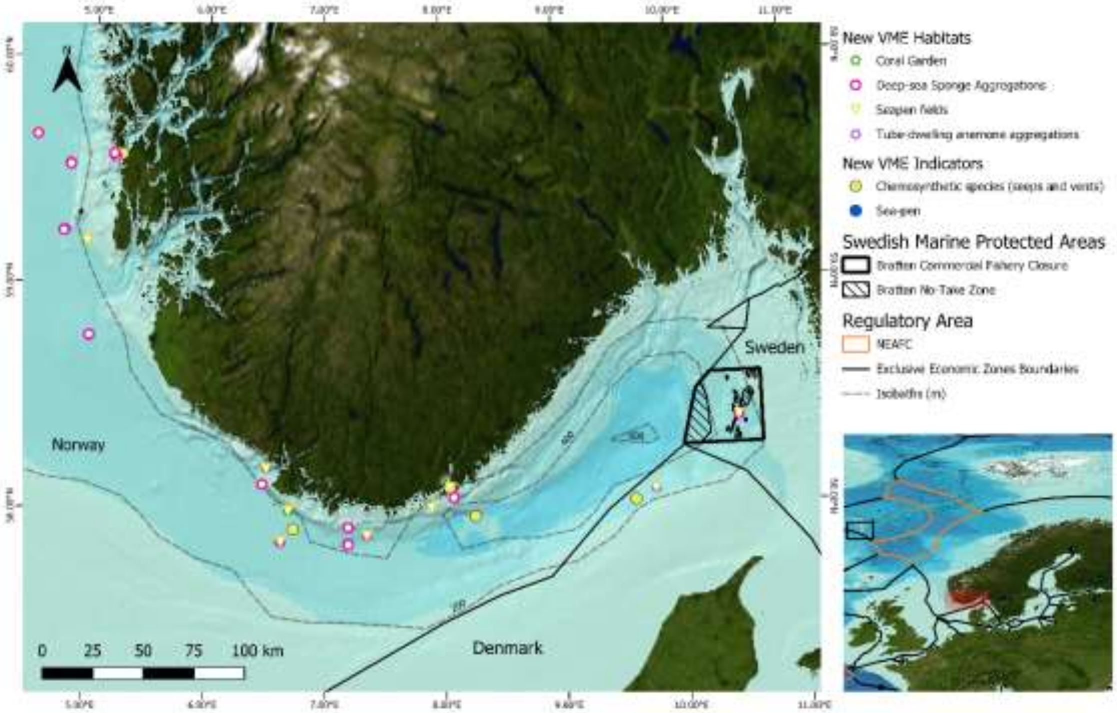


Figure 4.42 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.41). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.4.9 Norwegian Trench and Danish and Swedish Continental Slopes

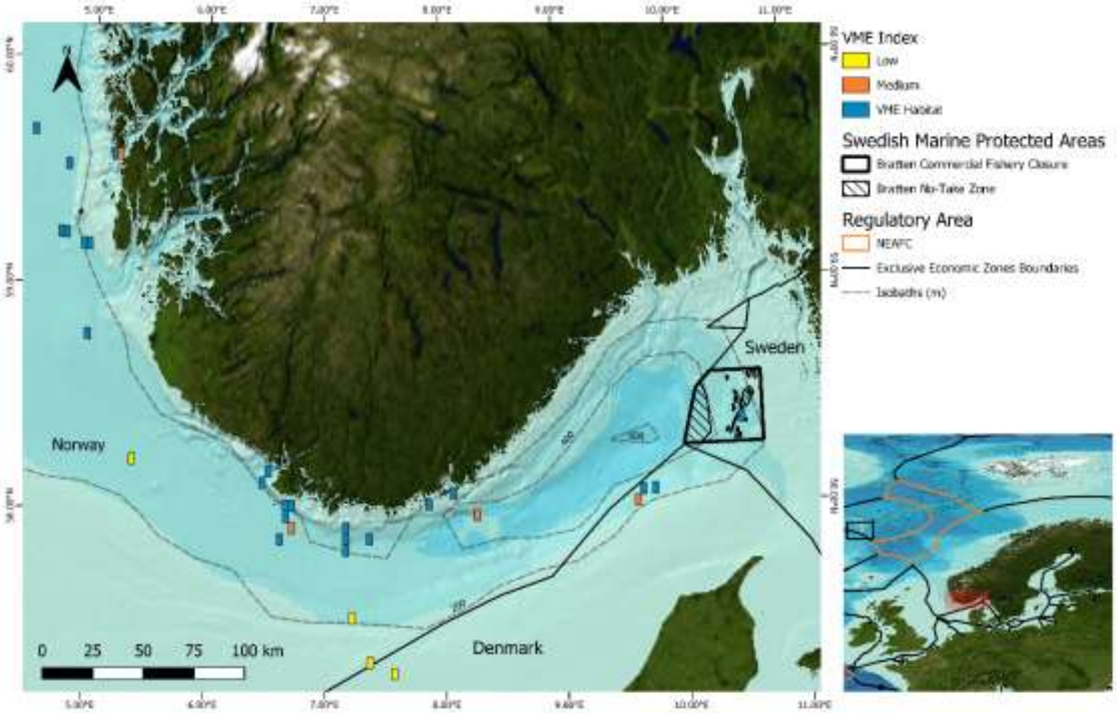
New VME habitat and indicator data were provided for areas of the Norwegian, Danish and Swedish Continental Slopes (Figure 4.43). VME data were provided by Oceana within the Norwegian Trench and the Danish Continental Slope. In addition, VME habitat data were submitted by the Swedish University of Agricultural Sciences for the Swedish Continental Slope. These records summarise data collected to define the area of VME represented by the Bratten MPA (Figure 4.43, Section 0).

Updated outputs of the weighting algorithm with these new VME data for these regions are shown in Figure 4.44, and the confidence layer for the VME index is shown in Figure 4.45.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=57 +lat_2=60 +lat_0=58 +lon_0=7 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs

Figure 4.43 New VME records submitted in 2020 for the Norwegian Trench and Danish and Swedish continental slopes within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=57 +lat_2=60 +lat_0=58 +lon_0=7 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs

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 2020) records from the ICES VME database.

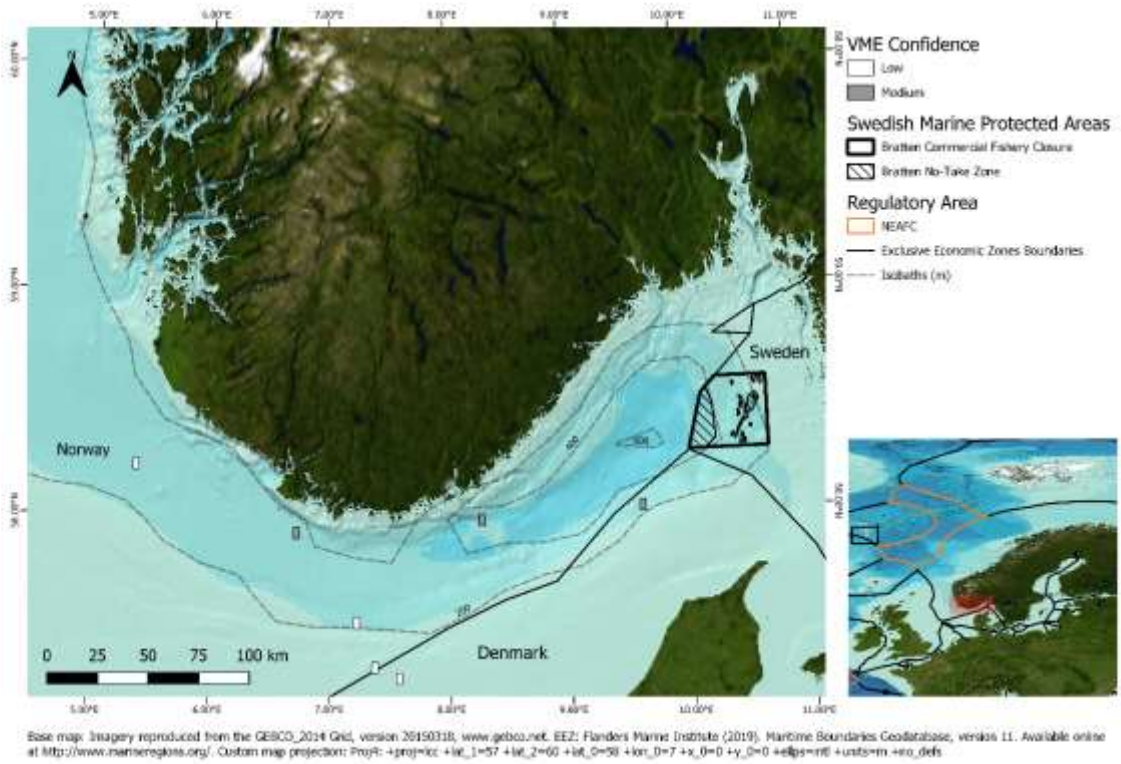


Figure 4.45 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.44). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2020) records from the ICES VME database.

4.5 Analysis of the 2019 VMS submission from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs)

4.5.1 Methods

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. The 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 to exclude all duplicate reports, polls outside the year 2019, 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.

Quality of the speed data was much improved on previous years (Figure 4.46). It was validated against a derived speed, 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 mobile bottom gears, 4 knots for vessels using static gears, and 6 knots for vessels with undefined gear types. Consecutive pings at fishing speeds for vessels using mobile-bottom contacting gears were grouped into putative "tows", manually reviewed to remove any erroneous sequences, and plotted, as a means to validate where fishing is taking place with the vessel tracks running parallel to bathymetric contours, as would be expected.

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	N
LL	76
LLS	745
NIL	39 448
OTB	54 579
PTB	1237

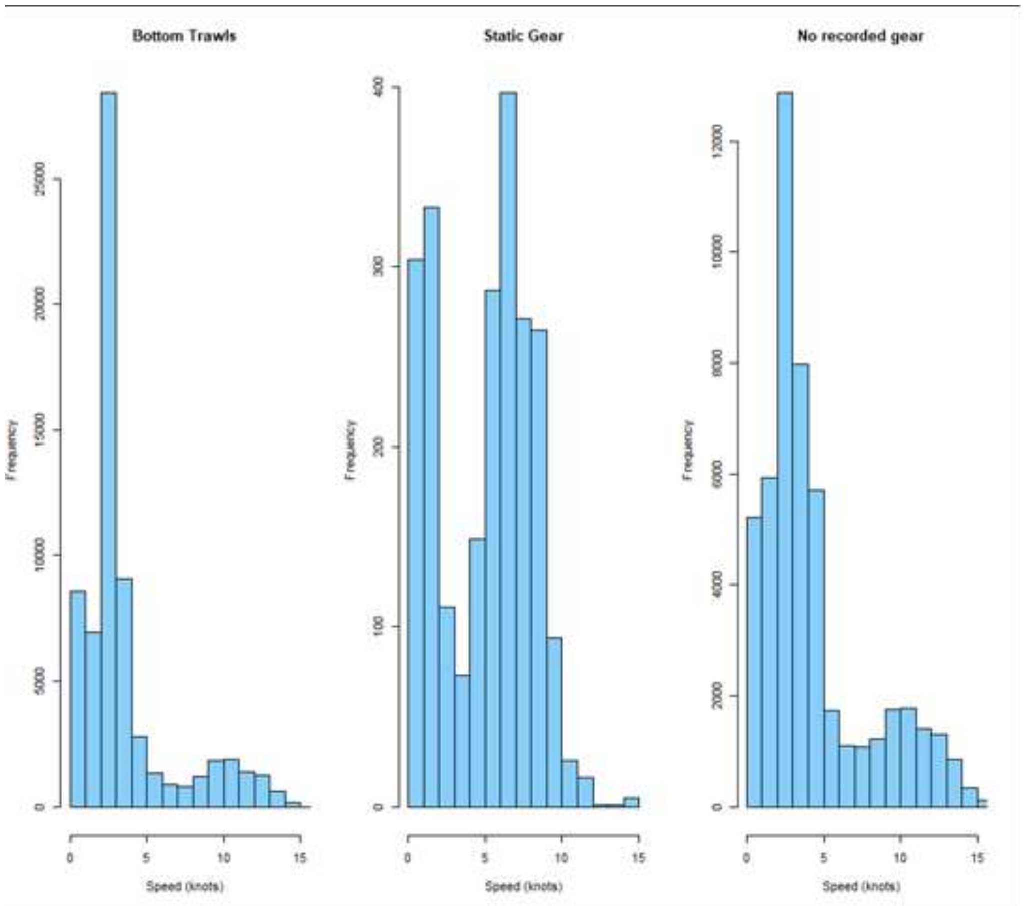


Figure 4.46 Histogram of reported speeds for bottom trawls, static gears and vessels without recorded gear which conforms to expected distribution for that gear type.

4.5.2 Results

The VMS data were reviewed by WGDEC and mapped together with the VME Index outputs, showing likelihood of VME presence based on the VME weighting algorithm, 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 Seamounts and the west of the Bay of Biscay (Josephine Seamount).

4.5.3 Hatton Bank

The closures to the northern side of Hatton Bank are generally well observed (Figure 4.47). A small number of bottom trawl tows appear to extend into the closed area at its northernmost edge, however, these incursions are limited. The highest intensities of trawling are closely associated with the boundary of the closed areas, particularly to the northeast (Figure 4.48). There was little evidence of vessels using static bottom contact gears (Figure 4.49), or activity of vessels without a registered gear type (Figure 4.50), in this area. Closures on the western side of the bank are also well observed (tow tracks: Figure 4.51 and gridded trawl data: Figure 4.52), no activity of static gears was observed in the area and only very limited activity from vessels without a registered gear type (Figure 4.53).

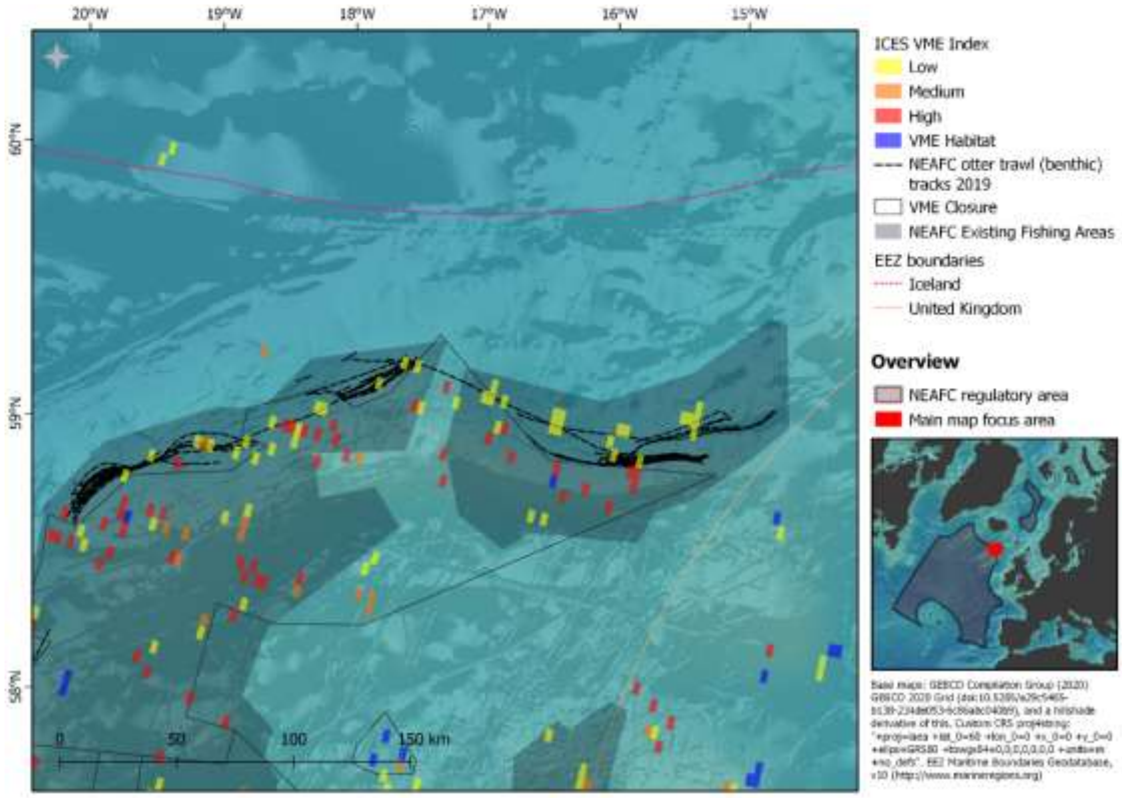


Figure 4.47 Bottom contacting otter trawl tow tracks to the north of Hatton Bank, overlain with the VME Index, VME closures, existing NEAFC fishing areas and EEZ boundaries.

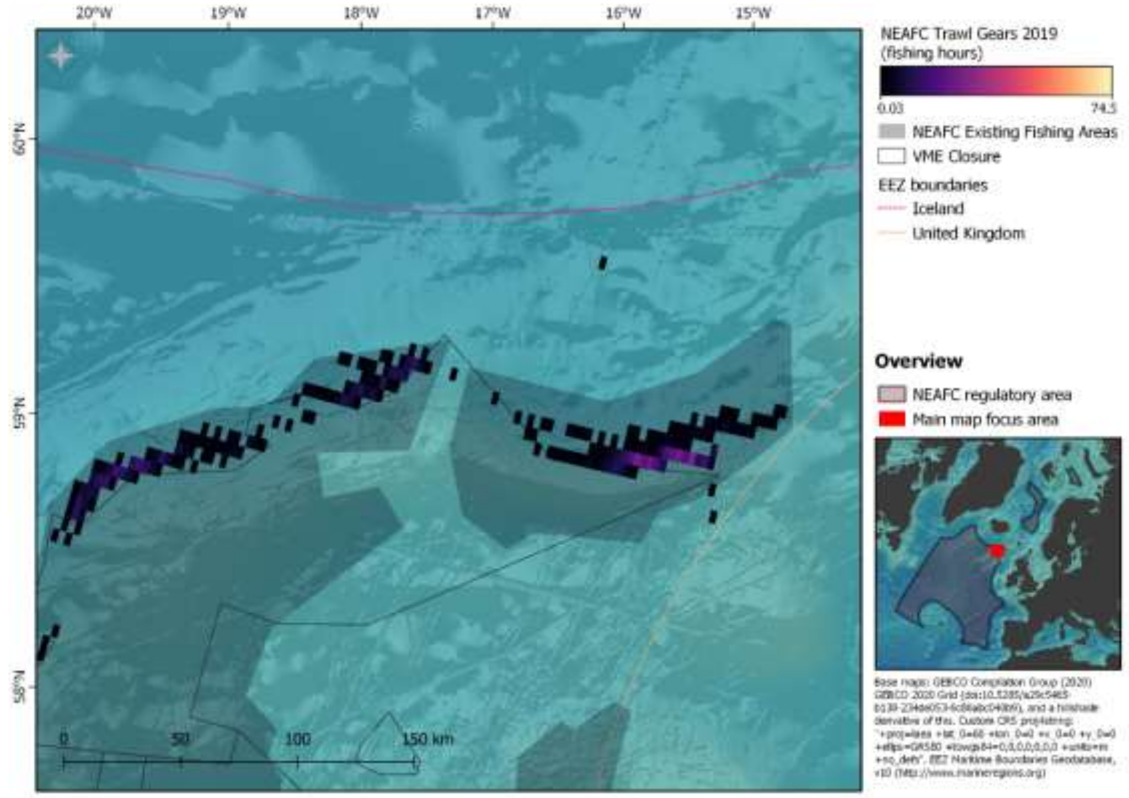


Figure 4.48 Gridded data (fishing hours) for bottom contacting trawl gears to the north of Hatton Bank, overlain with existing NEAFC fishing areas and EEZ boundaries.

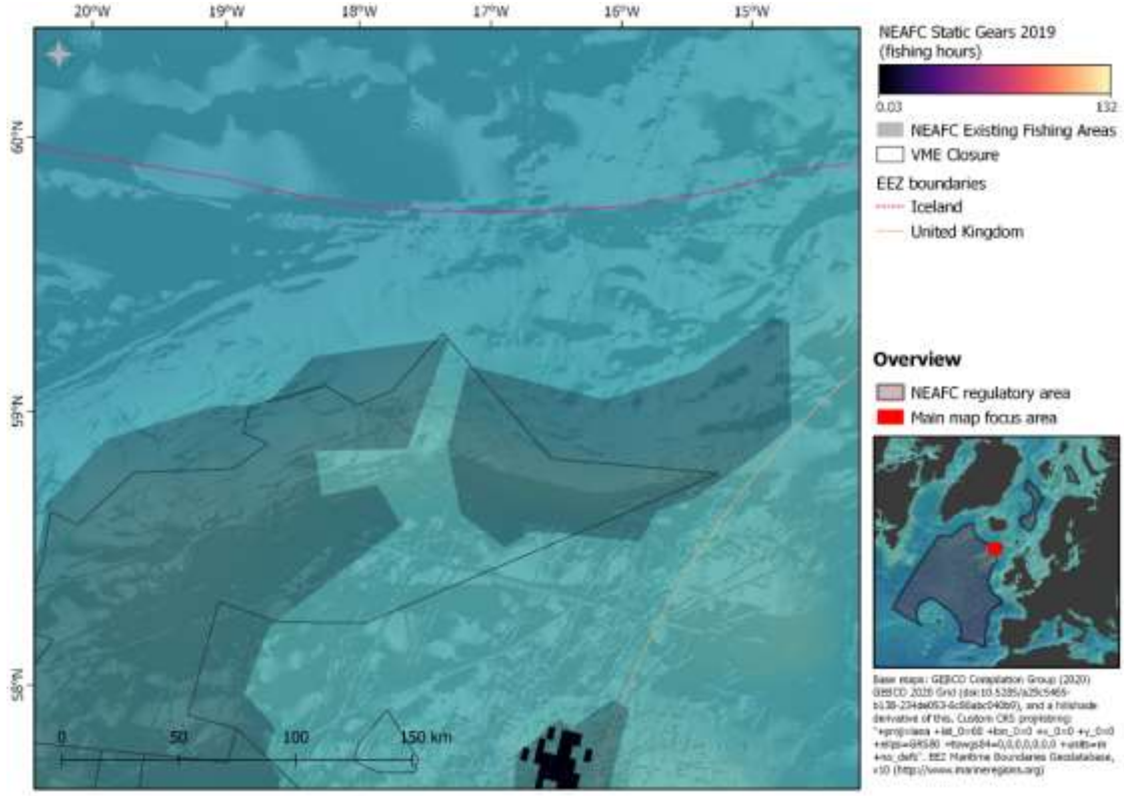


Figure 4.49 Gridded data (fishing hours) for bottom contacting static gears to the north of Hatton Bank, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries.

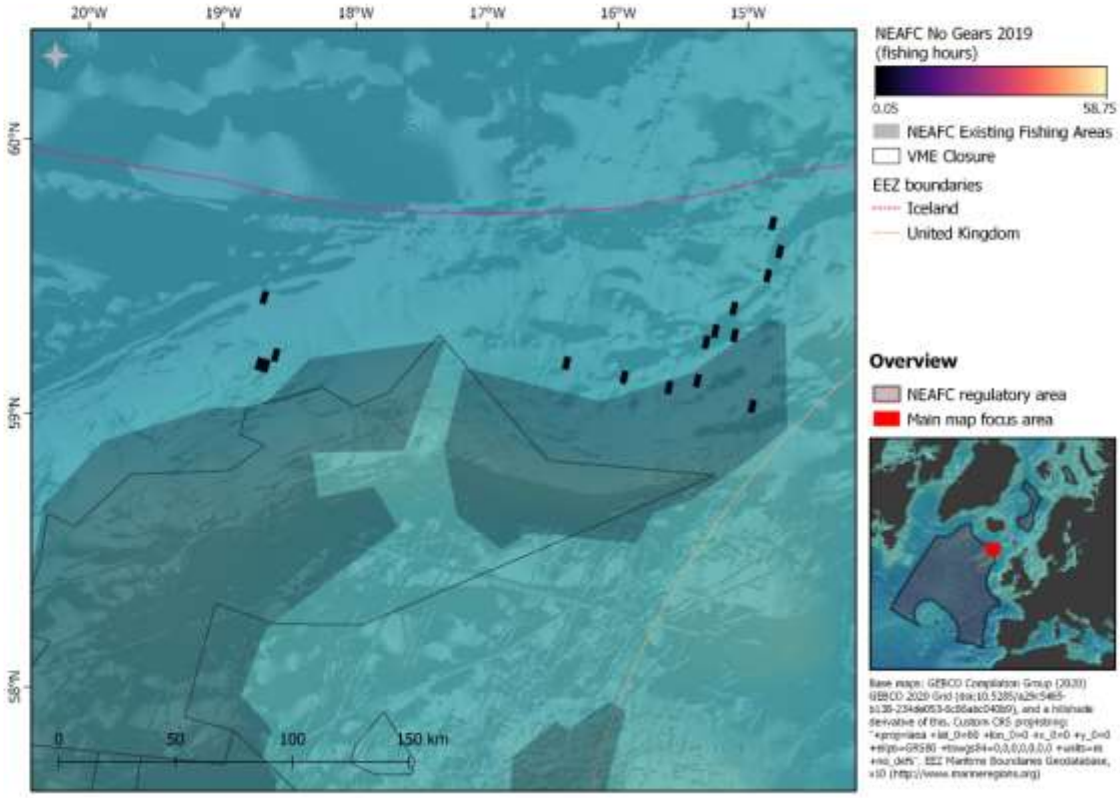


Figure 4.50 Gridded data (fishing hours) where no gear was registered to the north of Hatton Bank, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries.

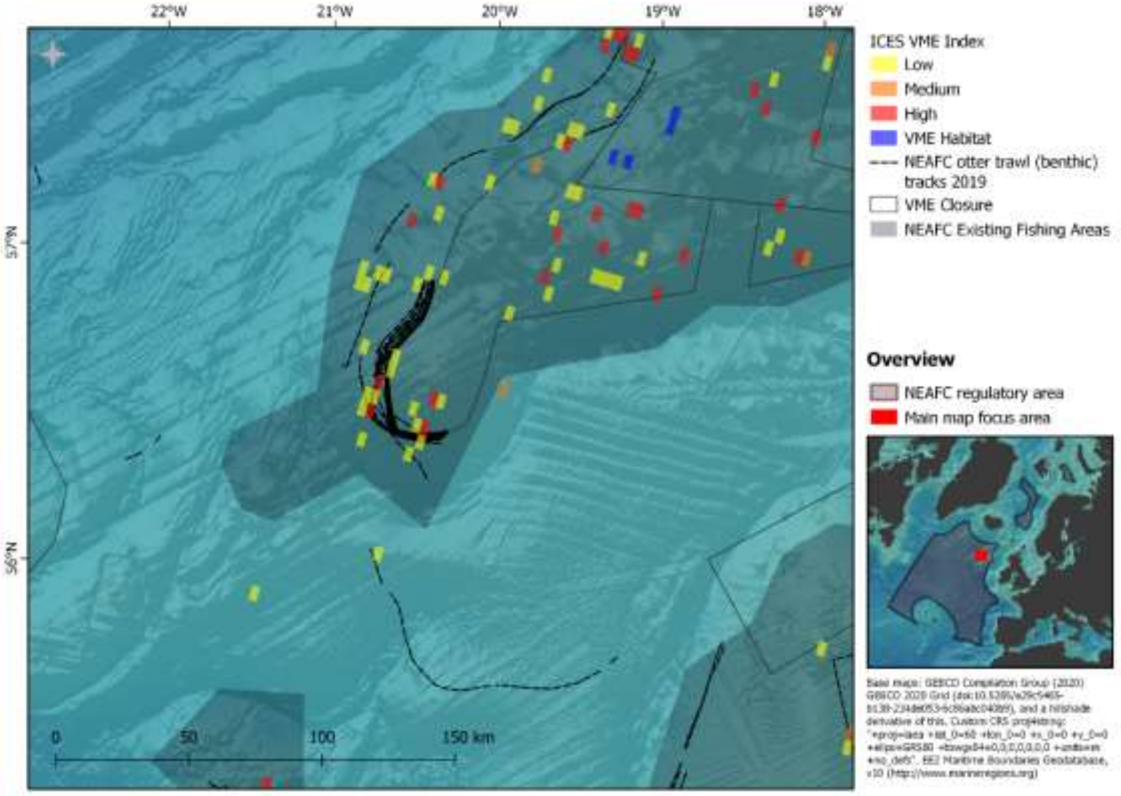


Figure 4.51 Bottom contacting otter trawl tow tracks to the west of Hatton Bank, overlain with the VME Index, VME closures and existing NEAFC fishing areas.

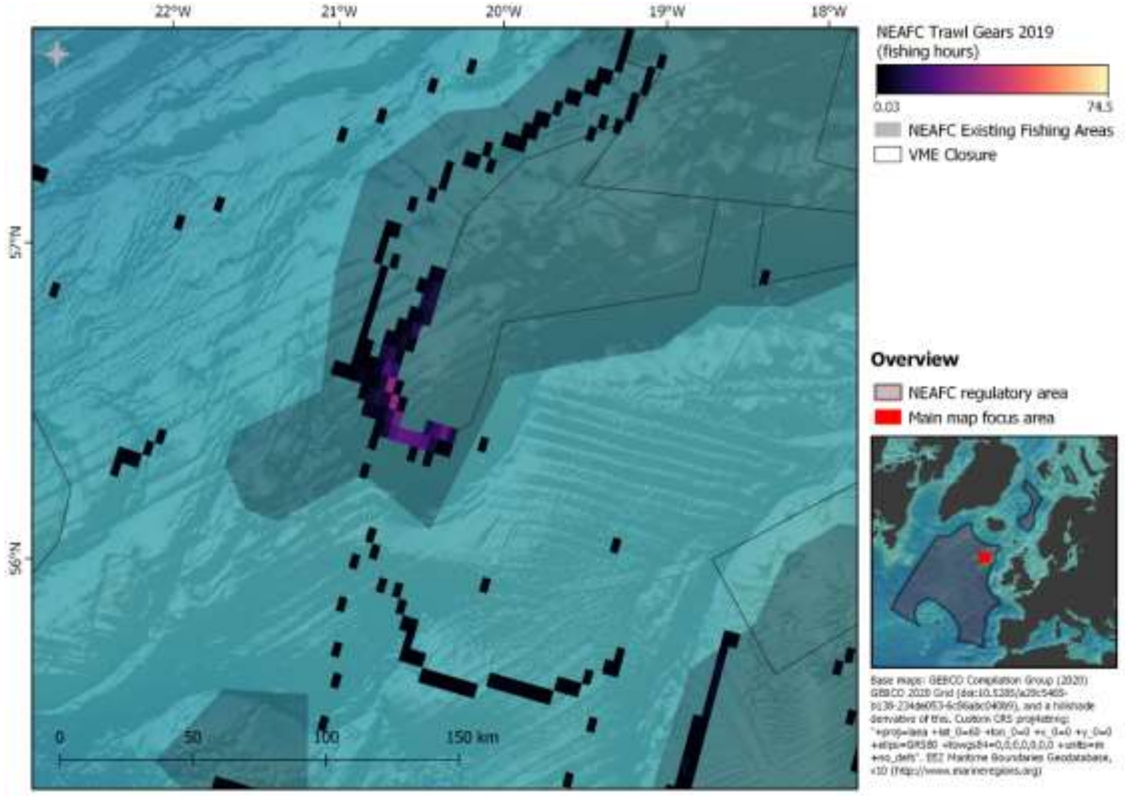


Figure 4.52 Gridded data (fishing hours) for bottom contacting trawl gears to the west of Hatton Bank, overlain with VME closures and existing NEAFC fishing areas.

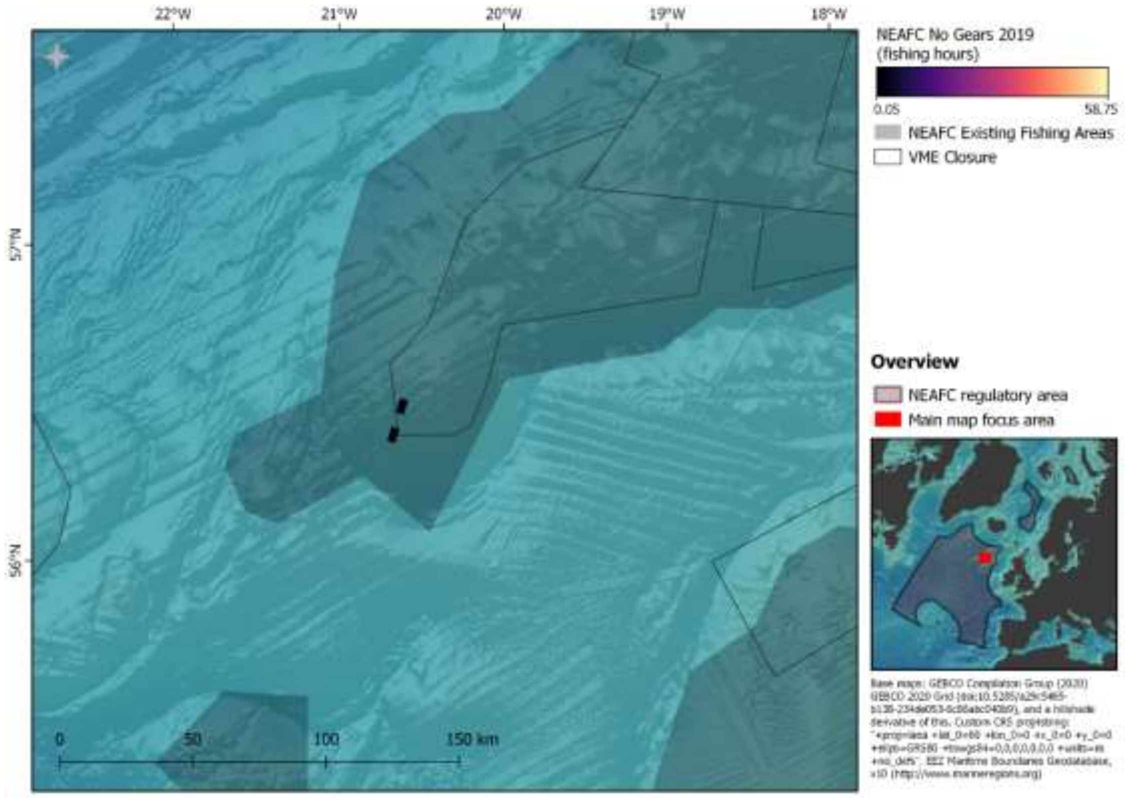


Figure 4.53 Gridded data (fishing hours) where no gear was registered to the west of Hatton Bank, overlain with VME closures and existing NEAFC fishing areas.

4.5.4 Rockall Bank

The VME closures on the eastern side of Rockall Bank are generally well observed, with the highest intensity of fishing occurring in an area that stretches along the western boundaries of the Northwest Rockall closure and the Haddock Box (Figure 4.54, Figure 4.55). A small number of bottom trawl tows appear to extend into the north-western quadrant of the Haddock Box, however, these incursions are limited. Similarly, there are a small number of tows in the larger closed area in southwest Rockall and in the Logachev Mounds closure, but again these are limited. Vessels registered as using static gears were active, at low levels, in the very northern part of the existing fishing areas on Rockall Bank and in the northwest quadrant of the Haddock Box (Figure 4.56). There is some evidence of vessels with no registered gear type operating within the Haddock Box, particularly in the western half of the area (Figure 4.57).

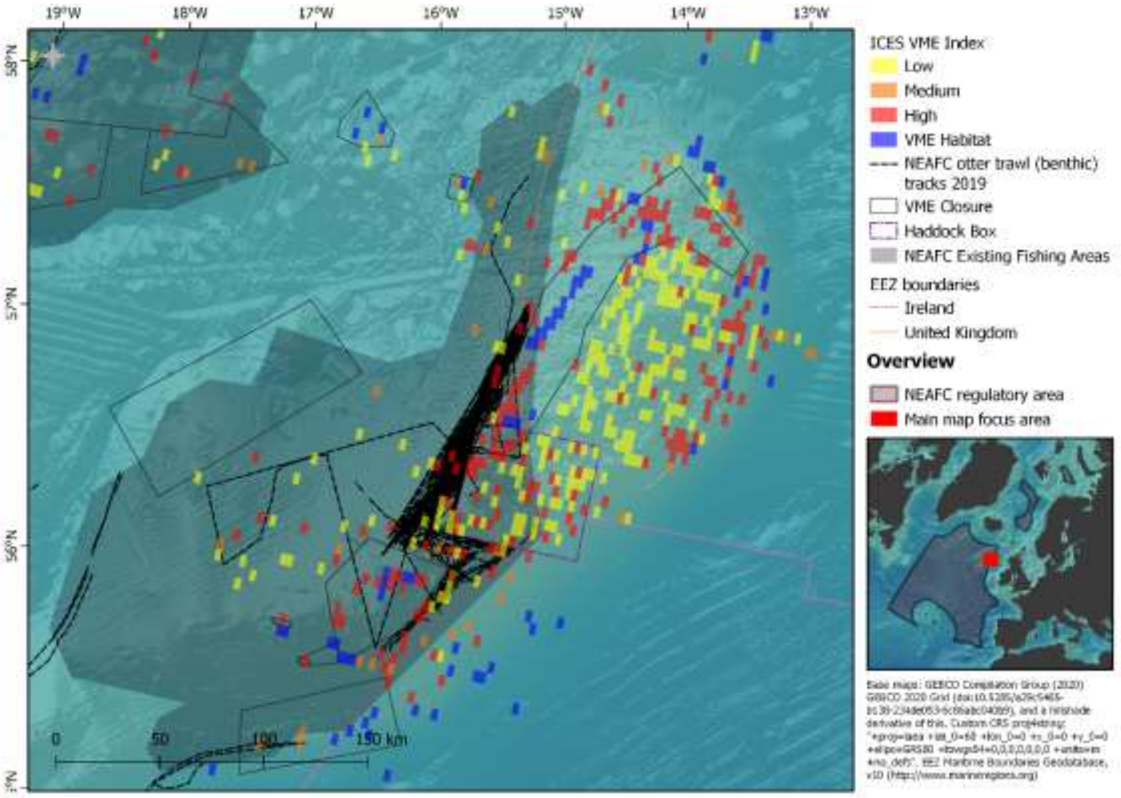


Figure 4.54 Bottom contacting otter trawl tow tracks on Rockall Bank, overlain with the VME Index, VME closures, existing NEAFC fishing areas and EEZ boundaries.

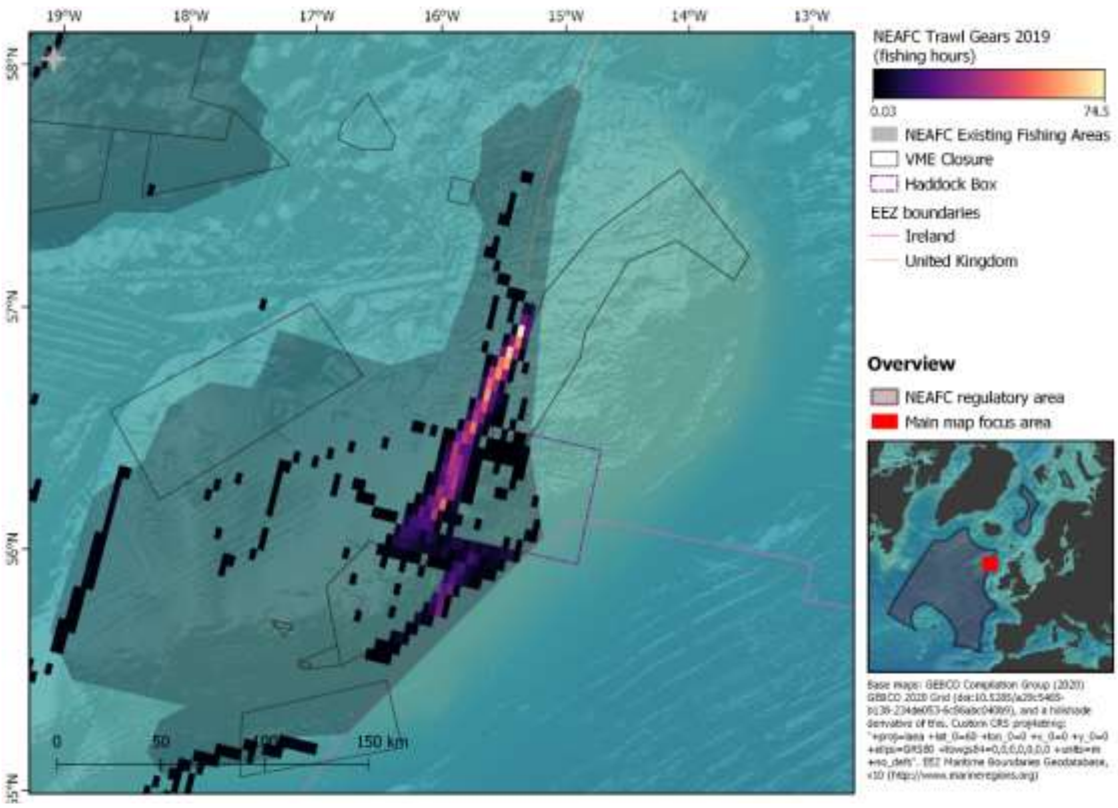


Figure 4.55 Gridded data (fishing hours) for bottom contacting trawl gears on Rockall Bank, overlain with VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

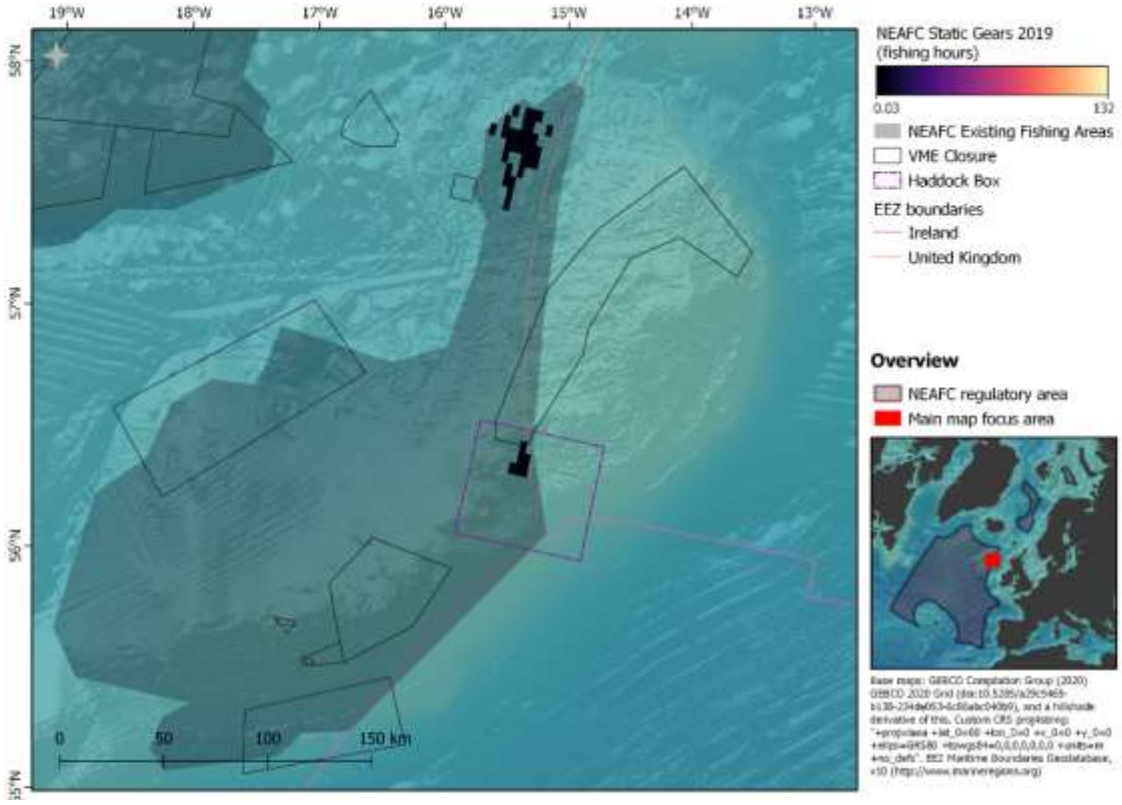


Figure 4.56 Gridded data (fishing hours) for bottom contacting static gears on Rockall Bank, overlain with VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

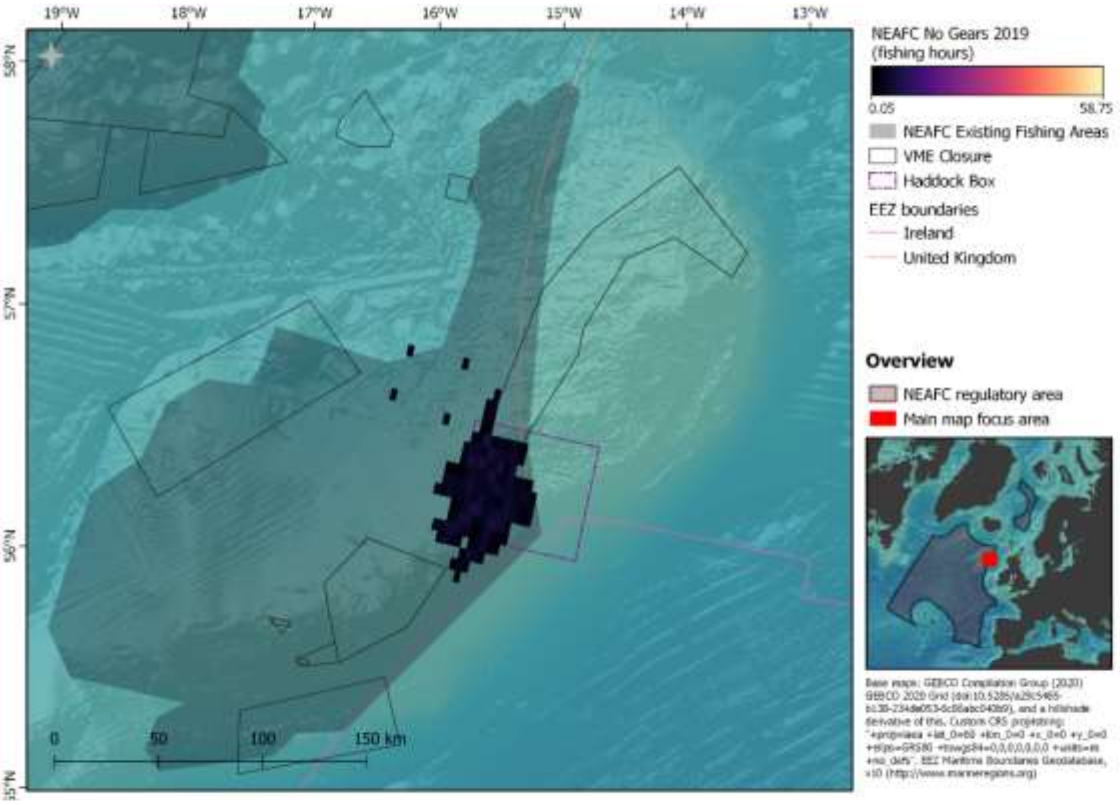


Figure 4.57 Gridded data (fishing hours) where no gear was registered on Rockall Bank, overlain with VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

4.5.5 South of Iceland

The pattern of bottom contact fishing activity around the Reykjanes Ridge is less confused than it has been in recent years (Figure 4.58). Activity is concentrated in an area to the north of the existing fishing area on Reykjanes Ridge, in water depths of around 2000 m. There is also evidence of some low levels of fishing in an area to the west of the Reykjanes Ridge, on the Danish EEZ (Figure 4.58). Activity to the south of Iceland is comprised of trawling gears (Figure 4.59) and vessels with no registered gear type (Figure 4.60), with no evidence of static gears being used in the region.

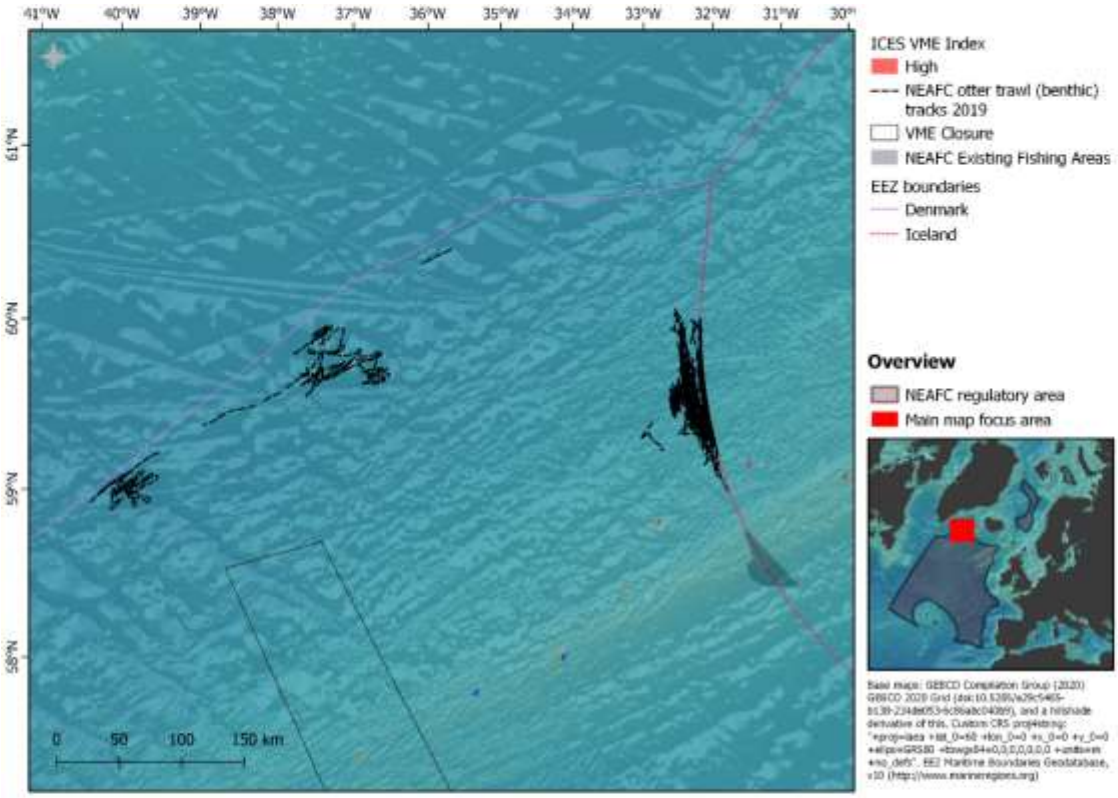


Figure 4.58 Bottom contacting otter trawl tow tracks south of Iceland, overlain with the VME Index, VME closures, existing NEAFC fishing areas and EEZ boundaries.

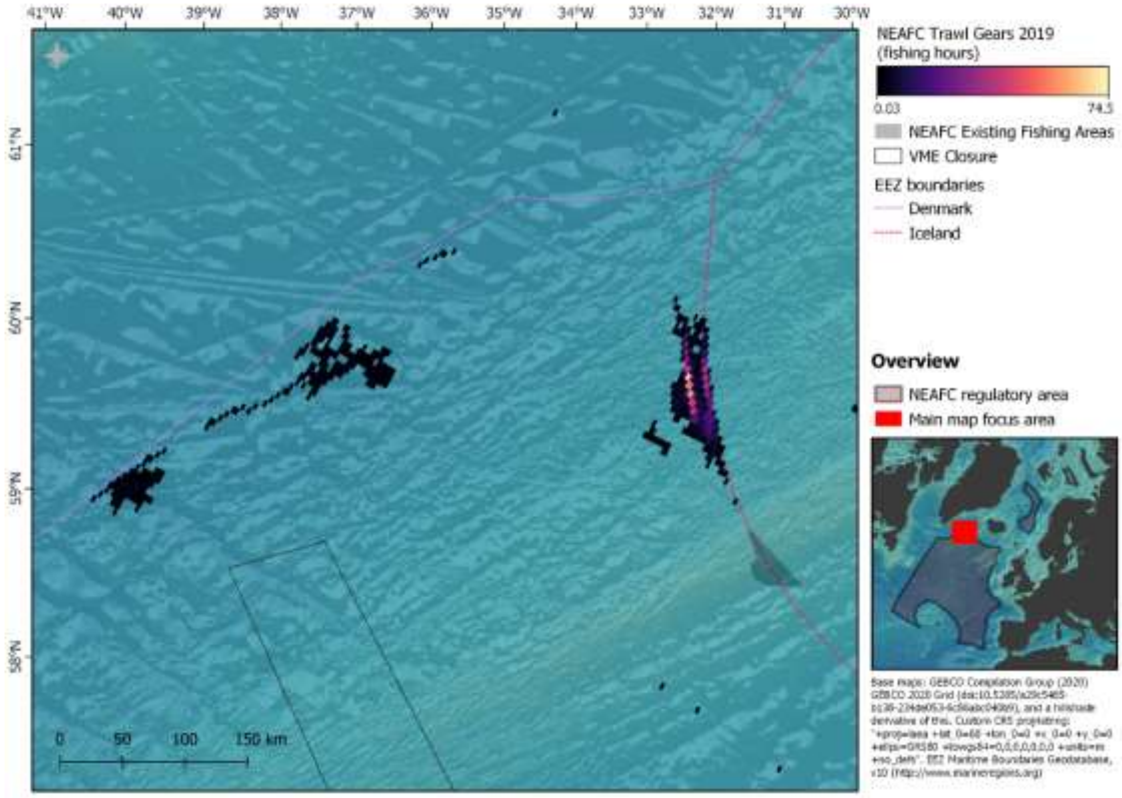


Figure 4.59 Gridded data (fishing hours) for bottom contacting trawl gears to the south of Iceland, overlain with existing NEAFC fishing areas and EEZ boundaries.

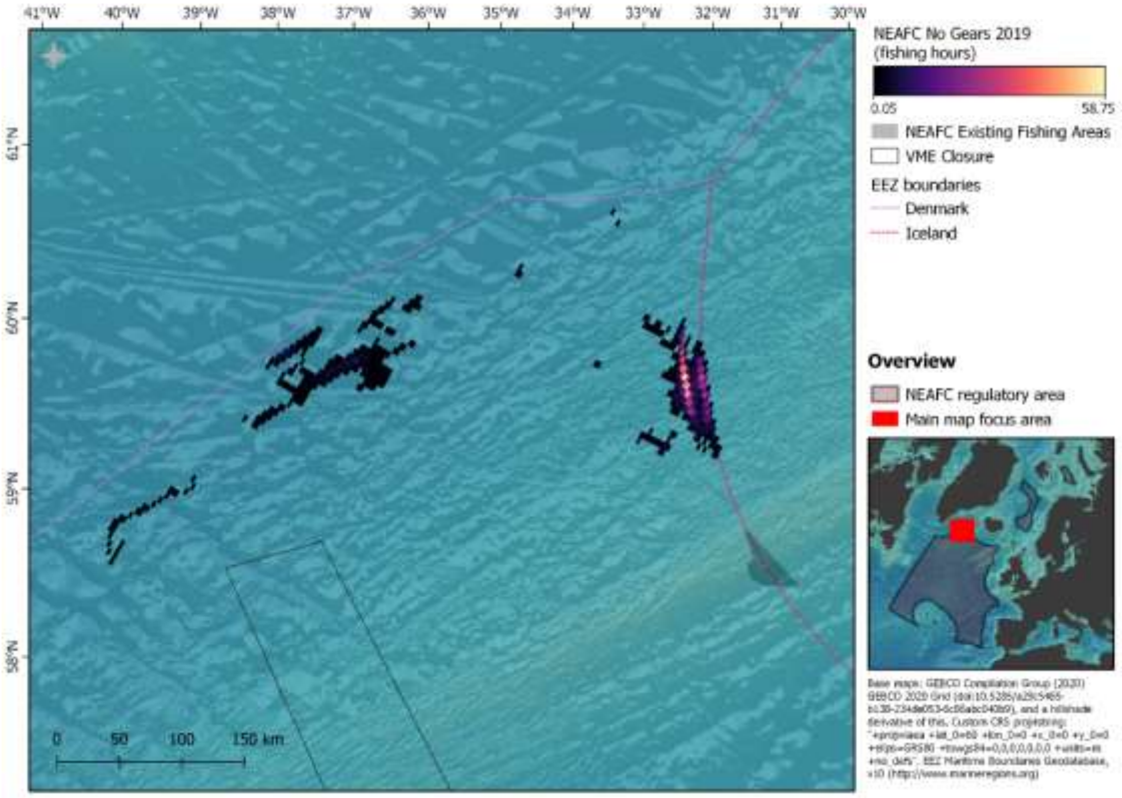


Figure 4.60 Gridded data (fishing hours) where no gear was registered to the south of Iceland, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries.

4.5.6 Mid Atlantic Ridge Seamounts

As seen in previous years, bottom trawling activity appears to be taking place at low intensities on an unnamed seamount to the south of the MAR closure, outside the existing bottom fishing area (Figure 4.61). Further south, bottom trawling takes place at low levels in and around the existing bottom fishing areas, as well as on a seamount to the west of the Olympus Knoll (Figure 4.62). The fishing observed in the years previous to last year on the Chaucer Seamounts to the south, including within the Southern MAR (C) closure area, continues to be absent this year. There is no evidence of static gears, or vessels with no registered gear type, operating in the area.

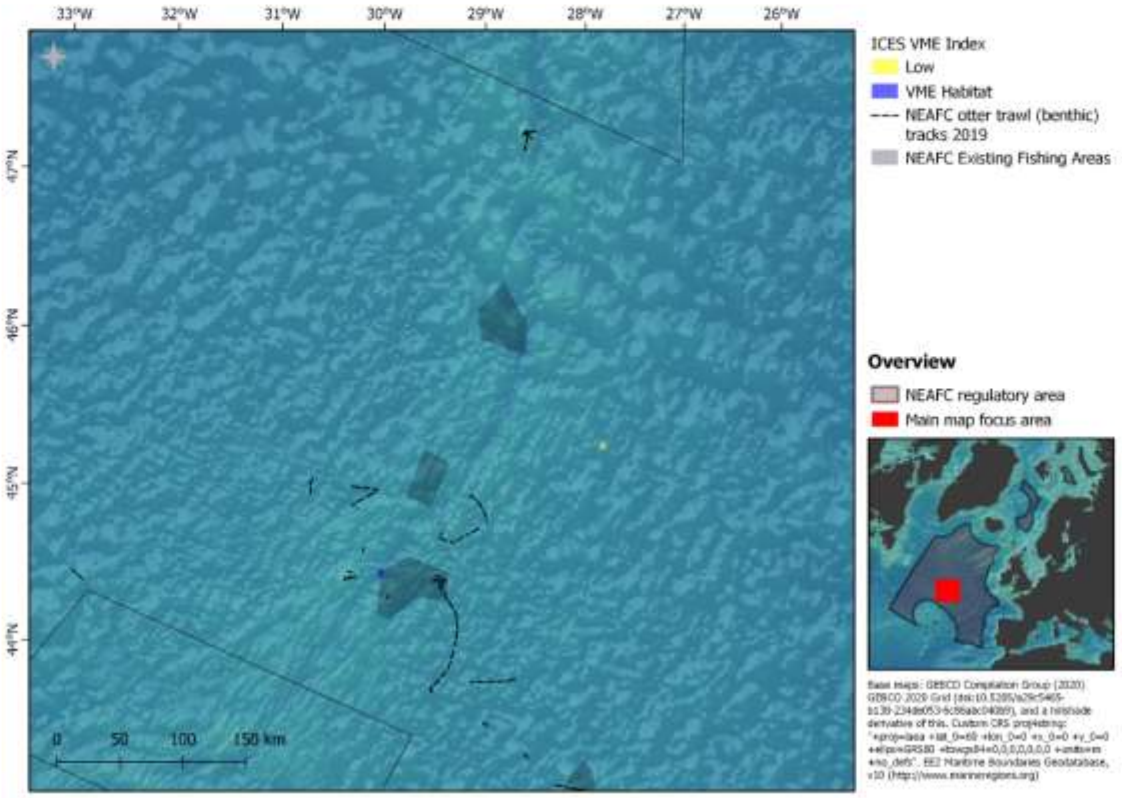


Figure 4.61 Bottom contacting otter trawl tow tracks on the Mid Atlantic Ridge seamounts, overlain with the VME Index, VME closures and existing NEAFC fishing areas.

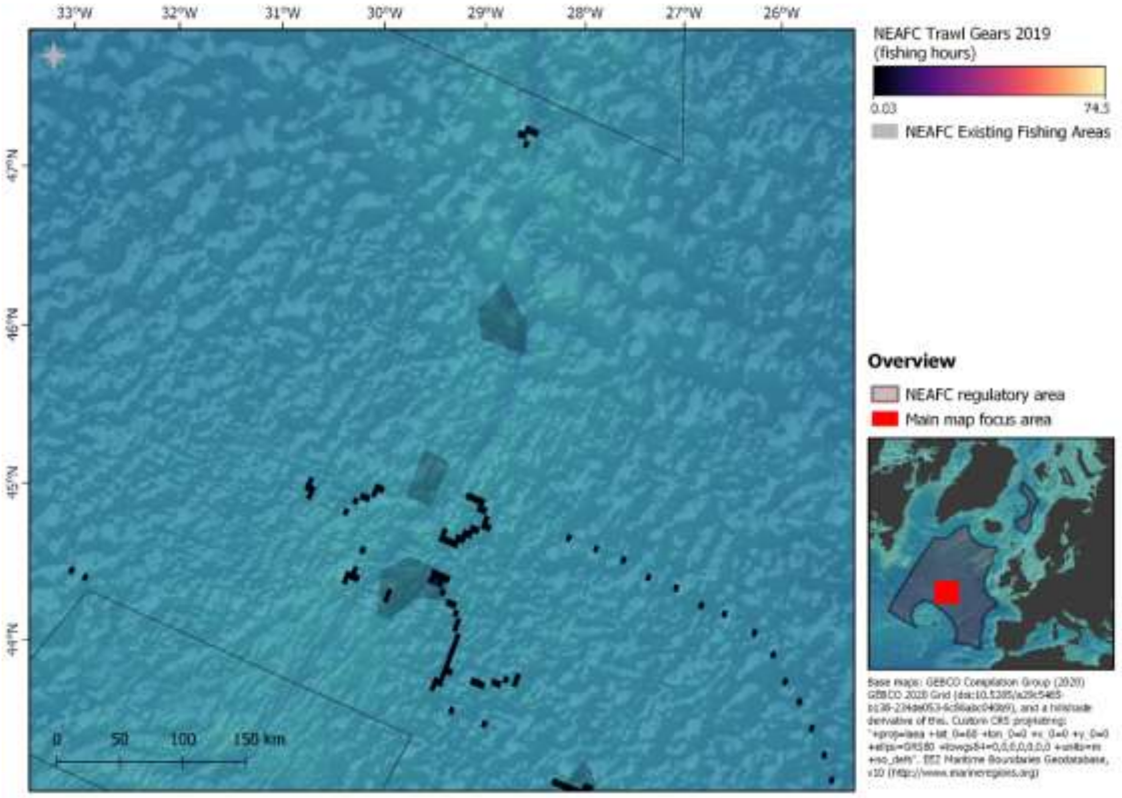


Figure 4.62 Gridded data (fishing hours) for bottom contacting trawl gears on the Mid Atlantic Ridge Seamounts, overlain with existing NEAFC fishing areas.

4.5.7 Josephine Seamount

The Josephine Seamount area that was noted last year, again shows high levels of static gear activity (Figure 4.63). The seamount represents a VME Element and a number of VME indicator records, for gorgonians and black corals, have previously been submitted to the VME database for this area. The low intensity use of static gears in the area to the west of the Josephine Seamount occurs across a larger area than was observed in 2019 (Figure 4.64). There was no activity of bottom trawling, or vessels without a registered gear type fishing in the area.

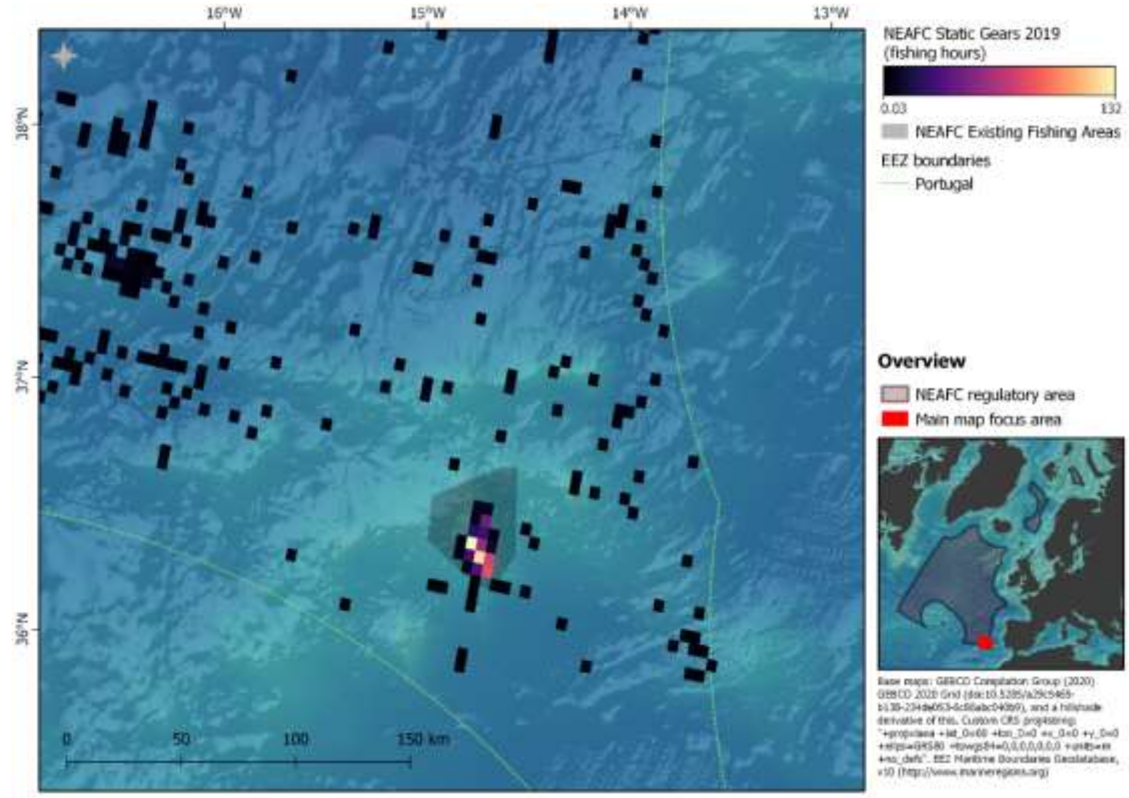


Figure 4.63 Gridded data (fishing hours) for bottom contacting static gears in the Josephine seamount area, existing NEAFC fishing areas and EEZ boundaries.

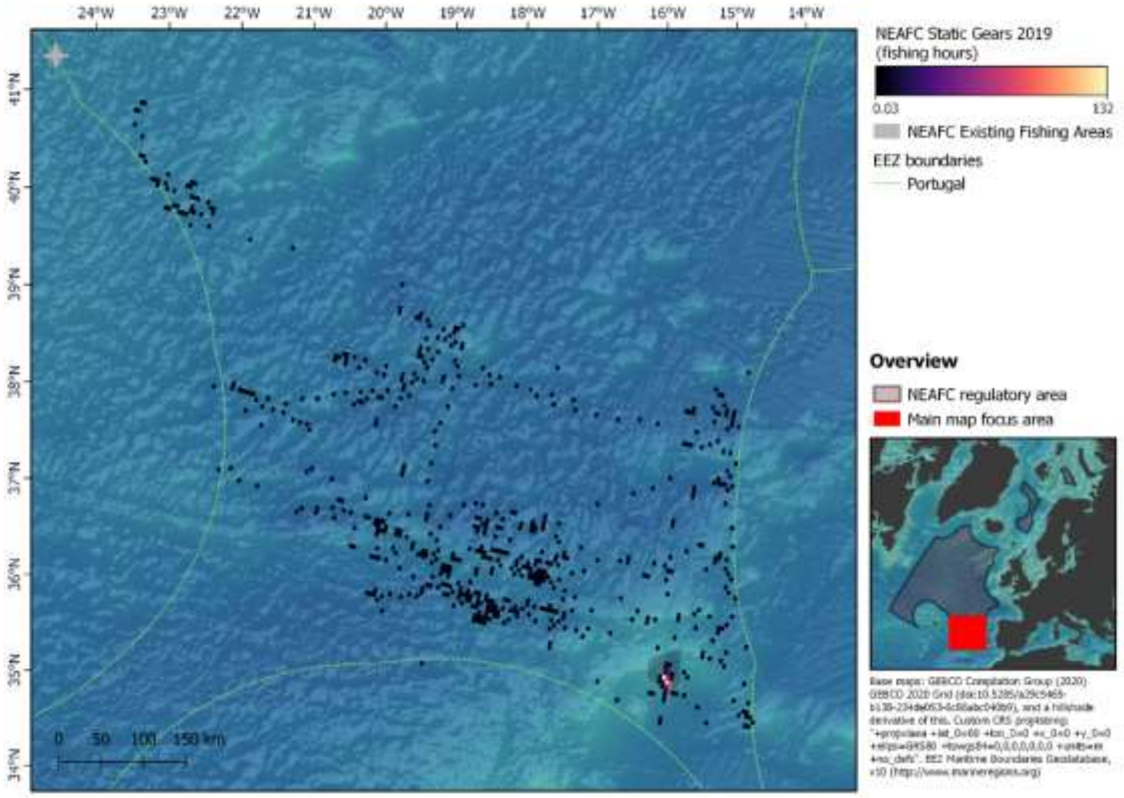


Figure 4.64 Gridded data (fishing hours) for bottom contacting static gears in the area northwest of the Josephine Seamount, overlain with existing NEAFC fishing areas and EEZ boundaries.

4.6 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. 126 pp.

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5 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 – ToR [c]

5.1 Introduction

Prior to the start of the WGDEC 2020 meeting it was agreed by the chair of WGDEC and the ICES Secretariat, in consultation with ACOM Leadership, that this ToR would be reduced to a brief introduction on the availability and provision of absence data and OSPAR habitat data to the ICES VME database. This was decided due to the restrictions on the ability to hold a full, productive meeting via WebEx and correspondence only. As such, the development of standards for the provision of absence data and OSPAR habitat data, and the utilisation of VME indicator data records to further develop and test kernel density estimation methods to assess VME likelihood, will be postponed until the WGDEC 2021 meeting.

This ToR has been split into two sections. The first section (Section 5.2) relates to how absence data should be entered into the ICES VME database and how these data could be used by WGDEC within future work. The second section (Section 5.3) relates to how data held in the OSPAR database of threatened and/or declining habitats could be imported into the ICES VME database.

5.2 Absence data

WGDEC 2019 considered issues on how to bring absence data in the ICES VME database. However, due to some outstanding questions on appropriate methods for the collection and reporting of absence data, it was decided that absence records would not be considered as part of ToR [b] (ICES, 2019a). Instead a ToR focused on developing standards for provision of absence data was proposed for WGDEC 2020. Due to time constraints the group has not been able to fully develop those standards and, instead, advice on the use and provision of absence data is provided.

An absence record reflects a specific position/location that has been sampled, but where no VMEs or VME indicators have been observed or sampled. Absence data should not be confounded with missing data, since the latter refers to a lack of sampling or survey in a specific position/location, where it is therefore not known if VMEs or VME indicators are present or absent. One of the reasons to include absence data is to better understand where these data gaps (missing data) are. For this reason, absences, specific to the sampling method, provide an overview of the areas surveyed. Typically, these will be more important for data collected from trawls which cover a larger area.

5.2.1 Uses of Absence data

5.2.1.1 Habitat mapping and species distribution modelling

Absence data are fundamental to fully evaluating the occurrence of VME habitats and indicators, and, specifically, for the performance of species distribution models (SDMs) and habitat suitability models (HSMs) to support mapping of benthic habitats. However, verified absence data for deep-water species and habitats (e.g. VMEs) are not often generated from research surveys. This hampers the ability to perform a proper assessment of the occurrence of VMEs, as it is difficult to establish if the lack of data plotted in maps is due to the actual absence of VMEs or due to a lack of sampling in the area.

One of the topics included in the ICES Working Group on Marine Habitat Mapping (WGMHM) 2019 meeting was the issue of reliable absence data availability and its use within marine habitat mapping and SDMs (ICES, 2019b). They noted that whilst SDMs can use presence-only data, they tend to be poorer than models using presence and absence data. To address this, methods have been developed by modellers to generate pseudo-absence and background data which include, for instance, designating absence status to species records that are known not to co-occur with the modelled species, or including randomly placed points within the modelled domain, often buffered away from presence observations (ICES, 2019b). There are, however, limitations to these methods and it is difficult to ensure that pseudo-absence and background points truly represent absences. As such, models relying on pseudo-absence and background data are more uncertain than those using observed absence data. One of the main conclusions extracted by the WGMHM in their 2019 meeting was the importance that modellers using absence data state:

i. how absence data were generated;
ii. how many absence points were included, in comparison to the number of presence points, and;
iii. any implications of the absence data method on overlap map accuracy and interpretability.

5.2.1.2 Loss of VME habitats and linking anthropogenic impacts to absence records

As more absence data is added to the VME database over time, it may become possible to identify areas where VME habitats have previously occurred but no longer do. Understanding how this loss occurred would be critical, especially if it were to happen in areas protected for VME habitats. In order to identify the cause of habitat loss, information on variables such as the fishing footprint will be important. Data have been submitted to the VME database from at least two studies which have attempted to identify causes of VME habitat loss.

1) A study based on towed-camera transects examined the structure of deep-sea sponge aggregations in areas inside and outside the Faroe-Shetland Channel Nature Conservation Marine Protected Area (FSC NCMPA) in the UK EEZ. Here, it was shown that deep-sea sponges (mainly massive and fan-shaped morphotypes likely belonging to the genera *Geodia* and *Phakellia*, respectively) had higher diversity of morphotypes, higher density (ind/m^2) and larger body size (cm) in areas inside than outside the MPA (see Figure 8 and Table 4 in Kazanidis et al., 2019). The main parameter driving these differences was lower bottom fishing activity occurring inside the MPA (see Table 5 in Kazanidis *et al*., 2019). It was, however, also shown that other parameters such as the type of substrate and water-mass characteristics (temperature, salinity), had a statis-

tically significant contribution in explaining the differences in deep-sea sponge aggregations inside and outside the MPA. Specifically, higher values of sponge density (up to 1.8 ind./m^2) were found where cobble/cobble with boulder were the major types of substrate, in contrast to the much lower values of sponge density in areas with a high coverage of soft sediments.

2) A study using towed-camera transects was conducted in 1983/4 and later in 2011, in the same area of the Porcupine Seabight. This study found that *Pheronema carpenteri* deep-sea sponge aggregations had declined in both numerical and biomass density. This decline was linked to increased demersal fishing activity in the study area since the 1980s, although the authors were not able to exclude other causes of changes in the sponge populations, due to the lack of data in the intervening period (Vieira *et al*., 2020).

5.2.2 Considerations when using absence data

5.2.2.1 Survey methods and scale

An added difficulty when dealing with absence data is the issue of scale. Benthic samples are collected in multiple ways, for example bottom trawling scientific surveys, box corers, video transects and photographs. These methods cover different spatial scales in terms of seafloor area and have different "sample catchability"; this makes comparison between different survey results challenging, and also illustrates a problem with the collection of absence data.

Without information on scale, absence data from imagery would be problematic to include in analyses with datasets collated from different methods. For example, it would be challenging to combine data on absence of VMEs from an image covering 6 m^2 seabed with absence data from videos representing aggregated information along a 1 km distance of the seabed. One solution is to present still images as points, and video transects as lines, so as not to interchange between the two scales.

Similar scale issues are also evident from presence or abundance data. For example, the physical extension or distribution pattern of VMEs on the seabed caught in a trawl is unknown. For video analysis results, there is the possibility of choosing the scale of reporting, however there is great variation in how video data are analysed and presented. In a video record of the seabed, all occurrences could be recorded as single events, providing a series of point data. Or, as applied more commonly; the video could be divided into subsamples of a chosen scale (distance along the seabed). This therefore results in two potential different scales of presence data.

These issues also illustrate the importance of knowing the scale of sampling units for absence data, since one single video could either be presented as a great number of consecutive absences, or only one absence, depending on the chosen scale of reporting.

It is also advised that absence data should not be scaled up to larger areas. For this reason, absence data are not incorporated into the VME weighting algorithm.

5.2.2.2 Absence vs missing data

As detailed above, absence data should not be confused with missing data. Missing data may consist of areas where sampling has not occurred, but could also include areas where sampling has occurred, but absence information was not recorded due lack of requirement/need from the specific survey. However, this provides another justification for the submission of absence data, as it also enables improved understanding of whether an area has been sampled or not.

When using absence records from the VME database, it is important to consider the list of VME habitats and indicators that were used by the data provider at the time of submission. The list of

VME habitat and indicators accepted by the VME database has changed on two occasions, firstly in December 2015 (ICES, 2016) and then in January 2020[2], with follow up changes due to take place following this 2020 meeting (see Section 7). Changes to the list would need to be considered when using absence data for certain applications. For example, for before/after comparisons, it would be incorrect to compare presence and absence of xenophyophore indicators using data submitted before 2015, as the xenophyophore indicator was only added in December 2015.

For this reason, it is suggested that the date of insertion into the database is checked if absence records are used for data analysis purposes, to confirm that the VME habitat and indicator categories are comparable. Date of insertion is provided as a field of the VME database extract.

5.2.3 Criteria for absence data submissions

Based on the discussions above, and in line with the guidance provided in the WGDEC 2020 data call[3], WGDEC 2021 agreed a series of criteria that must be fulfilled for any submissions of VME absence data to the VME database:

1. Record must not be of a VME habitat type;
2. Record must not have been collected using a commercial fishing trawl (due to difficulties in knowing if observers are recording the full suite of VME indicators during these surveys or just a 'subset');
3. Record must be from a survey where the presence of VMEs has been recorded on the same survey (this is to ensure that VMEs were being recorded during the survey, and that the record would therefore be a definite absence rather than missing data);
4. Record must not be from a sample that also contains presence records (i.e. two records with matching SampleIDs cannot have both presence and absence VME data)

5.2.4 Summary of absence records 2020

To summarise the absence records in the VME database, the definition from Section 5.2.3 has been followed. In order to meet this definition, Norwegian records for the Barents Sea which observed species that are indicators, as well as species not considered indicators, have been removed as they do not meet rule 4. These data will be reviewed prior to WGDEC 2021, to be updated in the database.

This resulted in 315 absence records in the VME database, mostly within the UK and Irish EEZs, but also a small proportion in the NEAFC area of Rockall Bank. All records are from research surveys conducted between 2012 and 2019. 43% were submitted to the VME database between December 2015 and January 2020 and the remaining 57% since January 2020 (thus using the updated VME indicator list). Absence records are available from four different methods of trawl sampling, and two different methods of seabed imagery sampling (Table 5.1). Table 5.1 replaces previous summaries of absence data provided in WGDEC 2019 (ICES, 2019a) as it uses the new, stricter definition of absence data.

It is important to note that due to differences in survey methods and scale, not all the data summarised in Table 5.1 will be suitable to compare in an analysis of presence and absence data. The

[2] A suggestive list of deep-water VMEs and their characteristic taxa – updated Jan 2020 https://www.ices.dk/data/Documents/VME/VMEs%20and%20their%20taxa.pdf

[3] WGDEC data call 2020 for Vulnerable Marine Ecosystems (VME) data; http://ices.dk/sites/pub/Publication%20Reports/Data%20calls/datacall.2020.WGDEC_VME_data.pdf. Accessed May 2020

underwater TV survey data submitted by the Marine Institute (Ireland) is presented here as an example of where absence and presence could be compared.

In the example of the Marine Institute's Underwater TV surveys, data was collected using a towed camera sledge from the southern flank of the Porcupine Bank. The sampling effort can be summarised as 444 camera transects, collected across 7 surveys between 2012 and 2019, in an area of approximately 7900 km^2. Sea pen presence and absence was recorded at each sampling station, resulting in 284 stations where sea pens were present and 160 where they were absent (Figure 5.1). Data were submitted in 2020 using the VME indicators from the updated, January 2020, VME list[4].

Table 5.1 Summary of absence data observations in the ICES VME database as of May 2020

		Survey method Trawls				*Survey method Seabed imagery*			
Database insertion period		**Bottom trawl**	**GOV trawl**	**Jackson Deep-water Trawl**	**Rock hopper otter trawl**	**ROV system**	**Towed camera system**	**Survey method not reported**	**Total per insertion period**
	31/12/2015 – 31/12/2020	0	23	35	22	1	0	53	**134**
	Since 01/01/2020	11	2	0	0	8	160	0	**181**
	Total pre-survey method	**11**	**25**	**35**	**22**	**9**	**160**	**53**	**315**

[4] https://www.ices.dk/data/Documents/VME/VMEs%20and%20their%20taxa.pdf

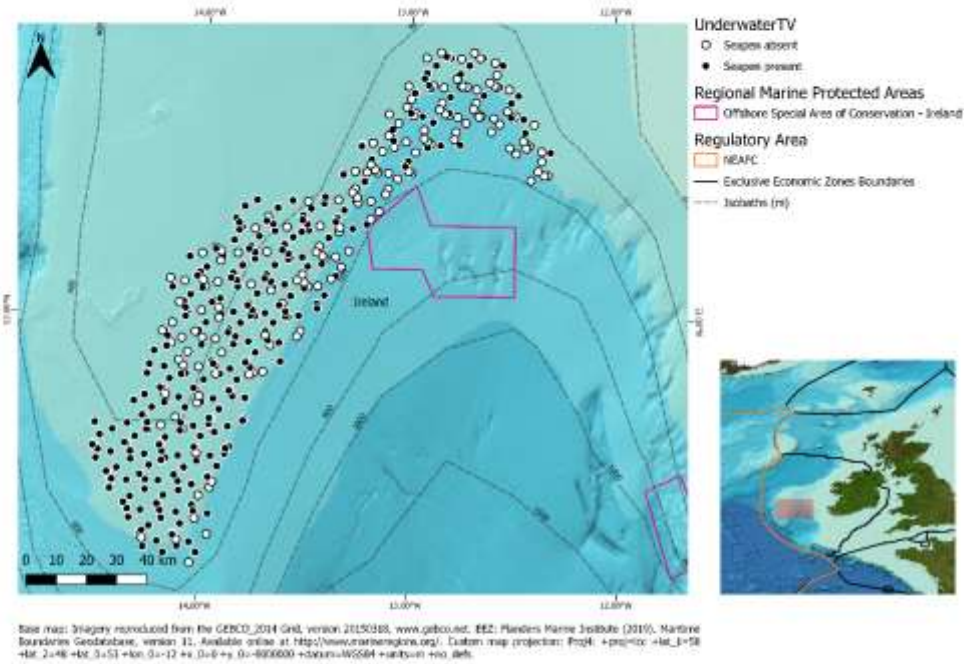

Figure 5.1 Spatial distribution of presence and absence records of sea pens collected by Marine Institute Underwater TV Surveys at Porcupine Bank.

5.2.5 Conclusions

Absence data have not, to date, been used by WGDEC within their work, but there is an increasing amount of absence data in the ICES VME database. These data have the potential for future use by WGDEC and other ICES groups, primarily for habitat mapping and species distribution modelling, but VME data providers should be encouraged to submit absence records only when they meet the four criteria detailed in Section 5.2.3.

Furthermore, absence data can be misinterpreted and therefore WGDEC recommend that for any future use, the considerations provided in Section 5.2.2 are taken into account. Additionally, the datasets that include absence data, should be checked to ensure they have used a comparable list of VME habitats and indicators, and that the dates of insertion into the database are stated (i.e. before December 2015, between December 2015 and January 2020, after January 2020). Lastly, absence data should not be scaled up to the level of the VME index c-square.

5.3 OSPAR data

The OSPAR database[5] contains information on the presence of OSPAR's 15 threatened and/or declining habitats (Table 5.2). These data are collated from the northeast Atlantic and include shelf sea and deep-sea habitats. Although much of the data in the OSPAR database has been submitted to the VME database, there are a significant number of records which have not.

In previous years, OSPAR records have been considered by WGDEC in parallel to the ICES VME database. This is not ideal as the databases have different formats which makes including them

[5] OSPAR Habitats 2018 point data : https://odims.ospar.org/layers/geonode:ospar2018_points. Accessed May 2020

both in the same analyses, such as production of the VME weighting algorithm, difficult or impossible. This section describes a process which can be used to import OSPAR records into the ICES VME database, firstly through the identification of records which are relevant to the ICES VME database and are currently not included, and secondly through quality assurance of these records, as well as other potential sources of VME data.

Table 5.2 List of all 15 OSPAR threatened and/or declining habitats and the ICES VME habitat types which have direct or partially matching definitions. *equivalent definition is classified as a VME Element by ICES (see Section 6.3.1), rather than a VME habitat.

OSPAR Habitat Type	VME Habitat Type	VME match to OSPAR
Carbonate Mounds	-	None
Coral Gardens	Coral garden	Direct match
Cymodocea Meadows	-	None
Deep-Sea Sponge Aggregations	Deep-sea sponge Aggregations	Direct match
Intertidal *Mytilus edulis* Beds on Mixed & Sandy Sediments	-	None
Intertidal Mudflats	-	None
Lophelia pertusa Reefs	Cold-water coral reef	Direct match
Maerl Beds	-	None
Modiolus modiolus beds	-	None
Oceanic Ridges with Hydrothermal Vents	Hydrothermal vents/fields	Direct match
Ostrea edulis Beds	-	None
Sabellaria spinulosa Reefs	-	None
Seamounts	-	None*
Sea pen & Burrowing Megafauna Communities	Sea pen fields	Partial match
Zostera Beds	-	None

5.3.1 Method for importing OSPAR records into the VME database

The OSPAR threatened and/or declining habitats database was translated into the same format as the ICES VME database template, to enable comparison of records. Fields were mapped from point records from the OSPAR habitats database to the fields in the ICES VME database using R (R Core Team, 2018). All mandatory fields for the VME database were mapped from OSPAR data, using ICES vocabularies, and where optional information was available that was also mapped.

OSPAR threatened and/or declining habitats that had a direct correlation to VME habitat types were selected (Table 5.2), namely:

- Coral Gardens
- Deep-sea sponge aggregations
- *Lophelia pertusa* reefs = Cold-water coral reef
- Oceanic ridges with hydrothermal vents/fields

Seamounts were excluded because they are a VME Element (see Section 6.3.1). Sea pen and burrowing megafauna communities were excluded because the definition of the OSPAR habitat meant that it would not be possible to include only those records where sea pens were present.

Data in the OSPAR database were further cleaned to include only records assigned as "certain" and whose data collection methods from the "OSPAR Survey" table included visual imagery (e.g. drop camera). Where multiple collection methods were listed, the data were assigned to the first method in the following order:

- Seabed imagery - ROV system
- Seabed imagery – drop camera system (photo/video)
- Seabed imagery – towed camera system (photo/video)

All the methods provided were also added to the comments field to allow further examination or change in assignment order if required.

Records depths were checked using the EMODnet Bathymetry REST service "avg" field and those shallower than 200 m were excluded.

Only those records not already in the ICES VME database were required and therefore, removal of "duplicates" was required. Owing to differences in data input, survey keys, date formats and variations in the number of decimal places used for the decimal degrees coordinates, it was not possible to match or exclude records automatically by field or directly by spatial intersection.

It was therefore decided to place a buffer around records from the VME database to spatially identify OSPAR records that could be the same as existing VME database records. The buffer size used was 11.1 km, which was based on the precision that a decimal degree to one decimal place would provide[6]. Most coordinate data in the databases were provided to at least two decimal points. If the OSPAR records did not intersect the VME buffered record, they were defined as not already occurring in the ICES VME database. For those records intersecting the VME buffered records, further manual checking of the OSPAR attributes (i.e., date range and similar survey name), to ensure the record was not already in the VME database, would be required before the record could be used. A spreadsheet of the spatially intersected OSPAR and buffered VME records, providing relevant attributes for comparison, was produced for this purpose.

5.3.2 Quality Assurance of OSPAR data

As the ICES VME database will be used to inform management decisions, it is critical that the data included meets a high standard of quality. For this reason, all data being transferred to the ICES VME database from OSPAR will need to be quality assured by members of the group before being imported. Part of this quality assurance check will be confirmation that an OSPAR record does match the requirements of a VME habitat. If this is not the case, OSPAR records may be entered as a VME indicator. If neither an appropriate VME habitat or indicator can be assigned, then the record should not be imported into the VME database.

For future submissions, data providers submitting the habitats listed above to OSPAR should be encouraged to submit the same data to ICES as well. To ensure ease of submission for data suppliers to both databases, WGDEC agreed that discussions between the ICES Data Centre and OSPAR database managers would be important, to establish ways to streamline the two data templates.

[6] https://en.wikipedia.org/wiki/Decimal_degrees. Accessed May 2020

5.3.3 Other sources of VME data

During the group discussion at WGDEC 2020, it was noted that there are other likely sources of VME data, some of which may not be present in the VME database.

Although there was not time to check other sources for data that could be added to the VME database during the meeting, some databases of relevance are described below. Three of the databases (EMODnet Biology, OBIS, and PANGAEA) serve to collate data on all marine (and sometimes terrestrial) species across specified geographic regions. The UNEP database is more specifically a collation of cold-water coral occurrences.

European Marine Observation and Data Network (EMODnet) Biology

The EMODnet Biology[7] database provides species data for European regional seas.

Ocean Biodiversity Information System OBIS

The OBIS[8] database collates data from other sources and provides a global marine species data portal.

PANGAEA

PANGAEA is a data publisher for Earth and Environmental Science. It hosts data on various topics, including Oceans, Biosphere, Ecology, Fisheries and Geophysics, with a global geographic coverage. It is operated as an open access library, which aims to archive and publish georeferenced data. Each dataset can be identified, shared, published and cited using a Digital Object Identifier (DOI). The data can be accessed at PANGAEA's website[9]. A search of PANGAEA in May 2020 using "cold-water corals" as the search term recovered 554 data sets.

United Nations Environment Programme (UNEP) Database on Cold-water corals

The UNEP Global Distribution of Cold-water Corals database, hereafter referred to as the UNEP database, shows the worldwide distribution of cold-water corals, as well as other taxa relevant to WGDEC. Occurrence records are given for 86 Families under the subclass Octocorallia (octocorals; also known as Alcyonaria) and four Orders (in Class Anthozoa): Scleractinia (reef-forming corals), Antipatharia (black corals), Zoanthidae (encrusting or button polyps), and Pennatulacea (sea pens). Occurrence records are also available for the Sub-Order Filifera (lace corals) in Class Hydrozoa (Freiwald *et al*., 2017; Freiwald *et al*., 2004). The UNEP database is available to download in a shapefile format (both point and polygon)[10].

Freiwald *et al*., (2017) also specifically state that the UNEP database is of relevance to VME policy as well as the following areas;

- Convention on Biological Diversity (CBD)
- Ecologically or Biologically Significant Area (EBSA)
- Specially Protected Areas of Mediterranean Importance (SPAMI)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Note that this database also cites OSPAR (2015) and there is likely duplication of records between the UNEP database and the OSPAR database, as well as potential duplication between the UNEP

[7] EMODnet Biology website https://www.emodnet-biology.eu/. Accessed May 2020
[8] OBIS's website https://obis.org/. Accessed May 2020
[9] PANGEAEA's website https://www.pangaea.de/. Accessed May 2020
[10] UNEP database records can be downloaded from https://data.unep-wcmc.org/datasets/3. Accessed May 2020

database and the ICES VME database. These sources of duplication would need to be reviewed before any data could be brought into the VME database or utilised separately by WGDEC.

5.4 References

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6 Building on work initiated in 2019, work jointly with the WGMHM to test the use of habitat suitability models for mapping VME presence, to assess how such information could be incorporated when, for example, recommending proposals for VME closures – ToR [d]

6.1 Clarification on change in ToR

WGDEC have previously reviewed the potential for using Species Distribution Models (SDMs) and Habitat Suitability Models (HSMs) within their work to support understanding of likely presence of VMEs. In 2019, the group noted that these have not yet been used to provide recommendations to ACOM on how to incorporate such information when suggesting VME closures through draft ICES advice. The group therefore identified the availability and differing resolutions of existing models and proposed next steps for model use (ICES, 2019a). Furthermore, the 2019 meeting was held jointly with the WGMHM, who reviewed the use of predictive models for estimating presence of VMEs and developed a 'roadmap' identifying the steps required for the implementation of their use by WGDEC and within ICES advice (ICES, 2019b).

This ToR planned to work jointly with WGMHM to test the use of SDM/HSMs for assessing VME likelihood for a case study area. However, following discussions between the WGDEC and WGMHM chairs, together with the ICES Secretariat and ACOM Leadership, it was agreed that this ToR would be further developed in 2021 when an in-person meeting was possible. Discussions were therefore held at WGDEC 2020 on the best way to take this work forward and the main focus for this ToR was changed to undertake mapping of VME Elements to support advice to the European Commission (see section 6.3).

6.2 Future use of Predictive Habitat Models within ICES advice

HSMs and SDMs are a commonly used method to predict the distribution of vulnerable marine ecosystems (VMEs) and can be particularly useful in deep-sea regions to fill gaps in observational data. These models utilise data on environmental variables, such as depth and water properties, to predict the occurrence of VMEs and indicator species. A range of models exist in the peer reviewed literature for different VME types and at different spatial scales (e.g. Yesson *et al*., 2012; Howell *et al*., 2016; Rooper *et al*., 2014; Ross *et al*., 2015; Kenchington *et al*., 2016).

The 'roadmap' developed by WGMHM (ICES, 2019) clarifies the need to generate a specification for the modelled outputs, to identify aspects such as which habitats/species to model, the spatial extent of the model, the minimum mapping resolution and how often the model should be rerun. In addition, they recommended a trial run for a subset of VME features, to optimise the model approaches, with the final methods published as part of the ICES 'Transparent Assessment Framework'.

Whilst the ToR for WGDEC/WGMHM was changed for WGDEC 2020, the group still considered the outputs from WGMHM 2019 and options for implementing the roadmap to ensure momentum was maintained on the best approaches to support future use of predictive models in ICES advice work. It was agreed that use of predictive models would provide a practical tool to support understanding of the likelihood of data-poor areas of the North Atlantic containing VMEs. However, the group also determined that a set of criteria should be derived, against which new and existing models could be reviewed to determine appropriate standards for their use for scientific advice. These outputs could then be used in the future to support the ICES advice process to the European Commission (EC) and NEAFC. In particular, it would add value to the advice to the EC on the deep-sea access regulations (EU) 2016/2336, for recommendations of closures to bottom trawling in areas where 'VMEs are likely to occur' within the 400–800 m footprint.

It was decided that it would be beneficial to run an intersessional benchmark workshop, prior to WGDEC 2021, to further this work and allow sufficient time to go through the 'roadmap' steps. A set of draft Terms of Reference were proposed by the group, see below.

The outputs of this workshop will be provided to ICES to determine the potential future application of predictive models within the ICES advice process.

6.2.1 Draft Terms of Reference for Predictive Habitat Models workshop

The **Benchmark Workshop on the Use of Predictive Habitat Models in ICES Advice** (WKPHM), chaired jointly by [TBC] will be established and will meet in [TBC] to:

- Review and recommend a set of criteria, similar to the existing ICES benchmarking system for regional fish stock assessments[11], underwhich new and existing predictive habitat models can be used for ICES scientific advice related to the distribution of vulnerable marine ecosystems (VMEs) (Science Plan code 6.2);
- Based on existing approaches, identify the methods for modelling VMEs that would be most appropriate for use within ICES advice, detailing 'required' and 'desirable' criteria, with emphasis on the deep-sea environment (considering bias of preferential sampling), PHM techniques (including spatial display of uncertainty) and required validation steps for the modelled outputs (Science Plan code 3.2);
- Develop clear standards for recording the caveats and assumptions inherent in the modelling method, for future use (Science Plan code 6.2);
- Conduct a trial run for a small number of existing models to ensure that both the approach and outputs are fit-for-purpose.

WKPHM will report by [TBC] for the attention of ACOM.

Supporting information

Priority	WGMHM and WGDEC have strongly advocated for the inclusion of predictive habitat models in ICES advice related to the distribution of vulnerable marine ecosystems. In order for ICES to utilize such models in their advice an agreed set of standards is required. With recurring requests from NEAFC, and potentially the EU, on the best scientific advice on where VMEs are known or likely to occur, this workshop is of a high priority.

[11] https://community.ices.dk/ExpertGroups/benchmarks/Shared%20Documents/Guidelines%20for%20Benchmark%20and%20Data%20Compilation%20Workshops.pdf

Scientific justification	Term of Reference a) Predictive habitat models (PHMs, also known as habitat suitability models, species distribution models or environmental niche models) are models that predict the likely distribution of a species or habitat using environmental variables as predictors. WGMHM and WGDEC have identified that PHMs which meet specific quality thresholds, represent the best available evidence for estimating where VMEs are likely to occur at a broad scale. However there is no agreed upon standard for what those quality thresholds should be. This ToR is aimed at providing benchmark standards for the use of such models in ICES advice related to the distribution of VMEs. Term of Reference b) WGMHM recommended in its 2019 report (ICES 2019) that guidance on the data sources, resolution and modelling approaches to be used would help to standardize ICES advice using PHMs and allow for direct comparison of outputs. This will render the data, methods and results from ICES assessments easy to find, explore and re-run and contribute to a Transparent Assessment Framework for PHM-related advice. Term of Reference c) Any modeling approach has associated caveats and assumptions. Standards on what should be reported will avoid misuse or misinterpretation of model outputs and will give greater credibility to PHM model-based advice. Term of Reference d) Having agreed on a common set of standards it will be necessary to conduct trial runs, using existing VME models,to make sure that the anticipated model outputs are fit for purpose. This approach will also allow for testing of the impacts of the recommendations from ToRs a and b.
Resource requirements	
Participants	The Group would likely by attended by some 20–25 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	ACOM
Linkages to other committees or groups	There is a very close working relationship with Working Groups on Benthic Ecology, Marine Planning and Coastal Zone Management and Spatial Fisheries Data. Data products will be used by WKEUVME in future.
Linkages to other organizations	FAO, NEAFC, EC, EMODnet.

6.3 VME element mapping

In response to a request from DGMARE to provide further scientific input to support implementation of the EU deep-sea access regulations (EU 2016/2336[12]), ICES organised a workshop on EU regulatory area options for VME protection (WKEUVME) to take place 18–22 May. WKEUVME will recommend a set of regulatory area options that vary in the degree of VME protection from bottom fishing. These will draw upon evidence of where VMEs occur, or are likely to occur, based on data collated through the ICES VME data calls and quality assured by WGDEC.

During the preparatory meeting for WKEUVME, a workflow was developed describing different VME protection scenarios, with criteria for area selection that could be used with relevant ICES datasets. This workflow proposed a stepwise approach to the inclusion of different data sources,

[12] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R2336

with decreasing data quality and associated confidence in VME presence. This would include known VME occurrences, using confirmed VME habitat data from the ICES VME database, and areas where VME are likely to occur based on VME indicator records from the database. It could also include, with lower levels of confidence, SDMs and HSMs of VME habitats/indicators, plus mapped areas of VME elements, based on the list in the Annex of the FAO International Guidelines (FAO, 2009).

Since the use of SDMs/HSMs requires further thought and testing before these models can be widely utilised within ICES work (see Section 6.2), this was not taken further during WGDEC/WGMHM 2020. However, the mapping of VME elements was considered to be a more achievable task. Whilst the location of VME elements is less certain than VME habitats and species, these data are obtainable from existing maps and modelled data using, for example, multibeam bathymetry datasets. It was therefore agreed that this year, the WGMHM would lead work, with support from WGDEC, to delineate areas of VME elements that could guide the identification of areas likely to contain VMEs within ICES Ecoregions.

6.3.1 VME elements

The FAO International Guidelines define VME elements as topographical, hydrophysical or geological features, including fragile geological structures, that potentially support VMEs (FAO, 2009). Elements include:

i. submerged edges and slopes (e.g. corals and sponges);
ii. summits and flanks of seamounts, guyots, banks, knolls, and hills (e.g. corals, sponges, xenophyphores);
iii. canyons and trenches (e.g. burrowed clay outcrops, corals);
iv. hydrothermal vents (e.g. microbial communities and endemic invertebrates); and
v. cold seeps (e.g. mud volcanoes for microbes, hard substrates for sessile invertebrates).

NAFO has also interpreted elements from these guidelines.

WGMHM therefore reviewed existing definitions, and developed working definitions for the analysis, for the following VME elements:

- Isolated seamounts;
- Steep-slopes and peaks on mid-ocean ridges;
- Knolls;
- Canyons;
- Steep flanks >6.4°
- Hydrothermal vents

In addition, they identified other geomorphological features which might have merit as VME Elements, and were termed ‘Candidate elements’, namely:

- Guyots (isolated or groups of seamounts with a smooth, flat top);
- Escarpments (elongated, linear, steep slopes separating gently sloping sectors of the seafloor in non-shelf areas); and
- Glacial troughs (elongated troughs formed by shelf valleys at high latitudes incised by glacial erosion during the Pleistocene).

6.3.2 VME element mapping methods

Full details on the method used to map the VME elements are reported in the WGMHM, 2020 report (ICES, 2020). However, they are briefly summarised here.

To map the VME elements, WGMHM mainly used the Grid Arendal Global Geomorphological maps provided by Harris *et al*. (2014), available as vector files from the Blue Habitats website[13].

"Steep slopes and peaks on mid-ocean ridges" and "Steep flanks >6.4°" were generated using the 2019 General Bathymetric Chart of the Oceans (GEBCO) bathymetric dataset. Slope was derived from the bathymetry data and a prescribed threshold of 6.4° was used to extract steep slope areas. The GRID-Arendal 'Ridge' feature polygon shapefile was used to extract the steep slopes that were contained within the extent of ridges. For hydrothermal vents, point data was extracted from the InterRidge database for active submarine hydrothermal vent fields. These were buffered with a radius of 500 m.

The final data outputs were clipped to the ICES Ecoregions, with a 10 km buffer included to ensure features on the ecoregion boundaries were included. These were provided to WKEUVME as vector shapefiles. In addition, a second dataset displaying the extent of the elements within the NEAFC region was also prepared.

Following mapping of these elements, WGMHM also reviewed the strength of association between VME elements and VME habitat and indicator observations. VME habitats from the ICES VME database were overlaid and connected with each element and candidate element, to obtain the percentage of VME observations contained within each element. The outputs of this work are detailed in the WGMHM, 2020 report (ICES, 2020)

6.3.3 Caveats and limitations

WGMHM recommended that the distribution of VME elements is regularly updated when elements are more clearly defined, and as better data sources become available. It was found during the analysis that the calculation of slope was highly dependent on the resolution of the bathymetric grid selected, and that the underlying data type (whether modelled/remotely sensed from satellites or observed by single-beam and multibeam echosounders), and hence quality, influenced the calculation of slope. Therefore, the reliance on slope, and thresholds of slope angles, for defining some elements was considered a significant weakness, and the method for deriving estimates of slope should be carefully stated when used.

WGMHM identified the following key points for the use of mapped VME element data:

1. Although VME elements have been provided, it is noted that the definition for each VME element is inadequate to ensure the exact reproduction of elements;
2. Elements are also listed without clear rule-sets for their consistent calculation (i.e. a specification that states the acceptable input data sets, working resolution, underlying data quality, exact method to produce terrain derivatives and the thresholds for delineating features);
3. The strength of association between specific elements and individual VME habitats is often poor;
4. Where the strength of association is high, the footprint of the Element is excessively large (either as a small number of large units or numerous small units) and unlikely to be useful for the fine-scale delineation of spatial advice;

[13] http://www.bluehabitats.org/?page_id=58

5. Based on the above issues, WGMHM does not recommend the use of VME elements without further refinement. We have however provided VME element maps for the imminent Workshop on EU regulatory area options for VME protection (WKEUVME). It is likely that this workshop will also provide additional insights into the value of VME elements within marine management.

6.4 References

FAO. 2009. International Guidelines for the Management of Deep-sea Fisheries in the High Seas. Rome, FAO. 493 73 pp. http://www.fao.org/3/i0816t/i0816t00.htm

ICES, 2019a. ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 1:56. 119 pp. http://doi.org/10.17895/ices.pub.5567

ICES. 2019b. Working Group on Marine Habitat Mapping (WGMHM). ICES Scientific Reports. 1:54. 28 pp. http://doi.org/10.17895/ices.pub.5578

ICES. 2020. Working Group on Marine Habitat Mapping (WGMHM). ICES Scientific Reports. 2:50. 59 pp. http://doi.org/10.17895/ices.pub.6034

7 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 – ToR [e]

7.1 Introduction

Following the implementation of the EU deep-sea access regulations (EU 2016/2336), ICES was requested by the European Commission to:

1. 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;
2. 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

For request 1, experts at WGDEC 2019 developed a list of representative taxa for hydrothermal vents/fields and cold seeps (see Annex 4, Table A4.1), as detailed in Section 8.3 of the WGDEC 2019 report (ICES, 2019) which was further reviewed and updated during WGDEC 2020, see details below.

For request 2, the group also reviewed Annex III of the regulations and provided initial proposals for updates to the list of VME habitats/sub-types, as detailed in Table 8.3 of the WGDEC 2019 report (ICES, 2019). These proposals were partly based on outputs of the ICES Workshop on VME (WKVME) (ICES, 2016), which updated the VME list specifically for use in data submissions to the ICES VME database, and partly based on new evidence provided by experts of the group. During WGDEC 2019, however, the revised list could not be completed due to time constraints and because not all relevant experts were able to attend. Therefore, it was agreed that a WGDEC sub-group would work intersessionally to finalise this request to ensure appropriate expertise was used, which took place from July–Sept 2019. Outputs of this work were reviewed during WGDEC 2020, with some further work taking place during the meeting. In particular, the group agreed that it was important to review any changes and additions to the list against the FAO criteria for VME, with further consideration of the potential for significant adverse impacts (FAO, 2009).

This section presents the final proposed updates to the VME habitats/sub-types and representative taxa. Where decisions to **add, remove** or **change** a habitat/sub-type were made at WGDEC 2019, the reasons for the decisions are briefly stated in brackets, and further information can be found in WGDEC 2019 report (ICES, 2019; section 8.3). Where the decision was made by the intersessional sub-group and WGDEC 2020, the reasons for the decisions are provided in more detail.

Changes to representative taxa are detailed in tables in Annex 4. In all cases, changes/additions are denoted in **bold text** and the evidence for these proposals is provided in a separate column. A full table recommended for submission to the European Commission, and as an update for the VME database, is provided in Table 7.6.

7.2 Review against FAO criteria

Following discussion during WGDEC 2019 and the intersessional sub-group meeting, the group agreed the need to evaluate all proposed VME indicator (representative) taxa against the FAO criteria for the prevention of significant adverse impacts on VMEs and the protection of marine biodiversity (FAO, 2009). This evaluation was accomplished using the criteria identified in Table 7.1 for properties relating to vulnerability, and potential for significant adverse impacts for specific characteristics of each property. Vulnerability is related to the likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what time frame. Significant adverse impacts are those that compromise ecosystem integrity (i.e. ecosystem structure or function) (FAO, 2009).

Table 7.1 FAO criteria for the prevention of significant adverse impacts on VMEs and protection of the marine biodiversity (FAO 2009).

Property	Guidance
Vulnerability	
Population, community, or habitat will experience substantial alteration from short-term or chronic disturbance (Para 14) by fishing gears (Para 15)	i. Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include: • habitats that contain endemic species; • habitats of rare, threatened or endangered species that occur only in discrete areas; or • nurseries or discrete feeding, breeding, or spawning areas.
	ii. Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.
	iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities.
	iv. Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: • slow growth rates; • late age of maturity; • low or unpredictable recruitment; or • long-lived.
	v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms (Para 42).
Timeframe in which a population, community, or habitat will recover from such disturbances (Para 14)	The most vulnerable ecosystems are those that are both easily disturbed and very slow to recover, or may never recover.
Examples of potentially vulnerable species groups, communities and habitats (Annex)	i. certain coldwater corals and hydroids, e.g. reef builders and coral forest including: stony corals (Scleractinia), alcyonaceans and gorgonians (Octocorallia), black corals (Antipatharia) and hydrocorals (Stylasteridae);
	ii. some types of sponge dominated communities;
	iii. communities composed of dense emergent fauna where large sessile protozoans (xenophyophores) and invertebrates (e.g. hydroids and bryozoans) form an important structural component of habitat; and

Property	Guidance
	iv. seep and vent communities comprised of invertebrate and microbial species found nowhere else (i.e. endemic).
Compromises ecosystem integrity (i.e. ecosystem structure or function). Impacts should be evaluated individually, in combination and cumulatively (Para 17)	Impacts that (i) impairs the ability of affected populations to replace themselves;
	(ii) degrades the long-term natural productivity of habitats;
	or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types.
Scale and significance of the impact (Para 18)	The following six factors should be considered: i. the intensity or severity of the impact at the specific site being affected;
	ii. the spatial extent of the impact relative to the availability of the habitat type affected;
	iii. The sensitivity/vulnerability of the ecosystem to the impact;
	iv. the ability of an ecosystem to recover from harm, and the rate of such recovery;
	v. the extent to which ecosystem functions may be altered by the impact;
	and vi. the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages.
Duration of impact (Para 19)	Temporary impacts are those that are limited in duration and that allow the particular ecosystem to recover over an acceptable time frame. Such time frames should be decided on a case-by-case basis and should be in the order of 5–20 years, taking into account the specific features of the populations and ecosystems (Para 19). In determining whether an impact is temporary, both the duration and the frequency at which an impact is repeated should be considered. If the interval between the expected disturbance of a habitat is shorter than the recovery time, the impact should be considered more than temporary (Para 20).
Precautionary Approach (Para 20)	In circumstances of limited information, States and RFMO/As should apply the precautionary approach in their determinations regarding the nature and duration of impacts.

7.3 Updates to VME habitat and representative taxa lists

7.3.1 Hydrothermal vents

Hydrothermal vents are unique habitats defined by fluids emanating from the seafloor with temperatures much higher than those of the surrounding deep sea. The process begins when seawater circulates downwards through the ocean crust in the presence of a heat source, resulting in significant chemical and physical modifications of both the seawater and the ocean crust. The heated and chemically modified seawater (hydrothermal fluid) is injected back into the ocean at hydrothermal fields. This hydrothermal fluid, full of metals, sulphide and gases (such as methane, carbon dioxide, etc.), creates a unique environmental chemistry that maintains a highly productive habitat.

For the purpose of this report, an exhaustive list of species is not provided. Instead, only those species that provide structure or habitat, or are large enough to be caught by some fishing gear, are included. Macro- or meiofauna were not included because of the low catchability by fishing gear unless attached or in combination with other, larger species or substrates. The selected species are indicators of the presence of hydrothermal vents specifically at the North Mid-Atlantic Ridge (MAR) and will vary across ocean basins.

In addition to listing species, geological structures are included in the list, i.e. sulphide or carbonate chimney-like structures, because they can serve as indicators of active or inactive hydrothermal vents and could be collected by fishing gear.

No representative fauna is included for inactive hydrothermal vents, because they are currently not known. However, some of the species that inhabit inactive hydrothermal vents likely have characteristics that would qualify them under the FAO VME criteria.

Indicator species for hydrothermal vent habitat were assessed against the FAO vulnerability criteria (**Table 7.2**). All species are endemic at hydrothermal vent fields, except the fish *Cataetyx laticeps*, which is mainly observed in association with the vent field Lucky Strike. The final list of VME indicator species for hydrothermal vents is provided in Annex 4, Table A4.1.

Uniqueness

The hydrothermal vents of the North MAR may represent a unique biogeographic region of invertebrate species (Van Dover *et al*., 2002). They have relatively high (>70%) (Wolf, 2004) proportions of endemic species (Tunnicliffe and Fowler, 1996; Van Dover *et al*., 2018), such as the blind shrimp *Rimicaris exoculata* and the mussel *Bathymodiolus azoricus* (Desbruyères *et al*., 2001).

Each vent is also unique in their diversity of geological and geophysical setting (depth, type of host rock) and water mass distribution over oceanic ridge crests, that in turn influence biodiversity and species composition (Van Dover *et al*., 2018).

Functional significance of the habitat

All hydrothermal vents rely on autotrophic production from microbes that oxidize the reduced compounds emitted in the vent fluids (Le Bris *et al*., 2019). Hydrothermal vent communities occur in discrete patches of biodiversity that have developed specialized adaptations to these environments (Van Dover *et al*., 2018). Such adaptations, e.g. major reorganization of internal tissues and physiologies to house microbial symbionts; biochemical adaptations to cope with sulphide poisoning; behavioural and molecular responses to high temperature; presence of metal-binding proteins and development of specialized sensory organs to locate hot chimneys (Tunnicliffe *et al*., 1998), allow the organisms to exploit the chemical setting of vent habitats and result in the most highly productive systems in the deep sea.

The endemic species are not known to survive for long periods outside the area of influence of the deep-sea hydrothermal vents. At the same time, it is recognized that there are also many levels of exchange between hydrothermal vents and the surrounding deep sea, including many interactive processes between species and the environment, with significance for ecosystem services, such as carbon cycling and sequestration, and fisheries production (e.g. Levin *et al*., 2016).

Fragility

The small spatial footprint (Van Dover *et al*., 2018) and linear distribution along the ridge axis can result in unpredictable recruitment, making these habitats highly susceptible to degradation by anthropogenic activities.

Life history

The lack of extensive knowledge on many aspects of early life histories of the species, such as spawning times, planktonic larval durations, and dispersal characteristics, pre-empt an assessment (but see below).

Unpredictable recruitment

Connectivity among vent fields in the MAR is poorly known, with 2–3 studies showing genetic and demographic exchange, but without an indication of the relevant temporal scales (Teixeira *et al*., 2012, Breusing *et al*., 2016). Some studies suggest that supply of larvae is discontinuous in time and varies between vent fields (Khripounoff *et al*., 2008).

Structural complexity

Hydrothermal vent fields are complex habitats that are comprised of both the geological structure and the biogenic structure generated by the large fauna distributed zonally along environmental gradients. Based on that zonation, different species provide particular types of biogenic structure that support and maintain associated biodiversity (Levin *et al*., 2016). This ecosystem enhances trophic and structural complexity, relative to the surrounding deep sea, and provides the setting for complex trophic interactions (e.g. Colaço *et al*., 2007; Portail *et al*., 2017). Chemosynthetic productivity from vents is exchanged with the nearby deep-sea environments, providing labile organic resources to benthic and pelagic ecosystems where food is otherwise limited (Levin *et al*., 2016).

7.3.2 Cold seeps

Cold seeps are benthic habitats where reduced chemicals emanate from the seafloor, supplied by sub-surface hydrocarbon reservoirs, gas hydrates, mud volcanoes or accumulations of organic matter. The methane and sulphides in these fluids are oxidised by free-living or symbiotic bacteria to produce organic matter through a process known as chemosynthesis. As for hydrothermal vents, this local primary productivity yields high biomass that contrasts with the food-poor deep sea. In particular, cold seeps are characterized by aggregations of large bivalves and tubeworms. These aggregations are patchily distributed among a cold seep site that is usually less than 1 km^2. In addition, many other species live in symbiosis with, or reliant on, chemosynthetic bacteria.

In the North Atlantic, cold-seeps are known from a variety of settings: mud volcanoes in the Gulf of Cadiz and on the continental slope of the Barents Sea, pockmarks on the Norwegian margin, and a diapir in the western Atlantic (Van Dover *et al*., 2003; Vanreusel *et al*., 2009). A new cold seep was recently discovered in the Hatton–Rockall Basin (Neat *et al*., 2019).

Indicator species for cold seep habitats were assessed against the FAO vulnerability criteria (**Table 7.2**). The final list of VME indicator species for cold seeps is provided in Annex 4, **Error! Reference source not found.**.

Uniqueness or rarity

Cold seeps are discrete benthic habitats sustaining symbiont-bearing bivalves and/or tubeworms. Most of these species are known from individual cold seeps and are thus considered endemics. For example, *Bobmarleya gadensis* (Hilário and Cunha, 2008) is a tube worm only known from a mud volcano in the Gulf of Cadiz, and *Isorropodon mackayi* (Oliver and Drewery, 2013) is a clam only known from a cold-seep in the Hatton–Rockall Basin. These symbiont-bearing species, and the genus they belong to, are considered as VME indicator taxa and listed in Annex 4, **Error! Reference source not found.**.

Functional significance of the habitat

As for vents, cold seep habitats are characterized by a high biomass derived from chemoautotrophy. Invertebrates have developed special adaptations and co-evolved with bacteria to survive in low O_2 and high H_2S concentrations. These large symbiont-bearing species rely on reduced fluids and are endemic to cold seeps. Methane seeps provide a number of ecosystem functions, particularly in global biogeochemical and elemental cycling. One important ecosystem function, which is reliant on the presence of seep biota, is that it acts as a methane filter, preventing methane stored in gas hydrates and the deep biosphere, from freely entering the hydrosphere and atmosphere, thus contributing to stabilising natural greenhouse gas seepage (Grupe *et al*., 2015). In addition, the three-dimensional complex seep microhabitats and associated structures (e.g. carbonate outcrops, rubble, clam beds) may offer refuge and trophic enhancement through increased biomass.

Fragility

Tube-worms are either partly buried in sediments or embedded in carbonate rocks. The latter would be highly sensitive to trawling if carbonate rocks are damaged. Among the bivalves, the mussels (*Bathymodiolus* sp.) are attached to carbonate concretions and are similarly sensitive. The other bivalves are completely or partly buried in sediments. The larger clams found at the sediment surface would be the most sensitive to trawling.

Life history

Many species are endemic to a single cold seep, thus the connectivity with other populations is unknown. Life history traits and the potential for recovery are also unknown for Northern Atlantic populations. However, some siboglinid tube-worms have been shown to live for hundreds of years in the Gulf of Mexico (Durkin *et al*., 2017).

Structural complexity

Authigenic carbonates in cold seeps provide a hard substrate for tube worms and mussels, as well as a unique habitat for a large number of small invertebrates (Levin *et al*., 2015). Bushes of tube worms also provide a structurally complex habitat that enhances local diversity (Bergquist *et al*., 2003). Bioturbation and biodiffusion by large clams facilitate the recruitment of infaunal communities (Guillon *et al*., 2017).

Table 7.2 Assessment of representative taxa of hydrothermal vents and cold seeps against the criteria for defining what constitutes a vulnerable marine ecosystem (FAO 2009). 'x' means direct evidence fitting to the criteria, '(x)' means criterion was inferred from the literature on other species.

VME habitat type and sub-type	VME representative taxa	Uniqueness	Functional significance	Fragility	Life History	Structural complexity
Hydrothermal vents/fields Active vents	KADOSACTINIDAE					
	Maractis rimicarivora	x	x	x	(x)	x
	MYTILIDAE					
	Bathymodiolus sp.	x	x	x	(x)	x
	Bathymodiolus azoricus	x	x	x	(x)	x
	ALVINOCARIDAE					
	Rimicaris exoculata	x	x	x	(x)	x
	Chorocaris chacei	x	x	x	(x)	x
	Mirocaris fortunata	x	x	x	(x)	x
	BYTHOGRAEIDAE					
	Segonzacia mesatlantica	x	x	x	(x)	
	BYTHITIDAE					

VME habitat type and sub-type	VME representative taxa	Uniqueness	Functional significance	Fragility	Life History	Structural complexity
	Cataetyx laticeps		x	x	(x)	
	ZOARCIDAE					
	Pachycara sp.	x	x	x	(x)	
Cold seeps	LUCINIDAE					
	Lucinoma sp.	x	x	x	(x)	x
	VESICOMYIDAE					
	Isorropodon mackayi	x	x	x	(x)	(x)
	THYASIRIDAE					
	Thyasira sp.	x	x	x	(x)	x
	MYTILIDAE					
	Bathymodiolus sp.	x	x	x	(x)	x
	SOLEMYDAE					
	Acharax sp.	x	x	x	(x)	x
	SIBOGLINIDAE					
	Siboglinum sp.	x	x	x	(x)	x
	Polybrachia sp.	x	x	x	(x)	x
	Spirobrachia sp.	x	x	x	(x)	x
	Bobmarleya sp.	x	x	x	(x)	x
	Lamellisabella sp.	x	x	x	(x)	x
	Sclerolinum sp. *Oligobrachia* sp.	x	x	x	(x)	x
	ZOARCIDAE					
	Lycodes squamiventer	x	x	x	(x)	

7.3.3 Cold-water coral reef

During WGDEC 2019, the group agreed to **change** the *Lophelia pertusa/Desmophyllum pertusum* reef sub-type to include the species *Madrepora oculata.* This scleractinian coral species is known to be a reef-building species (Schembri et al., 2007) and has been found to be commonly associated with *Lophelia pertusa/Desmophyllum pertusum*, with similar abundances of both species identified in many reefs in the North East Atlantic (Arnaud-Haond, *et al.*, 2017). Therefore, this habitat type is changed to:

- ***Lophelia pertusa/Madrepora oculata* reef (based on WGDEC 2019 decision)**

The representative taxa list was also updated to include *Madrepora oculata,* see Annex 4, **Error! Reference source not found.**.

7.3.4 Coral gardens

7.3.4.1 Habitat sub-types

During WGDEC 2020, the group agreed to **add** four new habitat sub-types:

- **Hard-bottom coral garden: Stylasterid corals (based on WGDEC 2019 decision)**
- **Hard-bottom coral gardens: Cup coral fields (proposal based on new evidence)**
- **Hard-bottom coral gardens: Cauliflower coral fields (proposal based on new evidence)**
- **Soft-bottom coral gardens: Non-reefal scleractinian aggregations (proposal based on new evidence)**

Hard-bottom coral gardens: Cup coral fields

For coral gardens, the list currently includes soft-bottom coral gardens: cup-coral fields, but not hard-bottom cup coral fields. During WGDEC 2019, examples of this habitat sub-type were noted from the South Atlantic, and from the North East Atlantic in UK waters from the Wyville-Thomson Ridge, comprised of *Caryophyllia* sp. (ICES, 2019) (Figure 7.1).

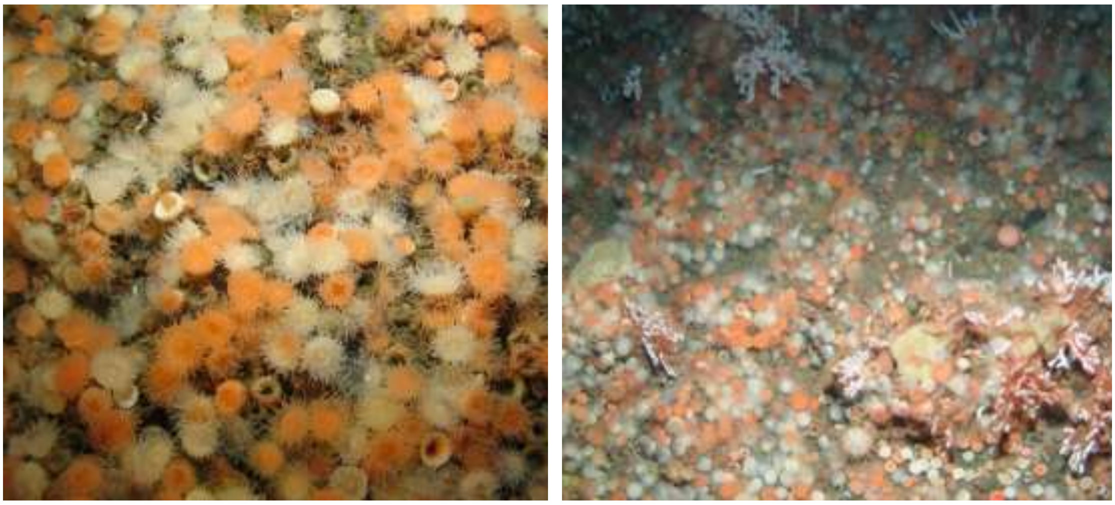

Figure 7.1 Hard bottom cup coral field seen at the Wyville-Thomson Ridge in UK waters. Images from tow WTR_4, from the Department of Trade and Industry (DTI) SEA_SAC 2006 survey. Image source: DTI

During WGDEC 2020, it was noted that evidence of the occurrence of hard bottom coral gardens formed by cup corals have also been documented in Pacific waters (Chilean fjords, Försterra et al., 2017) as well as in the submarine canyons in the NW Mediterranean (Aymá et al., 2019) for the cold-water coral solitary species *Desmophyllum dianthus*. In both cases the corals cover overhangs in remarkable densities (Figure 7.2(a)). In the Chilean fjords, densities of up to 1500 individuals m^2 have been reported (Försterra and Häusserman, 2003); in the Mediterranean canyon of La Fonera the density has not been quantified however large aggregations have been observed (Figure 7.2(b))

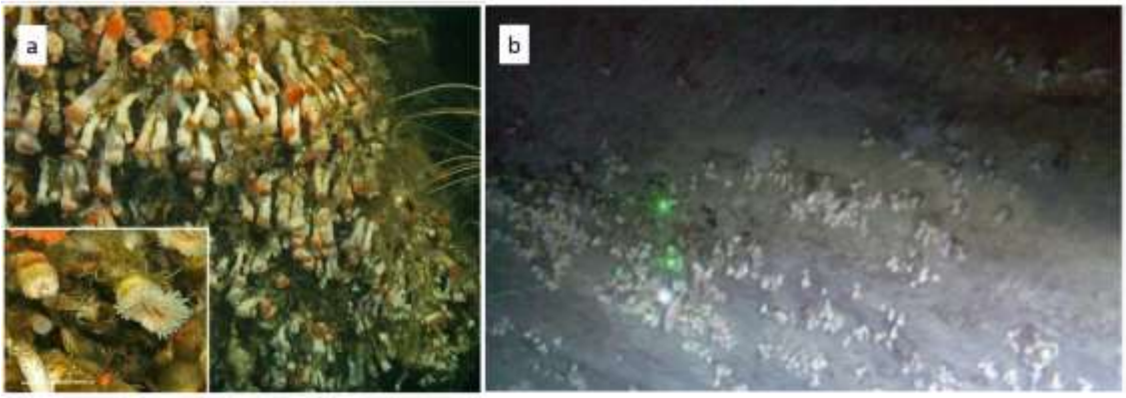

Figure 7.2 a) Hard bottom cup coral field formed by *Desmophyllum dianthus* seen at Chilean Fjords (Pacific waters) specifically in the Comau fjord at 25 m depth, however the species show a large bathymetric range (up to 2500 m depth); b) Hard bottom cup coral field formed by *Desmophyllum dianthus* in the Mediterranan cayon of La Fonera, at 1400 m depth. In both cases the corals grow in overhangs. (Sources of images: a: Försterra et al., 2017; Aymá et al., 2019).

Following further discussion on the proposal to add this habitat to the VME list, WGDEC 2020 reviewed the representative taxa against the FAO criteria (Table 7.3). Although there were no direct studies on the NE Atlantic *Caryophyllia* species, within NAFO waters attached cup coral species such as *Desmophyllym* spp. are known to be vulnerable to trawl and gillnet gears (Wareham and Edinger, 2007, in Fuller et al., 2008) and have been noted to be very slow growing and long-lived (Lazier et al., 1999; Risk et al., 2002, in Fuller et al., 2008). Since these meet at least two of the FAO criteria, the group agreed to add this as a new sub-type of coral gardens.

Hard-bottom coral gardens: Cauliflower coral fields

WGDEC 2020 also discussed whether another habitat sub-type should be included to represent cauliflower corals (Nephtheidae) on hard substrates. These species are already included on the VME list as a sub-type of coral gardens on soft substrata.

Understanding the geographic distribution of specific species in this family can be difficult due to taxonomic uncertainty and there have been multiple changes in genus names over time, with species moving between genera. However, four species of this family are known to occur in the North Atlantic, observed on hard substrates, and example images are shown in Figure 7.3. Analyses of an extensive species dataset from video surveys (MAREANO.no) in Arctic and sub-Arctic Norwegian waters identified that different Nephtheidae species are the characteristic fauna of four different biotopes (Buhl-Mortensen et al., 2020). These biotopes occur in different environments, but a confident species identification was not possible based on imagery. The most prominent example of this VME was observed on the upper slope of the Norwegian continental shelf in the northern Norwegian Sea. Here, dense aggregations of Nephtheidae were observed on gravelly bottoms, with frequent occurrences of basket stars (juvenile individuals in the corals and adults (Cf. *Gorgonocephalus eucnemis* on the substrate between the corals).

When considered against the FAO criteria, studies on life history traits indicate low reproductive output with the release of few, fairly large planulae from the parent colony (internal brooding) (Sun et al., 2010a,b; Sun et al., 2011). Laboratory studies on planulae suggest that when fertile colonies are damaged or torn by anthropogenic activities (e.g., bottom trawling), planulae that become free may grow into viable offspring (Henry et al., 2003; Sun et al., 2011). Gilkinson *et al.* (2004) found no significant immediate effect of dredging on soft coral abundance in an area of the Scotian Shelf, southeastern Atlantic Canada, or any long-term declines. Henry *et al.* (2006), also found that biomass of soft corals (*Clavularia* sp.) after 3 years of trawling was not significantly different from control areas, and there was no detectable indication of any accumulated effect of repeated trawling year-on-year. Nevertheless, the slow growth of primary polyps suggests slow recovery of deep-sea soft corals following damage by natural or anthropogenic disturbances (Sun et al., 2010b; 2011).

The representative taxa species met a number of the FAO criteria (Table 7.3). As such, it was agreed to **add** the hard substrata habitat as a sub-type of coral gardens.

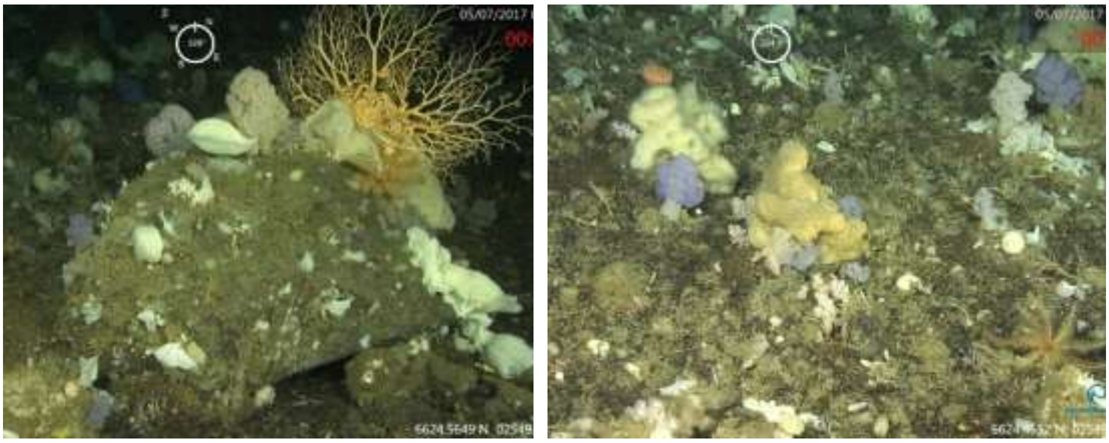

Figure 7.3. Cauliflower corals on hard substrate at 580 and 590 m depth in the Denmark Strait, west of Iceland. In the area, *Drifa glomerata*, *Duva florida, Pseudodrifa groenlandicus* and *Gersemia* sp. were observed. Image source: Marine and Freshwater Research Institute (MFRI).

Soft-bottom coral gardens: Non-reefal scleractinian aggregations

During WGDEC 2020, the group further discussed the inclusion of a new subtype of soft bottom coral gardens represented by the azooxanthellate scleractinian *Eguchipsammia* sp. (Dendrophylliidae; Cairns, 2000). *Eguchipsammia* has an amphi-Atlantic distribution but is presently only known to form extensive aggregations in the Azores (Tempera et al 2015; Morato et al 2019b). Corals of the genus *Eguchipsammia* are free-lying on the seabed (Zibrowius, 1980; Cairns, 2000) forming a semi-rigid network of inter-twined coral branches over soft sediments (< 1 m in height) that provide a wide variety of microhabitats to epi- and endofauna (Morato et al 2019b). In some areas, *Eguchipsammia* forms reef-like structures although these are smaller in extent and height than traditional cold-water coral reefs (Figure 7.4).

The particular nature of this habitat, its singularity in the North Atlantic and high susceptibility to trawling (Braga-Henriques pers. obs., cruise BIODIAZ M150) justifies its inclusion as a VME habitat. Therefore, it was agreed to add the soft-bottom substrata habitat as a sub-type of coral gardens.

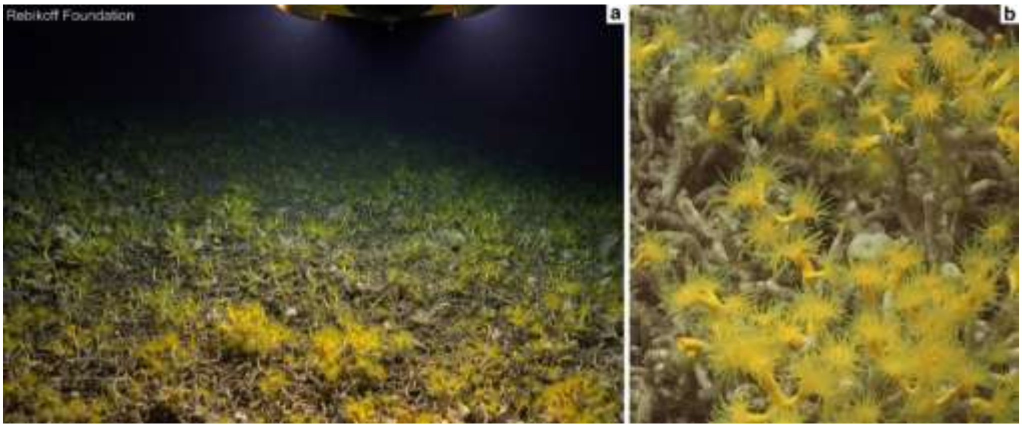

Figure 7.4 Proposed new habitat type "soft bottom coral gardens: non-reefal scleractinian aggregations" represented by the azooxanthellate scleractinian *Eguchipsammia* sp. at 300 m on Mon't Ana, off the Faial-Pico Channel, Azores. Image source: Rebikoff-Niggeler Foundation (DEEP-ML, MAR2020-P06M02-0535P, SRAAC, Government of Madeira).

7.3.4.2 Representative taxa

For the coral garden habitat sub-types, the group used knowledge of coral experts present in the meeting to review the list of representative taxa for all coral garden sub-types. The list was reviewed based on recent knowledge for the Mid-Atlantic Ridge, the Portuguese Archipelagos and the Arctic/sub-Arctic regions. A substantial update has been made and the list of taxa is provided in Annex 4, **Error! Reference source not found.** and illustrative images are shown in Figure 7.5.

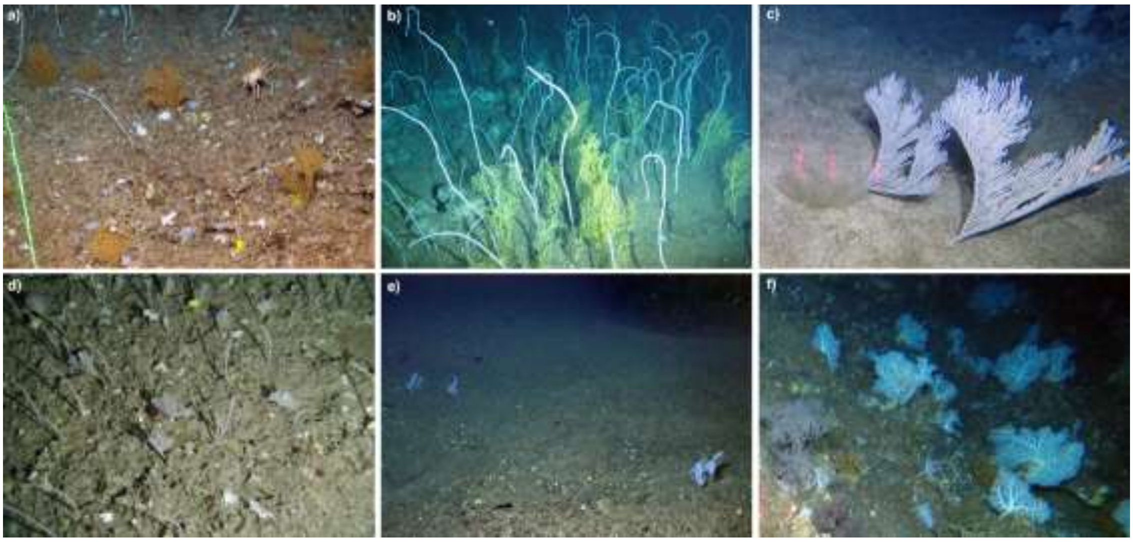

Figure 7.5 Proposed new indicator taxa of hard bottom coral gardens (subtype hard bottom gorgonian and black coral gardens). (a) gorgonian *Acanthogorgia hirsuta* at 450 m depth on the Gigante Seamount Complex (Azores Archipelago); (b) whip octocoral *Viminella flagellum* and fanshaped octocoral *Dentomuricea* aff. meteor at 250 m depth on Condor Seamount (Azores Archipelago) (c) octocoral *Paracalypthrophora josephinae* at 300 m on Voador Seamount (Azores Archipelago); (d) whip octocoral *Narella versluysi* and fanshaped octocoral *Narella bellissima* at 600 m on Cavalo seamount (Azores Archipelago); (e) octocoral *Eunicella* sp. at Madeira Archipelago; (f) stylasterid *Errina dabneyi* at 230 m depth on seamounts Southeast of Pico Island (Azores Archipelago). Images sources: (a,c,f) IMAR/OKEANOS-UAz, Drift camera, MapGES/ATLAS projects, (b) - Gavin Newman/Greenpeace, (d) NIOZ NICO 12a cruise; (e) Rebikoff-Niggeler Foundation (DEEP-ML, MAR2020-P06M02-0535P, SRAAC, Government of Madeira).

All proposed new indicator taxa were evaluated against the FAO criteria for VMEs (FAO 2009) (Table 7.1) and met one or more of the vulnerability criteria (Table 7.3). In general, there was limited information to assess the life history and functional significance of all species due to knowledge gaps on species reproductive cycles, growth and longevity, larvae biology and dispersal and their role in the functioning of the ecosystems, such as nursery areas, as well as nutrient regeneration, and carbon remineralization and sequestration. When available, information on closely related species was used to infer decisions against these criteria. There was also limited information on the potential for recovery of these species after impact, but given their life history traits, it is assumed that recovery for these deep-sea species is at high risk for significant adverse impacts by bottom-contact fishing, and the precautionary approach should be applied (code VIII in Table 7.1).

Table 7.3 Assessment of proposed representative taxa of coral garden habitats against the criteria for defining what constitutes a vulnerable marine ecosystem (FAO 2009). 'x' means direct evidence fitting to the criteria, '(x)' means criterion was inferred from the literature on other species; '?' means no information available and blank cell means that the criterion was not met.

VME habitat sub-type	VME representative taxa	Uniqueness	Functional significance	Fragility	Life History	Structural complexity
Hard bottom coral garden: Hard bottom gorgonian and black coral gardens	ACANTHOGORGIIDAE					
	Acanthogorgia hirsuta		(X)	X	?	X
	PARAGORGIIDAE					
	Paragorgia johnsoni		(X)	X	(X)	X
	ELLISELLIDAE					
	Viminella flagellum		X	X	(X)	X
	PLEXAURIDAE					
	Dentomuricea	X*	X	X	(X)	X
	PRIMNOIDAE					
	Paracalypthrophora josephinae		X	X	(X)	X
	Narella		(X)	X	?	X
	Eunicella		(X)	X	(X)	X
Hard bottom coral garden: Non-reefal scleractinian aggregations	DENDROPHYLLIIDAE					
	Dendrophyllia cornigera		X	X	?	X
	Dendrophyllia ramea		X	X	?	X
Soft bottom coral garden: Non-reefal scleractinian aggregations	*Eguchipsammia* sp.		(X)	X	?	X
Hard bottom coral garden: Stylasterid corals on hard substrata	STYLASTERIDAE					
	Errina dabneyi	X	(X)	X	X	X
Hard bottom coral garden: Cup coral fields	CARYOPHYLLIIDAE					
	Caryophyllia spp.			(X)	(X)	
	NEPHTHEIDAE					

VME habitat sub-type	VME representative taxa	Uniqueness	Functional significance	Fragility	Life History	Structural complexity
Hard bottom coral garden: Cauli-flower coral fields	*Drifa glomerata*		X	?	X	X
	Duva florida		X	?	X	X
	Pseudodrifa groen-landicus		X	?	?	X
	Gersemia spp.		X	?	X	X
Soft bottom coral garden: Soft bot-tom gorgonian and black coral gardens	ISIDIDAE					
	Isidella elongata		X	X	X	X
	Isidella lofotensis	X	X	X	X	X

***Presence only confirmed in the Great Meteor complex and the Azores (Grassoff ,1977; Braga-Henriques et al., 2013), but suspected in the Canary Islands.**

7.4 Deep-sea sponge aggregations

During WGDEC 2019, the group agreed to remove the 'glass sponge communities' habitat sutype for the deep-sea sponge aggregation VME habitat. The list of representative taxa associated with these habitats were also reviewed and updated during WGDEC 2019, using expertise available (see ICES, 2019). Some minor amendments were made to this list by the intersessional subgroup and further reviewed at the WGDEC 2020 meeting; the final list is provided in Annex 4, **Error! Reference source not found.**. All reference to substrate type as a subcategory was removed as many of these species live on both hard and soft bottoms and the categories were not considered useful. For example, *Geodia* species attach to hard substrate but that can be a pebble in an otherwise soft bottom or bedrock.

The list was cross-referenced with that produced by NAFO (NAFO, 2020) and was found to be highly consistent at the species and genus levels. Some of the species were not found in the NE Atlantic or vice versa, while some were present but not habitat-forming in the northeast. A few species listed by NAFO were considered and included in the WGDEC list of representative taxa (Annex 4, **Error! Reference source not found.**).

All species were evaluated against the FAO criteria for VMEs (FAO, 2009) (Table 7.1) and met one or more of the vulnerability criteria (Table 7.4). Less is known on the potential for recovery of these sponges, but given their presumed slow growth rates and high longevity (Leys and Lauzon, 1998; Fallon et al., 2010; Kahn et al., 2016), episodic recruitment and inability to reattach once brought on the deck of a fishing vessel (ICES, 2009), it is assumed that recovery for these deep-sea species is on a scale consistent with the potential for significant adverse impacts by bottom-contact fishing.

Table 7.4 Assessment of proposed representative taxa of sponge aggregation habitats against the criteria for defining what constitutes a vulnerable marine ecosystem (FAO 2009). 'x' means direct evidence fitting to the criteria, '(x)' means indirect evidence for fitting the criteria, '?' means no information available and blank cell means not fitting to the criteria.

VME representative taxa		Uniqueness	Functional significance	Fragility	Life History	Structural complexity
DEMOSPONGIAE						
GEODIIDAE	*Geodia phlegraei*		X	(X)	X	X
	Geodia hentscheli		X	X	(X)	X
	Geodia parva		X	X	(X)	X
ANCORINIDAE	*Stryphnus fortis* (change in species name)	X	X	X	(X)	X
	Stelletta normani (change in taxonomic level)	X	X	X	(X)	X
	Stelletta rhaphidiophora		X	X	(X)	X
THENEIDAE (change in family name)	*Thenea* spp.		X	X		X
AZORICIDAE	*Leiodermatium* spp		X	X		X
CORALLISTIDAE	*Neophrissospongia nolitangere*		X	X	(X)	X
	Neoschrammeniella spp.		X	X	(X)	X
MACANDREWIIDAE	*Macandrewia* spp.			X	(X)	X
TETILLIDAE	*Craniella* spp.			X		X
	Tetilla longipilis			X		X
AXINELLIDAE	*Axinella infundibuli-formis* (change in taxonomic level)			X		X
BUBARIDAE (change in family level)	*Phakellia* spp.		X	X		X
COELOSPHAERIDAE	*Lissodendoryx (Lissodendoryx) complicata*			X		X
MYCALIDAE	*Mycale (Mycale) lingua*		X	X		X
PETROSIIDAE	*Petrosia* spp.		X	X		X
HEXACTINELLIDA **HYALONEMATIDAE**	*Hyalonema* spp.	X		X	(X)	X

VME representative taxa		Uniqueness	Functional significance	Fragility	Life History	Structural complexity
ROSSELLIDAE	*Asconema setubalense*	X		X	(X)	X
	Asconema foliatum	X		X	(X)	X
	Schaudinnia rosea	X		X	(X)	X
	Scyphidium septentrionale	X		X	(X)	X
	Trichasterina borealis	X		X	(X)	X
PHERONEMATIDAE	*Poliopogon amadou*	X	X	X	(X)	X

7.5 Sea pen fields

The representative taxa list for the North Atlantic (including both the northeast and northwest) was reviewed by the intersessional sub-group and WGDEC 2020. It was noted that for the NAFO Regulatory Area, all sea pen species are considered VME indicators. WGDEC therefore followed a similar approach. For sea pen fields, no habitat sub-types were proposed.

Data and evidence from Williams (2011) were used to determine which sea pen genera are present in the North Atlantic Ocean. These were then reviewed within the WoRMS (2019) database and the Ocean Biogeographic Information System (OBIS) to confirm their distribution. As confidence in these datasets was not always high, recent taxonomic literature was consulted, and the list was also further reviewed by a sea pen expert Dr. Pablo López-González (Universidad de Sevilla, Seville, Spain), who examined the group for completeness and taxonomic validity. Based on his expert opinion, several species belonging to the genera *Protoptilum*, *Umbellula*, and *Pennatula* were separated based on insufficient characteristics, and require further morphological and/or molecular analyses to confirm their heterospecific status. Given their accepted status in WoRMS, all species belonging to these genera with a reported distribution in the North Atlantic were included but could be reviewed in the future if/when new evidence of their conspecific status becomes available. The final list of representative sea pen taxa is provided in Annex 4, Table A4.5.

During the WGDEC 2020 meeting, members reviewed all of the representative sea pen taxa against the FAO criteria for VMEs (Table 7.5) and all were considered to have met at least one of the vulnerability criteria. Although information on the distribution of sea pens is limited, none were considered unique/rare or endemic. Information on the functional significance of sea pens in terms of biodiversity enhancement and role as fish habitat, and on the life history traits which make recovery difficult (e.g. slow growth, longevity) was available for some species (Baillon et al., 2012; Murillo et al., 2020) that form expansive VME habitats in the NAFO Regulatory Area and in Canadian waters (Kenchington et al., 2016; NAFO, 2019). For all other species where this information was considered lacking, their functional significance and low recoverability was inferred from this literature.

There was some uncertainty as to whether all proposed sea pen taxa form significant concentrations and thereby meet the Structural Complexity criterion. Certain species, such as *Funiculina quadrangularis*, *Pennatula phosphorea*, *P. aculeata*, *Pteroeides griseum* and V*eretillum cynomorium* are known to form aggregations off Spain (Ruiz-Pico et al., 2017), but others lack evidence to confirm this. For Norwegian waters, the MAREANO mapping programme (MAREANO.no), and various coastal mapping surveys (Buhl-Mortensen & Buhl-Mortensen, 2014), have observed aggregations of mainly three species of sea pen: *Funiculina quadrangularis*, *Virgularia mirabilis*, and *Kophobelemnon stelliferum*. These may co-occur, but there is a trend indicating that *Kophobelemnon* is more dominant in coastal deep-waters, whereas *Virgularia* and *Funiculina* are more common in offshore areas. In the deeper part of the Norwegian continental shelf, *Umbellula encrinus* occur scattered and in low densities. In other parts of the Norwegian Sea, e.g. around the Jan Mayen island, this species has been observed in denser aggregations (Fossum et al., 2012). However, all taxa were considered to have the potential to aggregate under certain environmental conditions and given the lack of information on the density of most species, all were deemed to have the potential to meet this criterion. This information could be reviewed in the future if/when new evidence becomes available.

An analysis of significant adverse impacts (SAI) on sea pen VME in the NAFO Regulatory Area revealed that sea pens were at high risk of VME relative to large gorgonians and sponges (NAFO, 2011, 2016). Consequently, all proposed sea pen taxa that are known to occur in the NAFO Regulatory Area (NAFO, 2020) were deemed to be at high risk of SAI, while the precautionary approach was applied for those species where SAI have not yet been evaluated. Chimienti et al. (2018) found *Pennatula rubra* particularly vulnerable to trawl gear impact and also showed that it was morphologically similar to *P. aculeata* and *P. grandis*, two of the species listed here.

Table 7.5 Assessment of proposed representative taxa of sea pen fields against the criteria for defining what constitutes a vulnerable marine ecosystem (FAO 2009). 'x' means direct evidence fitting to the criteria, '(x)' means indirect evidence for fitting the criteria, '?' means no information available and blank cell means not fitting to the criteria.

VME representative taxa		Uniqueness	Functional significance	Fragility	Life History	Structural complexity
ANTHOPTILIDAE	*Anthoptilum Grandiflorum**		X	(X)	X	X
CHUNELLIDAE	*Porcupinella profunda*		(X)	(X)	(X)	X
	PENNATULIDAE					
	*Pennatula aculeata***		X	(X)	X	X
	*Pennatula grandis***		X	(X)	X	X
	Pteroeides spinosum		(X)	(X)	(X)	X
HALIPTERIDAE	*Halipteris finmarchica**		X	(X)	X	X
	*Halipteris christii**		X	(X)	(X)	X
KOPHOBELEMNIDAE	*Kophobelemnon macrospinosum*		(X)	(X)	(X)	X
PROTOPTILIDAE	*Distichoptilum gracile**		X	(X)	(X)	X
	*Protoptilum carpenterii**		X	X	(X)	X
	Protoptilum thomsonii		(X)	(X)	(X)	X
SCLEROPTILIDAE	*Scleroptilum grandiflorum*		(X)	(X)	(X)	X
UMBELLULIDAE	*Umbellula monocephalus*		(X)	(X)	(X)	X

VME representative taxa		Uniqueness	Functional significance	Fragility	Life History	Structural complexity
	Umbellula thomsoni		(X)	(X)	(X)	X
	Umbellula durissima		(X)	(X)	(X)	X
VIRGULARIDAE	*Virgularia glacialis*		(X)	(X)	(X)	X
	Virgularia tubercu-lata		(X)	(X)	(X)	X
	Stylatula elegans		(X)	(X)	(X)	X
VERETILLIDAE	*Cavernularia pusilla*		(X)	(X)	(X)	X
	Veretillum cynomorium		(X)	(X)	(X)	X

*** High risk of Significant Adverse Impact (Kenchington et al., 2011; NAFO, 2016); Compromises Ecosystem Integrity (SAI IV)**

**** High risk of Significant Adverse Impact (Chimienti et al. 2018; Kenchington et al., 2011; NAFO, 2016); Compromises Ecosystem Integrity (SAI IV)**

7.6 Additional VME habitats

During WGDEC 2019 and the intersessional sub-group, a few changes to habitat types and sub-types were agreed for the remaining VME habitats on the existing list, as follows:

- Tube-dwelling anemone patches changed to **Tube-dwelling anemone aggregations**
- Mud and sand emergent fauna habitat type removed and split into two new types: **Stalked crinoid aggregations and Xenophyophore aggregations**
- The stalked sponge aggregation was considered to be most relevant to the 'soft bottom sponge aggregation' sub-type instead and the representative taxa have been added to this sub-type (see section 7.4).

There was not time at WGDEC 2020 to review the representative taxa for these habitat types against the FAO VME and SAI criteria. Therefore, these have not been included in the report at this time, but this work will be undertaken intersessionally.

7.7 Conclusions

It should be highlighted that the presence of VME indicator taxa in a particular location does not automatically classify the area as a VME. In this regard, WGDEC considers that significant work is still required to improve the ICES multi-criteria assessment method (VME index) and the provision of VME data by member countries (e.g. by providing abundance, size, and ecosystem health information).

It was also noted that new evidence on deep-sea species is increasing over time, so updates to the representative taxa list may be needed on a more regular basis. Further to this, consideration needs to be made about how to address changes in taxonomy. The representative taxa proposed by WGDEC reflect the taxonomy of these species at the time of writing. However, if/when a species' taxonomy changes, the revised species should be updated within the VME representative taxa list. This could be added as a task to ToR [a] each year, to ensure that the taxonomic list is reviewed and edited if needed, particularly for the list used for the ICES VME database.

There were several issues the group discussed whilst defining new habitats and sub-types. One question was how to define mixed VME habitats, for example mixes of deep-sea sponge aggregations and coral gardens, or coral gardens and reefs. The group agreed to keep the habitat types and sub-types separate but clarified that the VME database does enable users to submit mixed habitat data. This is done by providing each habitat/sub-type as a separate record, using a different 'Record Key', but linking these records to the same 'patch' by providing them with the same 'VME key'.

The final list of VME habitats, sub-types and representative taxa is provided in **Error! Reference source not found.**Table 7.6**.** This has been simplified to only include representative taxa at family level, unless only specific species are relevant, in which case these species are listed.

The full list of representative taxa for each habitat and sub-type, including species, will also be made available as an updated table for VME data submissions to support data providers in decisions on which species data to submit to the database, following review of the remaining habitats mentioned in section 7.6.

Table 7.6 Proposed list of VME habitats/sub-types and representative taxa for ICES request

Proposed VME Habitat type	Proposed VME habitat subtype	Representative taxa
Cold-water coral reef	***Lophelia pertusa*/*Madrepora oculata* reef**	*Lophelia pertusa* ***Madrepora oculata***
	Solenosmilia variabilis reef	*Solenosmilia variabilis*
Coral garden	Hard-bottom coral garden	
	Hard-bottom coral garden: Hard-bottom gorgonian[14] and black coral gardens	ACANTHOGORGIIDAE **ALCYONIIDAE** ANTHOTHELIDAE **ANTIPATHIDAE** CHRYSOGORGIIDAE CORALLIIDAE **ELLISELLIDAE** ISIDIDAE, KERATOISIDINAE **LEIOPATHIDAE** PARAGORGIIDAE PLEXAURIDAE PRIMNOIDAE SCHIZOPATHIDAE
	Hard-bottom coral garden: Colonial scleractinians on rocky outcrops	*Lophelia pertusa* ***Madrepora oculata*** *Solenosmilia variabilis*
	Hard-bottom coral garden: Non-reefal scleractinian aggregations	*Enallopsammia rostrata* ***Lophelia pertusa*** *Madrepora oculata* ***Dendrophyllia cornigera***

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

Proposed VME Habitat type	**Proposed VME habitat subtype**	**Representative taxa**
		Dendrophyllia ramea
	Hard-bottom coral garden: Stylasterid corals on hard substrata	***Pliobothrus* spp.** ***Stylaster* spp.** ***Errina dabneyis***
	Hard-bottom coral garden: Cup coral fields	**CARYOPHYLLIIDAE**
	Hard-bottom coral garden: Cauliflower coral fields	**NEPHTHEIDAE**
	Soft bottom coral garden	
	Soft-bottom coral garden: Soft-bottom gorgonian[1] and black coral gardens	**ALCYONIIDAE** **ANTIPATHIDAE** CHRYSOGORGIIDAE **ISIDIDAE**
	Soft-bottom coral garden: Cup coral fields	CARYOPHYLLIIDAE
	Soft-bottom coral garden: Cauliflower coral fields	NEPHTHEIDAE
	Soft bottom coral garden: Non-reefal scleractinian aggregations	***Eguchipsammia* sp.**
Deep-sea sponge aggregations		ANCORINIDAE AXINELLIDAE **AZORICIDAE** **BUBARIDAE** **COELOSPHAERIDAE** **CORALLISTIDAE** **DEMOSPONGIAE** GEODIIDAE **HEXACTINELLIDA** **HYALONEMATIDAE** **MACANDREWIIDAE** MYCALIDAE **PETROSIIDAE** PHERONEMATIDAE POLYMASTIIDAE ROSSELLIDAE TETILLIDAE **THENEIDAE**
Sea pen fields		ANTHOPTILIDAE **CHUNELLIDAE** FUNICULINIDAE HALIPTERIDAE KOPHOBELEMNIDAE PENNATULIDAE PROTOPTILIDAE **SCLEROPTILIDAE** UMBELLULIDAE **VERETILLIDAE** VIRGULARIDAE

Proposed VME Habitat type	Proposed VME habitat subtype	Representative taxa
Hydrothermal vents/fields	**Active vents**	**KADOSACTINIDAE** **MYTILIDAE** **ALVINOCARIDAE** **BYTHOGRAEIDAE** **BYTHITIDAE** **ZOARCIDAE**
	Inactive vents	**See 'coral gardens' and 'deep-sea sponge aggregations'**
Cold seeps		**LUCINIDAE** **VESICOMYIDAE** **THYASIRIDAE** **MYTILIDAE** **SOLEMYDAE** **SIBOGLINIDAE** **ZOARCIDAE**

7.8 The need for revising the criteria for selecting VME indicators and defining VMEs

During the WGDEC 2020 meeting, the group had several discussions about how to apply the FAO criteria to selected VME indicator species. When multiple criteria are used, a clear procedure for deciding how to assess them in combination is needed to avoid subjectivity introduced by individual understanding. It was agreed that this issue should be treated in a relevant ToR for the next meeting of WGDEC. Similarly, to increase the confidence of accumulated information about VME distributions, available from the ICES VME database, clearer definitions of the VMEs should be developed. The existing VME definitions are generic and may vary from expert to expert. The group realises that developing such definitions (based on density of indicator species, occurrence of characteristic associated species, fulfilling of certain ecosystem functions, etc.) are challenging. Regardless, even simple, pragmatic definitions that can be referred to would aid the assessment of confidence to future VME mapped products. It would also be of benefit for the data providers in order for them to filter the data or label the records with greater confidence (i.e. indicating which definitions that have been applied when preparing the answer to ICES VME data calls). It is therefore proposed a Term of Reference for WGDEC 2021 will review, and consider revision of, existing VME definitions for specific use by WGDEC and the ICES VME database.

7.9 Acknowledgments

WGDEC would like to acknowledge and thank Javier Murillo, Pablo Lopez-Gonzalez, Hans Tore Rapp, Carlos Dominguez-Carrió and Manuela Ramos for their valuable input.

7.10 References

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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] 2022 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. This should also include information on the distribution of vulnerable habitats in subareas of the Regulatory Area that are closed to fishing for other purposes than VME protection. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters;
c) To support the use of the VME weighting algorithm outputs within future ICES advice, and considering known limitations, identify and trial approaches to improve the weighting algorithm method, and continue to explore alternative options for identifying areas where VME are likely to occur;
d) Review existing definitions of, and ongoing work to define, VMEs to develop a clear procedure for combining the FAO criteria for the assessment of taxa as VME indicators and develop pragmatic definitions of VME habitats for specific use by WGDEC and the ICES VME database.

Supporting Information

Priority	The current activities of this Group will enable ICES to respond to advice requests from a number of clients (NEAFC/EC). Consequently, these activities are considered to have a high priority.
Scientific justification	ToR [a] The Joint ICES/NAFO Working Group on Deep-water Ecology undertake a range of Terms of Reference each year; the scope of these cover the entire North Atlantic, and include aspects such as ocean basin processes. Therefore, collating information on vulnerable habitats (including important benthic species and communities) across this wide geographic area (and adjacent waters) is essential. To this end, a VME data call will be run in 2021, facilitated by the ICES Data Centre. Data will be quality checked/prepared at least one month in advance of WGDEC 2021 by the ICES Data Centre and a newly formed intersessional subgroup of WGDEC. 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. ToR [b] This information and associated maps are required to meet the NEAFC request “to continue to provide all available new information on distribution of vulnerable habitats in the NEAFC Convention Area” as well as part of the European Commission MoU request to “provide any new information regarding the impact of fisheries on sensitive habitats”. The location of newly discovered/mapped sensitive habitats is critical to these requests. ToR [c] 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. However, a number of limitations to the weighting algorithm have been identified, including those detailed in the WGDEC 2017 report. Furthermore, in 2019, new methods of determining VME likelihood were explored via kernel density estimation (KDE) and predictive habitat models. This ToR will focus on developing improvements to the method to the VME weighting algorithm, and will further explore alternative methods for assessing likelihood of VME presence, including considerations of outputs of the WKPHM. ToR [d] VMEs are currently defined within ICES work following the five FAO criteria; uniqueness/rarity; functional significance; fragility; slow recovery; and structural complexity. When multiple criteria are used, a clear procedure for deciding how to assess these in combination is needed, to avoid subjectivity introduced by individual understanding. Furthermore, to increase confidence in use of accumulated information on VME distributions from the ICES VME database, clearer definitions of the VMEs need to be developed. This ToR will therefore focus on the review of existing definitions of, and ongoing work to define, VMEs to develop a clear procedure for combining the FAO criteria for the assessment of taxa as VME indicators and to develop pragmatic definitions of VME habitats for specific use by WGDEC and the ICES VME database.
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 Coldwater Corals and Sponges in the North Atlantic as reported in observations obtained by Russian fishing vessels in 2019

Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC) 2020

Working Document

K. Fomin

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

Introduction

A targeted research of vulnerable marine ecosystems (VMEs) in the North Atlantic conducted by Russian fishing vessels started in 2007–2008 (Vinnichenko et al., 2009). Afterwards, the research was continued on a 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; Kanischev and Zavoloka, 2016; Fomin, 2018; Fomin, 2019).

The objective of this document is to submit information on the results of Russian studies of VMEs conducted in the North Atlantic in 2019 to ICES WGDEC. These data will be submitted to the database for WGDEC 2021.

Material and methods

Data on VMEs was collected by observers during 6 cruises of fishing vessels on the Grand Bank of Newfoundland and the Flemish Cap (NAFO divisions 3LMNO) in January-September 2019 (Table A3. 1). An encounter of VMEs also occurred on 27 Dec 2019 in the Norwegian Sea.

The observations included:

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

Results

In 2019, in the NAFO Regulatory Area (RA), bottom trawling was conducted on a vast area of the Flemish Cap, the Flemish Pass and the Grand Banks of Newfoundland between 42°46' – 48°26' N, 44°16' – 51°53' W over the depth range from 160 to 1224 m (Figure 3.1).

Coldwater corals were recorded in small amounts across the fishing areas (

Table A3. 2). Most of the encountered corals were identified as *Duva florida.* Representatives of *Drifa glomerata, Hormathia digitata* and others of 9-324 g also occurred. Sea pens were mostly identified as *Anthoptilum grandiflorum* and *Halipteris finnmarchica* and were 12-746 g in mass. Sponges in the catches were mainly of *Axinella, Geodia* and *Polymastia* genera and 14-430 g in mass. Some VMEs indicator species in the hauls were impossible to weigh as they were too light in weight. The amount of caught VME indicator species everywhere did not exceed 1 kg per haul.

Near the Norwegian Sea between 77°31′-77°59′ N and 9°35′-11°22′ W, one catch of the sponge, *Geodia* sp., occurred with an overall mass of 14.5 kg (

Table A3. 3).

There were also 117 hauls registered with no VMEs indicator species (

Table A3. 4).

Discussions and conclusions

The data on VME indicator species has been regularly collected by the Russian fishing vessels in the NAFO RA for twelve years. Observations covered an extensive area of bottom fisheries outside of the closed areas to protect VMEs, and there was no evidence of coral and sponge aggregations in the catches. Data collected in 2019 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.

Despite the limited amount of Russian studies, in 2019 in the NAFO RA and the Norwegian Sea, some new data was collected that contributes to understanding of corals species composition and their distribution in the North-Eastern Atlantic.

Table A3. 1 Areas of North Atlantic VMEs research covered by Russian fishing vessels in 2019.

Area	Coordinates		Depths, m	Target species	Number of hauls
	Northern latitude	Western longitude			
Newfoundland area	42°46' - 48°26'	44°16' - 51°53'	160-1224	Greenland halibut, redfish, cod	959

Table A3. 2 Composition and amount of coldwater corals and sponges caught by Russian trawlers in NAFO RA in 2019. NB, species identifications need to be verified prior to entry into the database.

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Status	Weight, kg
Set of gear		Sampling							
N	W	N	W						
43	49.72	42.97	49.73	293-305	*Polymastia spp.*	1	4		<1
					Cladocroce spp.	2	10-20		<1
43	49.73	42.95	49.73	340-343	*Tedania sp.*	1	8		<1
					Polymastia spp.	2	4-5		<1
					Geodia spp.	1	3		<1
					Drifa glomerata	2	3-4		<1
43	49.7	42.97	49.73	329-356	*Cladocroce spp.*	1	15		<1
42.92	49.85	42.85	49.88	279-330	*Drifa glomerata*	1	15		<1
					Duva florida	1	7		<1
					Tedania sp.	1	6		<1
43	49.7	43.03	49.77	324-346	*Polymastia spp.*	1	6		<1
					Duva florida	1	15		<1
					Drifa glomerata	4	7-15		<1
42.83	49.9	42.85	49.9	325-328	*Duva florida*	1	8		<1
					Drifa glomerata	1	18		<1
42.82	49.93	42.93	49.83	316-326	*Mycale sp.*	1	8		<1
					Polymastia spp.	2	4-5		<1
					Vazella spp.	1	10		<1

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Status	Weight, kg
Set of gear		Sampling							
N	W	N	W						
					Geodia spp.	1	4		<1
					Spongionella spp.	1	7		<1
					Drifa glomerata	4	6-10		<1
42.85	49.88	42.82	49.77	310-334	*Vazella spp.*	2	5-7		<1
					Eucratea loricata	1	10		<1
					Haliclona spp.	2	10		<1
42.8	49.05	n/a	n/a	373	*Drifa glomerata*	1	4		<1
42.87	49.85	42.85	49.88	360-361	*Drifa glomerata*	1	10		<1
					Duva florida	1	7		<1
42.87	49.85	42.82	49.95	340-348	*Polymastia spp.*	1	4		<1
					Geodia spp.	1	5		<1
42.9	49.85	42.82	49.93	305-395	*Phakellia spp.*	1	25		<1
42.82	49.93	42.88	49.98	372-374	*Drifa glomerata*	1	9		<1
43.78	49.02	43.83	49.05	320-365	*Duva florida*	2	8-10		<1
42.83	49.9	42.82	49.93	375-385	*Drifa glomerata*	2	10-15		<1
					Polymastia spp.	1	4		<1
45.42	48.45	45.58	48.2	860-914	*Anthoptilum sp.*	2	20-25		<1
45.63	48.05	45.8	47.78	941-982	*Anthoptilum sp.*	3	15-25		<1
					Duva florida	3	7-13		<1
					Drifa glomerata	3	7-18		<1
					Chonelasma spp.	1	8		<1
43.11	51.11	43.33	51.65	430-514	*Anthoptilum gran-diflorum*	2	30-33		0.13
43.42	49.3	43.37	49.3	380-390	*Duva florida*	1	9		0.055
42.92	49.84	42.81	49.97	325-375	*Stauropathes spp.*	2	8-10		0.009
					Duva florida	4	4-5		0.084
43.32	49.32	43.31	49.34	390-405	*Axinellidae*	1	19		0.16
43.12	51.09	43.3	51.53	255-390	*Anthoptilum gran-diflorum*	1	51		0.075
					Halipteris finmar-chica	1	57		0.035
43.18	51.34	43.14	51.15	325-385	*Anthoptilum gran-diflorum*	4	30-48		0.186
					Halipteris finmar-chica	11	11-21		0.274
					Pennatula	8	9-11		0.084
43.25	51.45	43.16	51.29	336-440	*Anthoptilum gran-diflorum*	3	13-50		0.117
					Halipteris finmar-chica	2	35-47		0.058
					Pennatula	2	8-10		0.017

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Status	Weight, kg
Set of gear		Sampling							
N	W	N	W						
43.4	51.69	43.15	51.21	400-445	*Anthoptilum gran-diflorum*	1	38		0.06
					Halipteris finmar-chica	1	42		0.031
					Pennatula	4	8-12		0.04
46.31	46.75	46.85	46.83	1180-1195	*Anthoptilum gran-diflorum*	12	12-40		0.19
					Halipteris finmar-chica	2	40-45		0.072
46.82	46.78	46.66	46.77	1130-1175	*Duva florida*	1	14		0.072
					Anthoptilum gran-diflorum	17	10-42		0.258
46.28	46.75	46.73	46.77	1105-1195	*Anthoptilum gran-diflorum*	2	38-47		0.138
					Pennatula	2	10		0.018
46.29	46.76	46.8	46.78	1175-1224	*Anthoptilum gran-diflorum*	28	9-36		0.258
46.73	46.77	46.34	46.76	1110-1190	*Anthoptilum gran-diflorum*	16	10-32		0.242
47.76	46.72	48.12	46.59	990-1026	*Halipteris finmar-chica*	5	28-75		0.247
					Pennatula	57	9-12		0.746
48.55	45.9	48.25	46.47	910-1070	*Anthoptilum gran-diflorum*	3	32-47		0.205
					Pennatula	6	9-10		0.052
48.62	45.69	48.32	46.32	990-1105	*Anthoptilum gran-diflorum*	3	35-38		0.156
46.32	47.33	46.55	47.31	315-370	*Geodia spp.*	6	4-6		0.16
42.91	49.84	42.82	50.21	330-370	*Duva florida*	4	5-8		0.148
					Euplectella spp.	3	15-25		0.43
42.79	50.04	42.78	50.25	385-405	*Duva florida*	6	7-13		0.324
					Anthoptilum gran-diflorum	2	28-32		0.131
					Polymastia spp.	4	4-6		0.082
					Rhizaxinella sp.	2	6		0.028
42.93	49.86	42.82	50.28	270-385	*Duva florida*	5	9-13		0.292
					Euplectella spp.	1	18		0.168
42.85	50.34	42.86	50.39	205-210	*Duva florida*	2	10		0.129
43.32	49.32	43.4	49.31	380-395	*Duva florida*	2	8		0.101
					Axinellidae	1	6		0.039
44.26	48.97	44.07	48.97	375-410	*Duva florida*	2	4-5		0.049
43.32	49.31	43.4	49.3	370-385	*Axinellidae*	1	20		0.152

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Status	Weight, kg
Set of gear		Sampling							
N	W	N	W						
47.36	44.56	47.405	44.785	195	*Axinella sp.*	1	20		0.089
47.22	44.82	47.20	45.17	170	*Axinella sp.*	1	21		0.028
					Stryphnus fortis	1	12		0.09
					Polymastia spp.	1	7		0.035
46.81	46.99	45.02	45.15	160	*Hormathia digitata*	2	3-5		0.074
					Axinella sp.	1	14		0.022
					Stryphnus fortis	1	7		0.086
47.01	45.17	46.82	45.03	170	*Craniella cranium*	1	5		0.019
46.76	45.04	47.01	45.15	180	*Hormathia digitata*	2	2-4		0.028
					Axinella sp.	1	11		0.014
					Polymastia spp.	1	5		0.042
					Vazella pourtalesii	1	9		0.093
					Forcepia sp.	1	16		0.023
					Thenea muricata	1	6		0.062
46.84	45.1	47.04	45.22	180	*Vazella pourtalesii*	2	13-16		0.197
					Axinella sp.	1	20		0.032
					Forcepia sp.	1	19		0.042
47.13	44.95	47.03	45.12	160	*Weberella bursa*	1	14		0.17
47.40	44.36	47.36	44.29	260	*Hormathia digitata*	1	7		0.085
					Axinella sp.	1	36		0.383
46.13	47.2	46.13	47.7	980	*Duva florida*	4	5-8		0.03
48.63	45.67	48.42	46.18	1145	*Anthoptilum spp.*	3	4-6		0.2
48.18	46.95	48.28	46.62	960	*Duva florida*	5	5-8		0.03
48.13	47.62	48.13	47.13	930	*Anthoptilum spp.*	3	4-6		0.1
48.32	46.52	48.15	47.05	1050	*Duva florida*	5	5-6		0.03
48.3	46.47	48.45	46.05	924-1021	*Phakellia spp.*	2	3-5		0.025
					Polymastia spp.	2	4-5		0.046
					Anthoptilum spp.	1	13		0.018
48.3	46.45	48.47	46.02	927-1034	*Polymastia spp.*	3	3-6		0.038
					Duva florida	2	9-12		0.069
48.13	47.13	48.13	47.58	977-1012	*Geodia spp.*	2	3-4		0.055
					Anthoptilum spp.	1	11		0.012
42.9	49.88	42.87	49.97	231-234	*Geodia spp.*	3	5-6		0.121
					Anthoptilum spp.	1	17		0.023
					Polymastia spp.	1	4		0.031
42.87	50.5	42.88	50.37	200-220	*Duva florida*	5	5-8		0.06

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Status	Weight, kg
Set of gear		Sampling							
N	W	N	W						
					Polymastia spp.	3	3-4		0.084
					Geodia spp.	1	5		0.032
42.87	50.3	42.85	50.35	215-220	*Duva florida*	2	7-11		0.112
					Geodia spp.	1	5		0.037
43.8	49.07	43.78	49.07	235-240	*Polymastia spp.*	3	4-6		0.047
					Phakellia spp.	1	7		0.015
48.13	47.62	48.13	47.1	1046-1070	*Lophelia pertusa*	1	3		0.016
					Geodia spp.	3	4-5		0.078
					Polymastia spp.	4	3-4		0.044

Table A3. 3 Composition and amount of sponges caught by Russian trawlers in the Norwegian Sea in 2019.

Coordinates of hauls				Depth, m	Species	Amount of specimen	Length, sm	Sta-tus	Weight, kg
Set of gear		Sampling							
N	E	N	E						
77°31’	11°22’	77°59’	09°35'	420	*Geodia sp.*	4	20-45		14500

Table A3. 4 Coordinates of hauls with no VMEs indicator species, 2019.

Coordinates of hauls			
Set of gear		Sampling	
N	W	N	W
45.5384	48.4114	45.4321	48.5594
45.405	48.4767	45.6025	48.1704
45.57	48.225	45.4083	48.4683
44.4483	49.0117	44.32133	48.9987
44.2633	49.0167	44.17	48.995
43.0083	49.7183	42.98467	49.724
42.9933	49.7183	42.9767	49.7617
43.0246	49.7175	42.9983	49.7083
43.0033	49.705	42.99	49.8433
43.0167	49.7167	42.9733	49.73
42.958	49.7573	42.9783	49.715
42.8233	50.025	42.7777	50.1247
42.865	49.9167	42.8924	49.8676
42.9483	49.7833	42.975	49.7283
42.9431	49.7976	42.943	49.7904
43.0117	49.7067	42.9866	49.717
43.0467	49.72	42.96733	49.72
43.01933	49.7053	42.9615	49.7469
42.9478	49.7825	43.0309	49.707
43.0167	49.7067	42.9583	49.775
42.8433	49.945	42.905	49.855
42.8883	49.8783	42.83	49.9633
43.0183	49.7067	42.9954	49.7093
43.0146	49.7145	43.0435	49.6985
42.965	49.7425	43.0235	49.7098
42.9878	49.7451	43.03	49.725
43.0037	49.7149	43.0184	49.7025
43.0167	49.7	43.0354	49.734
42.9783	49.7433	43.0199	49.7258
43.0317	49.7267	43.0607	49.7147
43.0181	49.7111	42.9701	49.7452
42.9759	49.747	43.0333	49.7226
43.0167	49.72	42.9583	49.76
43.0117	49.7267	43.0381	49.7199
42.953	49.7889	43.0223	49.7217
43.0367	49.7217	42.9509	49.7729
43.0583	49.72	43.0048	49.7213

Coordinates of hauls			
Set of gear		Sampling	
N	W	N	W
42.9617	49.7667	42.97	49.7517
43.015	49.705	42.962	49.7367
42.9735	49.7313	42.9533	49.7667
42.9583	49.7617	43.0158	49.7127
43.0101	49.7133	42.9417	49.78
42.8945	49.8652	42.94	49.8417
42.906	49.8534	42.8555	49.9332
42.842	49.952	42.9317	49.8517
42.9617	49.7667	43.0226	49.7109
42.9283	49.8617	42.8967	49.8733
42.9111	49.8677	42.8724	49.9162
43.7867	49.0733	43.8267	49.0433
43.8417	49.0517	43.8892	49.0391
43.9017	49.0317	43.78	49.0517
43.7968	49.0442	43.89	49.0283
43.9	49.0317	43.9183	49.0433
43.7967	49.045	43.88	49.025
43.8417	49.0333	43.935	49.0817
43.9406	49.1029	43.83	49.0483
43.8202	49.0441	43.9298	49.0795
43.82533	49.0413	43.9271	49.0554
43.9363	49.0717	43.9417	49.09
42.905	49.855	42.8422	49.9529
42.8305	49.9671	42.9167	49.8533
43.8317	49.04	43.9	49.03
43.8867	49.0317	43.8392	49.0341
43.93	49.0525	43.93333	49.062
43.8583	49.0517	43.97	49.0867
44.355	48.9917	44.43	49.0053
43.79	49.0683	43.915	49.0567
43.9164	49.0613	43.8353	49.0575
43.8285	49.0374	43.9217	49.0417
43.0067	49.7145	42.9474	49.7853
42.9567	49.77	43.0067	49.7117
42.9967	49.715	42.9632	49.7887
42.9102	49.8472	42.8747	49.8857
42.9133	49.8483	42.8417	49.9667

Coordinates of hauls			
Set of gear		Sampling	
N	W	N	W
42.9933	49.7117	42.985	49.7167
43.0017	49.7133	43.01	49.705
42.9583	49.7633	42.9733	49.73
43.7883	49.065	43.9233	49.0617
43.9267	49.0783	43.8	49.0467
42.98067	49.7293	43.0318	49.7795
42.9608	49.7401	42.9397	49.766
43.0033	49.7067	42.9433	49.815
42.92	49.8533	42.8714	49.8841
43.01267	49.706	43.0333	49.77
43.0148	49.7221	42.9486	49.8014
42.8702	49.9029	42.8351	49.9612
42.805	50.0606	42.8193	50.1233
42.9983	49.7367	42.9793	49.7467
43.01	49.73	42.9417	49.7767
42.92	49.8583	42.8467	49.9117
42.8433	49.9167	42.8217	49.97
43.0217	49.714	42.9696	49.7346
43.0083	49.7117	43.0262	49.7462
42.9367	49.77	43.0233	49.705
42.9817	49.74	43.015	49.7033
42.9517	49.7493	42.926	49.784

Coordinates of hauls			
Set of gear		Sampling	
N	W	N	W
42.9617	49.7383	43.0379	49.7207
42.9717	49.74	42.9315	49.7575
43.013	49.7131	42.9467	49.7767
42.9	49.8571	42.8467	49.9217
42.8583	49.9067	42.8551	49.9298
42.8833	49.85	42.91333	49.836
42.9133	49.835	42.9183	49.8367
42.8683	49.885	42.8633	49.8883
42.94	50.6733	42.9117	50.5817
42.82533	49.9567	42.8664	49.8934
42.9533	49.7617	43.015	49.7033
42.96	49.7417	43.0383	49.7067
43.02	49.7067	42.9283	49.7717
42.829	49.9491	42.825	49.9633
42.9683	49.7433	43.02	49.705
42.9383	49.765	42.9533	49.7467
42.9683	49.73	43.0328	49.7124
43.025	49.71	42.9382	49.7801
42.955	49.7467	43.0148	49.694
42.9747	49.7137	42.97	49.7217
42.9817	49.7433	42.965	49.7267

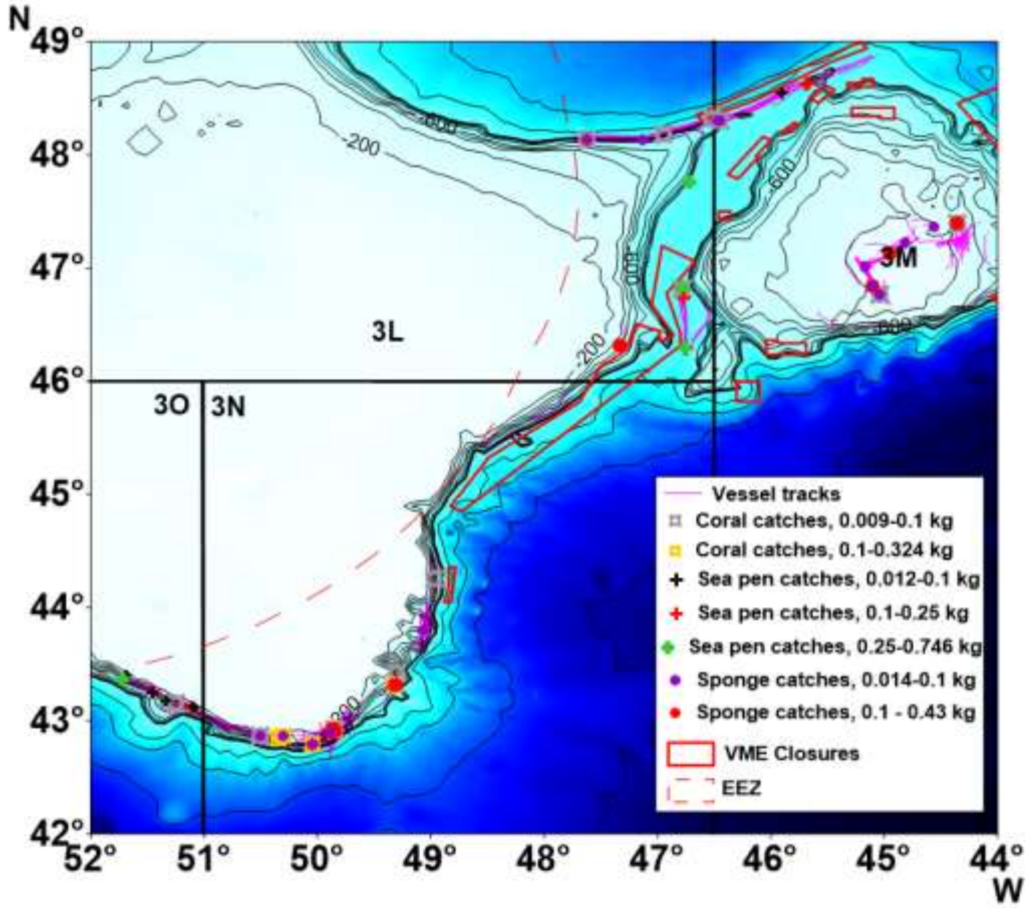

Figure A3. 1 Tracks of Russian vessels' hauls with observers onboard (satellite monitoring) and occurrence of coldwater corals and sponges in the NAFO RA in 2019. Weight of caught VMEs indicator species was 0.019–0.746 kg.

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Annex 4: Updated VME habitat and indicator (representative taxa) lists following review against the FAO criteria

The tables below are split by VME habitat type. Table A4.1 represents a new habitat category for hydrothermal vents and cold seeps, with associated sub-types and representative taxa. The other tables, A4.2–A4.5, represent existing VME habitats from the EU deep-sea access regulations' Annex III list, but with new sub-types and/or representative taxa proposed. **Bold text** denotes new additions to the lists. Justification for new additions is provided in a separate column. Full references are provided in Section 7.10.

Hydrothermal Vents and Cold seeps

Table A4.1 Proposed list of VME habitat types, sub-types and representative taxa for hydrothermal vents/fields and cold seeps.

Proposed VME habitat type	Proposed VME habitat subtype	Representative taxa
Hydrothermal vents/fields	**Active vents**	**KADOSACTINIDAE**
		Maractis rimicarivora
		MYTILIDAE
		***Bathymodiolus* sp.**
		Bathymodiolus azoricu
		ALVINOCARIDAE
		Rimicaris exoculata
		Chorocaris chacei
		Mirocaris fortunata
		BYTHOGRAEIDAE
		Segonzacia mesatlantica
		BYTHITIDAE
		Cataetyx laticeps
		ZOARCIDAE
		***Pachycara* 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		**LUCINIDAE**
		***Lucinoma* sp.**
		VESICOMYIDAE
		Isorropodon mackayi
		THYASIRIDAE
		***Thyasira* sp.**
		MYTILIDAE
		***Bathymodiolus* sp.**
		SOLEMYDAE
		Acharax sp.
		SIBOGLINIDAE

Proposed VME habitat type	Proposed VME habitat subtype	Representative taxa
		Siboglinum **sp.**
		Polybrachia **sp.**
		Spirobracha **sp.**
		Bobmarleya **sp.**
		Lamellisabella **sp.**
		Sclerolinum **sp.** ***Oligobrachia*** **sp.**
		ZOARCIDAE
		Lycodes squamiventer

Cold-water coral reef

Table A4.2 Proposed changes to VME habitat sub-types representative taxa for cold-water coral reefs. References are provided in Section 7.9.

VME habitat sub-type and proposed changes	Proposed changes to representative taxa	Justification for changes/remarks
Lophelia pertusa/Madrepora oculata **reef** *Solenosmilia variabilis* reef	*Lophelia pertusa* [1]***Madrepora oculata*** **– new addition** *Solenosmilia variabilis*	[1]*Madrepora oculata* is known to be a reef-building species (Schembri et al., 2007) and has been found to be commonly associated with *Lophelia pertusa*, with similar abundances of both species identified in many reefs in the North East Atlantic (Arnaud-Haond, et al., 2017).

Coral gardens

Table A4.3 Proposed changes to VME habitat sub-types and representative taxa for coral gardens. References are provided in Section 7.9.

VME habitat sub-type and proposed changes	Proposed changes to representative taxa	Justification for changes/remarks
Hard bottom coral garden: Hard bottom gorgonian and black coral gardens	ACANTHOGORGIIDAE *Acanthogorgia armata* [1]***Acanthogorgia hirsuta*** **– new addition** ANTHOTHELIDAE CHRYSOGORGIIDAE CORALLIIDAE ISIDIDAE, KERATOISIDINAE *Acanella arbuscula* *Keratoisis spp.* *Lepidisis spp.* PARAGORGIIDAE *Paragorgia arborea* [2]***Paragorgia johnsoni*** **– new addition** **ELLISELLIDAE – new addition** [3]***Viminella flagellum*** **– new addition** PLEXAURIDAE *Paramuricea spp.* *Swiftia spp.*	[1]Forms structurally complex habitats in Azores region; important as biodiversity enhancement (Braga-Henriques et al 2012, 2014; Morato et al 2018a,2019a; Orejas et al 2017). Often accidentally captured as bycatch during long-line fishing operations (Braga-Henriques et al 2013). The species is also abundant in bathyal rocky and/or dead coral bottoms in the Gulf of Cadiz (Rueda et al. 2016). Slow growth rates based on transplantation studies (M. Carreiro-Silva, pers. comm., MERCES project) [2]Forms structurally complex habitats in the MAR, with colonies attaining 1 m in height and 1.5 m in diameter important as biodiversity enhancement, often showing signs of damage by long-line fishing operations (Morato et al 2018a, 2019a) [3] Forms structurally complex habitats in the Azores, Madeira and the Mediterranean (Tempera et al 2012, 2013; Braga-

VME habitat sub-type and proposed changes	Proposed changes to representative taxa	Justification for changes/remarks
	[4]***Swiftia dubia* – change in species name** [5]***Dentomuricea* – new addition** **PRIMNOIDAE** *Callogorgia verticillata* *Primnoa resedaeformis* [6]***Paracalyptrophora josephinae* – new addition** [7]***Narella* – new addition** **GORGONIIDAE** [8]***Eunicella- new addition*** ALCYONIIDAE *Anthomastus grandiflorus* *Pseudoanthomastus agaricus* ANTIPATHIDAE *Stichopathes gravieri* LEIOPATHIDAE *Leiopathes* spp. SCHIZOPATHIDAE *Bathypathes* spp. *Parantipathes hirondelle* *Parantipathes* spp. *Stauropathes arctica*	Henriques 2014; Grinyó et al., 2016; Morato et al 2018a, 2019a; Braga-Henriques et al 2020); important as biodiversity enhancement (Gomes-Pereira et al 2013, Porteiro et al 2013; Braga-Henriques 2014, Angiolillo et al 2014; Giusti et al 2017). Highly vulnerable to bottom longline fishing operations (Sampaio et al 2012, Pham et al. 2014) [4] *Swiftia pallida* has been synonymized with *Swiftia dubia* [5] Presence confirmed in the Great Meteor complex and the Azores (Grassoff 1977; Braga-Henriques et al. 2013), suspected in the Canary Islands. It forms structurally complex habitats; important as biodiversity enhancement in the Azores (Porteiro et al 2013; Tempera et al 2013; Braga-Henriques et al 2014; Gomes Pereira et al 2017; Morato et al 2018b; 2019a). Highly vulnerable to bottom longline fishing operations (Sampaio et al 2012; Pham et al 2014) [6] Forms large colonies (max. 2 m tall) as part of coral gardens in the Azores and MAR and is important as biodiversity enhancement (Tempera et al 2013; Braga-Henriques 2014; Morato et al 2019a). Highly susceptible to bottom long-line fishing (Sampaio et al 2012). Low growth rates and recovery capacity based on transplantation studies (M. Carreiro-Silva, pers. comm., MERCES project) [7]Species of the genus *Narella* (e.g. *Narella bellissima* and *Narella versluysi*) form structurally complex habitats in the Azores region (Braga-Henriques 2014; Orejas et al. 2017; Morato et al 2019a,2019b) and Bay of Biscay (JS Davies, pers. Comm.) important as biodiversity enhancement (Orejas et al. 2017; Morato et al 2019a,b) Moderately vulnerable to long-line fishing operations in the Azores (Sampaio et al 2012). [8]Forms structurally complex habitats in the Mediterranean, Gorringe seamount (Oliveira et al 2017) and deep slopes of Madeira island with a few colonies showing signs of damage by fishing operations (Braga-Henriques pers. obs., DEEP-MADEIRA project).
Hard bottom coral garden: Colonial scleractinians on rocky outcrops	*Lophelia pertusa* *Madrepora oculata* *Solenosmilia variabilis*	
Hard bottom coral garden: Non-reefal scleractinian aggregations	*Enallopsammia rostrata* *Lophelia pertusa* *Madrepora oculata* [9]***Dendrophyllia cornigera* – new addition**	[9] Forms non-reefal aggregations in some seamounts in the Azores, Gulf of Cadiz, shelf of Portugal (Ormonde Seamount) and in the Mediterranean, important as biodiversity enhancement (Oceana

VME habitat sub-type and proposed changes	Proposed changes to representative taxa	Justification for changes/remarks
	[10]***Dendrophyllia ramea*** **– new addition**	2005; Orejas et al 2009; Bo et al 2013; Gori et al 2014; Orejas et al 2017). Highly susceptible to trawling in the Mediterranean (Orejas et al., 2015) and bottom longline fishing operations in the Azores (Sampaio et al 2012; Braga-Henriques et al 2013). The species is categorised as "endangered" in the Mediterranean (IUCN red list) (Orejas et al., 2015) and included in the Barcelona Convention. [10] Forms dense aggregations in Atlantic waters, especially in the Canary Islands (Brito and Ocaña 2004), and recently it has been documented forming dense populations in softs substrate off Cyprus (Eastern Mediterranean, Orejas et al. 2019). The species is categorised as "vulnerable" in the Mediterranean (IUCN red list) and included in Barcelona Convention. Species is also present in the Azores and Madeira but not forming large aggregations (Braga-Henriques et al 2013, 2020).
Hard bottom coral garden: **Stylasterid corals on hard substrata – new addition**	**STYLASTERIDAE** *Pliobothrus spp.* *Stylaster spp.* [11]***Errina dabneyi*** **– new addition**	[11] Endemic to the Azores (Zibrowius and Cairns 1992; Braga-Henriques et al. 2013). Forms structurally complex habitats, important as biodiversity enhancement (Braga-Henriques et al 2011; Tempera et al 2013; Braga-Henriques 2014 ; Morato et al 2019). Very sensitive to physical impacts by bottom longline fishing operations (Sampaio et al 2012,). Slow growth (Wisshak et al 2009)
Hard bottom coral garden: **Cup coral fields – new addition**	**CARYOPHYLLIIDAE** [12]***Caryophyllia*** **spp. – new addition**	[12] Identified from imagery data at Wyville-Thomson Ridge in the North East Atlantic. Proxy species show very slow growth rates (Fuller et al., 2008) and are long-lived (Lazier et al., 1999; Risk et al., 2002). Vulnerable to trawl and gillnet gears (Wareham and Edinger, 2007).
Hard bottom coral garden: **Cauliflower coral fields – new addition**	**NEPHTHEIDAE** [13]***Drifa glomerata*** **– new addition** [13]***Duva florida*** **– new addition** [13]***Pseudodrifa groenlandicus*** **– new addition** [13]***Gersemia*** **spp. – new addition**	[13] Forms dense aggregations to the west of Iceland (based on MFRI imagery data) and Artic and sub-Artic Norwegian waters important as biodiversity enhancement (Buhl_Mortensen et al 2020); low reproductive output and slow growth (Sun 2010a,b, 2011)
Soft bottom coral garden: Soft bottom gorgonian and black coral gardens	ALCYONIIDAE *Anthomastus grandiflorus* ANTIPATHIDAE *Stichopathes gravieri* CHRYSOGORGIIDAE *Radicipes* spp. ISIDIDAE *Acanella arbuscula* [14]***Isidella elongata*** **– new addition** [15]***Isidella lofotensis*** **– new addition**	[14] Forms structurally complex habitats in the Mediterranean important for commercial fish and biodiversity enhancement (Maynou and Cartes 2012; Mytilineou et al 2013; Cartes et al 2013) but currently very scarce due to trawling impacts (Cartes et al. 2013; Mastrototaro et al. 2017); it is categorised as "critically endangered" in the Mediterranean (IUCN red list) and is included in the Barcelona Convention. Isididae species display low recovery capacity due to extremely slow growth rates and a very

VME habitat sub-type and proposed changes	Proposed changes to representative taxa	Justification for changes/remarks
		long life span (Andrews et al. 2009; Sherwood et al 2009) [15] Forms structurally complex habitats in various Norwegian fjords (Buhl-Mortensen & Buhl-Mortensen 2013), susceptible to trawling impacts; Isididae species display low recovery capacity due to extremely slow growth rates and a very long life span (Andrews et al. 2009; Sherwood et al 2009)
Soft bottom coral garden: Cup-coral fields	CARYOPHYLLIIDAE *Caryophyllia* spp. *Stephanocyathus moseleyanus*	
Soft bottom coral garden: Cauliflower Coral Fields	NEPHTHEIDAE *Duva florida* *Drifa glomerata* *Gersemia* spp.	
Soft bottom coral garden: **Non-reefal scleractinian aggregations – new addition**	[16]***Eguchipsammia* sp.**	[16] Forms dense aggregations in the Azores (Tempera et al 2015; Morato et al 2019a); Highly vulnerable to trawling (Braga-Henriques pers. obs., cruise BIODIAZ M150)

Deep-sea sponge aggregations

Table A4.4 Proposed changes to representative taxa for deep-sea sponge aggregations. References are provided in Section 7.9.

VME habitat type	Proposed changes to representative taxa	Justification for changes/remarks
Deep-sea sponge aggregations	**DEMOSPONGIAE** GEODIIDAE *Geodia barretti* *Geodia macandrewi* *Geodia atlantica* [1]***Geodia phlegraei* – new addition** [2]***Geodia hentscheli** – new addition** [2]***Geodia parva** – new addition** ANCORINIDAE [3]***Stryphnus fortis* – change in species name** [4]***Stelletta normani* – change in taxonomic level** [4]***Stelletta rhaphidiophora** – new addition** [5]**THENEIDAE – change in family name** [5]*Thenea spp.* AZORICIDAE [6]***Leiodermatium* spp. – new addition** CORALLISTIDAE [6]***Neophrissospongia nolitangere* – new addition** [6]***Neoschrammeniella* spp. – new addition**	[1]*Geodia phlegraei* is another geodiid typical of the boreal grounds (Klitgaard & Tendal, 2004; Cárdenas et al., 2013). Sponge grounds formed by *Geodia* spp. in Norway have been characterized as hot-spots of benthic respiration and nutrient cycling in the deep sea (Hoffmann et al., 2009; Kutti et al., 2013; Cathalot et al., 2015; Rooks et al., 2020). Studies have shown the vulnerability of *Geodia* to exploration drilling and submarine tailings disposal releasing large amounts of suspended crushed rock (Kutti et al. 2015), suspended sediments (Tjensvoll et al. 2013; Edge et al. 2016) and fisheries (Kazanidis et al., 2019; Pham et al., 2019; Vad et al., 2018, 2020). [2,4,16] Species marked with* are characteristic of the arctic sponge grounds (Klitgaard & Tendal, 2004; Cárdenas et al., 2013; Meyer et al., 2019). In some areas they are found over a spicule mat several cm in

VME habitat type	Proposed changes to representative taxa	Justification for changes/remarks
	MACANDREWIIDAE [6]***Macandrewia*** **spp. – new addition** TETILLIDAE [7]***Craniella*** **spp. – new addition** [7]***Tetilla longipilis*** **– new addition** AXINELLIDAE [8]***Axinella infundibuliformis*** **- change in taxonomic level** [8]**BUBARIDAE – change in family name** *Phakellia* spp. COELOSPHAERIDAE [9]***Lissodendoryx (Lissodendoryx) complicata*** **– new addition** MYCALIDAE [10]***Mycale (Mycale) lingua*** **- new addition** POLYMASTIIDAE *Polymastia* spp. PETROSIIDAE [11]***Petrosia*** **spp. – new addition** **HEXACTINELLIDA** HYALONEMATIDAE [12]***Hyalonema*** **spp. – new addition** ROSSELLIDAE [13]*Caulophacus arcticus* [14]***Asconema setubalense*** **- new addition** [15]***Asconema foliatum**** **- new addition** [16]***Schaudinnia rosea**** **- new addition** [16]***Scyphidium septentrionale**** **- new addition** [16]***Trichasterina borealis**** **- new addition** PHERONEMATIDAE [17]*Pheronema carpenteri* [18] ***Poliopogon amadou*** **– new addition**	thickness (not always on hard-bottoms). [3]The *Stryphnus* species commonly found on boreal grounds (Klitgaard & Tendal, 2004) has been mistakenly called *Stryphnus ponderosus* for many years (Cárdenas & Rapp, 2015). This needs to be corrected to *Stryphnus fortis*. *S. fortis,* like most key sponge grounds key species, plays an important role in the nitrogen cycle (Rooks et al., 2020). [4]The species present on the soft/hard bottom boreal and temperate grounds is *Stelletta normani*, whereas in the soft/hard bottom arctic grounds it is *Stelletta rhaphidiophora*. *S. rhaphidiophora,* like most key sponge grounds key species, plays an important role in the nitrogen cycle (Rooks et al., 2020). [5] *Thenea* have been moved from the Pachastrellidae to the Theneidae Cárdenas & Rapp (2012). Specimens of *Thenea levis* collected in the outer shelf and upper slope at the Faroe Islands (northeast Atlantic) had the highest number of epi- and infaunal taxa per sponge specimen compared to other demosponges (see Table 4 in Klitgaard, 1995). *Thenea* spp. are found in abundance in boreo-arctic soft bottoms (Barthel & Tendal, 1993; Cárdenas & Rapp, 2012; Cárdenas & Rapp, 2015). [6] Several species of lithistid (or rock) sponges form structural habitats both in the temperate NE Atlantic and in the Mediterranean (e.g. Pereira, 2013; Maldonado et al., 2015, Carvalho et al., 2020). [7] Deep-sea *Craniella* can occur in large numbers, in boreal or arctic sponge grounds (P. Cárdenas, pers. observation). *Tetilla longipilis* form large aggregations on the Rosemary Bank (McIntyre et al., 2016). *Craniella* are found on soft or hard bottoms, while *Tetilla longipilis* are typical of soft bottoms. [8] After some confusion in the literature, especially with the genus *Phakellia*, *A. infundibuliformis* is the only known deep-sea Northeast Atlantic *Axinella* commonly found on boreal sponge grounds. *Phakellia* spp. do not belong to the family Axinellidae anymore, they are now part of family Bubaridae (e.g. Redmond et al., 2013) [9] A typical and very common poecilosclerid in arctic sponge grounds

VME habitat type	Proposed changes to representative taxa	Justification for changes/remarks
		(Meyer et al., 2019) and has been reported from the boreal sponge grounds of Flemish Cap, northwest (Kenchington et al., 2015)
		[10] *Mycale lingua* is a frequent species in the boreal tetractinellid grounds (e.g. Klitgaard & Tendal, 2004; Kutti et al., 2013) as well as living on CWC *Lophelia* reefs in Norway (P. Cárdenas, pers. observation).
		[11] Petrosiids are very common in multispecific sponge grounds of the temperate northeast Atlantic. In boreal sponge grounds, we usually have the species *Petrosia crassa*.
		[12]Several species of *Hyalonema* occur in variable densities in soft bottom across mostly in boreal and temperate regions, sometimes alongside other hexactinellids (e.g. *Pheronema carpenteri*)
		[13]*Caulophacus arcticus* - is found in various seabed types, but always attached to hard substrates such as pebbles.
		[14] Aggregations of *A. setubalense* are known to occur off Portugal, in the Cantabrian Sea and on islands and seamounts (sub-areas 8, 9 and CECAF 34.1.2).
		[15] *Asconema foliatum* is an important driver of benthic biodiversity in the Flemish Cap region, northwest (Beazley et al., 2013; NAFO, 2019; Murillo et al., 2020).
		[17] *Pheronema carpenteri* forms large aggregations in both soft and hard substrate (e.g. Rice et al., 1990) and is vulnerable to bottom trawling (Vieira et al., 2020).
		[18] The glass sponge *Poliopogon amadou* is known to form dense aggregations on seamount slopes in Areas Beyond National Jurisdiction (Xavier *et al.* 2015; Ramiro-Sanchez *et al.* 2019) but in very deep areas (below 2000 m depth), so it may be less relevant to the deep-sea access regulations due to the bottom trawl ban at depths > 800 m. However, it has been included on the list for completeness.

Sea pen fields

Table A4.5 Proposed changes to representative taxa for sea pen fields. References are provided in Section 7.9.

VME habitat type	Proposed changes to representative taxa	Justification for changes/remarks
Sea pen fields	ANTHOPTILIDAE *Anthoptilum murrayi* **[1]*Anthoptilum grandiflorum* – new addition** **CHUNELLIDAE** **[2]*Porcupinella profunda* – new addition** PENNATULIDAE *Pennatula phosphorea* **[3]*Pennatula aculeata* – new addition** **[4]*Pteroeides spinosum* – new addition** **[5]*Pennatula grandis* – new addition** **[6]*Ptilella grayi*** FUNICULINIDAE *Funiculina quadrangularis* HALIPTERIDAE **[7]*Halipteris finmarchica* – new addition** **[8]*Halipteris christii* – new addition** KOPHOBELEMNIDAE *Kophobelemnon stelliferum* **[9]*Kophobelemnon macrospinosum* – new addition** PROTOPTILIDAE **[10]*Distichoptilum gracile* – new addition** **[11]*Protoptilum carpenterii* – new addition** **[12]*Protoptilum thomsonii* – new addition** **SCLEROPTILIDAE – new addition** **[13]*Scleroptilum grandiflorum* – new addition** UMBELLULIDAE *Umbellula encrinus* *Umbellula huxleyi* *Umbellula lindahli* **[14]*Umbellula monocephalus*– new addition** **[15]*Umbellula thomsoni* – new addition** **[16]*Umbellula durissima* – new addition** VIRGULARIDAE *Virgularia mirabilis* **[17]*Virgularia glacialis* – new addition** **[18]*Virgularia tuberculata* – new addition** **[19]*Stylatula elegans*– new addition** **VERETILLIDAE – new addition** **[20]*Cavernularia pusilla* – new addition** **[21]*Veretillum cynomorium* – new addition**	[1]Important as nursery grounds; biodiversity enhancement (Baillon et al. 2012; 2014; Murillo et al., 2020); Slow growth; decadal longevity (Murillo et al. 2018); Forms structurally complex habitats in the NW Atlantic: Kenchington et al., 2015; NE Atlantic: Williams, 2011, Ruiz-Pico et al., 2017 [2] Forms structurally complex habitats in the NE Atlantic, Porcupine Abyssal Plain: López- González & Williams, 2001 [3]Important as nursery grounds; biodiversi-ty enhancement (Baillon et al. 2012; Murillo et al., 2020); Slow growth; decadal longevity (Murillo et al. 2018); Forms structurally complex habitats in the NW Atlantic: Kenchington et al., 2015; NE Atlantic: Ruiz-Pico et al., 2017 [4] Forms structurally complex habitats in the NE Atlantic: WoRMS, Ruiz-Pico et al., 2017 [5] Important as nursery grounds; biodiversity enhancement (Baillon et al. 2012; Murillo et al., 2020); Slow growth; deca-dal longevity (Murillo et al. 2018); Forms structurally complex habitats in the NW Atlantic: Kenchington et al., 2015; NE Atlantic: WoRMS, Ruiz-Pico et al., 2017 [6]Newly described species. Forms structurally complex habitats in the NE Atlantic: García-Cárdenas et al., 2019 [7] [7] Important as nursery grounds; biodiversity enhancement (Baillon et al. 2012; 2014; Murillo et al., 2020); Slow growth; decadal longevity (de Moura Neves 2015; Murillo et al. 2018); Forms structurally complex habitats in the NW & NE Atlantic: WoRMS; NW Atlantic: Kenchington et al., 2015 [8] Forms structurally complex habitats in the NW & NE Atlantic: WoRMS;

VME habitat type	Proposed changes to representative taxa	Justification for changes/remarks
		NW Atlantic: Murillo et al., 2011, NE Atlantic: Buhl-Mortensen et al., 2019 [9] Important as biodiversity enhancement (Murillo et al., 2020); Forms structurally complex habitats in the Mid-Atlantic Ridge & NE Atlantic, WoRMS & Molodtsova et al., 2008 [10] Important as biodiversity enhancement (Murillo et al., 2020); Forms structurally complex habitats in the NW Atlantic: WoRMS & Kenchington et al., 2015 [11] Important as biodiversity enhancement (Murillo et al., 2020); Forms structurally complex habitats in the NW & NE Atlantic: WoRMS; NW Atlantic: Baker et al., 2012; Mediterranean: Mastrototaro et al., 2014 [12] Present in the NW & NE Atlantic, Gulf of Mexico: WoRMS; NE Atlantic (Spain): Ruiz-Pico et al., 2017 [13] Present in the Azores: Sampaio et al., 2019; NW & NE Atlantic: WoRMS, Molodtsova et al., 2008 [14] Present in the NE Atlantic, Porcupine Abyssal Plain: López- González & Williams, 2001 [15] Present in the Mid-Atlantic Ridge: Molodtsova et al., 2008, South Africa: WoRMS, Azores: Sampaio et al., 2019 [16] Present in the Azores: Sampaio et al., 2019; NW & NE, Mid-Atlantic Ridge: WoRMS, Molodtsova et al., 2008 [17] Present in the NE Atlantic: WoRMS, Buhl-Mortensen et al., 2019 [18] Present in the NE Atlantic: WoRMS, Ruiz-Pico et al., 2017, Buhl-Mortensen et al., 2019 [19] Present in the NW & NE Atlantic: WoRMS, NE Atlantic: Buhl-Mortensen et al., 2019 [20] Present in the NE Atlantic: WoRMS, Ruiz-Pico et al., 2017, Altuna et al. 2008)

VME habitat type	Proposed changes to representative taxa	Justification for changes/remarks
		[21] Present in the NE Atlantic: WoRMS, Ruiz-Pico et al., 2017