WORKSHOP ON EU REGULATORY AREA OPTIONS FOR VME PROTECTION (WKEUVME)

VOLUME 2 | ISSUE 114

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM COUNSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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

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

ISSN number: 2618-1371 I © 2020 International Council for the Exploration of the Sea

ICES Scientific Reports

Volume 2 | Issue 114

WORKSHOP ON EU REGULATORY AREA OPTIONS FOR VME PROTECTION (WKEUVME)

Recommended format for purpose of citation:

ICES. 2020. Workshop on EU regulatory area options for VME protection (WKEUVME).
ICES Scientific Reports. 2:114. 237 pp. https://doi.org/10.17895/ices.pub.7618

Editors

Peter Hopkins • Ellen L. Kenchington

Authors

Caroline Alibert Deprez • Louise Allcock • Andreia Braga-Henriques • Benoit Caillart • Neil Campbell • Sylvaine Carteron • Gonçalo Carvalho • Alda Centeio • Juan-Antonio Espejo • Johanna Ferretti • Matthew Gianni • José Manuel González Irusta • Anna Gruszczynska • Kerstin Heck • Jan Geert Hiddink • Helen Holah • Peter Hopkins • Raluca Ivanescu • Graham Johnston • Georgios Kazandis • Ellen L. Kenchington • Andrew Kenny • Stavroula Kremmydiotou • Camille Lirette • Marcos Llope • Raquel López González • Lénaick Menot • Javier Murillo-Perez • Eugene Nixon • Covadonga Orejas Saco Del Valle • Debbi Pedreschi • Cristina Perdiguero Arenas • Sandrine Polti • Andrea Ripol • Jean-Marie Robert • Laura Robson • Alexandre Rodriguez • Alberto Serrano • Ana Silva • David Stirling • Justyna Szumlicz • Isabel Teixeira • Elsa Tudal • Phillip J. Turner • Aare Tuvi • Sebastian Valanko • Daniel Van Denderen • Karl-Michael Werner • Joana R. Xavier

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

Contents

i Executive summary ii
ii Expert group information iv
1 Meeting Format 1
2 Terms of Reference 2
3 Establish a draft workflow, with respective criteria for area selection, which can be applied to propose a set of regulatory area options using available ICES data. The regulatory area options will vary in the priority given to VME protection and fisheries. The applicability of the workflow will be demonstrated in a test area. – TOR [a] 5
4 Establish for the larger area, based on review by WGECO, a set of regulatory area options that vary in the degree of VME protection and estimate for each of the options how it will affect bottom fisheries. Prepare a dissemination document of the regulatory area options, and the workflow and criteria used, in a way appropriate to get input from stakeholders during a meeting with EU Member States and/or relevant Advisory Council members. The dissemination document will be delivered by 5 June. – TOR [b] 6
4.1 Ecoregion Summaries 6
4.2 Data on Vulnerable Marine Ecosystems 13
4.3 Establishment of a Fishing Footprint 23
4.4 Fishing Intensity 39
4.5 Closed Area Scenarios 47
4.6 Assessment Sheets 57
4.7 Future Directions 177
4.8 Update of Annual Advice 180
5 Run a dissemination meeting in Brussels, Belgium (24-25 June) to discuss the regulatory area options that the workflow and criteria produce. Gather stakeholder arguments and preferences that can be used to fine-tune a list of closed area boundaries and identify knowledge gaps associated with each proposed area.– ToR [c] 183
Annex 1: Working Document for WKEUVME: Draft Workflow in Response to TORa 189
Annex 2: List of participants 210
Annex 3: Dissemination Document 214
Annex 4: Questionnaire 233

i Executive summary

Under regulation (EU) 2016/2336, the EU fleet will be banned from bottom fishing in all waters between 400 and 800m in depth, apart from within the existing fishing footprint. Within the fishing footprint, EU vessels will be prohibited from bottom fishing in any closed areas that might be introduced to protect VMEs. To meet these regulatory requirements, ICES was requested by the European Commission to provide "*advice on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas* (ref. (EU)2016/2336)".

The ICES workshop WKEUVME was tasked to produce the technical evidence base for producing a set of regulatory area options, building on 2019 work (Technical Service and WKREG workshop), as well as previous ICES advice (ICES 2018a) and technical services (ICES 2018b). The work drew upon the most recent fishing activity and vulnerable marine ecosystem (VME) distribution data at ICES, which has been quality assured following the respective annual ICES data calls for VMS/logbook (link) and VMEs (link). The assessment procedure herein is fully documented, with the respective scripts to run the assessment available on an open source platform (WKEUVME GitHub site).

Two "assessment sheets" with respective regulatory area options for two larger ecoregions (Bay of Biscay and Iberian Coast, and the Celtic Seas) were produced. These assessment sheets served as the basis for dissemination documents for managers – stakeholders meeting of WKEUVME in September 2020, and could be incorporated into their respective annual ICES Ecosystem and Fisheries Overviews in future. There are also strong links to shallower water assessment procedures developed by WGFBIT (Working Group on Fisheries Benthic Impact and Trade-offs) that have been developed for the ICES Ecosystem Overview advice in the context of Descriptor 6 seafloor integrity of the EC's marine strategy framework directive (MSFD).

WKEUVME used a data-driven approach to provide management options for this request. Two broad scenarios were provided, each with two options. For each option a set of rules was defined for producing the outcomes. The first scenario defined VME closure polygons without any modification by known fishing activity. The first option under this scenario focused on VME habitats and areas with a High or Medium VME Index score (a multi-criteria assessment method developed by WGDEC). The second option included areas identified in option 1 and added in areas where four types of VME elements were present (areas where VMEs *are likely to occur*: seamounts, banks, coral mounds, and mud volcanoes); allowing managers to choose the level of precaution they wish to apply in protecting VMEs. The second scenario identified areas where the fishing footprint overlapped with VMEs and then used VME biomass/fishing intensity relationships to identify a threshold (swept-area ratio (SAR) < 0.43) for areas where effort was low and unlikely to have caused Significant Adverse Impacts to the VMEs (at C-square resolution). Two options for closing areas under this scenario were presented: the first where VME habitats and areas with a High or Medium VME Index score (irrespective of fishing effort) and only Low VME Index score with low fishing effort were closed; the other where all areas of VME presence (habitats and Low, Medium and High VME Index values) were closed, but only in areas of low fishing effort, on the basis that any VME habitat in heavily fished C-squares would be degraded.

To allow managers to evaluate the impact that closing these areas might have on different fishing métiers, and the trade-offs with protection of VMEs, WKEUVME tabulated fisheries data summarizing the percent of the fishing activity occurring within the 400-800 m depth band, relative to the EEZ of the relevant countries in each ecoregion. Further, WKEUVME used the percentiles of fishing effort (SAR) to map core fishing grounds both in the fishing footprint years (2009-2011) and in two, 4-year periods following. Summary statistics, graphs and maps were produced for

the assessments. Achieving a high level of VME protection in closures requires the creation of many closures (>100) with many small (~ 50 km^2) and fewer larger closures (> 1000 km^2). Full protection of all areas with a high probability of containing VMEs will affect 9-11% of the footprint of the fishery, while closure scenarios that avoid highly fished areas, and that are therefore less likely to support viable VMEs, would reduce this to around 3-9% of the footprint.

Through this process a number of data sources that were not in the ICES VME Database were identified; e.g., data from the Northern Iberian Shelf, the Gettysburg Seamount on Gorringe Bank, the Tasyo mud volcano field and the Guadalquivir Diapiric Ridge in the Gulf of Cádiz. WKEUVME used this and other published information as supporting material for the assessments until such time as the data is submitted to ICES.

A meeting with managers and stakeholders was subsequently held. This commenced with presentations describing the availability of fisheries and VME data and the way in which they were utilised by the Workshop, the rationale behind the scenarios and options that were selected, and the management implications of each option. The advantages and disadvantages of the regulatory options in terms of VME protection and the impact of potential closed areas on the fisheries were examined separately for the Celtic Sea Ecoregion and the Bay of Biscay and Iberian Coast Ecoregion, where stakeholders familiar with each region were able to express their preferences. The stakeholders present were supportive of the work done by ICES and felt that the 4 options were operationally feasible. Concerns were expressed over the data limitations, notably the occurrence of VMEs that are not in the ICES VME Database.

ii Expert group information

Expert group name	Workshop on EU regulatory area options for VME protection (WKEUVME)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair(s)	Ellen Kenchington, Canada
	Peter Hopkins, UK
Meeting venue(s) and dates	23–24 March 2020, by correspondence (9 participants); ToRa
	18–28 May 2020, by correspondence (27 participants); ToRb
	1–3 September 2020, by correspondence (32 participants); ToRc

1 Meeting Format

The three WKEUVME TORs (see Section 2) represent three separate meetings. The meetings were held sequentially and had different participants (Annex 2). The first meeting (TORa) was addressed by the Planning Committee on 23-24 March 2020 and produced a workflow (Annex 1) that was subsequently reviewed and adapted as a working paper going into the second meeting of WKEUVME held 18- 28 May 2020. The second meeting addressed the core of the response to the EU request (Section 4), i.e. TORb, and is the primary focus of this report. The third and last meeting of WKEUVME (TORc) (1-3 September 2020) presented the technical work detailed herein with the respective options to managers to receive comments.

WKEUVME commenced in plenary at 1300 CET on Monday 18th May 2020. Following a welcome from the WKEUVME Co-Chairs and from Mark Dickey-Colas, ACOM Chair, introductions were made and confirmation of no conflicts of interest from the group was obtained. The skill sets of the WKEUVME participants included benthic ecologists, fisheries scientists, specialists on VMEs, spatial fisheries data, trawling impacts and those with ecoregion-specific knowledge, as well as experience working with providing similar advice to managers in the two North Atlantic Regional Fisheries Management Organisations, NEAFC and NAFO.

In advance of the workshop, templates for each ecoregion and the report were produced and a series of tasks identified. Each task had a lead and group members associated with it, with the lead given the responsibility of organizing sub-group meetings for the task, reporting back on issues and progress to plenary, and taking responsibility for producing text. Tasks that were duplicated in each ecoregion further required the task leads to communicate with their counterpart working in the other ecoregion. Task Leads were:

Celtic Seas Ecoregion: Debbi Pedreschi (Ireland), Georgios Kazanidis (UK), Jan Hiddink (UK);
Bay of Biscay and Iberian Coast Ecoregion: Lenaick Menot (France), Marcos Llope (Spain), Phil Turner (Belgium);
Report: Andy Kenny (UK), Daniel van Denderen (ICES), Ellen Kenchington (Canada), Helen Holah (UK), Laura Robson (UK), Neil Campbell (UK), Peter Hopkins (Belgium), Sebastian Valanko (ICES).

Support for data analyses was provided by Daniel van Denderen (ICES), Javier Murillo (Canada), David Stirling (UK), and Cam Lirette (Canada- by correspondence). The ICES Professional officer was Sebastian Valanko and Supporting officer, Eirini Glyki.

WKEUVME experts, including task leads, worked on multiple tasks and created a dynamic, interactive group that worked efficiently and effectively over the two weeks of the virtual workshop. With the trans-Atlantic time zones a consideration, the agenda was planned with plenary sessions beginning at 1300 CET. Mornings (CET) were used for sub-group or individual work on tasks. Dedicated plenary sessions were held on six of the nine working days for one to four hours, with the other days being used for sub-group and individual work. Due to the evolving nature of the work, a detailed agenda was provided one to two days in advance to capture the state of progress. Task Leaders provided a number of presentations in plenary, outlining the approaches discussed in their sub-groups, followed by group discussion. The workshop was formally closed at 1500 (CET) 28th May 2020 by the co-chairs. Task Leaders were given until 5th June to make final changes to their text by correspondence and a draft report was circulated to the WKEUVME on 8th June. The report was finalized on 15th June 2020.

2 Terms of Reference

Note: *Please be advised that in accordance with the WKEUVME chairs' decision, the second meeting of this process, scheduled for the 18-22 May in Copenhagen, has been moved to a WebEx meeting and work by correspondence over a longer period (18-28 May) due to the COVID-19 outbreak. Note also that other dates have changed in the process and/or may be subject to future changes given the COVID-19 outbreak and physical meeting/travel restrictions.*

2020/2/FRSG44

The **Workshop on EU regulatory area options for VME protection (WKEUVME)**, chaired by Ellen Kenchington (Canada) and Peter Hopkins (Belgium) will meet 18-28 May 2020 by correspondence, and 1-3 September in Brussels, Belgium. The workshop is tasked to:

a) Establish a draft workflow, with respective criteria for area selection, which can be applied to propose a set of regulatory area options using available ICES data. The regulatory area options will vary in the priority given to VME protection and fisheries. The applicability of the workflow will be demonstrated in a test area.

b) Establish for the larger area, based on review by WGECO, a set of regulatory area options that vary in the degree of VME protection and estimate for each of the options how it will affect bottom fisheries. Prepare a dissemination document of the regulatory area options, and the workflow and criteria used, in a way appropriate to get input from stakeholders during a meeting with EU Member States and/or relevant Advisory Council members. The dissemination document will be delivered by 15 July.

c) Run a dissemination meeting in Brussels, Belgium (1-3 September) to discuss the regulatory area options that the workflow and criteria produce. Gather stakeholder arguments and preferences that can be used to fine-tune a list of closed area boundaries and identify knowledge gaps associated with each proposed area.

In preparation for the workshop meeting, the Chairs Ellen Kenchington (Canada) and Peter Hopkins (Belgium), together with five ACOM invited attendees will facilitate coordination and consolidation of work on TOR a-c. This group will also help ensure that the workshop report is finalized.

WKEUVME will report to the attention of ACOM by 9 September 2020.

Supporting information

Scientific justification	WKEUVME will suggest regulatory areas options in line with the deep-sea access regulation that vary in the degree of VME protection from bottom fishing. The work will build on from Phase 1 (Technical Service and WKREG workshop), as well as previous ICES advice (ICES 2018a) and technical services (ICES 2018b). All work will draw upon the available VMEs and fishing activity data at ICES that has been quality assured following the respective annual ICES data calls for VMS/logbook (link) and VMEs (link).

Term of Reference a)

Members of the planning team, i.e., the core group, will also meet 23-24 March. This core group for WKEUVME will propose, as a working document, a workflow that can be used to propose a set of regulatory area options. The workflow will have criteria for area selection that can be used with available data at ICES. The workflow will include a set of constraints (e.g. depth limits, enforceable areas, number of coordinates per area) in line with the deep-sea access regulation (EU) 2016/2336 to assess proposed area closures. The workflow will describe different VME protection scenarios with definitions of any terms and values used. The workflow will serve as input to carry out the required technical work. The applicability of the workflow will be demonstrated in a test area where WKEUVME will suggest regulatory area options. These options should vary in the degree of VME protection from bottom fishing. The work plan and test case area will be delivered as a working document to WGECO for review by 31 March.

Term of Reference b)

Using the developed workflow and criteria reviewed by WGECO, WKEUVME will establish a set of regulatory area options in a second meeting (18-29 May). Scientific participation from EU countries in the North East Atlantic that can enhance the information content of the data (add additional knowledge of VME and fisheries, identify current closed areas in the relevant locations etc). WKEUVME will estimate for each of the regulatory area options how area closures for VME protection will affect fisheries (e.g. spatial footprint and intensity of bottom fishing).

Term of Reference c)

WKEUVME will prepare a dissemination document of workshop material in a way appropriate to get input from stakeholders during a meeting (1-3 September) with EU Member States and/or relevant Advisory Council members. The dissemination document will be delivered by 15 July.

3 a) Establish a draft workflow, with respective criteria for area selection, which can be applied to propose a set of regulatory area options using available ICES data. The regulatory area options will vary in the priority given to VME protection and fisheries. The applicability of the workflow will be demonstrated in a test area. – TOR [a]

The draft workflow produced by the WKEUVME Planning Committee in response to TORa can be found in Annex 1. This working paper was reviewed by the ICES WGECO (ICES, 2020) and their comments and subsequent changes to the workflow that were implemented are summarized in Section 3.1. It should be noted that in operationalizing the workflow WKEUVME further improved the approach to determining regulatory options (Section 4). Therefore Section 3 and Annex 1 of this report serve to document the process leading up to the May meeting of WKEUVME which provided the response to the EU request (TORb).

3.1 Follow-up Actions After Review by WGECO

WGECO, at their March 2020 meeting (ICES, 2020), reviewed a WKEUVME workflow working paper (Annex 1) offering advice options to protect vulnerable marine ecosystems (VME) while considering restrictions on fishing activities in northeast Atlantic waters (their TOR e). WGECO agreed that the workflow provided the necessary steps to propose regulatory options to managers for protecting VMEs and offered extensive and useful comment on the proposed workflow.

WGECO noted that the workflow can also be improved, and WGECO's review summarized major comments to point out sections of the workflow where improvements could occur. These were: 1) applying a more conventional risk-assessment framework to the workflow; 2) providing details regarding Species Distribution Models, decision support tools, and their application; 3) providing clarity on VME confidence and the intended precautionary approach; and 4) developing concrete management actions for closed area selection to fully inform trade-off analysis. Additional comments were made considering the presentation of trade-offs to managers for selecting different closed areas, considering previous ICES work and advice relevant to the workflow and deep-sea access regulation, and how the workflow can accommodate future data updates to ensure data are fully documented and adhere to ICES data standards.

After consideration of that review the planning committee for WKEUVME undertook the following modifications to the workflow document presented above:

- Moved discussion of trade-offs to a Future Directions section;
- Removed the sections on Possible Management Actions for Protecting VMEs and Translating C-squares to Polygons, and replaced it with a more general scenario framework;
- Updated advice on buffer zones to include the most recent ICES advice (ICES, 2018);

- Included assessments of 2011-2019 fishing patterns in assessment sheets to see if current fishing is impacted.

WKEUVME also made additional changes which were stimulated by the WGECO comments but not directly attributed to them:

- Applied Ecosystem Overview templates to create draft assessment sheets for two ecoregions for the May workshop. This will enable outputs to be used in the former and will facilitate an ecosystem-level assessment of impacts in future.

Other comments were seen as areas to develop in the future, although initial steps to develop a benchmark for inclusion of SDMs in ICES advice has been initiated. Consequently, the workflow presented in Annex 1 was used as a guide to initiate the WKEUVME technical work for TORb. It was further modified by WKEUVME participants as they began to operationalize it for the production of closed area options. Rather than recreate a new workflow WKEUVME in response to TORb provided a set of steps for implementing the closed area options using ICES data products, and provided the data layers and R-code to do so for future applications (Section 4).

Decision to Exclude Existing Protected Areas

Both WKREG (ICES, 2019) and WGECO (ICES, 2020) suggested adding information on existing national or other closed areas to the response to the request. WKREG provided partial lists of measures which are already in place through national conservation initiatives, such as the designation of Special Areas of Conservation (SACs) under the Habitats Directive, OSPAR marine protected areas, Common Fisheries Policy (CFP) technical conservation measures supporting the conservation objectives of Natura 2000 etc. The planning committee requested clarity on this issue and was told that we should not consider these closures in our recommendations. This is because the different initiatives respond to different Directives within the EU and their conservation goals may be broader than those for this specific request. The legal bases and the specific restrictions that apply inside those protected areas vary, which makes it impractical for the Workshop to try to take them into account. Further, any proposals for closed areas to protect VMEs based on the recommendations from WKEUVME would be subject to changes arising from links to these other policy measures if they were considered.

References

ICES. 2018. Advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, sr.2018.10. 12 pp. https://doi.org/10.17895/ices.pub.4429

ICES. 2019. Stakeholder workshop to disseminate the ICES deep-sea access regulation technical service, and scope the required steps for regulatory purposes (WKREG). ICES Scientific Reports. 1:ISS NO. 31 pp. http://doi.org/10.17895/ices.pub.5636

ICES. 2020. Working Group on the Ecosystem Effects of Fishing Activities (WGECO). ICES Scientific Reports. 2:26. 43 pp. http://doi.org/10.17895/ices.pub.6005

4 Establish for the larger area, based on review by WGECO, a set of regulatory area options that vary in the degree of VME protection and estimate for each of the options how it will affect bottom fisheries. Prepare a dissemination document of the regulatory area options, and the workflow and criteria used, in a way appropriate to get input from stakeholders during a meeting with EU Member States and/or relevant Advisory Council members. The dissemination document will be delivered by 5 June. – TOR [b]

4.1 Ecoregion Summaries

ICES uses ecoregions as the spatial units to synthesise the evidence for the ecosystem approach. The ICES network uses them to monitor, assess, address and solve regional scientific challenges and for geographical allocation and reporting of ICES advice. All ICES advice is now linked to an ecoregion, or a collection of ecoregions. The current ecoregions were instigated in 2015 after a process that began in 2004. The ICES process of developing ecoregions has influenced many spatial management definitions and supra-national legislation (e.g., the EU Marine Strategy Framework Directive, MSFD). Once defined, the ecoregions adapt slowly, and occasionally in response to changes in management areas and dialogues with regional managers. The ICES system of ecoregions is different from the ICES fishing area system, and reflects ICES move toward providing the evidence for ecosystem-based management. The use of consolidated ecoregions enhances ICES ability to research ecosystem and social dynamics and translate those findings into consolidated ecosystem-based advice. Accordingly WKEUVME has opted to deliver its recommendations by ecoregion. Most of the EU waters between 400 and 800 m depth fall into either the Celtic Seas Ecoregion, or the Bay of Biscay and Iberian Coast Ecoregion. For each of those regions WKEUVME prepared assessment sheets in the style of the Ecoystem Overviews with the following headings:

Ecoregion Description

Distribution of Vulnerable Marine Ecosystems

Fisheries Data

Overlap Between VMEs and Fisheries

Closed Area Scenarios

Future Directions

Areas Not Included in the Two Ecoregion Assessments

Danish EEZ

Only a small area of Denmark's EEZ has water depths of 400-800 m on the edge of the EEZ boundary. This area falls in the Skagerrak which reaches its deepest point at 700 m, located within the Greater North Sea Ecoregion. Within this region, only one C-square (Rees, 2003) recording VME habitat, representing a cold seep, occurs deeper than 400 m, with a maximum depth of 450 m. The remaining two VME Index C-squares in the area occur shallower than 400 m (Figure 4.1). Furthermore, investigation of the level of fishing that occurs in this region showed that none of the fishing activity occurs in areas where VMEs were known or likely to occur. The co-ordinates of the C-square in the Danish EEZ that falls within the 400-800 m depth zone that is shown in Figure 4.1 are:

Vertex 1	58° 06' 00'' N	9° 39' 00'' E
Vertex 2	58° 06' 00'' N	9° 42' 00'' E
Vertex 3	58° 03' 00'' N	9° 42' 00'' E
Vertex 4	58° 03' 00'' N	9° 39' 00'' E.

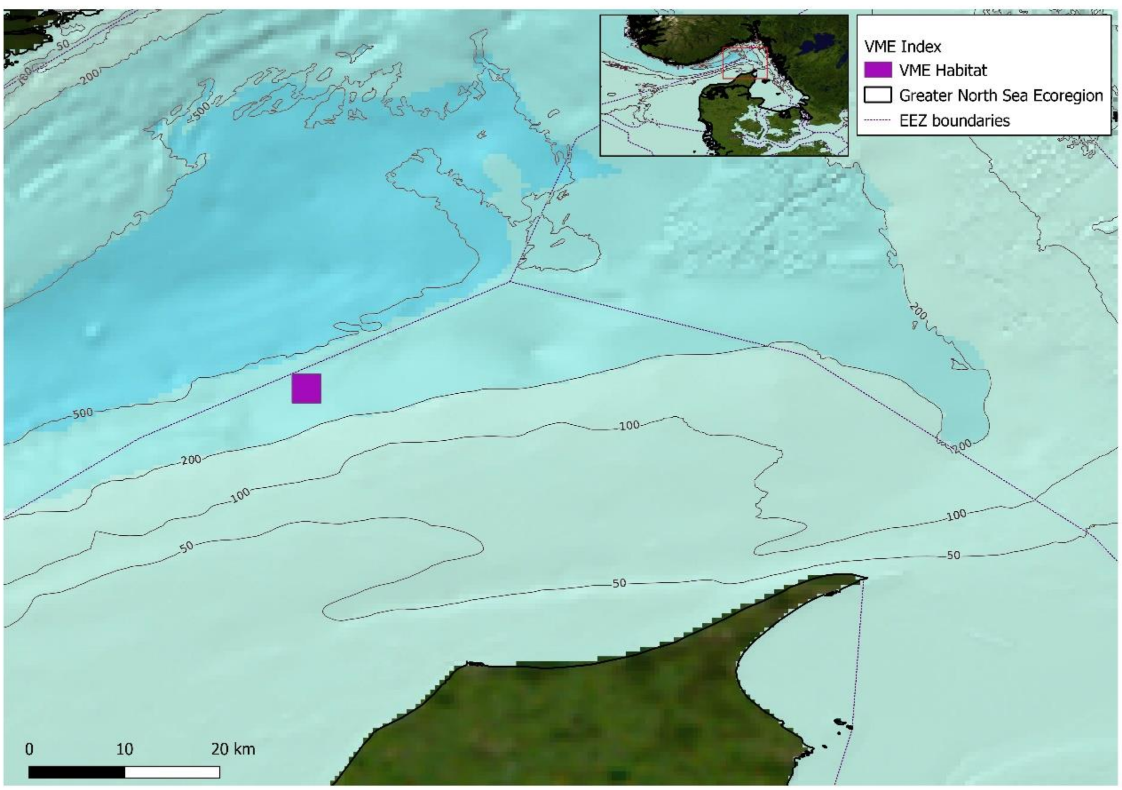


Figure 4.1. The Danish continental slope area within the Greater North Sea ecoregion, showing the VME Index within the 400-800 m depth zone only. Inset map shows the area of the Greater North Sea ecoregion detailed. Copyright: Base map imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. Depth contours: EMODnet bathymetry WMS v 1.3.0. Map projection: EPSG:4326 - WGS 84.

Azores EEZ

The Azores is a Portuguese archipelago composed of nine islands with almost no geological continental shelf. The Azores Exclusive Economic Zone (EEZ) includes 461 identified seamounts (ICES, 2019). There are a small number of areas within the Azores EEZ that occur within the 400-800 m depth zone, mainly along the steep island slopes and offshore seamounts. However, these are biodiversity-rich areas both in terms of VME habitats and indicators, and consequently are vulnerable to cumulative pressures from static gears (Braga-Henriques *et al*., 2013; Tempera *et al*., 2013a; Pham *et al*., 2014; Joana Xavier Pers. Comm.).

Among known VME habitats are sponge aggregations dominated by *Pheronema carpenteri* (e.g., Tempera *et al*., 2012) and mixed coral gardens composed of primnoid gorgonians *Narella bellissima* and *Narella versluysi* (Braga-Henriques *et al*., 2011, 2014; Tempera *et al*., 2012). Unattached coral reef structures formed by the dendrophylliid coral, *Eguchipsammia,* have also been described from upper bathyal depths, i.e., 280–300 m (Tempera *et al.,* 2015), and recently many specimens of the same genus were collected during benthic trawl surveys in deeper areas (A. Braga-Henriques, Pers. Comm., cruise BIODIAZ-M150). These new findings stress the potential existence of dense, living aggregations on other slopes of the archipelago. In addition, the pennatulacean fauna of the Azores EEZ is taxonomically diverse, represented by 13 species assigned to 8 families (Sampaio *et al*., 2019). The occurrence of sea pen gardens in soft sediments habitats is thus also expected in this ecoregion.

For the 400-800 m depth zone of the Azores ecoregion, the VME Database currently includes two VME habitat C-squares, representing hydrothermal vent and coral garden habitats, and a small number of medium VME Index C-squares where VME indicator records have been submitted to the VME Database for black corals, gorgonians and soft corals. Very few of the VME Index C-squares which occur within the 400-800 m depth zone are contiguous, and they mostly represent small isolated examples of presumably larger habitats.

Additional data on VME habitats and indicators for the region would support improved understanding of potential closures within the 400-800 m depth zone. Descriptions of known areas of VME are provided in the following sections, specifically for the Cabeço do Luís and Formigas Seamounts (Figure 4.2). These represent two examples of relevant data for the region, known by workshop attendees. There was insufficient time during the workshop for a comprehensive literature review for additional data for the Azores ecoregion. However, it is likely there are further data sources available and inclusion of all these data to the VME Database will be encouraged by WGDEC in 2021, to support further understanding of the VMEs in this ecoregion.

Due to limited data on VME within the 400-800 m regions currently in the VME Database and highlighted by the VME Index (Figure 4.2), we have not considered this area further for the VME closure proposals. However, this should be reconsidered when new data is submitted to the VME Database. This could be used to support a full ecoregion assessment for the Azores if desired.

Example Areas of Known VME Occurrence within the 400-800 m Depth Zone, for the Azores Ecoregion

Cabeço do Luís Seamount

Cabeço do Luís is a small volcanic elevation located one nautical mile away from the southwestern coast of Pico Island, on the southern flank of the Faial-Pico Passage (Figure 4.2). The hill has a conical shape and rises from depths of 400 m in the north and 700 m in the south, culminating in a shallow peak at approximately ~ 150 m. The bottom is rough and blocky, with medium and large- sized boulders. Small coarse sediment patches occur in areas with a less pronounced slope (de Matos *et al*., 2014).

A monospecific forest of the black coral *Antipathella subpinnata* has been reported near Pico Island, more precisely in the Cabeço do Luís Seamount (Figure 4.3). Average colony density was 0.75 colonies/m^2, with a maximum density of 2.64 colonies/m^2 observed between 155 and 165 m depths (de Matos *et al*., 2014).

Formigas Seamount

The Formigas Islets (Figure 4.2) are part of a promontory named Formigas Bank (Abdel-Monem *et al*., 1975), located next to the junction of the East Atlantic Fracture Zone (EAFZ) and Terceira Rift (Tempera *et al*., 2013b). On the western sector, an 1800 m deep, flat abyssal plain extends, with no remarkable morphological features except for a few gullies on its flank. On the northeastern side, at least twenty knolls are spread across an area of 130 km^2. These are likely to be part of a volcanic field extending to the northeast. Formigas was extensively surveyed during the "MEDiterranean out flow WAter and Vulnerable EcosystemS" (MEDWAVES) cruise, as part of the activities of the Atlas H2020 project (Orejas *et al*., 2017) (Figure 4.4).

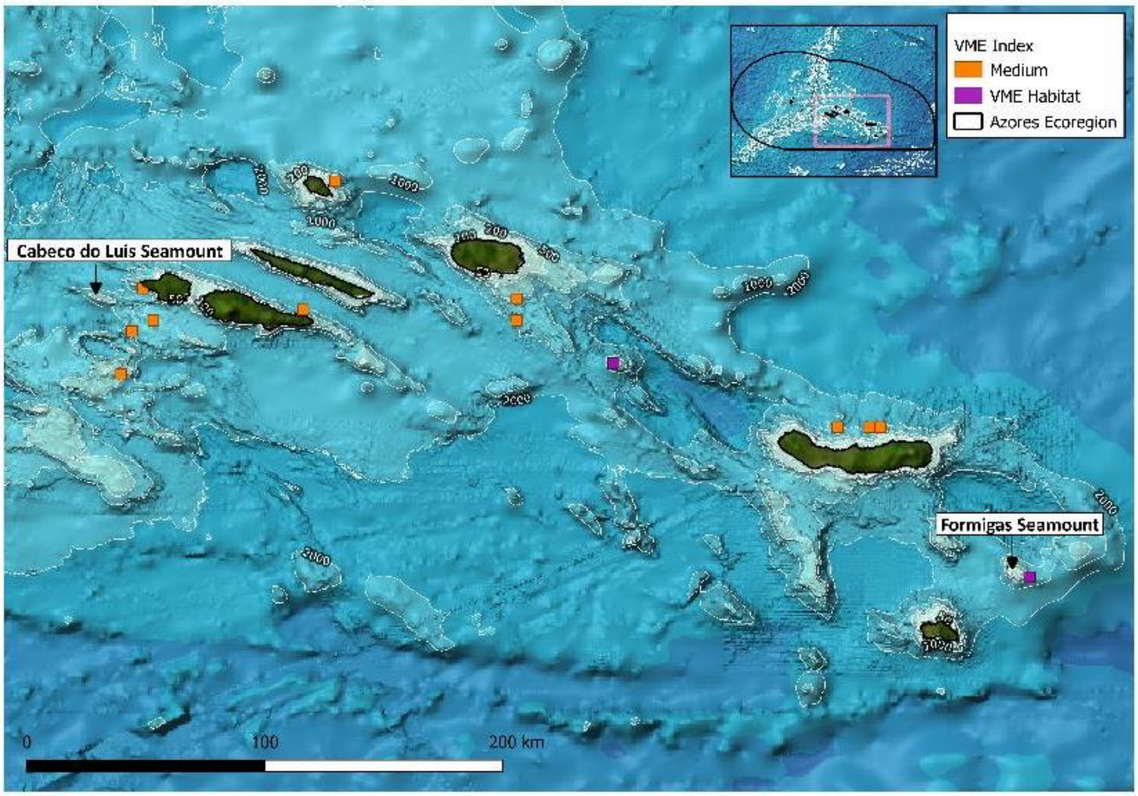


Figure 4.2. The Cabeço do Luís and Formigas Seamounts within the Azores ecoregion, showing the VME Index within the 400-800 m depth zone only. Inset map shows the area of the Azores ecoregion detailed. Copyright: Base map imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. Depth contours: EMODnet bathymetry WMS v 1.3.0. Map projection: EPSG:4326 - WGS 84.

The surveys conducted during MEDWAVES covered a depth range of 500 - 1575 m at different seamount orientations. A brief summary of the benthic communities that constituted VME within the 400 – 800 m depth range is presented here. Figure 4.5 illustrates some of the communities documented at Formigas (Orejas *et al*., 2017).

In addition to these habitats, a range of VME habitats were identified through the MEDWAVES cruise at depths > 800 m. These are not detailed here as they are outside the 400 – 800 m depth range of interest, but they indicate the significant presence of VMEs within the Azores ecoregion.

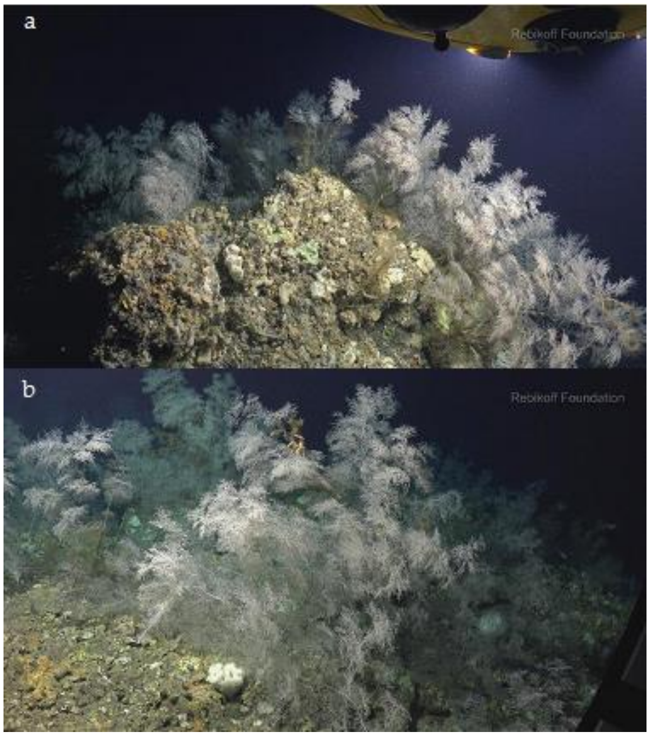


Figure 4.3. (a) Dense monospecific black coral forest in Cabeço do Luís seamount. (b) The spider crab *Rochinia rissoana* on a branch of *Antipathella subpinnata* © Deep-sea imagery archive from Rebikoff-Niggeler Foundation, Azores: dive #34 with manned submersible LULA1000.

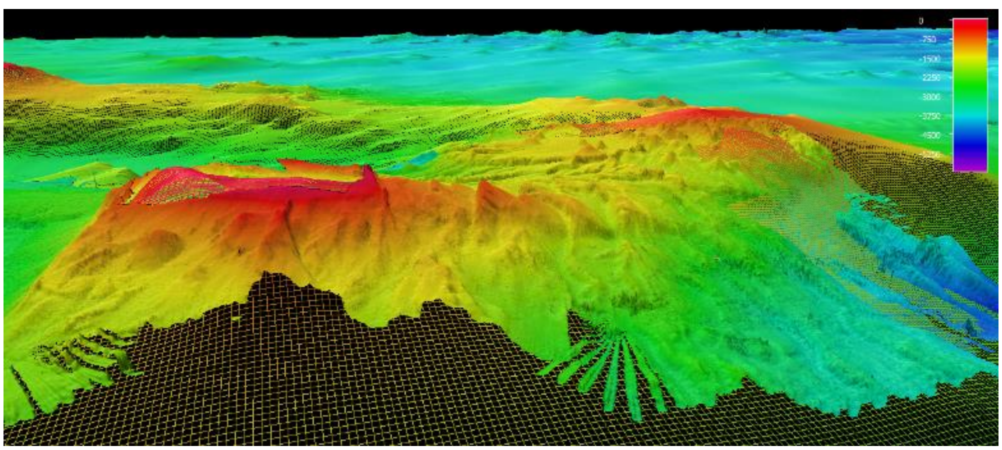


Figure 4.4. Swath bathymetry for the Formigas Bank acquired during the MEDWAVES cruise.

Coral gardens and sponge aggregations (400-740 m depth, SE Flank)

At these depth ranges, hard substrates (mostly rocks and pebbles) were the most common, with some patches of soft detritic materials. In the deepest region, *Narella versluysi* was dominant, forming high density areas, with *Narella bellissima* taking over in others. The shallowest parts of the transect (478 – 560 m depth) were characterized by large rocks, with a high abundance of different morphotypes of Porifera, together with some dense patches of the gorgonian "Plexauridae White sp. 1". The occurrence of specimens belonging to the family Nidaliidae was also reported. Some specimens of gorgonian *Corallium tricolor* also occurred in the shallower areas, with black corals of the genera *Stichopathes*.

Coral gardens (750 - 1000 m depth, SE Flank)

The dominant substrate at this depth range was hard flagstone and rocks with some patches of mud, sand and soft detritic materials. The hard substrate areas hosted a mixed community of cnidarians and poriferans. In some areas the gorgonian *Narella versluysi* dominated, with the morphotypes "Porifera digitate sp.1" and "Porifera encrusting transparent". In others, *Narella bellissima* dominated, with the morphotype "Porifera encrusting transparent". The gorgonian cf. *Acanthogorgia armata* was also present, but at lower abundances than the morphotypes previously mentioned. Variations in depth across the transect as well as across substrates did not produce significant changes in species composition.

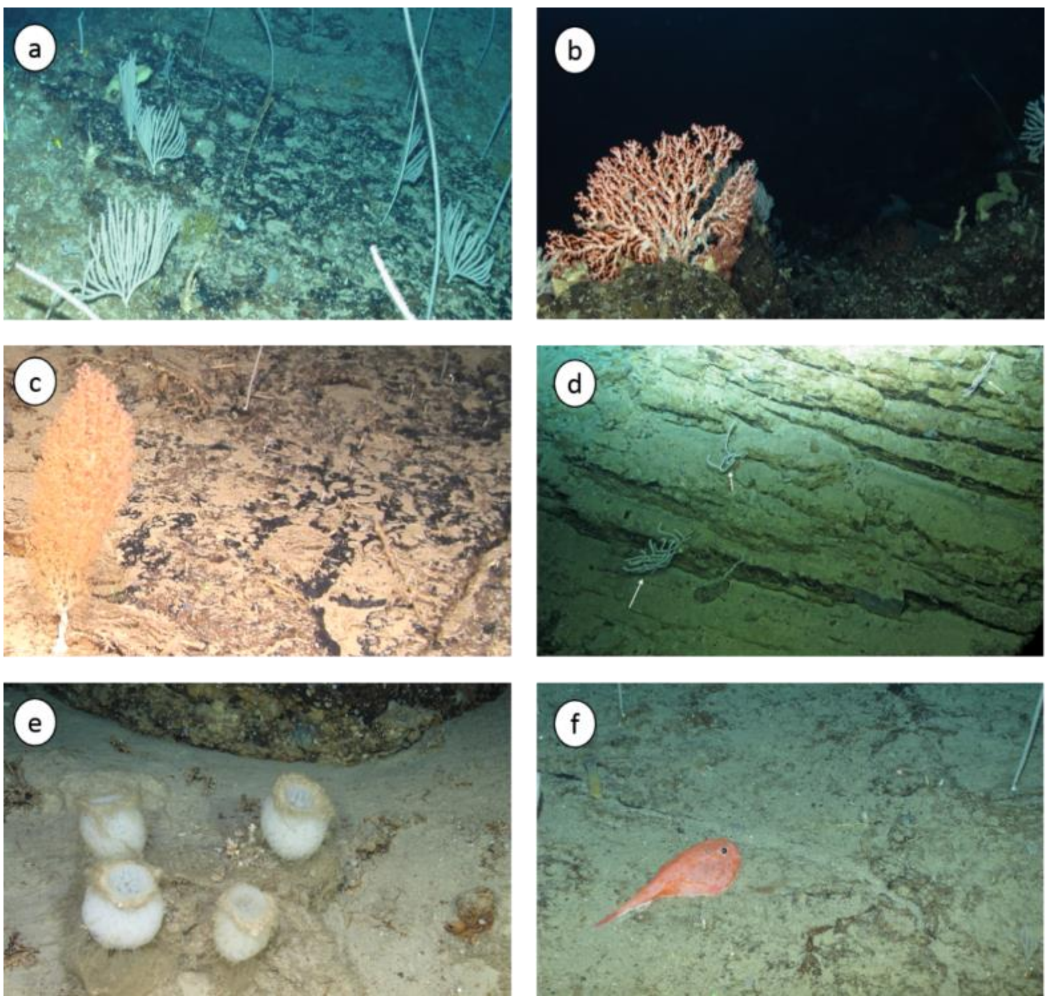


Figure 4.5. Examples images of the benthic habitats of Formigas seamount. a) coral garden dominated by *Narella bellissima* (740-780 m depth), b) specimen of *Corallium tricolor* at ca. 1230 m depth, c) specimen of the bamboo coral *Acanella arbuscula* at ca. 1300 m depth, d) specimens of the "Pleaxauridae white species 1" in a vertical rocky wall at ca. 1400 m depth, e) *Pheronema carpenteri* in a mixed substrate of sand and rocks at ca.1200 m depth, f) specimen of *Chaunax* sp. at ca. 900 m depth.

References

Abdel-Monem, A.A., Fernandez, L.A., and Boone, G.M. 1975. K-Ar ages from the eastern Azores group (Santa Maria, São Miguel and the Formigas Islands). Lithos 8: 247–254. doi:10.1016/0024-4937(75)90008-0

Braga-Henriques, A., *et al*. 2011. Cold-water coral communities on Condor Seamount: initial interpretations, *In*: CONDOR Observatory for long-term study and monitoring of Azorean seamount ecosystems, Final Project Report, Arquivos do DOP, Série Estudos 1/2012, Horta, Portugal, 105–114.

Braga-Henriques, A., *et al*. 2013. Diversity, distribution and spatial structure of the cold-water coral fauna of the Azores (NE Atlantic). Biogeosciences 10: 4009–4036.

Braga-Henriques, A. 2014. Cold-water coral communities in the Azores: diversity, habitat and conservation. Ph.D. Thesis. University of the Azores, Portugal. http://hdl.handle.net/10400.3/3615

de Matos ,V., Gomes-Pereira, J.N., Tempera, F., Ribeiro, P.A., Braga-Henriques, A., and Porteiro, F.M. 2014. First record of *Antipathella subpinnata* (Anthozoa, Antipatharia) in the Azores (NE Atlantic), with description of the first monotypic garden for this species. Deep-Sea Research Pt. II 99: 113–121. http://dx.doi.org/10.1016/j.dsr2.2013.07.003

ICES. 2019. Azores ecoregion – Ecosystem overview. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, Section 3.1. https://doi.org/10.17895/ices.advice.5753.

Orejas, C., *et al*. 2017. Cruise report MEDWAVES survey. (MEDiterranean out flow WAter and Vulnerable EcosystemS) ATLAS Project H2020. 211 pp and Appendixes

Pham, C. K., *et al*. 2014. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. Scientific Reports 4: 1–6. https://doi.org/10.1038/srep04837

Rees, T. 2003. "C-squares", a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography 16(1): 11–19.

Sampaio, Í., Freiwald, A., Porteiro, F.M., Menezes, G., and Carreiro-Silva, M. 2019. Census of Octocorallia (Cnidaria: Anthozoa) of the Azores (NE Atlantic) with a nomenclature update. Zootaxa 4550 (4): 451–498.

Tempera, F., *et al*. 2012. 59. Mapping Condor Seamount Seafloor Environment and Associated Biological Assemblages (Azores, NE Atlantic). Pp. 808-818. Seafloor Geomorphology as Benthic Habitat. Elsevier.

Tempera, F., Atchoi, E., Amorim, P., Gomes-Pereira, J. and Gonçalves, J. 2013a. Atlantic Area Marine Habitats. Adding new Macaronesian habitat types from the Azores to the EUNIS Habitat Classification. Technical Report No. 4/2013 - MeshAtlantic, IMAR/DOP-UAç, Horta, 126pp.

Tempera, F., Hipólito, A., Madeira, J., Vieira, S., Campos, A.S., and Mitchell, N.C. 2013b. Condor seamount (Azores, NE Atlantic): A morpho-tectonic interpretation. Deep Sea Research Part II Topical Studies in Oceanography 98: 7–23. doi:10.1016/j.dsr2.2013.09.016

Tempera, F., Carreiro-Silva, M., Jakobsen, K., Porteiro, F.M., Braga-Henriques, A., and Jakobsen, J. 2015. An *Eguchipsammia* (Dendrophylliidae) topping on the cone. Marine Biodiversity 45: 3–4.

4.2 Data on Vulnerable Marine Ecosystems

ICES VME Data Call and VME Database

The ICES Data Centre together with the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC) maintain a central database holding information on the distribution and abundance of habitats and species considered to be indicators of vulnerable marine ecosystems (VMEs) across the North Atlantic. This ICES VME Database aims to store and make available all known VME habitat and indicator records in the North Atlantic (covering deep water areas inside and outside national jurisdiction) for use by ICES and the wider marine community.

Each year, a data call is sent out to ICES member states requesting any new data on VMEs to be submitted to the VME Database. The data call is issued to member countries in advance of the WGDEC meeting, commonly in January, with a 2-month response period (usually February – March) (link). The data call is addressed to a single point of contact for each country; for EU countries these are the DCF contacts (link) and for non-EU countries, the ICES ACOM members (link).

As an international science organisation, ICES does not prescribe how national level data are managed. It is the responsibility of each point of contact that receives the data call to coordinate data submission at a national level, and ensure data are submitted to ICES correctly and by the deadline. To support data submission, good communication and collaboration is encouraged between VME experts who collect and hold data, and the national point of contact (DCF and/or ACOM member). Experts that collect and hold data are also encouraged to be members of the respective ICES working groups; in the long term, expert participation in ICES working groups will help to build trust in the ICES advice process and understand what the VME data are used for.

ICES WGDEC members (who are nominated by member countries or invited by the working group Chair) may also submit data to ICES. When submitting data that have been collected during multinational research projects, the data submitter is asked to confirm that there is a data agreement between the countries involved in the research project. Other sources of data (i.e., other databases, projects, etc.) can also be considered for submission and are done so on a case-by-case basis. In such cases, submissions are done in cooperation with the ICES Secretariat and the Chair of the ICES Working Group. The data submitter must have usage rights on the data that they submit to ICES.

The definition of VMEs for submission to the database are based on the five criteria defined by the FAO (2009):

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

The data call provides a list of habitats and associated representative taxa “indicators”, that are currently recognised as VME by WGDEC1. VME data submissions can take three forms:

---

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

1. **VME habitats –** records for which there is unequivocal evidence for a VME, e.g., ROV observations of a coral reef;
2. **VME indicators** - records that suggest the presence of a VME with varying degrees of uncertainty, e.g., bycatch of gorgonians (sea fans) from a fishing vessel;
3. **Absence data –** samples where neither a VME nor a VME indicator has been identified.

Specific considerations apply for the inclusion of absence data, as detailed in ICES (2017). Any questions or requests for support on data submissions can be sent to the ICES Data Centre (data.call@ices.dk).

VME Database Quality Control

All data submitted to the ICES VME Database are subject to quality control (QC) standards via the ICES Data Centre and WGDEC. A data flow illustrating the quality control process for VME data submission is shown in Figure 4.6.

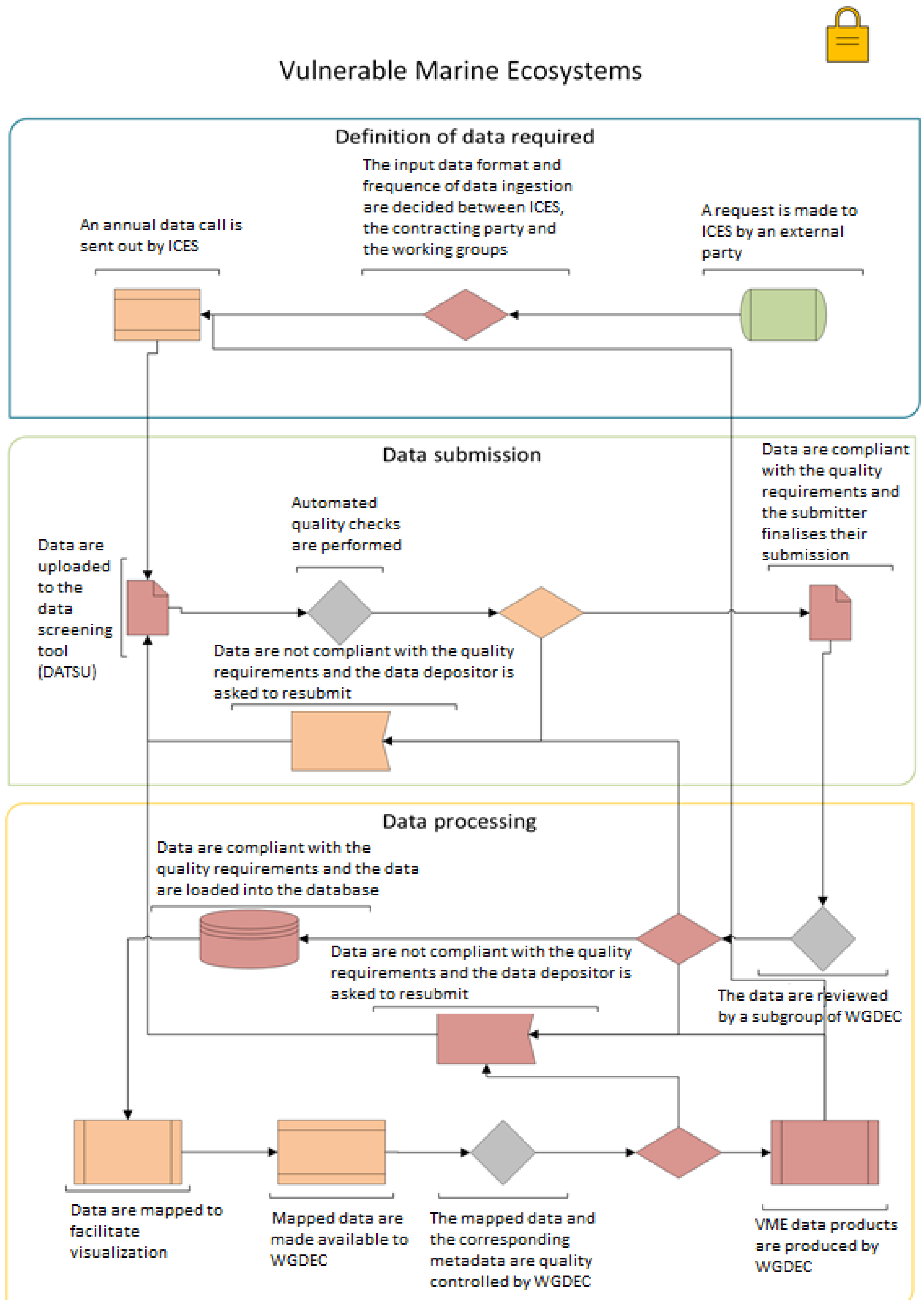


Figure 4.6. ICES VME data flow schematic draft. Please note that the above ICES VME data flow is a partial draft version produced prior to formal acceptance by the ICES advisory committee (ACOM) and its publication. The above version of the VME data flow schematic may thus differ once finalized.

Following the VME data call, data are uploaded to a data screening tool (DATSU), developed by the ICES Data Centre. This tool runs a series of automated QC checks which flag initial problems to the data provider that need addressing before the data can be formally accepted to the database, for example, warnings of coordinates being located on land, or species linked to incorrect VME indicator types. Support is available via the ICES Data Centre for any queries over these errors.

Once the data are compliant with these initial QC checks, the data are then reviewed by a sub-group of WGDEC. If any issues are noted during this stage, these are addressed with the data supplier, and if not, the data are uploaded into the database. Data are then put into draft maps to be reviewed during the WGDEC meeting for sign off. Again, any issues noted during this stage are addressed with the data supplier and a request made for data re-submission if needed.

VMEs and Associated Confidence Index

When the ICES VME Database was set up, data were originally only captured in the form of VME indicators, rather than VME habitats. WGDEC therefore identified that there needed to be some understanding of the confidence and quality of these VME indicator records if recommendations coming from the Working Group were to be transparent and based on best available evidence.

One of the biggest challenges with the use of the VME Database, is that it stores data from multiple sources, collected at different times, through different survey collection methods, including older data from the scientific literature. These data are therefore not standardised and cannot easily be compared against each other for data analysis purposes (e.g., there is no information on trawl/video transect distance, duration, trawl width, etc.). Whilst improvements are being made to the quality control procedures behind new data submissions to the database (see above section on quality control), there are still substantial older datasets that provide valuable information on VMEs from many years' worth of data collection. Furthermore, there is uncertainty in understanding the likelihood of a VME indicator representing an actual VME (habitat).

Therefore, in 2015 and 2016, WGDEC developed the VME weighting algorithm; a multi-criteria assessment system that follows a series of transparent steps to come up with a VME score and a confidence score, to make best use of these valuable data, whilst acknowledging their limitations. This method produces the "VME Index", which indicates the likelihood of an area containing a VME, based on the underlying data from the VME Database. The index combines two sources of information:

1. A ranked VME indicator 'vulnerability score', based on expert knowledge of each indicator species considered against the five FAO criteria for VMEs (FAO, 2009);
2. Available data on the abundance of VME indicator species records, where provided in the database.

The VME Index combines these two parameters and scores overall VME likelihood as either high, medium or low. The index was created on a spatial C-square grid scale of 0.05 x 0.05 degrees (approximately 3 km x 5 km), allowing multiple records of VME indicators in the same grid cell to be used to detect likelihood. Records of VME habitat submitted to the database are automatically assigned to a 'VME habitat' category, and therefore do not sit on the 'likelihood' scale.

Further to the VME Index, a confidence index was also developed, based on four criteria: type of survey method; number of surveys (within C-squares); time span/range of surveys undertaken and time since last survey. The outputs of this scoring system are categorised into high, medium or low confidence, and mapped at the C-square grid scale. Maps of the VME Index and confidence are provided in the WGDEC reports for all areas where new VME data has been submitted through the annual ICES VME data calls.

Full details on the method for the VME weighting algorithm are provided in Section 7 of the 2018 WGDEC report (ICES, 2018) and Morato *et al*. (2018).

Caveats and Limitations of the VME Index

Although the VME Index has been used since 2018 in ICES advice, it is recognised that there are a number of improvements that could be made to support its use for ICES moving forward, for example those detailed by WGDEC in 2018 (ICES, 2018, Section 7.3).

Firstly, the VME Index is based on a mix of information on the presence of VME indicator groups, the characteristics of these species, and measures of their abundance, and it is hard to disentangle how each of these contributes to the index when using the final C-square gridded outputs. This means that it is difficult to infer what an index value within a specific location is likely to represent. This is relevant because clarity about the nature of the indicator ('concreteness') is vital for acceptance of outcomes by managers and stakeholders (Rice and Rochet, 2005), and for the appropriate use by scientists.

Secondly, the characteristics of the VME indicator groups are used to assign a value to different VME indicators in the index, scoring how 'well' the indicator meets the VME designation criteria (FAO, 2009). However, the process of deciding what a VME is has been carried out elsewhere and a list of what constitutes a VME already exists, so there may be no need to value different types of VMEs again in this index. Different types of VMEs may require different types and levels of protection, and this is likely to be related to the FAO criteria (e.g., fragility and recovery potential), but these differences would need to feed into the management measures implemented once a VME has been detected. Therefore, other methods of detecting whether a VME indicator may represent a VME habitat should be explored.

Thirdly, the way in which abundance feeds into the index down-weights the importance of some VME types, such as sea pens, and gives unduly weight to others, such as stony corals. As it stands, sea pens can never attain the status of 'High VME Index' and even when bycatch totals more than 30 kg of sea pens (which represents 1000-100000s of sea pens), they only reach the threshold to be considered as 'Medium VME Index'. At the other extreme, any amount of stony coral causes a designation as High VME Index. As a result, the index risks becoming an index of perceived vulnerability rather than likelihood of occurrence. This could be improved on by reviewing the VME weight thresholds used for particular VME indicators, as proposed by WGDEC in 2018 (ICES, 2018, section 7.3.2).

WKREG also expressed concern that historic VME information was down-weighted in the multi-criteria assessment evaluation through the confidence index. Given the longevity of many of these taxa, the threshold for down-weighting may not be meaningful. Hence the weighting algorithm used and its impacts on the results should be investigated further (ICES, 2019). WKEUVME notes that the use of the VME Index as it is now, may result in under-representation of sea pen VMEs in the selection of closed areas under all scenarios and options except Scenario 2 option 2 (see Section 4.5).

Use of VME Data by WKEUVME

The outputs of the VME weighting algorithm enable users to map known VME habitat areas (VME habitat), and VME likelihood of presence (VME Index). The VME Index mapped outputs have been used for the WKEUVME workshop to illustrate where VMEs occur within each ecoregion of interest, in relation to the depth zone of 400-800 m. The locations of specific VME habitats and indicator species through point data has also been used by WKEUVME, to identify further information on the types of VME occurring in each ecoregion.

VME Elements

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 (Annex 1). This workflow proposed a stepwise approach to the inclusion of different data sources, 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 ICES VME Database, as well as species distribution models of VMEs/VME indicators (to be utilised in the future), and presence of VME elements. VME elements are defined in the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO, 2009) as topographical, hydrophysical or geological features, including fragile geological structures, that potentially support VMEs. 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).

Whilst confirmed records of VMEs and VME indicators are readily available from the ICES VME Database, and mapped by WGDEC, the location of VME elements is less certain. These data are, however, obtainable from existing maps and modelled data using, for example, multibeam bathymetry datasets.

To support this area of work, the Working Group on Marine Habitat Mapping (WGMHM), in collaboration with WGDEC, set up a Term of Reference for their 2020 meeting, to delineate areas of VME elements within the two ICES ecoregions of interest for WKEUVME, to guide the identification of areas likely to contain VMEs.

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.

Existing definitions were reviewed and working definitions for the analysis were applied for five VME elements:

3. Isolated seamounts
4. Steep-slopes and peaks on mid-ocean ridges
5. Knolls
6. Canyons
7. Steep flanks > 6.4°
8. Hydrothermal vents

In addition, WGMHM identified 3 other geomorphological features which could be considered as VME elements, namely:

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

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 website2. "Flanks" and "Steep slopes on ridges" 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. 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 and used in the qualitative descriptions of the 'Distribution of Vulnerable Marine Ecosystems' in the Assessment Sheets (Section 4.6).

WGMHM recommended that the distribution of 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, unless the method for deriving estimates of slope is 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 sometimes poor (due to insufficient data);
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;
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.

WKEUVME acknowledged the reservations expressed by WGMHM regarding the use of VME elements but notes that these are indicated in the high-level policy agreements to which this request is responding to, and that NEAFC has applied VME elements in their decision-making process to protect VMEs (Annex 1).

However, WKEUVME identified the EMODnet seafloor geology as an additional source of information on VME elements. The EMODnet seafloor geology is publicly available and provides georeferenced geological and biogenic structures such as banks, coral mounds, mud volcanoes and seamounts at a higher spatial resolution than other global sources of information such as those utilized by WGMHM. Given that this

2 http://www.bluehabitats.org/?page_id=58

dataset addresses many of the concerns raised by WGMHM, EMODnet seafloor geology data were also used to identify VME elements in this report. In particular the VME element 'banks' was an important feature in linking VME data records in the Bay of Biscay and Iberian Coast ecoregion. EMODnet data were used to select VME elements in the development of management options (Section 4.5).

Species Distribution Models

Species distribution models (SDMs) can also be used to provide an evaluation of whether a VME or VME indicator is `*likely to occur*' (see Annex 1) and have been used for such advice in NAFO and in Canada in the North Atlantic (NAFO, 2019; Kenchington *et al*., 2016). There, the SDMs are used to refine the distribution the VMEs within the larger VME polygons (NAFO, 2019) and to estimate the probability of occurrence of the VME between data points. These models use a range of environmental predictors, including oceanographic and topographic variables, to approximate distribution of particular VME species (e.g., cold-water corals, sponges) based on species' abiotic preferences. These models can be verified with independent groundtruthing data where available. A number of SDM models have been published for different VME indicators in the northeast Atlantic. However, ICES has yet to establish standards for accepting these models into the advisory stream. A process has been established to initiate a benchmarking workshop in 2020 so that SDM models can be used in future to identify areas where VME are *likely to occur* (Section 4.7). Until then, WKEUVME used SDMs as supporting information for the assessments. An overview of available models is provided for the Celtic Seas ecoregion, as an example of the extent of this information for future applications.

Predictive Models for the Celtic Seas Ecoregion

Species distribution models have been developed for a number of VME indicator taxa, with a particular focus on reef-forming scleractinian corals – most notably *Lophelia pertusa*, now known as *Desmophyllum pertusum*. Models range from global (e.g., Davies *et al*., 2008) to regional (e.g., Ross and Howell, 2013) scales and vary in resolution, with global models tending naturally to have coarser resolution than regional models. Importantly, model resolution in the Celtic Seas is aided by very high-resolution bathymetry data and although other environmental parameters may be available only at coarser resolutions, model output raster cells tend to be considerably smaller than C-squares.

Ease of identification, as well as funding for EU projects such as HERMES and CoralFish, has placed a particular focus on *Lophelia pertusa* (now known as *Desmophyllum pertusum*) in the Celtic Seas (e.g., Dolan *et al.*, 2008; Guinan *et al*., 2009a,b; Rengstorf *et al*., 2013, 2014; Mohn *et al*., 2014). Although maps of modelled distributions exist in published papers, few data are publicly available. Exceptions include the modelled distributions of *Desmophyllum pertusum* on the Hatton and George Bligh Banks (Howell *et al*., 2011), and in the Celtic Seas (Ross and Howell, 2013), which are available through EMODnet (https://www.emodnet-seabedhabitats.eu/).

Development of models for other vulnerable marine indicator taxa has been slower: modelled species in the Celtic Seas include *Pheronema carpenteri* (hexactinellid sponge) and *Syringammina fragilis* (xenophyophore) (Ross and Howell, 2013), both of which occur deeper than 800 m, and ostur aggregations (Howell *et al*., 2016). Global models of octocorals that cover the Celtic Seas (Yesson *et al*., 2012) have limited resolution. Habitat suitability models also allow future distributions to be modelled under climate change scenarios (e.g., Morato *et al*., 2020). This can facilitate identification of potential climate refugia that could be pertinent when prioritizing areas to be protected from fishing now. ICES has initiated a workshop to set standards for bringing SDM work into the advisory process (see Section 4.7).

References

Davies, A.J., Wisshak, M., Orr, J.C. and Roberts, J.M. 2008. Predicting suitable habitat for the cold-water coral Lophelia pertusa (Scleractinia). Deep Sea Research Part I: Oceanographic Research Papers 55: 1048-1062. https://doi.org/10.1016/j.dsr.2008.04.010

Dolan, M., Grehan, A.J., Guinan, J.C., and Brown, C. 2008. Modelling the local distribution of cold-water corals in relation to bathymetric variables: Adding spatial context to deep-sea video data. Deep-Sea Research I 55: 1564-1579.

FAO. 2009. The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas. Activities pages. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 30 April 2013. http://www.fao.org/fishery/topic/166308/en

Guinan, J., Grehan, A.J., Dolan, M.F.J., and Brown, C. 2009a. Quantifying relationships be-tween video observations of cold-water coral cover and seafloor features in Rockall Trough, west of Ireland. Marine Ecology Progress Series 375: 125-138.

Guinan, J., Brown, C., Dolan, M.F.J., and Grehan, A.J. 2009b. Ecological niche modelling of the distribution of cold-water coral habitat using underwater remote sensing data. Ecological Informatics 4:83-92.

Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K. 2014. Geomorphology of the oceans. Marine Geology 352: 4-24.

Howell, K.L., Piechaud, N., Downie, A.L. and Kenny, A. 2016. The distribution of deep-sea sponge aggregations in the North Atlantic and implications for their effective spatial management. Deep Sea Research Part I: Oceanographic Research Papers 115: 309-320.

Howell, K.L., Holt, R., Endrino, I.P. and Stewart, H. 2011. When the species is also a habitat: comparing the predictively modelled distributions of *Lophelia pertusa* and the reef habitat it forms. Biological Conservation 144: 2656–2665.

ICES. 2017. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 20–24 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:25. 121 pp.

ICES. 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.

ICES. 2019. Stakeholder workshop to disseminate the ICES deep-sea access regulation technical service, and scope the required steps for regulatory purposes (WKREG). ICES Scientific Re-ports. 1:ISS NO. 31 pp. http://doi.org/10.17895/ices.pub.5636

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

Kenchington, E., *et al*. 2016. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada Using Kernel Density Analyses and Species Distribution Models. DFO Canadian Science Advisory Secretariat Research Document 2016/093. vi + 178 p.

Mohn, C., *et al*. 2014. Linking benthic hydrodynamics and cold-water coral occurrences: A high-resolution model study at three cold-water coral provinces in the NE Atlantic. Progress in Oceanography 122: 92-104.

Morato, T., *et al*. 2020. Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic. Global Change Biology 26(4):2181-2202. doi:10.1111/gcb.14996

Morato, T., *et al.* 2018. A Multi Criteria Assessment Method for Identifying Vulnerable Marine Ecosystems in the North-East Atlantic. Frontiers in Marine Science 5, doi:10.3389/fmars.2018.00460

NAFO. 2019. SC Working Group on Ecosystem Science and Assessment – November 2019. Report of the 12th Meeting of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WG-ESA). NAFO SCS Doc. 19.25, Serial No N7027.

Rengstorf, A.M., Yesson, C., Brown, C., and Grehan, A.J. 2013. High-resolution habitat suit-ability modelling can improve conservation of vulnerable marine ecosystems in the deep sea. Journal of Biogeography 40: 1702-1714.

Rengstorf, A.M., Mohn, C., Brown, C., Wisz, M.S., and Grehan, A.J. 2014. Predicting the dis-tribution of deep-sea vulnerable marine ecosystems using high-resolution data: Considerations and novel approaches. Deep-Sea Research I 93: 72-82.

Rice, J.C. and Rochet, M.J. 2005. A framework for selecting a suite of indicators for fisheries management. ICES Journal of Marine Science 62: 516-527.

Ross, R.E., and Howell, K.L. 2013. Use of predictive habitat modelling to assess the distribution and extent of the current protection of 'listed' deep-sea habitats. Diversity and Distributions 19: 433-445.

Yesson, C., *et al.* 2012. Global habitat suitability of cold-water octocorals. Journal of Biogeography 39(7): 1278-1292.

4.3 Establishment of a Fishing Footprint

ICES VMS Data Call

The coupling of VMS (vessel monitoring systems) data with logbook data is currently the most practical and cost-effective method for describing the spatial dynamics of fishing activities. Since 2012 ICES has requested VMS and logbook data from ICES member countries via an annual data call (**link**). EU member states are obligated to make such data available to support scientific analysis and as a basis for advice to fisheries management. A summary of the raw format of VMS data and the methods used to combine it with logbook information is given in Annex 1 of this report.

VMS Data Quality Control

Standardisation of methods for both the analysis of input data and the production of products to describe the development of fisheries in space and time is a fundamental part of the work of the ICES WGSFD (see data flow Figure 4.7). Downstream this benefits users of its data products by ensuring confidence when using these as the basis of advice. In line with its terms of reference WGSFD is continually improving methods and ensuring high quality of VMS and logbook data processing in its data requests and quality checks; working in conjunction with the ICES Secretariat.

The quality of outputs produced by the ICES Secretariat and WGSFD is dependent on the quality of the data produced by member states, as well as the routines used to process and analyse these data. The ICES Secretariat, ICES Data Centre and WGSFD use a multi-step approach, following a four-eye principle to ensure that data submissions and subsequent aggregated data are of the best quality possible. The complexity of the data and differences in national setups for holding, extracting and processing VMS and logbook data make the development of standardised workflows a challenging task. The status of the latest national data submissions provided to WGSFD is available in Table 1 of the latest WGSFD report (ICES, 2019a).

Inter-annual differences that may suggest data issues are detected by scrutinising national data using standardised R-scripts to check for questionable deviations in summaries of the most important variables (fisheries effort, landings etc.); maps of inter-annual differences are then reviewed by the WGSFD chairs and feedback is passed on to the ICES Data Centre and data providers. National datasets are then aggregated and similar visual checks are carried out on maps of each of the main combined BENTHIS métiers (see Annex 1).

All scripts (R and SQL) used to run the quality checks are stored on the ICES GitHub so that the routines can be checked and updated as part of the VMS data workflow and downloaded by data submitters afresh each year. To reduce workloads associated with the quality control process, WGSFD and the ICES Secretariat have begun working on an R-shiny web application that would allow data submitters to view summaries and maps of their data prior to uploading it. Data submitters are likely to have greater knowledge of their own national fisheries and would be best placed to quality check their data in the first instance.

ICES Data Products and Use of VMS Data for WKEUVME

ICES has an agreed VMS/logbook access and use policy for data resulting from its data call. This governs the process of who has access and what purposes the data can be used for. In the first instance the ICES

Data Centre works closely with the Working Group on Spatial Fisheries Data (WGSFD) to analyse the data for estimating the spatial distribution of fishing activity and its impact on the seabed.

VMS data products produced through the ICES VMS and Logbook data call are currently aggregated at a spatial resolution of 0.05 x 0.05 degrees by national data submitters. These national datasets are combined by the ICES Secretariat to produce combined outputs. The C-square cell size used for this aggregation was chosen as it represents an optimum solution given the current time interval between the polling frequency seen in the available VMS data (typically one hour, but ranging between 15 minutes and 2 hours) and the distance a vessel travelling at speeds consistent with fishing will cover during this period. This minimises the probability of a vessel crossing a cell without being observed. To move to a finer spatial resolution involves balancing trade-offs in terms of precision, computational complexity and confidence in the comprehensiveness of the data. It also results in more spatial units that have fewer vessels present which will increase the quantity of data which would need to be supressed to protect anonymity and sensitive data. The costs and benefits associated with changes in spatial resolution of the VMS data aggregation is being investigated within the current terms of reference of WGSFD. ICES uses VMS data in a number of its advisory products, the two most widely used are the spatial distribution of effort (kW fishing hours) and the surface and/or subsurface disturbance by mobile bottom-contacting fishing gear, expressed as average swept-area ratios (SAR).

Fishing effort (kW fishing hours) represents all vessels > 12 m which have vessel monitoring systems. The number of hours fished is provided with the data call. It is acknowledged that fishing effort by vessels < 12 m may be significant, particularly in inshore areas. The swept area is calculated as hours fished x average fishing speed x gear width. The gear width which is expressed as surface and subsurface bottom contact is estimated based on relationships between average gear widths and average vessel length or engine power (kW), as stated in Eigaard *et al.* (2016) and using ICES expert input. The swept-area ratio is the sum of the swept area divided by the area of each grid cell. Therefore the C-square SAR value indicates the theoretical number of times the entire grid cell has been swept if effort was evenly distributed within the cell. The swept-area ratio is calculated separately for surface and subsurface contact.

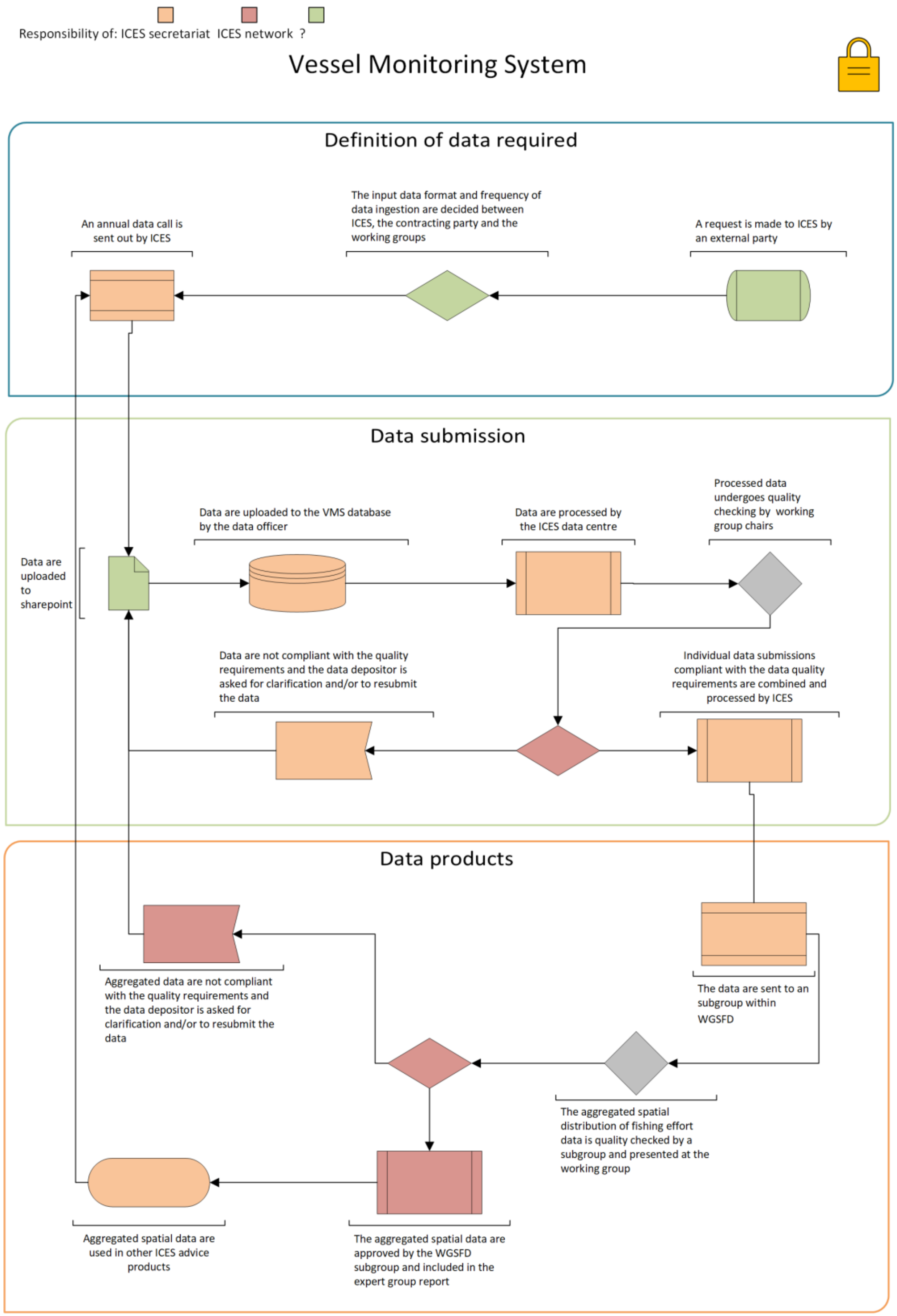


Figure 4.7. ICES VMS and logbook data flow schematic draft. Please note that the above ICES VMS and logbook data flow is draft version produced prior to formal acceptance by the ICES advisory committee (ACOM) and its publication. The above version of the VME data flow schematic may thus differ once finalized.

To meet the TORs for WKEUVME presence/absence and SAR fishing data layers for a selection of gear métiers were made available to the workshop. SAR is assumed to be the best fishing intensity metric when considering the impact of fisheries on benthic communities given that it accounts for gear contact with the seabed. There is an existing literature base documenting the relationship between the biomass of benthic species and SARs (Hiddink *et al*., 2018; ICES, 2019b). The SAR value has also been used in ICES WGFBIT as a descriptor of value of areas to the fishermen, as it is likely to be an approximation of the net profitability of the location, since effort is likely to be concentrated on the most profitable fishing grounds.

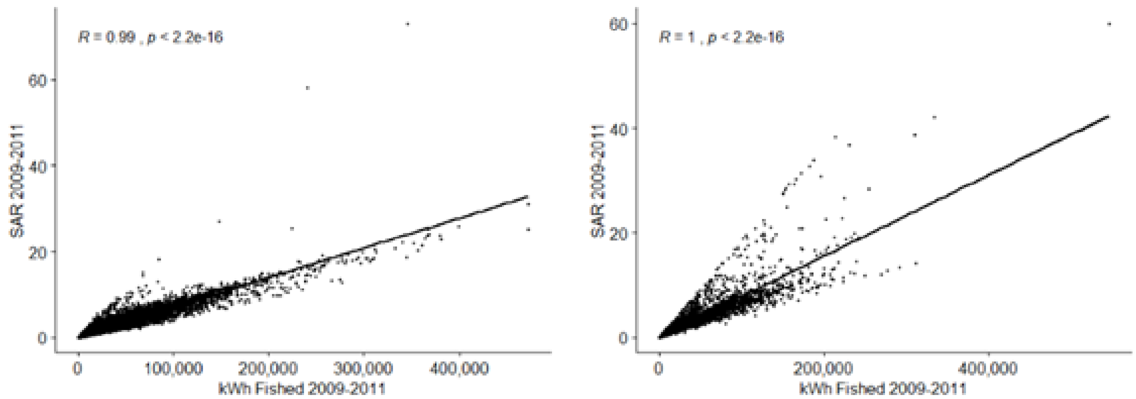


Figure 4.8. Scatterplots with Spearman's rank correlations between SAR and fishing kWh values for all C-squares (2009-2011) in the Celtic Seas (left) and Bay of Biscay Iberian Coast (right) Ecoregions.

During WKEUVME plenary sessions, interest was also expressed in kW fishing hours as an alternative measure of fishing intensity to SAR fishing impact metrics. Analysis of the correlations between SAR and mW fishing hour values for C-squares showed the two measures to be highly correlated in both ecoregions (Figure 4.8) and consistent over time both during and after the reference period (2009-2011). In addition to this, the distribution of the percentiles of the C-squares was near identical with minor deviations in the more sparsely fished areas of the fishing footprint (Figures 4.9, 4.10). On this basis it was decided to develop the VME closure scenarios (Section 4.5) using SAR value thresholds as the measure of fishing impact.

Workflow and Criteria Used to Delineate the Fishing Footprint

To establish rules for how the footprint could be refined, a set of scenarios were proposed (Table 4.1). All scenarios presented use C-squares (0.05 × 0.05 degree cells) as the basic unit; this will result in a marginally larger footprint than is actually fished as the fished area will be defined in C-squares rather than actual ground covered by fishing tracks. This is an inevitable decision given the resolution of the ICES WGSFD data products is at a C-square level and further refinement using individual vessel track data is not within the scope of this application. C-squares were considered to be fished where either the Swept Area Ratio (SAR) for mobile bottom-contacting fishing gears was > 0 or there was a presence of fishing activity for static gears.

Scenario 0, the baseline case, includes all C-squares for which any part of the C-square lies within the 400-800 m contour and was fished within the reference period (2009-2011). In Scenario 1 a bathymetric rule for establishing the bounds of the footprint is applied to include all C-squares within waters of 400-800 m depth, regardless of fishing presence. This approach may offer a simplistic solution for EEZs where the percentage of fished C-squares within this bathymetric range is very high; for example France (97%) and Ireland (97%) (Table 4.2). This would be a precautionary approach (sensu FAO). given that the reference period in this request is narrow, and the extent and proportion of the fished area within the 400-800 m depth range may not be constant.

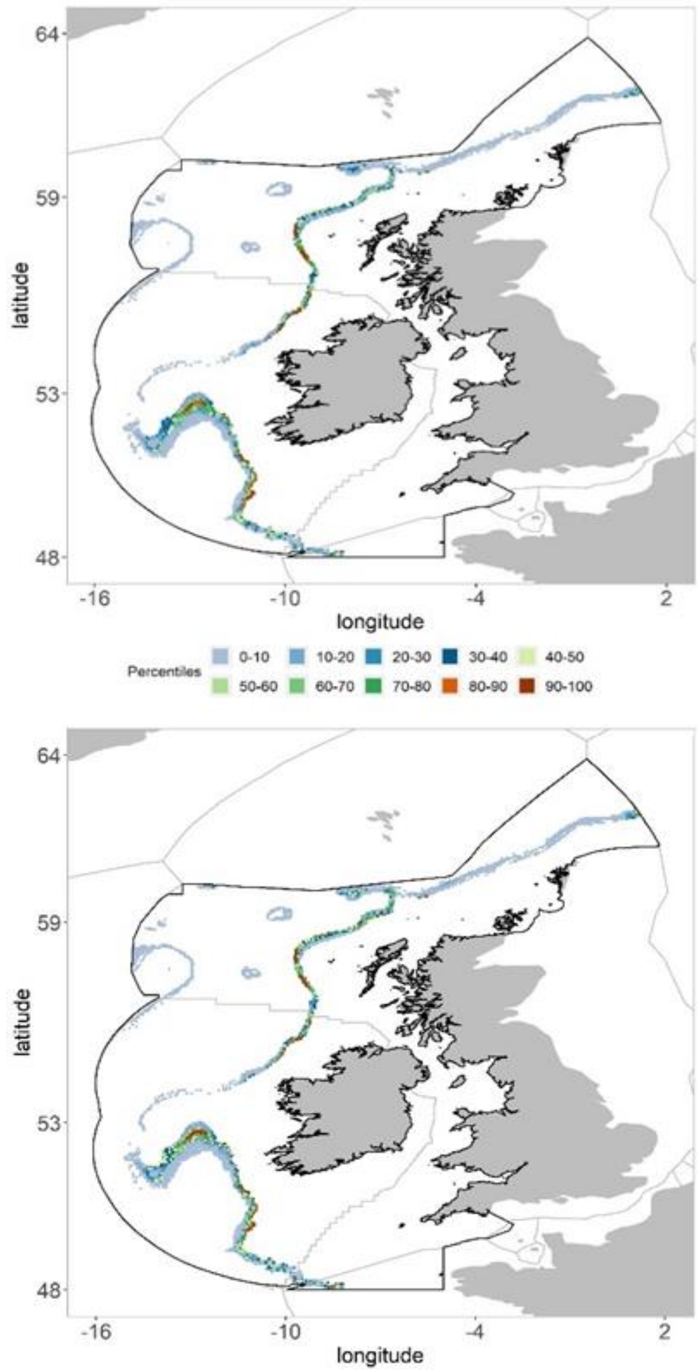


Figure 4.9. Top: The area associated with each 10th-percentile interval of the SAR effort in the Celtic Seas Ecoregion. Bottom: The area associated with each 10th-percentile interval of fishing (kWh). Data for both maps are for the reference period 2009-2011. The light blue C-squares are least fished and the brown C-squares are the most fished.

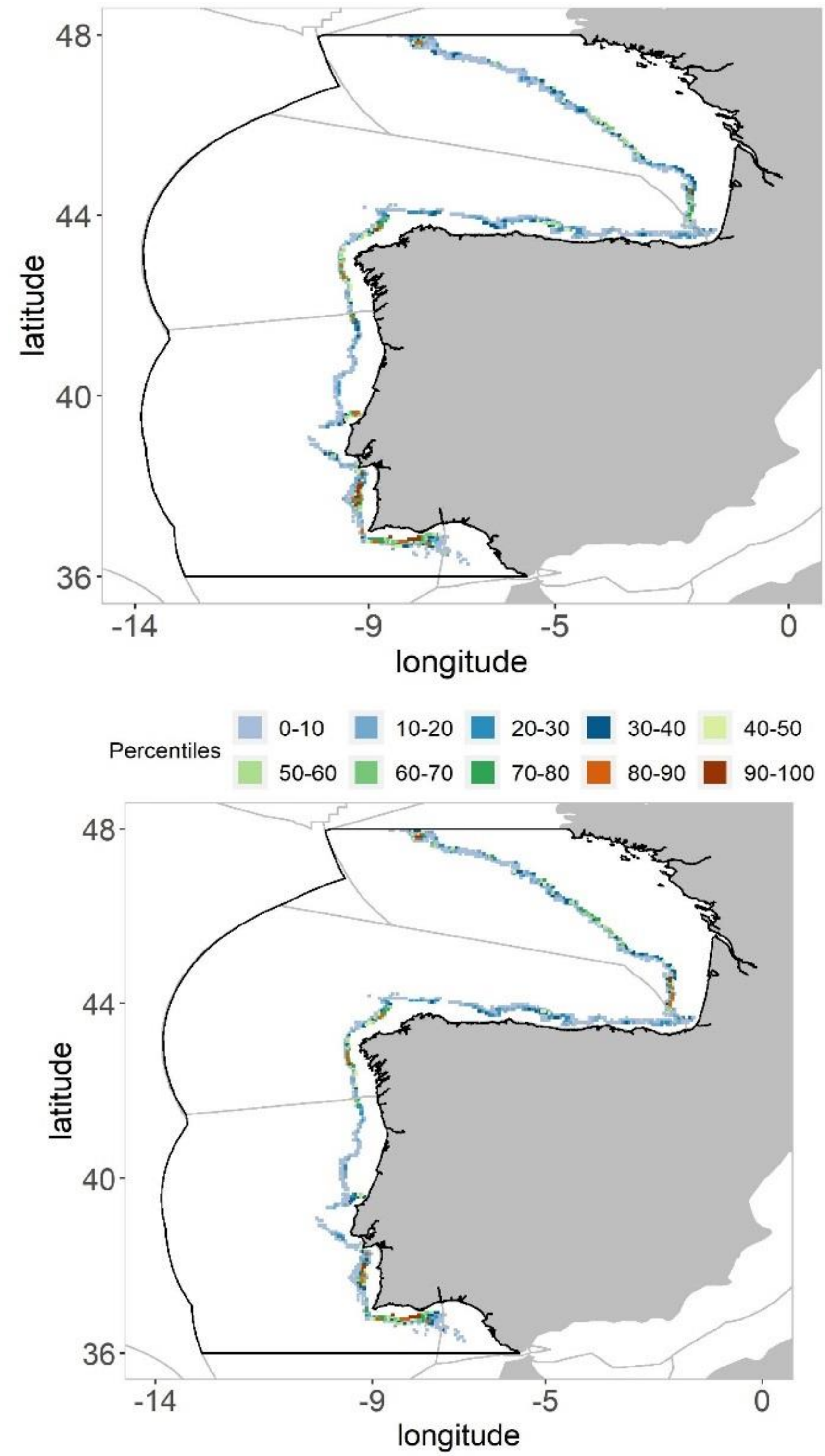
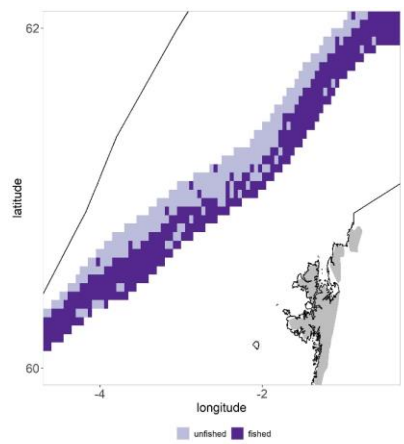


Figure 4.10. Top: The area associated with each 10th-percentile interval of the SAR effort in the Bay of Biscay and Iberian Coast Ecoregion. Bottom: The area associated with each 10th-percentile interval of fishing (kWh). Data in both maps are for the reference period 2009-2011. The light blue C-squares are least fished and the brown C-squares are the most fished.

Table 4.1. Proposed scenarios for defining the fishing footprint (presence/absence of mobile bottom contact gear (MBCG) and static gears) using ICES WGSFD data products. Scenario 2 was used by WKEUVME to assess fishing overlap with VMEs.

Scenario	Description	Rationale
Scenario 0	C-squares where there is fishing activity recorded during 2009-2011 in waters of European Union member states between 400-800m depth.	The "base case" scenario against which other options can be explored.
Scenario 1	All C-squares in waters of EU member states, bounded by the 400m and 800m isobaths, regardless of fishing activity in the 2009-11 period.	A simple bathymetric rule for establishing the footprint in management measures.
Scenario 2	C-squares as defined in Scenario 0, with a stipulation that to be included in the footprint, a cell must touch one other cell on an edge or vertex.	As for the base case, however "orphaned" C-squares which fall outside of contiguous areas are culled from the footprint.
Scenario 3	C-squares as defined in Scenario 0, with a stipulation that to be included in the footprint, a cell must touch two other cells on an edge or vertex.	As for Scenario 2, but creates smoother edges on the contiguous polygons.



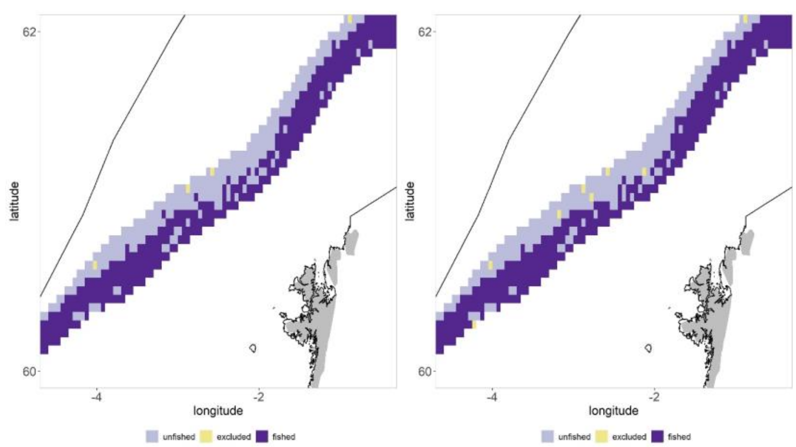


Figure 4.11. Top: Scenario 0 = Fishing footprint (MBCG and Static) in 2009-2011 (between 400 m and 800 m depth). Bottom Left: Scenario 2 = Fishing footprint of all (MBCG and Static) in 2009-2011 (between 400 m and 800 m depth) excluding C-squares with no shared vertices. Bottom Right: Scenario 3 = Fishing footprint (MBCG and Static) in 2009-2011 (between 400 m and 800 m depth) excluding C-squares that share vertices with less than two other C-squares.

The rationale for Scenarios 2 and 3 is to refine the footprint by removing less contiguous C-squares that are more likely to represent artefacts in the VMS data. These could represent VMS points classified as fishing based on speed profiles, where in fact the vessels may have been transiting at low speeds due to poor weather conditions, or low frequencies of fishing pings at the edge of fishing grounds. All isolated C-squares that do not share any boundaries by edge or vertex with another fished C-square are removed in Scenario 2. Scenario 3 extends this approach to remove all C-squares sharing less than 2 boundaries (Figure 4.11).

The scenario options listed are suggestions of rule's on which the definition of the fishery footprint extent could be based, however, they are by no means a conclusive list. For the work carried out in WKEUVME the expert group chose to work with a fishery footprint as designated by Scenario 2 which is carried through to all subsequent analyses of fishing overlap with VMEs.

When discussing issues of relevance to the area defined by the footprint, it is useful to consider the way in which it has been framed in legislation (Regulation (EU) 2016/2336) and in which similar footprints have been used in the North Atlantic RFMO's. In each case, where a footprint has been defined, it is considered an "existing fishing area", where fishing can be conducted in a normal manner, subject to the agreed rules of the organisation. Outside of this footprint is considered an "exploratory area", where fishing can still take place, subject to, for example, enhanced rules around data collection. Areas outside of the footprint should therefore not necessarily be seen as areas where fishing is "prohibited", other than where they overlay areas where VME's, both biological and physical, are known to exist and measures are in place for their protection, but rather simply as areas where fishing has not occurred within the reference period.

The area considered in this work is bounded to the lower depth by the 800 m contour, corresponding with European legislation (Regulation (EU) 2016/2336; European Union, 2016), which prohibits fishing below this depth. An upper bound of 400 m has been used, which is a practical decision, and while it may not represent all of the activity of vessels with an authorisation to fish for deep-sea species, it does align with Article 9 of Regulation (EU) 2016/2336 (European Union, 2016), which aims to implement specific requirements for the protection of VMEs in waters below this depth. Fishing activity by vessels authorised to fish in waters shallower than 400 m may take place, however, this licence condition is not specified within the ICES VMS data call, therefore it is not possible to advise on the actual extent fished by these vessels, and it may be beyond the scope of this group, which aims to advise on interactions between fisheries and VMEs in the context of this legislation, to do so.

Table 4.2 Total numbers of C-squares within the fishing footprint (mobile bottom contact gear (MBCG) and static gears) under each scenario (Table 4.1) for the Celtic Seas Ecoregion.

EEZ	Scenario 0	Scenario 1	Scenario 2	Scenario 3
United Kingdom	1925	2442	1920	1911
Ireland	2230	2306	2229	2227
France	72	75	72	72

Table 4.3. Total numbers of C-squares within the fishing footprint (mobile bottom contact gear (MBCG) and static gears) under each scenario (Table 4.1) for the Bay of Biscay and Iberian Coast Ecoregion.

EEZ	Scenario 0	Scenario 1	Scenario 2	Scenario 3
France	487	501	487	484
Portugal	571	696	569	563
Spain	669	866	666	656

Creating a fishing footprint based on Scenario 1 (Table 4.1), which assumes all C-squares within the bathymetric range 400-800 m are fished, results in the largest footprint. The increase in C-squares is greatest for the United Kingdom, Portugal and Spain which have the lowest percentages of fished C-squares within their EEZs. For Ireland and France the increase is minimal as the depth range in their EEZ is almost entirely fished (Tables 4.2, 4.3). Scenarios 2 and 3 (Table 4.1) result in very similar number of C-squares within the fishing footprint of all EEZs; this demonstrates that there are very few isolated C-squares or C-squares with vertex contacts with only one other C-square of the larger fishing footprint. The United Kingdom and Spain see the largest reductions in numbers of C-squares but this amounts to only 14 and 13 less than the full fished extent.

Caveats and Limitations of the Fishing Footprint

There are two primary quality assurance issues relating to the fishery footprint as defined using the aggregated data provided by WGSFD. These are that associated with matching of positional and logbook data, and those for vessels for which VMS data are not available (e.g., < 12 m). The level of correctly assigning effort (VMS) to logbook landings, known as matching, is highly variable across métiers and regions, ranging from 1% for dredges in the Bay of Biscay to 100% of demersal seines in the Celtic Seas (ICES, 2016). In relation to otter trawls, the percentages vary from 60% in the Bay of Biscay and Iberian coast to 97% in Arctic waters. Knowledge of localised fisheries behaviour and distribution patterns may be required to refine the fishing footprint.

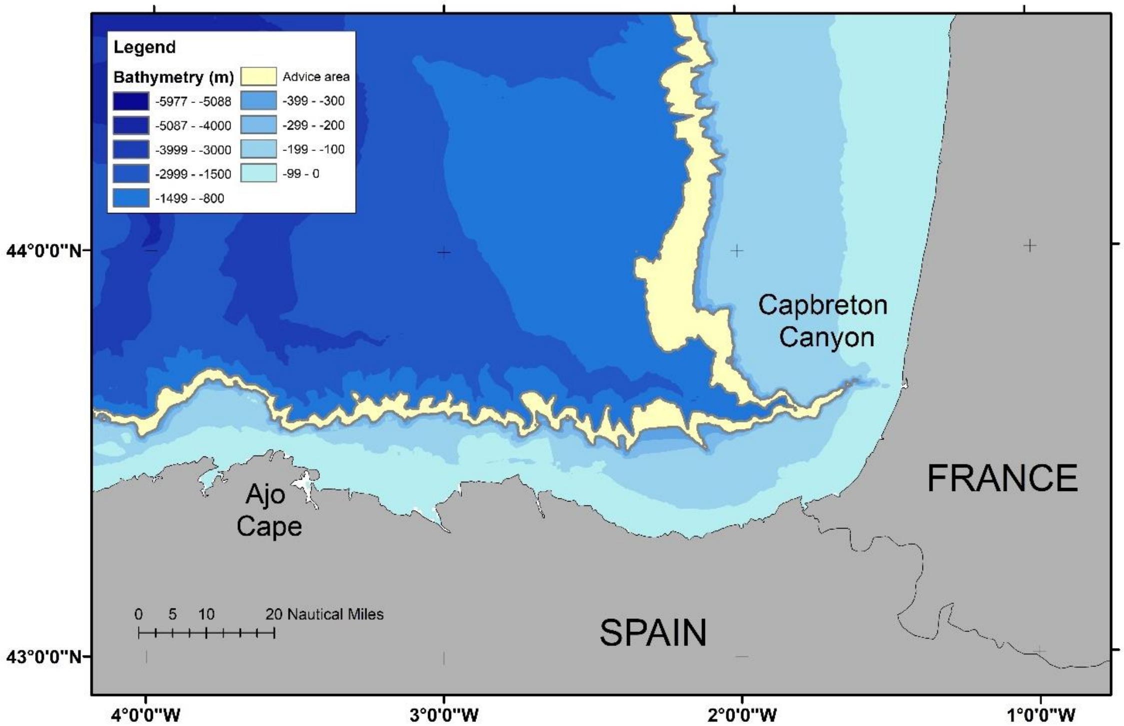


Figure 4.12. Map illustrating the narrowness of the continental shelf and the proximity of the deep-sea to the coast in some areas of the Iberian peninsula (e.g., in Ajo Cape and Capbreton canyon the advice area is less than 10 nm from the shoreline). This feature is common across the Iberian region, including some areas of Portugal and the Gulf of Cádiz.

These two quality assurance issues are both relevant for the Bay of Biscay and Iberian Coast Ecoregion. The proximity in some areas of the deep-sea to the coast (Figure 4.12) means that the deep-sea is also accessible to small boats which do not have VMS. Therefore, in these areas the fishery footprint could potentially be underestimated. This issue mainly affects static gears which are able to operate in these depths despite small vessel lengths.

The matching of Spanish effort and catch data in the data provided to ICES for this data call is believed to be quite low particularly for the reference period (2009-2011). A low percentage of matching means that the effort mapped is likely to underestimate the fishery footprint which may not reflect the full extent of the fishing activity because of the absence from the footprint of trawlable grounds exposed to low or very low effort. This caveat has been recently identified for this Spanish data and a new approach for merging the data which allows much higher percentages of matching in some specific gear (e.g., > 90% for OTB see Table 4.4) has been used for the submission in response to the latest ICES WGSFD data call.

Table 4.4. Evolution in the percentage of trips which have been successfully matched using fishing effort (present in the logbooks) and VMS data for the Spanish fleet for métier and year (period 2009-2011). The percentage in ICES data is the matching percentage obtained in November 2018 in the first submission of Spanish data to ICES. The current percentages refer to the percentage values which are expected to be obtain in the update. Métiers; GNS (Gillnet), LLD (Drifting longlines), LLS (Set longlines), OTB (Bottom otter trawl).

Percentage of Effort from Trips with VMS Data			
Métier	Year	Current Percentage in ICES Data (%)	Current Percentage after Updating (%)
GNS	2009	8	29
GNS	2010	7	29
GNS	2011	7	27
LLD	2009	82	83
LLD	2010	85	85
LLD	2011	85	85
LLS	2009	25	42
LLS	2010	22	40
LLS	2011	22	41
OTB	2009	37	92
OTB	2010	38	91
OTB	2011	42	92
Period 2009-2011		50-60%	80-85%

Issues with Static Gears

While it is possible to quantify the impacts of mobile bottom-contacting gears using VMS data, issues still surround the use of VMS data from vessels fishing with static gears. Spatial effort indicators can only be developed where both VMS and logbook data are provided, and therefore miss a substantial proportion of the fleets' fishing with passive gears that are below the length at which vessels are required to have logbooks and VMS (< 10 m; < 8 m in the Baltic). VMS coverage is low for static gears both in relation to effort and landing weight. Where VMS data are available there are often other key parameters needed to estimate static gear fishing effort that are missing. Due to variation in reported details it is not always clear what the start and stop timing or positions represent for static gear and in some instances these are overlapping. Disparity in the countries submitting data results in values that are not directly comparable to similar summaries provided by WGSFD in previous years. A summary of VMS coverage for vessels fishing with static gears between 2009-2018 from logbook data submitted to the ICES VMS data call is found in Table 9 of the WGSFD 2019 report (ICES, 2019a). ICES WGSFD has a term of reference to explore this issue, however, at present, it is only possible to reliably infer presence/absence and relative metrics of effort. The benthic footprint and impacts of these gears are also largely unknown.

Assessing Social and Economic Impacts

Ecosystem-based fisheries management is a core goal of ICES (ICES 2019c). Furthermore, the CFP (European Union, 2013) enshrines the ecosystem approach to fisheries management in legislation, aiming to achieve environmentally, economically and socially sustainable fisheries. Implementing an ecosystem approach requires careful consideration of the trade-offs that come when management decisions are made (Levin *et al.*, 2009; Voss *et al.*, 2014; ICES, 2017). This is particularly relevant in the context of the current request, which seeks to identify the appropriate areas of seabed to close to fishing in order to protect vulnerable marine ecosystems, at the expense of fishing effort. As this report presents numerous ways in which these decisions can be made and the data presented (multiple levels of precision, numerous scenarios) it would also be pertinent to take into account the potential social and economic impacts of these decisions. In order to accurately assess impacts, it is important to know who is fishing (which nations), how much, and how reliant they are on the resource (i.e., how affected they will be). The provision of the data as fishing presence/absence within an EEZ currently does not allow identification of which nations are fishing in each region, nor how much.

Fishing Footprint Polygons

Once the fishing presence/absence data has been refined into a footprint by applying a rule such as one of the scenarios proposed in Table 4.1, the remaining fished C-squares can be aggregated into fished polygons such as seen in NAFO and NEAFC. This can be done by combining or unioning the C-square polygons which are touching, and resolving their internal boundaries to return single polygon geometries. It is optional to either retain or fill in unfished holes in the polygons. For the fishing footprint polygons of the two ecoregions explored here, the holes are small and it seems appropriate to fill them in; if they were larger unfished holes, further clarification in the form of rules might be needed. An example of unioning the fishing footprints of the Celtic Seas and Bay of Biscay Iberian Coast Ecoregions is shown below in Figure 4.13 where Scenario 2 (Table 4.1) has been applied, whereby all satellite fished C-squares are removed from the fishing footprint. Figure 4.13 shows that this results in six fishing footprint polygons for the Celtic Seas and nine for the Bay of Biscay Iberian Coast Ecoregions.

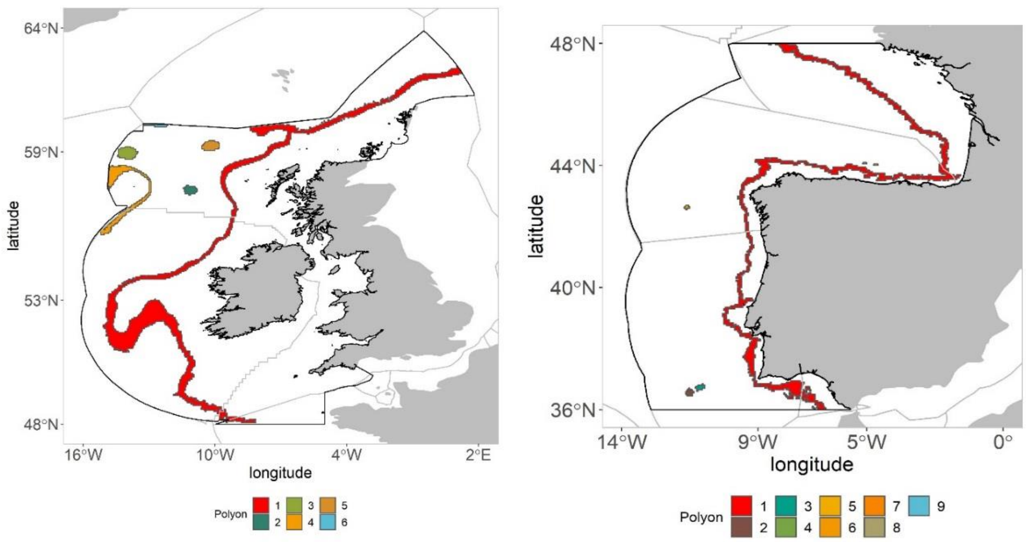


Figure 4.13. Fishing footprint (MBCG + Static) polygons following the unioning of touching fished C-squares for the Celtic Seas Ecoregion (left) and the Bay of Biscay Iberian Coast Ecoregion (right).

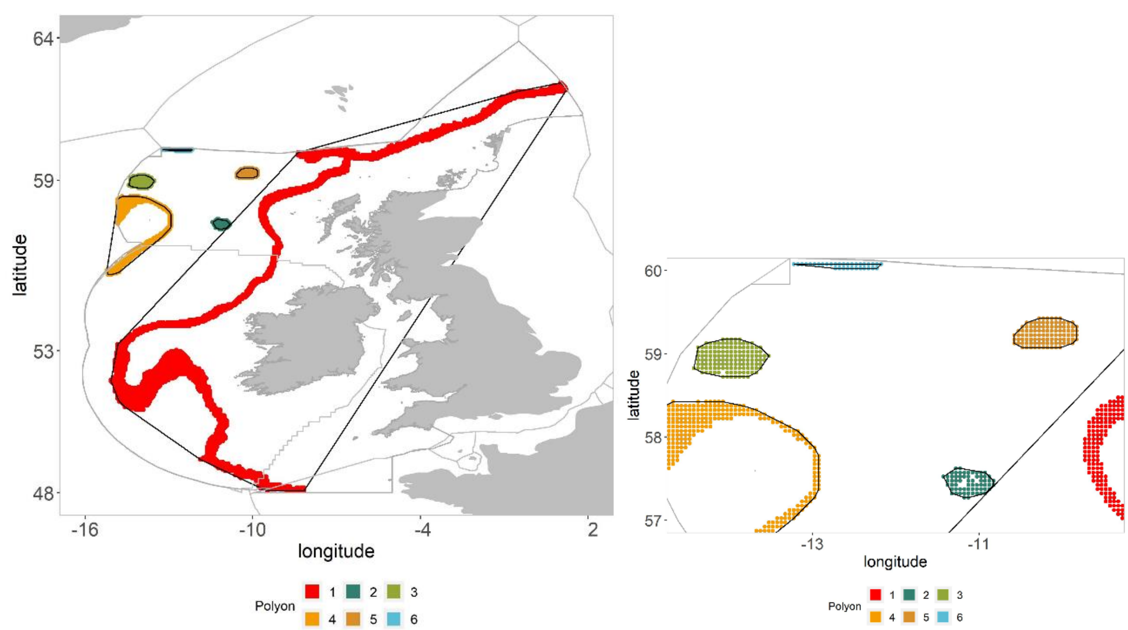


Figure 4.14. Convex hulls applied to the centroids of fished (MBCG + Static) C-squares grouped by touching C-squares (left). The figure on the right shows a zoomed in section of the plot to show that the convex hull method is appropriate for use in definining fishing footprint polygons for seamount and banks where the whole topography is fished.

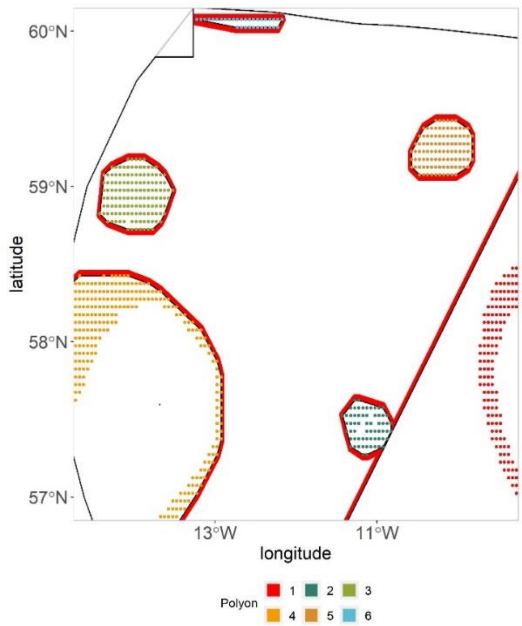


Figure 4.15. Buffers of half C-square diagonal (0.03535°) applied to the convex hulls of the Celtic Seas fishing (MBCG + Static) footprint polygons.

Whilst the number of fishing polygons in each ecoregion is small, their shape complexity and number of coordinate points is very high, which would potentially cause issues for management and fishers. There are a number of ways to simplify the boundaries surrounding groups of spatial point or polygon data. For these to be applied, firstly each fished C-square must be identified as falling within one of the outlined fishing footprint polygons from Figure 4.13. Secondly the C-squares can then be transformed into pairs of latitudes and longitudes to dissolve the coordinates of the vertices into a cloud of points on which a minimum convex hull algorithm can be run. A minimum convex hull polygon draws the smallest polygon around a set of points with all interior angles less than 180 degrees. There are several R packages that have functions for creating convex hulls including alphahull, dismo, geom, geometry, grDevices and rgeos. When a convex hull algorithm is applied to the centroids of fished C-squares we can that this method is only suitable for creating polygon closures around isolated symmetric aggregations of fished C-squares (Figure 4.14) such as George Bligh Bank, Rosemary Bank, Anton Dohrn Seamount and Lousy Bank. The method is not suitable for coastal shelf/bank edge fishery footprints that have narrow and winding geometries.

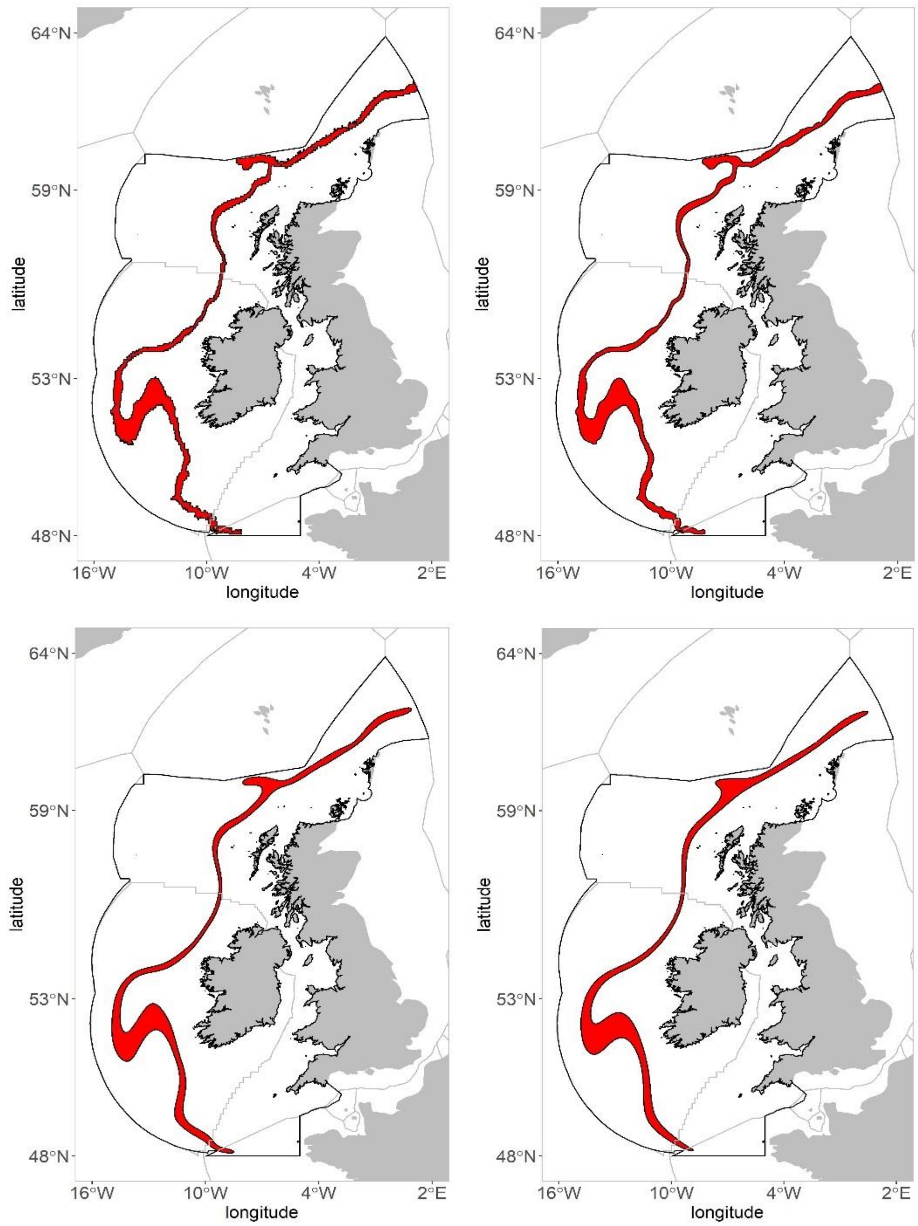


Figure 4.16. Kernel smoothed fishing (MBCG + Static) footprint polygon for the Celtic Seas coastal shelf edge with an increase of the degree of smoothing and generalization by increasing the smoothness parameter from 0, 10, 50, 100 moving from left to right, top to bottom.

Where each C-squares is now being represented by its centroid point (as in the convex hull application; Figure 4.14) it is then advisable to apply a buffer (half the C-square diagonal 0.03535) to the convex hull perimeter (Figure 4.15) to ensure that the full extent of the C-square is included in the fishing footprint polygon. This is in line with the assumption that the SAR value for that C-square could represent fishing activity in any area of the C-square.

For the coastal shelf edge and deep-water bank edge polygons (Figure 4.13) which have a greater shape complexity, the convex hull method is not appropriate. In these instances a concave hull which bends inwards rather than outwards is required to achieve a simplification of the clouds geometry. This can be done either by applying a concave hull (using R packages such as alpha-hull or concaveman) or a smoother (using the smoothr R package). Smoothr offers tools for smoothing or tidying spatial features in this case polygons, Figure 4.16 shows how kernel smoothing (using a Gaussian kernel regression) has been applied to simultaneously smooth and generalise the perimeter of the coastal shelf fished footprint polygon. In this example the smoothness parameter has been increased from 0-100 moving from top left to bottom right. An approach such as this may offer a solution for simplifying the shape complexity of fishing footprints. It could then be an option to subsample the polygon vertices/boundary to get a concise set of co-ordinates for use by management in future.

References

Eigaard, O.R., *et al*. 2016. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science: Journal du Conseil 73: i27i43

European Union. 2013. Regulation(EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. Official Journal of the European Union, 354. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1380.

European Union. 2016. Regulation (EU) 2016/2336 of the European Parliament and of the Council of 14 December 2016 establishing specific conditions for fishing for deep-sea stocks in the north-east Atlantic and provisions for fishing in international waters of the north-east Atlantic and repealing Council Regulation (EC) No 2347/2002 http://data.europa.eu/eli/reg/2016/2336/oj.

Hiddink, J.G., *et al.* 2018. Assessing bottom-trawling impacts based on the longevity of benthic invertebrates. Journal of Applied Ecology 56 (5):1075-1084. https://doi.org/10.1111/1365-2664.13278

ICES. 2016. OSPAR request for further development of fishing intensity and pressure mapping. http://ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special_Requests/OSPAR_further_development_of_fishing_intensity_and_pressure_mapping.pdf

ICES. 2017. Report of the Workshop to evaluate trade-offs between the impact on seafloor habitats and provisions of catch/value (WKTRADE): 112.

ICES. 2019a. Working Group on Spatial Fisheries Data (WGSFD). ICES Scientific Reports. 1:52. 144 pp. http://doi.org/10.17895/ices.pub.5648

ICES. 2019b. Interim Report of the Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), 12–16 November 2018, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/HAPISG:21. 74 pp.

ICES. 2019c. Strategic Plan. http://doi.org/10.17895/ices.pub.5470

Levin, P. S., Fogarty, M. J., Murawski, S. A., and Fluharty, D. 2009. Integrated Ecosystem Assessments: Developing the Scientific Basis for Ecosystem-Based Management of the Ocean. PLoS Biology, 7: e1000014.

Voss, R., Quaas, M. F., Schmidt, J. O., Tahvonen, O., Lindegren, M., and Möllmann, C. 2014. Assessing Social – Ecological Trade-Offs to Advance Ecosystem-Based Fisheries Management. PLoS ONE, 9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4182428/ (Accessed 28 May 2020).

4.4 Fishing Intensity

To understand the distribution of fishing pressure it is necessary to derive a spatially resolved index of fishing intensity. For mobile bottom-contacting gears, the available metric for such fishing intensity is the area swept per unit area, or "swept area ratio" (SAR), i.e., the area of the seabed which is contacted by the fishing gear, in relation to a surface area of the C-square. Information on fishing intensity is drawn from VMS (vessel monitoring system) and fisheries logbook data. In its raw format, VMS data are geographically distinct points, so-called "pings", providing information about the state of a vessel at a point in time: its position, instantaneous speed and heading. In EU waters VMS is transmitted at a minimum interval of approximately 2 hours, but with higher polling rates for some countries, fisheries or vessels. VMS data points can be linked to logbook data in order to get additional information about the vessel flag country, gear code (equivalent to Data Collection Framework (DCF) level 4), fishing activity category (DCF level 6), average fishing speed, fishing hour, average vessel length, average engine power (kW), total landings weight and total value of all species caught. Following some analytical steps to identify for example, mis-reported pings (ICES, 2015), the vessel state (steaming, fishing or floating) is identified using the speed information. Only data which are assumed to represent fishing activity are then assigned to a C-square which is 0.05 x 0.05 degrees grid, about 15 km² (3km x 5km) at 60°N latitude, using the C-square approach (Rees, 2003).

In order to convert from a gridded sum of points to fishing intensity values, certain assumptions about the spread of the gear, the extent of bottom-contact and the fishing speed of the vessel need to be made (ICES, 2015). Submitted VMS datasets usually contain information on the gear based on standard DCF métiers (from EU logbooks, usually at the resolution of métier level 6) and the gear-specific fishing speed, but not on gear size and geometry. Therefore, vessel size - gear size relationships developed by the EU FP7 project BENTHIS project (Eigaard *et al*., 2016) are used to approximate the bottom-contact (e.g., gear width). To do this, it is necessary to aggregate métier level 6 to lower and more meaningful gear groups (so-called "BENTHIS métiers"), for which assumptions regarding the extent of bottom-contact were robust. Following this, fishing effort (hours) is aggregated per C-square for each métier and year. Fishing speeds are based on average speed values for each métier and grid cell submitted as part of the data call, or, where missing, a generalized estimate of speed is derived. Similarly, vessel length and engine power are submitted through the data call but where missing, average vessel length/engine power values are taken from the BENTHIS survey (Eigaard *et al*., 2016).

The fishing footprint describes the presence at any intensity of any gears that touch or have the potential to touch the bottom. A complementary way to describe the intensity of "areas fished with mobile bottom gear" is based on the SAR intensity values for otter trawls (Figures 4.17, 4.18); the dominant gear grouping in the 400-800 metre depth range. Following an approach used by NAFO (NAFO, 2016), Figure 4.17 shows the distribution of SAR intensity using the percentiles of total SAR for the Celtic Seas Ecoregion, while Figure 4.18 shows the same for the Bay of Biscay and Iberian Coast Ecoregion. The figures illustrate that 90% of total SAR intensity (core fishing area) occurs in < 50 % of the C-squares that are fished with otter trawls (dark bluein Figures 4.17b, 4.18b). The remaining C-squares are fished with low intensities and only contribute to 10% of total SAR (light blue in Figures 4.17b, 4.18b). Within the core fishing area, there are different hotspots where most of the fishing occurs (orange and brown in Figures 4.17c, 4.18c). The core fishing area and the locations with highest intensity are largely stable over time in the Celtic Seas Ecoregion; compare the period 2009-2011 (Figure 4.17c) with 2016-2019 (Figure 4.17d). In the Bay of Biscay and Iberian Coast Ecoregion, there is a lower intensity in the Gulf of Cádiz in the period 2016-2019 (Figure 4.18d) than in the reference period (Figure 4.18c), possibly reflecting missing data.

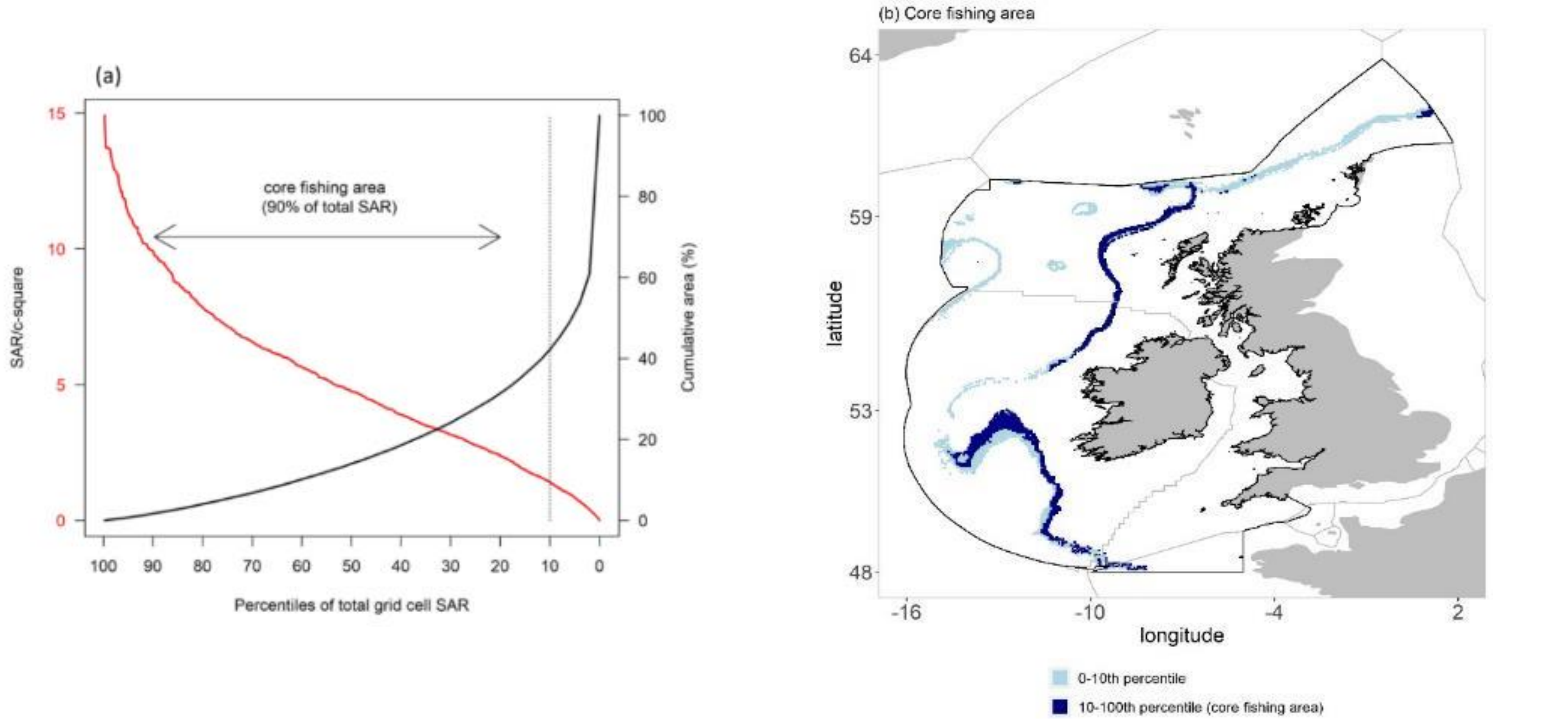


Figure 4.17. Celtic Seas Ecoregion. a) Percentiles of the total swept area ratio per year (average 2009-2011) sorted from high to low SAR C-squares for otter trawl gears within the fishing footprint in the 400-800 metre range; otter trawls are the dominant gear grouping at this depth (Table 4.5). 90% of the SAR effort occurs in less than 50% of the fished area (see vertical dashed line). The distribution of the 90% of the SAR effort is shown in b).

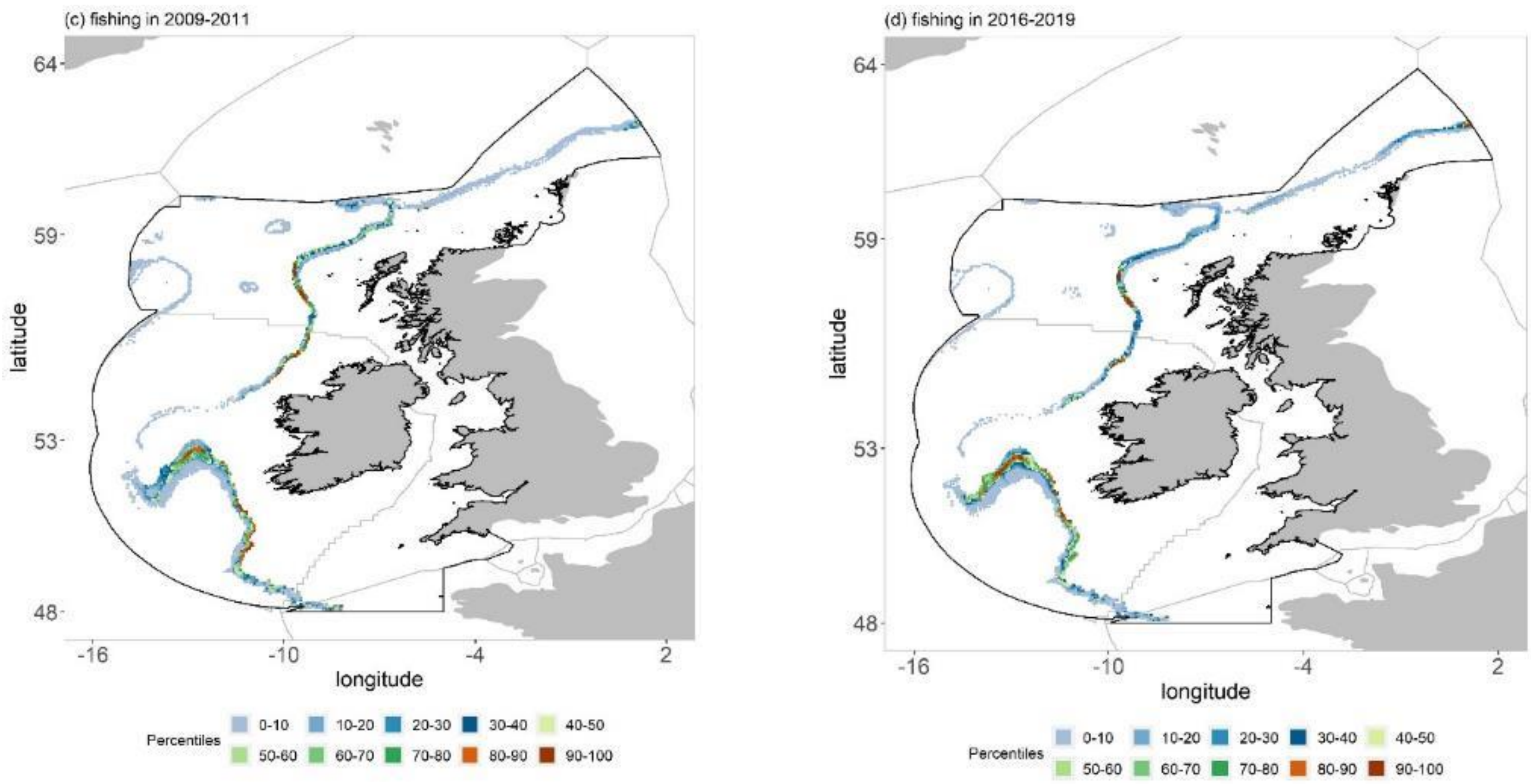


Figure 4.17. cont'd. The area associated with each 10-percentile interval (the dark blue C-squares are least fished; the brown C-squares are most fished) for c) the period 2009-2011 and d) the most recent fishing years (2016-2019).

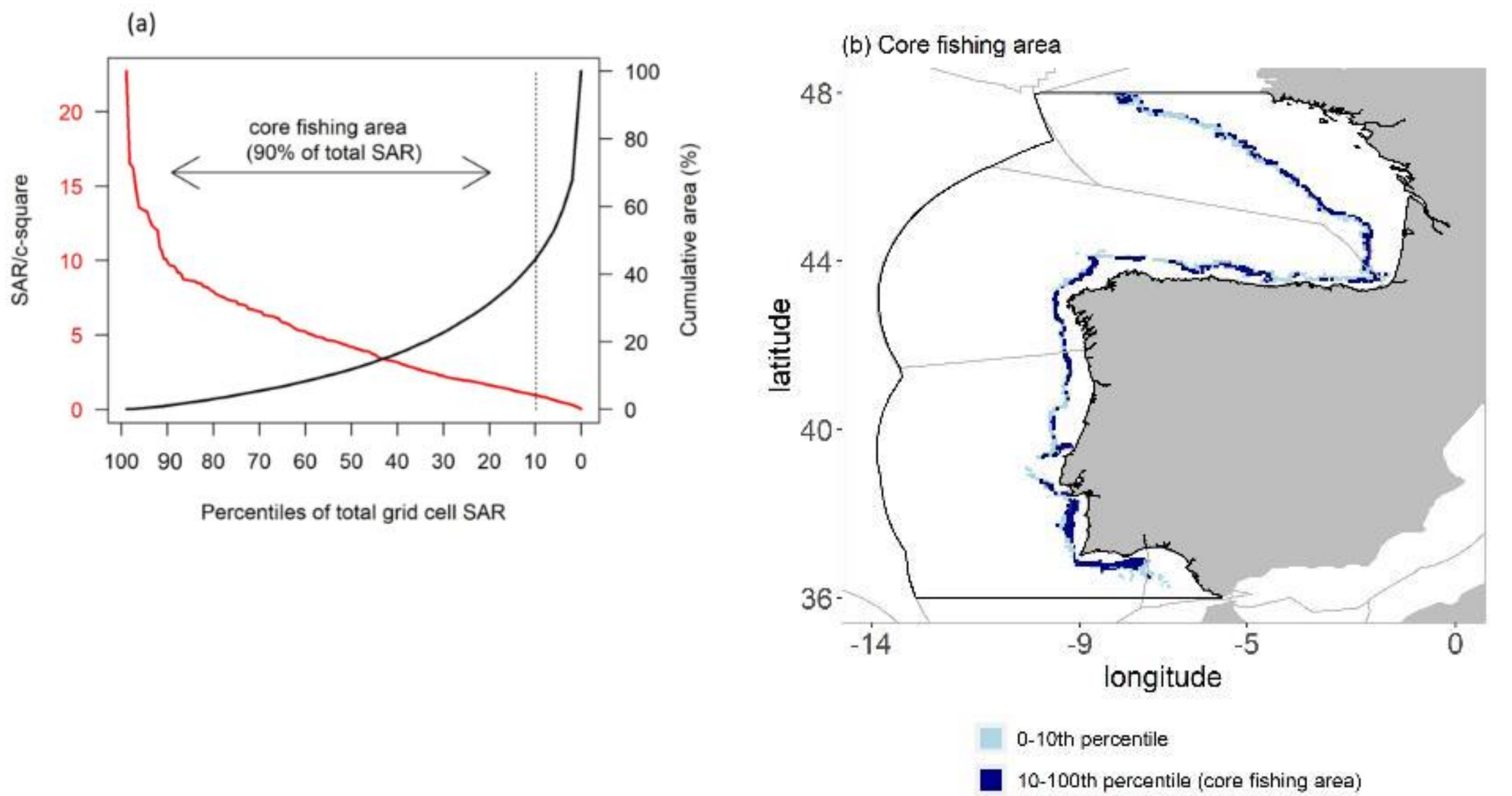


Figure 4.18. Bay of Biscay and Iberian Coast Ecoregion. a) Percentiles of the total swept area ratio per year (average 2009-2011) sorted from high to low SAR C-squares for otter trawl gears within the fishing footprint in the 400-800 metre range; otter trawls are the dominant gear grouping at this depth (Table 4.5). 90% of the SAR effort occurs in less than 50% of the fished area (see vertical dashed line). The distribution of the 90% of the SAR effort is shown in b).

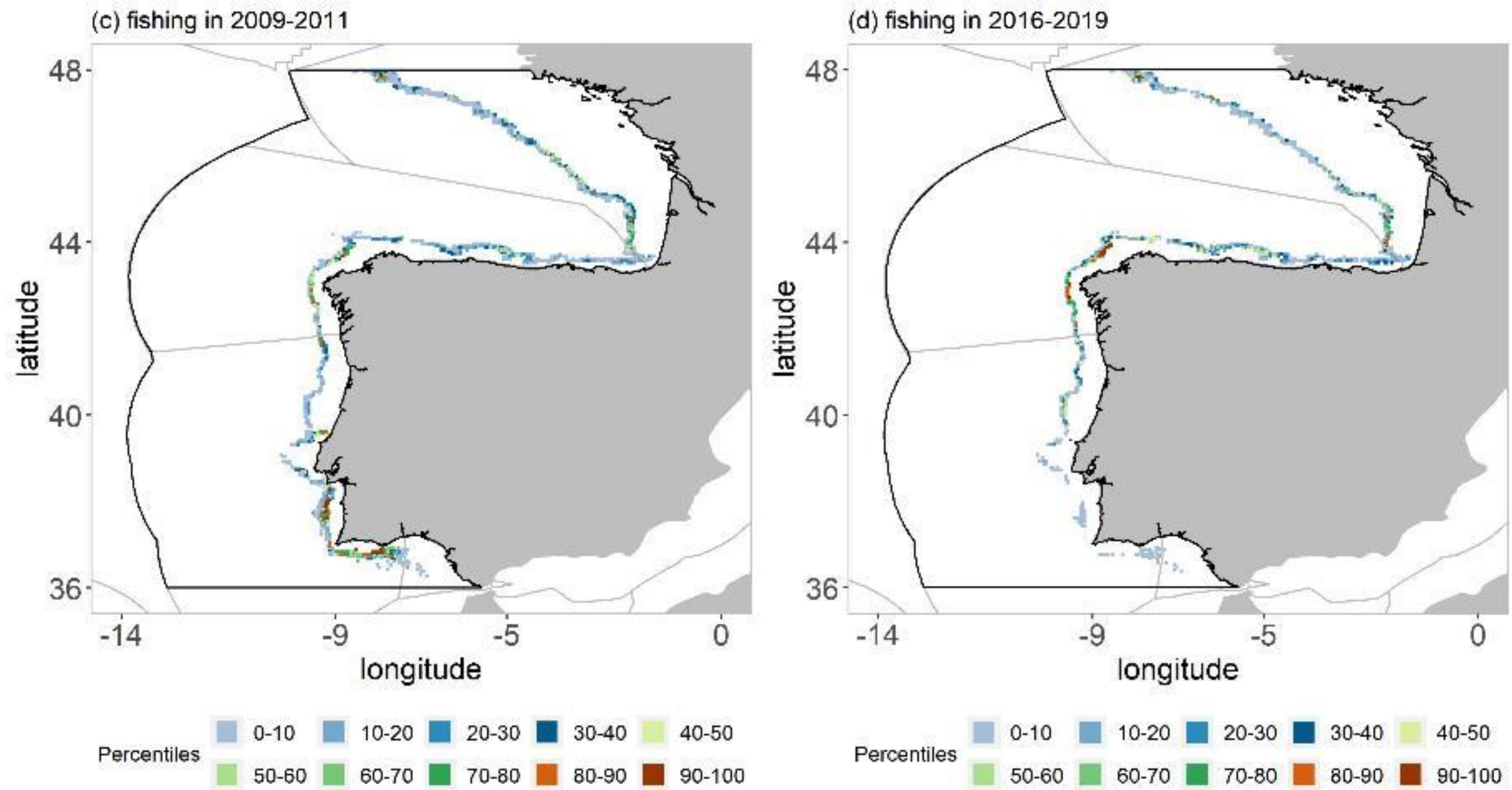


Figure 4.18. cont'd. The area associated with each 10-percentile interval (the dark blue C-squares are least fished; the brown C-squares are most fished) for c) the period 2009-2011 and d) the most recent fishing years (2016-2019).

Relationship Between VME Biomass and Fishing Intensity (SAR)

Structure-forming VMEs are subject to direct damage from bottom-contact fishing gears, suffering immediate declines through direct removal and further reductions in population densities due to indirect impacts (e.g., sedimentation, increased predation) and delayed mortality. An understanding of the relationship between VME biomass and fishing intensity is fundamental in the assessment of Significant Adverse Impacts (SAI) (FAO, 2009). SAI are defined as those that compromise ecosystem integrity (i.e., ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats, or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively (FAO, 2009).

Several regional fisheries management organisations (RFMOs) have made a commitment to investigate the potential for SAI as part of their response to the UNGA Resolution 61/105 on sustainable fisheries (UNGA, 2006). The resolution calls upon States and RFMOs to identify VME in the high seas and to consider whether fishing activities would have SAI on these ecosystems. One of the difficulties in assessing SAI in the past has been the inaccessibility or lack of data of sufficient quality and resolution, both temporally and spatially, on the extent of fishing activities and of the identity and distribution of VME. Only recently have suitable datasets become available. Capitalising on the availability of such datasets, NAFO has developed an approach for analysing and evaluating SAI, thus contributing to a qualitative risk assessment and management framework to avoid SAI on VME (NAFO, 2015). Central to this approach is the assertion that: *frequently fished areas of VME will tend to support lower biomass of VME indicator taxa compared to areas of the same VME that have been fished less frequently.*

Accordingly, cumulative VME biomass (for a specific VME indicator taxon) plotted against fishing effort should theoretically reveal a biomass response curve similar to the one shown in Figure 4.19. The characteristics of the plot enable the identification of the level of fishing effort above which there is no new biomass observed, that is, the point where the maximum impact occurs for the least amount of fishing effort (a fishing effort cut-off value is defined where 95% of VME cumulative biomass occurs).

Any areas of seabed subject to fishing effort at less than this value would be expected to have increasing levels VME biomass present and therefore be at greater risk of impact from fishing. It may also be expected that the slope of the response curve will vary depending on how resilient the VME indicator species is, such that a steeper curve would indicate a less resilient species. Therefore, identifying the level of fishing effort associated with 95% of the VME biomass for the most resilient (least sensitive VME) can be used to define an area of fishing activity where the likelihood of observing any VME (even that associated with the least sensitive VME) would be very low. Given that deep-sea VME taxa of the same type (e.g., sea pens) show similar functional characteristics across large areas of the North Atlantic it may be expected that a cut-off value derived from studies in the NAFO area (NAFO, 2016) could be applied to fisheries in the north-east Atlantic.

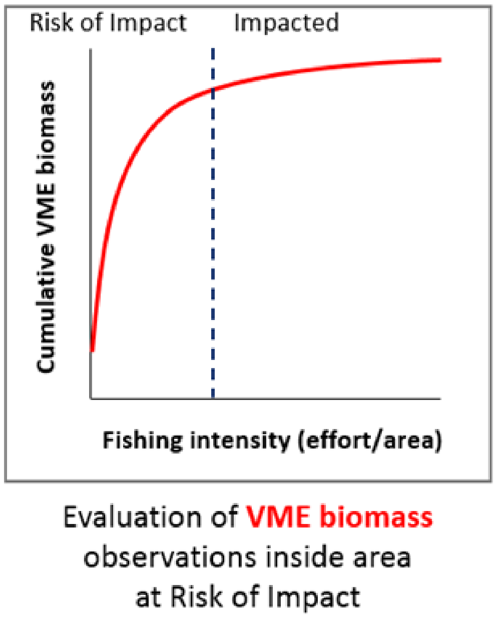


Figure 4.19. Theoretical relationship between cumulative VME biomass and fishing effort.

Figure 4.20 shows the cumulative response curves for three VME indicator taxa (large sponges, sea pens, and large gorgonian corals) from the NAFO area. A test of significance was applied to the cumulative plots in the form of a randomised permutation test, i.e., the order of the biomass was randomised against the fishing effort to generate 1000 sets of data against which the observed cumulative plot of biomass against fishing effort was compared (NAFO, 2016). It clearly reveals that of the three taxa groups studied sea pens are the least sensitive. They have a fishing effort cut-off value corresponding to 0.5 hrs trawling/km^2/year.

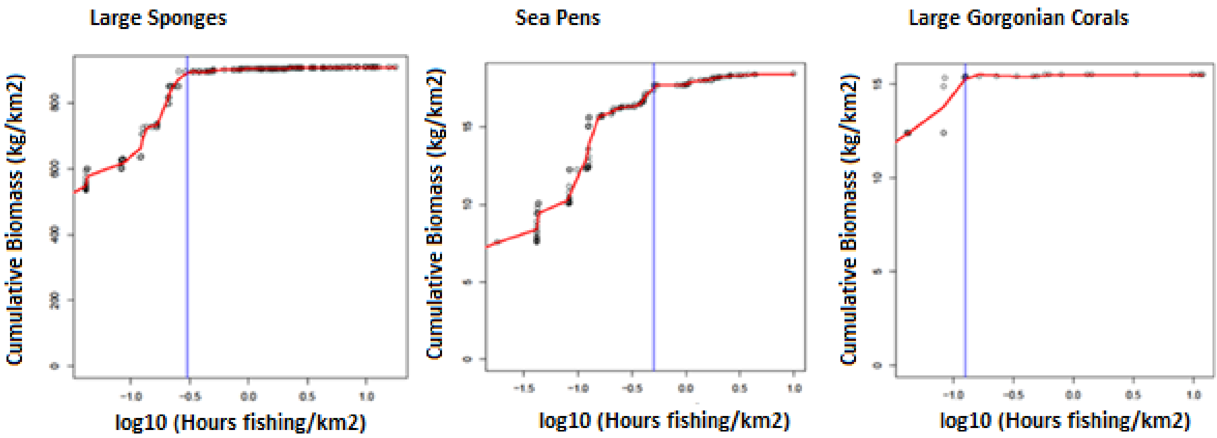


Figure 4.20. Left: Cumulative plot of sponge VME biomass against fishing effort/year, inflexion cut- off value of 0.3 hrs km-2, p = <0.05. Centre: cumulative plot of sea pen VME biomass against fishing effort/year, inflexion cut-off value of 0.5 hrs km-2, p = >0.05 <0.1. Right: cumulative plot of large gorgonian coral VME biomass against fishing effort/year, inflexion cut- off value of 0.1 hrs km-2, p = >0.1<0.25. Figure taken from NAFO (2016, Fig. 4.2.5.3.6).

WKEUVME considered this approach for relevance to the protection of VME in EU waters and for incorporating it into the options for managers (Section 4.5). Although some VME species differ on both sides of the Atlantic, they share similar biomass and morphologies within functional groups – often belonging to the same genera or families (e.g., for sponges see Cárdenas *et al.*, 2013). Considering the shared response curve shapes of the three disparate taxa (Figure 4.20), and the similar fishing gears used, it was agreed that in the absence of similar biomass and effort data in EU waters, adoption of the NAFO fishing intensity threshold of 0.5 hrs/km²/year would be an ecologically-relevant threshold for providing management options. By confining fishing activities to an area where the risk of new impact will be lowest (i.e., at > 0.5 hrs/km²/year) it will avoid further SAI on VMEs.

In order to apply the NAFO approach to this request it was necessary to convert the NAFO fishing effort cut-off value to a SAR (using known vessel speeds and gear dimensions for NAFO fisheries (NAFO, 2016)) so that a SAR minimum threshold can be applied to the fisheries data in both ecoregions. This value, using fishing gear dimensions for the halibut trawl fishery in NAFO (NAFO, 2016), equates to 0.43 SAR. Therefore in the present study a cut-off of 0.43 has been applied to the SAR fishing effort to define an area of fishing activity where the risk of VME impact is very high (< 0.43 SAR) and conversely, to areas which are greater than 0.43 SAR and therefore are at potentially relatively low risk of VME impact as it is assumed that the ecosystem is already degraded. This defined core area of low risk VME fishing impact has been used by WKEUVME for the development of regulatory options (Scenario 2, Section 4.5).

References

Cárdenas, P., Rapp, H.T., Klitgaard, A.B., Best, M., Thollesson, M. and Tendal, O.S., 2013. Taxonomy, biogeography and DNA barcodes of *Geodia* species (Porifera, Demospongiae, Tetractinellida) in the Atlantic boreo-arctic region. Zoological Journal of the Linnean Society 169: 251–311.

Eigaard, O.R., *et al*. 2016. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science: Journal du Conseil 73: i27i43

FAO. 2009. The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas. Activities pages. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 30 April 2013. http://www.fao.org/fishery/topic/166308/en

ICES. 2015. Report of the Working Group on Spatial Fisheries Data (WGSFD), 8–12 June 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/SSGEPI:18. 150 pp.

NAFO. 2015. Report of the 8th Meeting of the NAFO Scientific Council (SC) Working Group on Ecosystem Science and Assessment (WGESA). NAFO SCS Doc. 15/19, Serial No. N6549. https://www.nafo.int/Portals/0/PDFs/sc/2015/scs15-19.pdf

NAFO. 2016. Report of the Scientific Council Meeting. 03-16 June 2016, Halifax, Nova Scotia. NAFO SCS Doc. 16-14 Rev., Serial No. N6587.

Rees, T. 2003. "C-squares", a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography 16(1): 11–19.

UNGA. 2006. Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. Resolution adopted by the General Assembly on 8 December 2006. 61st session, Agenda item 71(b). Oceans and the Law of the Sea in the General Assembly of the United Nations, A/RES761/105, pp. 21. https://documents-dds-ny.un.org/doc/UNDOC/GEN/N06/500/73/PDF/N0650073.pdf?OpenElement

4.5 Closed Area Scenarios

WKEUVME established a framework for the presentation of closed area options based on the relationship between mobile bottom contact gear (MBCG) fishing intensity (SAR) and destruction of VMEs, drawing on trawling impact literature and empirical observations on similar VME indicators made in the NAFO Regulatory Area (NAFO, 2016). Two scenarios have been defined - rules which apply to the VME C-squares only (Scenario 1) and rules which apply to the VME C-squares, but also take into account known fishing impacts (Scenario 2) (see Section 4.4). Two options per scenario are presented (Table 4.5). The implications of each option for management are shown in Table 4.6.

Both closure scenarios used data on VME habitat and the VME Index (Section 4.2). In addition, Scenario 1 option 2 also included data on VME elements from EMODnet. The VME elements used for Scenario 1 option 2 were limited to topographic highs (seamounts, banks) as well as small elements spatially well-constrained (coral mounds, mud volcanoes). Information on cold seeps (also spatially constrained) was provided by the VME Database, where they are included as VME habitats, as the list of cold seeps provided by EMODnet is incomplete. Other VME elements that were large and spatially not well constrained, such as steep slopes or canyon systems, were excluded because their spatial footprint was considered too large relative to the evidence of VME occurrences. In future, data from SDM models could be used in the same way as that of VME elements (Scenario 1 option 2), but for now were used as supporting information for the selected areas. VME data sources are described above in "*Data on Vulnerable Marine Ecosystems*" (Section 4.2). Scenario 2 further included information on fishing intensity (SAR per year) from all mobile bottom-contacting fishing gears, the most common mobile gear type operating in the ecoregions (Table 4 Celtic Seas Assessment; Table 5 Bay of Biscay and Iberian Coast Ecosystem Assessment). These data were used to estimate whether C-squares fall above or below the SAR threshold value of 0.43 (see Section 4.4, "*Relationship Between VME Biomass and Fishing Intensity (SAR)*"). Selection of C-squares with a SAR < 0.43 will select areas where the SAR is low enough to allow the persistence of VMEs, while selecting against areas with SAR > 0.43 selects against areas where VMEs are unlikely to persist under the fishing pressure. This was determined for all mobile bottom-contacting gears using the average SAR per year for 2009-2019. The fisheries data is described above in Sections 4.3 and 4.4. WKEUVME notes that the use of the VME Index as it now is may result in under-representation of sea pen VMEs in the selection of closed areas under all scenarios and options except Scenario 2 option 2 (see Section 4.2).

Table 4.5. Summary of the scenarios and options used to define closure areas. The main differences between scenarios and options are underlined.

	Scenario 1 **VME distribution only**	**Scenario 2** **VME and VMS distributions**
Option 1	All VME habitats, High and Medium VME Index. <u>Low VME Index: only if adjacent to higher Index VMEs</u>	All VME habitats, High and Medium VME Index. Low VME Index: only if adjacent to higher index VMEs and <u>Low VME Index in C-squares with low fishing pressure (SAR < 0.43)</u>
Option 2	Option 1 + selected <u>VME elements (banks, seamounts, coral mounds, mud volcanoes) associated with any VME records.</u>	All VME habitats, High, Medium and Low VME Index <u>excluding C-squares with high fishing pressure (SAR > 0.43)</u>

The scenario rules were used to create closure areas for the whole area irrespective of the depth and the boundary of the ecoregion. The closures were afterwards clipped to the 400-800 meter depth range. The different scenarios/options resulted in different areal extents and numbers of closures in the 400-800 meter depth range. These were compared and contrasted for each ecoregion. The consequences of the closures for protecting VMEs and their potential impact on the fisheries, drawing on fishing activity data, are also tabulated and discussed for each ecoregion. The fisheries consequences were evaluated for the reference period 2009-2011, the period 2012-2015 and the most recent period 2016-2019. The R-scripts which produced the closed area options and data summaries, including closure .shp files, are available on an open source platform (WKEUVME GitHub site).

Table 4.6. Description of management scenarios and options presented by WKEUVME with associated management implications for the protection of VMEs and general impacts to fisheries.

Scenario	Option	Description	Management Implication
Scenario 1	Option 1	C-squares between 400-800m depth with all VMEs supported by data in the VME Database, with priority to medium to high 'confidence', regardless of fishing activity in the 2009-11 period.	Prioritizes protection of VMEs where they are known to occur, irrespective of fishing activity.
Scenario 1	Option 2	C-squares between 400-800m depth with all VMEs and VME elements supported by data in the VME Database, with priority to medium to high 'confidence', regardless of fishing activity in the 2009-11 period.	Prioritizes protection of VMEs where they are known and where they are likely to occur, irrespective of fishing activity.
Scenario 2	Option 1	As for Scenario 1 Option 1 but includes low VME Index C-squares if fishing pressure is low (< 0.43 SAR).	Prioritizes protection of VMEs where they are known to occur, and includes areas where the confidence of VME presence is lower but where fishing activity is also low and VMEs unlikely to be degraded by fishing.
Scenario 2	Option 2	C-squares between 400-800m depth with all VMEs supported by data in the VME Database excluding C-squares with high fishing pressure (SAR > 0.43).	Prioritizes protection of VMEs where they are known to occur, but excludes areas that have been heavily fished (core fishing areas) and where VMEs are likely to have been degraded by fishing.

Buffer Zones

In 2018, ICES (2018) advised that buffers are required in all cases and that the buffer around VME closures should have a width of at least twice the water depth (800 to 1600m). The decision appears to have been made on the basis of expert opinion and the relationship between the buffer and depth was not clear. WKEUVME adopted a half-C-square buffer in its work. C-squares are 0.05° x 0.05°, therefore a 0.025° buffer was applied (2780 m of latitude, 4451 m of longitude at 37°N). This decision was also made by expert opinion and is considered to be more transparent in the lack of scientific support underpinning the choice.

Note that all analyses of the fisheries impacts and VME benefits of closures are carried out at the C-square scale, as that is the scale at which data layers are available. This approach implicitly assumes that the distribution of VMEs and fishing activity is homogeneous within a C-square. This is a reasonable assumption on the flat muddy grounds on which sea pens occur, which is unlikely to be true in topographically complex areas, such as canyon heads, where coral species may be found. There may therefore appear to be more overlap between fishing and VMEs in some of these areas, and it may be desirable to explore closure boundaries at scales smaller than a C-square for such areas.

Scenario 1: No Consideration of Fishing Pressure

Option 1 - Protection for VME Habitat and Medium and High VME Index C-squares

Step 1. Select all VME Habitat, and High and Medium VME Index C-squares and create a ½ C-square buffer around them (Figure 4.21). *These cells are known or likely to contain VMEs and the buffer zones account for the offset between vessel positions and the position of their gear, which can be substantial in deep water, and the effects of sediment resuspension, which can have detrimental effects on VMEs.*

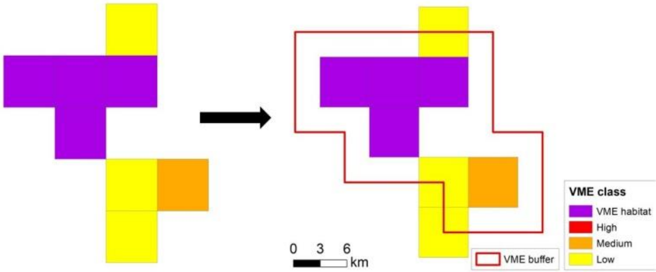


Figure 4.21. Scenario 1 Option 1, Step 1 illustrating the selection of C-squares and creation of buffer.

Step 2. Where Low VME Index C-squares are adjacent and joining any C-squares in Step 1, these should be selected and a ½ C-square buffer placed around the C-square (Figure 4.22). *These cells are considered more likely to contain VMEs than other low index cells by their proximity to higher index cells.*

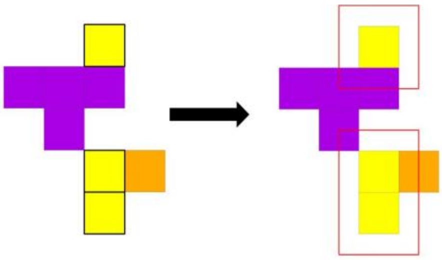


Figure 4.22. Scenario 1 Option 1, Step 2 illustrating inclusion of adjacent VME Index Low C-squares and associated buffers.

Step 3. Where two or more C-squares from Steps 1 and 2 are joined by their buffers or directly joined (in any way) they will be combined into one VME closure polygon (Figure 4.23). *This reduces the number of polygons in a data-layer but does not change the protected area.*

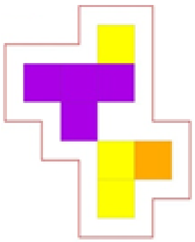


Figure 4.23. Scenario 1 Option 1, Step 3 illustrating the final VME closure polygon with buffers (red line).

Step 4. All satellite VME C-squares in Step 1 above should be defined as individual VME closures with associated ½ C-square buffer (Figure 4.24). *Many VMEs types can naturally consist of small patches of about one C-square in size or smaller.*

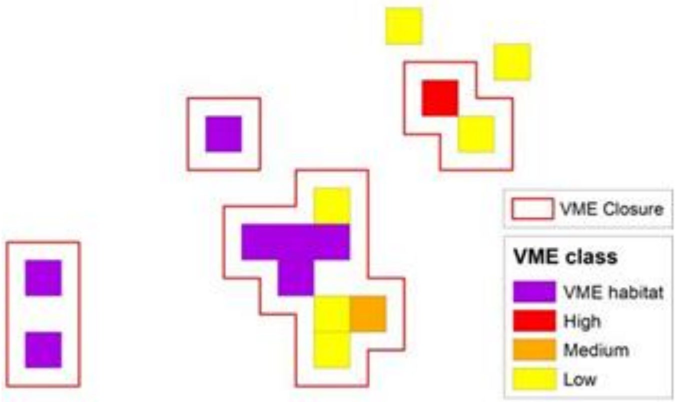


Figure 4.24. Scenario 1 Option 1, Step 4 illustrating the inclusion of isolated C-squares with buffers.

Step 5. Fill all holes with 1 or 2 C-squares inside VME closures (Figure 4.25). *Fishing vessels are unlikely to be able to fish effectively in very small areas without risking straying into closed areas. A trawler that fishes at 3.5 knots will cover 7nm in a typical 2h haul, which is equivalent to about between 2 and 3 C-squares. Open holes of less than 3 C-squares are therefore not considered practical.*

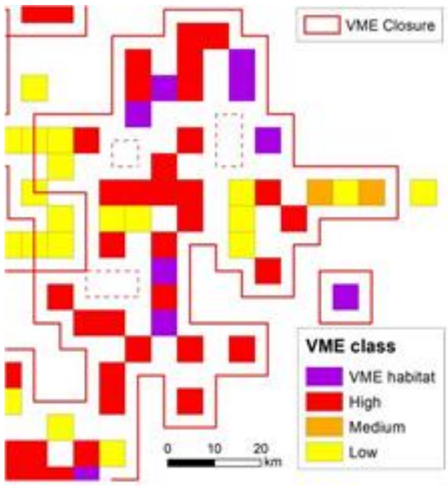


Figure 4.25. Scenario 1 Option 1, Step 5 illustrating the filling of holes (dashed lines) within the VME polygons (dark red lines) produced from Steps 1-4.

Option 2 - Protection for VME Habitat, VME Index C-squares and VME Elements

Step 1. Select the VME elements (bank, coral mound, mud volcano, seamount) with an occurrence of a VME Habitat or VME Indicator (High, Medium and Low). VME elements are selected with the VME points (using middle point position) rather than the C-squares to avoid selecting elements that intersect with the buffer of a C-square but not with a VME record per se (Figure 4.26). *These four VME elements are known to be important drivers of VME presence, and when this is confirmed by the presence of VME indicators, it is likely that the whole element contains VMEs. The VME elements used for Scenario 1 option 2 were limited to topographic highs (seamounts, banks) as well as small elements spatially well constrained (coral mounds, mud volcanoes) in EMODnet. Other VME elements that were large and spatially not well constrained, such as steep slopes or canyon systems, were excluded because their spatial footprint was considered too large relative to the evidence of VME occurrences. Using the point data for the VMEs ensures that the VME element is associated with the VME record.*

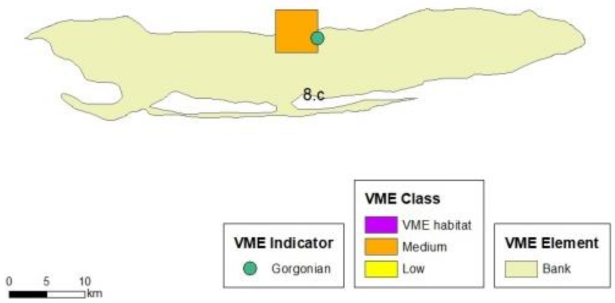


Figure 4.26. Scenario 1 Option 2, Step 1 illustrating the selection of VME elements (bank) with an occurrence of a VME Indicator (Medium).

Step 2. Clip the VME selected in Step 1 to the 400-800 m depth band.

Step 3. Select the C-squares overlapping with the VME elements selected in step 2 (Figure 4.27).

These three technical steps bring the VME elements which are most likely to contain VMEs into the closures. At the same time, VME elements for which there are no supporting evidence of VMEs are not included.

Figure 4.27. Scenario 1 Option 2, Step 3 illustrating the selection of the C-squares overlapping with the VME elements selected in step 2.

Step 4. Remove the C-square buffer from **Scenario 1 Option 1** that intersects with VME elements but does not overlap with the C-squares selected in Step 3 above, and include all C-squares that overlap with the VME element (Figure 4.28). *The VME elements were not buffered. This is because the areas with VME elements are generally large and only C-squares along the periphery of the VME elements would potentially be subject to direct or indirect effects of bottom contact fishing. Retaining a buffer such as the hatched area in Figure 4.28 would create buffers only where the VME data happen to overlap with the VME element.*

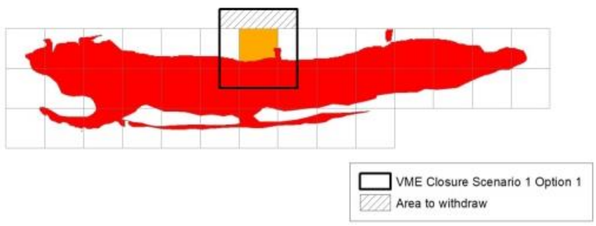


Figure 4.28. Scenario 1 Option 2, Step 4 illustrating the C-squares and its buffer from Scenario 1 Option 1 that intersect with the VME element (orange C-square with black surrounding buffer). In Step 4 the buffer (hatched area above the C-square) is removed.

Step 5. Merge Step 4 above with Scenario 1 Option 1. *This captures areas where VMEs are known or likely to occur (Figure 4.29). There may still be an under-representation of sea pen VMEs in this option.*

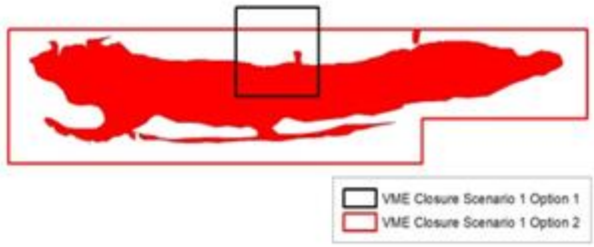


Figure 4.29. Scenario 1 Option 2, illustrating the difference between Scenario 1 Option 1 that does not include the VME element (black line) and Scenario 1 Option 2 that includes the VME element (red line).

Scenario 1 and United Nations General Assembly Policy

The two options presented for Scenario 1 prioritize protection of VME, irrespective of the fishing activity (Table 4.6). These are consistent with the United Nations General Assembly (UNGA) resolutions, specifically UNGA 61/105, paragraph 83:

> (*c*) In respect of areas where vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, are known to occur or are likely to occur based on the best available scientific information, *to close such areas to bottom fishing* and ensure that such activities do not proceed unless conservation and management measures have been established to prevent significant adverse impacts on vulnerable marine ecosystems (UNGA, 2006).

Scenario 2: Consideration of Fishing Pressure

Option 1 - Protection for VME Habitat, Medium and High VME Index C-squares (irrespective of fishing effort) and only Low VME Index C-squares which coincide with Low Fishing Effort

Step 1. Select all VME Habitat, High and Medium VME Index C-squares and create a ½ C-square buffer around them (Figure 4.21). *These cells are known or likely to contain VMEs and the buffer zones account for the offset between vessel positions and the position of their gear, which can be substantial in deep water, and the effects of sediment resuspension, which can have detrimental effects on VMEs. This selection is the same as in Scenario 1 option 1 Step 1.*

Step 2. Select all Low VME Index C-squares which have a SAR < 0.43 (as determined by NAFO methodology, see Section 4.4) and add a ½ C-square buffer to them (Figure 4.30). *Because they are fished at intensities that allow persistence of VME types, and because they are less important for fishing, it can be worthwhile closing these C-squares even if the presence of VMEs is uncertain. Due to the bias in the VME Index against sea pens in particular (Section 4.2) this will ensure that more sea pen habitat is protected.*

Step 3. Where Low VME Index C-squares are adjacent and joining any C-squares in Steps 1 and 2, these should be selected and a ½ C-square buffer placed around the C-square (Figure 4.30). *These cells are considered more likely to contain VMEs than other Low VME Index cells by their proximity to higher VME Index cells.*

Step 4. Where two or more C-squares from Steps 1, 2 and 3 are joined by their buffers or directly joined (in any way) they will be combined into one VME closure polygon (Figure 4.30). *This reduces the number of polygons in a data-layer but does not change the number of C-squares in the protected area.*

Step 5. All satellite VME C-squares in Steps 1 and 2 above should be defined as individual VME closures with associated ½ C-square buffer. *Many VME habitats naturally occur at the size of a C-square or smaller. These single C-squares can still offer meaningful protection.*

Step 6. Fill all holes with 1 or 2 C-squares inside VME closures. *Fishing vessels are unlikely to be able to fish effectively in very small areas without risking straying into closed areas. A trawler that fishes at 3.5 knots will cover 7nm in a typical 2h haul, which is equivalent to about between 2 and 3 C-squares. Open holes of less than 3 C-squares are therefore not considered practical.*

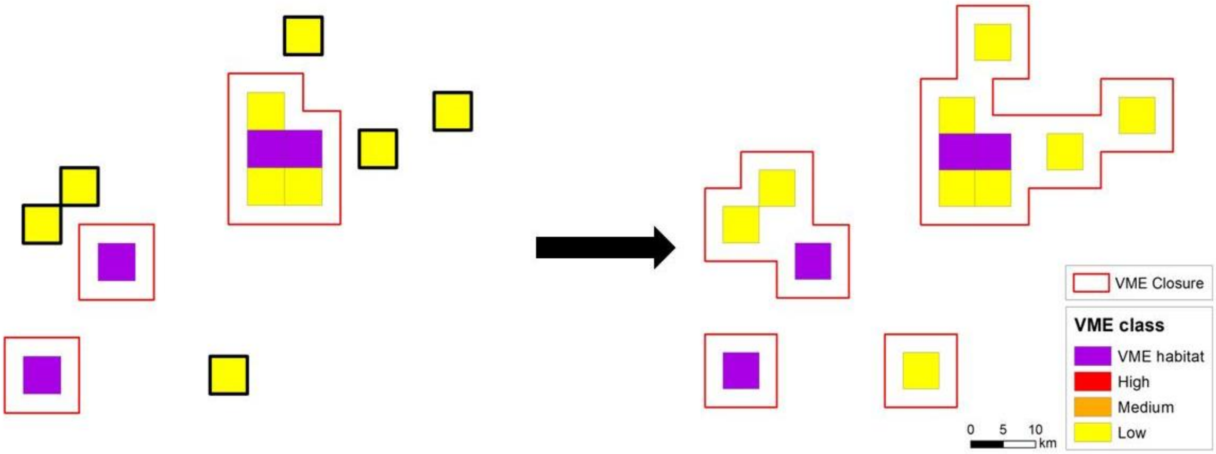


Figure 4.30. Scenario 2 Option 1, Steps 2 to 4 illustrating the inclusion of Low VME Index C-squares with fishing effort less than 0.43 SAR (yellow outlined in black on left panel).

Option 2 - Protection for all VME Habitat, and Low, Medium and High VME Index C-squares but only in Areas of Low Fishing Effort.

Step 1. Determine the 'core' area of fishing activity which is at or above the SAR VME impact threshold (> 0.43 SAR) as determined for the least sensitive VME indicators species (sea pens) following NAFO methodology (NAFO, 2016). *This area corresponds to a sufficiently high level of fishing activity where effectively the risk of future or new VME impact is low because persistence of VMEs is unlikely due to their vulnerability. The defined area essentially represents an area of 'low risk of further VME fishing impact'.*

Step 2. Select all VME C-squares (Habitat, and High, Medium and Low VME Index) which do not overlap with the 'low risk of further VME fishing impact' or 'core' fishing area as defined in Step 1 above, and create a ½ C-square buffer around them (Figure 4.31). *These are the VME C-squares which are more likely to have VME present on account of being subject to only low or no fishing pressure.*

Step 3. Where two or more C-squares from Step 2 above are joined by their buffers or directly joined (in any way) they will be combined into one VME closure polygon. *This is because they are likely to form the same VME type.*

Step 4. All satellite VME C-squares in Step 2 above should be defined as individual VME closures with associated ½ C-square buffer. *Many VME habitats naturally occur at the size of a C-square or smaller. These single C-squares can still offer meaningful protection.*

Step 5. Fill all holes with 1 or 2 C-squares inside VME closures. *Fishing vessels are unlikely to be able to fish effectively in very small areas without risking straying into closed areas. A trawler that fishes at 3.5 knots will cover 7nm in a typical 2h haul, which is equivalent to about between 2 and 3 C-squares. Open holes of less than 3 C-squares are therefore not considered practical.*

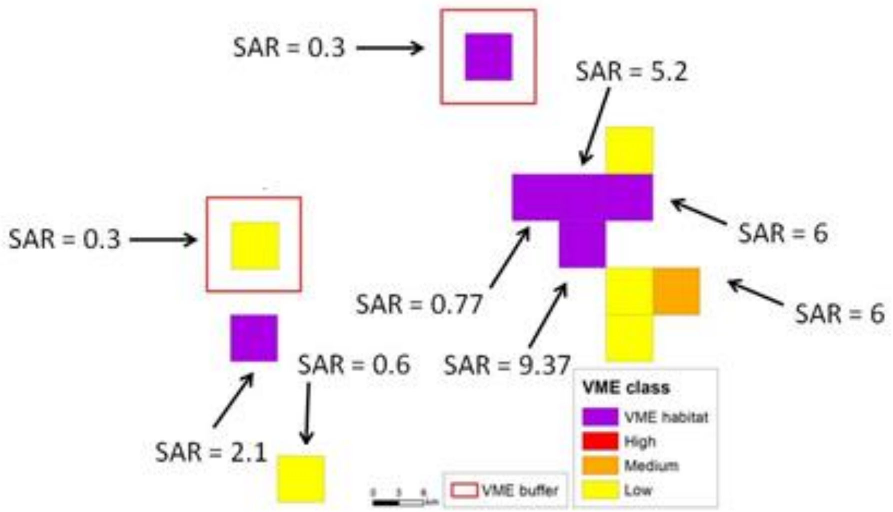


Figure 4.31. Scenario 2 Option 2, Step 2 illustrating the exclusion of C-squares with VME Habitats and VME Index (Low, Medium or High) when fishing effort is greater than 0.43 SAR, and the application of the buffer (red lines). In this example only two C-squares have fishing effort < 0.43 SAR, one with VME habitat and one with a Low VME Index.

Scenario 2 and United Nations General Assembly Policy

The two options presented for Scenario 2 prioritize protection of VME but incorporate a threshold for the level of fishing activity that is linked to significant adverse impacts (Table 4.6). These are consistent with the United Nations General Assembly (UNGA) resolutions, specifically UNGA 61/105, paragraph 83:

a) To assess, on the basis of the best available scientific information, whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems, and to ensure that if it is assessed that these activities would have significant adverse impacts, they are managed to prevent such impacts, or not authorized to proceed (UNGA, 2006).

Coordinates Associated with the Closed Areas Developed Under Each Management Option

The R-scripts which produced the closed area options and data summaries, including closure .shp files, are available on an open source platform (WKEUVME GitHub site). For each Ecoregion/Management Option/Closed Area script for creating a table of the coordinates for each closed area polygon has been produced (see Table 4.7 for an example). The table also indicates the VME habitat, VME indicator and VME element data present in each closed area. The closed areas are also mapped and .shp files produced for each.

Table 4.7. Example Table for the Presentation of Co-ordinates for Each Closed Area Developed Under Each of the Four Management Options. Boundary points delineating each of three closure polygons included in Scenario 1 option 1 for the Celtic Seas Ecoregion. VME habitat, VME indicator and VME element recorded in each closure are indicated.

Closed Area Polygon No.	Coordinate No.	Latitude	Longitude	VME habitat	VME indicator	VME element
1	1.1	48° 01' 30" N	8° 25' 30" W		Gorgonian	
1	1.2	48° 01' 30" N	8° 31' 30" W			
1	1.3	48° 07' 30" N	8° 31' 30" W			
1	1.4	48° 07' 30" N	8° 25' 30" W			
2	2.1	48° 04' 30" N	8° 46' 30" W	Cold-water coral reef, coral garden	Anemones, black coral, cup coral, gorgonian, soft coral, sponge, stony coral	
2	2.2	48° 04' 30" N	8° 52' 30" W			
2	2.3	48° 10' 30" N	8° 52' 30" W			
2	2.4	48° 10' 30" N	8° 46' 30" W			
3	3.1	48° 16' 30" N	9° 07' 30" W	Cold-water coral reef, coral garden, deep-sea sponge aggregation	Anemones, black coral, cup coral, gorgonian, sea pen, soft coral, sponge, stony coral	
3	3.2	48° 13' 30" N	9° 07' 30" W			
3	3.3	48° 13' 30" N	9° 01' 30" W			
3	3.4	48° 07' 30" N	9° 01' 30" W			
3	3.5	48° 07' 30" N	9° 04' 30" W			
3	3.6	48° 04' 30" N	9° 04' 30" W			
3	3.7	48° 04' 30" N	9° 13' 30" W			
3	3.8	48° 10' 30" N	9° 13' 30" W			
3	3.9	48° 10' 30" N	9° 19' 30" W			

Closed Area Polygon No.	**Coordinate No.**	**Latitude**	**Longitude**	**VME habitat**	**VME indicator**	**VME element**
3	3.10	48° 16' 30" N	9° 19' 30" W			

References

ICES. 2018. Advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, sr.2018.10. 12 pp. https://doi.org/10.17895/ices.pub.4429.

NAFO. 2016. Report of the Scientific Council Meeting. 03-16 June 2016, Halifax, Nova Scotia. NAFO SCS Doc. 16-14 Rev., Serial No. N6587.

UNGA. 2006. Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. Resolution adopted by the General Assembly on 8 December 2006. 61st session, Agenda item 71(b). Oceans and the Law of the Sea in the General Assembly of the United Nations, A/RES761/105, pp. 21, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N06/500/73/PDF/N0650073.pdf?OpenElemen

4.6 Assessment Sheets

Using the data products described above (Sections 4.2, 4.3, 4.4) and the management options described in Section 4.5, WKEUVME prepared separate assessment sheets for the Celtic Seas and Bay of Biscay Iberian Coast ecoregions (see Section 4.1 for rationale behind this choice). **As these are intended to become stand-alone documents details of the methodology is in some cases repeated both between the assessments and within the reports. Further, the numbering of tables and figures has been started afresh in each document.** The format and style of the assessment sheets follow those of the ICES Ecosystem and Fisheries Overviews. These assessment sheets will serve as the basis for dissemination documents for a managers – stakeholders meeting of WKEUVME in September 2020, and could be incorporated into their respective annual ICES Ecosystem and Fisheries Overviews in future.

4.6.1 Celtic Seas Ecoregion

The Celtic Seas ecoregion covers the northwestern shelf seas of the EU. It includes areas of the deeper eastern Atlantic Ocean between depths of 400 and 800 m (Figure 1). The Celtic Seas ecoregion includes all or parts of the Exclusive Economic Zones (EEZs) of three EU Member States (Ireland, United Kingdom & France). Fisheries in the Celtic Seas are managed through national administrations via the EU Common Fisheries Policy (CFP: European Union, 2013), with fisheries of some stocks managed by the North East Atlantic Fisheries Commission (NEAFC) and by coastal state agreements. Responsibility for salmon fisheries is taken by the North Atlantic Salmon Conservation Organization (NASCO) and for large pelagic fish by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Collective fisheries advice is provided by the International Council for the Exploration of the Sea (ICES), the European Commission's Scientific Technical and Economic Committee for Fisheries (STECF), and the North Western Waters and Pelagic Advisory Council (NWWAC). Environmental policy is managed by national governments and agencies via the Marine Strategy Framework Directive (MSFD: European Commission, 2008, 2017), and the Birds and Habitat Directives (European Commission, 1992, 2010). Advice is provided by national agencies, OSPAR, the European Environment Agency (EEA), and ICES.

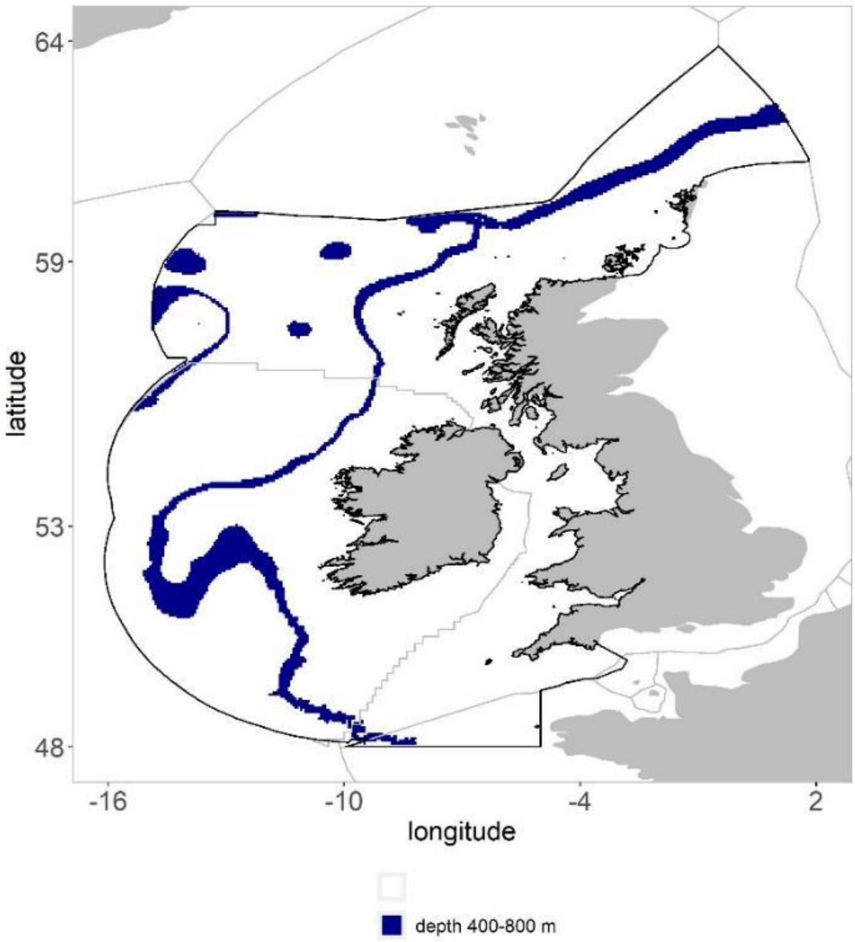


Figure 1. Celtic Seas ecoregion with area between 400 m and 800 m depth (blue shade). Depth is extracted from bathymetry data of EmodNet (EmodNet Bathymetry Consortium, 2018). Each C-square has approximately 2300 depth observations and is included in the blue shaded area when one depth observation is within the 400 to 800 m depth range.

The ecoregion ranges from north of Shetland to Brittany in the south. Five key areas constitute this ecoregion and are proposed for inclusion in the Celtic Sea ecosystem update currently underway: Northwest of Scotland, the Malin Shelf, the Celtic Sea, West of Ireland, and the Irish Sea. The Celtic Sea and Malin Shelf comprise large shelf areas, with slope and canyon habitats extending along their fringes with sharp changes in bathymetry (increasing depth: Figure 1). Northwest of Scotland and West of Ireland are the oceanic Atlantic-facing edge of the Irish-Scottish shelf, limited westward by the Rockall Trough and Faroe-Shetland Channel, with the Goban Spur and Porcupine Bank forming long extensions of the coastal continental shelf. The Irish Sea is a relatively shallow, semi-enclosed region lacking in vulnerable marine ecosystems (VMEs) due to its shallow nature (max. depth < 400 m).

The Celtic Seas ecoregion is characterized by a diversity of habitats and extensive VME elements, such as extensive slope, canyons, ridges and guyots that support VMEs. Water-mass characteristics also influence and affect VMEs such as cold-water coral and sponges, particularly in the context of climate change (Puerta *et al.*, 2020). The Celtic Sea ecoregion is heavily influenced by oceanic inputs such as the North Atlantic Drift and intermediate Mediterranean Outflow Water (White *et al.*, 2005). Generally water movements are from south to north, and strongest winds are from the west and south, with exceptions in the more sheltered Irish Sea (OSPAR Commission, 2000).

At the time of the 2019 ecoregion assessment the five most important human pressures in the Celtic Seas ecoregion were the selective extraction of species, abrasion, smothering, and substrate loss, and nutrient and organic enrichment. These pressures are mainly linked to the following human activities: fishing, aquaculture, dredging, offshore structures, agriculture and forestry, and urban and industry run off. Below 400 m, fishing is the main activity that can potentially impact VMEs through selective extraction of species, abrasion and smothering. Further information on these pressures and impacts can be found in the Ecosystem Overviews.

Distribution of Vulnerable Marine Ecosystems

The ICES Working Group on Deep-water Ecology (WGDEC) provides the science and data, consistent with ICES scientific and data quality policies, to deliver the best available evidence of VME presence (ICES, 2020a). The ICES Working Group on Marine Habitat Mapping (WGMHM) coordinates the review of habitat classification and mapping activities in the ICES area and has prepared maps of VME elements (ICES, 2020b) which have been upgraded here, using higher resolution EMODnet seafloor geomorphic features. The EMODNET seafloor geology is publicly available and provides georeferenced geological and biogenic structures such as banks, coral mounds, mud volcanoes and seamounts at a higher spatial resolution than other global sources of information. These data provide the input to the management options presented below. Despite being the best available, there is uncertainty in the data in terms of the likelihood of a C-square (Rees, 2003) containing VMEs. Managing environmental uncertainty of this nature requires the application of the precautionary approach (sensu FAO).

Data on VMEs in the ICES VME Database were collected following the annual ICES data call for VME data (link). The database includes point and line data on individual VME indicator and habitat records, where available. VME habitats, verified with *in situ* imagery, are mapped at C-square3 resolution (Figure 2). In addition, data on the potential location of VME habitats (e.g., where VME *are likely to occur*) has been determined by WGDEC using a published multi-criteria assessment method (ICES, 2018a; Morato *et al.*, 2018). This collates VME indicator point records within a C-square and determines whether a VME is likely to be present (Figures 3, 4) based on an evaluation of the vulnerability of the indicator species present and their abundance, where this information is available (see Section 7 of ICES, 2018a). It also assesses the confidence placed in the data (low, medium or high), based on four criteria: data collection method, number of samples within the C-square, time span of data (between first and last record) and time since last survey. The VME likelihood and confidence scores collectively provide the best current evaluation of the certainty of the VME habitat being present (Table 1). Known VME habitats are mapped as such, and do not go through the VME Index.

Broad-scale habitat features ('VME elements') such as canyons, seamounts and ridges can be mapped using bathymetric data (Figure 5) and used as a proxy for VME presence, since these areas are commonly known to support VMEs (FAO, 2009). The North East Atlantic Fisheries Commission (NEAFC) recognizes isolated seamounts, steep-slopes and peaks on mid-ocean ridges, knolls, canyons and steep flanks > 6.4° as VME elements (NEAFC, 2014). Use of VME elements can fill in gaps between direct observations of VMEs derived from the VME Database and are a good proxy for where VMEs are *likely to occur*.

3 The C-square resolution used here is a 0.05 x 0.05 degree grid, equivalent to approximately 15 km² at 60°N latitude, using the approach detailed in Rees (2003). For more details see http://www.cmar.csiro.au/csquares/spec1-1.htm

Table 1. Linking degree of precaution required to make management decisions with characteristics of the VME data.

Degree of Precau-tion	Confidence of VME presence	Data source	Notes
Low	Known	VME Database	ICES VME habitat confirmed using VME records from the ICES VME Database and mapped by C-square (Figure 2).
Medium	High/Medium	VME Index	ICES VME High/Medium quality data with Medium confidence using the multi-criteria assessment tool (Figure 3).
High	Low	VME Index	ICES VME Low quality with Low Confidence using the multi-criteria assessment tool (Figure 4). WKEUVME notes some caveats with this category resulting in under-representation of sea pen VMEs in higher categories.
High	Low	Species Distribution Models (SDM)	Not available at this time but may be incorporated into future assessments.
High	Low	VME element mapping	Presence of the VME elements (Figure 5) listed in the Annex of the FAO International Guidelines noted above (FAO, 2009)

VMEs in the Celtic Seas Ecoregion

In the Celtic Seas ecoregion, there are many VME habitats, VME indicator records and VME elements. In total the ICES VME Database has 3,091 records for VME habitats (NB: "NAs" omitted) and 9,278 records for VME indicators (Accessed May 2020). This information from across the Celtic Seas ecoregion has been collected through various gear types and survey methods, i.e., Agassiz trawl (130 records), box corer (11 records), bottom trawl (1,230 records), Grande Ouverture Verticale (GOV) trawl (358 records), Granton trawl (2 records), Jackson trawl/modified otter trawl (293), photos (1,234 records), rock hopper otter trawl (31 records), seabed imagery - ROV system (4,176 records), seabed imagery – towed camera system (1,337 records), seabed imagery - drop camera (70 records) and video - towed video (77 records).

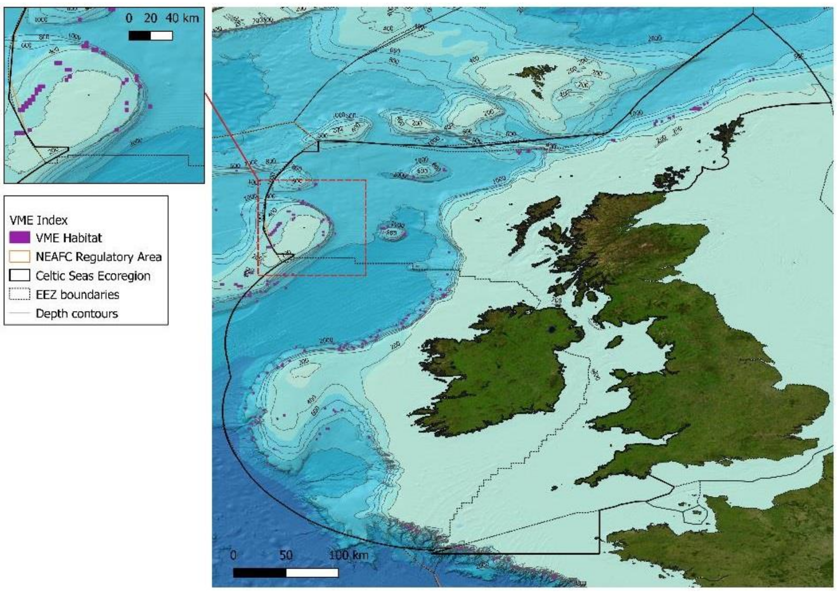


Figure 2. Celtic Seas Ecoregion, showing areas of known VME (VME Habitat) mapped at the scale of C-square grids. Inset shows North West Rockall Bank. Copyright: Base map imagery GEBCO_2014 Grid, version 20150318. EEZ: Flanders Marine Institute (2020) Maritime Boundaries Geodatabase, version 11. Depth contours: GEBCO (2004). Map projection: EPSG:4326 - WGS 84.

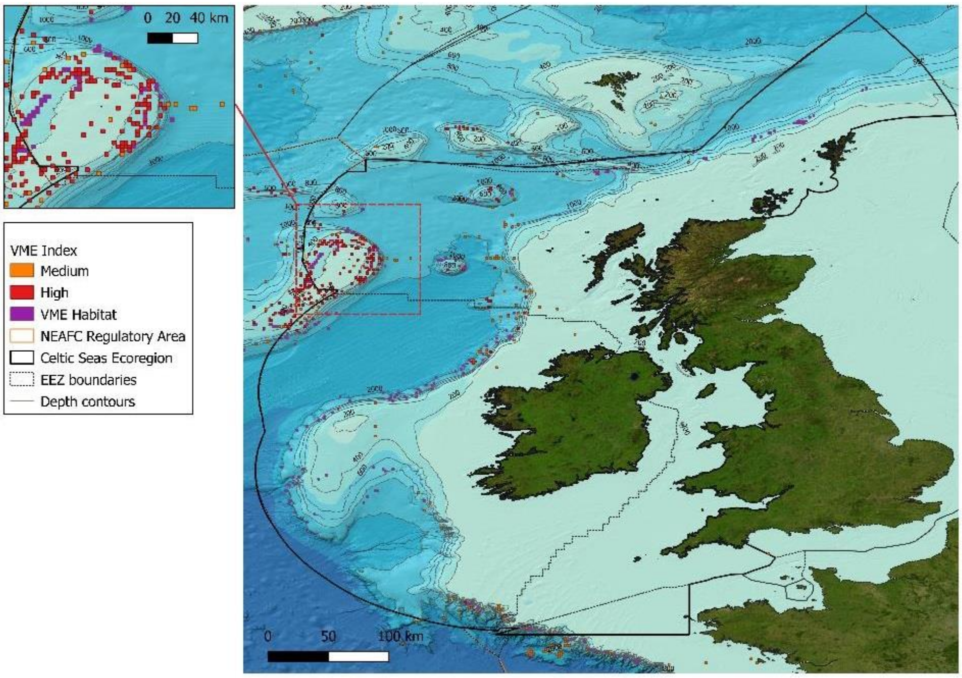


Figure 3. Celtic Seas Ecoregion, showing areas of known VME (VME Habitat) and High and Medium VMEs from the VME Index, mapped at the scale of C-square grids. Inset shows North West Rockall Bank. Copyright: as for Figure 2.

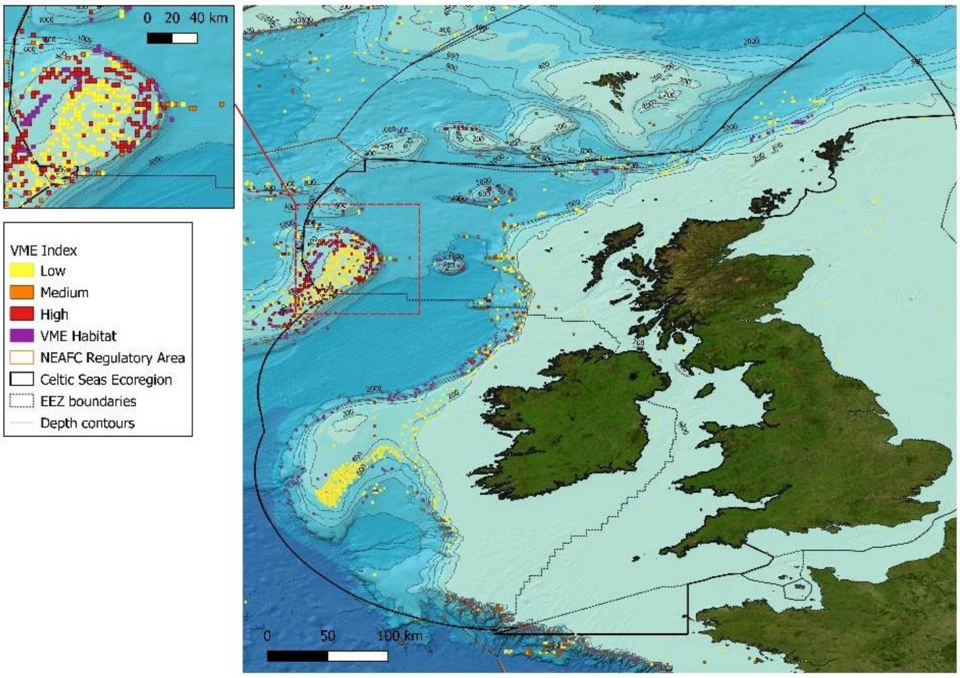


Figure 4. Celtic Seas Ecoregion, showing areas of known VME (VME Habitat) and High, Medium and Low VMEs from the VME Index, mapped at the scale of C-square grids. Inset shows North West Rockall Bank. Copyright: as in Figure 2.

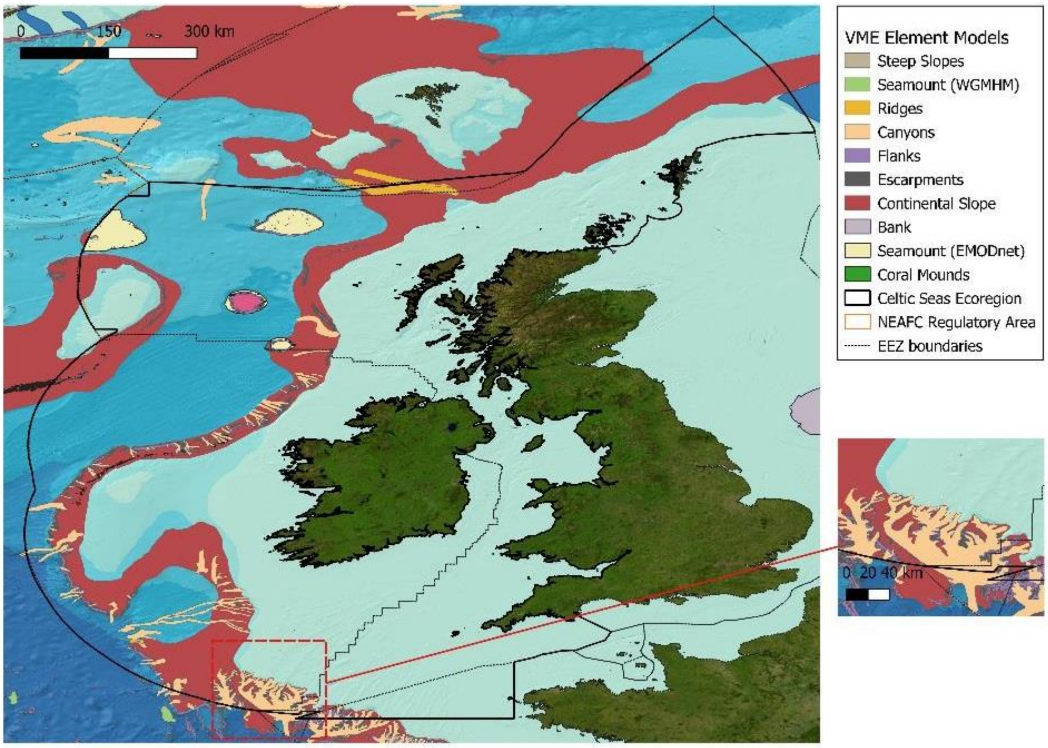


Figure 5. Celtic Seas Ecoregion, showing location of VME elements based on models. Copyright: as for Figure 2. VME element models from Seafloor Geomorphic Features Map (Harris et al., 2014) and EMODnet Geology. Map projection: EPSG:4326 - WGS 84.

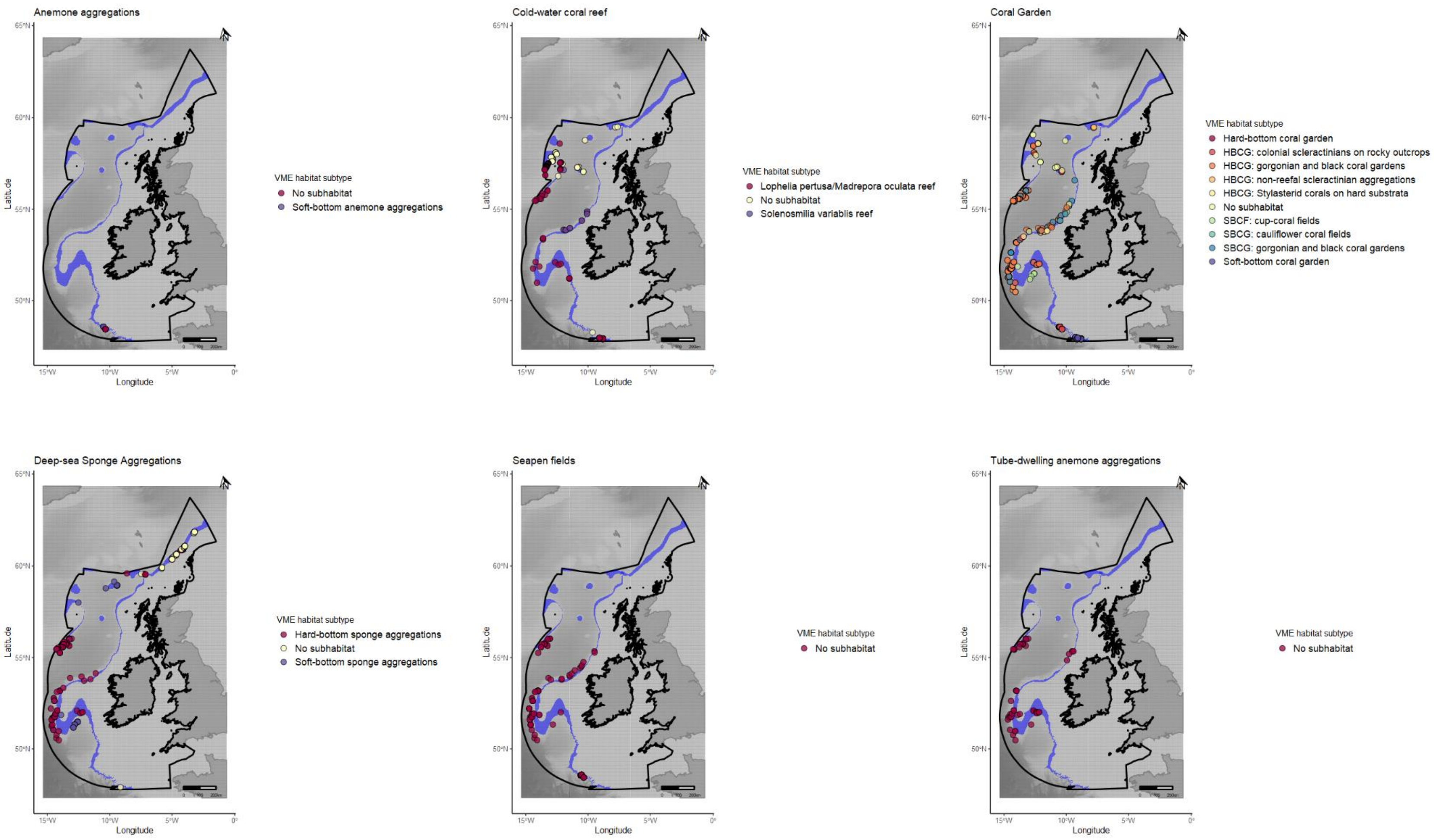


Figure 6. Location of VME habitat types and subtypes across the Celtic Seas ecoregion. For the Coral Garden subhabitats: HBCG = Hard-bottom coral garden, SBCG = soft-bottom coral garden, and SBCF = soft-bottom coral field. No subhabitat means that the habitat category is not specified further. The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMODnet bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84 / UTM zone 29N.

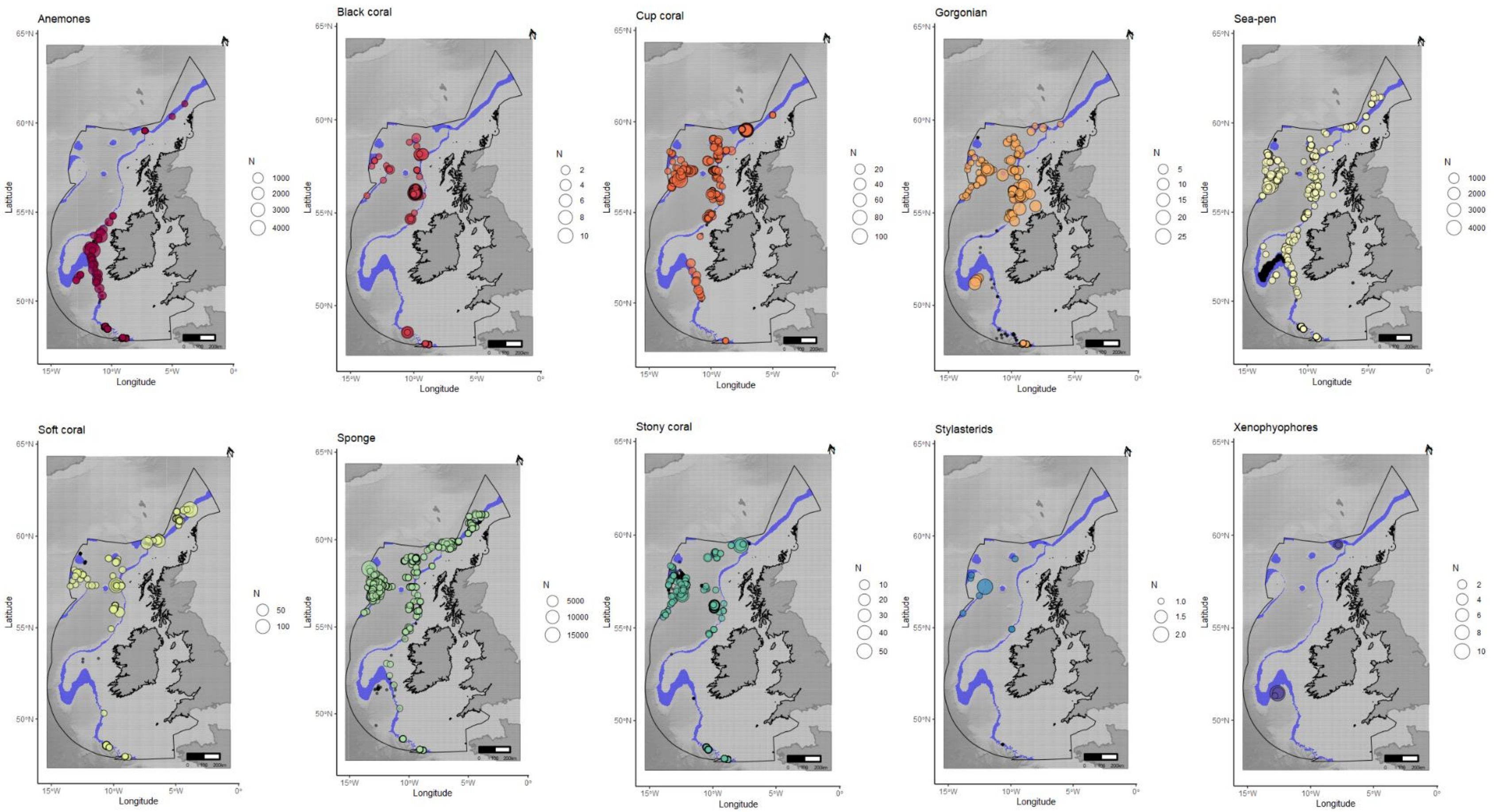


Figure 7. Location of VME indicators across the Celtic Seas ecoregion. "N" number of individuals associated with record in the ICES VME Database accessed May 2020. Where no value was associated with the record it is plotted as a black filled circle. The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMODnet bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84/ UTM zone 29N

The VME habitats include anemone aggregations (22 records), cold-water coral reefs (386 records), coral gardens (1,384 records), deep-sea sponge aggregations (739 records), sea pen fields (458 records), stalked crinoid aggregations (6 records), tube-dwelling anemone aggregations (55 records) and xenophyophore aggregations (41 records) (Figure 6). VME indicators recorded are: anemones (612 records), black corals (728 records), cup corals (364 records), gorgonians (337 records), sea pens (1,349 records), soft corals (213 records), sponges (2,758 records), stony corals (1,534 records), stylasterids (16 records) and xenophyophores (10 records) (Figure 7). It should be highlighted that all the records for the VME habitats come from the northwest of Scotland, west of Ireland and the Celtic Sea while no records have been made for the Malin Shelf and the Irish Sea. Similarly, almost all the records for the VME indicators come from the northwest of Scotland, west of Ireland and the Celtic Sea with only a small portion of these records having be made in the Malin Shelf and the Irish Sea.

The VME habitats, VME indicators and VME elements located within each of the five key areas within the Celtic Seas are summarized below. The presentation of information found in the ICES VME Database is accompanied by information collected from the scientific literature for the VME habitats, indicators, and elements. We have mainly focused on ecological studies as well as information coming from species distribution models (e.g., Dolan *et al*., 2008; Guinan *et al*. 2009a,b; Howell *et al*., 2011; Rengstorf *et al*., 2013, 2014; Ross and Howell, 2013; Mohn *et al*., 2014). For the key areas: Northwest of Scotland, West of Ireland and the Celtic Sea, we have identified nine subareas for which there was a relatively higher availability of data compared to other areas of the ecoregion. These nine subareas are: the Faroe-Shetland Channel, the Wyville Thomson Ridge, the Darwin Mounds, the Rosemary Bank Seamount, Anton Dohrn Seamount, the Hebrides Terrace Seamount, the Hatton-Rockall Plateau and George Bligh Bank, the Scottish and Irish shelf and slope, the Porcupine Bank and Porcupine Seabight (including references to the Whittard and Explorer canyons) (Figure 8).

4.6.1.1 Malin Shelf and the Irish Sea key areas

Due to the very small number of observations related to the Malin Shelf and the Irish Sea, these two key areas are presented together. Currently in the ICES VME Database are no records about VME habitats in these two areas. The mechanisms driving this situation are not known in detail yet, but a first suggestion could be the existence of unsuitable environmental conditions [e.g., relatively shallow waters (Lewis *et al*., 2015) and unfavourable water-mass characteristics] that do not support the proliferation of the organisms at such an extent that habitats could be formed. In addition, the small number of records could be due to limited sampling effort. With respect to VME indicators, there is a very limited number of records all of which refer to sea pens (Figure 7).

4.6.1.2 Northwest of Scotland

4.6.1.3 Faroe-Shetland Channel

- VME habitat(s): i) deep-sea sponge aggregations
- VME indicator(s): i) anemones, ii) cup coral, iii) sea pen, iv) sponge, v) soft coral
- VME element(s): none identified

The Faroe-Shetland Chanel hosts complex sedimentary (e.g., iceberg ploughmarks, a contourite band) and oceanographic settings as five water masses flow through it: North Atlantic Water, Modified North Atlantic Water, Modified East Icelandic Water, Norwegian Sea Arctic Intermediate Water, and Norwegian Sea Deep Water (Bett, 2003 and references therein).

Deep-sea sponge aggregations are the VME habitat identified in this area (Henry and Roberts, 2014; Kazanidis *et al*., 2019). These deep-sea sponge aggregations are mainly composed of massive (possibly *Geodia* spp.) and fan-shaped sponges (possibly *Phakelia* sp.). Based on towed-camera surveys it was shown that the maximum density of this VME habitat is recorded at a narrow depth zone at 400-450 m water depth (Kazanidis *et al*., 2019). Studies have shown that the density, morphotype diversity and body size of these sponge aggregations are higher in areas inside than outside the Faroe-Shetland Channel Nature Conservation Marine Protected Area (FSC NCMPA). It has been suggested that the low fishing pressure and the high-food supply promoted by the interactions of the water masses with the slope promote the proliferation of these deep-sea sponge aggregations inside the FSC NCMPA (Kazanidis *et al.*, 2019).

The VME indicators recorded in Faroe-Shetland Channel are anemones (2 records), cup corals (3 records), sea pens (10 records), soft corals (32 records) and sponges (773 records) (Howell *et al*., 2010). Between the areas demarked as Faroe-Shetland Channel and the Wyville Thompson Ridge (Figure 8) VME elements, i.e., steep flanks, occur at depths between 400 and 800 m, associated with the southern edge of the Munkagrunnur Ridge at the south-west extent of the Faroe-Shetland Channel.

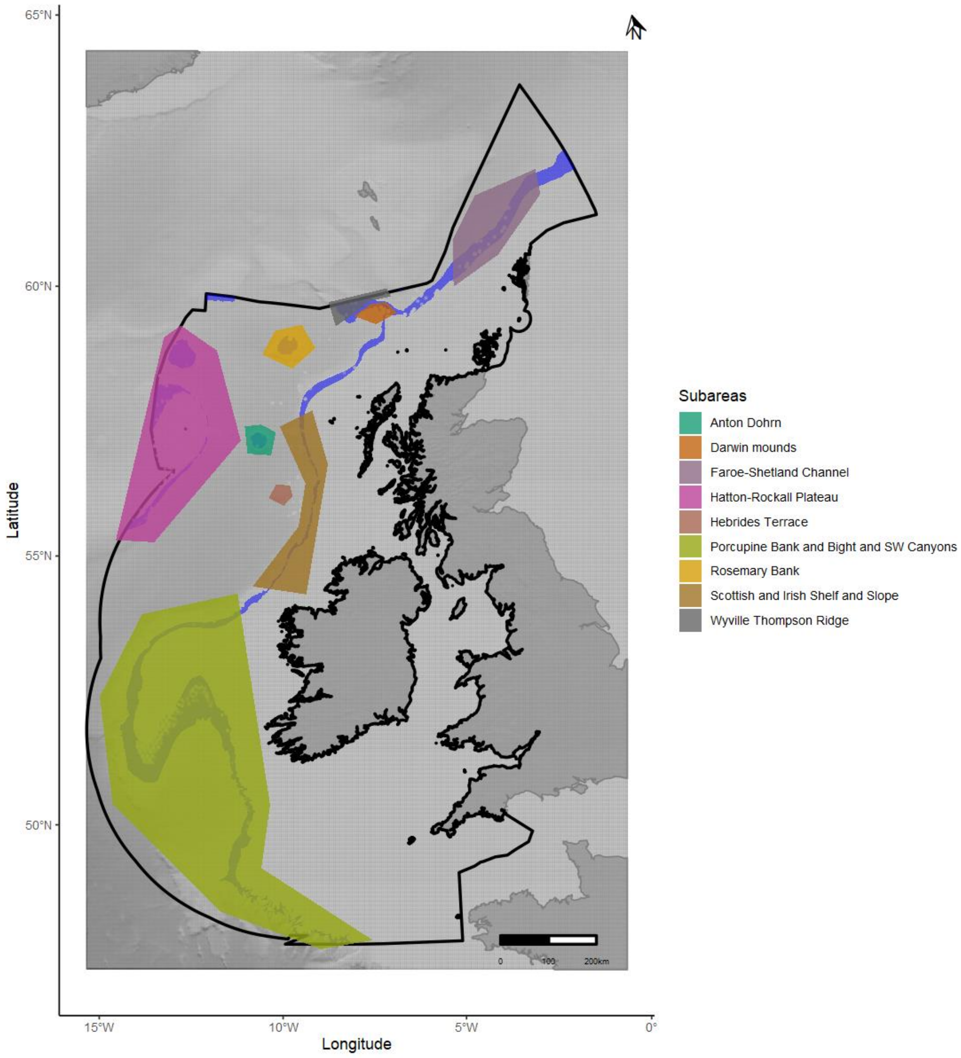


Figure 8. The Celtic Seas ecoregion highlighting the nine key subareas identified within the key areas of Northwest of Scotland, West of Ireland and the Celtic Sea. The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMODnet bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84 / UTM zone 29N.

4.6.1.4 Wyville Thomson Ridge

- VME habitat(s): i) deep-sea sponge aggregations
- VME indicator(s): i) gorgonian, ii) sea pen, iii) soft coral, iv) sponge, v) stony coral
- VME element(s): i) steep flanks

The Wyville Thomson Ridge is a rocky plateau to the north-east of the Rockall Trough. The Wyville Thomson Ridge separates the Faroe-Shetland Channel from the Rockall Trough, acting as a natural geological barrier that prevents the inflow of cold Faroe-Shetland Channel Bottom Water to the Rockall Trough. Due to this barrier, the deep cold water, flows northwestwards along the Wyville Thomson Ridge to the Faroe Bank Channel (McCartney and Mauritzen, 2001). In the southern edge of the Wyville Thomson Ridge the major water mass is the North Atlantic Water (Turrell *et al*., 1999) which receives the contribution from the northwards flowing Eastern North Atlantic Water (Holliday *et al*., 2000; Johnson *et al*., 2010).

The Wyville Thomson Ridge is composed of extensive stony reef intermixed with areas containing gravel and bedrock reefs in its flanks (Taylor *et al*., 2019). These habitats support diverse communities. According to the ICES VME Database the VME habitats in the area are the deep-sea sponge aggregations and the VME indicators are gorgonians (2 records), sea pens (2 records), soft corals (5 records), sponges (28 records) and stony corals (2 records). The area seems also to host stylasterids, cup corals and high densities of feather stars (Howell *et al*., 2010; Taylor *et al*., 2019). It is thought that the stony reef has been formed by the ploughing of icebergs at the end of the last ice age (Taylor *et al*., 2019). This is consistent with steep flanks on the Ymir Ridge and Wyville Thomson Ridge, overlapping with the 400-800 m depth zone at the eastern limits of both ridges.

4.6.1.5 Darwin Mounds

- VME habitat(s): i) cold water coral reef, ii) coral garden, iii) xenophyophore aggregations, iv) deep-sea sponge aggregations
- VME indicator(s): i) anemones, ii) cup coral, iii) gorgonian, iv) soft coral, v) sponge, vi) stony coral, vii) xenophyophores
- VME element(s): (i) steep flanks

The Darwin Mounds are small mounds (each up to 75 m across and 5 m high) located at ~1000 m water depth in the northern Rockall Trough (Masson and Jacobs, 1999). The Darwin Mounds are bathed in the lower part of the Eastern North Atlantic Water which runs across the Rockall Trough and is deflected towards the west after reaching the Wyville Thomson Ridge (Masson *et al*., 2003; see also above in Wyville Thomson Ridge section). These sand mounds are covered with cold-water corals, with the main species being *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata* (Masson *et al*., 2003). Soft corals and sponges, among other sessile and mobile fauna, have also been recorded (Howell *et al*., 2014). In the surrounding areas high abundance of the xenophyophore *Syringammina fragilissima* has been found (Hughes and Gooday, 2004). The Darwin Mounds are the first offshore MPA for the UK in 2003 (De Santo, 2013) and designated, under the EC Habitats Directive, as a Special Area of Conservation in 2015 (JNCC, 2015). Video surveys carried out in 2011 revealed no coral recolonization and very little regrowth in the Eastern Darwin Mounds, following 8 years of fisheries closure (Huvenne *et al*., 2016).

Based on the ICES VME Database the VME indicators in the area are anemones (19 records), cup corals (87 records), gorgonians (4 records), soft corals (7 records), sponges (269 records), xenophyophores (5 records) and stony corals (115 records). In terms of VME indicator elements, to the north of the mounds, within the area demarcated in Figure 8, are steep flanks between 400-800 m depth.

4.6.1.6 Rosemary Bank Seamount

- VME habitat(s): i) cold-water coral reef, ii) coral garden, iii) deep-sea sponge aggregations
- VME indicator(s): i) black coral, ii) cup coral, iii) gorgonian, iv) sea pen, v) soft coral, vi) sponge, vii) stony coral, viii) stylasterids
- VME element(s): i) steep flanks, ii) isolated seamount

The Rosemary Bank Seamount, an extinct seamount, is found in the Rockall Trough. The seamount is under the influence of Arctic (Norwegian Sea and Wyville-Thompson overflow water) and Atlantic water masses (Howe *et al*., 2006); the interactions of these masses with the seamount create a hydrodynamic regime which enhances the food supply to the benthic fauna (Eerkes-Medrano *et al*., 2020).

According to the ICES VME Database the seamount hosts the VME habitats cold-water coral reef, coral garden and deep-sea sponge aggregations while the VME indicators are black corals (3 records), cup corals (19 records), gorgonian corals (9 records), sea pens (14 records), soft corals (5 records), sponges (156 records), stony corals (30 records) and stylasterids (1 record).

Studies using towed cameras, drop-frame cameras and Agassiz trawls have revealed depth zones hosting distinct faunal communities (Eerkes-Medrano *et al*., 2020). Within the seamount's summit, pinnacles and upper slope of the seamount depth zone (330–700 m depth) *Desmophyllum dianthus*, *Lophelia pertusa* (i.e., *Desmophyllum pertusum*), *Madrepora oculata,* stylasterids and the gorgonian *Placogorgia* cf. *graciosa* were found; none of these, though, were found in quantities that would indicate reefs. In mid-slope depth zone (700-1100 m) *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata* were found in small quantities accompanied by hard-bottom gorgonian coral (*Acanthogorgia* cf. *armata* and *Placogorgia* cf. *graciosa*), the black coral *Parantipathes hirondelle,* the sea pen *Ptitella grandis* and several cup-corals (*Caryophyllia atlantica*, *Desmophyllum dianthus* and *Stephanocyathus moseleyanus*). In the deep slope mixed sponge aggregations mainly composed from five *Geodia* species *(G. atlantica, G. barretti, G. macandrewii, G. pachydermata, G. phlegraei), 'Tetilla' longipilis*, *Thenea levis, Stelletta* sp., *Pheronema carpenteri,* and several *Craniella* species, dominated up to a depth of 1500 m (McIntyre *et al*., 2016; Eerkes-Medrano *et al*., 2020).

There are small areas of steep flanks at 400-800 m depth which could provide suitable habitat for VMEs. The region is an isolated seamount, which is, itself, a VME indicator element.

4.6.1.7 Anton Dohrn Seamount

- VME habitat(s): i) cold-water coral reef, ii) coral garden
- VME indicator(s): i) gorgonian, ii) stony coral, iii) sea pen
- VME element(s): i) steep flanks, ii) isolated seamount

The Anton Dohrn Seamount is a seamount located to the west of Scotland between the Hebrides Shelf and the Rockall Bank, with its summit being found at ~600 m rising from a depth over 2000 m (Davies *et al*., 2015). The Anton Dohrn Seamount is under the influence of the relatively warm and salty Eastern North Atlantic Water (Ellett *et al*., 1986) while its north-west flank is influenced by Arctic waters (Johnson *et al*., 2010).

Based on records from the ICES VME Database, the VME habitats here are cold-water coral reefs and coral gardens. The VME indicators on this seamount are gorgonian corals (1 record), sea pens (1 record) and stony corals (69 records).

Multibeam echosounder and video surveys showed that the northwest and southeast sides of the seamount host 13 biotopes, 10 of which could be characterized as VME habitats: three coral gardens, four cold-water coral reefs, two xenophyophore communities and one sponge dominated community (Davies *et al*., 2015). Reefs formed by *Lophelia pertusa* (i.e., *Desmophyllum* *pertusum*) and *Solenosmilia variabilis* were found at depths 747-791 m (cliff top mounds) and 1318-1351 m (radial ridge), respectively. Xenophyophore biotopes were found on the southeast side of the seamount's summit edge (1104-1154 m), on both sides' flanks and once in a radial ridge on both sides' flanks. The sponge aggregations were found on the northwest and southeast sides of the seamount associated with the escarpment feature (854–1345 m) (Davies *et al*., 2015). Apart from a small area in the northwestern part, any steep flanks on the Anton Dohrn Seamount tend to be greater than 800 m depth. The region is an isolated seamount, which is, itself, a VME indicator element.

4.6.1.8 Hebrides Terrace Seamount

- VME habitat(s): none identified
- VME indicator(s): i) black coral, ii) cup coral, iii) gorgonian, iv) sea pen, v) soft coral, vi) sponge, vii) stony coral
- VME element(s): none identified between 400-800 m

The Hebrides Terrace Seamount is an elliptical flat-topped guyot in the Rockall Trough. Along the southern and western flanks of the seamount, several canyons, gullies and escarpments are found (Sacchetti *et al*., 2012). In terms of water-mass characteristics, the upper layers are under the influence of the North Atlantic Current (NAC) and overlay a zone at 600-1200 m depth that is shaped by the northward-flowing warm and saline Eastern North Atlantic Water. At depths greater than 1200 m cooler dense water masses come from the Norwegian Sea overflowing the Wyville Thomson Ridge (Wyville Thomson Ridge Overflow Water (WTOW); Johnson *et al*., 2010) while at ~1500 m WTOW transitions to Labrador Sea water down to about ~2000 m (McGrath *et al*., 2012).

Based on records in the ICES Database the area hosts the VME indicators black corals (497 records), cup corals (28 records), gorgonian corals (123 records), sea pens (93 records), soft corals (58 records), sponges (506 records) and stony corals (393 records).

Three ROV dives and examination of video material from the Hebrides Terrace Seamount revealed that a coral reef framework on the seamount was formed by *Solenosmilia variabilis* and hosted a rich mixture of associated species such as black corals, bamboo corals, cup corals, sponges, crinoids, and tunicates (Henry *et al.*, 2014). In addition, two peaks in species richness across depth were found: the first took place at 1300-1400 m where cold Wyville Thomson Ridge Overflow Water is mixed with subtropical gyre waters; the second peak was recorded at 1500-1600 m where the Overflow Water is mixed with subpolar mode waters (Henry *et al*., 2014). The top of the Hebrides Terrace Seamount lies deeper than 800 m depth so, although the seamount itself is a VME indicator element, and it has steep flanks on all sides, there are no VME indicator elements between 400-800 m depth.

4.6.2 West of Ireland and Celtic Sea

4.6.2.1 Hatton-Rockall Plateau and George Bligh Bank

- VME habitat(s): i) cold-water coral reef, ii) deep-sea sponge aggregations, iii) coral garden, iv) tube-dwelling anemone aggregations, v) sea pen fields, vi) xenophyophore aggregations
- VME indicator(s): i) black coral, ii) cup coral, iii) gorgonian, iv) sea pen, v) soft coral, vi) sponge, vii) stony coral, viii) stylasterids
- VME element(s): i) steep flanks

The Rockall Bank is an offshore Bank ~400 km west of the Outer Hebrides Sea, lying on the north side of the Rockall Trough. The upper water column in the area is characterized by the relatively warm and salty Eastern North Atlantic Water while below 1200 m the deep Labrador Sea Water is trapped by the shallowing topography in the north which prevents through flow but allows recirculation within the basin (Holliday *et al*., 2000).

Based on records in the ICES Database, the VME habitats are cold-water coral reefs, deep-sea sponge aggregations, coral gardens, tube-dwelling anemone aggregations, sea pen fields and xenophyophore aggregations. The VME indicators are black corals (23 records), cup corals (143 records), gorgonian corals (53 records), sea pens (257 records), soft corals (53 records), sponges (891 records), stony corals (541 records) and stylasterids (5 records). Studies have mentioned that living *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) has high abundance between 600-800 m in the southern Rockall Trough (White *et al*., 2005). Within this depth zone (600-800 m) in the southern Rockall Trough, the corals are closely associated with the carbonate mounds in the flanks of the Rockall Bank (Wilson, 1979; van Weering *et al*., 2003; White *et al*., 2005; Duineveld *et al*., 2007; see also below for the Porcupine Bank). Indeed, studies on the coral mounds in the southeast Rockall Bank have shown that cold-water coral reefs act as hot spots of biodiversity, biomass and carbon cycling (van Oevelen *et al*., 2009). Apart from the depth zone of 600-800 m water depth, *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata* cold-water coral reefs are also found in shallower parts of the Rockall Bank ranging from 200 m down to 600 m (Narayanaswamy *et al*., 2006; Howell *et al*., 2014). Deep-sea sponge aggregations are mentioned in the upper Rockall Bank (~180-190 m; Narayanaswamy *et al*., 2006) and deeper parts (400-800 m; Henry and Roberts, 2014; ICES, 2020a). Dense stylasterid aggregations are found in the upper Rockall Bank (~180-190 m; Narayanaswamy *et al*., 2006) and coral gardens between 400 m and 800 m in the northern Rockall Bank (ICES, 2020a). In the George Bligh Bank, extensive areas of reef framework by *Lophelia pertusa* (now known as *Desmophyllum pertusum*) and *Madrepora oculata* were found between 500 and 900 m (Narayanaswamy *et al*., 2006, 2013). In terms of VME indicator elements, there is a limited area of steep flank on the George Bligh Bank, but extensive areas on the Rockall Bank coinciding with the 400 - 800 m depth zone.

4.6.2.2 Scottish and Irish Continental Shelves and Slopes

- VME habitat(s): i) cold-water coral reef, ii) stalked crinoid aggregations, iii) coral garden, iv) tube-dwelling anemone aggregations, v) sea pen fields, vi) xenophyophore aggregations
- VME indicator(s): i) black coral, ii) cup coral, iii) gorgonian, iv) sea pen, v) soft coral, vi) sponge, vii) stony coral, viii) stylasterids, ix) anemones
- VME element(s): i) canyons, ii) steep flanks

Based on records in the ICES Database the area hosts the following VME habitats: cold-water coral reef, stalked crinoid aggregations, coral garden, tube-dwelling anemone aggregations, sea pen fields and xenophyophore aggregations. The VME indicators are anemones (6 records), black coral (16 records), cup coral (76 records), gorgonian corals (46 records), sea pens (104 records), soft corals (9 records), sponges (78 records), stony corals (13 records) and stylasterids (2 records). The reef building *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) has been found in relatively few places up to now in the Scottish and Irish continental shelf and slope (e.g., in the Stanton Bank; see Figure 1 in Roberts *et al*., 2003, 2009). Species distribution models predict the presence of *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and xenophyophores, *Syringammina fragilissima*, along the Scottish and Irish continental shelf and slope (see Figure 2 in Ross and Howell, 2013). The presence of the sea pens *Virgularia mirabilis, Pennatula phosphorea* and *Funiculina quadrangularis* has been recorded in the Outer Hebrides Sea (Scottish continental shelf). Following the SACFOR scale (Strong and Johnson, 2020), the abundance of *Virgularia mirabilis* was mainly marked as occasional while the abundance of *Pennatula phosphorea* and *Funiculina quadrangularis* was marked as occasional/frequent and common/frequent, respectively (see Figures 3, 4, 5 in Greathead *et al*., 2007). At least a dozen canyon heads intersect with the 400 - 800 m depth contour on the Irish-Scottish continental slope north of the Porcupine Bank, with additional canyon features deeper than this. There are also extensive but narrow (in depth) steep flanks between the 400- 800 m depth contours southward from 55.5°N.

4.6.2.3 Porcupine Bank and Porcupine Seabight (including references to the Whittard and Explorer canyons)

- VME habitats: i) anemone aggregations, ii) cold-water coral reef, iii) coral garden, iv) deep-sea sponge aggregations, v) sea pen fields, vi) tube-dwelling anemone aggregations, vii) xenophyophore aggregations, viii) stalked crinoid aggregations
- VME indicators: i) anemones, ii) black coral, iii) cup coral, iv) gorgonian, v) sea pen, vi) soft coral, vii) sponge, viii) stony coral, ix) xenophyophores, x) stylasterids
- VME element(s): i) canyons, ii) steep flanks

VME habitats formed by cold-water corals (e.g., the scleractinian *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata*) on coral mounds in the Porcupine Bank and Porcupine Seabight are closely associated with carbonate mounds (e.g., along the flanks of the Porcupine Bank) and topographic ridges (e.g., in the Porcupine Seabight) (van Weering *et al*., 2003; White *et al*., 2005). The environmental settings around these geological structures are characterized by strong currents and seafloor erosion that supply a hard substratum for the settlement of corals, promote the suspension of food particles and prevent the settlement of sediments that otherwise would smother the developing corals (Frederiksen *et al*., 1992; Wheeler *et al*., 2005; White, 2006).

According to the ICES VME Database the areas host the VME habitats anemone aggregations, cold-water coral reef, coral garden, deep-sea sponge aggregations, sea pen fields, tube-dwelling anemone aggregations, xenophyophore aggregations and stalked crinoid aggregations. The VME indicators are anemones (574 records), black corals (189 records), cup corals (23 records), gorgonians (81 records), sea pens (897 records), soft corals (42 records), sponges (101 records), stony corals (549 records), xenophyophores (5 records) and stylasterids (8 records). The mounds and their corals, which support a rich biodiversity of sessile and suspension feeders (Henry and Roberts, 2007), are found within the depth zone dominated by the warm upper Eastern North Atlantic Water and intermediate Mediterranean Outflow Water (White *et al*., 2005). Apart from the Porcupine Bank and Porcupine Seabight, dense cold-water coral communities have been found in the Whittard canyon in depths ranging from 880 to 3300 m water depth. They were dominated by the soft coral *Anthomastus* sp., the stony coral *Lophelia pertusa* (i.e., *Desmophyllum pertusum*), and the octocorals *Primnoa* sp., *Acanthogorgia* sp. and *Acanella* sp. (Huvenne *et al*., 2011). The highest density of *Lophelia pertusa* was recorded in the eastern branch of the Whittard canyon, on a 1600 m long cliff (Huvenne *et al*., 2011). The scleractinian corals *Desmophyllum dianthus* and *Madrepora oculata* are also found at vertical walls at depths less than 800 m in canyon heads in Whittard Canyon (Johnson *et al*., 2013).

In the Explorer Canyon, a tributary of Whittard Canyon, reef-building scleractinians have been recorded on a spur midway up canyon's branch at 795–940 m depth (Davies *et al*., 2014; Price *et al*., 2019). Deep-sea sponge aggregations formed by *Pheronema carpenteri* in the bathyal Porcupine Seabight (~1200 m water depth) were examined in 1983/4 (Rice *et al*., 1990) and revisited almost 30 years later (Vieira *et al*., 2020). Over the years a very substantial reduction in the standing stock of sponges was recorded possibly due to demersal fishing (Vieira *et al*., 2020).

In terms of VME indicator elements, this area is characterised by its canyons, particularly the Porcupine Bank Canyon, and Whittard Canyon, and many of the canyon branches are themselves characterized by steep flanks.

Fisheries Data

The required data on fisheries was based on that available following the annual ICES data calls for VMS/logbook (link). Analyses of this data has been fully documented using the ICES Transparent Assessment Framework (TAF).

Fishing Footprint

The EC request requires that ICES '*provide a description of the existing deep-sea fishing areas based on the reference years 2009-2011*'. Previous work (ICES, 2018c) has grouped all bottom-contacting gear (mobile bottom contacting gears (MBCG) and static gears) into either presence or absence under the assumption that any contacts to VMEs will impact them.

There are some bounds on the possibilities when using the data collected through the ICES VMS and Logbook data call. In both NAFO and NEAFC, point data aggregated into individual fishing activity tracks has been used to refine edges of VME closures to ensure they are appropriate. Such fine-tuning is not possible with the gridded data products available here due to the need to use aggregated data from fishing activities. However, other information could be used to supplement the appropriateness of the boundaries, such as slope direction, seabed depth or substrate.

To meet this request, fishing activity needs to be described only for where the regulation applies which is limited to EU waters of the NE Atlantic (nested within the overarching ICES region, and where we have data). All countries' vessels that have submitted data in response to the ICES VMS and logbook data call are included. Disaggregation by countries' vessels is not possible. The countries which have not thus far participated in the VMS and logbook data call (Russia and Faroes) do not have extensive interests in deep-water fisheries in EU waters, therefore their omission is unlikely to be a significant factor in interpreting patterns of activity.

The fishing footprint shown in Figure 9a represents all C-squares, in which there is a SAR of > 0 for mobile bottom-contacting gears or a presence of fishing activity of static gears, that share at least one vertex with another fished C-square (during the reference period 2009-2011).

Table 2. Total numbers of C-squares and numbers of C-squares fished (MBCG + Static) in the Celtic Seas Ecoregion per EEZ within 400-800 m depth range.

EEZ	Number of C-squares within 400-800 m depth range	Number of C-squares fished within 400-800 m depth range	Percentage Fished (%)
United Kingdom	2442	1920	79
Ireland	2306	2229	97
France	75	72	96
Total	4823	4221	88

For this ecoregion the fishing footprint is extensive covering almost all (88%) of the 400-800 m depth (Table 2). Along the continental shelf the unfished C-squares are most commonly found on the deeper edge of the bathymetric range. This is most apparent on the northern shelf edge of the United Kingdom EEZ north of the Wyville-Thomson ridge where just over half of the depth range appears to be fished moving from shallow into deeper waters. This is also visible to a lesser extent around the Porcupine Bank. There appears to be slightly differing distributions of fishing presence on the isolated banks and seamounts. At George Bligh Bank there is a perimeter of unfished C-squares; a small aggregation of unfished C-squares can be seen in the centre of the Anton Dohrn seamount and no deep-sea waters at Rosemary Bank are unfished (Figure 9a).

The areas of the fishery footprint that is fished by the most sub-gears (see Table 4 for list) are the shelf edge south of Wyville-Thomson Ridge stopping north of the Porcupine Bank, to the south of the shelf edge surrounding Porcupine Seabight and in the Hatton-Rockall Basin. The C-squares with the fewest sub-gears present include the isolated banks and seamounts and appear to reflect the areas where unfished squares are more frequently observed (Figure 9b).

In this ecoregion the EEZs of the UK and Ireland have the greatest number of C-squares within the 400-800 m depth range (Table 2). The percentage of these C-squares that are fished in each EEZ ranges from 79% in UK to 97% in Ireland (Table 2). Fishing in the 400-800 m depth contour accounts for 11% (UK), 15% (Ireland) and 5% (France) of each country's fished area. A map showing the presence and absence of fishing is shown in Figure 9a, and Figure 9b and Table 3 highlights the numbers of sub-gears recorded in each C-square. The majority of C-squares experience fishing pressure from multiple gears, with only 19% experiencing only one gear type (Table 3). The difference in fishing presence/absence between the reference period (2009-2011) and more recent activity (2012-2019) is illustrated in Figure 10.

Table 3. Total numbers of C-squares fished by multiple Sub-gears (MBCG and Static as listed in Table 4) in the Celtic Seas Ecoregion and per EEZ within 400-800 m depth range.

Number of Sub-gears Fishing in C-square	France	Ireland	United Kingdom	Total
1	0	293	491	784
2	2	506	751	1,259
3	14	589	490	1,093
4	35	482	150	667
5	19	315	37	371
6	2	43	1	46
7	0	1	0	1
Total	72	2,229	1,920	4,221

Otter trawl gears are the dominant gear grouping (spatially) within the 400-800 m depth range of the Celtic Seas ecoregion, closely followed by static gears (Table 4). Within otter trawls, the largest footprint within the 400-800 m depth range belongs to gadoid directed fisheries (OT_DMF) followed by benthic fisheries (OT_MIX_DMF_BEN: Table 4). Within the static gears, the largest footprint within the 400-800 m depth range belongs to gill nets (GNS), followed by longlines (LLS: Table 4). There is little evidence for other gears being used in deep waters (Table 4). Across the entire ecoregion, otter trawlers and demersal seiners account for the majority of the fishing effort in the ecoregion. Otter trawl fishing is highest and spatially concentrated on the *Nephrops* grounds in the Celtic Sea, and close to the continental shelf edge. Demersal seiners are mainly active in the Celtic Sea. Static gears (longlines and gillnets) account for the next highest levels of effort; these fisheries are also concentrated close to the continental shelf edge, particularly in the southern and northern parts of the ecoregion. The largest demersal fishery in the ecoregion targets hake along the shelf edge using gillnets and longlines. There are also large mixed bottom-trawl fisheries targeting benthic species, *Nephrops,* and gadoids. The species composition of these mixed fisheries tend to vary, depending on the area and the countries involved in the fishery (ICES, 2018b).

Fourteen nations currently have fisheries targeting the many marine stocks within this diverse and extensive ecoregion. The greatest amount of landings are by Norway, UK, Ireland, the Netherlands, and France. Lesser amounts are landed by Germany, Spain, Belgium, Lithuania, Poland, and Estonia (ICES, 2018b).

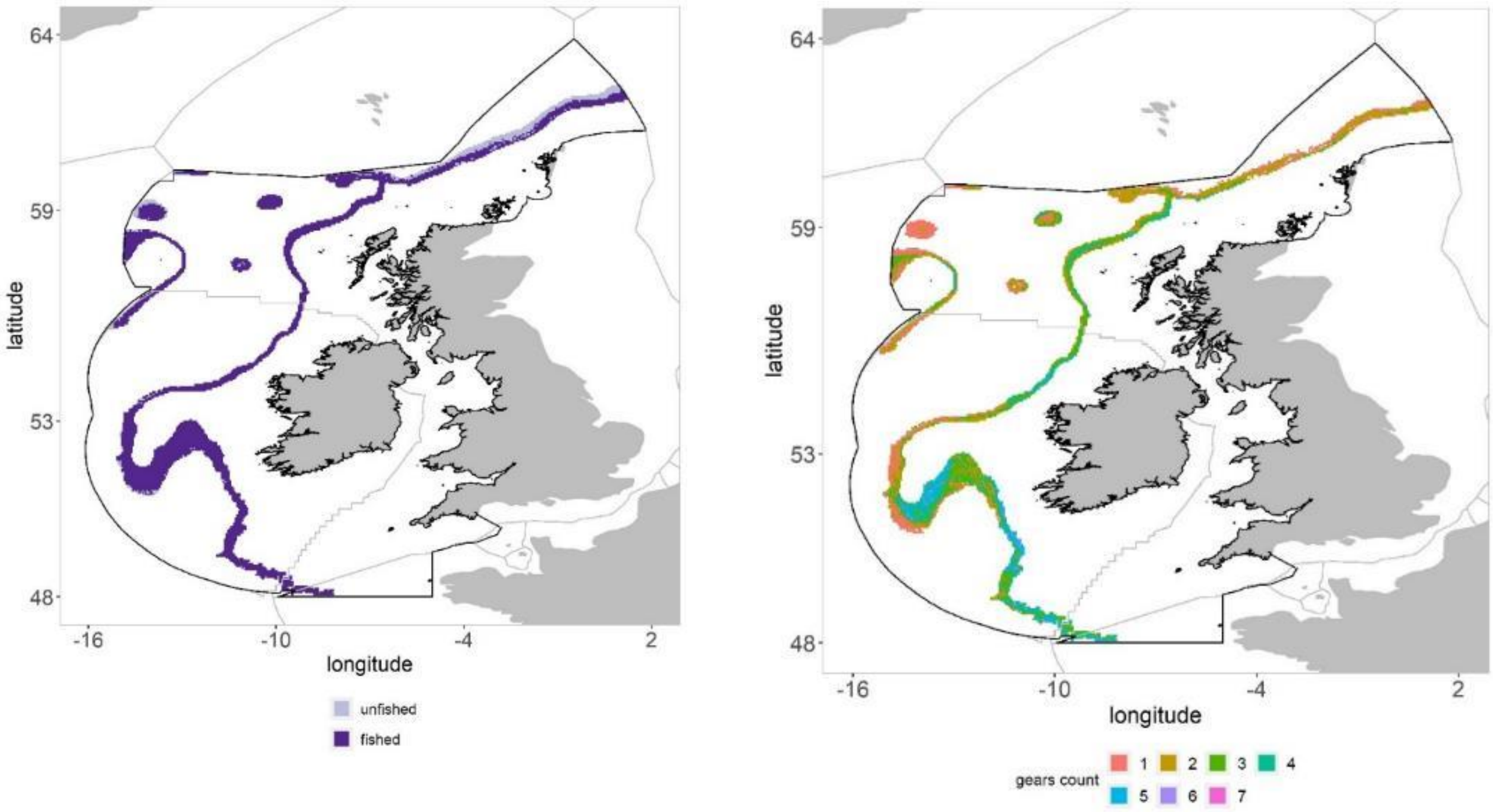


Figure 9. A) Fishing footprint (between 400 m and 800 m depth) of all bottom-contacting fishing gears (MBCG and Static) in 2009-2011 highlighting fished vs. unfished areas. B) Fishing footprint (between 400 m and 800 m depth) of all mobile bottom-contacting fishing gears (MBCG and Static) in 2009-2011 highlighting the number of gear types recorded in each C-square. Copyright: EEZ: Flanders Marine Institute (2020). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Depth contours: EmodNet Bathymetry Consortium (2018). Map projection: EPSG:4326 - WGS 84.

Table 4. Numbers of C-squares fished (MBCG and Static) between 2009-2011 within 400-800 m depth range and the total region for the Celtic Seas Ecoregion (covering the EEZs of UK, Ireland, and France). Sub-gear métiers and Typical Target Species follow Eigaard *et al*. (2015) and are described in Annex 9 of ICES WGSFD 2015 report. OT=Otter Trawl; DMF=Demersal Fisheries (e.g., Cod or Plaice); CRU=Crustaceans (e.g., Nephops or shrimp); SPF=Sprat Fishery; BEN=Benthic Fish; GNS=Set Gillnets; LLS=Set Longlines; FPO=Fish Operation Pots.

		France		Ireland		United Kingdom		Total	
		400-800	**Region**	**400-800**	**Region**	**400-800**	**Region**	**400-800**	**Region**
Total footprint		72	1,337	2,229	14,425	1,920	17,554	4,221	33,316
Gear type									
Otter		72	1,336	1,700	12,279	1,538	14,413	3,310	28,028
Static		72	854	1,896	10,601	1,268	9,486	3,236	20,941
Beam		0	663	0	1,675	0	3,193	0	5,531
Seine		0	84	0	1,851	0	2,240	0	4,175
Dredge		0	61	0	733	0	3,130	0	3,924
Sub-gears Otter (OT)	**Typical Target Species**								
OT_DMF	Cod or plaice or Norway pout	72	1,332	1,616	11,610	1,381	12,865	3,069	25,807
OT_MIX_DMF_BEN	Benthic fish	35	166	978	3,245	1,169	3,402	2,182	3,568
OT_CRU	Nephrops or shrimps	33	139	1,000	5,189	29	3,799	1,062	9,127
OT_MIX	Individual species not informed	2	931	145	1,157	119	2,340	266	4,428
OT_SPF	Sprat or sandeel	0	31	4	101	13	263	17	395
OT_MIX_CRU_DMF	Nephrops and mixed demersal	0	0	0	203	0	413	0	616
Sub-gears Static	**Typical Target Species**								

		France		Ireland		United Kingdom		Total	
		400-800	**Region**	**400-800**	**Region**	**400-800**	**Region**	**400-800**	**Region**
GNS	Hake and monkfish	72	403	1,598	8,327	871	4,952	2,541	13,682
LLS	Hake, ling, blue ling, deep-water sharks	70	525	1,152	3,250	493	1,959	1,715	5,734
FPO	Shellfish	9	330	347	2,416	179	4,677	535	7,423

Countries targeting demersal stocks in the Celtic Seas ecoregion include:

- France: the offshore fishery is mostly composed of bottom trawlers (18–35 m, around 350 vessels) targeting gadoids, *Nephrops* or anglerfish, megrim, and rays, with less than ten vessels using Danish seine. In the west of Scotland around ten bottom trawlers target both saithe and deep-sea fish (at depths less than 800 m). Seventeen longline vessels currently fish in the ecoregion, an increase from 1 in 2000. Five smaller vessels target hake using set-nets (ICES, 2019).
- Germany: about seven German vessels target anglerfish and hake with gillnets and longline.
- Ireland: vessels in the 12– 25 m length range target *Nephrops* using trawls on several grounds around Ireland and on the Porcupine Bank. Both inshore and offshore mixed demersal fisheries use trawls and seine nets to target gadoids and benthic species. Vessels using gillnets target hake offshore and pollack, monkfish, and cod in inshore areas. Ten beam trawlers target benthic species such as megrim, anglerfish, flatfish, and rays.
- Norway: demersal longline fishery mainly targeting ling and blue ling.
- Spain: 67 vessels >24 m that operate mainly in the Porcupine and Great Sole banks and, to a lesser degree, west of Scotland. All of these vessels target demersal species: set longlines targeting hake (44 vessels), bottom otter trawl targeting megrim, anglerfish, and hake (21 vessels), and set gillnet targeting hake (2 vessels).
- United Kingdom:
    - Scotland: most fishing occurs west of Scotland. Around 62 demersal trawlers (mostly >10 m) fish for mixed gadoids and benthic species such as anglerfish and megrim. A small number of boats target haddock at Rockall. Around 60 larger vessels (> 10 m) fish for crustaceans (mainly brown crab) in more offshore areas to the far north and west of Scotland. Trawling for *Nephrops* also occurs at the Porcupine Bank and in the Celtic Sea. Mixed-fish trawling, longlining, and gillnetting occurs in the Celtic Sea and western English Channel.
    - Northern Ireland: The Northern Irish fleet consists of around 130 ≥ 10 m and 180 < 10 m vessels. The fleet predominantly operates within the Irish Sea, Western English Channel, and West of Scotland. A small number of vessels trawl for haddock, hake, and (historically) cod.
    - England and Wales: Vessels employing otter trawls (~300 vessels, around half of which are < 10 m) take a mixture of demersal stocks although some target whitefish and elasmobranchs. This sector employs otter trawls that use selective gear to reduce whitefish bycatch. Beam-trawling activity (~60 vessels) is dominated by vessels longer than 15 m (~45 vessels), taking a mixture of flatfish and anglerfish with evidence of an increasing targeted fishery for cuttlefish in the English Channel.

Until 2016, deep-water trawl fisheries were conducted in the Celtic Seas, principally by France, with some Spanish, Irish, and Scottish participation. Trawling deeper than 800 m has been banned since December 2016 (*Regulation (EU) 2016/2336 of the European Parliament and of the Council of 14 December 2016 establishing specific conditions for fishing for deep-sea stocks in the north-east Atlantic and provisions for fishing in international waters of the north-east Atlantic and repealing Council Regulation (EC) No 2347/2002*, 2016). This mixed deep-water trawl fishery mainly targeted roundnose grenadier, black scabbardfish, and blue ling, with a bycatch mainly of smoothheads and deep-water sharks on the continental slope and offshore banks of the ecoregion.

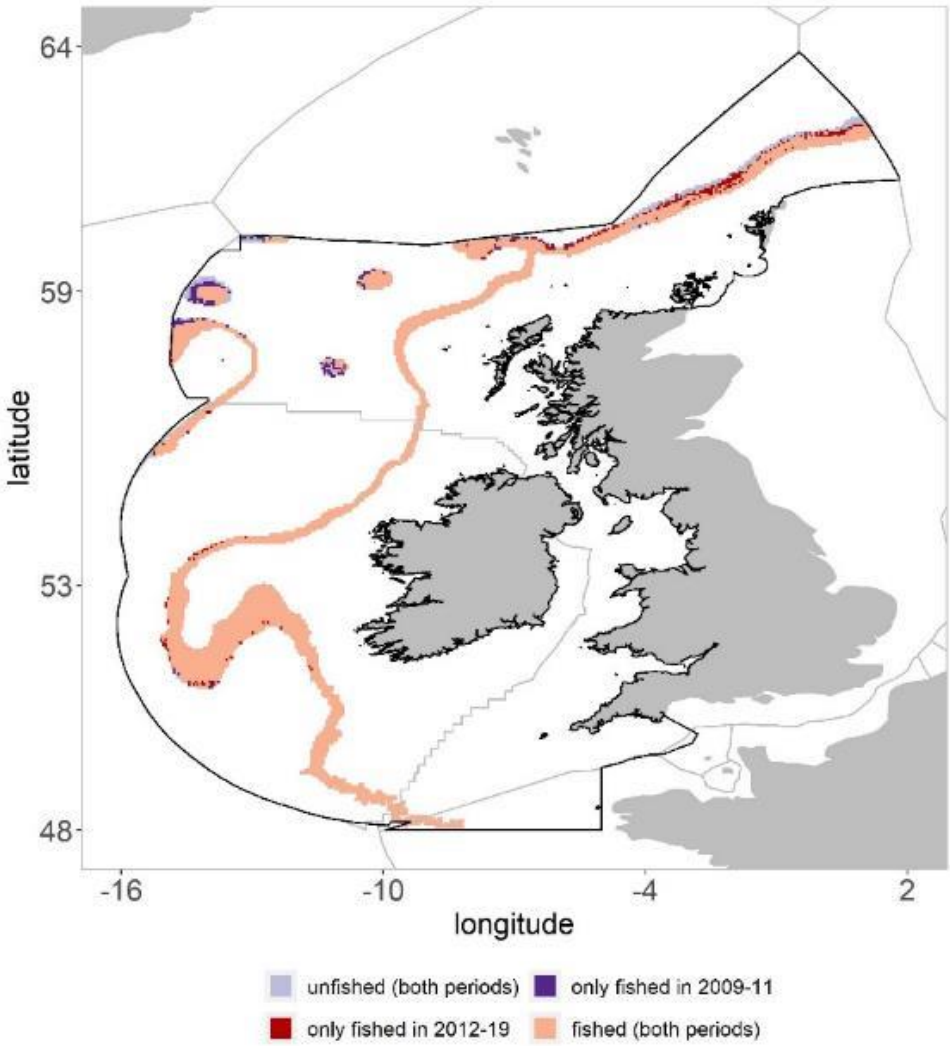


Figure 10. Difference in fishing occurrences in C-squares between the reference period (2009-2011) (Figure 9) and the period 2012-2019. Most C-squares are either unfished or fished in the two periods.

Fisheries Impacts on VMEs

The principal current human activity resulting in physical disturbance in the deep sea is fishing, in particular bottom trawling (Benn *et al*., 2010) but also longlining (Lumsden *et al.* 2007, Mytilineou *et al.* 2014, Pham *et al*., 2014). Mobile gears such as trawls are known to have the greatest impact on VMEs (Hiddink *et al*., 2018). Declining condition (density, body size) of deep-sea sponge aggregations have been observed associated with the impacts of demersal fisheries (Vieira *et al*., 2020). In some studies, marine protected areas have been shown to be effective in protecting deep-sea sponge (Kazanidis *et al*., 2019), whereas in others, cold-water coral reefs showed little recovery after 8 years of closure to bottom trawling (Huvenne *et al*., 2016). Continued abrasion and physical disturbance as a result of mobile fishing activities can negatively affect the community structure of shelf and deepwater sediment habitats. Physical damage from bottom trawling and dredging also impact benthic habitats through displacement or overturning of boulders and cobbles, removing or damaging epifaunal species, disturbing sediments and damaging fragile deep-sea communities including sponge aggregations, coral gardens, and deep-water coral reefs. Within the Celtic Seas ecoregion, mobile bottom-contacting gears are concentrated on the *Nephrops* grounds, along the continental shelf edge, and throughout the Celtic Sea. There is less activity by mobile bottom-contacting gears in much of the area west of Scotland and west of Ireland.

Deep-sea bottom longlining has been shown to have little impact on VMEs, reducing bycatch of cold-water corals and limiting additional damage to benthic communities (Pham *et al.*, 2014). Moreover, as longlining mainly targets large colonies with complex morphologies (e.g., coral gardens) it may cause shifts in the faunal composition of VME habitats (Lumsden *et al.*, 2007; Mytilineou *et al.*, 2014; Pham *et al.*, 2014).

Faunal communities in deep-sea sedimentary habitats live in cold waters with a relatively low supply of food, with slow life-histories, low population growth, recovery rates and long lifespans (Gageand Tyler, 1991; Billett *et al.*, 2001; Benn *et al.*, 2010; ICES, 2020a). Even low fishing rates may have serious impacts under these conditions. Extensive areas of biogenic reefs may also have been impacted through abrasion, e.g., cold water corals such as *Lophelia* (i.e., *Desmophyllum pertusum*) in deep-water habitats on the western shelf of the Celtic Sea ecoregion (Hall-Spencer *et al*., 2002).

Smothering due to resuspension of sediments can result also in physical loss and damage. The degree of permanence of any habitat changes will be dependent on the substrate type, the presence of sensitive or vulnerable communities, and the frequency of the activity (van Dalfsen *et al.*, 2000; Robinson *et al.*, 2005; Foden *et al.*, 2009).

Overlap Between VME and Fisheries

Overlap between VME and fishing data shows that fishing occurs in 95% of C-squares with known VME occurrence or likely occurrence (Table 5). Overlap is most pronounced in France (100%), however the fewest VME occurrences (7) are within the French EEZ in this ecoregion. VMEs are most numerous within the Irish EEZ (243) where 98% are fished, followed by the United Kingdom with 142 known or likely VMEs (88% fished). The overlap is estimated using data on all gear types but is mostly coming from otter trawl gears that are the dominant fishing gear operating in the 400-800 m depth range (Table 4). These trawls predominantly target gadoid, *Nephrops*, and benthic fish species, and are primarily active within the Irish EEZ (highest overlap of gears: Table 5). However, static gears are not insignificant; pots (FPO) overlap with 12% of the C-squares with known or likely VME occurrence, whereas longlines (LLS) overlap with 49% and gillnets (GNS) 67% (Table 6). A map illustrating overlap between VME presence at different levels of precaution and fishing (by all gears) and overlap between VME presence (all levels of precaution) and fishing by otter trawl gears at different levels of intensity is shown in Figure 11. Fishing intensity is detailed in the WKEUVME report (Section 4.4).

Table 5. Number of C-squares with VME occurrence and likely occurrence within 400-800 m depth range categorized by the degree of precaution (low (presence of VMEs certain), medium and high (presence of VMEs uncertain), Table 1) for the total region and per EEZ. The C-square is defined as fished when the SAR > 0 (average 2009-2011). Note that the selection of C-squares with a high degree of precaution is only based on the ICES VME Index data.

Region	VME presence	Precaution low		Precaution medium		Precaution high	
		fished	total	fished	total	fished	total
Ireland	243	27	31	25	25	187	187
United Kingdom	142	35	41	43	43	47	58
France	7	4	4	3	3	0	0
Total region	392	66	76	71	71	234	245

Table 6. Number of C-squares with VME occurrence and likely occurrence within 400-800 m depth range categorized by the degree of precaution (low, medium and high, Table 1) per EEZ and by Sub-gear. See Table 4 for typical target species of each gear. The C-square is defined as fished when the SAR > 0 (average 2009-2011) for MBCG and fishing presence for static gears. Note that the selection of C-squares with a high degree of precaution is only based on the ICES VME Index data. OT=Otter Trawl; DMF=Demersal Fisheries (e.g., Cod or Plaice); CRU=Crustaceans (e.g., Nephops or shrimp); SPF=Sprat Fishery; BEN=Benthic Fish; GNS=Set Gillnets; LLS=Set Longlines; FPO=Fish Operation Pots.

EEZ	VME presence	Precaution low		Precaution medium		Precaution high	
		fished	total	fished	total	fished	total
Ireland							
OT_MIX_CRU_DMF	243	0	31	0	25	0	187
OT_CRU	243	6	31	5	25	172	187
OT_DMF	243	12	31	19	25	186	187
OT_MIX	243	1	31	2	25	2	187
OT_MIX_DMF_BEN	243	7	31	9	25	125	187
OT_SPF	243	0	31	0	25	1	187
FPO	243	8	31	7	25	20	187
GNS	243	18	31	17	25	147	187
LLS	243	13	31	14	25	132	187
United Kingdom							
OT_MIX_CRU_DMF	142	0	41	0	43	0	58
OT_CRU	142	0	41	0	43	0	58
OT_DMF	142	19	41	32	43	45	58
OT_MIX	142	0	41	2	43	8	58

EEZ	VME presence	Precaution low		Precaution medium		Precaution high	
		fished	total	fished	total	fished	total
OT_MIX_DMF_BEN	142	18	41	16	43	41	58
OT_SPF	142	0	41	0	43	1	58
FPO	142	2	41	6	43	1	58
GNS	142	22	41	33	43	18	58
LLS	142	4	41	5	43	18	58
France							
OT_MIX_CRU_DMF	7	0	4	0	3	0	0
OT_CRU	7	1	4	3	3	0	0
OT_DMF	7	4	4	3	3	0	0
OT_MIX	7	0	4	0	3	0	0
OT_MIX_DMF_BEN	7	0	4	1	3	0	0
OT_SPF	7	0	4	0	3	0	0
FPO	7	2	4	0	3	0	0
GNS	7	4	4	3	3	0	0
LLS	7	3	4	3	3	0	0

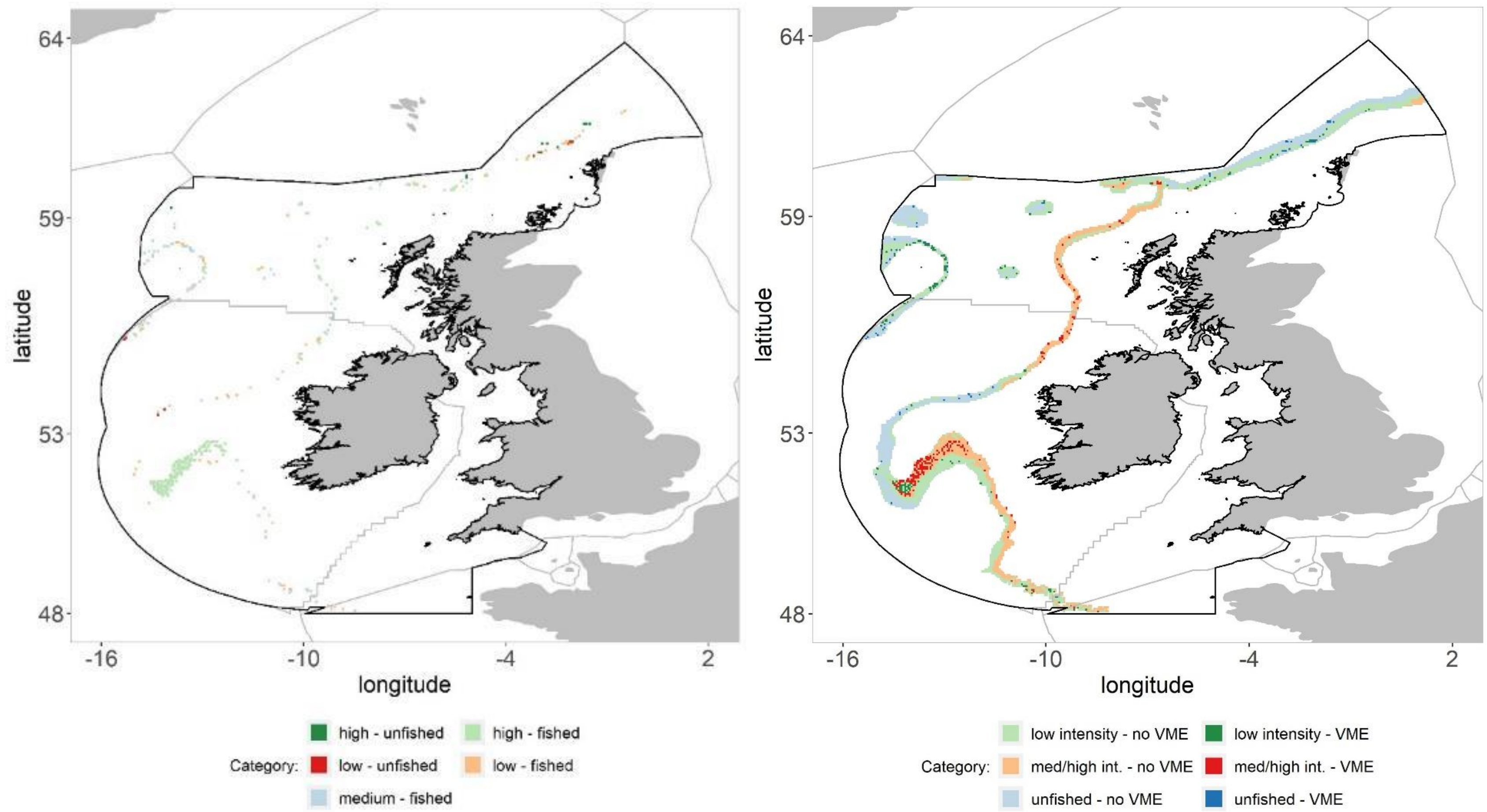


Figure 11. Left. Plot of the Celtic Seas showing the overlap between VMEs at different levels of VME precaution (Table 1; low, medium and high) and the fishing footprint (MBCG and Static) within the 400-800 m depth range. Right. Plot of the Celtic Seas showing the overlap between VMEs and the fishing footprint of otter trawl gears at different levels of intensity (unfished, low intensity is 0-10th percentile, med/high intensity is 10-100th percentile (see Section 4.4 of the WKEUVME Report) within the 400-800 m depth range.

Closed Area Scenarios

WKEUVME established a framework for the presentation of closed area options based on the relationship between mobile bottom contact gear (MBCG) fishing intensity (SAR) and destruction of VMEs, drawing on trawling impact literature and empirical observations on similar VME indicators made in the NAFO Regulatory Area (NAFO, 2016). Two scenarios have been defined - rules which apply to the VME C-squares only (Scenario 1) and rules which apply to the VME C-squares, but also take into account known fishing impacts (Scenario 2) (see Section 4.4). Two options per scenario are presented (Table 7). The implications of each option for management are shown in Table 8.

Table 7. Summary of the scenarios and options used to define closure areas. The main differences between scenarios and options are underlined.

	Scenario 1 VME distribution only	Scenario 2 VME and VMS distributions
Option 1	All VME habitats, High and Medium VME Index. Low VME Index: only if adjacent to higher Index VMEs	All VME habitats, High and Medium VME Index. Low VME Index: only if adjacent to higher index VMEs and Low VME Index in C-squares with low fishing pressure (SAR < 0.43)
Option 2	Option 1 + selected VME elements (banks, seamounts, coral mounds, mud volcanoes) associated with any VME records.	All VME habitats, High, Medium and Low VME Index excluding C-squares with high fishing pressure (SAR > 0.43)

Table 8. Description of management scenarios and options presented by WKEUVME with associated management implications for the protection of VMEs and general impacts to fisheries.

Scenario	Option	Description	Management Implication
Scenario 1	Option 1	C-squares between 400-800m depth with all VMEs supported by data in the VME Database, with priority to medium to high 'confidence', regardless of fishing activity in the 2009-11 period.	Prioritizes protection of VMEs where they are known to occur, irrespective of fishing activity.
Scenario 1	Option 2	C-squares between 400-800m depth with all VMEs and VME elements supported by data in the VME Database, with priority to medium to high 'confidence', regardless of fishing activity in the 2009-11 period.	Prioritizes protection of VMEs where they are known and where they are likely to occur, irrespective of fishing activity.
Scenario 2	Option 1	As for Scenario 1 Option 1 but includes low VME Index C-squares if fishing pressure is low (< 0.43 SAR).	Prioritizes protection of VMEs where they are known to occur, and includes areas where the confidence of VME presence is lower but where fishing activity is also low and VMEs unlikely to be degraded by fishing.
Scenario 2	Option 2	C-squares between 400-800m depth with all VMEs supported by data in the VME Database excluding C-squares with high fishing pressure (SAR > 0.43).	Prioritizes protection of VMEs where they are known to occur, but excludes areas that have been heavily fished (core fishing areas) and where VMEs are likely to have been degraded by fishing.

Both closure scenarios used data on VME habitat and VME Index. In addition, Scenario 1 option 2 also included data on VME elements. These data sources are described above in "*Distribution of Vulnerable Marine Ecosystems: VMEs in the Celtic Seas Ecoregion*". WKEUVME notes that the use of the VME Index as it now is may result in under-representation of sea pen VMEs in the selection of closed areas under all scenarios and options, except Scenario 2 option 2. Scenario 2 further included information on fishing intensity (SAR per year) from all mobile bottom-contacting fishing gears. These data were used to estimate whether C-squares fall above or below the SAR threshold value of 0.43 used to distinguish between fishing that is likely to have caused Significant Adverse Impacts (FAO, 2009) on the VMEs (> 0.43 SAR) or not (< 0.43 SAR). This was determined for all mobile bottom-contacting gears using the average SAR per year for 2009-2019. The fisheries data is described above in *"Fisheries data"*.

The scenario rules were used to create closures for the whole area (see Section 4.5 of the WKEUVME report), irrespective of the depth and the boundary of the ecoregion. The closures were afterwards clipped to the 400-800 meter depth range and ecoregion boundary (Figure 12).

The consequences of the closures for protecting VMEs and their potential impact on the fisheries are shown in Table 9. Since buffers around VME habitat and VME Index C-squares may affect ¼ or ½ of a C-square, in this Table we estimated the number of C-squares as the sum of all whole, half and quarter C-squares. Similarly, we assumed that SAR intensity and kWh were distributed equally across the C-square. Hence, if a C-square is closed for 25%, SAR intensity that is lost to the fisheries is ¼ · SAR C-square. The fisheries consequences were evaluated for the reference period 2009-2011, the period 2012-2015 and the most recent period 2016-2019 (Table 9).

The number of records of VME indicator groups in the ICES VME Database inside each of the closure scenarios was also evaluated (Table 10). The C-square is the common spatial resolution between the VME Index and VMS data. However, the VME Database holds records at the level of a point or line. In order to assess how the different closure scenarios and options captured these records, the VME Database was summarised across the following six areas; the Celtic Seas ecoregion, the 400 – 800 m depth band within the ecoregion and the four closure option areas within the 400 – 800 m depth band (Table 10, Figures 14, 15 and 16). Where the record geometry was recorded as a line, that is, if it arose from a trawl, the mid-point of the line was taken and it was treated as a point record. Our evaluation counts all records per group, including multiple records inside a single C-square.

The different scenarios resulted in a different areal extent and number of closures in the 400-800 metre depth range. Scenario 2 option 1 had most closed areas (n=97), which were predominantly small in areal extent (Figure 13). Scenario 1 option 2 had fewest closures (n=74) but covered a larger area due to the closing of different seamounts (Figures 15-16).

The results in Table 9 show that VME protection is equal for option 1 and 2 in Scenario 1 (Figure 17). VME protection is higher in Scenario 2 option 1 as all low VME Index C-squares are additionally closed. Scenario 2 option 2 does not close VMEs when SAR intensity in the C-square is relatively high (SAR threshold is 0.43 per year), assuming that the likelihood of a VME habitat present is low due to high disturbance of recent fisheries. The result of Scenario 2 option 2 is a lower overlap between closures and C-squares with VME habitat and high/medium index (Figure 17a). The reduced overlap of closures with VME C-squares where fishing occurs lowers the overlap of Scenario 2 option 2 closure with the fisheries (Figure 17b-h). The lowered overlap is evident in the overlap between closures and 1) the total footprint (Figure 17b), 2) the presence of static gears and mobile gears (Figure 17c, e, g), and 3) the core fishing grounds (Figure 17d, f, h). Approximately, 5% of total SAR intensity in Scenario 2 option 2 is in C-squares that are prescribed as closed, irrespective of temporal period evaluated (Figure 17d, f, h).

The effect of Scenario 1 option 1 and Scenario 2 option 1 is largely the same. There is more protection of VMEs than in Scenario 2 option 2, but the overlap with the fisheries is larger. Approximately, 10% of total SAR intensity is in C-squares that are prescribed as closed, irrespective of temporal period evaluated (Table 9). Scenario 1 option 2 does not close more VME habitat or VME Index than Scenario 1 option 1, but covers a larger closure area due to the closing of VME elements. The closures have as such a larger overlap with the fishing footprint and the presence of static and mobile gears. Yet, the areas that are prescribed as closed are not fished with high intensity by mobile gears. As such, Scenario 1 option 2 only affects approximately 10% of total SAR intensity, which is the same as Scenario 1 option 1 and Scenario 2 option 1.

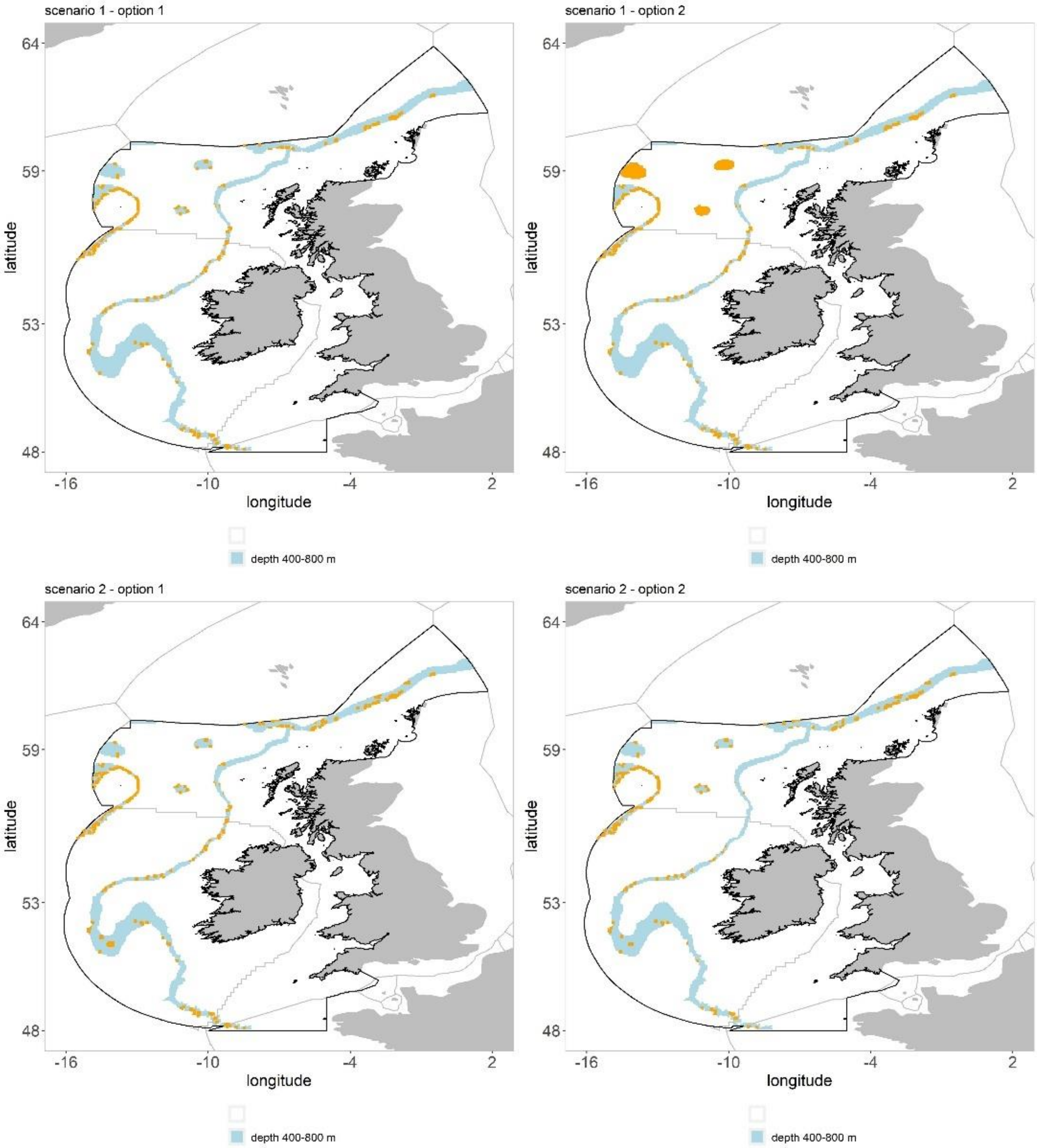


Figure 12. Map of closures (orange) that overlap with the 400-800 metre depth range following the two different Scenarios, each with two options.

Table 9. Table evaluating each of the 4 closure Scenario/options by impact on fishery and protection of VME habitat and index.

	Scenario 1 Option 1		Scenario 1 Option 2		Scenario 2 Option 1		Scenario 2 Option 2	
	within closure	outside closures	within closure	outside closures	within closure	outside closures	within closure	outside closures
VME protection								
nb of C-squares with VME habitat	78	0	78	0	78	0	68	10
nb of C-squares with VME Index High	41	0	41	0	41	0	35	6
nb of C-squares with VME Index Medium	30	0	30	0	30	0	18	12
nb of C-squares with VME Index Low	27	219	27	219	74	172	52	194
VME protection and fishing impact threshold								
nb of C-squares with VME habitat/index below SAR 0.43 threshold (2009-2019)	131	24	131	24	155	0	155	0
nb of C-squares with closed VME habitat/index above SAR 0.43 threshold (2009-2019)	45	195	45	195	68	172	18	222
Fisheries footprint								
nb of C-squares part of fishing footprint	802	3419	1035.25	3185.75	943	3278	718	3503
Fisheries overlap (presence/absence) (2009-2011)								
nb of C-squares with static bottom fishing (present in footprint)	678	2570	902.25	2345.75	774	2474	589	2659
nb of C-squares with mobile bottom fishing (SAR > 0 in footprint)	579	2758	663	2674	726	2611	501	2836
Fisheries overlap (core fishing ground) (2009-2011)								
nb of C-squares that form core fishing area based on SAR in footprint	155	1201	155	1201	184	1172	39	1317

	Scenario 1 Option 1		Scenario 1 Option 2		Scenario 2 Option 1		Scenario 2 Option 2	
	within closure	outside closures	within closure	outside closures	within closure	outside closures	within closure	outside closures
fraction of total SAR in footprint	0.11	0.89	0.11	0.89	0.14	0.86	0.03	0.97
Fisheries consequences (presence/absence) (2012-2015)								
nb of C-squares with static bottom fishing (present in footprint)	626	2631	746.75	2510.25	732	2525	546	2711
nb of C-squares with mobile bottom fishing (SAR > 0 in footprint)	560	2647	566.25	2640.75	684	2523	462	2745
Fisheries consequences (core fishing ground) (2012-2015)								
nb of C-squares that form core fishing area based on SAR in footprint	142	1176	142	1176	164	1154	44	1274
fraction of total SAR in footprint	0.09	0.91	0.09	0.91	0.11	0.89	0.03	0.97
Fisheries consequences (presence/absence) (2016-2019)								
nb of C-squares with static bottom fishing (present in footprint)	603	2531	723.25	2410.75	716	2418	527	2607
nb of C-squares with mobile bottom fishing (SAR > 0 in footprint)	610	2700	626.25	2683.75	731	2579	508	2802
Fisheries consequences (core fishing ground) (2016-2019)								
nb of C-squares that form core fishing area based on SAR in footprint	120	1188	120	1188	144	1164	30	1278
fraction of total SAR in footprint	0.08	0.92	0.08	0.92	0.09	0.91	0.03	0.97

Table 10. VME indicator and habitat records from the VME Database within the Celtic Seas Ecoregion, the 400 – 800 m depth band, and for each closure option within the depth 400 – 800 m depth band.

	Celtic Seas Ecoregion	400-800 m Depth	Scenario 1 Option 1	Scenario 1 Option 2	Scenario 2 Option 1	Scenario 2 Option 2
VME Indicator						
Anemones	612	234	228	228	228	168
Black coral	728	138	138	138	138	124
Cup coral	364	107	101	101	101	57
Gorgonian	337	38	38	38	38	19
Sea pen	1,349	488	106	106	159	130
Soft coral	213	24	14	14	22	19
Sponge	2,758	1,200	1,052	1,052	1,147	891
Stony coral	1,534	323	323	323	323	289
Stylasterids	16	6	6	6	6	4
Xenophyophores	10	-	-	-	-	-
VME Habitat						
Cold-water coral reef	386	146	146	146	146	132
Coral Garden	1384	303	303	303	303	269
Deep-sea Sponge Aggregations	739	617	617	617	617	614
Sea pen fields	458	166	166	166	166	166
Tube-dwelling anemone aggregations	55	55	55	55	55	10

VME Habitat						
Xenophyophore aggregations	41	41	41	41	41	2
Anemone aggregations	22	22	22	22	22	-
Stalked crinoid aggregations	6	-	-	-	-	-

Both Scenario 1 closure options capture the same number of VME records including all available VME habitat records in the 400 – 800 m depth band and all, or nearly all VME indicator records apart from sea pen (106/488), soft coral (14/24) and sponge (1,052/1,200) records (Table 10). Closure Scenario 2 option 1 captures the same number of VME records as the Scenario 1 closure options, including all VME habitat records, and more sea pen (159), soft coral (22) and sponge (1,147) VME indicator records. Closure Scenario 2 option 2 captures fewer VME habitats than the other closure options, for: deep-sea sponge aggregations (614/617), tube-dwelling anemone aggregations (10/55), Xenophyophore aggregations (2/41) and Anemone aggregations (0/22). Closure Scenario 2 option 2 captures fewer anemones, cup coral, sponge and stony coral indicator records than the other closure options, but captures more sea pen and soft coral records than the Scenario 1 closure options (Table 10). Figure 16 shows the example of sponge VME indicator records that lie within the Celtic Sea ecoregion, 400 – 800 m depth band and the four closure options.

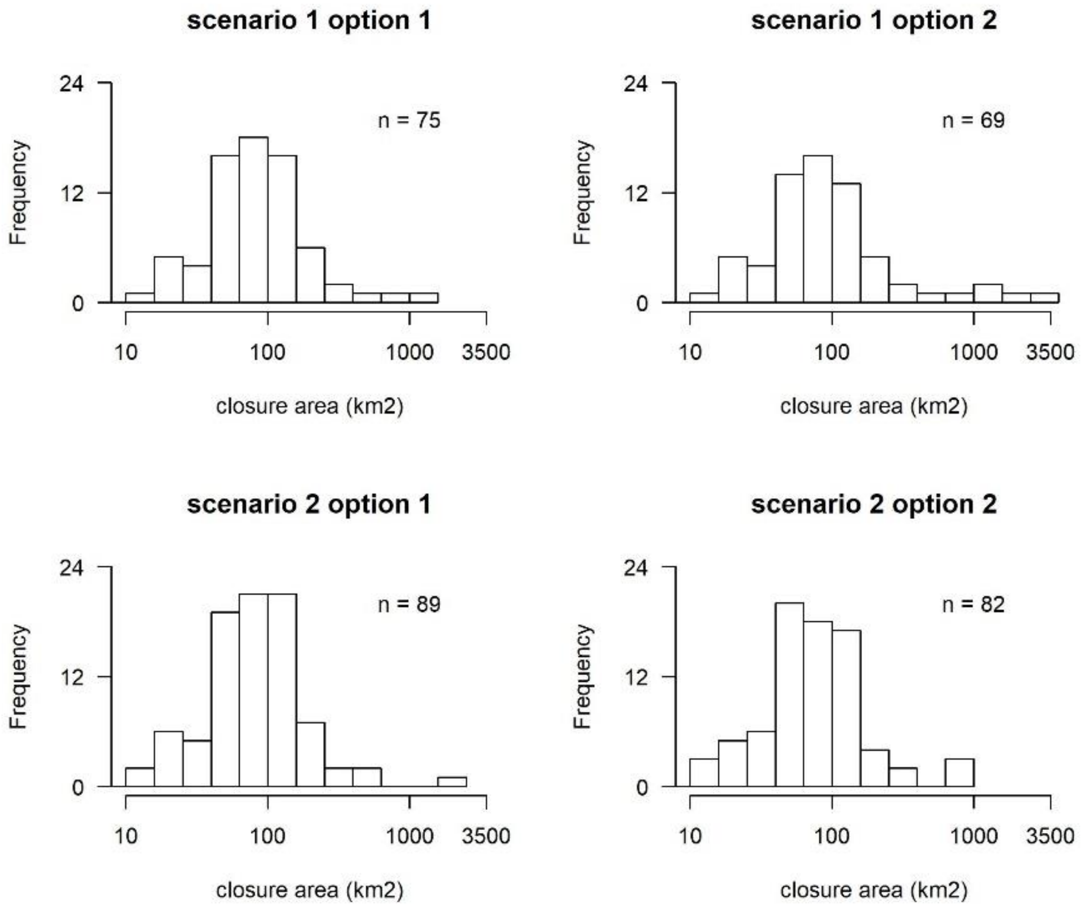


Figure 13. Histograms of the size of the closed areas that overlap with the 400-800 meter depth range following the two different scenarios, each with two options (see maps in Figure 12). The total number of closure areas is in the upper right.

The R-scripts which produced the closed area options and data summaries, including closure .shp files, are available on an open source platform (WKEUVME GitHub site). For each Ecoregion/Management Option/Closed Area script for creating a table of the coordinates for each closed area polygon has been produced. The table also indicates the VME habitat, VME indicator and VME element data present in each closed area. The closed areas are also mapped and .shp files produced for each.

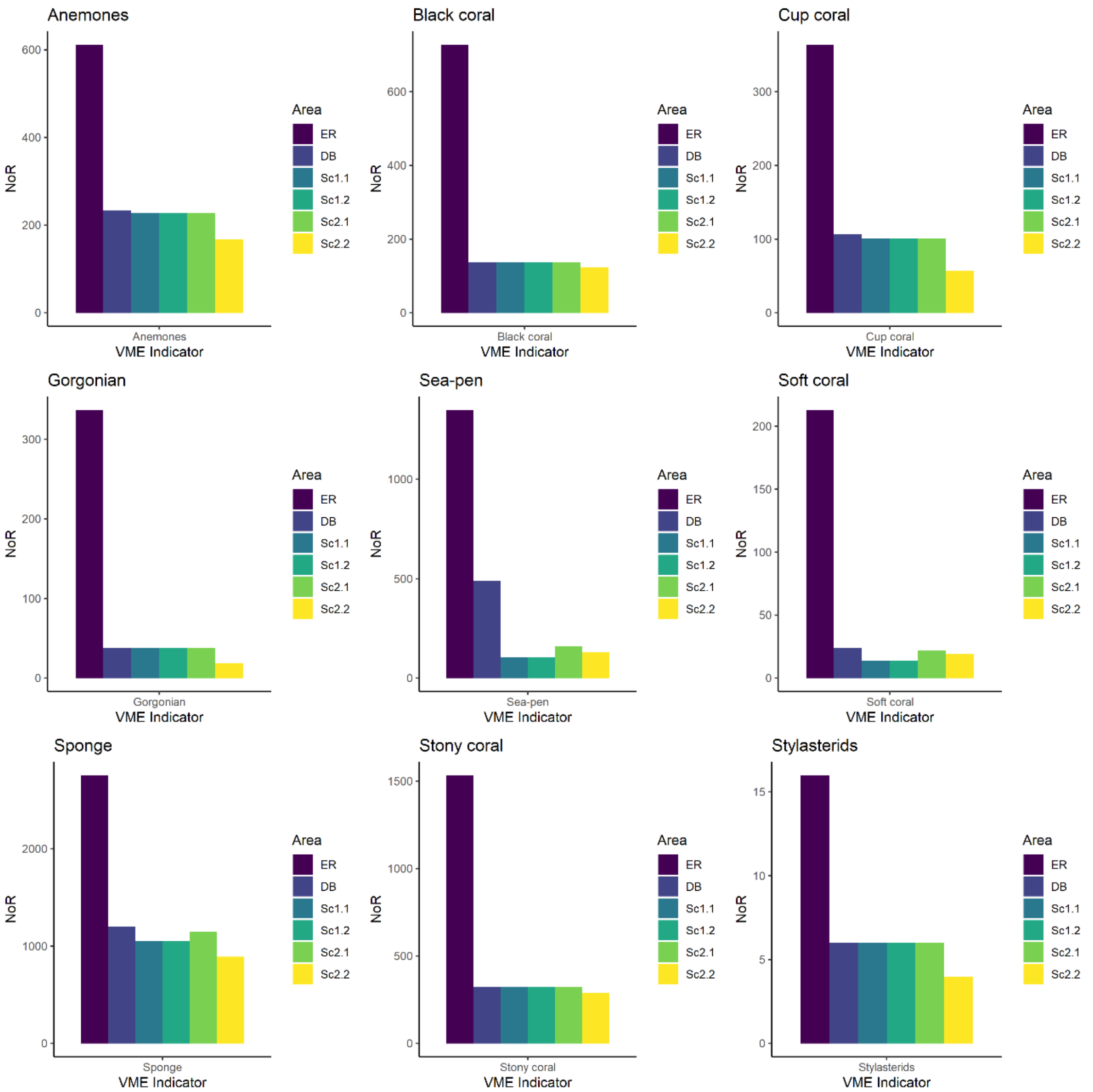


Figure 14. The number of VME indicator records (NoR) from the VME Database within each of the areas: Celtic Seas Ecoregion (ER), the 400 – 800 m depth band (DB), and for each closure option within the depth 400 – 800 m depth band (Scenario 1 Option 1 = Sc1.1, Scenario 1 Option 2 = Sc1.2, etc.); Xenophyophores were not plotted as they were not recorded as an indicator in the 400 – 800 m depth band. Note that the Y-axis differs between plots.

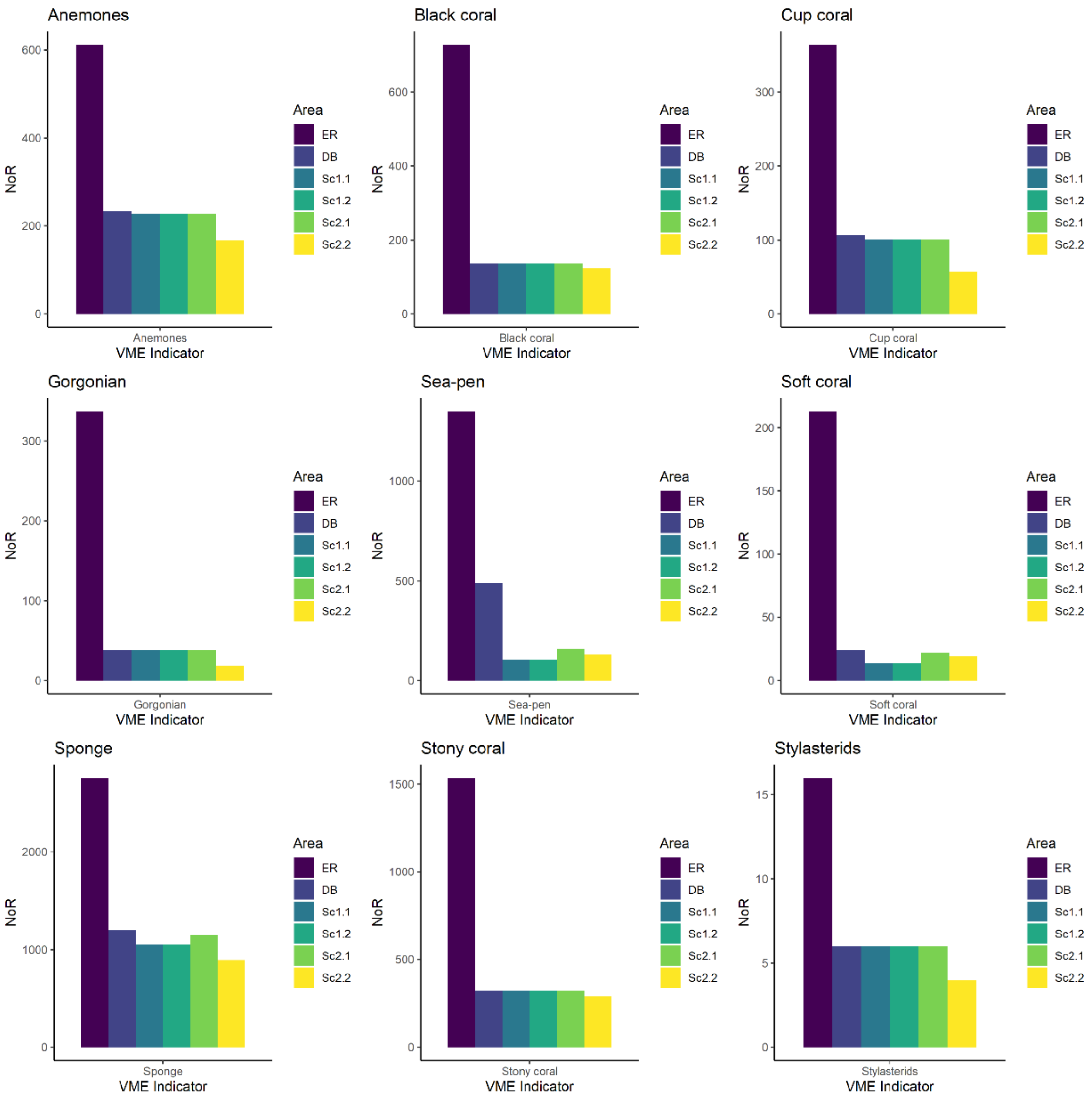


Figure 15. The number of VME habitat records (NoR) from the VME Database within each of the areas: Celtic Seas Ecoregion (ER), the 400 – 800 m depth band (DB), and for each closure option within the depth 400 – 800 m depth band (Scenario 1 Option 1 = Sc1.1, Scenario 1 Option 2 = Sc1.2, etc.). Note that the Y-axis differs between plots.

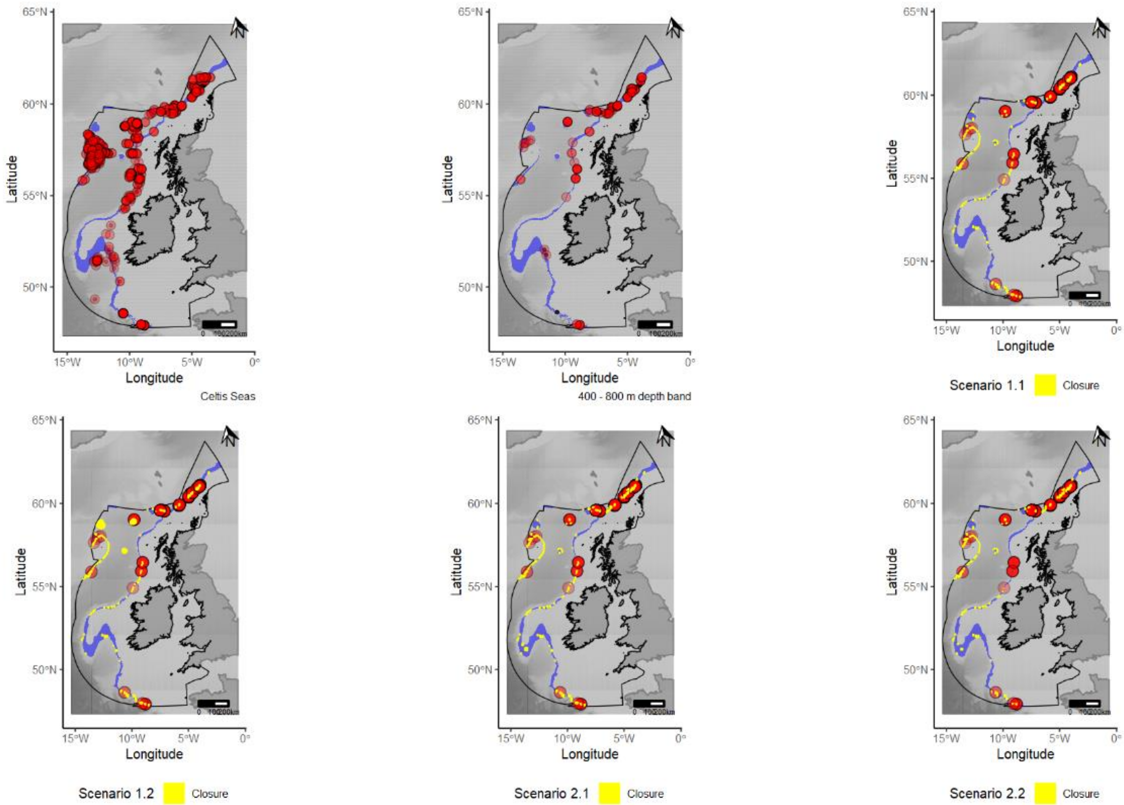


Figure 16. Sponge VME indicator records within each of the areas: Celtic Seas Ecoregion (top left), the 400 – 800 m depth band (top middle), and for each closure option within the depth 400 – 800 m depth band (Scenario 1 Option 1 = Scenario 1.1, etc.). The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMODnet bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84 / UTM zone 29N.

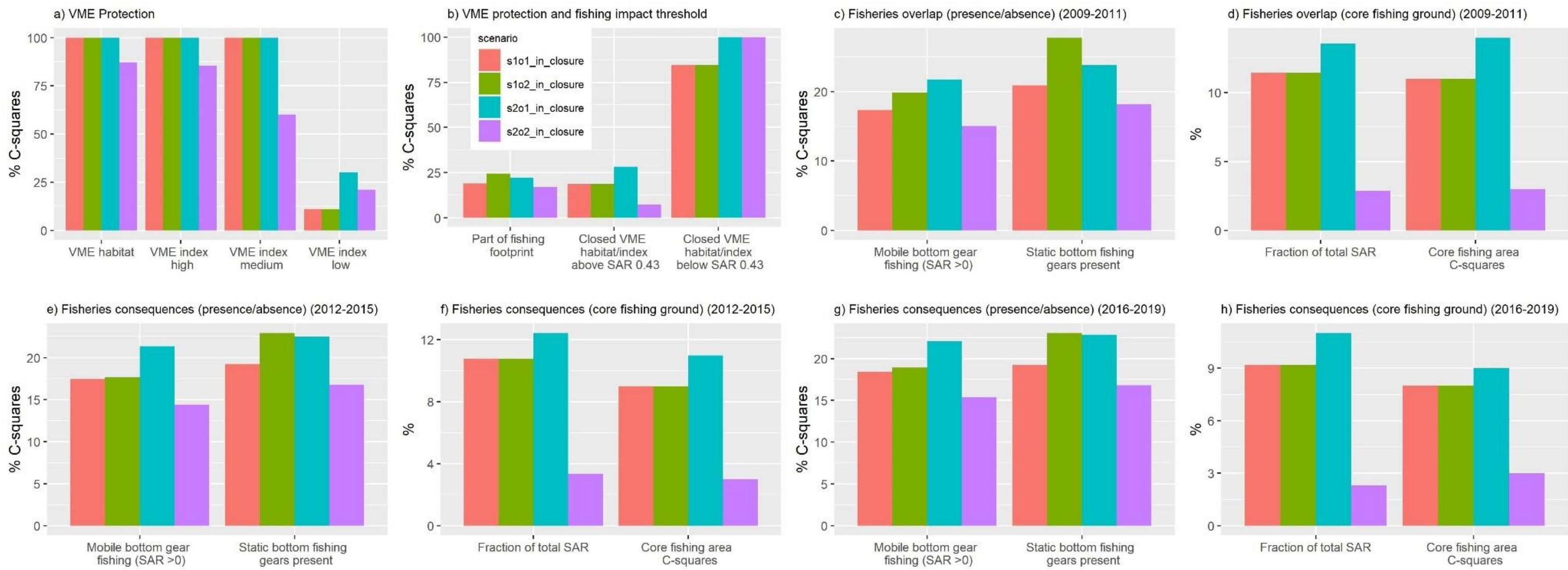


Figure 17. Bar charts showing the effect of the different Scenarios and options (legend in b): Scenario 1 Option 1 =s1o1, etc.) as percentages. a) Percentage of VME protection for the different scenarios and options; b) Percentage of fishing footprint in the closure scenarios and percentage of VME C-squares above/below SAR threshold of 0.43; c) Percentage of C-squares with mobile or static bottom fishing in the closures for the period 2009-2011; d) Percentage of total SAR in the closures and percentage of C-squares that form the core fishing area in the closure for the period 2009-2011; e) Percentage of C-squares with mobile or static bottom fishing in the closures for the period 2012-2015; f) Percentage of total SAR in the closures and percentage of C-squares that form the core fishing area in the closure for the period 2012-2015; g) Percentage of C-squares with mobile or static bottom fishing in the closures for the period 2016-2019; h) Percentage of total SAR in the closures and percentage of C-squares that form the core fishing area in the closure for the period 2012-2015.

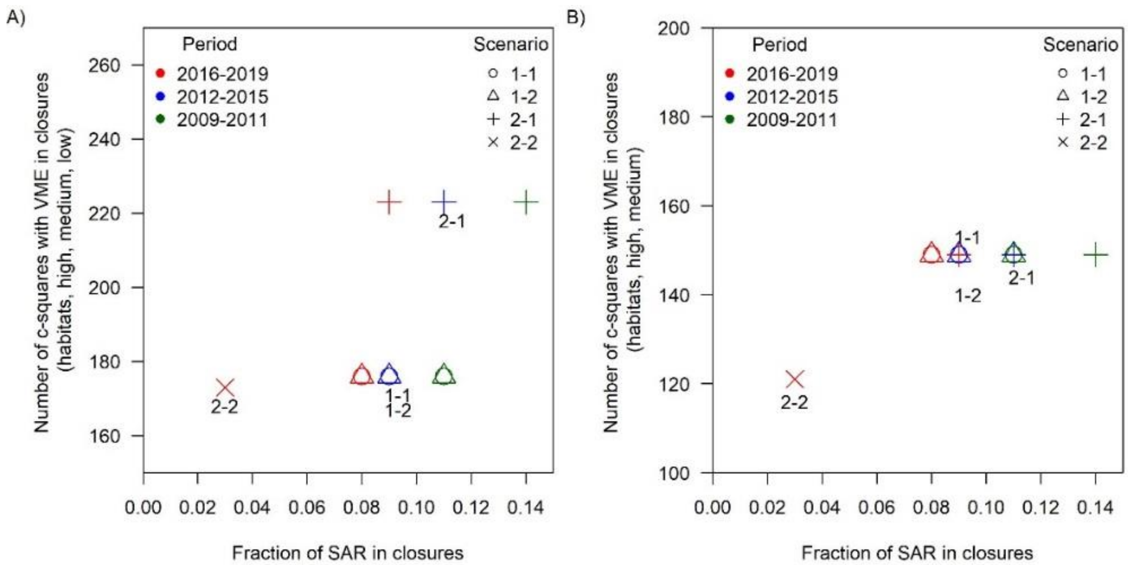


Figure 18. a) The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total fraction of the SAR in the closures for the three different time periods. b) The number of VME habitat and index cells (only high and medium) included in each of the closure scenarios, as a function of the total fraction of the SAR in the closures for the three different time periods.

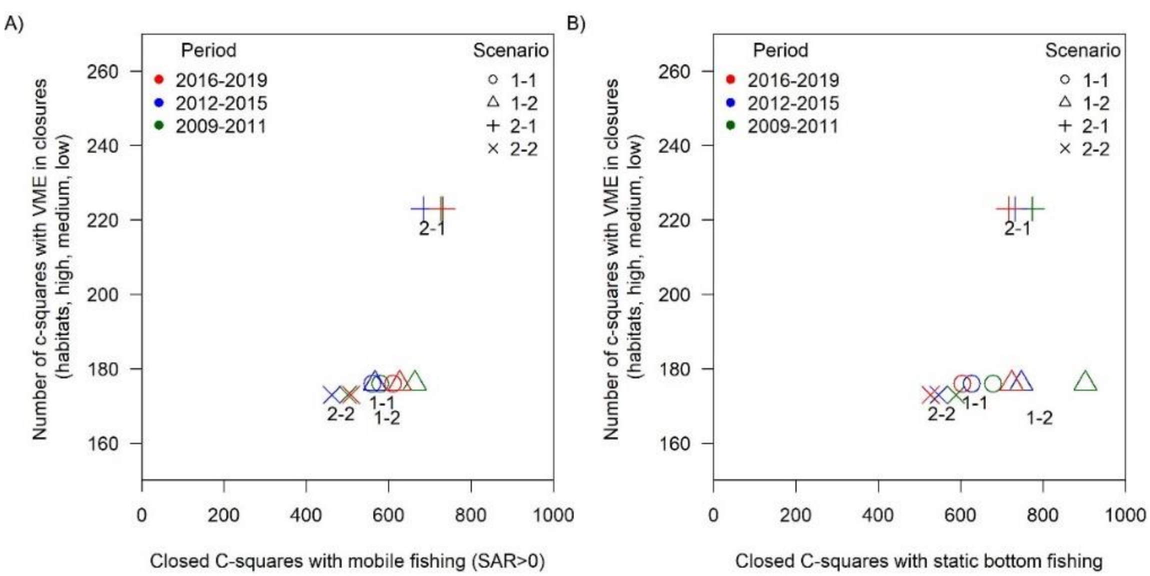


Figure 19. a) The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total number of C-squares that were fished by mobile gears (SAR>0) for the three different time periods. b) The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total number of C-squares that were fished by static gears for the three different time periods.

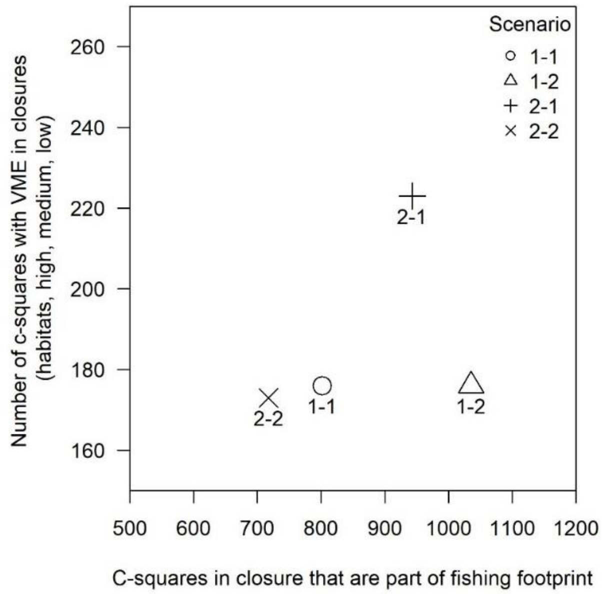


Figure 20. The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total number of C-squares that were fished of the fishing footprint in 2009-2011.

Analysis of Trade-offs Between Closures and Impact on Fisheries

An ideal closure scenario protects all potential VMEs while having a minimal impact on fishing activities. Figures 18-21 show the trade-off between different measures of the number of VME's in closures versus different measures of the impact on fishing activities. Scenarios that protect most VMEs and have the smallest impact on fishing activities are found towards the top-left of these plots. Scenarios that protect fewer VMEs and have a high impact on fishing activities are found towards the bottom right. Fishing effort is evaluated in three different time periods, to be able to capture the effect in the 2009-2011 reference period as well as the effect on more recent activities. The potential benefits of closures are evaluated as: 1) all C-squares with VME habitats and any level of VME Index, 2) all C-squares with VME habitats and VME Index ≥ medium, 3) the number of records of VME indicator groups, in closures.

The number of C-squares with VME habitats and index records is the same for Scenario 1 option 1 and Scenario 1 option 2 because Scenario 1 option 1 already closed all ≥ medium VME Index cells, and Scenario 1 option 2 is based on extending closures based on VME elements that did not contain further records. The additional impact on fishing activities of Scenario 1 option 2 compared to Scenario 1 option 1 is small, presumably because the closed VME elements had a low fishing intensity.

As a general rule, Scenario 1 option 1 and Scenario 1 option 2 performed similarly, with Scenario 1 option 2 affecting some more fishing activity and particularly so when evaluated as the footprint rather than as SAR. Scenario 2 option 1 closures capture many more low VME Index cells at a low additional impact on fishing activities, while Scenario 2 option 2 strongly reduces the impact on fishing activities at the expense of not closing some VME habitats, high and medium index cells (12%, 12% and 36% of C-squares in those categories respectively).

Different measures of fishing activity suggest moderately different impacts on fishing activities. Although Scenario 2 option 2 only closes about half of the total SAR of the mobile fleet relative to other scenarios, the number of C-squares that is closed is not much lower than for the other scenarios. This illustrates that fishing activity is concentrated in high effort C-squares and that there are a lot of C-squares with minimal effort levels. Effects of the different scenarios on static and mobile fishing activities appear very similar.

The impact of closures on mobile and static bottom fishing activities seem to be smaller when evaluating more recent time periods compared to the 2009-2011 reference period. The exception to this is when fishing activity is quantified as the number of C-squares with mobile fishing at SAR > 0, suggesting that recently mobile fishing has maintained its spatial extent while reducing the total fishing effort.

The pattern for the VME indicator groups (Figure 21) is not consistent across groups. For most groups, Scenario 2 option 2 protects a smaller number of records than the other scenarios. The main deviation from this pattern are sea pens. Because sea pens would rarely classify above 'low VME Index', inclusion of lightly-fished low-index cells in Scenario 2 option 1 and Scenario 2 option 2 increases the number of sea pen records included in the closures by > 50%.

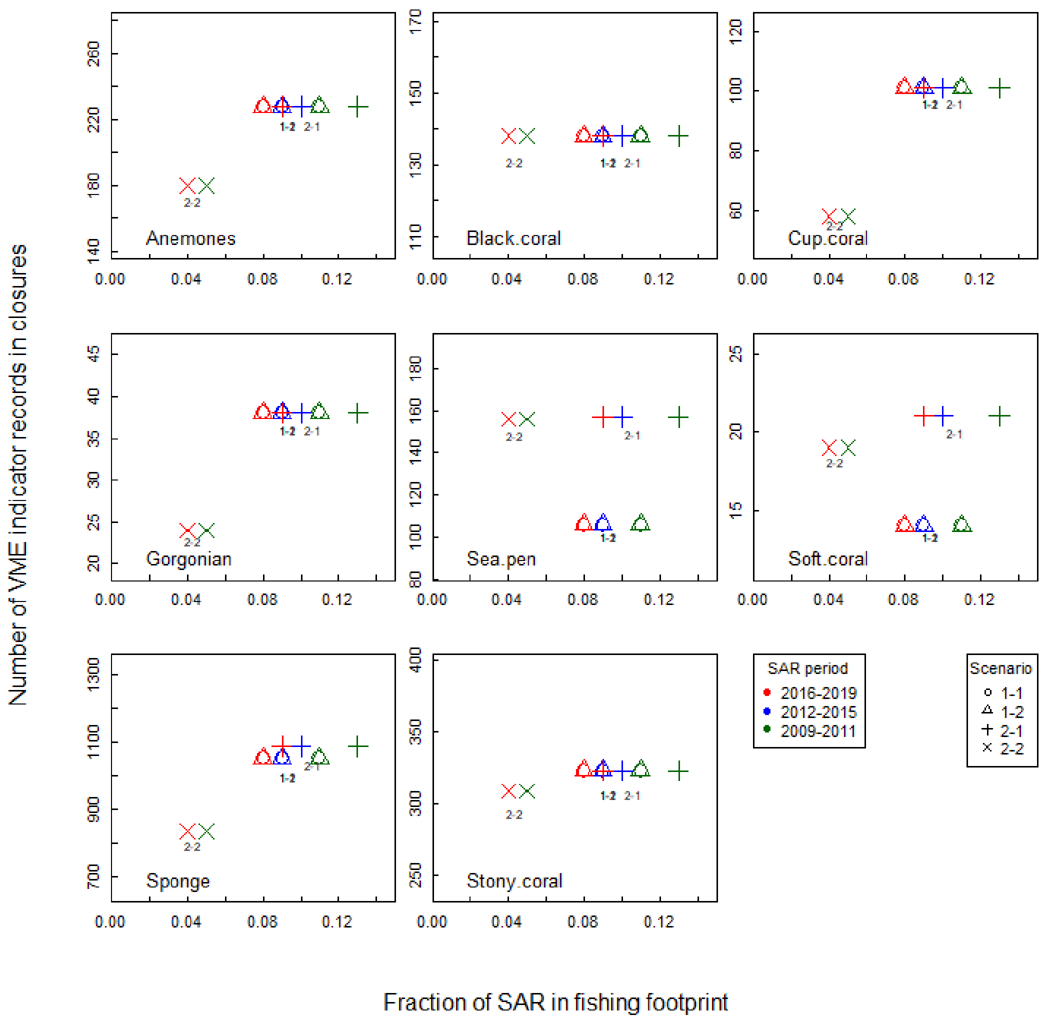


Figure 21. The number of records of VME indicator groups included in each of the closure scenarios, as a function of the total number of C-squares that were fished of the fishing footprint in 2009-2011.

Future Directions

Under regulation (EU) 2016/2336 there will be a requirement for an annual update of the assessment of areas where VMEs are known to occur or are likely to occur. The formal ICES advisory process would be used to provide such an update to the European Commission (as is done for NEAFC VME advice). An integral part of this annual advisory process will be the ICES VME and fishing activity (VMS and logbook) data flows, which feed into the assessment procedure that is presented in this assessment sheet for the Celtic Sea Ecoregion. This assessment procedure is fully documented using ICES TAF (transparent assessment framework) principles, with the respective scripts to run the assessment made publically available on an open source platform (WKEUVME GitHub site). In this annual process to update the assessment, the ICES Data Centre works closely with WGDEC (Working Group on Deep-water Ecology) and WGSFD (Working Group on Spatial Fisheries Data), to make the provision of spatial data consistent across various data sources, thus enabling clear and traceable provenance of scientific information used in decision making. Specific ICES expert groups would also be involved in the annual assessment to also synthesis knowledge that can be used to further supplement these annual assessments. This will form a solid foundation on which ICES can base any annual assessment on.

As part of the formal ICES advisory process, the annual assessment prepared by ICES experts would be peer-reviewed. Following this review, the response to the request is drafted by an ACOM appointed advice-drafting group. This draft advice is scrutinised by ACOM and, if approved, delivered to the requestor and published by ICES. The evidence and supporting rationale are explained in the advice, with reference to the underlying technical work. Upon delivery of the advice, the EC may wish to iteratively refine the subsequent advice question(s) as part of collaborative agreements with ICES to provide annual advice. Similarly, in the future and following the annual Advisory Committee (ACOM) advice process, ICES may wish to update the established assessment procedure with improvements to incorporate, for example, VME species distribution models (SDMs) or by further improvements to how the VME Index is calculated.

ICES may wish to include the assessment (or parts of them) in further iterations of the annual Ecosystem Overview (EOs) advice and Fisheries Overview (FOs) advice. There are also strong links to shallower water assessment procedures developed by WGFBIT (Working Group on Fisheries Benthic Impact and Trade-offs) that have been developed for the ICES Ecosystem Overview advice in the context of Descriptor 6 seafloor integrity of the EC's marine strategy framework directive (MSFD).

Experts contributing to this assessment sheet for the Celtic Sea Ecoregion identified a number of potential VME data sources that could be encouraged to submit their data to ICES and, following quality assurance checks, be used in the provision of formal ICES advice (Table 11). Other national VME data holders are also encouraged to submit data. Any submissions should be made by national data holders in response to the annual VME data call (link) issued by ICES to member countries with a 2-month period (usually February – March). Data on VME habitats, VME indictors and VME absence data is encouraged, and the data submitter must have usage rights on the data that they submit to ICES. It is important that the VME data conforms to the FAO VME criteria and/or ICES WGDEC VME taxa and that duplicate records are removed.

Table 11. Potential VME data sources identified by WKEUVME, with respective metadata. Whether the dataset relates to VME Habitats (H) and/or VME indicators (I) is identified, along with a point of contact for the data source. '?' denotes unknowns

Dataset information					**Country to submit**			**Data holder or potential submitter**	
Dataset	VME data type	Year of survey	Is VME data compliant with FAO VME criteria and/or ICES WGDEC VME taxa list?	Publication	Country of origin:	Can data be submitted in Jan 2021	National ICES ACOM member and DCF point of contact	Point of contact (POC)	Does POC have usage rights on data?
Area: Celtic Seas									
Malin Shelf	I	?	?	Roberts et al. 2003	UK	?	Pieter-Jan Schön / Matthew Elliott	J Murray Roberts (murray.roberts.@ed.ac.uk)	?
Porcupine Seabight	H & I	2019	?	O'Sullivan et al. 2019	Ireland	?	Jonathan White / Leonie O'Dowd	David O'Sullivan	?

References

Benn, A. R., *et al*. 2010. Human Activities on the Deep Seafloor in the North East Atlantic: An Assessment of Spatial Extent. PLoS ONE, 5: e12730. Public Library of Science.

Bett, B. 2003. An Introduction to the Benthic Ecology of the Faroe-Shetland Channel (SEA4). Department of Trade and Industry, London, UK. 84 pp.

Billett, D. S. M., *et al*. 2001. Long-term change in the megabenthos of the Porcupine Abyssal Plain (NE Atlantic). Progress in Oceanography 50: 325–348.

Davies, J.S., *et al*. 2015. Benthic assemblages of the Anton Dohrn Seamount (NE Atlantic): Defining deep-sea biotopes to support habitat mapping and management efforts with a focus on vulnerable marine ecosystems. PLoS ONE 10: e0124815.

Davies, J.S., Howell, K.L., Stewart, H.A., Guinan, J., and Golding, N. 2014. Defining biological assemblages (biotopes) of conservation interest in the submarine canyons of the South West Approaches (offshore United Kingdom) for use in marine habitat mapping. Deep-Sea Res Part II Topical Studies in Oceanography 104:208–229.

De Santo, E.M. 2013. The Darwin Mounds special area of conservation: implications for offshore marine governance. Marine Policy 41: 25–32.

Dolan, M., Grehan, A.J., Guinan, J.C., and Brown, C. 2008. Modelling the local distribution of cold-water corals in relation to bathymetric variables: Adding spatial context to deep-sea video data. Deep-Sea Research Part I 55:1564-1579.

Duineveld, G.C.A., Lavaleye, M.S.S., Bergman, M.J.N., de Stigter, H., and Mienis, F. 2007. Trophic structure of a cold-water coral mound community (Rockall Bank, NE Atlantic) in relation to the near-bottom particle supply and current regime. Bulletin of Marine Science 81:449-467.

Eerkes-Medrano, D., *et al*. 2020. A community assessment of the demersal fish and benthic invertebrates of the Rosemary Bank Seamount marine protected area (NE Atlantic). Deep-Sea Research Part I 156:103180.

Eigaard, O. R., *et al*. 2015. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science, 73(Suppl. 1): 27–43. https://doi.org/10.1093/icesjms/fsv099

Ellett, D.J., Edwards, A., and Bowers, R. 1986. The hydrography of the Rockall Channel—an overview. Proceedings of the Royal Society of Edinburgh B 88:61–81.

EMODnet Bathymetry Consortium. 2018. EMODnet Digital Bathymetry (DTM 2018). EMODnet Bathymetry Consortium. https://doi.org/10.12770/18ff0d48-b203-4a65-94a9-5fd8b0ec35f6. Data downloaded April 2020 (ESRI ASCII Mean Sea Level format).

European Commission. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Union, OJ L. http://data.europa.eu/eli/dir/1992/43/oj/eng (Accessed 21 May 2020).

European Commission. 2008. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union, 164: 19–40.

European Commission. 2010. Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. Official Journal of the European Union, OJ L. http://data.europa.eu/eli/dir/2009/147/oj/eng (Accessed 21 May 2020).

European Commission. 2017. COMMISSION DECISION (EU) 2017/ 848 - laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/ 477/ EU: 32.

European Union. 2013. Regulation(EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. Official Journal of the European Union, 354. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1380.

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

Foden, J., Rogers, S. I., and Jones, A. P. 2009. Recovery rates of UK seabed habitats after cessation of aggregate extraction. Marine Ecology Progress Series 390: 15–26.

Frederiksen, R., Jensen, A., and Westerberg, H. 1992. The distribution of the scleractinian coral *Lophelia pertusa* around the Faeroe Islands and the relation to internal tidal mixing. Sarsia 77:157-171.

Gage, J. D., and Tyler, P. A. (editors). 1991. Deep-sea biology: a natural history of organisms at the deep-sea floor. xvi, 504p. Cambridge University Press.

Greathead, C.F., Donnan, D.W., Mair, J.M., and Saunders, G.R. 2007. The sea pens *Virgularia mirabilis*, *Pennatula phosphorea* and *Funiculina quadrangularis*: distribution and conservation issues in Scottish waters. Journal of the Marine Biological Association of the United Kingdom 87:1095-1103.

Guinan, J., Grehan, A.J., Dolan, M.F.J., and Brown, C. 2009a. Quantifying relationships between video observations of cold-water coral cover and seafloor features in Rockall Trough, west of Ireland. Marine Ecology Progress Series 375: 125-138.

Guinan, J., Brown, C., Dolan, M.F.J., and Grehan, A.J. 2009b. Ecological niche modelling of the distribution of cold-water coral habitat using underwater remote sensing data. Ecological Informatics 4:83-92.

Hall–Spencer, J., Allain, V., and Fosså, J.H. 2002. Trawling damage to Northeast Atlantic ancient coral reefs. Proceedings of the Royal Society London B.269507–511 https://doi.org/10.1098/rspb.2001.1910

Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K. 2014. Geomorphology of the oceans. Marine Geology 352: 4-24

Henry, L-A., and Roberts, J.M. 2007. Biodiversity and ecological composition of macrobenthos on cold-water coral mounds and adjacent off-mound habitat in the bathyal Porcupine Seabight, NE Atlantic. Deep-Sea Research Part I 54:654-672.

Henry, L.-A., and Roberts, J. M. 2014. Applying the OSPAR habitat definition of deep-sea sponge aggregations to verify suspected records of the habitat in UK Waters. Joint Nature Conservation Committee Report No 508, Peterborough, UK. 45 pp.

Henry, L-A., Vad, J., Findlay, H., Murillo, J., Milligan, R., and Roberts, J.M. 2014. Environmental variability and biodiversity of megabenthos on the Hebrides Terrace Seamount (Northeast Atlantic). Scientific Reports 4:5589.

Hiddink, J.G., *et al.* 2018. Assessing bottom-trawling impacts based on the longevity of benthic invertebrates. Journal of Applied Ecology 56 (5):1075-1084. https://doi.org/10.1111/1365-2664.13278

Holliday, N.P., Pollard, R.T., Read, J.F., and Leach, H. 2000. Water mass properties and fluxes in the Rockall Trough: 1975 to 1998. Deep-Sea Research Part I 47:1303-1332.

Howe, J.A., *et al*. 2006. Seabed morphology and the bottom-current pathways around Rosemary Bank seamount, northern Rockall Trough, North Atlantic. Marine and Petroleum Geology 23: 165–181.

Howell, K.L., Davies, J.S., and Narayanaswamy, B.E. 2010. Identifying deep-sea megafaunal epibenthic assemblages for use in habitat mapping and marine protected area network design. Journal of the Marine Biological Association of the United Kingdom 90: 33-68.

Howell, K.L., Holt, R., Endrino, I.P., and Stewart, H. 2011. When the species is also a habitat: comparing the predictively modelled distributions of *Lophelia pertusa* and the reef habitat it forms. Biological Conservation 144: 2656–2665

Howell, K.L., Huvenne, V., Piechaud, N., Robert, K., and Ross, R.E. 2014. Analysis of biological data from the JC060 survey of areas of conservation interest in deep waters off north and west Scotland. Joint Nature Conservation Committee Report No. 528. Peterborough, UK. 109 pp.

Hughes, J.A., and Gooday, A.J. 2004. Associations between living benthic foraminifera and dead tests of *Syringammina fragilissima* (Xenophyophorea) in the Darwin Mounds region (NE Atlantic). Deep-Sea Research Part I 51:1741–1758.

Huvenne, V.A.I., *et al*. 2011. A picture on the wall: innovative mapping reveals cold-water coral refuge in submarine canyon. PLoS ONE 6: e28755.

Huvenne, V.A.I., Bett, B.J., Masson, D.G., Le Bas, T.P., and Wheeler, A.J. 2016. Effectiveness of a deep-sea cold-water coral Marine Protected Area, following eight years of fisheries closure. Biological Conservation 200: 60-69.

ICES. 2018a. 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. http://community.ices.dk/ExpertGroups/wgdec/2018%20Meeting%20documents/03.%20Report%202018/WGDEC_2018.pdf

ICES. 2018b. Celtic Seas ecoregion: Fisheries overview, including mixed-fisheries considerations. ICES. http://www.ices.dk/sites/pub/Publication Reports/Forms/DispForm.aspx?ID=35064 (Accessed 21 May 2020).

ICES. 2018c. Advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, sr.2018.10. 12 pp. https://doi.org/10.17895/ices.pub.4429

ICES. 2019. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES. http://www.ices.dk/sites/pub/Publication Reports/Forms/DispForm.aspx?ID=35519 (Accessed 21 May 2020).

ICES. 2020a. Report of the 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

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

JNCC. 2015. Latest changes to the UK SAC list. http://jncc.defra.gov.uk/page-1488

Johnson, C., Sherwin, T., Smythe-Wright, D., Shimmield, T., and Turrell, W. R. 2010. Wyville Thomson Ridge Overflow Water: spatial and temporal distribution in the Rockall Trough. Deep-Sea Research Part I 57: 1153–1162.

Johnson, M.P, *et al*. 2013. A Vertical wall dominated by *Acesta excavata* and *Neopycnodonte zibrowii*, part of an undersampled group of deep-sea habitats. PLoS ONE 8:e79917.

Kazanidis, G., *et al*. 2019. Distribution of deep-sea sponge aggregations in an area of multisectoral activities and changing oceanic conditions. Frontiers in Marine Science, 6, p.163.

Lewis, M., Neill, S.P., Robins, P.E., and Hashemi, M.R. 2015. Resource assessment for future generations of tidal-stream energy arrays. Energy 83: 403-415.

Lumsden, S.E., Hourigan, T.F., Bruckner, A.W., and Dorr, G. (editors). 2007. The State of Deep Coral Ecosystems of the United States. NOA Technical Memorandum CRCP-3. Silver Spring MD https://www.coris.noaa.gov/activities/deepcoral_rpt/

Masson, D.G., and Jacobs, C.L. 1999. RV Colonel Templer Cruises 01 & 02/98, 22 Apr–18 Jun 1998. TOBI Surveys of the Continental Slope North and West of Scotland Southampton Oceanography Centre Cruise Report, 22. Southampton Oceanography Centre, Southampton, UK. 66pp.

Masson, D.G., Bett, B.J., Billett, D.S.M., Jacobs, C.L., Wheeler, A.J., and Wynn, R.B. 2003. The origin of deep-water, coral-topped mounds in the northern Rockall Trough, Northeast Atlantic. Marine Geology 194: 159–180.

McCartney, M. S., and Mauritzen, C. 2001. On the origin of the warm inflow to the Nordic Seas. Progress in Oceanography 51: 125–214.

McGrath, T., Nolan, G. and McGovern, E. 2012. Chemical characteristics of water masses in the Rockall Trough. Deep-Sea Research Part I 61:57–73.

McIntyre, F.D., Drewery, J., Eerkes-Medrano, D., and Neat, F.C. 2016. Distribution and diversity of deep-sea sponge grounds on the Rosemary Bank Seamount, NE Atlantic. Marine Biology 163:143

Mohn, C., *et al.* 2014. Linking benthic hydrodynamics and cold-water coral occurrences: A high-resolution model study at three cold-water coral provinces in the NE Atlantic. Progress in Oceanography 122: 92-104.

Morato, T., *et al.* 2018. A multicriteria assessment nethod for identifying vulnerable marine ecosystems in the north-east Atlantic. Frontiers in Marine Science 5:460. https://www.frontiersin.org/articles/10.3389/fmars.2018.00460/full

Mytilineou, Ch., *et al*. 2014. New cold-water coral occurrences in the Eastern Ionian Sea: Results from experimental long line fishing. Deep Sea Research II 99:146-157.

NAFO. 2016. Report of the Scientific Council Meeting. 03-16 June 2016, Halifax, Nova Scotia. NAFO SCS Doc. 16-14 Rev., Serial No. N6587.

Narayanaswamy, B.E., Howell, K.L., Hughes, D.J., Davies, J.S., Roberts, J.M., and Black, K.D. 2006. Strategic Environmental Assessment Area 7 Photographic Analysis – Report. UK Department of Trade and Industry.

Narayanaswamy, B.E., Hughes, D.J., Howell, K.L., Davies, J., and Jacobs, C. 2013. First observations of megafaunal communities inhabiting George Bligh Bank, Northeast Atlantic. Deep-Sea Research II 92:79-86.

NEAFC. 2014. Recommendation 19:2014. Articles 2(c), 4 and 6(8). https://www.neafc.org/system/files/Rec19-Protection-of-VMEs_0.pdf

OSPAR Commission. 2000. Region 3: Celtic Seas. Quality status report 2000. London. 116 pp.

Pham, C. K., *et al*. 2014. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. Scientific Reports, 4: 4837. Nature Publishing Group.

Price, D.M., Robert, K., Callaway, A., Lo Iacono, C., Hall, R.A., and Huvenne, V.A.I. 2019. Using 3D photogrammetry from ROV video to quantify cold-water coral reef structural complexity and investigate its influence on biodiversity and community assemblage. Coral Reefs 38:1007-1021.

Puerta, P., *et al.* 2020. Influence of Water Masses on the Biodiversity and Biogeography of Deep-Sea Benthic Ecosystems in the North Atlantic. Frontiers in Marine Science, 7. Frontiers. https://www.frontiersin.org/articles/10.3389/fmars.2020.00239/full (Accessed 21 May 2020).

Rees, T. 2003. "C-squares", a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography, 16(1): 11–19.

Regulation (EU) 2016/2336 of the European Parliament and of the Council of 14 December 2016 establishing specific conditions for fishing for deep-sea stocks in the north-east Atlantic and provisions for fishing in international waters of the north-east Atlantic and repealing Council Regulation (EC) No 2347/2002. 2016. . 32016R2336. http://data.europa.eu/eli/reg/2016/2336/oj/eng (Accessed 21 May 2020).

Rengstorf, A.M., Yesson, C., Brown, C., and Grehan, A.J. 2013. High-resolution habitat suitability modelling can improve conservation of vulnerable marine ecosystems in the deep sea. Journal of Biogeography 40: 1702-1714.

Rengstorf, A.M., Mohn, C., Brown, C., Wisz, M.S., and Grehan, A.J. 2014. Predicting the distribution of deep-sea vulnerable marine ecosystems using high-resolution data: Considerations and novel approaches. Deep-Sea Research Part I 93:72-82.

Rice, A.L., Thurston, M.H., and New, A.L. 1990. Dense aggregations of a hexactinellid sponge, *Pheronema carpenteri*, in the Porcupine Seabight (northeast Atlantic Ocean), and possible causes. Progress in Oceanography 24:179–196.

Roberts, J.M., Long, D., Wilson, J.B., Mortensen, P.B., and Gage, J.D. 2003. The cold-water coral *Lophelia pertusa* (Scleractinia) and enigmatic seabed mounds along the north-east Atlantic margin: are they related? Marine Pollution Bulletin 46:7-20.

Roberts, J.M., *et al*. 2009. Mingulay reef complex: an interdisciplinary study of cold-water coral habitat, hydrography and biodiversity. Marine Ecology Progress Series 397:139-151.

Robinson, J. E., Newell, R. C., Seiderer, L. J., and Simpson, N. M. 2005. Impacts of aggregate dredging on sediment composition and associated benthic fauna at an offshore dredge site in the southern North Sea. Marine Environmental Research 60: 51–68.

Ross, R.E., and Howell, K.L. 2013. Use of predictive habitat modelling to assess the distribution and extent of the current protection of 'listed' deep-sea habitats. Diversity and Distributions 19: 433-445.

Sacchetti, F., *et al*. 2012. Deep-water geomorphology of the glacial Irish margin from high-resolution marine geophysical data. Marine Geology 291–294:113–131.

Strong, J.A., and Johnson, M. 2020. Converting SACFOR data for statistical analysis: validation, demonstration and further possibilities. Marine Biodiversity Records 13. https://doi.org/10.1186/s41200-020-0184-3

Taylor, J., Drewery, J. and Boulcott, P. 2019. 1218S Cruise Report: Monitoring survey of Faroe-Shetland Sponge Belt NCMPA, Rosemary Bank Seamount NCMPA and Wyville Thomson Ridge SAC. *JNCC Report No. 630*. JNCC, Peterborough, ISSN 0963-8091.

Turrell, W. R., Slesser, G., Adams, R. D., Payne, R., and Gillibrand, P. A. 1999. Decadal variability in the composition of Faroe Shetland Channel bottom water. Deep-Sea Research Part I 46:1–25.

Van Dalfsen, J. A., Essink, K., Madsen, H. T., Birklund, J., Romero, J., and Manzanera, M. 2000. Differential response of macrozoobenthos to marine sand extraction in the North Sea and the Western Mediterranean. ICES Journal of Marine Science, 57: 1439–1445. Oxford Academic.

Van Oevelen, D., Duineveld, G., Lavaleye, M., Mienis, F., Soetaert, K., and Heip, C.H.R. 2009. The cold-water coral community as a hot spot for carbon cycling on continental margins: A food-web analysis from Rockall Bank (northeast Atlantic). Limnology and Oceanography 54:1829-1844.

Van Weering, T.C.E., de Haas, H., de Stigter, H.C., Lykke-Andersen, H., and Kouvaev, I. 2003. Structure and development of giant carbonate mounds at the SW and SE Rockall Trough margins, NE Atlantic Ocean. Marine Geology 198:67-81.

Vieira, R.P., *et al.* 2020. Deep-sea sponge aggregations (Pheronema carpenteri) in the Porcupine Seabight (NE Atlantic) potentially degraded by demersal fishing. *Progress in Oceanography*, *183*, p.102189.

Wheeler, A.J., *et al*. 2005. Sedimentary processes and carbonate mounds in the Belgica Mound province, Porcupine Seabight, NE Atlantic. In: Freiwald, A., Roberts, J.M. (Eds.), Cold-water Corals and Ecosystems. Springer-Verlag Berlin Heidelberg, pp. 571–603.

White, M., Mohn, C., de Stigter, H., and Mottram, G. 2005. Deep-water coral development as a function of hydrodynamics and surface productivity around the submarine banks of the Rockall Trough, NE Atlantic. In: Freiwald, A., Roberts, J.M. (Eds.), Cold-water Corals and Ecosystems. Springer-Verlag Berlin Heidelberg, pp. 503-514.

White, M. 2006. Benthic dynamics at the carbonate mound regions of the Porcupine Sea Bight continental margin. International Journal of Earth Sciences, published on-line, doi:10.1007/s00531-006-0099-1.

Wilson, J.B. 1979. The distribution of the coral *Lophelia pertusa* (L.) [*L. prolifera* (PALLAS)] in the north-east Atlantic. Journal of the Marine Biological Association of the United Kingdom 59:149-164.

4.6.3 Bay of Biscay and Iberian Coast Ecoregion

The Bay of Biscay and Iberian Coast ecoregion covers the southeastern shelf seas of the EU. It includes areas of the deeper eastern Atlantic Ocean between depths of 400 and 800 m (Figure 1). The Bay of Biscay and Iberian Coast ecoregion includes all or parts of the Exclusive Economic Zones (EEZs) of three EU Member States (France, Spain and Portugal) and a small proportion of high-seas area. Fisheries in the Bay of Biscay and Iberian Coast are managed through national administrations via the EU Common Fisheries Policy (CFP; European Union, 2013), with fisheries of some stocks managed by the North East Atlantic Fisheries Commission (NEAFC) and by coastal state agreements. Responsibility for salmon fisheries is taken by the North Atlantic Salmon Conservation Organization (NASCO) and for large pelagic fish by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Collective fisheries advice is provided by the International Council for the Exploration of the Sea (ICES), the European Commission's Scientific Technical and Economic Committee for Fisheries (STECF), and the South West Waters Advisory Council (SWWAC). The EU's marine conservation policy is coordinated by the Habitats Directive and the Marine Strategy Framework Directive (MSFD; European Commission 2008, 2017). In coordination with the Birds Directive (European Commission, 2010), the Habitat Directive (European Commission, 1992) has established the EU Natura 2000 ecological network of protected areas. In deep waters of the ecoregion, two habitats of the Habitat Directive that may match the criteria of Vulnerable Marine Ecosystems (VMEs) as defined by the FAO are the "1170 Reefs" and "1180 Submarine structures made by leaking gases". It was FAO (FAO, 2009) that elaborated on the term vulnerable marine ecosystems (VME) in response to United Nations General Assembly sustainable fishing resolutions. Natura 2000 includes some VMEs. The CFP supports the sustainability of EU fisheries and that they do not damage the marine environment. The CFP pays particular attention to deep-sea stocks and to the adverse impacts these fisheries can have on VMEs. Guidance is provided by national agencies, OSPAR, the European Environment Agency (EEA) and ICES.

The Bay of Biscay and Iberian Coast ecoregion ranges from Brittany in the north to the Gulf of Cádiz in the south; four key areas constitute the ecoregion: (1) the Bay of Biscay, characterized by a wide shelf extending west of France, (2) the Cantabrian Sea (Northern Iberian Shelf), (3) Western Iberian Shelf, characterized by a narrow shelf, which makes waters and habitats below 400 m depth relatively close (and hence accessible) from the coast, and (4) the Gulf of Cádiz, where the shelf widens again, particularly towards the east.

The ecoregion is characterized by a diversity of VME elements, such as submarine canyons, seamounts, steep slopes and mud volcanoes that support a number of VMEs. From north to south, the continental slope of the Bay of Biscay, Cantabrian Sea and Iberian margin is incised by over a hundred canyons. In the Bay of Biscay, VME habitats dominated by cold-water corals have been found in each of the 24 submarine canyons explored so far (van den Beld *et al*., 2017a). Coral reefs and coral gardens on hard substrates were preferably found in the northern Bay of Biscay. Coral gardens on soft-substrates were more common in the southern Bay of Biscay. The northern Iberian margin is characterized by two large banks, El Cachucho (Le Danois Bank) and Galicia Bank, as well as by the Avilés and La Gaviera submarine canyons, which are all known to host VMEs (Sanchez *et al*., 2008, 2014a; Louzao *et al*., 2010; García-Alegre *et al*., 2014; Serrano *et al*., 2017a,b; Rodriguez-Basalo *et al*., 2019; Prado *et al*., 2019). Off the southern coast of Portugal, the Gorringe Bank/Ridge is another key VME element made of two seamounts (Gettysburg and Ormonde) that rise from abyssal depth to just 25 m below the sea surface. The presence of VME habitats and/or indicators have been documented in both seamounts (Xavier and Van Soest, 2007; Ramos *et al*., 2016; OCEANA, 2014), specifically VME habitats are included in the ICES VME Database for Ormonde. In the Gulf of Cádiz, mud volcanoes host cold seeps and other VME habitats, some of the mud volcanoes are included as VME habitats and indicators in the ICES VME Database, whereas the ones not included in this database are known to harbour VME habitats (e.g., Cunha *et al*., 2013; Díaz del Rio, 2014; Rueda *et al*., 2012; Palomino *et al*., 2019; Lozano *et al*., 2019).

The five most important pressures (link) in the Bay of Biscay and Iberian Coast ecoregion are the selective extraction of species, abrasion, nutrient and organic enrichment, smothering, and substrate loss. These pressures are mainly linked to the following human activities: fishing, shipping, tourism and recreation, land-based industry, and agriculture. Below 400 m, fishing (remarkably bottom contact fishing gears) is the main activity that, as mentioned above, can potentially impact VMEs through selective extraction of species, abrasion and smothering. Marine litter found in the canyons consists of lost nets and fishing gears, also a result of fishing (Mordecai *et al.* 2011, Oliveira *et al*., 2015; van den Beld *et al*., 2017b). Further information on these pressures and impacts can be found in the corresponding Ecosystem Overview.

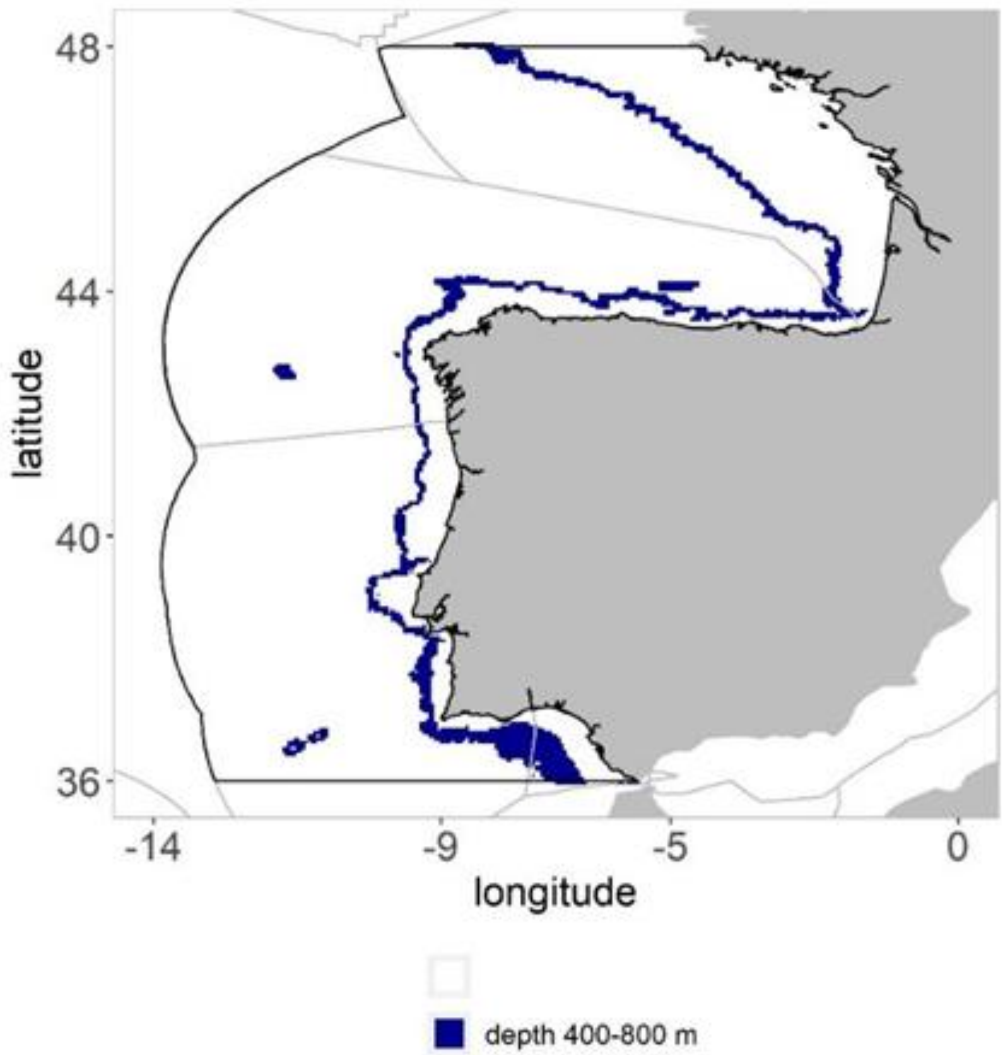


Figure 1. Bay of Biscay and Iberian Coast ecoregion with area between 400 m and 800 m depth (blue shade). Depth is extracted from bathymetry data of EmodNet (EmodNet Bathymetry Consortium, 2018). Each C-square has approximately 2300 depth observations and is included in the blue shaded area when one depth observation is within the 400 to 800 metre depth range.

Distribution of Vulnerable Marine Ecosystems

The ICES Working Group on Deep-water Ecology (WGDEC) provides the science and data, consistent with ICES scientific and data quality policies, to deliver the best available evidence of VME presence (ICES, 2020a). The ICES Working Group on Marine Habitat Mapping (WGMHM) coordinates the review of habitat classification and mapping activities in the ICES area and has prepared maps of VME elements (ICES, 2020b) which have been upgraded here, using higher resolution EMODnet seafloor geomorphic features. The EMODNET seafloor geology is publicly available and provides georeferenced geological and biogenic structures such as banks, coral mounds, mud volcanoes and seamounts at a higher spatial resolution than other global sources of information. These data provide the input to the management options presented below. Despite being the best available, there is uncertainty in the data in terms of the likelihood of a C-square (Rees, 2003) containing VMEs. Managing environmental uncertainty of this nature requires the application of the precautionary approach (sensu FAO).

Table 1. Linking degree of precaution required to make management decisions with characteristics of the VME data.

Degree of Precaution	Confidence of VME presence	Data source	Notes
Low	Known	VME Database	ICES VME habitat confirmed using VME records from the ICES VME Database and mapped by C-square (Figure 2).
Medium	High/Medium	VME Index	ICES VME High/Medium quality data with Medium confidence using the multi-criteria assessment tool (Figure 3).
High	Low	VME Index	ICES VME Low quality with Low Confidence using the multi-criteria assessment tool (Figure 4). WKEUVME notes some caveats with this category resulting in under-representation of sea pen VMEs in higher categories.
High	Low	Species Distribution Models (SDM)	Not available at this time but may be incorporated into future assessments.
High	Low	VME element mapping	Presence of the VME elements (Figure 5) listed in the Annex of the FAO International Guidelines noted above (FAO, 2009)

Data on VMEs in the ICES VME Database were collected following the annual ICES data call for VME data (link). The database includes point and line data on individual VME indicator and habitat records, where available. VME habitats, verified with *in situ* imagery, are mapped at C-square4 resolution (Figure 2). In addition, data on the potential location of VME habitats (e.g., where VME *are likely to occur*) has been determined by the WGDEC, using a published multi-criteria assessment method (ICES, 2018a; Morato *et al.*, 2018). This collates VME indicator point records within a C-square and determines whether a VME is likely to be present (Figures 3, 4), based on an evaluation of the vulnerability of the indicator species present and their abundance where this information is available (see Section 7 of ICES, 2018a). It also assesses the confidence placed in the data (low, medium or high), based on four criteria: data collection method, number of samples within the C-square, time span of data (between first and last record) and time since last survey.

4 The C-square resolution used here is a 0.05 x 0.05 degree grid, equivalent to approximately 15 km² at 60°N latitude, using the approach detailed in Rees (2003). For more details see http://www.cmar.csiro.au/csquares/spec1-1.htm

The VME likelihood and confidence scores collectively provide an evaluation of the certainty of the VME habitat being present (Table 1). Known VME habitats are mapped as such, and do not go through the VME Index.

Broad-scale habitat features (‘VME elements') such as canyons, seamounts and ridges can be mapped using bathymetric data (Figure 5) and used as a proxy for VME presence, since these areas are commonly known to support VMEs (FAO, 2009). The North East Atlantic Fisheries Commission (NEAFC) recognizes isolated seamounts, steep-slopes and peaks on mid-ocean ridges, knolls, canyons and steep flanks > 6.4° as VME elements (NEAFC, 2014). Use of VME elements can fill in gaps between direct observations of VMEs derived from the VME Database and are a good proxy for where VMEs are *likely to occur*.

VMEs in the Bay of Biscay and Iberian Coast Ecoregion

Within the Bay of Biscay and Iberian Coast ecoregion there are a multitude of known VME habitats and VME indicator records as well as broad-scale habitat features (VME elements) that typically support VMEs. In total, the ICES VME Database holds 3,834 records for VME habitats and indicators within this ecoregion; however, these records are unevenly distributed across the Exclusive Economic Zones of France, Spain and Portugal (Table 2). The distribution of VME habitat and indicator records is presented in Figure 6 and 7 respectively.

With the exception of some specific features (e.g., Mériadzek Terrace, Ormonde Seamount, São Vicente Canyon, Gazul Mud Volcano, Tasyo mud volcano field and Guadalquivir Diapiric Ridge) there is a low level of data coverage within the ICES VME Database. The potential for additional VME habitats to be discovered in this ecoregion is highlighted by habitat suitability models, which predict the existence of suitable habitat across bathyal depths (300 to 1000 m) for some VME indicators. For example, suitable habitat has been modelled for several reef-forming corals (e.g., *Enallopsammia rostrata*, *Lophelia pertusa* (i.e., *Desmophyllum pertusum*), *Madrepora oculata* and *Solenosmilia variabilis*; Davies and Guinotte, 2011) as well as sponge aggregations dominated by *Pheronema carpenteri* (Howell *et al*., 2016). Habitat suitability models have also identified areas within this ecoregion that may act as refugia under future climate change scenarios for the scleractinian corals *Lophelia pertusa* (i.e., *Desmophyllum pertusum*), *Madrepora oculata* and *Desmophyllum dianthus* (Morato *et al*., 2020), providing a basis by which climate change can be considered in future decision making (Morato *et al*., 2020).

Additional records for VME habitats and indicator taxa (particularly sponges and corals) are available within other public databases (e.g., EMODnet, UNEP, OBIS, OSPAR’s ODIMS and GBIF) and the scientific literature; however, this data has yet to be submitted to ICES, quality checked, indexed and included in the ICES Database as part of an ICES VME data call. A summary of the VMEs and VME elements located within the ecoregion follows.

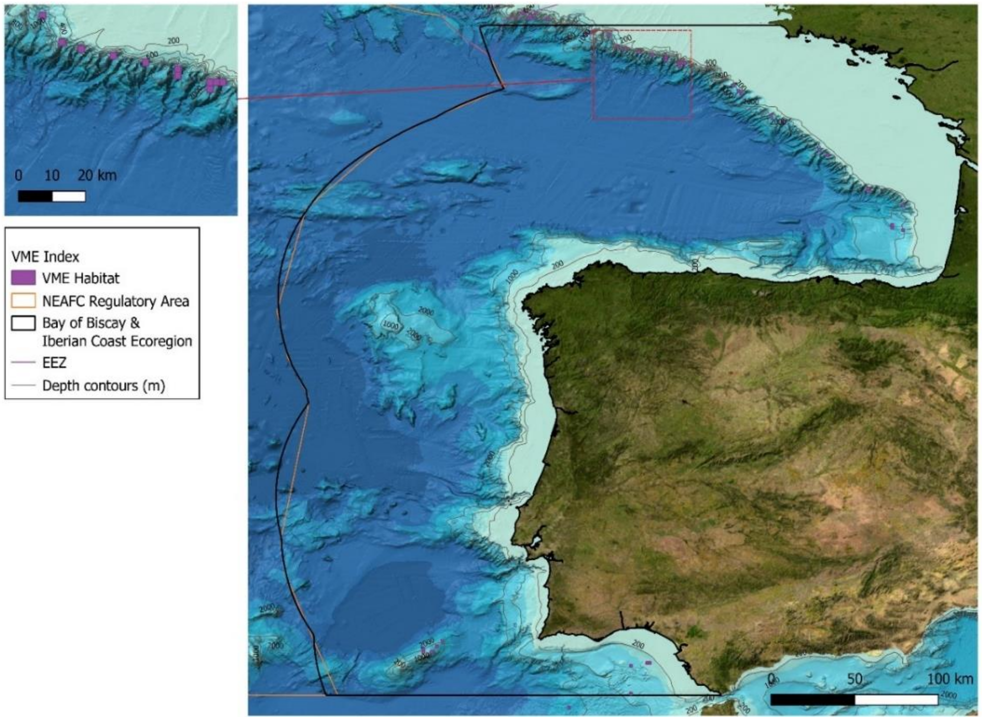


Figure 2. Bay of Biscay and the Iberian Coast Ecoregion, showing areas of known VME (VME Habitat) mapped at the scale of C-square. Inset shows a section of the continental margin between the Berthois and the Bourcart spurs. Copyright: Base map imagery GEBCO_2014 Grid, version 20150318. EEZ: Flanders Marine Institute (2020) Maritime Boundaries Geodatabase, version 11. Depth contours: GEBCO (2004). Map projection: EPSG:4326 - WGS 84.

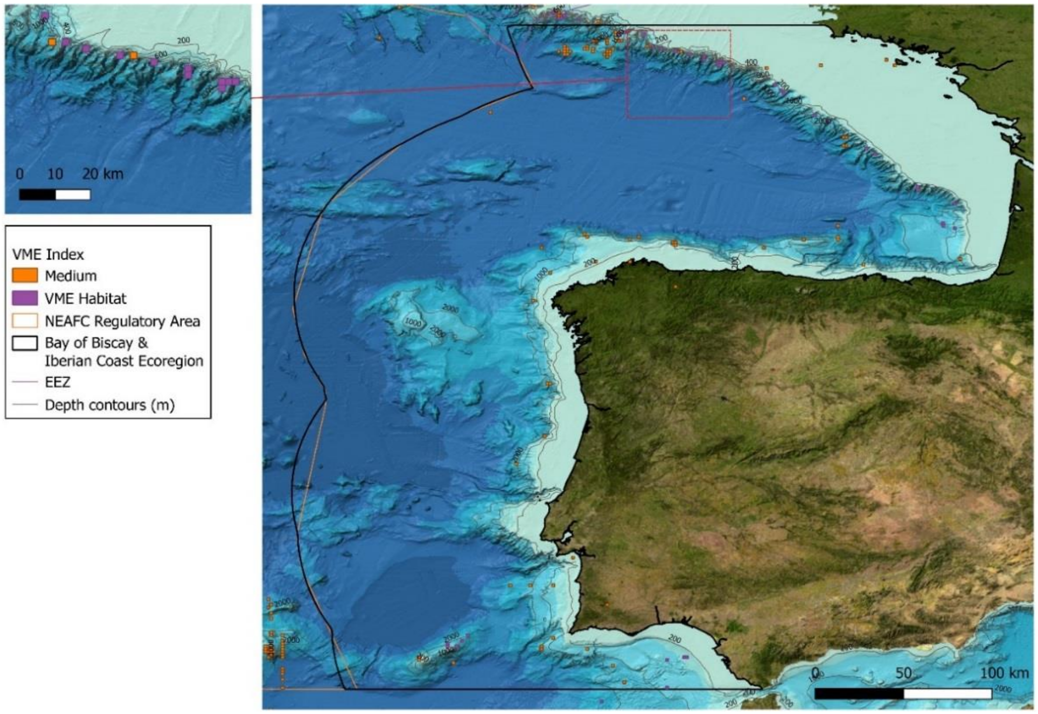


Figure 3. Bay of Biscay and the Iberian Coast Ecoregion, showing areas of known VME (VME Habitat) and Medium VME Index, mapped at the scale of C-square. There are no High VME Index records for this ecoregion at present. Inset shows a section of the continental margin between the Berthois and the Bourcart spurs. Copyright: as for Figure 2. Map projection: EPSG:4326 - WGS 84.

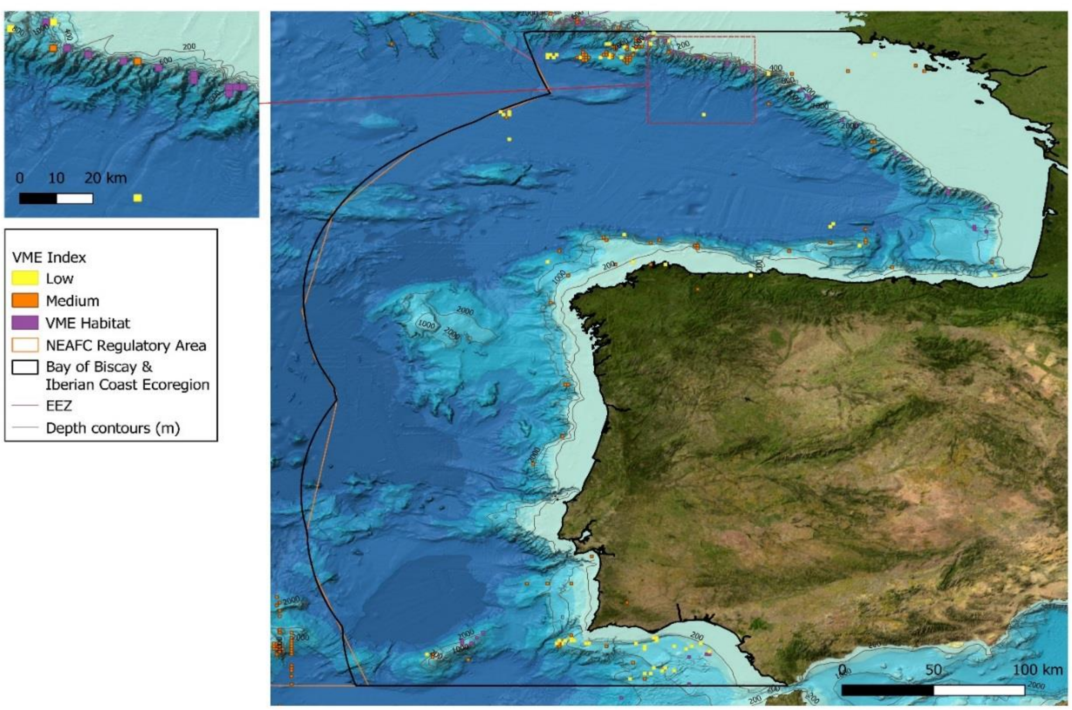


Figure 4. Bay of Biscay and the Iberian Coast Ecoregion showing areas of known VME (VME Habitat) and Medium and Low VME Index records, mapped at the scale of C-square. There are no High VME Index records for this ecoregion at present. Inset shows a section of the continental margin between the Berthois and the Bourcart spurs. Copyright: as for Figure 2. Map projection: EPSG:4326 - WGS 84.

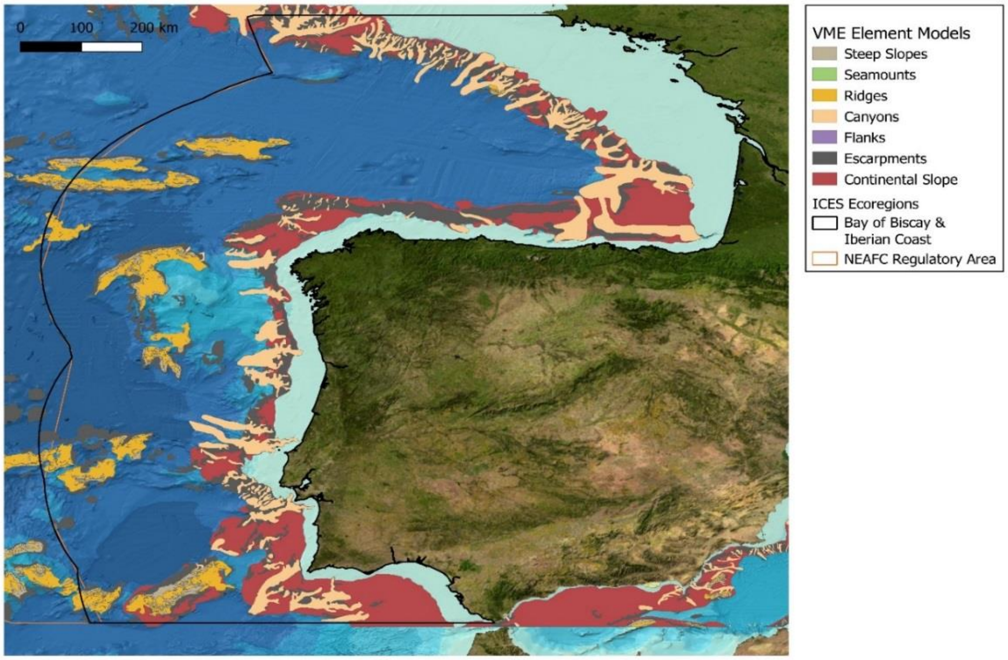


Figure 5. Bay of Biscay and the Iberian Coast Ecoregion, showing location of VME elements based on models. Copyright: as for Figure 2. VME element models from Seafloor Geomorphic Features Map (Harris et al., 2014) and EMODnet Geology. Map projection: EPSG:4326 - WGS 84.

Table 2. The number of VME Habitat and VME Indicator records within the ICES VME Database for each of the four key areas within the Bay of Biscay and Iberian Coast Ecoregion: Western France (Bay of Biscay), Northern Spain (Northern Iberian Shelf), Portugal (Western Iberian Shelf & Gulf of Cádiz), Southern Spain (Gulf of Cádiz). Data correct as of May 2020.

VME Habitats	Western France	Northern Spain	Portugal	Southern Spain
Coral gardens	1,985	0	1	8
Cold-water coral reefs	1,015	0	0	1
Deep-sea sponge aggregations	0	0	5	5
Cold seeps	0	0	0	2
Mud and sand emergent fauna	0	0	0	4
Absence Records	666	39	98	5
Total	3,666	39	104	25
VME Indicators				
Anemones	959	0	0	0
Stony corals	883	0	0	0
Gorgonians	582	24	33	0
Sea pens	532	13	50	5

Black corals	439	0	1	0
Sponges	182	0	5	0
Cup corals	51	0	0	0
Soft corals	30	2	15	0
Stylasterids	1	0	0	0
Absence Records	7	0	0	20
Total	3,666	39	104	25

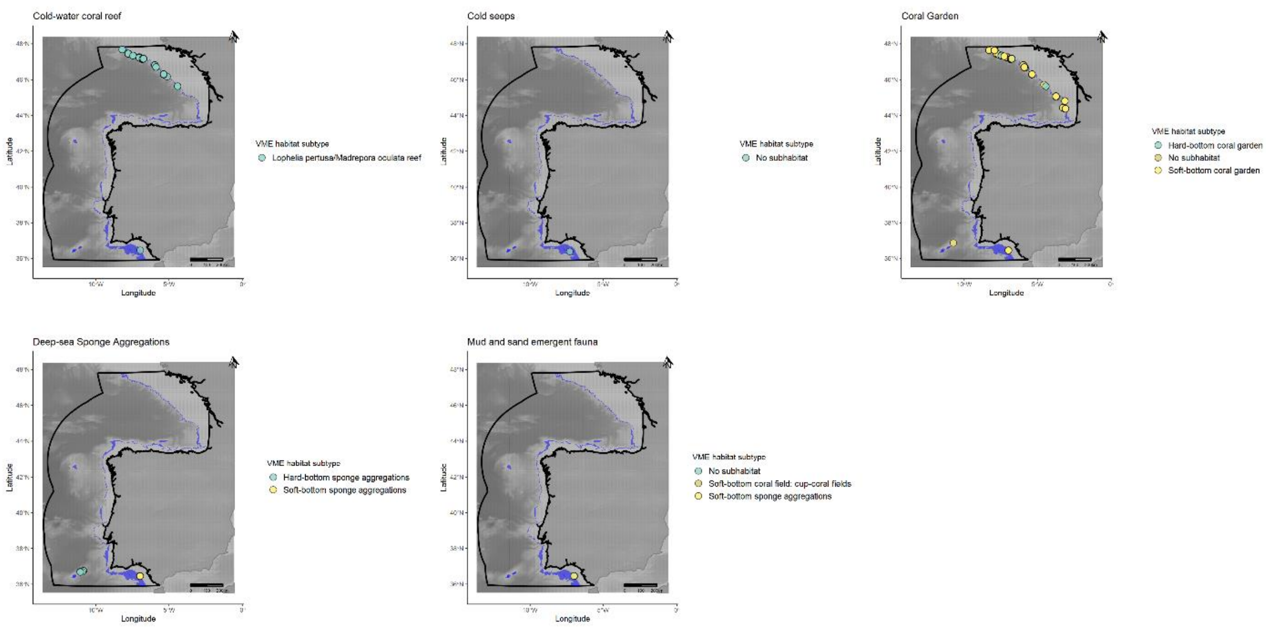


Figure 6. Location of VME habitat types and subtypes available within the ICES VME Database for the Bay of Biscay and Iberian Coast Ecoregion. No subhabitat means that the habitat category is not specified further. The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMODnet bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84 / UTM zone 29N.

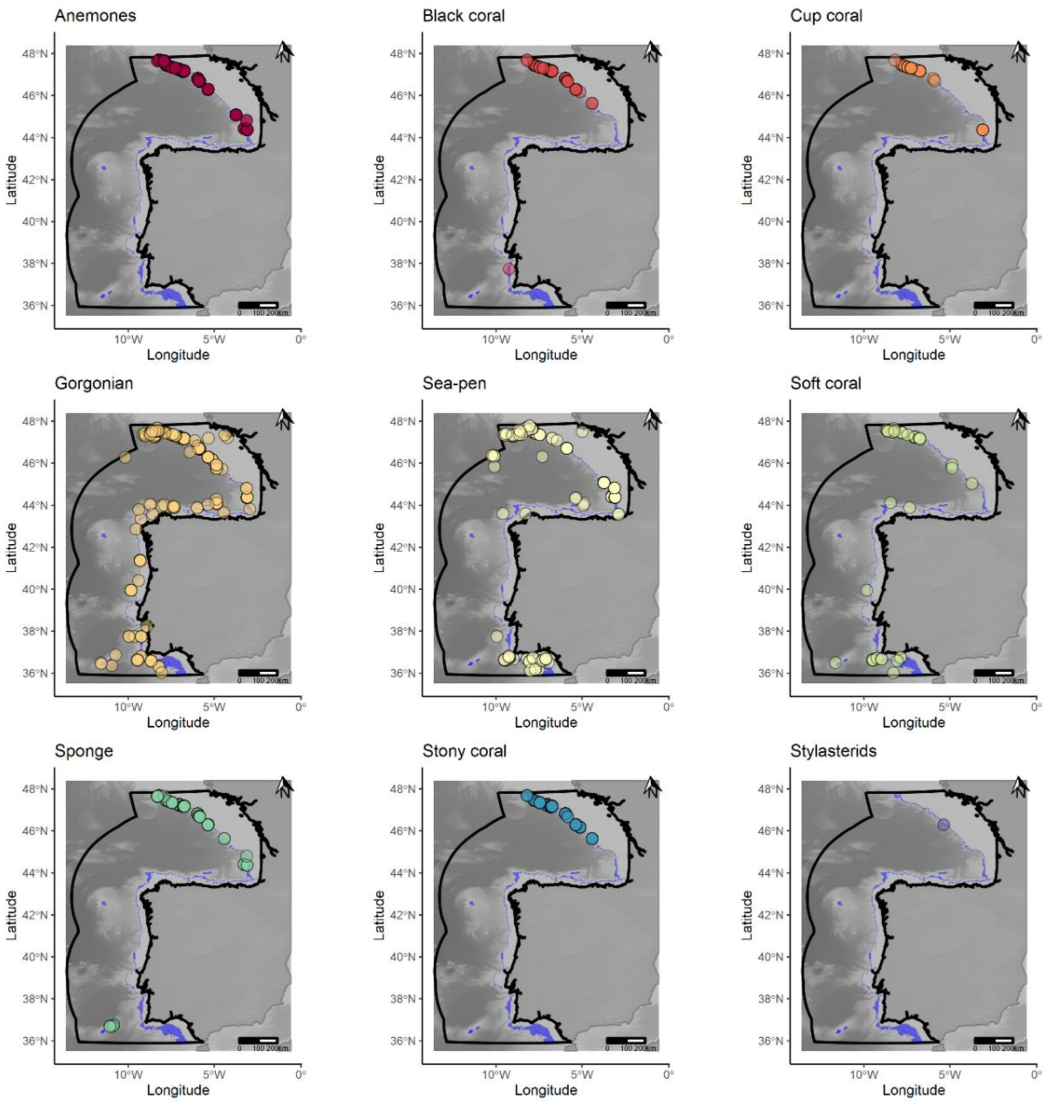


Figure 7. Location of VME indicator records available within the ICES VME Database for the Bay of Biscay and Iberian Coast Ecoregion. ICES VME Database accessed May 2020. The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMOD-net bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84 / UTM zone 29N.

Western France: Bay of Biscay

- VME habitat(s) within the ICES database: i) coral gardens, ii) cold-water coral reefs
- VME indicator(s) within the ICES database: i) anemones, ii) stony corals, iii) gorgonians, iv) sea pens, v) black corals, vi) sponges, vii) cup corals, viii) soft corals, ix) stylasterids
- VME element(s): i) canyons, ii) steep flanks, iii) escarpments, iv) ridges, v) steep slopes, vi) sea-mounts

The ICES VME Database contains 3,000 records of VME habitats within the Bay of Biscay, namely cold-water coral reefs (1,015 records) and coral gardens (1,985 records), of which 1,631 records are identified as soft-bottom coral gardens and 342 records are identified as hard-bottom coral gardens.

Cold-water coral reefs in the Bay of Biscay are built by the scleractinian corals *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata* (Arnaud-Haond *et al*., 2017) and are characterised by an underlying dead coral framework topped with live individual corals (van den Beld *et al*., 2017; De Mol *et al*., 2011). Together, the dead coral framework and live corals form a complex three-dimensional structure that can provide habitat for other deep-sea species. The three most abundant taxa associated with cold-water coral reefs in the Bay of Biscay are the black corals *Leiopathes* sp. (1,923 colonies observed) and *Stichopathes gravieri* (293 colonies observed) as well as the soft coral *Narella versluysi* (238 colonies observed). Overall, cold-water coral reefs in the Bay of Biscay are smaller than those found elsewhere in the NE Atlantic margin (van den Beld *et al*., 2017) but represent as essential transition zone between the northern European margin and the Mediterranean (van den Beld *et al*., 2017; Reveillaud *et al*., 2008; De Mol *et al*., 2011). Cold-water coral reefs have been observed in ten submarine canyons ranging in depth from 655 m to 1239 m.

Hard-bottom coral gardens occur with varying community compositions (van den Beld *et al*., 2017a). Some coral gardens are dominated by either isidid soft corals (e.g., *Acanella* cf. *arbuscula*) or antipathid black corals (e.g., *Antipathes dichotoma* and *A. viminalis*) whereas other coral gardens include a mix of species found in fairly similar abundance, including: soft corals (e.g., *Narella versluysi*), black corals (e.g., *A. viminalis*, *A. dichotoma*, *Stichopathes gravieri, Parantipathes* sp. 1, *Leiopathes* spp.), solitary scleractinians (e.g., the cup corals *Caryophyllia* sp. and *Vaughanella* sp.) and (or) colonial scleractinians (e.g., *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata*). Coral gardens dominated by gorgonians or black corals have been observed in nine canyons ranging in depth from 580 m to 2348 m (van den Beld *et al*., 2017a); mixed coral gardens have been observed in 12 canyons at depths ranging from 678m to 1816m (van den Beld *et al*., 2017a).

Soft-bottom coral gardens also occur with varying community compositions but are typically characterised by a single species (van den Beld *et al*., 2017a). Aggregations of the bamboo coral *Acanella* cf. *arbuscula* have been observed in five canyons ranging in depth from 763 m to 1847 m. Monospecific aggregations of sea pens (*Kophobelemnon* cf. *stelliferum, Pennatula* sp., *Funiculina quadrangularis* or *Distichoptilum gracile*) have been observed in nine canyons from 234 m to 2305 m, and aggregations of cup corals belonging to the family Flabellidae have been observed in five canyons at depths ranging from 752 m to 1085 m. Mixed aggregations of the soft coral *Acanella* cf. *arbuscula* and the sea pen *Kophobelemnon* cf. *stelliferum* have been observed in three canyons but associations of these two species were rare.

The VME habitats described above were identified from 46 ROV surveys conducted between 2009 and 2012, and are closely association with twenty-four submarine canyons (van den Beld *et al*., 2017a). Additional data comes from 11 submersible dives conducted in Shamrock canyon during the CYAMOR cruise in 1981 (Grasshoff, 1985; Zibrowius, 1985). Submarine canyons are the most conspicuous VME element in the Bay of Biscay, with more than 80 canyons marking the continental slope (Reveillaud *et al*., 2008); the larger canyons are illustrated by the map of VME elements produced by the ICES Working Group on Marine Habitat Mapping (WGMHM) (ICES, 2020b; Figure 5). The fact VME habitats have been discovered in each of the twenty-four canyons where ROV and towed camera surveys have been conducted highlights the potential for additional VME habitats to be discovered within these VME elements following additional exploration.

The ICES VME Database also contains 666 records of VME indicators outside of those assigned to a specific VME habitat. Of these remaining records, 75% are sea pens (502 records) and 14% are gorgonian corals (94 records). Many of the sea pen and gorgonian coral indicator records are associated with the Mériadzek Terrace, which was sampled using a beam trawl during the BIOGAS project in the 1970s (Laubier and Monniot, 1985). Grasshoff (1981a, b; 1985) reported 52 bathyal species of gorgonian corals, black corals and sea pens; Zibrowius (1985) reported 17 species of scleractinian coral in the area.

Northern Spain: Northern Iberian Shelf

- VME habitat(s) within the ICES database: none are listed but this does not reflect the scientific literature (described below)
- VME indicator(s) within the ICES database: i) gorgonians, ii) sea pens, iii) soft corals, but more are known within the scientific literature (described below)
- VME element(s): i) canyons, ii) steep flanks, iii) escarpments, iv) banks, v) ridges, vi) steep slopes, vii) seamount

The ICES VME Database does not contain any records of VME habitats on the northern Iberian Shelf. Similarly, there are only 39 records for VME indicators, including: gorgonian corals (24 records across 14 species), sea pens (13 records across 5 species) and soft corals (2 records belonging to the order Alcyonacea).

This apparent lack of data does not reflect VME habitats or indicator records that are known to exist in other public databases as well as the scientific literature. Below we provide an overview of VME habitats and indicator records that are available for this area, and the VME elements from which the records originate. Maps showing the location of data known to exist but currently missing in the ICES VME Database is provided for Galicia Bank, El Cachucho and the Avilés Canyon System (Figure 8).

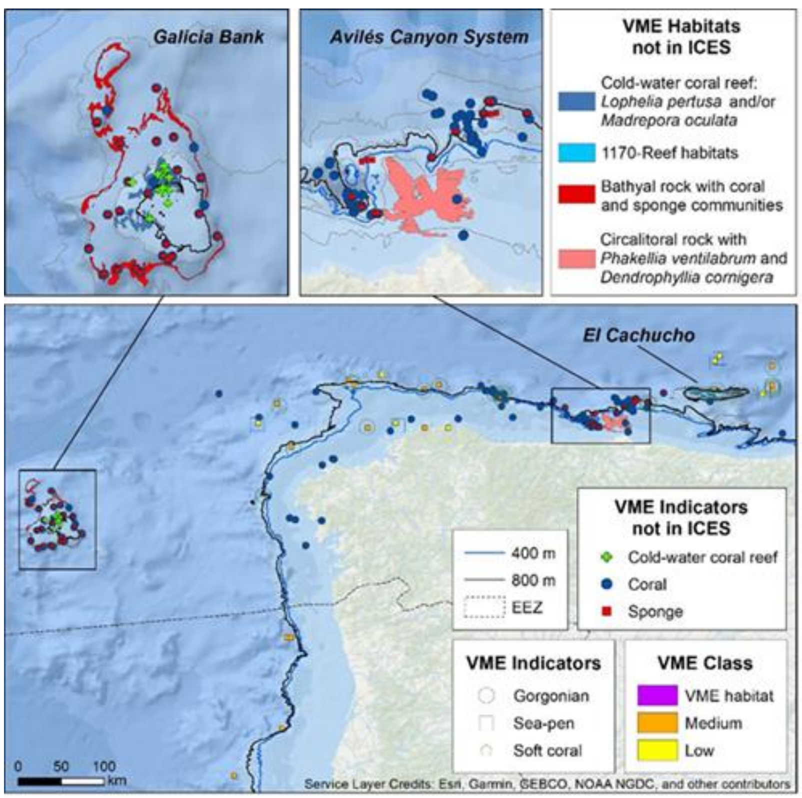


Figure 8. VME habitat and indicator records for the Northern Iberian Shelf; records include those already in the ICES VME Database and those known to exist in scientific publications and other public databases. Galicia Bank and the Avilés Canyon System are highlighted as two areas where data is available but not currently represented by the ICES VME Database. El Cachucho is known to host a number of 1170-Reef habitats (EU Habitats Directive), including sponges (*Asconema setubalense*, *Geodia* sp. and *Phakellia robusta*), soft corals (*Callogorgia verticillata* and *Paramuricea* cf. *placomus*) and black corals (*Leiopathes glaberrima*). Map Source: Javier Murillo, ICES WKEUVME 2020.

Galicia Bank

Galicia Bank is a non-volcanic seamount located ~220 km from the northwest coast of Spain with a bathymetric range of 600 to >2000 m (Serrano *et al*., 2017a). The seamount interacts with three different water masses (i.e., the Eastern North Atlantic Central Water, Mediterranean Outflow Water and Labrador Sea Water; Iorga and Lozier, 1999; Serrano *et al*., 2017a), which in turn influence benthic environmental conditions and biodiversity patterns (Serrano *et al*., 2017a). The biological communities on Galicia Bank are separated from those on the continental slope by Galicia Interior Basin, a U-shaped trough that reaches depths of 2800-4000 m (Murillas *et al*., 1990).

Although *Lophelia pertusa* corals have been known to exist on Galicia Bank since at least 1998 (Lavaleye *et al*., 2002 in Duineveld *et al*., 2004) it was not until the INDEMARES project (www.indemares.es) that the biodiversity of Galicia Bank was studied in detail. Three surveys conducted in 2009, 2010 and 2011 highlight the presence of VME indicators typical of cold-water coral reefs, coral gardens and deep-sea sponge aggregations (Figure 6; de la Torriente *et al*., 2014; Serrano *et al*., 2017a, b). VME indicators include: 36 samples of scleractinian corals (mainly *Lophelia pertusa* and *Madrepora oculata*), 50 samples of gorgonians (e.g., *Acanthogorgia spp., Swiftia rosea, Acanella arbuscula, Narella bellisima*), 23 samples of black coral (e.g. *Parantipathes spp., Trissopathes spp., Schizopathes* spp., *Bathypathes* spp.) and 42 samples of deep-sea sponges (e.g. *Asconema setubalense, Aphrocallistes Beatrix, Phakellia robusta, Geodia megastrella, Geodia pachydermata*). There has been limited exploration of Galicia Bank using visual research methods; however, surveys of hard substrate habitats have observed cold-water coral reefs built by the scleractinian corals *Lophelia pertusa* and *Madrepora oculata* as well as hard-bottom coral gardens characterized by gorgonians, bamboo corals and black corals (de la Torriente *et al*., 2014). The presence of such taxa has led to the proposed designation of Galicia Bank as a Site of Community Importance (SCI) within the Natura 2000 network.

El Cachucho (Le Danois Bank)

Le Danois Bank, known by local fisherman as “El Cachucho” fishing ground (the local name for *Beryx decadactylus*; Sánchez *et al*., 2008), is a marginal shelf located in the central Cantabrian Sea ~55 km from the Asturias coast (Spain). The ~1,100 km² bank is separated from the coast by an intraslope basin (Sánchez *et al*., 2008), rising from ~800 m to a minimum depth of 400-600m (García-Alegre *et al*., 2014). The northern flank of the bank forms the continental slope reaching depths of ~4400 m (García-Alegre *et al*., 2014). In 2011, El Cachucho became the first offshore Marine Protected Area (MPA) in Spain and has been included in the OSPAR network of MPAs as well as the EU-wide Natura 2000 Network as a Special Area of Conservation (Sánchez *et al*., 2017; Rodríguez-Basalo *et al*., 2019).

In the last 17 years, research projects (e.g., ECOMARG and ESMAREC) have dramatically increased our understanding of the biological communities on El Cachucho. Seven surveys conducted between 2003 and 2017, using a variety of direct (e.g., rock dredges and trawls) and indirect (e.g., photogrammetry sledge and ROV) sampling methods, highlight the presence of VME indicators typical of coral gardens and deep-sea sponge aggregations (Figure 8; Rodríguez-Basalo *et al*., 2019). Some of these VME indicators are depicted in Figure 9. The most commonly observed species include: black corals (*Leiopathes glaberrima*), soft corals (*Placogorgia sp*., and *Callogorgoa verticillata*), demosponges (G*eodia cf. barretti* and *Phakellia robusta*) and the hexactinallid sponge *Asconema setubalense* (García-Alegre *et al*., 2014; Sánchez *et al*., 2017; Rodríguez-Basalo *et al*., 2019). Visual surveys (i.e., 23 transects ranging in depth from 427 to 1379m; Sánchez *et al*., 2017) highlight the presence of potential VME habitats, including aggregations of soft corals (*Callogorgia verticillata* and *Paramuricea* cf. *placomus*), the scleractinian coral *Dendrophyllia cornigera* and deep-sea sponges (*Asconema setubalense Geodia* sp. and *Phakellia robusta;* Sánchez *et al*., 2017; Prado *et al*., 2019; Rodríguez-Basalo *et al*., 2019).

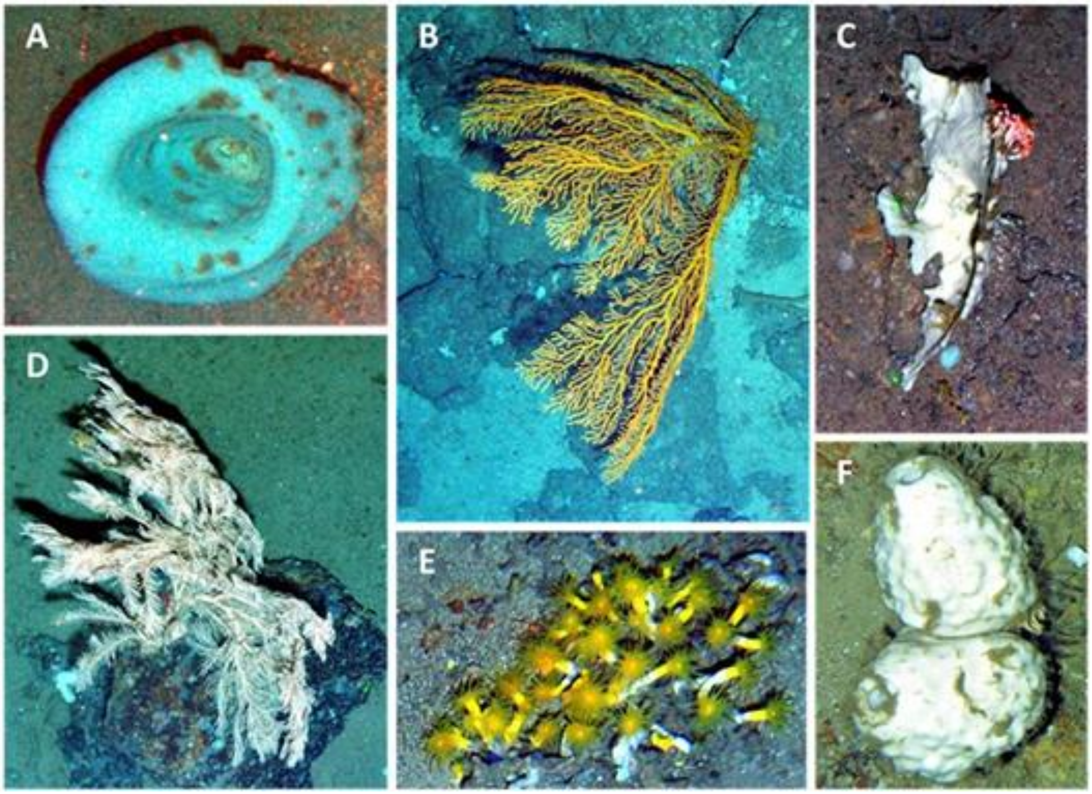


Figure 9. Representative VME indicator taxa present at El Cachucho (Le Danois Bank, figure taken from Sánchez et al. (2017). A) Asconema setubalense, B) Paramuricea cf. placamus C) Phakellia robusta, D) Callogorgia verticillata E) Dendrophyllia cornigera F) Geodia msp.1.

Avilés Canyon System

Located in the central Cantabrian Sea off the western coast of Asturias (Spain), the Avilés Canyon System is formed by three submarine canyons (Avilés, El Corviru and La Gaviera), a marginal platform (El Cantu Nuavu) and the Agudo de Fuera topographic high (Sánchez *et al*., 2014a; Gómez-Ballesteros *et al*., 2014). The canyon system is structurally complex, with an overall length of ~120 km and ranging in depth from ~120 m to 4800 m (Gómez-Ballesteros *et al*., 2014).

The Avilés Canyon System was surveyed extensively as part of the INDEMARES project, and continues to be surveyed with the INTEMARES project. Five surveys were conducted from 2010 to 2012 using a variety of sampling techniques (e.g., rock dredges, trawls, photogrammetry sledges and ROVs; Sánchez *et al*., 2014a). The surveys document the occurrence of numerous VME indicators (Figure 8), some of which are depicted in Figure 10. VME indicators include: deep-sea sponges (e.g., *Phakellia robusta*, *Phakellia ventilabrum* and *Regadrella phoenix*) and black corals (e.g. *Trissopathes sp., Parantipathes cf. hirondelle, Bathypathes sp., Leiopathes sp.*) as well as an abundance of the scleractinian coral *Dendrophyllia cornigera* on rocky outcrops on the continental shelf (Sánchez *et al*., 2014a). Visual surveys have observed deep-sea sponge aggregations (*Pheronema* sp.; Sánchez *et al*., 2014b) and mapped cold-water coral reefs built by the scleractinian corals *Lophelia pertusa* and *Madrepora oculata* in La Gaviera Cayon (Sánchez *et al*., 2014a), which were first described in the Avilés Canyon System by Le Danois (1948). The presence of such taxa has led to the proposed designation of the Avilés Canyon System as a Site of Community Importance (SCI) within the Natura 2000 network.

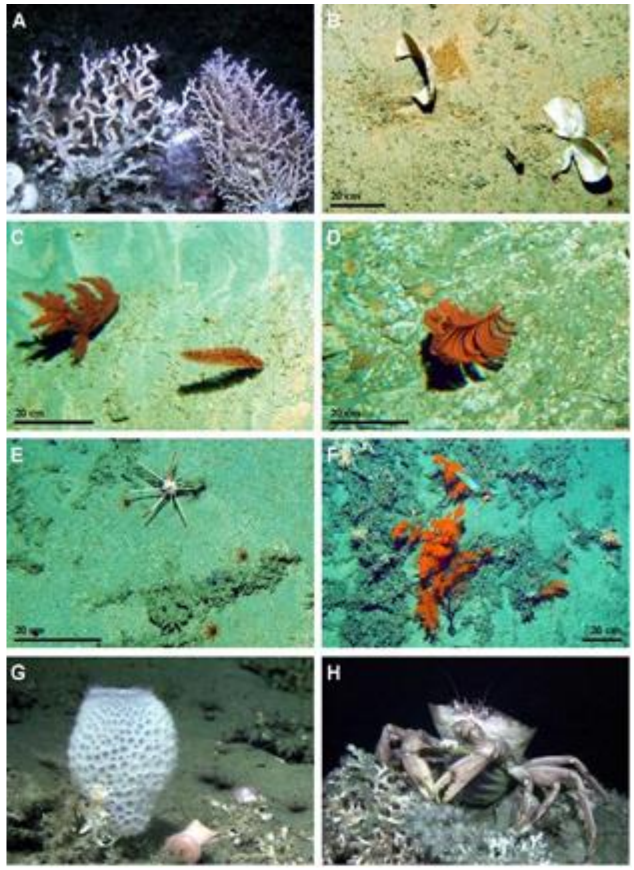


Figure 10. Representative VME indicator taxa present in the Avilés Canyon System, figure taken from Sánchez et al. (2014). (A) *Lophelia pertusa* (left) and *Madrepora oculata* (rigtht), (B) *Phakellia robusta*, (C) *Trissopathes* sp. (left) and *Parantipathes* cf. *hirondelle* (right), (D) *Bathypathes* sp., (E) *Cerianthid* sp. (perhaps *Cerianthus lloydii*) and *Cidaris cidaris*, (F) *Leiopathes* sp., (G) *Regadrella phoenix*, and (H) *Chaceon affinis*.

Portugal: Western Iberian Shelf and Gulf of Cádiz

- VME habitat(s) within the ICES database: i) coral gardens, ii) deep-sea sponge aggregations
- VME indicator(s) within the ICES database: i) gorgonians, ii) sea pens, iii) soft corals, iv) black corals, v) sponges
- VME element(s): i) canyons, ii) steep flanks, iii) escarpments, iv) ridges, v) steep slopes, vi) seamounts

The ICES VME Database contains six records of VME habitats along the Portuguese continental shelf, namely deep-sea sponge aggregations (5 records) and a single coral garden record, all of which are associated with Ormonde Seamount on the Gorringe Bank/Ridge (as discussed below). There are 98 records for VME indicators outside of those assigned to a specific VME habitat, including: gorgonian corals (32 records across 16+ species), sea pens (50 records across 8+ species), soft corals (15 records belonging to the order Alcyonacea, including one record of *Anthothela grandiflora*) and a single record for the black coral *Parantipathes hirondelle*.

Many VME indicator records cluster around the southern flank of São Vicente Canyon and the nearby continental slope. São Vicente Canyon is one of several large canyons that mark the Portuguese western continental margin. It is located ~12 km off the southwestern tip of the country (Cape São Vicente) and extends for 120 km with a NE-SW orientation towards the Horseshoe abyssal plain (Terrinha *et al*., 2009).

There are 44 VME indicator records in the ICES database for this feature, 31 of which refer to sea pens (*Funiculina quadrangularis*, *Kophobelemnon stelliferum*, *Protoptilum thomsoni*, *Umbellula pallida*, *Pennatula aculeata*, *Stylatula elegans* and *Virgularia gracilis*). Seven records relate to unidentified soft corals of the family Alcyonacea, four records to the gorgonian *Radicipes challengeri* and two records to the gorgonian *Acanella arbuscula*. In addition to these records, underwater imagery obtained from three exploratory dives made by the NGO OCEANA in 2012 revealed the occurrence of sea pen fields, black coral gardens, mixed gorgonian gardens, rocky overhangs dominated by the red coral *Corallium rubrum* and deep-sea sponge aggregations (Oceana, 2020). Some of these VMEs, namely gardens of the black coral *Antipathella subpinnata* and aggregations of the glass sponge *Asconema setubalense*, are also portrayed in a study that assessed (based on the same dives) the distribution and composition of marine litter in the canyon (Oliveira *et al*., 2015).

Information for other features on the Portuguese Shelf is scarce, however, VME indicators (scleractinian corals) have been documented in the works conducted in the European projects HERMES and HERMIONE for the Setúbal, Nazaré and Lisbon submarine canyons (see de Stiegter *et al*., 2011), these records have been also included in the UNEP CWC database (https://data.unep-wcmc.org/datasets/3).

Gorringe Bank or Ridge: Ormonde and Gettysburg Seamounts

Gorringe Bank or ridge is a 200 km volcanic ridge that lies along the Gloria Fault at the eastern end of the Azores-Gibraltar plate boundary, the ridge is located around 125-150 nm WSW of Cape St. Vicent in Portugal. The bank is dominated by two summits ~50 km apart, Gettysburg Seamount to the southwest and Ormonde Seamount to the northeast (Hayward *et al*., 1999; OCEANA, 2014; Xavier and van Soest, 2007).

Five ROV transects were conducted at Ormonde Seamount during the 2016 MEDWAVES cruise as part of the Horizon 2020 project ATLAS (Orejas *et al*., 2017), revealing three areas with deep-sea sponge aggregations as well as a coral garden, which are briefly described in the following paragraphs. These VME habitats are included in the ICES VME Database.

Deep-sea sponge aggregations were observed at depths ranging from 660 m to 1230 m (Moreno, 2020). The highest density of sponges (up to 26 sponges per m^2) was observed on rocky outcrops between 660m and 870 m, including aggregations of sponges with fistulose morphotype., *Macandrewia azorica*, *Gedgia* cf. *atlantica* and *Petrosia* sp. (Moreno, 2020). Sponges were often observed with a variety of associated fauna, including isolated observations of the octocoral *Acanthogorgia* sp. and cerianthid anemones (Moreno, 2020). Deeper sponge aggregations were also observed on rocky areas between 945 m and 1230 m, and were characterised by aggregations of an unidentified fistulose-morphotypes species (up to 6 sponges per m^2) and *Petrosia* sp. (up to 10 sponges per m^2). Demosponges (e.g., *Characella pachastrelloides*, *Hexadella dedritifera*, *Macandrewia azorica*, *Geodia* cf. *atlantica*), hexactinellid sponges (e.g., *Regadrella phoenix*, *Aphrocallistes beatrix, Hyalonema* cf. *thomsoni, Pheronema carpenteri*) and octocorals (e.g., *Acanthogorgia* sp., *Narella versluysi*, *Swiftia* sp.) were also commonly observed, increasing community complexity (Moreno, 2020).

The coral garden observed between 1940 m and 1970 m was characterized by a high diversity coral species (Moreno, 2020). In terms of soft corals (Alcyonacea), the most common was the bamboo coral *Acanella arbuscula* (reaching densities up to 4 individuals per m^2) followed by Plexauridae sp.1, *Iridogorgia* sp. and *Metallogorgia* sp. (Moreno, 2020). In terms of black corals, the most common species was *Stichopathes* sp. (reaching densities up to 4 individuals per m^2), with occasional observations of *Bathypathes* sp. (Moreno, 2020). Hexactinellid sponges were also observed in this area but never in aggregations, the most commonly observed species were *Regadrella phoenix* and *Farrea occa* (Moreno, 2020).

Regarding Gettysburg Seamount, information on the composition and structure of benthic communities is considerably scarcer than Ormonde Seamount. The few published records originate from the Seamount-1 campaign and report the occurrence of five species of large lithistid sponges between 305 and 1035 m depth

(Carvalho *et al*., 2020). A photographic guide developed from the OCEANA ROV surveys to the Gorringe Bank report over 60 sponge species including the habitat-forming species *Pachastrella monilifera*, *Poecillastra compressa*, *Asconema setubalense* and *Leiodermatium* sp. (Oliveira *et al*., 2017). Within the ICES VME Database, Gettysburg Seamount contains three VME indicator records relating to gorgonian corals.

Overall, taxonomic and ecological studies conducted in both shallow (e.g., Xavier and van Soest, 2007; Ramos *et al*., 2016) and deeper (e.g., Carvalho *et al*., 2020) areas of the two seamounts have revealed diverse and highly structured megabenthic communities. Benthic communities include several VME indicator taxa (e.g., corals and sponges) that in some cases form dense aggregations and may constitute VME habitats. The two seamounts are considered to be part of the same geomorphological feature, separated by an 800 m-depth depression that is punctuated with smaller volcanic knolls (Orejas *et al*., 2017). Although more is known about the VME habitats on Ormonde Seamount, the benthic fauna are expected to be similar on Gettysburg Seamount due to the proximity of the two peaks; furthermore, the fact gorgonian corals have been recorded at both Gettysburg and Ormonde Seamount supports their characterization as a single geomorphological feature – i.e., Gorringe Bank.

The importance of Gorringe Bank, as a whole, has been highlighted within the Convention on Biological Diversity's process to describe ecologically or biologically significant marine areas (EBSAs) in the northeast Atlantic, with Gorringe Bank featuring in the description of Madeira-Tore as an area that meets the EBSA criteria (CBD, 2019, p. 155). Gorringe Bank has also been proposed as a Site of Community Importance within the Natura 2000 network.

Southern Spain: Gulf of Cádiz

- VME habitat(s) within the ICES database: i) coral gardens, ii) cold-water coral reefs, iii) deep-sea sponge aggregations, iv) cold seeps, v) mud and sand emergent fauna
- VME indicator(s) within the ICES database: i) sea pens, but more are known within the scientific literature (described below)
- VME element(s): i) mud volcanoes

The ICES VME Database contains 20 records of VME habitats within the Spanish portion of the Gulf of Cádiz. Records include: soft-bottom coral gardens (8 records), soft-bottom sponge aggregations (5 records), mud and sand emergent fauna (4 records, including two cup-coral fields and one sponge aggregation), cold seeps (2 records) and a single record for a cold-water coral reef built by the scleractinian corals *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata*. All of these VME habitats are associated with mud volcanoes (i.e., geological structures where clay-like argillaceous material is emitted from the seafloor in a semi-liquid state having been mixed with water and natural gas; Dimitrov, 2002).

Specific features of interest include the Gazul mud volcano, the Tasyo mud volcano field and the Guadalquivir Diapiric Ridge. The triangular area between these three features is also known to host several VME habitats and VME indicator records, but these are not represented in the ICES VME Database (Figure 11). In total, the ICES VME Database contains 5 records of VME indicators, these records correspond to sea pens (e.g., *Kophobelemnon stelliferum*, *Pennatula phosphorea* and *Virgularia mirabilis*) located on the continental shelf and slope. Below we provide an overview of VME habitats and indicator records that are available for these three features. Maps showing the location of data known to exist for these mud volcanoes but currently missing in the ICES VME Database are provided in Figure 11 and Figure 12.

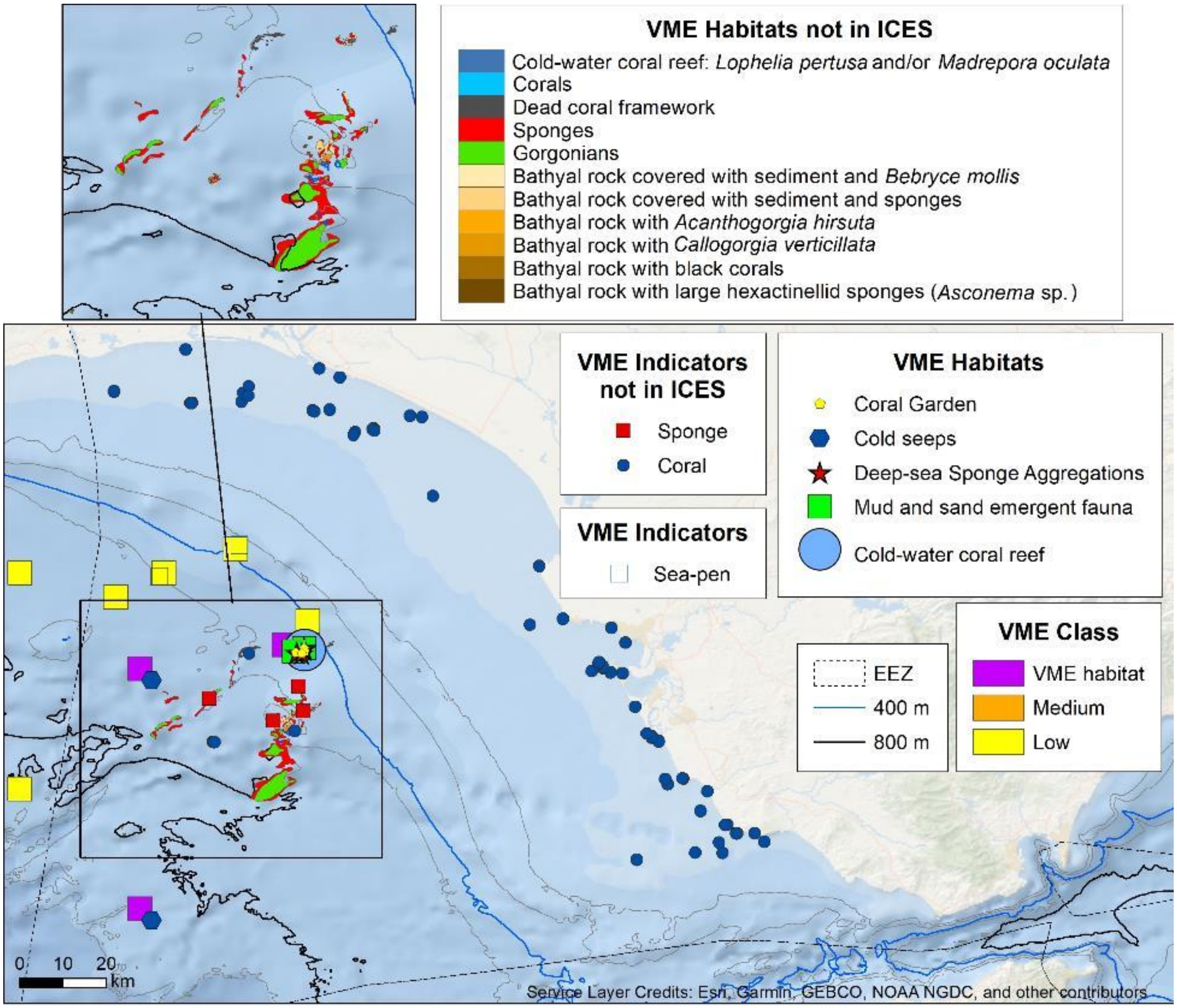


Figure 11. VME habitats in the Gulf of Cádiz, including those identified within the ICES VME Database and other VME habitats known to occur in the area. Note that the coral gardens and deep-sea sponge grounds in-between the areas identified as VME habitats within the ICES VME Database are located in an area where fishing activity takes place. Map Source: Javier Murillo, ICES WKEUVME 2020.

Gazul mud volcano, Tasyo mud volcano field, Guadalquivir Diapiric Ridge and surrounding area

The Gazul mud volcano is a biodiversity hotspot within the Gulf of Cádiz, hosting a number of VME habitats such as: cold-water coral reefs, coral gardens and deep-sea sponge aggregations. Intense bottom currents associated with Mediterranean Outflow Water have created a depression either side of the volcano cone (see Orejas *et al*., 2017 and references therein), exposing hard substrata and providing habitat for cold-water corals and sponges (Rueda *et al*., 2012; Orejas *et al*., 2017). At the Gazul mud volcano, deeper areas (450-470 m) are characterised by either soft sediment communities dominated by the anemone *Actinauge richardi* with scattered observations of the solitary cup coral *Flabellum chunii*, or hard substrates colonized by a mixed community of sponges and soft corals (*Acanthogorgia* sp.). In shallower areas (380-450m), the solitary cup coral *Flabellum chunii* dominates soft substrate habitats whereas hard substrates are characterised by sponges with scattered observations of soft corals (*Acanthogorgia* sp.) and the scleractinian corals *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata*.

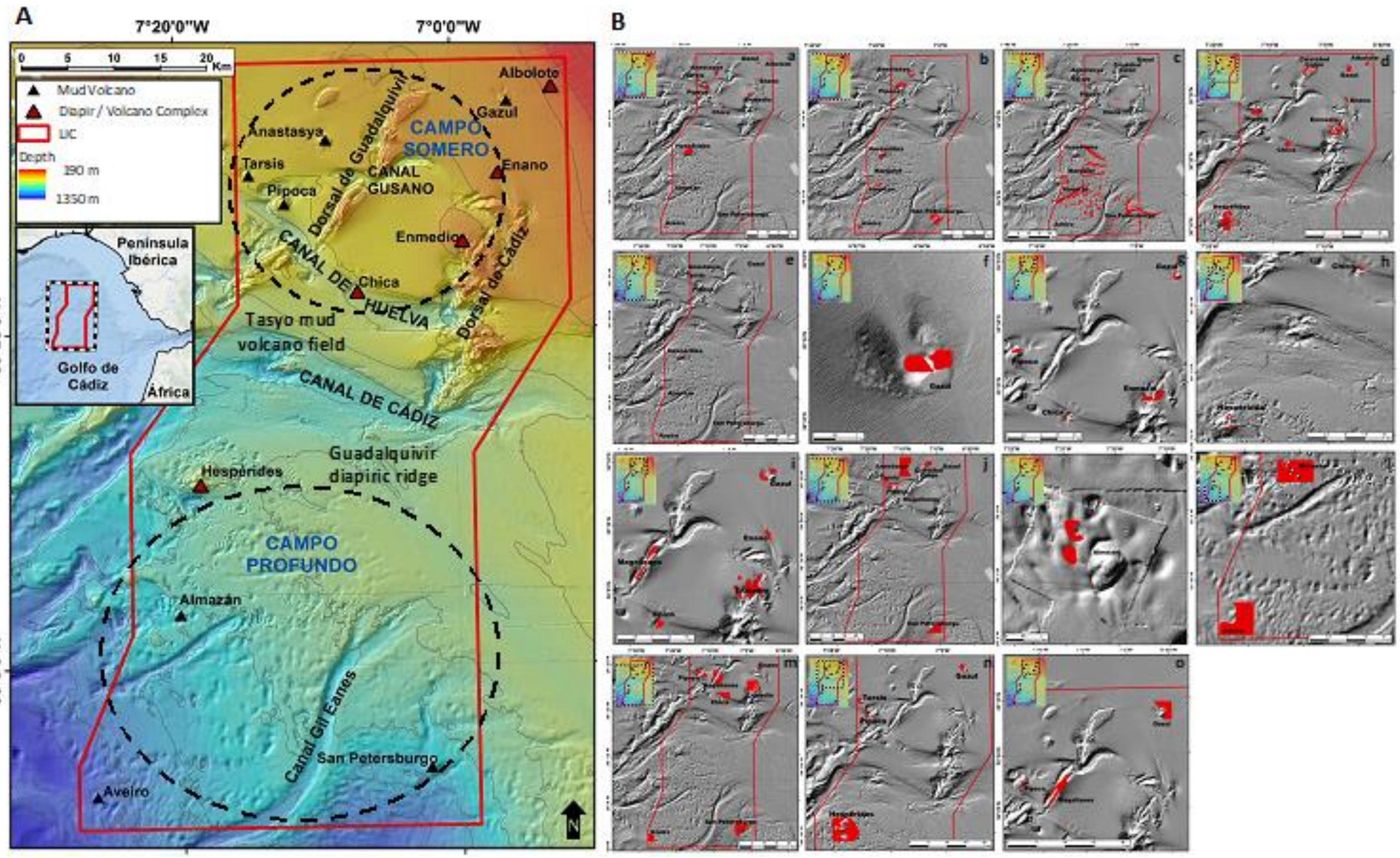


Figure 12. Overview of deep-sea habitats associated with 12 mud volcanoes in the Gulf of Cádiz. A) Provides an overview of the area of community importance (LIC, Lugares de Importancia Comunitaria) as well as the location of the Gazul mud volcano, the Tasyo mud volcano field (shallow field / campo somero) and the Guadalquivir diapiric ridge (deep field / campo profundo). B) Shows which habitats are known to occur at each mud volcano; habitats include: a) mud volcanoes*, b) collapse depressions caused by natural gas seepage, c) pockmarks, d) structures originating from natural gas seepage with carbonate substrates of chemosynthetic origin, e) structures originated by from natural gas seepage with chemosynthetic species*, f) cold-water coral reefs of *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata, g) coral gardens with *Bebryce mollis, Callogorgia verticillata* and *Acanthogorgia hirsuta* on bathyal rocky outcrops, h) Bathyal rocky outcrops with black corals (*Leiopathes glaberrima* and *Antipathes dichotoma*), i) Bathyal rocky outcrops with large hexactinellid sponges (*Asconema setubalense*)*, j) Bathyal mud with sea pens *Kophobelemnon stelliferum* and/*or Funiculina quadrangularis*, k) Bathyal muds with *Radicipes* sp., l) compact bathyal muds with *Isidella elongata*, m) Bathyal muds with *Phaeronema carpentieri* and *Thenea muricata*, n) Bathyal mud and detritic substrate with *Flabellum* sp., o) Bathyal detritic substrate with *Leptometra phalangium*. Habitats marked with an asterix (*) are included in the ICES VME Database. Source: modified from Díaz del Río *et al*. (2014**

Within the ICES VME Database, the Tasyo mud volcano field and the Guadalquivir Diapiric Ridge are simply classed as "cold seeps" and are represented by point locations. This classification does not reflect the twelve known mud volcanoes in this area (Figure 12), namely: Gazul, Albolote, Enano, Enmedio, Chica, Anastasya, Pipoca, Tarsis, Hespérides, Almazán, Aveiro and St. Petersburgo. Nor does this classification represent the VME indicator records and VME habitats known to exist in association with these mud volcanoes, which were explored during the INDEMARES project (Figure 12; Díaz del Río *et al*., 2014).

The INDEMARES project identified a number of VME indicators, including: 1) black corals (*Leiopathes* sp., *Antipathes* sp. and *Stichopathes* sp.) at the Gazul, Chica, Hespérides and Almazán mud volcanoes; 2) solitary cup corals (*Flabellum* sp.) at Gazul, Tarsis, Pipoca and Hespérides mud volcanoes; 3) aggregations of sponges (e.g., *Phaeronema carpentieri* and *Thenea muricata*) at Gazul, Magallanes, Enano, Pipoca, Enmedio, Chica, Aveiro and St. Petersburgo mud volcanoes; 4) mixed communities of soft coral (*Callogorgia verticillata*) and demosponges at Enmedio mud volcano; and 5) scattered observations of octocorals (*Swiftia* sp., *Bebryce* sp. and *Placogorgia* sp.) and scleractinians (*Lophelia pertusa, Madrepora oculata, Dendrophyllia alternate*) on dead coral-reef deposits at Gazul, Albolote, Hespérides, Almazán and Aveiro mud volcanoes (Díaz del Río *et al*., 2014).

The INDEMARES project identified a number of VME habitats, including: 1) cold-water coral reefs built by the scleractinian corals *Lophelia pertusa* (i.e., *Desmophyllum pertusum*) and *Madrepora oculata* at Gazul mud volcano; 2) coral gardens featuring the soft corals *Bebryce mollis, Acanthogorgia hirsute, Callogorgia verticillata* and *Radicipes* sp. at Gazul, Pipoca, Chica, Enmedio and Almazán mud volcanoes; 3) coral gardens featuring the soft coral *Isidella elongate* at Almazán and Aveiro mud volcanoes; 4) aggregations of the large hexactinellid sponge *Asconema setubalense* at Gazul, Enano, Enmedio, Chica and Magallanes mud volcanoes; and 5) aggregations of sea pens (*Kophobelemnon stelliferum* and/or *Funiculina quadrangularis*) at Gazul, Anastasya, Tarsis, Pipoca and St. Petersburgo mud volcano (Díaz del Río *et al*., 2014).

The cold-water coral reefs, coral gardens and deep-sea sponge grounds that are known to exist in this area but have not yet been included in the ICES VME Database are presented alongside data within the ICES VME Database in Figure 11.

Fisheries Data

The required data on fisheries was based on that available following the annual ICES data calls for VMS/logbook (link). Analyses of this data has been fully documented using the ICES Transparent Assessment Framework (TAF).

Fishing Footprint

The EC request requires that ICES '*provide a description of the existing deep-sea fishing areas based on the reference years 2009-2011*'. Previous work (ICES, 2018b) has grouped all bottom-contacting gear (mobile bottom contacting and static gears) into either presence or absence under the assumption that any contacts to VMEs will impact them.

There are some bounds on the possibilities when using the data collected through the ICES VMS and Logbook data call. In both NAFO and NEAFC, point data aggregated into individual fishing activity tracks has been used to refine edges of VME closures to ensure they are appropriate. Such fine-tuning is not possible with the gridded data products available here due to the need to use aggregated data from fishing activities. However, other information could be used to check the appropriateness of the boundaries, such as slope direction, seabed depth or substrate.

To meet this request, fishing activity needs to be described only for where the regulation applies which is limited to EU waters of the NE Atlantic (nested within the overarching ICES region, and where we have data). All countries' vessels that have submitted data in response to the ICES VMS and logbook data call are included. Disaggregation by countries' vessels is not possible. The countries which have not thus far participated in the VMS and logbook data call (Russia and Faroes) do not have extensive interests in deep-water fisheries in EU waters, therefore their omission is unlikely to be a significant factor in interpreting patterns of activity.

The fishing footprint shown in Figure 13a has been defined according to Scenario 2 of those suggested in the WKEUVME Report. Therefore this fishing footprint represents all C-squares, in which there is a SAR of > 0 for mobile bottom-contacting gears or a presence of fishing activity of static gears, that share at least one vertex (is contiguous) with another fished C-square (during the reference period 2009-2011).

For this ecoregion, the fishing footprint is extensive covering almost all (83.5%) of the 400-800 m depth (Table 3). Most of the unfished areas seems to be concentrated in Spanish waters (23% of C-squares unfished) followed by Portuguese waters (18% of C-squares unfished) whereas there are very few unfished areas in French waters (3%). Most of the unfished C-squares are concentrated in 3 areas: el Cachucho Bank, Galicia Bank and the Gulf of Cádiz (including both Spanish and Portuguese waters). However, due the proximity of some of these deep-water areas (especially in the Cantabrian Sea) to the coast (and therefore its accessibility to small boats without VMS) and omission of a large proportion of fishing effort for the Spanish fleet (see section 4.3. WKEUVME report) caution is advised in assuming that all the unfished C-squares in this region are really unfished.

Table 3. Total numbers of C-squares and numbers of C-squares in the fishing footprint (MBCG + Static) in the Bay of Biscay and Iberian Coast Ecoregion and per EEZ within 400-800 m depth range.

EEZ	Number of C-squares within 400-800 metre depth range	Number of C-squares fished within 400-800 metre depth range	Percentage Fished (%)
Spain	866	666	77
Portu-gal	696	569	82
France	501	487	97
Total	2063	1722	83

Table 4. Total numbers of C-squares fished by multiple Sub-gears (MBCG + Static as listed in Table 4) in the Bay of Biscay and Iberian Coast Ecoregion and per EEZ within 400-800 m depth range.

Number of Sub-gears Fishing in C-square	France	Portugal	Spain	Total
1	13	211	139	363
2	50	180	187	417
3	157	158	277	592
4	136	20	49	205

Number of Sub-gears Fishing in C-square	France	Portugal	Spain	Total
5	85	0	10	95
6	38	0	3	41
7	8	0	1	9
Total	487	569	666	1,722

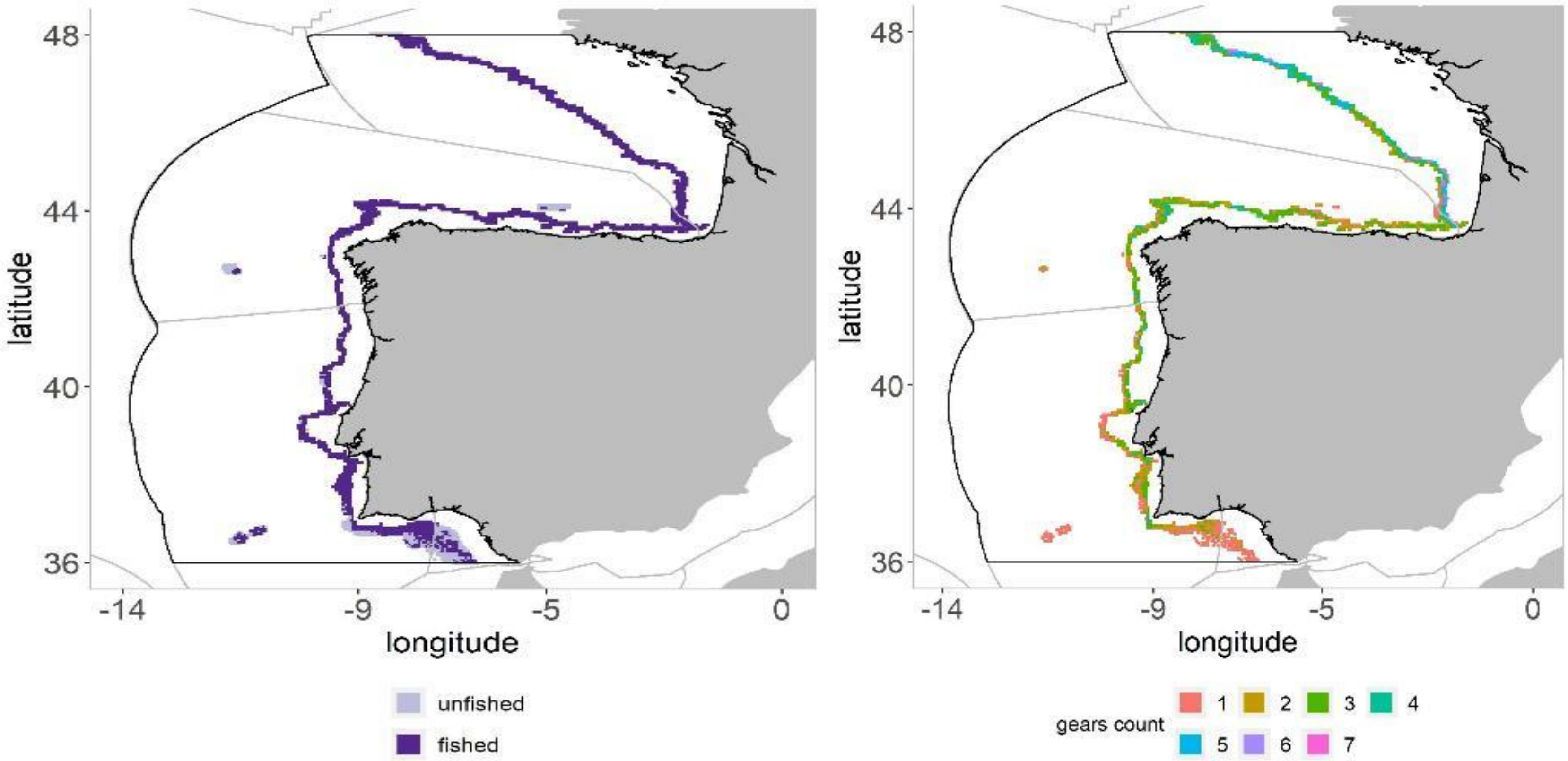


Figure 13. A) Fishing footprint (between 400 m and 800 m depth) of all mobile bottom-contacting fishing gears (MBCG and Static) in 2009-2011 highlighting fished vs. unfished areas. B) Fishing footprint (between 400 m and 800 m depth) of all mobile bottom-contacting fishing gears (MBCG and Static) in 2009-2011 highlighting the number of gear types recorded in each C-square. Copyright: EEZ: Flanders Marine Institute (2020). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Depth contours: EmodNet Bathymetry Consortium (2018). Map projection: EPSG:4326 - WGS 84.

Table 5. Numbers of C-squares fished (MBCG + Static) between 2009-2011 within 400-800 m and the total region for the Bay of Biscay and Iberian Coast Ecoregion (covering the EEZs of France, Spain and Portugal). Sub-gear métiers and Typical Target Species follow Eigaard *et al*. (2015) and are described in Annex 9 of ICES WGSFD 2015 report. OT=Otter Trawl; DMF=Demersal Fisheries (e.g., Cod or Plaice); CRU=Crustaceans (e.g., Nephops or shrimp); SPF=Sprat Fishery; BEN=Benthic Fish; GNS=Set Gillnets; LLS=Set Longlines; FPO=Fish Operation Pots.

		France		**Portugal**		**Spain**		**Total**	
		400-800	Region	400-800	Region	400-800	Region	400-800	Region
Total footprint		487	5,132	569	2,074	666	3,273	1,722	10,479
Gear type									
Static		481	4,507	394	1,605	634	2,862	1,509	8,974
Otter		449	4,572	441	1,497	457	1,705	1,347	7,774
Seine		105	1,351	0	0	0	0	105	1,351
Beam		4	601	0	0	0	0	4	601
Dredge		0	22	1	7	10	55	11	84
Sub-gears Otter (OT)	**Typical Target Species**								
OT_DMF	hake	444	4,520	342	1,363	453	1,692	1,239	7,575
OT_CRU	Nephrops or shrimps	89	2,396	258	573	21	47	368	3,016
OT_MIX	Individual species not informed	95	2,678	0	0	22	34	117	2,712
OT_SPF	blue whiting or mackerel	77	1,972	0	0	9	23	86	1,995
OT_MIX_DMF_BEN	Benthic fish,	137	567	0	0	2	3	139	570
OT_MIX_CRU_DMF	Nephrops, rose shrimp	0	0	0	0	0	0	0	0

		France		Portugal		Spain		Total	
Sub-gears Static	**Typical Target Species**								
GNS	Hake and anglerfishes	458	3,670	162	786	506	1,822	1,126	6,278
LLS	Hake (blue whiting)	437	2,364	351	1,213	527	1,938	1,315	5,515
FPO	mix	100	979	12	234	75	330	187	1,543

Of all fished C-squares in the EEZ of Portugal 27.4% lay within the 400-800 m depth range, this percentage gets reduced to 20.3 % in Spain and 9.5% in France (Table 5). Figure 13b shows the number of gears per fishing C-square within this depth range. A fairly well-defined north-south gradient can be identified, with the northern Bay of Biscay waters accounting for the highest diversity of gear used, ranging from an average of 3 to 5 gears per C-square (reaching 6 and even 7 in some cases, see Table 4) to the southernmost stretches of the ecoregion where the lowest diversity are reported, with 1 gear per C-square in the Spanish Gulf of Cádiz (but again, see caveats of fishing footprint for this region in Section 4.3 WKEUVME report). The Cantabrian Sea and Western Iberian Shelf display intermediate values, with 2 to 4 gears per C-square. The difference in fishing presence/absence between the reference period (2009-2011) and more recent activity (2012-2019) is illustrated in Figure 14.

Otter trawl gears are the dominant gear grouping in this ecoregion within the 400-800 m depth range followed by static gears (Table 5), in particular longlines and gillnets. Gillnets (GNS) are roughly as important as longlines (LLS) in France and Spain, while in Portugal these are considerably less used (Table 5). Pots and traps (FPO) are far less important across the ecoregion. Note that mobile and static gears are not directly comparable since the latter are reported as presence/absence and therefore without an intensity measure. Otter trawls target mixed demersal and benthic species, whose composition depends on the area and the cod-end mesh size. The most common species are hake, followed by anglerfishes or megrims, which are the target of the dominant métier in France and Spain (OT_DMF), also in Portugal. However, in this country the crustaceans-directed fishery (Norway lobster and shrimp, OT_CRU) follow closely in importance. Only in France, other métiers have a remarkable relative weight, e.g., OT_MIX_DMF_BEN, OT_MIX, OT_SPF (see Table 5). Portugal has a fleet of 80 otter trawlers, of which 25 target rose shrimp, Norway lobster and blue whiting in waters from 200-800 m. The remaining (55 vessels) target finfish in shallower (< 500 m) waters. All of them mainly operate in the Portuguese EEZ. France has an offshore fleet of bottom trawler, netters and a few longliners. Spain has 75 vessels that operate bottom- and pairtrawl to target horse mackerel, mackerel, blue whiting and hake. There is a Spanish fleet of otter trawlers operating in the BoB waters (French EEZ) targeting mainly anglerfish. However, most of its activity (> 90%) is carried out in waters shallower than 400 m (Castro *et al.*, 2012).

In the Bay of Biscay, the main gillnet fishery involving Spanish and French vessels target hake along the continental slope. Spain has a fleet of 65 gillnetters targeting mainly hake and anglerfishes.

Longliners target hake along the continental slope, with bycatches of other deep-water species. Spain has a fleet of 55 demersal longliners operating in its EZZ (hake and European conger) and about 42 in the Bay of Biscay (hake). In the Cantabrian Sea and Galicia there is a considerable number (> 6500) of small vessels that operate close to the coast, and sometimes within the 400-800 m range due to the narrow, or very narrow, continental shelf in this subregion. This artisanal fleet (< 15 m) lacks VMS tracking system and hence its effort and spatial distribution is unknown. However, and despite the uncertainty, its impact could be significant in some areas. In Asturias, for instance, this fleet (395 vessels) comprises 92% of the total.

Portugal has a deep-water longline fleet composed of 15 vessels that operate offshore and at the slope at depths ranging from 800 to 1450 m (targeting black scabbard fish) and a small-scale fleet of 2000 vessels (gillnet, trammelnet, hand and longline, pots and dredges) operating within 30 miles from the coast. The effect of gears other than longlines is considered as minor and not overlapping within the 400-800 m contour.

The use of beam trawl and seine has only been reported for France, whereas dredge is only relevant in Spain. Dredges are mainly used in the Gulf of Cádiz in the striped venus (*Chamelea gallina*) and wedge (*Donax trunculus*) clam fisheries, which are very coastal and, hence, do not overlap with any VMEs in the area. Invetigation of the 10 C-squares reported in Table 4 for Spain has shown that these are likely to be artefacts, possibly resulting from VMS pings of vessels transiting at low speeds being classified at fishing.

Other nations fishing in the area are Belgium, with 15 vessels operating beam trawl in the Bay of Biscay, Ireland with a hake gillnet fishery composed of 40 vessels and 8 otter trawl vessels.

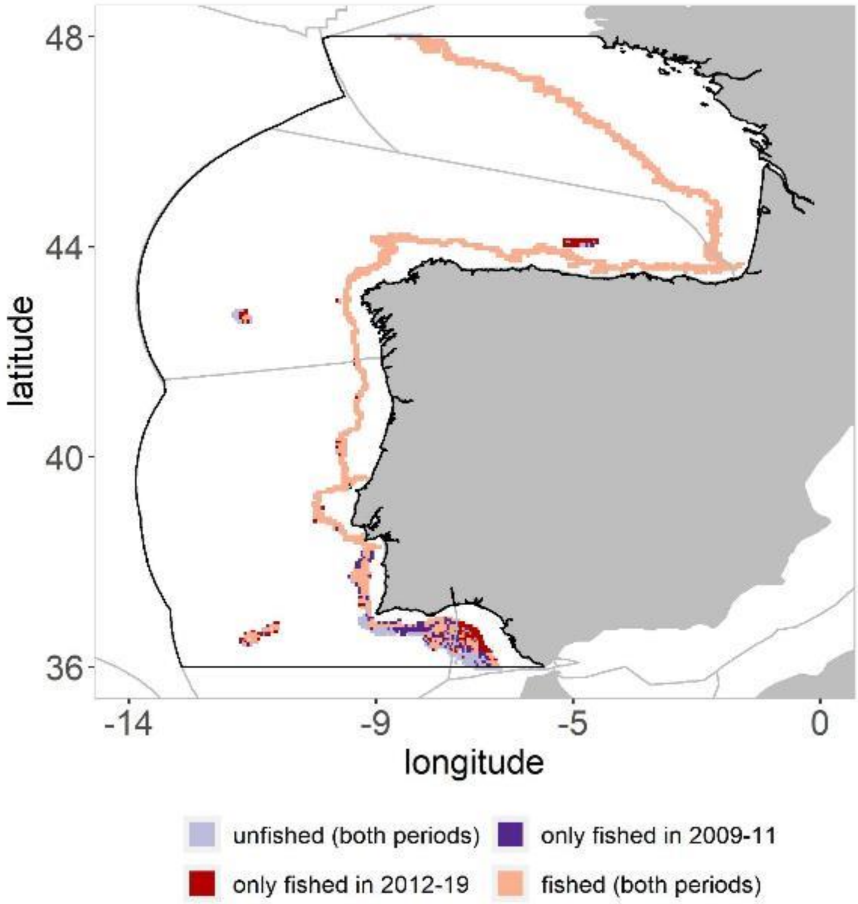


Figure 14. Difference in fishing occurrences in C-squares between the fishing footprint of the reference period (2009-2011) (Figure 13) and the period 2012-2019. Most C-squares are either unfished or fished in the two periods.

Fisheries Impacts on VMEs

The principal current human activity resulting in physical disturbance in the deep sea is fishing, in particular bottom trawling (Althaus *et al.*, 2009; Benn *et al.*, 2010, Puig *et al.*, 2012; Pusceddu *et al.*, 2014; Pierdomenico *et al.*, 2018). Continued abrasion and physical disturbance as a result of mobile fishing activities can negatively affect the community structure of deep-water habitats. Physical damage from bottom trawling and dredging impact benthic habitats through displacement or overturning of boulders and cobbles, removing or damaging epifaunal species, disturbing sediments and damaging fragile deep-sea communities including sponge aggregations, coral gardens, and deep-water coral reefs.

Faunal communities in deep-sea sedimentary habitats live in cold waters with a relatively low supply of food, slow life-histories, low growth (and therefore poor recovery rates to perturbance) and long lifespans (Gage and Tyler, 1991; Billett *et al.*, 2001; Benn *et al.*, 2010; ICES, 2020a). For example, even low fishing rates may have serious impacts on the communities dominated by the bamboo coral *Isidella elongata* (Pierdomenico *et al.*, 2018).

Smothering due to resuspension of sediments can also result in physical loss and damage, which in some cases have been seen to be considerable (Ferré *et al.*, 2008). The resilience of any habitat changes brought about by bottom fishing will be dependent on the substrate type, the presence of sensitive or vulnerable communities, and the frequency and intensity of the activity (Van Dalfsen *et al.*, 2000; Robinson *et al.*, 2005; Foden *et al.*, 2009).

Trawls are known to have the greatest impact on VMEs (Hiddink *et al.*, 2018). Declining condition (density, body size) of deep-sea sponge aggregations have been observed associated with the impacts of demersal fisheries (Vieira *et al.*, 2020). In the northern coast of Spain reductions of up to 90% in abundance of sensitive species, as a consequence of trawling, have been reported and mapped (González-Irusta *et al.*, 2018). In some studies, marine protected areas have been shown to be effective in protecting deep-sea sponge (Kazanidis *et al.*, 2019), whereas in others, cold-water coral reefs showed little recovery after 8 years of closure to bottom trawling (Huvenne *et al.*, 2016). In other cases bamboo coral populations have almost completely disappeared as a result of fishing (Maynou and Cartes, 2012).

Longlining has a relatively low impact on VME Habitats - much lower than bottom trawling. It's been estimated that bottom impacts of one deep-sea bottom trawl is equivalent to that of 296 to 1,719 longlines, depending on the morphological complexity of the impacted species (Pham *et al.*, 2014). However, longlines can access rocky areas that are inaccessible to trawls (Durán-Muñoz *et al.*, 2011). Moreover, as a selective operation, damaging mainly large colonies with complex morphologies (e.g., coral gardens), longlines may cause shifts in the faunal composition of VME habitats (Lumsden *et al.*, 2007; Mytilineou *et al.*, 2014; Pham *et al.*, 2014). Deep-sea bottom longlining has been shown to have little impact on VMEs around the Azores archipelago, reducing bycatch of cold-water corals and limiting additional damage to benthic communities relative to trawls (Pham *et al.*, 2014). Despite its lower impact on the benthic communities in some areas, damage/impact produced by longlining can be relatively important in other subregions or locations as have been documented in the USA cold-water coral ecosystems (Lumsden *et al.*, 2007), in the Mediterranean Sea (Orejas *et al.*, 2009; Mytilineou *et al.*, 2014) or in areas where the slope is close to the coast, like in the Cantabrian Sea, due to its accessibility to small vessels. Since most of these small vessels (< 15 m) lack VMS system its activity is not tracked and hence numbers in Table 5 might be underestimating the impact of this fleet.

Overlap Between VME and Fisheries

Overlap between VME and fishing data shows that fishing occurs in 78% of C-squares with known VME occurrence or likely occurrence (Table 6). Overlap is most pronounced in France with 100%, which is also the country whose EZZ hosts the larger number of VMEs C-squares (26) in this ecoregion (Table 6). Spain and Portugal have similar numbers of C-squares with VME occurrence (18, 20, respectively) and similar percentages of overlap between VME and fishing in those C-squares (61%, 65%). Taking into account the degree of precaution, Spain's overlap concentrates on medium precaution C-squares (10 out of 11) while Portugal has a more even distribution for the medium and high levels (60%, 62%) and complete overlap for the low (100%). As mentioned above France reports fishing in all C-squares, hence there are no differences with regard to precaution level. The overlap is estimated using data on all gear types but is mostly coming from otter trawl, longline and gillnet gears that are the dominant fishing gears operating in the 400-800 m depth range (Table 5).

Table 6. Number of C-squares with VME occurrence and likely occurrence within the 400-800 m depth range categorized by the degree of precaution (low, medium and high, Table 1) for the total region and per EEZ.

Region	VME presence	Precaution low		Precaution medium		Precaution high	
		fished	total	fished	total	fished	total
France	26	20	20	2	2	4	4
Portugal	20	2	2	3	5	8	13
Spain	18	0	3	10	11	1	4
Total region	64	22	25	15	18	13	21

Table 7. Number of C-squares with VME occurrence and likely occurrence within 400-800 m depth range categorized by the degree of precaution (low, medium and high, Table 1) per EEZ and by Sub-gear. The C-square is defined as fished when the SAR > 0 (average 2009-2011) for MBCG and fishing presence for static gears. Note that the selection of C-squares with a high degree of precaution is only based on the ICES VME Index data. OT=Otter Trawl; DMF=Demersal Fisheries (e.g., Cod or Plaice); CRU=Crustaceans (e.g., Nephops or shrimp); SPF=Sprat Fishery; BEN=Benthic Fish; GNS=Set Gillnets; LLS=Set Longlines; FPO=Fish Operation Pots.

EEZ	VME presence	Precaution low		Precaution medium		Precautionary high	
		fished	total	fished	total	fished	total
France							
OT_MIX_CRU_DMF	26	0	20	0	2	0	4
OT_CRU	26	0	20	0	2	0	4
OT_DMF	26	18	20	2	2	4	4
OT_MIX	26	0	20	0	2	0	4
OT_MIX_DMF_BEN	26	9	20	2	2	3	4
OT_SPF	26	1	20	0	2	0	4
FPO	26	6	20	1	2	1	4
GNS	26	18	20	1	2	4	4
LLS	26	19	20	2	2	4	4
Portugal							
OT_MIX_CRU_DMF	20	0	2	0	5	0	13
OT_CRU	20	0	2	1	5	8	13
OT_DMF	20	0	2	1	5	2	13

EEZ	VME presence	Precaution low		Precaution medium		Precautionary high	
		fished	total	fished	total	fished	total
OT_MIX	20	0	2	0	5	0	13
OT_MIX_DMF_BEN	20	0	2	0	5	0	13
OT_SPF	20	0	2	0	5	0	13
FPO	20	0	2	0	5	0	13
GNS	20	0	2	0	5	0	13
LLS	20	2	2	2	5	2	13
Spain							
OT_MIX_CRU_DMF	18	0	3	0	11	0	4
OT_CRU	18	0	3	1	11	0	4
OT_DMF	18	0	3	6	11	0	4
OT_MIX	18	0	3	0	11	0	4
OT_MIX_DMF_BEN	18	0	3	0	11	0	4
OT_SPF	18	0	3	0	11	0	4
FPO	18	0	3	1	11	0	4
GNS	18	0	3	10	11	0	4
LLS	18	0	3	10	11	1	4

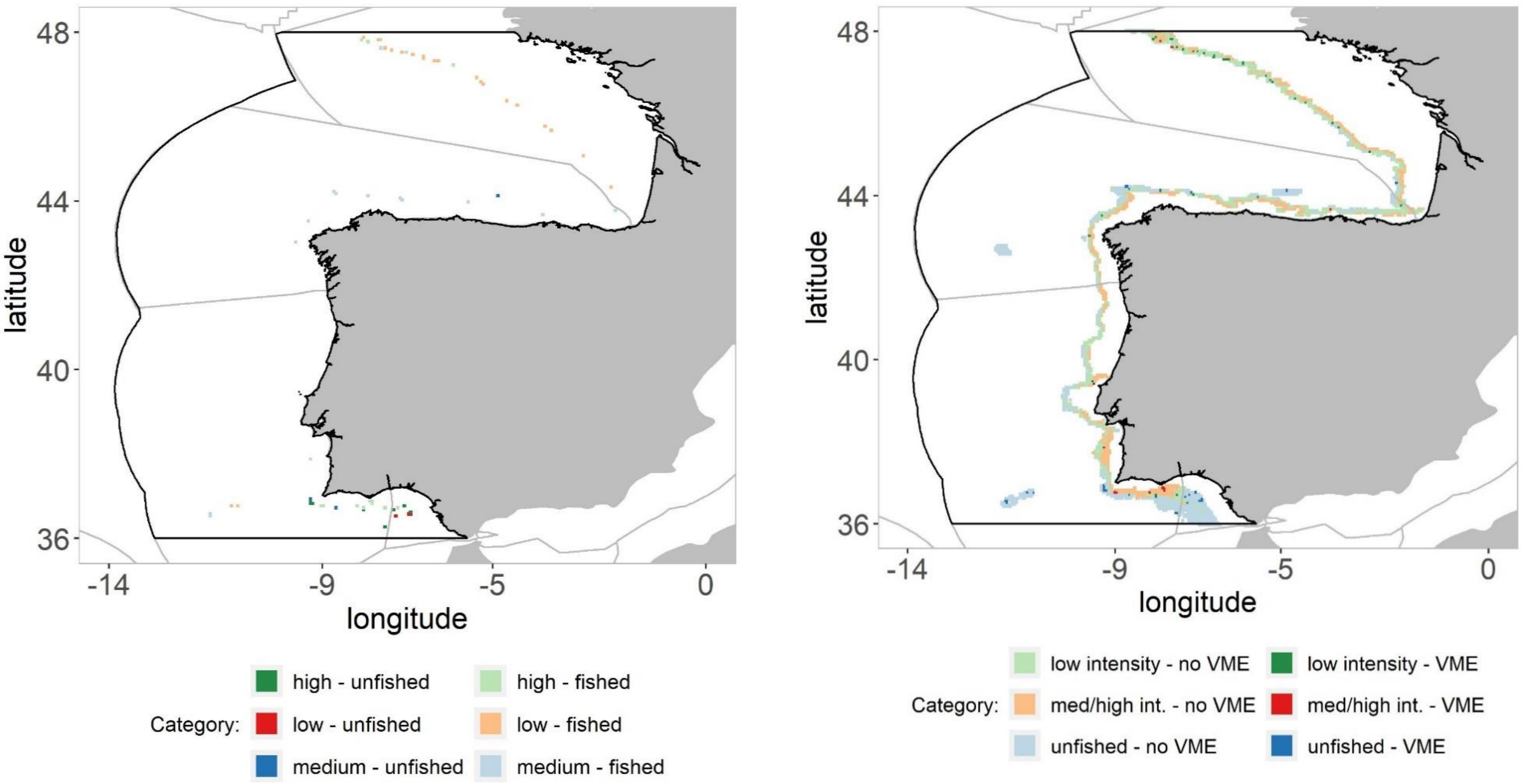


Figure 15. Left. Plot of the Bay of Biscay and Iberian Coast showing the overlap between VMEs at different levels of VME precaution (Table 1; low, medium and high) and the fishing footprint (MBCG + Static) within the 400-800 metre depth range. Right. Plot of the Bay of Biscay and Iberian Coast showing the overlap between VMEs and the fishing footprint of otter trawl gears at different levels of intensity (unfished, low intensity is 0-10th percentile, med/high intensity is 10-100th percentile, (see Section 4.4 of the WKEUVME Report) within the 400-800 m depth range.

Otter trawls (OT_DMF, OT_MIX_DME_BEN) predominantly target demersal fish (hake, megrims and anglerfishes) and crustaceans (OT_CRU, mainly Norway lobster). It is worth noticing than crustaceans are a very important target in Portugal, marginal in Spain and absent in France (Table 7). Hake is also the main target of static gears (LLS, GNS) along the slope. Longlines (LLS) are the only gear that Spain operates in high VME precaution areas (Table 7). Gillnets (GNS) are intensively used in France and Spain but not in Portugal while pots and traps (FPO) are only relevant in France, negligible in Spain and non-existent in Portugal. A map illustrating overlap between VME at different levels of precaution and fishing (by all gears) and fishing by otter trawl gears at different levels of intensity are shown in Figure 15.

Closed Area Scenarios

WKEUVME established a framework for the presentation of closed area options based on the relationship between mobile bottom contact gear (MBCG) fishing intensity (SAR) and destruction of VMEs, drawing on trawling impact literature and empirical observations on similar VME indicators made in the NAFO Regulatory Area (NAFO, 2016). Two scenarios have been defined - rules which apply to the VME C-squares only (Scenario 1) and rules which apply to the VME C-squares, but also take into account known fishing impacts (Scenario 2) (see Section 4.4). Two options per scenario are presented (Table 8). The implications of each option for management are shown in Table 9.

Table 8. Summary of the scenarios and options used to defined closure areas. The main differences between scenarios and options are underlined.

	Scenario 1 VME distribution only	Scenario 2 VME and VMS distributions
Option 1	All VME habitats, High and Medium VME Index. Low VME Index: only if adjacent to higher Index VMEs	All VME habitats, High and Medium VME Index. Low VME Index: only if adjacent to higher index VMEs and Low VME Index in C-squares with low fishing pressure (SAR < 0.43)
Option 2	Option 1 + selected VME elements (banks, seamounts, coral mounds, mud volcanoes) associated with any VME records.	All VME habitats, High, Medium and Low VME Index excluding C-squares with high fishing pressure (SAR > 0.43)

Both closure scenarios used data on VME habitat and VME Index. In addition, Scenario 1 option 2 also included data on VME elements. These data sources are described above in "*Distribution of Vulnerable Marine Ecosystems*". WKEUVME notes that the use of the VME Index as it now is may result in under-representation of sea pen VMEs in the selection of closed areas under all scenarios and options, except Scenario 2 option 2. Scenario 2 further included information on fishing intensity (SAR per year) from all mobile bottom-contacting fishing gears. These data were used to estimate whether C-squares fall above or below the SAR threshold value of 0.43 used to distinguish between fishing that is likely to have caused significant adverse impacts on the VMEs (> 0.43 SAR) or not (< 0.43 SAR). This was determined for all mobile bottom-contacting gears using the average SAR per year for 2009-2019. The fisheries data is described above in *"Fisheries data"*. Static gears could not be treated this way as there is only presence data.

The scenario rules were used to create closure areas for the whole area (see Section 4.5 of the WKEUVME report); irrespective of the depth and the boundary of the ecoregion. The closures were afterwards clipped to the 400-800 meter depth range (Figure 16). The different scenarios resulted in a different areal extent and number of closures in the 400-800 meter depth range. Scenario 2 option 1 had most closed areas (n=48), which were predominantly small in areal extent (Figure 17). Scenario 1 had fewest closures (n=37 to 39, for options 2 and 1 respectively) but option 2 covered a larger area due to the closing of the two seamounts on the Gorringe Bank as well as the Le Danois Bank (Figure 16).

Table 9. Description of management scenarios and options presented by WKEUVME with associated management implications for the protection of VMEs and general impacts to fisheries.

Scenario	Option	Description	Management Implication
Scenario 1	Option 1	C-squares between 400-800m depth with all VMEs supported by data in the VME Database, with priority to medium to high 'confidence', regardless of fishing activity in the 2009-11 period.	Prioritizes protection of VMEs where they are known to occur, irrespective of fishing activity.
Scenario 1	Option 2	C-squares between 400-800m depth with all VMEs and VME elements supported by data in the VME Database, with priority to medium to high 'confidence', regardless of fishing activity in the 2009-11 period.	Prioritizes protection of VMEs where they are known and where they are likely to occur, irrespective of fishing activity.
Scenario 2	Option 1	As for Scenario 1 Option 1 but includes low VME Index C-squares if fishing pressure is low (< 0.43 SAR).	Prioritizes protection of VMEs where they are known to occur, and includes areas where the confidence of VME presence is lower but where fishing activity is also low and VMEs unlikely to be degraded by fishing.
Scenario 2	Option 2	C-squares between 400-800m depth with all VMEs supported by data in the VME Database excluding C-squares with high fishing pressure (SAR > 0.43).	Prioritizes protection of VMEs where they are known to occur, but excludes areas that have been heavily fished (core fishing areas) and where VMEs are likely to have been degraded by fishing.

The consequences of the closures for protecting VMEs and their potential impact on the fisheries are shown in Table 10. Since buffers around VME habitat and index C-squares may affect ¼ or ½ of a C-square, in preparing this Table we estimated the number of C-squares as the sum of all whole, half and quarter C-squares. Similarly, we assumed that SAR intensity and kw/h were distributed equally across the C-square. Hence, if a C-square is closed for 25%, SAR intensity that is lost to the fisheries is ¼ · SAR C-square. The fisheries consequences were evaluated for the reference period 2009-2011, the period 2012-2015 and the most recent period 2016-2019 (Table 10).

The number of records of VME indicator groups in the ICES VME Database inside each of the closure scenarios was also evaluated (Table 11). The C-square is the common spatial resolution between the VME Index and VMS data. However, the VME Database holds records at the level of a point or line. In order to assess how the different closure scenarios and options captured these records, the VME Database was summarised across the following six areas; the Bay of Biscay and Iberian coast ecoregion, the 400 – 800 m depth band within the ecoregion and the four closure option areas within the 400 – 800 m depth band (Table 11, Figure 18 and Figure 19). Where the record geometry was recorded as a line, that is, if it arose from a trawl, the mid-point of the line was taken and it was treated as a point record. Our evaluation counts all records per group, including multiple records inside a single C-square. Figure 20 shows the example of sponge VME indicator records that lie within the Bay of Biscay and Iberian Coast ecoregion, 400 – 800 m depth band and the four closure options.

Influence of Scenarios on VME Protection

The results in Table 10 show that VME protection is equal for option 1 and 2 in Scenario 1. VME protection is higher in Scenario 2 option 1 as a higher percentage of VME Index C-squares with VME low index are closed (Figure 21A). Scenario 2 option 2 does not close VMEs when SAR intensity in the C-square is relatively high (SAR > 0.43 per year), based on the assumption that the likelihood of a VME habitat being present is low due to high disturbance of recent fisheries. The result of Scenario 2 option 2 is a lower overlap between closures and C-squares with VME medium index.

Scenario 1 option 2 covers a larger closure area (Figures 16, 17) but does not close more VME habitat or VME Index than Scenario 1 option 1. Yet, in this scenario, two VME elements are included in the closures: Le Danois Bank, on the NW Iberian margin, and the two seamounts of the Gorringe Bank (Ormond and Gettysburg) off southern Portugal (Figure 16). Scenario 1 option 2 thus increases the likelihood that VMEs not yet recorded are included in closures.

A closer look at VME records shows that within the 400 m – 800 m depth band, the different scenarios have no influence on the level of protection of VME habitats (Figure 18). In each case, all records of VME habitats between 400 m and 800 m depth are included in the closure areas. The different scenarios have slightly different outcomes on the level of protection of VME indicators (Figure 19). Anemones, cup coral and sponges receive the same level of protection, and all records within the depth band are included in closure areas. Black corals and gorgonians, which are ranked medium to high according to their vulnerability, are slightly less protected by Scenario 2 option 2. In this scenario, 98% of black coral records, and 95% of gorgonian records are included in the closure areas, while the other scenarios are fully protective for these two taxa. This is because in Scenario 2 option 2 C-squares that have been already heavily fished (SAR > 0.43) are excluded from closure areas on the assumption that no VME will have survived such fishing effort. However, considering the size of a C-square relative to the clumped distribution of both fishing footprint and VME patches, C-squares with high SAR and VME records are to be expected. This is exemplified in the Bay of Biscay by canyon heads. The head of submarine canyons classify as VME elements and in the Bay of Biscay are about the size of one or a couple C-squares. The occurrence of VMEs in a canyon lead to the closure of that canyon within the 400-800 m depth band for all closure scenarios except Scenario 2 option 2. In Scenario 2 option 2, there are instances where canyons are excluded from closure probably because the flat interfluves at the periphery of canyon heads are targeted by fisheries.

The sea pen and the soft coral, whose vulnerability is lower according the WGDEC weighting system, are less protected in Scenario 1 than Scenario 2. These VME indicator taxa are also the only two that are not fully protected by any of the scenarios. Within the 400-800 m depth band, from a total of 256 records of sea pen, 95% to 98% are included in closure areas for Scenario 1 and 2 respectively, while from a total of 10 records of soft corals, 50% to 60% are included in closure areas for Scenario 1 and 2 respectively. This is because orphan C-squares with low VME Index are not protected at all in Scenario 1 and protected in C-squares with low SAR (< 0.43) in Scenario 2.

Influence of Scenarios on Fisheries

The influence of scenarios on fisheries is summarized on Table 10 and Figure 21 (c to h). The fraction of the total fishing footprint in C-squares that are prescribed as closed is lower for Scenario 1 option 1 (14.5%) and Scenario 2 option 2 (15%) and higher for Scenario 1 option 2 (16%) and Scenario 2 option 1 (Figure 21 b). The inclusion of fishing intensity in the second scenario thus have mixed consequences on fisheries. The option 1 increases the impact on fishing footprint due to the addition of VME with low index, while the option 2 decreases the impact on fishing footprint by excluding some of the core fishing areas. Overall, the differences in the impact of closures on the fishing footprint are low, reaching a maximum of 33 C-squares (2% of fishing footprint) between Scenario 1 option 1 and Scenario 2 option 1.

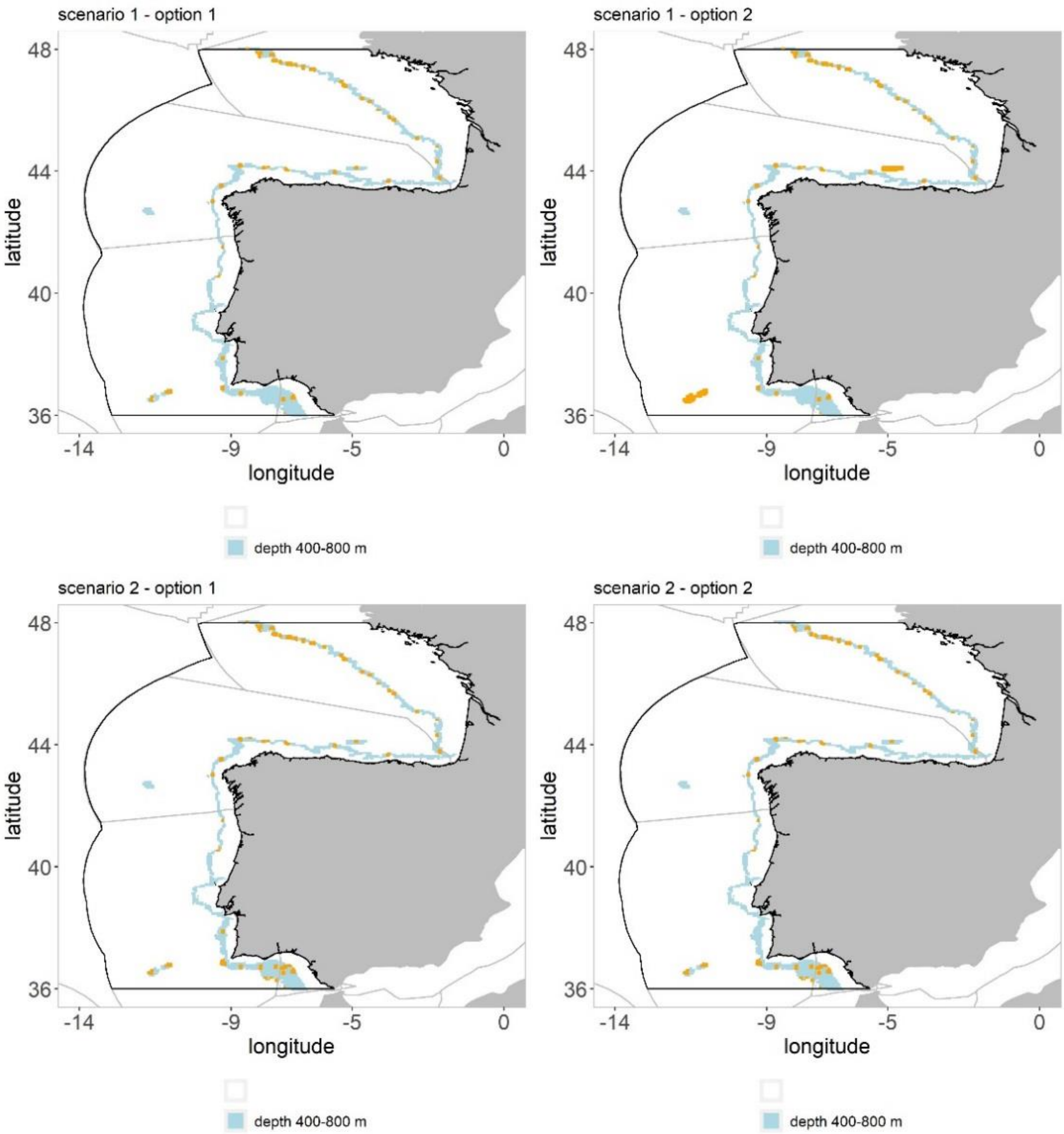


Figure 16. Map of closures (orange) that overlap with the 400-800 meter depth range following the two different scenarios, each with two options.

The impact of closures on mobile and static gears (Figure 21 c, e, g) highlights 1) the highest impact on mobile gears of the Scenario 2 option 1 and 2) the highest impact on static gears of

Scenario 1 option 2. The patterns are consistent across the three time periods. Regarding mobile gears, the impact of closures on the fraction of total SAR and the core fishing areas (Figure 23 d, f, h) further highlights the lowest impact on fisheries of the Scenario 2 option 2. This pattern is also consistent across the three time periods. Regarding static gears, the impact of the different scenarios cannot be fully assessed as the fishing effort is not quantified. Overall, the differences between scenarios remain low. During the most recent period (2016-2019), the highest difference in the number of closed C-square is 25 C-squares with static bottom fishing (1.8% of the total static footprint), 22 C-squares with mobile bottom fishing (2% of the total mobile footprint) and 10 C-squares that from core fishing areas (2.5% of the total core fishing areas).

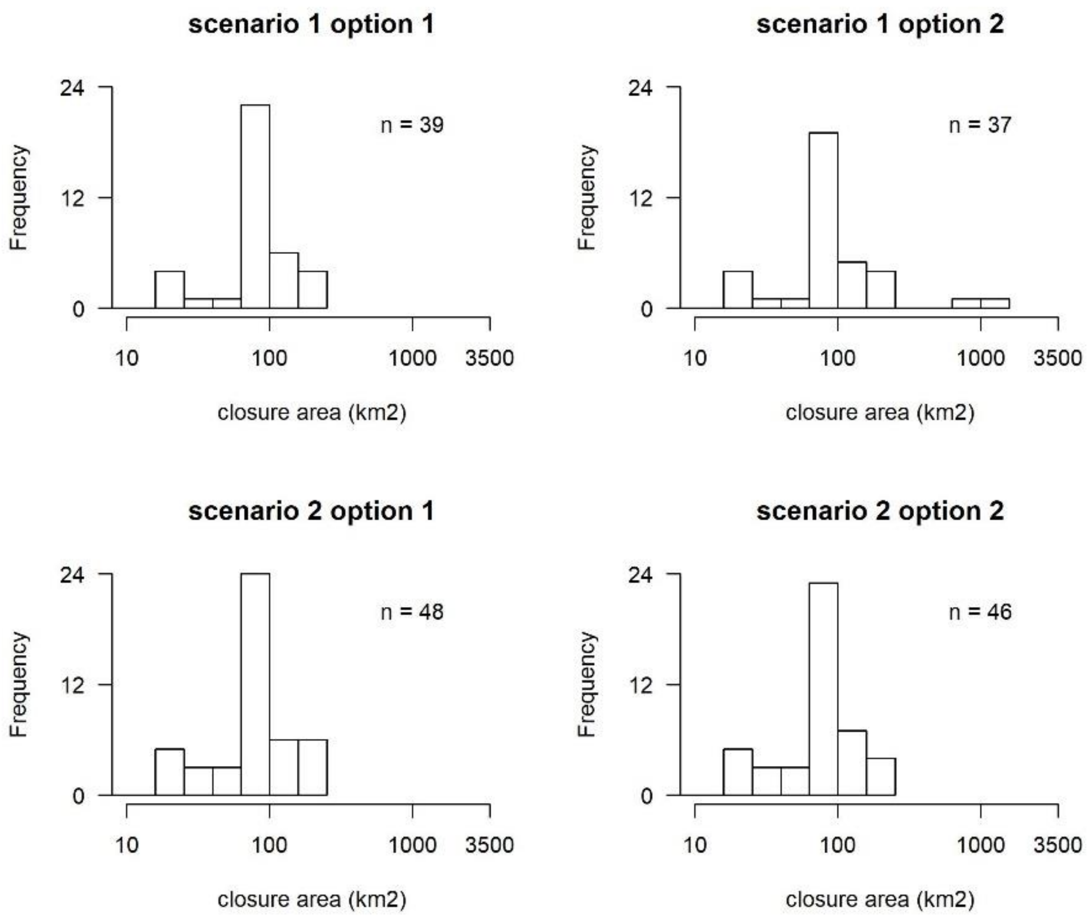


Figure 17. Histograms of the size of the closed areas that overlap with the 400-800 meter depth range following the two different Scenarios, each with two options (see maps in Figure 16). The total number of closure areas is in the upper right.

The R-scripts which produced the closed area options and data summaries, including closure .shp files, are available on an open source platform (WKEUVME GitHub site). For each Ecoregion/Management Option/Closed Area script for creating a table of the coordinates for each closed area polygon has been produced. The table also indicates the VME habitat, VME indicator and VME element data present in each closed area. The closed areas are also mapped and .shp files produced for each.

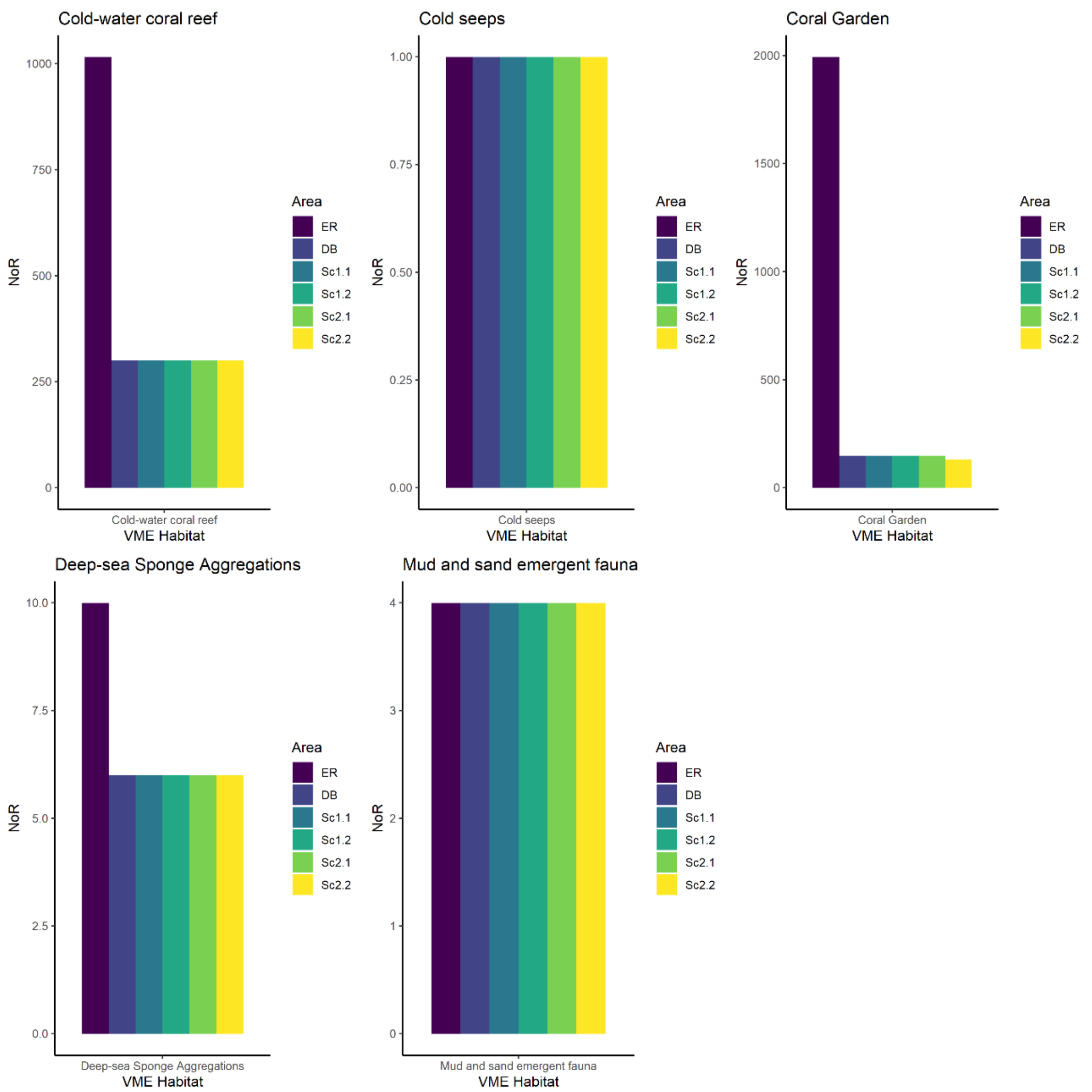


Figure 18. The number of VME habitat records (NoR) from the VME Database within each of the areas: : Bay of Biscay and Iberian Coast Ecoregion Ecoregion (ER), the 400 – 800 m depth band (DB), and for each closure option within the depth 400 – 800 m depth band (Scenario 1 Option 1 = Sc1.1, Scenario 1 Option 2 = Sc1.2, etc.). Note that the Y-axis differs between plots.

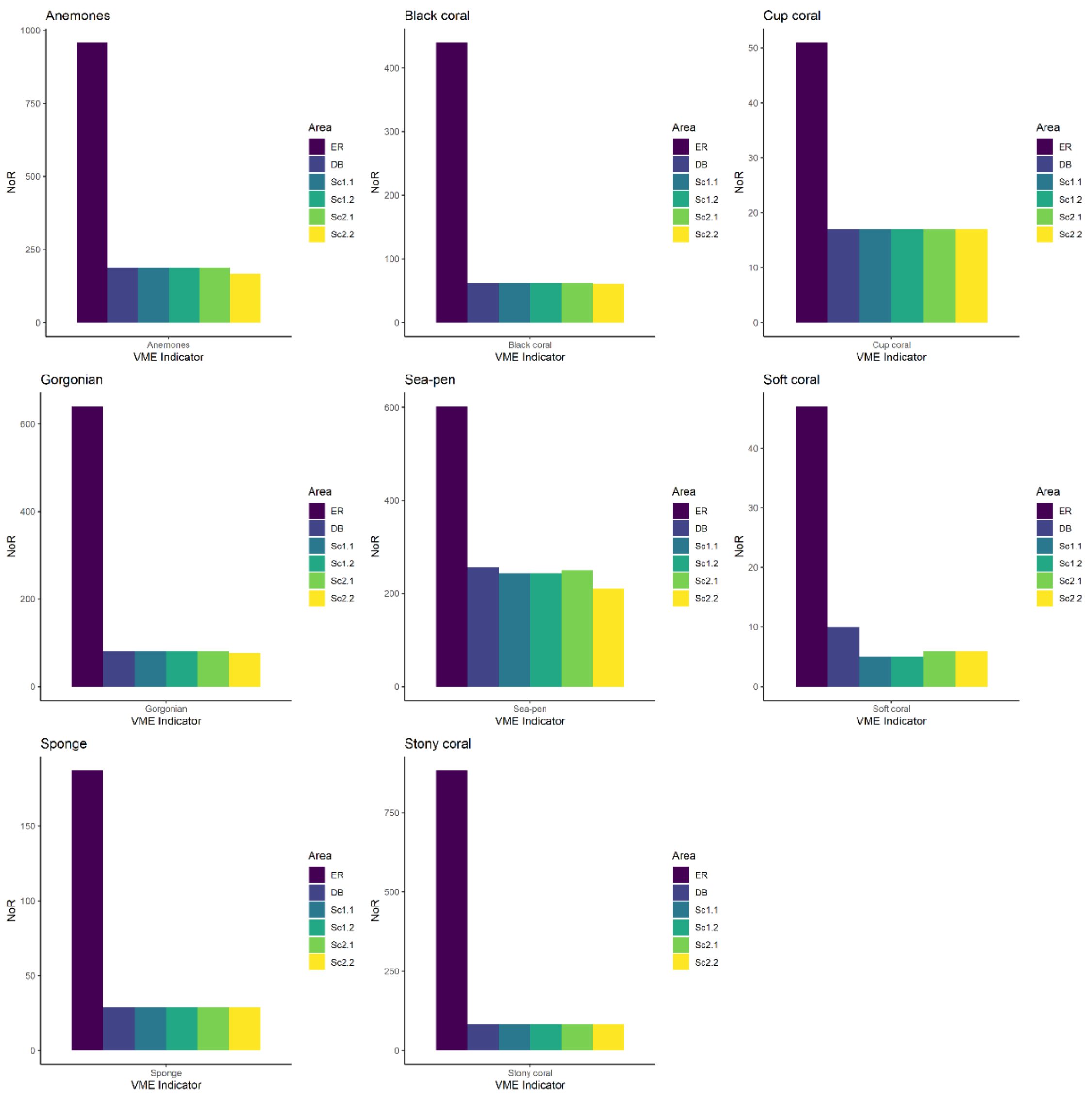


Figure 19. The number of VME indicator records (NoR) from the VME Database within each of the areas: Bay of Biscay and Iberian Coast Ecoregion (ER), the 400 – 800 m depth band (DB), and for each closure option within the depth 400 – 800 m depth band (Scenario 1 Option 1 = Sc1.1, Scenario 1 Option 2 = Sc1.2, etc.). Note that the Y-axis differs between plots.

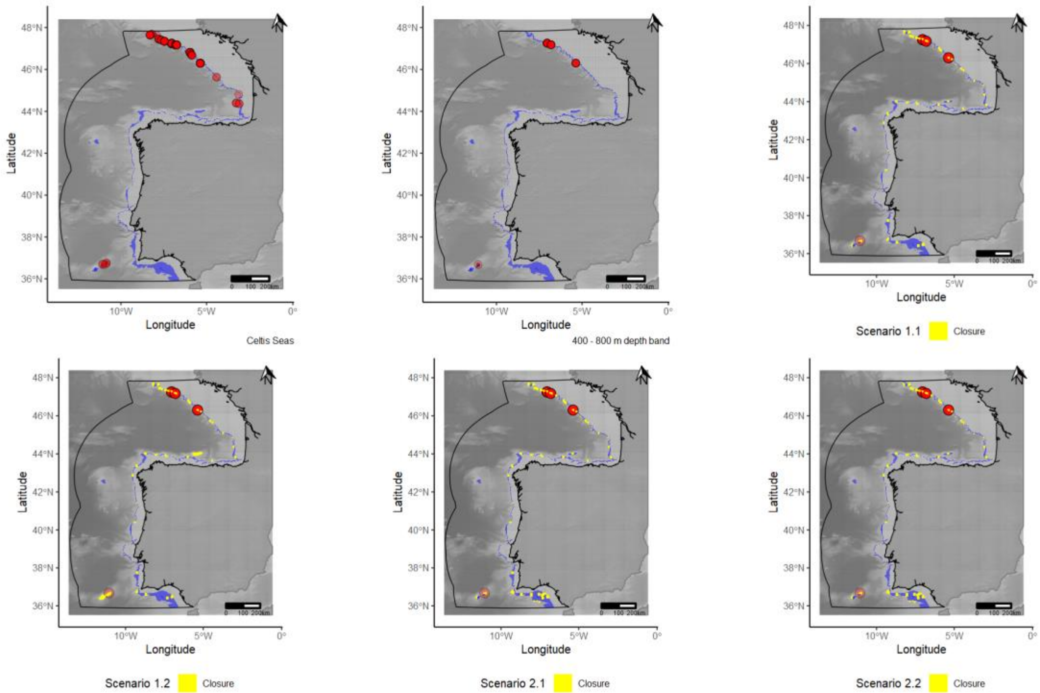


Figure 20. Sponge VME indicator records within each of the areas: Celtic Seas Ecoregion (top left), the 400 – 800 m depth band (top middle), and for each closure option within the depth 400 – 800 m depth band (Scenario 1 Option 1 = Scenario 1.1, etc.). The 400 – 800 m depth band is plotted as the blue polygon, and was derived from the EMODnet bathymetry product. The base maps are derived from GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). Map projection: EPSG: 32629, WGS 84 / UTM zone 29N.

Analysis of Trade-offs Between Closures and Impact on Fisheries

An ideal closure scenario protects all potential VMEs while having a minimal impact on fishing activities. Figures 22-25 show the trade-off between different measures of the number of VME's in closures versus different measures of the impact on fishing activities. Scenarios that protect most VMEs and have the smallest impact on fishing activities are found towards the top-left of these plots. Scenarios that protect fewer VMEs and have a high impact on fishing activities are found towards the bottom right. Fishing effort is evaluated in three different time periods, to be able to capture the effect in the 2009-2011 reference period as well as the effect on more recent activities. The potential benefits of closures are evaluated as: 1) all C-squares with VME habitats and any level of VME Index, 2) all C-squares with VME habitats and VME Index ≥ medium, 3) the number of records of VME indicator groups, in closures.

The number of C-squares with VME habitats and index records is the same for Scenario 1 option 1 and Scenario 1 option 2 because Scenario 1 option 1 already closed all ≥ medium VME Index cells, and Scenario 1 option 2 is based on extending closures based on VME elements that did not contain further records, but may increase the likelihood of protecting VMEs that have not yet been recorded. The additional impact on fishing activities of Scenario 1 option 2 compared to Scenario 1 option 1 is small, presumably because the closed VME elements had a low fishing intensity.

As a general rule, Scenario 1 option 1 and Scenario 1 option 2 performed similarly, with Scenario 1 option 2 affecting some more fishing activity and particularly so when evaluated as the footprint (Figure 24) rather than as SAR (Figure 22). Scenario 2 option 1 closures capture more low

VME Index cells at a low additional impact on fishing activities, while Scenario 2 option 2 slightly reduces the impact on fishing activities at the expense of not closing some VME habitats, high and medium index cells.

Different measures of fishing activity suggest moderately different impacts on fishing activities. For the most recent period, Scenario 2 option 2 closes 9% of the total SAR of the mobile fleet, and the other scenarios 11% to 12%. This illustrates that fishing activity is concentrated in high effort C-squares and that there are a lot of C-squares with minimal effort levels. Effects of the different scenarios on static and mobile fishing activities appear very similar (Figure 23).

The pattern for the VME indicator groups (Figure 25) is not consistent across groups. Although differences are small, two patterns can be highlighted: i) the two options in Scenario 1 tend to under-preserve soft-corals and sea pens because these two indicators get a low vulnerability index score according to the WGDEC weighting system; and ii) Scenario 2 option 2 tends to under-preserve gorgonians and black corals, which qualify as highly vulnerable according to WGDEC weighting system but which distribution overlap with highly fished C-squares. At the size of a C-square however, VME and high SAR can probably co-exist, for example near canyon heads where mobile fishing gears are deployed on the flat periphery of the canyon and VME occur on the steep slopes of the canyon.

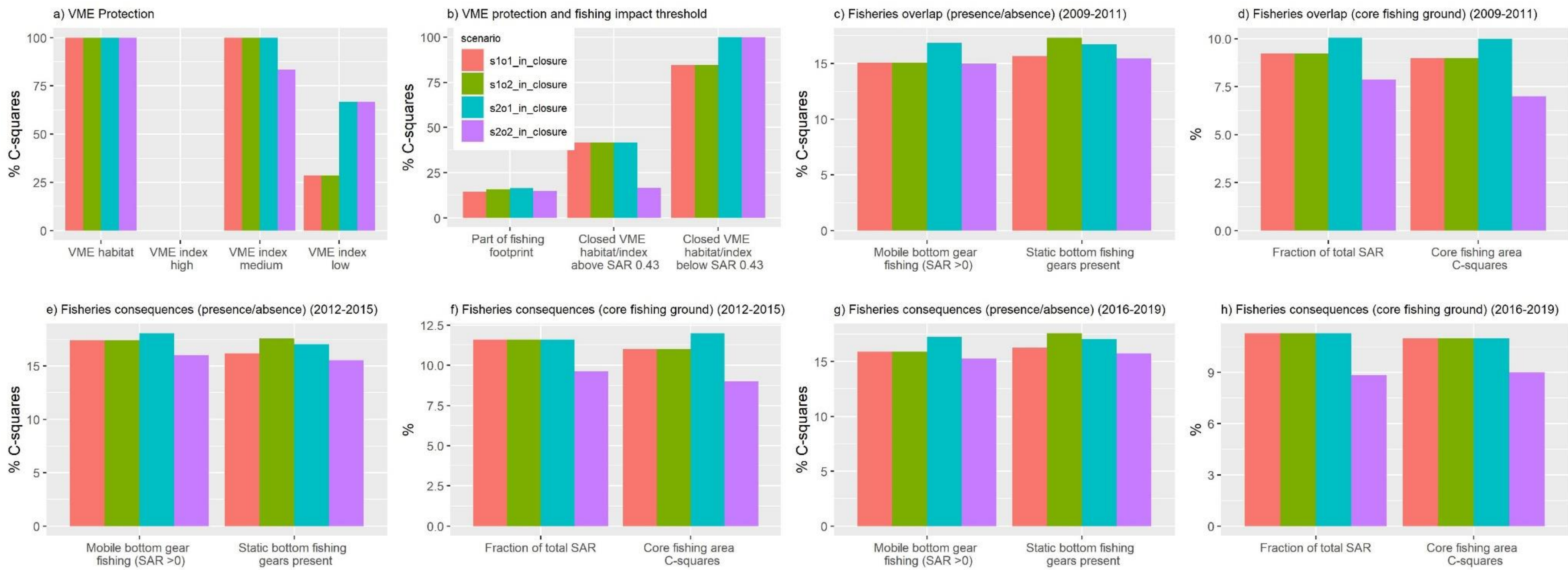


Figure 21. Bar charts showing the effect of the different Scenarios and options (legend in b): Scenario 1 Option 1 =s1o1, etc.) as percentages. a) Percentage of VME protection for the different scenarios and options; b) Percentage of fishing footprint in the closure scenarios and percentage of VME C-squares above/below SAR threshold of 0.43; c) Percentage of C-squares with mobile or static bottom fishing in the closures for the period 2009-2011; d) Percentage of total SAR in the closures and percentage of C-squares that form the core fishing area in the closure for the period 2009-2011; e) Percentage of C-squares with mobile or static bottom fishing in the closures for the period 2012-2015; f) Percentage of total SAR in the closures and percentage of C-squares that form the core fishing area in the closure for the period 2012-2015; g) Percentage of C-squares with mobile or static bottom fishing in the closures for the period 2016-2019; h) Percentage of total SAR in the closures and percentage of C-squares that form the core fishing area in the closure for the period 2012-2015.

Table 10. Evaluating each of the 4 closure Scenario/options by impact on fishery and protection of VME habitat and index.

	Scenario 1 option 1		Scenario 1 option 2		Scenario 2 option 1		Scenario 2 option 2	
	Within closure	**outside closures**	**within closure**	**outside closures**	**within closure**	**outside closures**	**within closure**	**outside closures**
VME protection								
nb of C-squares with VME habitat	25	0	25	0	25	0	25	0
nb of C-squares with VME Index high	0	0	0	0	0	0	0	0
nb of C-squares with VME Index medium	18	0	18	0	18	0	15	3
nb of C-squares with VME Index low	6	15	6	15	14	7	14	7
VME protection and fishing impact threshold								
nb of C-squares with VME habitat/index below SAR 0.43 threshold (2009-2019)	44	8	44	8	52	0	52	0
nb of C-squares with closed VME habitat/index above SAR 0.43 threshold (2009-2019)	5	7	5	7	5	7	2	10
Fisheries footprint								
nb of C-squares part of fishing footprint	250	1472	275.25	1446.75	283	1439	257	1465
Fisheries overlap (presence/absence) (2009-2011)								
nb of C-squares with static bottom fishing (present in footprint)	236	1273	261.25	1247.75	252	1257	233	1276
nb of C-squares with mobile bottom fishing (SAR > 0 in footprint)	204	1151	204	1151	228	1127	203	1152

	Scenario 1 option 1		Scenario 1 option 2		Scenario 2 option 1		Scenario 2 option 2	
	Within closure	outside closures	within closure	outside closures	within closure	outside closures	within closure	outside closures
Fisheries overlap (core fishing ground) (2009-2011)								
nb of C-squares that form core fishing area based on SAR in footprint	55	541	55	541	60	536	47	549
fraction of total SAR in footprint	0.09	0.91	0.09	0.91	0.1	0.9	0.07	0.93
Fisheries consequences (presence/absence) (2012-2015)								
nb of C-squares with static bottom fishing (present in footprint)	228	1182	247.75	1162.25	240	1170	219	1191
nb of C-squares with mobile bottom fishing (SAR > 0 in footprint)	187	887	187	887	194	880	172	902
Fisheries consequences (core fishing ground) (2012-2015)								
nb of C-squares that form core fishing area based on SAR in footprint	47	358	47	358	47	358	39	366
fraction of total SAR in footprint	0.11	0.89	0.11	0.89	0.12	0.88	0.09	0.91
Fisheries consequences (presence/absence) (2016-2019)								
nb of C-squares with static bottom fishing (present in footprint)	221	1138	239	1120	232	1127	214	1145
nb of C-squares with mobile bottom fishing (SAR > 0 in footprint)	178	942	178	942	193	927	171	949
Fisheries consequences (core fishing ground) (2016-2019)								
nb of C-squares that form core fishing area based on SAR in footprint	46	361	46	361	46	361	36	371
fraction of total SAR in footprint	0.11	0.89	0.11	0.89	0.11	0.89	0.09	0.91

Table 11. VME indicator and habitat records from the VME Database within the Bay of Biscay and Iberian Coast Ecoregion, the 400 – 800 m depth band, and for each closure option within the depth 400 – 800 m depth band.

	BoB-IC Ecoregion	400-800 m Depth	Scenario 1 Option 1	Scenario 1 Option 2	Scenario 2 Option 1	Scenario 2 Option 2
VME Indicator						
Anemones	959	188	188	188	188	168
Black coral	440	62	62	62	62	61
Cup coral	51	17	17	17	17	17
Gorgonian	640	81	81	81	81	77
Sea pen	602	256	244	244	250	211
Soft coral	47	10	5	5	6	6
Sponge	187	29	29	29	29	29
Stony coral	883	84	84	84	84	84
Stylasterids	1	-	-	-	-	-
VME Habitat						
Cold-water coral reef	1,016	300	300	300	300	300
Cold seeps	1	1	1	1	1	1
Coral Garden	1,994	149	149	149	149	129
Deep-sea Sponge Aggregations	10	6	6	6	6	6
Mud and sand emergent fauna	4	4	4	4	4	4

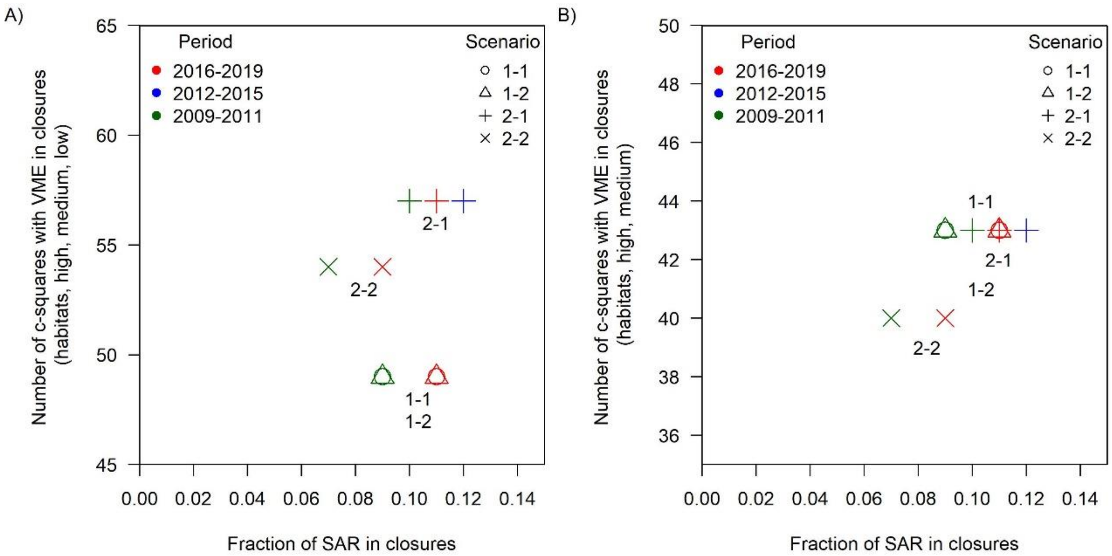


Figure 22. a) The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total fraction of the SAR in the closures for the three different time periods. b) The number of VME habitat and index cells (only high and medium) included in each of the closure scenarios, as a function of the total fraction of the SAR in the closures for the three different time periods.

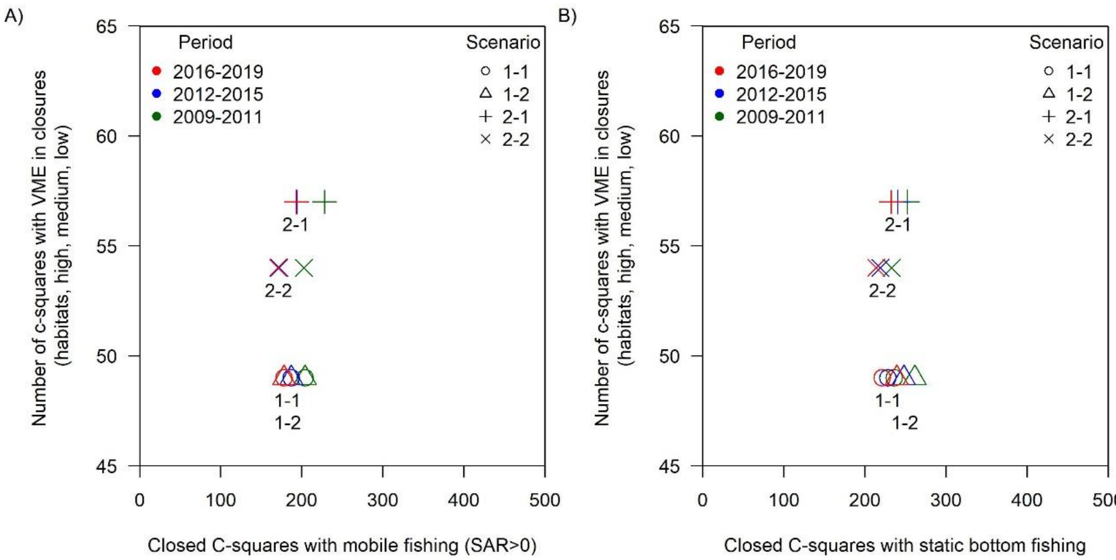


Figure 23. a) The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total number of C-squares that were fished by mobile gears (SAR>0) for the three different time periods. b) The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total number of C-squares that were fished by static gears for the three different time periods.

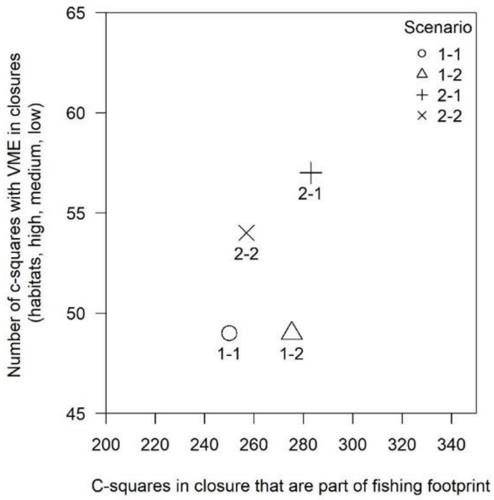


Figure 24. The number of VME habitat and index cells (all types) included in each of the closure scenarios, as a function of the total number of C-squares that were fished of the fishing footprint in 2009-2011.

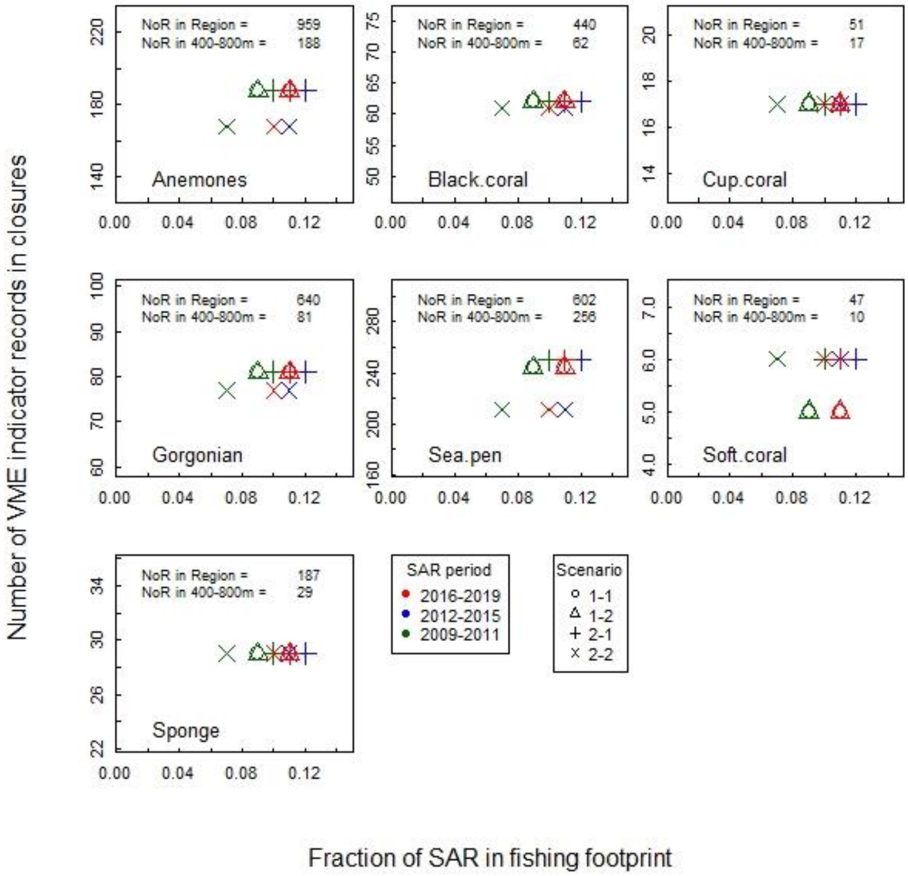


Figure 25. The Number of Records (NoR) of VME indicator groups included in closure areas as function of the fraction of SAR closed to fishing, for each scenario and time period.

Future Directions

Under regulation (EU) 2016/2336 there will be a requirement for an annual update of the assessment of areas where VMEs are known to occur or are likely to occur. The formal ICES advisory process will be used to provide such an update to the European Commission (as is done for NEAFC VME advice). An integral part of this annual advisory process will be the ICES VME and fishing activity (VMS and logbook) data flows, which feed into the assessment procedure that is presented in this assessment sheet for the Bay of Biscay Iberian Ecoregion. This assessment procedure is fully documented using ICES TAF (transparent assessment framework) principles, with the respective scripts to run the assessment made publically available on an open source platform (WKEUVME GitHub site). At present, for the Bay of Biscay Iberian Ecoregion, there is an absence of quality-assured VME data in the ICES VME Database; the assessment procedure has had to make use of modelled information on VME elements to highlight some important features (e.g., Gorringe Bank and El Cachucho**)** but others remain unaccounted for (e.g., Avilés Canyon System, Galicia Bank and a number of mud volcanoes in the Gulf of Cádiz. Once VME data is submitted to ICES, the subsequent assessment procedure can also be updated. In this annual process the ICES Data Centre works closely with WGDEC (Working Group on Deep-water Ecology) and WGSFD (Working Group on Spatial Fisheries Data), to make the provision of spatial data consistent across various data sources, thus enabling clear and traceable provenance of scientific information used in decision making. Specific ICES expert groups would also be involved in the annual assessment to synthesize knowledge that can be used to further supplement these annual assessments. This will form a solid foundation on which ICES can base any annual assessment on.

As part of the formal ICES advisory process, the annual assessment prepared by ICES experts would be peer-reviewed. Following this review, the response to the request is drafted by an ACOM appointed advice-drafting group. This draft advice is scrutinised by ACOM and, if approved, delivered to the requestor and published by ICES. The evidence and supporting rationale are explained in the advice, with reference to the underlying technical work. Upon delivery of the advice, the EC may wish to iteratively refine the subsequent advice question(s) as part of collaborative agreements with ICES to provide annual advice. Similarly, in the future and following the annual Advisory Committee (ACOM) advice process, ICES may wish to update the established assessment procedure with improvements to incorporate, for example, VME species distribution models (SDMs) or by further improvements to how the VME Index is calculated.

ICES may wish to include the assessment (or parts of them) in further iterations of the annual Ecosystem Overview (EOs) advice and Fisheries Overview (FOs) advice. There are also strong links to shallower water assessment procedures developed by WGFBIT (Working Group on Fisheries Benthic Impact and Trade-offs) that have been developed for the ICES Ecosystem Overview advice in the context of Descriptor 6 seafloor integrity of the EC’s marine strategy framework directive (MSFD).

Experts contributing to this assessment sheet for the Bay of Biscay Iberian Ecoregion identified a number of potential VME data sources that could be encouraged to submit their data to ICES and, following quality assurance checks, be used in the provision of formal ICES advice (Table 12). Other national VME data holders are encouraged to submit data. Any submissions should be made by national data holders in response to the annual VME data call (link) issued by ICES to member countries with a 2-month period (usually February – March). Data on VME habitats, VME indictors and VME absence data is encouraged, and the data submitter must have usage rights on the data that they submit to ICES. It is important that the VME data conforms to the FAO VME criteria and/or ICES WGDEC VME taxa and that duplicate records (e.g., those already in the database) are identified.

Table 12. Potential VME data sources identified by WKEUVME, with respective metadata. Whether the dataset relates to VME Habitats (H) and/or VME indicators (I) is identified, along with a point of contact for the data source. '?' denotes unknowns.

Dataset information					**Country to submit**			**Data holder or potential submitter**	
Dataset	VME data type	Year of survey	Is VME data compliant with FAO VME criteria and/or ICES WGDEC VME taxa list?	Publication	Country of origin:	Can data be submitted in Jan 2021	National ICES ACOM member and DCF point of contact	Point of contact (POC)	Does POC have usage rights on data?
Area: Bay of Biscay									
Bay of Biscay: Scleractinian Coral Records	I	?	?	Reveillaud et al. 2008	France	?	Alain Biseau / Camille Dross /	Julie Reveillaud (reveillaud.j@gmail.com)	?
Area: Northern Iberian Shelf									
Galicia Bank	H & I	2009-2011	Partially	Serrano et al. 2017	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Alberto Serrano (alberto.serrano@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Galicia Bank	I	2005, 2007, 2009	No	Somoza et al. 2014	Spain	No		Luis Somoza (l.somoza@igme.es)	No
Avilés Canyon System	I	1987-1988	No	Louzao et al. 2010	Spain	No		Maite Louzao (maite.louzao@gmail.com)	Yes

Area: Bay of Biscay									
Avilés Canyon System	I	2010-2012	Partially	Altuna & Rios 2014	Spain	Yes		Alvaro Altuna (alvaro.altuna@telefonica.net) Pilar Rios (pilar.rios.lopez@gmail.com) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Avilés Canyon System	I	2010-2012	Partially	Sánchez et al. 2015	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
La Gaviera Canyon	H & I	2010-2012	Partially	Sánchez et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	I	2003, 2004, 2008, 2009	Partially	http://dx.doi.org/10.1016/j.jmarsys.2007.04.008 Gargia-Alegre et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) Ana Garcia-Alegre (ana.garciaalegre@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	H	2005	Partially	Sánchez et al. 2009	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es)	Yes

Area: Bay of Biscay									
El Cachucho	H	2014, 2017	Partially	Sánchez et al. 2017 Prado et al. 2019 Rodríguez-Basalo et al. 2019	Spain	?		Francisco Sánchez (francisco.sanchez@ieo.es) Elena Prado (elena.prado@ieo.es) Augusto Rodriguez-Basalo (augusto.rodriguez@ieo.com)	Yes
N. Iberian Shelf	I	1995-2010	Partially	Ruiz-Pico et al. 2017	Spain	Yes		Susana Ruiz-Pico (susana.ruiz@st.ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
N. Iberian Shelf	I	?	No	OCEANA 2009	Spain	?		Ricardo Aguilar (raguilar@oceana.org)	No
Cap Breton Canyon	H	2011	Partially	Flögel et al. 2014	Germany	No	Christopher Zimmermann / Christoph Stransky	Sascha Flögel (sfloegel@geomar.de)	No

Area: Gulf of Cádiz										
	Mud volcanoes	H & I	2004-2005	?	Cunha et al. 2013	Portugal	?	Maria de Fátima Borges / Emilia Batista	Marina Cunha (marina.cunha@ua.pt) Clara Rodrigues (clara.rodrigues@ua.pt)	?
		H & I	2000-2009	?	Rodrigues et al. 2013	Portugal	?			?
	Mud volcanoes & other seafloor structures (e.g., diapirs, diapiric ridges and diapir / mud volcano complexes)	H & I	2000-2008	?	Rueda et al. 2011	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	José Luis Rueda (jose.rueda@ieo.es) Marine Geosciences at IEO (gemar@ieo.es)	Yes
		H & I	2008-2012	?	Rueda et al. 2012	Spain	Yes			Yes
		H & I	2008-2012	?	Díaz del Río et al. 2014	Spain	Yes			Yes
		H & I	2008-2012	?	Palomino et al. 2016	Spain	Yes			Yes
		H & I	2008-2012	?	Rueda et al. 2016	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Gerardo Bruque (gerardo.bruque@ieo.es)	Yes
		H & I	2008-2016	?	Palomino et al. 2019	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Desirée Palomino	Yes
		H & I	2008-2012	?	Sitjà et al. 2019	Spain	?		Manuel Maldonado (maldonado@ceab.csic.es)	?
		H & I	2008-2017	?	Lozano et al. 2019 Lozano et al. 2020	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Pablo Lozano	Yes
		H & I	?	?	Van Rensbergen et al. 2005	Spain and Belgium?	?	Francisco Velasco Guevara / María Pilar Vara del Río / Els Torreele	Pieter Van Rensbergen (pieter_vanrensbergen@yahoo.com)	?
		H & I	?	?	Hebbeln et al. 2019	Germany	?	Christopher	Dierk Hebbeln (dierk.hebbeln@marum.de)	?

	Zimmermann / Christoph Stransky	

Dataset information					Country to submit			Data holder or potential submitter	
Dataset	VME data type	Year of survey	Is VME data compliant with FAO VME criteria and/or ICES WGDEC VME taxa list?	Publication	Country of origin:	Can data be submitted in Jan 2021	National ICES ACOM member and DCF point of contact	Point of contact (POC)	Does POC have usage rights on data?
Area: Bay of Biscay									
Bay of Biscay: Sclera ctinian Coral Records	I	?	?	Reveillaud et al. 2008	France	?	Alain Biseau / Camille Dross /	Julie Reveillaud (reveillaud.j@gmail.com)	?
Area: Northern Iberian Shelf									
Galicia Bank	H & I	2009-2011	Partially	Serrano et al. 2017	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Alberto Serrano (alberto.serrano@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Galicia Bank	I	2005, 2007, 2009	No	Somoza et al. 2014	Spain	No		Luis Somoza (l.somoza@igme.es)	No
Avilés Canyon System	I	1987-1988	No	Louzao et al. 2010	Spain	No		Maite Louzao (maite.louzao@gmail.com)	Yes

Area: Bay of Biscay									
Avilés Canyon System	I	2010-2012	Partially	Altuna & Rios 2014	Spain	Yes		Alvaro Altuna (alvaro.altuna@telefonica.net) Pilar Rios (pilar.rios.lopez@gmail.com) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Avilés Canyon System	I	2010-2012	Partially	Sánchez et al. 2015	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
La Gaviera Canyon	H & I	2010-2012	Partially	Sánchez et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	I	2003, 2004, 2008, 2009	Partially	http://dx.doi.org/10.1016/j.jmarsys.2007.04.008 Gargia-Alegre et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) Ana Garcia-Alegre (ana.garciaalegre@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	H	2005	Partially	Sánchez et al. 2009	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es)	Yes

Area: Bay of Biscay									
El Cachucho	H	2014, 2017	Partially	Sánchez et al. 2017 Prado et al. 2019 Rodríguez-Basalo et al. 2019	Spain	?		Francisco Sánchez (francisco.sanchez@ieo.es) Elena Prado (elena.prado@ieo.es) Augusto Rodriguez-Basalo (augusto.rodriguez@ieo.com)	Yes
N. Iberian Shelf	I	1995-2010	Partially	Ruiz-Pico et al. 2017	Spain	Yes		Susana Ruiz-Pico (susana.ruiz@st.ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
N. Iberian Shelf	I	?	No	OCEANA 2009	Spain	?		Ricardo Aguilar (raguilar@oceana.org)	No
Cap Breton Canyon	H	2011	Partially	Flögel et al. 2014	Germany	No	Christopher Zimmermann / Christoph Stransky	Sascha Flögel (sfloegel@geomar.de)	No

Area: Gulf of Cádiz									
Mud volcanoes	H & I	2004-2005	?	Cunha et al. 2013	Portugal	?	Maria de Fátima Borges / Emilia Batista	Marina Cunha (marina.cunha@ua.pt) Clara Rodrigues (clara.rodrigues@ua.pt)	?
	H & I	2000-2009	?	Rodrigues et al. 2013	Portugal	?			?
Mud volcanoes & other seafloor structures (e.g., diapirs, diapiric ridges and diapir / mud volcano complexes)	H & I	2000-2008	?	Rueda et al. 2011	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	José Luis Rueda (jose.rueda@ieo.es) Marine Geosciences at IEO (gemar@ieo.es)	Yes
	H & I	2008-2012	?	Rueda et al. 2012	Spain	Yes			Yes
	H & I	2008-2012	?	Díaz del Río et al. 2014	Spain	Yes			Yes
	H & I	2008-2012	?	Palomino et al. 2016	Spain	Yes			Yes
	H & I	2008-2012	?	Rueda et al. 2016	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Gerardo Bruque (gerardo.bruque@ieo.es)	Yes
	H & I	2008-2016	?	Palomino et al. 2019	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Desirée Palomino	Yes
	H & I	2008-2012	?	Sitjà et al. 2019	Spain	?		Manuel Maldonado (maldonado@ceab.csic.es)	?
	H & I	2008-2017	?	Lozano et al. 2019 Lozano et al. 2020	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Pablo Lozano	Yes
	H & I	?	?	Van Rensbergen et al. 2005	Spain and Belgium?	?	Francisco Velasco Guevara / María Pilar Vara del Río / Els Torreele	Pieter Van Rensbergen (pieter_vanrensbergen@yahoo.com)	?
	H & I	?	?	Hebbeln et al. 2019	Germany	?	Christopher	Dierk Hebbeln (dierk.hebbeln@marum.de)	?

	Zim- mer- mann / Chris- toph Stran- sky	

Dataset information					Country to submit			Data holder or potential submitter	
Dataset	VME data type	Year of survey	Is VME data compliant with FAO VME criteria and/or ICES WGDEC VME taxa list?	Publication	Country of origin:	Can data be submitted in Jan 2021	National ICES ACOM member and DCF point of contact	Point of contact (POC)	Does POC have usage rights on data?
Area: Bay of Biscay									
Bay of Biscay: Scleractinian Coral Records	I	?	?	Reveillaud et al. 2008	France	?	Alain Biseau / Camille Dross /	Julie Reveillaud (reveillaud.j@gmail.com)	?
Area: Northern Iberian Shelf									
Galicia Bank	H & I	2009-2011	Partially	Serrano et al. 2017	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Alberto Serrano (alberto.serrano@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Galicia Bank	I	2005, 2007, 2009	No	Somoza et al. 2014	Spain	No		Luis Somoza (l.somoza@igme.es)	No
Avilés Canyon System	I	1987-1988	No	Louzao et al. 2010	Spain	No		Maite Louzao (maite.louzao@gmail.com)	Yes

Area: Bay of Biscay									
Avilés Canyon System	I	2010-2012	Partially	Altuna & Rios 2014	Spain	Yes		Alvaro Altuna (alvaro.altuna@telefonica.net) Pilar Rios (pilar.rios.lopez@gmail.com) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Avilés Canyon System	I	2010-2012	Partially	Sánchez et al. 2015	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
La Gaviera Canyon	H & I	2010-2012	Partially	Sánchez et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	I	2003, 2004, 2008, 2009	Partially	http://dx.doi.org/10.1016/j.jmarsys.2007.04.008 Gargia-Alegre et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) Ana Garcia-Alegre (ana.garciaalegre@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	H	2005	Partially	Sánchez et al. 2009	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es)	Yes

Area: Bay of Biscay									
El Cachucho	H	2014, 2017	Partially	Sánchez et al. 2017 Prado et al. 2019 Rodríguez-Basalo et al. 2019	Spain	?		Francisco Sánchez (francisco.sanchez@ieo.es) Elena Prado (elena.prado@ieo.es) Augusto Rodriguez-Basalo (augusto.rodriguez@ieo.com)	Yes
N. Iberian Shelf	I	1995-2010	Partially	Ruiz-Pico et al. 2017	Spain	Yes		Susana Ruiz-Pico (susana.ruiz@st.ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
N. Iberian Shelf	I	?	No	OCEANA 2009	Spain	?		Ricardo Aguilar (raguilar@oceana.org)	No
Cap Breton Canyon	H	2011	Partially	Flögel et al. 2014	Germany	No	Christopher Zimmermann / Christoph Stransky	Sascha Flögel (sfloegel@geomar.de)	No

Area: Gulf of Cádiz									
Mud volcanoes	H & I	2004-2005	?	Cunha et al. 2013	Portugal	?	Maria de Fátima Borges / Emilia Batista	Marina Cunha (marina.cunha@ua.pt) Clara Rodrigues (clara.rodrigues@ua.pt)	?
	H & I	2000-2009	?	Rodrigues et al. 2013	Portugal	?			?
Mud volcanoes & other seafloor structures (e.g., diapirs, diapiric ridges and diapir / mud volcano complexes)	H & I	2000-2008	?	Rueda et al. 2011	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	José Luis Rueda (jose.rueda@ieo.es) Marine Geosciences at IEO (gemar@ieo.es)	Yes
	H & I	2008-2012	?	Rueda et al. 2012	Spain	Yes			Yes
	H & I	2008-2012	?	Díaz del Río et al. 2014	Spain	Yes			Yes
	H & I	2008-2012	?	Palomino et al. 2016	Spain	Yes			Yes
	H & I	2008-2012	?	Rueda et al. 2016	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Gerardo Bruque (gerardo.bruque@ieo.es)	Yes
	H & I	2008-2016	?	Palomino et al. 2019	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Desirée Palomino	Yes
	H & I	2008-2012	?	Sitjà et al. 2019	Spain	?		Manuel Maldonado (maldonado@ceab.csic.es)	?
	H & I	2008-2017	?	Lozano et al. 2019 Lozano et al. 2020	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Pablo Lozano	Yes
	H & I	?	?	Van Rensbergen et al. 2005	Spain and Belgium?	?	Francisco Velasco Guevara / María Pilar Vara del Río / Els Torreele	Pieter Van Rensbergen (pieter_vanrensbergen@yahoo.com)	?
	H & I	?	?	Hebbeln et al. 2019	Germany	?	Christopher	Dierk Hebbeln (dierk.hebbeln@marum.de)	?

	Zimmermann / Christoph Stransky	

Dataset information					Country to submit			Data holder or potential submitter	
Dataset	VME data type	Year of survey	Is VME data compliant with FAO VME criteria and/or ICES WGDEC VME taxa list?	Publication	Country of origin:	Can data be submitted in Jan 2021	National ICES ACOM member and DCF point of contact	Point of contact (POC)	Does POC have usage rights on data?
Area: Bay of Biscay									
Bay of Biscay: Scleractinian Coral Records	I	?	?	Reveillaud et al. 2008	France	?	Alain Biseau / Camille Dross /	Julie Reveillaud (reveillaud.j@gmail.com)	?
Area: Northern Iberian Shelf									
Galicia Bank	H & I	2009-2011	Partially	Serrano et al. 2017	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Alberto Serrano (alberto.serrano@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Galicia Bank	I	2005, 2007, 2009	No	Somoza et al. 2014	Spain	No		Luis Somoza (l.somoza@igme.es)	No
Avilés Canyon System	I	1987-1988	No	Louzao et al. 2010	Spain	No		Maite Louzao (maite.louzao@gmail.com)	Yes

Area: Bay of Biscay									
Avilés Canyon System	I	2010-2012	Partially	Altuna & Rios 2014	Spain	Yes		Alvaro Altuna (alvaro.altuna@telefonica.net) Pilar Rios (pilar.rios.lopez@gmail.com) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
Avilés Canyon System	I	2010-2012	Partially	Sánchez et al. 2015	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
La Gaviera Canyon	H & I	2010-2012	Partially	Sánchez et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	I	2003, 2004, 2008, 2009	Partially	http://dx.doi.org/10.1016/j.jmarsys.2007.04.008 Gargia-Alegre et al. 2014	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es) Ana Garcia-Alegre (ana.garciaalegre@ieo.es) José Manuel González Irusta (jmanuel.gonzalez@ieo.es)	Yes
El Cachucho	H	2005	Partially	Sánchez et al. 2009	Spain	Yes		Francisco Sánchez (francisco.sanchez@ieo.es)	Yes

Area: Bay of Biscay									
El Ca-chu cho	H	201 4, 201 7	Par-tiall y	Sánchez et al. 2017 Prado et al. 2019 Rodríguez-Basalo et al. 2019	Spai n	?		Francisco Sánchez (francisco.san-chez@ieo.es) Elena Prado (elena.prado@ieo.es) Augusto Rodriguez-Ba-salo (augusto.rodri-guez@ieo.com)	Y es
N. Ibe-rian Shel f	I	199 5-201 0	Par-tiall y	Ruiz-Pico et al. 2017	Spai n	Y es		Susana Ruiz-Pico (susana.ruiz@st.ieo.es) José Manuel González Irusta (jmanuel.gonza-lez@ieo.es)	Y es
N. Ibe-rian Shel f	I	?	No	OCEANA 2009	Spai n	?		Ricardo Aguilar (raguilar@oceana.org)	N o
Cap Bre-ton Can yon	H	201 1	Par-tiall y	Flögel et al. 2014	Ger-man y	N o	Chris-topher Zim-mer-mann / Chris-toph Stran-sky	Sascha Flögel (sfloegel@geomar.de)	N o

Area: Gulf of Cádiz									
Mud volcanoes	H & I	2004-2005	?	Cunha et al. 2013	Portugal	?	Maria de Fátima Borges / Emilia Batista	Marina Cunha (marina.cunha@ua.pt) Clara Rodrigues (clara.rodrigues@ua.pt)	?
	H & I	2000-2009	?	Rodrigues et al. 2013	Portugal	?			?
Mud volcanoes & other seafloor structures (e.g., diapirs, diapiric ridges and diapir / mud volcano complexes)	H & I	2000-2008	?	Rueda et al. 2011	Spain	Yes	Francisco Velasco Guevara / María Pilar Vara del Río	José Luis Rueda (jose.rueda@ieo.es) Marine Geosciences at IEO (gemar@ieo.es)	Yes
	H & I	2008-2012	?	Rueda et al. 2012	Spain	Yes			Yes
	H & I	2008-2012	?	Díaz del Río et al. 2014	Spain	Yes			Yes
	H & I	2008-2012	?	Palomino et al. 2016	Spain	Yes			Yes
	H & I	2008-2012	?	Rueda et al. 2016	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Gerardo Bruque (gerardo.bruque@ieo.es)	Yes
	H & I	2008-2016	?	Palomino et al. 2019	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Desirée Palomino	Yes
	H & I	2008-2012	?	Sitjà et al. 2019	Spain	?		Manuel Maldonado (maldonado@ceab.csic.es)	?
	H & I	2008-2017	?	Lozano et al. 2019 Lozano et al. 2020	Spain	Yes		José Luis Rueda (jose.rueda@ieo.es), Pablo Lozano	Yes
	H & I	?	?	Van Rensbergen et al. 2005	Spain and Belgium?	?	Francisco Velasco Guevara / María Pilar Vara del Río / Els Torreele	Pieter Van Rensbergen (pieter_vanrensbergen@yahoo.com)	?
	H & I	?	?	Hebbeln et al. 2019	Germany	?	Christopher	Dierk Hebbeln (dierk.hebbeln@marum.de)	?

	Zimmermann / Christoph Stransky	

References

Althaus F, *et al*. 2009. Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. Marine Ecology Progress Series 397: 279-294. https://doi.org/10.3354/meps08248

Arnaud-Haond, S., *et al.* 2017. Two "pillars" of cold-water coral reefs along Atlantic European margins: prevalent association of Madrepora oculata with *Lophelia pertusa*, from reef to colony scale. Deep Sea Research Part II: Topical Studies in Oceanography 145: 110-119.

Benn, A.R., *et al.* 2010. Human activities on the deep seafloor in the north east Atlantic: An assessment of spatial extent. PLoS ONE, 5: e12730. https://doi.org/10.1371/journal.pone.0012730

Billett, D.S.M., *et al*. 2001. Long-term change in the megabenthos of the Porcupine Abyssal Plain (NE Atlantic), Progress in Oceanography 50: 325–348. https://doi.org/10.1016/S0079-6611(01)00060-X

Carvalho, F.C., Cárdenas, P., Ríos, P., Cristobo, J., Rapp, H.T. and Xavier, J.R. 2020. Rock sponges (lithistid Demospongiae) of the Northeast Atlantic seamounts, with description of ten new species. Peer J 8, p.e8703.

Castro, J., Marín, M., Pérez, N., Pierce, G.J., and Punzón, A. 2012. Identification of métiers based on economic and biological data: The Spanish bottom otter trawl fleet operating in non-Iberian European waters. Fisheries Research 125–126: 77–86. doi: 10.1016/j.fishres.2012.02.010

CBD. 2019. CBD/EBSA/WS/2019/1/4: Report of the Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas in the North-East Atlantic Ocean. Available at: http://www.ices.dk/sites/pub/Publication Reports/Advice/2013/Special requests/OSPAR- [Accessed March 3, 2020].

Cunha, M. R., Rodrigues, C. F., Genio, L., Hilario, A., Ravara, A., and Pfannkuche O. 2013. Macrofaunal assemblages from mud volcanoes in the Gulf of Cádiz : abundance, biodiversity and diversity partitioning across spatial. Biogeosciences 10: 2553–2568. http://doi.org/10.5194/bg-10-2553-2013

Davies, A.J. and Guinotte, J.M., 2011. Global habitat suitability for framework-forming cold-water corals. PloS ONE 6(4).

de la Torriente, A., Cartes, J.E., Papiol, V. and Macpherson, E. 2014. Banco de Galicia. Áreas de estudio del proyecto Proyecto LIFE+ INDEMARES.

De Mol, L., *et al*. 2011. Cold-water coral habitats in the Penmarc'h and Guilvinec Canyons (Bay of Biscay): Deep-water versus shallow-water settings. Marine Geology 282(1-2): 40-52.

De Stigter, H.C., Jesus, C.C., Boer, W., Richter, T.O., Costa, A., and van Weering, T.C.E. 2011 Recent sediment transport and deposition in the Lisbon-Setúbal and Cascais submarine canyons, Portuguese continental margin. Deep Sea Research II 58: 2321-2344.

Díaz del Río, V., *et al*. 2014. Volcanes de fango del golfo de Cádiz, Proyecto LIFE+INDEMARES. Ed. Fundación Biodiversidad del Ministerio de Agricultura, Alimentación y Medio Ambiente, Madrid (España), 1–128.

Dimitrov, L.I. 2002. Mud volcanoes—the most important pathway for degassing deeply buried sediments. Earth-Science Reviews 59(1-4): 49-76.

Duineveld, G.C.A., Lavaleye, M.S.S. and Berghuis, E.M. 2004. Particle flux and food supply to a seamount cold-water coral community (Galicia Bank, NW Spain). Marine Ecology Progress Series 277:13-23.

Durán Muñoz, P., *et al.* 2011. Effects of deep-sea bottom longlining on the Hatton Bank fish communities and benthic ecosystem, north-east Atlantic. Journal of the Marine Biological Association of the United Kingdom 91(4): 939-952. https://doi.org/10.1017/S0025315410001773

Eigaard, O. R., *et al*. 2015. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science 73(Suppl. 1): 27–43. https://doi.org/10.1093/icesjms/fsv099

EMODnet Bathymetry Consortium. 2018. EMODnet Digital Bathymetry (DTM 2018). EMODnet Bathymetry Consortium. https://doi.org/10.12770/18ff0d48-b203-4a65-94a9-5fd8b0ec35f6. Data downloaded April 2020 (ESRI ASCII Mean Sea Level format).

European Commission. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Union, OJ L. http://data.europa.eu/eli/dir/1992/43/oj/eng (Accessed 21 May 2020).

European Commission. 2008. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union, 164: 19–40.

European Commission. 2010. Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. Official Journal of the European Union, OJ L. http://data.europa.eu/eli/dir/2009/147/oj/eng (Accessed 21 May 2020).

European Commission. 2017. COMMISSION DECISION (EU) 2017/ 848 - laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/ 477/ EU: 32.

European Union. 2013. Regulation(EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. Official Journal of the European Union, 354. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1380.

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

Ferré, B., Durrieu de Madron, X., Estournel, C., Ulses, C., and Le Corre, G. 2008. Impact of natural (waves and currents) and anthropogenic (trawl) resuspension on the export of particulate matter to the open ocean: application to the Gulf of Lion (NW Mediterranean). Continental Shelf Research 28: 2071-2091. https://doi.org/10.1016/j.csr.2008.02.002

Foden, J., Rogers, S.I., and Jones, A.P. 2009. Recovery rates of UK seabed habitats after cessation of aggregate extraction. Marine Ecology Progress Series 390: 15–26. https://doi.org/10.3354/meps08169

Gage, J.D., and Tyler, P.A. 1991. (editors) Deep-sea biology: a natural history of organisms at the deep-sea floor. xvi, 504p. Cambridge University Press. https://doi.org/10.1017/S0025315400070156

García-Alegre, A., Sánchez, F., Gómez-Ballesteros, M., Hinz, H., Serrano, A. and Parra, S. 2014. Modelling and mapping the local distribution of representative species on the Le Danois bank, El Cachucho marine protected area (Cantabrian sea). Deep Sea Research Part II: Topical Studies in Oceanography 106:151-164.

Gómez-Ballesteros, M., *et al*. 2014. Geomorphology of the Avilés Canyon System, Cantabrian Sea (Bay of Biscay). Deep Sea Research Part II: Topical Studies in Oceanography 106: 99-117.

González-Irusta, J.M., De la Torriente, A., Punzón, A., Blanco, M., and Serrano, A. 2018. Determining and mapping species sensitivity to trawling impacts: the BEnthos Sensitivity Index to Trawling Operations (BESITO). ICES Journal of Marine Science 75(5): 1710-1721. https://doi.org/10.1093/icesjms/fsy030

Grasshoff, M. 1981a. Die Gorgonaria, Pennatularia und Antipatharia des Tiefenwassers der Biscaya (Cnidaria, Anthozoa). Ergebnisse der franzosischen Expeditionen Biogas, Polygas, Geomanche, Incal, Noratlante, une Fahrten der « Thalassa ». I - Allgemeiner Teil Bulletin du Muséum national d'Histoire naturelle, Paris (3), 731-766.

Grasshoff, M. 1981b. Die Gorgonaria, Pennatularia und Antipatharia des Tiefwassers der Biscaya (Cnidaria, Anthozoa). II - Taxonomischer Teil. Bulletin du Muséum national d'Histoire naturelle, Paris (3), 941-978.

Grasshoff, M. 1985. Die Gorgonaria, Pennatularia und Antipatharia. In: Laubier, L., Monniot, C. (Eds.), Peuplements profonds du Golfe de Gascogne, Paris, pp. 299-310.

Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K. 2014. Geomorphology of the oceans. Marine Geology 352: 4-24.

Hayward, N., Watts, A.B., Westbrook, G.K. and Collier, J.S. 1999. A seismic reflection and GLORIA study of compressional deformation in the Gorringe Bank region, eastern North Atlantic. Geophysical Journal International 138(3): 831-850.

Hiddink, J., *et al.* 2018. Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. Proceedings of the National Academy of Sciences of the USA 114: 8301-8306. https://doi.org/10.1073/pnas.1618858114

Howell, K.L., Piechaud, N., Downie, A.L. and Kenny, A. 2016. The distribution of deep-sea sponge aggregations in the North Atlantic and implications for their effective spatial management. Deep Sea Research Part I: Oceanographic Research Papers 115: 309-320.

Huvenne, V.A.I., Bett, B.J., Masson, D.G., Le Bas, T.P., and Wheeler, A.J. 2016. Effectiveness of a deep-sea cold-water coral Marine Protected Area, following eight years of fisheries closure. Biological Conservation 200: 60-69, https://doi.org/10.1016/j.biocon.2016.05.030

ICES. 2018a. 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. http://community.ices.dk/ExpertGroups/wgdec/2018%20Meeting%20documents/03.%20Report%202018/WGDEC_2018.pdf

ICES. 2018b. Advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011. *In* Report of the ICES Advisory Committee, 2018. ICES Advice 2018, sr.2018.10. 12 pp. https://doi.org/10.17895/ices.pub.4429

ICES. 2020a. Report of the 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

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

Iorga, M.C. and Lozier, M.S. 1999. Signatures of the Mediterranean outflow from a North Atlantic climatology: 1. Salinity and density fields. Journal of Geophysical Research: Oceans 104(C11): 25985-26009.

Kazanidis, G., *et al.* 2019. Distribution of Deep-Sea Sponge Aggregations in an Area of Multisectoral Activities and Changing Oceanic Conditions. Frontiers in Marine Science 6: 163, https://www.frontiersin.org/article/10.3389/fmars.2019.00163

Laubier, L., and Monniot, C. (Editors). 1985. Peuplements profonds du Golfe de Gascogne. Campagnes BIOGAS. Ifremer. https://archimer.ifremer.fr/doc/00000/4350/

Lavaleye, M.S.S., Duineveld, G.C.A., Berghuis, E.M., Kok, A. and Witbaard, R. 2002. A comparison between the megafauna communities on the NW Iberian and Celtic continental margins—effects of coastal upwelling? Progress in Oceanography 52(2-4): 459-476.

Le Danois, E. 1948. *Les profondeurs de la mer: trente ans de recherches sur la faune sous-marine au large des cotes de France* (No. 591.92). Payot.

Lozano, P., *et al.* 2019. Habitat distribution and associated biota in different geomorphic features within a fluid venting area of the Gulf of Cádiz (South Western Iberian Peninsula, NE Atlantic Ocean). In: Harris, P.T., Baker, E.K. (Eds.), Seafloor Geomorphology as Benthic Habitat. Elsevier Science, London, pp. 717-726. https://doi.org/10.1016/B978-0-12-814960-7.00052-X

Lumsden, S.E., Hourigan, T.F., Bruckner, A.W., and Dorr, G. 2007. The State of Deep Coral Ecosystems of the United States, (NOAA Technical Memorandum CRCP-3. Silver Spring MD).

Maynou, F., and Cartes, J.E. 2012. Effects of trawling on fish and invertebrates from deep-sea coral facies of Isidella elongata in the western Mediterranean. Journal of the Marine Biological Association of the United Kingdom 92(7): 1501-1507. https://doi.org/10.1017/S0025315411001603

Morato, T., *et al*. 2018. A Multi Criteria Assessment Method for Identifying Vulnerable Marine Ecosystems in the North-East Atlantic. Frontiers in Marine Science 5:460. https://www.frontiersin.org/articles/10.3389/fmars.2018.00460/full

Morato, T., *et al.* 2020. Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic. Global Change Biology 26(4): 2181-2202.

Mordecai, G., Tyler, P.A., Masson, D.G., and Huvenne, V.A.I. 2011. Litter in submarine canyons off the west coast of Portugal, Deep Sea Research Part II 58: 2489–2496. https://doi.org/10.1016/j.dsr2.2011.08.009

Moreno, D. 2020. Description and quantification of the deep-sea megabenthic communities in Ormonde Seamount (NE Atlantic) using video analyses. Master Thesis. IMBR Sea master program, University of Ghent.

Murillas, J., Mougenot, D., Boulot, G., Comas, M.C., Banda, E. and Mauffret, A. 1990. Structure and evolution of the Galicia Interior Basin (Atlantic western Iberian continental margin). Tectonophysics 184(3-4): 297-319.

Mytilineou, C., *et al.* 2014. New cold-water coral occurrences in the Eastern Ionian Sea: Results from experimental long line fishing. Deep Sea Research II 99:146-157. https://doi.org/10.1016/j.dsr2.2013.07.007

NAFO. 2016. Report of the Scientific Council Meeting. 03-16 June 2016, Halifax, Nova Scotia. NAFO SCS Doc. 16-14 Rev., Serial No. N6587.

NEAFC. 2014. Recommendation 19:2014. Articles 2(c), 4 and 6(8). https://www.neafc.org/system/files/Rec19-Protection-of-VMEs_0.pdf

OCEANA. 2014. The seamounts of the Gorringe Bank. In: Fondazione Ermenegildo Zegna-Oceana. Doi.org/10.1016/0038-092X(86)90130-1

OCEANA. 2020. Unprotected marine treasures. An Oceana proposal to protect 15 marine biodiversity hotspots in Europe. Madrid, Spain. 20 pp. http://doi.org/10.5281/zenodo.3813183

Oliveira, F., Monteiro, P., Bentes, L., Henriques, N.S., Aguilar, R. and Gonçalves, J.M. 2015. Marine litter in the upper São Vicente submarine canyon (SW Portugal): Abundance, distribution, composition and fauna interactions. Marine Pollution Bulletin 97(1-2): 401-407.

Oliveira, F., *et al*. 2017. A photographic guide of the species of the Gorringe. Centro de Ciências do Mar/Oceana, Faro, Portugal, 312 pp. ISBN: 978-989-95587-4-8.

Orejas, C., Gori, A., Lo Iacono, C., Puig, P., Gili, .J-M., and Dale, M.R.T. 2009. Cold-water corals in the Cap de Creus canyon, northwestern Mediterranean: spatial distribution, density and anthropogenic impact. Marine Ecology Progress Series 397: 37-51. https://doi.org/10.3354/meps08314

Orejas C, *et al*. 2017. Cruise report MEDWAVES survey. (MEDiterranean out flow WAter and Vulnerable EcosystemS) ATLAS Project H2020. 211 pp and Appendixes

Palomino, D., *et al.* 2019. Cold-water corals in fluid venting submarine structures. In: Orejas, C., Jiménez, C. (Eds.), Mediterranean Cold-Water Corals: Past, Present and Future. Coral Reefs of the World, v.9 Springer, Cham. https://doi.org/10.1007/978-3-319-91608-8_24

Pham, C., *et al*. 2015. Deep-water longline fishing has reduced impact on Vulnerable Marine Ecosystems. Scientific Reports 4: 4837, https://doi.org/10.1038/srep04837

Pierdomenico, M., *et al*. 2018. Effects of trawling activity on the bamboo-coral Isidella elongata and the sea pen Funiculina quadrangularis along the Gioia Canyon (Western Mediterranean, southern Tyrrhenian Sea). Progress in Oceanography 169: 214-226. https://doi.org/10.1016/j.pocean.2018.02.019

Prado, E., Sánchez, F., Rodríguez-Basalo, A., Altuna, Á. and Cobo, A. 2019. Analysis of the population structure of a gorgonian forest (Placogorgia sp.) using a photogrammetric 3D modeling approach at Le Danois Bank, Cantabrian Sea. Deep Sea Research Part I: Oceanographic Research Papers 153:103-124.

Puig, P., *et al*. 2012. Ploughing the deep sea floor. Nature 489 : 286-289. https://doi.org/10.1038/nature11410

Pusceddu, A., *et al*. 2014. Chronic and intensive bottom trawling impairs deep-sea biodiversity and ecosystem functioning. Proceedings of the National Academy of Sciences 111(24): 8861-8866. https://doi.org/10.1073/pnas.1405454111

Ramos, M., Bertocci, I., Tempera, F., Calado, G., Albuquerque, M. and Duarte, P. 2016. Patterns in megabenthic assemblages on a seamount summit (Ormonde Peak, Gorringe Bank, Northeast Atlantic). Marine Ecology 37(5):1057-1072.

Rees, T. 2003. "C-squares", a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography 16(1): 11–19.

Reveillaud, J., *et al*. 2008. The distribution of scleractinian corals in the Bay of Biscay, NE Atlantic. Facies *54*(3):317-331.

Robinson, J.E., Newell, R.C., Seiderer, L.J., and Simpson, N.M. 2005. Impacts of aggregate dredging on sediment composition and associated benthic fauna at an offshore dredge site in the southern North Sea. Marine Environmental Research 60: 51–68. https://doi.org/10.1016/j.marenvres.2004.09.001

Rodríguez-Basalo, A., Sánchez, F., Punzón, A. and Gómez-Ballesteros, M. 2019. Updating the Master Management Plan for El Cachucho MPA (Cantabrian Sea) using a spatial planning approach. Continental Shelf Research 184: 54-65.

Rueda, J.L., Díaz-del-Río, V., Sayago-Gil, M., López-González, N., Fernández-Salas, L.M. and Vázquez, J.T. 2012. Fluid venting through the seabed in the Gulf of Cádiz (SE Atlantic Ocean, Western Iberian peninsula): geomorphic features, habitats, and associated fauna. In *Seafloor geomorphology as benthic habitat* (pp. 831-841). Elsevier.

Sánchez, F., Serrano, A., Parra, S., Ballesteros, M. and Cartes, J.E. 2008. Habitat characteristics as determinant of the structure and spatial distribution of epibenthic and demersal communities of Le Danois Bank (Cantabrian Sea, N. Spain). Journal of Marine Systems 72(1-4): 64-86.

Sánchez, F., *et al.* 2014a. Habitat characterization of deep-water coral reefs in La Gaviera canyon (Avilés Canyon System, Cantabrian Sea). Deep Sea Research Part II: Topical Studies in Oceanography 106:118-140.

Sánchez, F., Cartes, J.E. and Papiol, V. 2014b. Sistema de Cañones Submarinos de Avilés. Áreas de estudio del proyecto Proyecto LIFE+ INDEMARES.

Sánchez, F., Basalo, A.R., García-Alegre, A. and Gómez-Ballesteros, M. 2017. Hard-bottom bathyal habitats and keystone epibenthic species on Le Danois Bank (Cantabrian Sea). Journal of Sea Research 130: 134-153.

Serrano, A., *et al*. 2017a. Epibenthic communities of sedimentary habitats in a NE Atlantic deep seamount (Galicia Bank). Journal of Sea Research 130:154-165.

Serrano, A., *et al.* 2017b. Deep-sea benthic habitats modeling and mapping in a NE Atlantic seamount (Galicia Bank). Deep Sea Research Part I: Oceanographic Research Papers 126:115-127.

Terrinha, P., *et al.* 2009. Morphotectonics and strain partitioning at the Iberia–Africa plate boundary from multibeam and seismic reflection data. Marine Geology 267(3-4):156-174.

van Dalfsen, J.A., Essink, K., Madsen, H.T., Birklund, J., Romero, J., and Manzanera, M. 2000. Differential response of macrozoobenthos to marine sand extraction in the North Sea and the Western Mediterranean. ICES Journal of Marine Science 57: 1439–1445. https://doi.org/10.1006/jmsc.2000.0919 van den Beld, I.M., *et al.* 2017a. Cold-water coral habitats in submarine canyons of the Bay of Biscay. Frontiers in Marine Science 4, p.118.

van den Beld, I.M.J., Guillaumont, B., Menot, L., Bayle, C., Arnaud-Haond, S., and Bourillet, J-F. 2017b. Marine litter in submarine canyons of the Bay of Biscay. Deep Sea Research Part II: Topical Studies in Oceanography 145: 142-152. https://doi.org/10.1016/j.dsr2.2016.04.013

Vieira, R.P., *et al.* 2020. Deep-sea sponge aggregations (Pheronema carpenteri) in the Porcupine Seabight (NE Atlantic) potentially degraded by demersal fishing. Progress in Oceanography 183: 102189, https://doi.org/10.1016/j.pocean.2019.102189.

Xavier, J. and van Soest, R. 2007. Demosponge fauna of Ormonde and Gettysburg Seamounts (Gorringe Bank, north-east Atlantic): diversity and zoogeographical affinities. Journal of the Marine Biological Association of the United Kingdom 87(6):1643-1653.

Zibrowius, H. 1985. Scléractiniaires bathyaux et abyssaux des l'Atlantique Nord-Oriental: Campagnes BIOGAS (POLYGAS) et INCAL. In: Laubier, L., Monniot, C. (Eds.), Peuplements profonds du Golfe de Gascogne, Paris, pp. 299-310.

4.7 Future Directions

Encouraging Further VME Data Submission to ICES VME Database

To ensure that the best available evidence is used within the ICES advice process, it is important that all relevant VME data are submitted during formal data calls. Only when data are submitted can the information be used to provide an update on the assessment of areas where VMEs are known to occur or are likely to occur.

During a review of VME data and the VME Index, the WKEUVME workshop identified a number of potential VME data sources that have not yet been submitted to the VME Database. These data sources would add value to the delineation of areas where VME occur or are likely to occur, particularly in areas of the Bay of Biscay and Iberian Coast ecoregion where data coverage within the ICES VME Database is particularly sparse. Potential VME data sources are listed in the assessment sheets for each ecoregion and we suggest that data holders be encouraged to submit data in future VME data calls. These data sources likely contain VME habitat and indicator records, as defined by the FAO criteria and the ICES WGDEC VME taxa list. However, these will need to be assessed against such definitions prior to formal submission through the VME data call, and therefore not all these data may be submitted to the VME Database.

Encouraging future data submission

In the future, data submission may be further encouraged by connecting national points of contact with the project offices of deep-sea research projects. If on-going or recently completed projects are highlighted in the data call as a potential source of information, the latest developments in deep-sea research may be better reflected in the ICES VME Database. Drawing on experts within ICES working groups to either identify relevant research projects or to share the data call with project offices may be an easy first step to encourage further VME data submissions.

SDM Benchmarking Workshop

Habitat suitability models (HSM) and species distribution models (SDM) 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; Kenchington *et al*., 2016).

In 2014, WGDEC reviewed existing 'terrain-based models' for predicting VME distribution and concluded that published (peer reviewed) models should be taken into consideration for management decisions on deep-sea ecosystems (ICES, 2014). In 2018, the Review Group on Vulnerable Marine Ecosystems (RGVME) also recommended that statistical modelling techniques that produce predicted probability surfaces for VMEs should be further investigated by WGDEC, for the provision of new information on where VMEs are likely to occur, to support ICES advice to the EU and NEAFC. As a result, the 2019 WGDEC meeting was jointly held with the Working Group on Marine Habitat Mapping (WGMHM), who explored the use of HSMs and SDMs for mapping VME distribution in the North Atlantic. Through this work, WGMHM recommended that predictive models should be adopted by WGDEC to enhance their package of evidence provided to ICES for VME management, and they developed a 'roadmap' setting out the proposed steps to facilitate this adoption (ICES, 2019).

The roadmap from WGMHM 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 re-run. 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'.

WGDEC further considered the outputs from WGMHM at their 2020 meeting and options for implementing the roadmap. 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 (see Section 3.3). However, they 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 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.

As a result, it was decided that it would be beneficial to run an intersessional workshop, prior to WGDEC 2021, to further this work. A set of draft Terms of Reference were proposed by the group to:

a) Review and recommend a set of criteria, similar to the existing ICES benchmarking system for regional fish stock assessments, 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);
b) 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, PHM techniques (including spatial display of uncertainty) and required validation steps for the modelled outputs (Science Plan code 3.2);
c) Develop clear standards for recording the caveats and assumptions inherent in the modelling method, for future use (Science Plan code 6.2);
d) Conduct a trial run for a small number of existing models to ensure that both the approach and outputs are fit-for-purpose

The outputs of this workshop will be provided to ICES to determine the potential future application of predictive models within the ICES advice process. It is therefore suggested that future iterations of the closure recommendations to the European Commission take these predictive models into account as areas where VMES 'are likely to occur'. The WKEUVME would consider these in a similar way to the 'VME element' maps, to provide context and additional supporting information in areas where data is not available from the VME Database.

WGDEC VME Index

Towards Solutions

As noted in Section 4.2, there are some limitations to use of the VME Index in its current form and a number of improvements that could be made to support its use for ICES moving forward have been detailed by WGDEC in 2018 (ICES, 2018, Section 7.3). To aid that work, WKEUVME notes that the FAO definition does not recognise one VME as more valuable than another VME, therefore we could conclude that all VMEs should be afforded equal importance when determining their presence. If we accept that what a VME is has been defined and operationalised elsewhere (e.g., FAO, WGDEC and NEAFC), a revised index should focus solely on quantifying the likelihood of the presence of VMEs. For those relatively few datasets where abundance is available in the VME Database, this could be done by evaluating the recorded abundance for VME indicators species relative to a VME type-specific threshold. For example, the prevalence/dominance of 'Representative Taxa' (defined by NEAFC) could be used to identify the most likely VME Habitat Type in a C-square. This may require better identification of submitted records (e.g., beyond 'gorgonian'), but photo identification guides could be easily produced for representative taxa as has been done for other areas (e.g., Kenchington *et al*., 2015). The quality of a VME should be considered only with respect to other examples of that VME habitat type. Thus the abundance of cold-water coral reef indicator taxa in any given C-square should be ranked relative to the abundance of cold-water coral reef indicator taxa in all other C-squares, providing a quality ranking for cold-water coral reef C-squares. This ranking can then be divided in categories where needed. Gear efficiencies, and known weight of individuals of various taxa, could be used to develop more appropriate abundance thresholds, to help determine a cut-off point in C-square rankings that reflects VME quality/richness. Methods have been outlined previously for deep-sea sponge aggregations (Henry and Roberts, 2014), and these could be developed for each VME habitat type. Records of 'abundance' or 'density' take a variety of forms, thus multiple ways of assessing abundance or density are required.

References

Henry, L.A. and Roberts, J.M. 2014. Applying the OSPAR habitat definition of deep-sea sponge aggregations to verify suspected records of the habitat in UK waters. JNCC Report No. 508

Howell, K.L., Piechaud, N., Downie, A.L. and Kenny, A. 2016. The distribution of deep-sea sponge aggregations in the North Atlantic and implications for their effective spatial management. Deep Sea Research Part I: Oceanographic Research Papers 115: 309-320.

ICES. 2014. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 24–28 February 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:29. 70 pp.

ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 126 pp.

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

Kenchington, E., Beazley, L., Murillo, F.J., Tompkins MacDonald, G., and Baker, E. 2015. Coral, sponge, and other Vulnerable Marine Ecosystem indicator identification guide, NAFO Area. NAFO Scientific Council Studies 47: 1–74. doi:10.2960/S.v47.m1

Kenchington, E., *et al*. 2016. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada Using Kernel Density Analyses and Species Distribution Models. DFO Canadian Science Advisory Secretariat Research Document 2016/093. vi + 178 p.

Yesson, C., *et al*. 2012. Global habitat suitability of cold-water octocorals. Journal of Biogeography 39(7): 1278-1292.

4.8 Update of Annual Advice

ICES and Annual Advice Update for Regulation (EU) 2016/2336

Under regulation (EU) 2016/2336 there is a requirement for a competent scientific advisory body, such as ICES, to carry out an annual assessment of areas where VMEs are known to occur or are likely to occur. Below we outline how such an annual ICES advice process could be set up, in terms of 1) the established ICES VME and fishing activity data flows, 2) the subsequent assessment procedure now being developed, and how this links up to 3) the formal ICES advisory process.

ICES VME and Fishing Activity Data Flows

ICES has established a system involving formal data calls for both VME and fishing activity (VMS and logbook) data on an annual basis from its 20 member countries. The ICES Data Centre works closely with WGDEC (Working Group on Deep-water Ecology) and WGSFD (Working Group on Spatial Fisheries Data), to make the provision of spatial data from multiple sources consistent, thus ensuring clear and traceable provenance of the scientific information that is used in decision making. By implementing best practice data principles, both the quality and spatial and temporal coverage of these regional data sets has improved over time. This ensures that the best available, quality-assured evidence is used within the ICES advice processes, and that these processes are transparent and unbiased.

The Assessment Procedure

Once the data processing steps for both VME and fishing activity (VMS and logbook) data have passed through the respective data governance groups (WGDEC and WGSFD), the information can be combined to provide an update on the assessment of areas where VMEs are known to occur or are likely to occur and could be exposed to fishing pressure. This assessment would be based on the procedure now being established through this response to the EU's advice request on VMEs and the deep-sea access regulation. The assessment procedures that WKEUVME are developing incorporate a high degree of iteration with managers and stakeholders to ensure the request and response is understood both by them and ICES. This approach is consistent with the ecosystem approach, but maintains ICES' independence with respect to the content of the advice and is consistent with the ICES Advisory Plan.

The assessment procedure being developed can be used to annually review and update the scientific advice on closed areas upon request from the EU (DGMARE). Information derived using respective VME and fishing activity data flows will serve as input to operationalize a workflow that is fully documented using ICES TAF (transparent assessment framework, see Figure 4.32 below) principles. The workflow, with its respective scripts, is available on an open source platform (WKEUVME GitHub site). This will also ensure the ICES advice is based on evidence that conforms to the FAIR principles, to ensure that data are fully documented and processed using ICES best practice guidelines (ICES, 2019). This workflow also contains the scripts to establish the closures, the closure shape files for each option and the scripts to assess the consequences of these closures on VME protection and fisheries. These can be updated annually with new information.

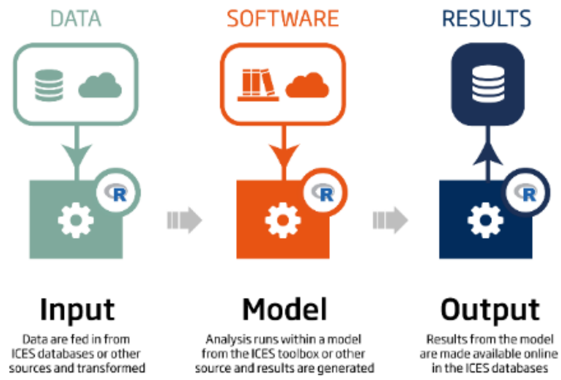


Figure 4.32. Conceptual diagram of the ICES transparent assessment framework enables anyone to easily find, reference, download, and run the assessment from any stage in the process leading to the published ICES advice.

Following the annual Advisory Committee (ACOM) advice process, the established assessment procedure can also be revised and/or updated by ICES in the future. This could incorporate, for example, the use of habitat suitability and species distribution models (see below) or further refinement of the VME Index method (see below). Before incorporation, any improvements to the procedure would need to go through a peer-review process, to be considered by the ACOM advisory process.

Next to the fisheries activity and VME data, three data layers were used for the production of data products and will be updated when new information becomes available:

- Shapefiles Exclusive Economic Zones: EEZ_land_union_v2_201410 - VLIZ (2014). Union of the ESRI Country shapefile and the Exclusive Economic Zones (version 2). Available online at http://www.marineregions.org/ Accessed June 2019.
- Shapefiles ICES ecoregions: *ICES_ecoregions_20171207* ICES ecoregions (2017) http://gis.ices.dk/shapefiles/ICES_ecoregions.zip Accessed June 2019.
- Bathymetry data for the selection of C-squares within the 400-800 meter depth range: EMODNET. ESRI ASCII Mean Sea Level format EMODnet Bathymetry Consortium (2018). EMODnet Digital Bathymetry (DTM 2018). EMODnet Bathymetry Consortium. https://doi.org/10.12770/18ff0d48-b203-4a65-94a9-5fd8b0ec35f6. Accessed *April 2020.*

Formal ICES Advisory Process

The formal ICES advisory process would be used to provide annual assessment updates of areas where VMEs are known to occur or are likely to occur (as is done for NEAFC VME advice). As an international scientific body, ICES is able to draw on its network of experts from its 20 member countries and beyond to provide objective and transparent science and advice. Below we highlight the steps in the process.

The ICES VME and fishing activity data flows, and the assessment procedure developed via the advice process for WKEUVME will form a solid foundation on which ICES can base any future updates on. The annual update of areas where VMEs are known to occur or are likely to occur will also require an ICES expert group to synthesise knowledge, which will supplement the annual assessments for use under regulation (EU) 2016/2336. This knowledge synthesis phase of the ICES advice process will be guided by the ICES Data Policy (ICES, 2016), the ICES advice framework (link) and the code of conduct (link).

The advisory services of ICES are coordinated by the Advisory Committee (ACOM) with members from all its 20 member countries. Upon receipt of a request for an annual review, ACOM will task specific ICES expert groups, and/or ICES will convene a workshop, to compile and analyse the data and, informed by the best available science, prepare the technical input for the response.

Annual Advice request EU (DG MARE) -> ICES ACOM, process and TORs

1. Data Call - annual call for VME and fishing activity (VMS and logbook) data
2. Data submission quality checks (QC) and feedback to submitting countries - by ICES data centre working with respective data governance groups, WGDEC and WGSFD.
3. Data products produced by WGDEC and WGSFD expert groups using respective data.
4. Annual assessment - VME and fishing activity data products serve as input data to run the assessment procedure.
5. Expert interpretation of assessment that can be supplemented with other information.
6. Annual update to areas where VMEs are known to occur or are likely to occur

ICES **peer-review** of assessment sheets – in relation to request

Advice Drafting Group meeting (Advisory Committee, ACOM) – draft advice

Annual ICES **Advice** to EU (DGMARE)

Once the technical work has been carried out by ICES experts, a peer review is undertaken. This is an independent review of data and methods, ensuring that the best available evidence and science has been used. Following this review, the response to the request is drafted by an ACOM appointed advice drafting group. This draft advice is scrutinised by ACOM and, if approved delivered to the requestor and published on the ICES website. The evidence and supporting rationale are explained in the advice, with reference to the underlying technical work.

Upon delivery of the advice the EC may wish to iteratively refine the subsequent advice question(s) as part of collaborative agreements with ICES to provide annual advice.

ICES may also wish to include the assessment (or parts of them) in further iterations of the annual Ecosystem Overview (EOs) advice and Fisheries Overview (FOs) advice. There are also strong links to shallower water assessment procedures developed by WGFBIT (Working Group on Fisheries Benthic Impact and Trade-offs) that have been developed for the ICES Ecosystem Overview advice in the context of Descriptor 6 seafloor integrity of the EC's marine strategy framework directive (MSFD).

References

ICES. 2019. ICES User Handbook: Best practice for Data Management. Copenhagen, Denmark, International Council for the Exploration of the Sea, 16pp. http://doi.org/10.17895/ices.pub.4889

5 Run a dissemination meeting in Brussels, Belgium (24-25 June) to discuss the regulatory area options that the workflow and criteria produce. Gather stakeholder arguments and preferences that can be used to fine-tune a list of closed area boundaries and identify knowledge gaps associated with each proposed area.– ToR [c]

Day 1

The workshop convened through WebEx at 1200 CET on 1 September. All participants (Annex 2) were welcomed by the co-chairs, Peter Hopkins and Ellen Kenchington and by the Chair of ACOM, Mark Dickey-Collas. Thereafter those present introduced themselves and briefly recounted their expertise and interest in attending the workshop. In advance of the meeting all participants were given a Dissemination Document (Annex 3), questionnaire to consider (Annex 4), and an explanation of how to access and use the interactive maps that were prepared to support the meeting.

Eugene Nixon (ICES) opened with a presentation on the background to the request and the overall approach taken by ICES. Following that, Laura Robson and Helen Holah provided overviews of the ICES data on vulnerable marine ecosystems (VMEs) and fishing activity respectively. Other than points of clarification the questions were focused on how the fishing footprint was created and how the data on fishing activity was used:

a) The footprint is defined in the legislation as the area fished by vessels with deep sea fishing licences in the period 2009 – 2011. However, as ICES does not have information on licences, but on VMS records transmitted by Member States, the fishing footprint identified by the Workshop is restricted to the depth range 400-800 metres, where it is assumed that the vessels active in those waters had deep-sea licences. Moreover, the closures to protect VMEs will be defined in this depth range. Nevertheless, managers should be aware that they may need to extend the footprint defined by the Workshop to include shallower waters when it comes to deciding the areas that the vessels are permitted to fish in the future. It should be noted that the footprint delineated by the Workshop relates to the activity of vessels in the 400-800 metre depth range, whereas the footprint defined by Regulation 2016/2339 would also include any activity by vessels with deep sea fishing licences outside this depth range.

b) Helen Holah made the point that only the WKEUVME members who undertook the technical work and had signed the ICES data policy had access to the ICES aggregated Swept Area Ratio (SAR) data product. This data set included values for C-squares with fewer than 3 vessels fishing and all data was taken into account in creating the fishing footprint in response to the EU request. As the underlying data values of the fishing footprint were not publicly available there was no problem with data confidentiality.

c) The information given in the report on the C-squares that would be closed under each of the scenarios include squares both inside and outside the fishing footprint, but all are within the 400 – 800 metre depth range. However, it may be that the buffer zone and hence the closure extends into waters shallower than 400 metres or deeper than 800 metres. Conversely, it may be that the buffer zone of a VME outside the 400 – 800 metre depth range extends into that depth range, which would therefore result in a closure.

Peter Hopkins made a presentation on the management implications of the scenarios and options, highlighting how the scenarios were determined and what the distinctions were between them from a management perspective. This was supported by a presentation by Daniel van Denderen on using the interactive maps. Daniel showed how closed areas were created under the different scenarios/options using the interactive maps. The discussions raised the following points:

a) Low VME index C-squares are not closed under Scenario 1 (unless they are next to a *bona fide* VME habitat or High or Medium index C-squares). If Low VME index C-squares were included it would close large areas to fishing where there is scant evidence, given the limitations in data collection (see Annex 2), of VME presence. Low index VME squares were included in Scenario 2, where fishing activity is explicitly considered. This has the advantage of protecting certain VME types, such as sea pens, which are generally classified as Low index squares based on the way in which abundance feeds into the VME index. As it stands, sea pens can never attain the status of 'High VME Index' and only reach the threshold to be considered as 'Medium VME Index' when bycatch totals more than 30 kg of sea pens. In the Celtic Sea region there is a lot of information on sea pens, which covered a large number of Low VME index C-squares. Given the issues associated with the VME index, and with Low VME index values in particular, the Technical Workshop decided to treat the Low VME index values differently. The Workshop is presenting the available information in as an objective manner as possible, and it is up to managers to decide on their preferred options on the basis of that information.

b) Reference was made to a report on a methodology by Pitcher *et al.* that may provide insights in setting threshold abundance values for the VME Index: https://www.sprfmo.int/assets/2019-SC7/Meeting-Docs/SC7-DW21-rev1-Uncertainty-in-model-predictions-and-VME-thresholds-for-CMM-03-2019.pdf

c) Some participants considered that a combination of Scenario 2 option 1 and Scenario 1 option 2 would have the greatest conservation benefit, i.e. including VME elements in the fishing Scenario 2. The technical Workshop did not consider this option due to concerns over the resolution of the base maps available for mapping VME elements on the continental margin, but managers are able to explore the implications for VME protection and for the impact on fisheries by using the interactive maps.

d) There is no distinction made between squares that have been surveyed or sampled but no VMEs found and squares that have never been surveyed or sampled. It was noted that WGDEC are working towards including validated absences in the database, but this issue has not yet been fully resolved. This is one of the reasons that VME elements are included in Scenario 1 Option 2. In the future it is hoped that species distribution models will be able to add to the knowledge base for where VMEs are likely to occur. ICES expects to hold a workshop in 2021 to develop standards for the use of such models in ICES advice. It was also pointed out that a VME observation in one corner of a C-square would result in the closure of the whole C-square, as well as the half C-square buffer area. This is precautionary and protects a large area with potential VME presence.

e) The number closures are very similar between scenarios, but the impact on fishing of Scenario 2 option 2 is substantially lower. This is because Scenario 2 option 2 does not close areas that are fished above a swept area of 0.43. How this value was derived is explained in the Technical Report but is based on evidence from NAFO showing that C-square fished at swept area greater than 0.43 are at potentially relatively low risk of VME impact as it is assumed that the ecosystem is already degraded. This assumption was not accepted by all participants., regardless of the VME index level. Even excluding a small area that is heavily fished can reduce the impact on the fisheries quite substantially.

Day 2

Day 2 began with presentations from Jan Geert Hiddink and Lenaick Menot that focussed on the implications of the options for each of the Celtic Seas Ecoregion and the Bay of Biscay and Iberian Coast Ecoregion respectively.

The discussions raised the following points:

a) The impact on the fishing activity is measured only as the proportion of the total Swept Area Ratio that would be included in the closures. There is no economic assessment of the value of the fisheries in the closed areas compared to the value outside the closed areas. Such information is not readily available. Member States may provide their own analyses, which could be considered by the Commission when drawing up its proposals for closed areas. It was however noted that C-squares with low fishing intensity (based on swept area) are unlikely to be the most valuable (otherwise they would have attracted a higher fishing intensity). There is a section in the Technical Report on this issue (page 31) explaining the reasons for the absence of an economic evaluation. There are however tables in the report regarding the impact on the various métiers and the associated fisheries.

b) Coral obligate species, including commercially fished species, have not yet been identified, however it is known that fish use the VME habitats for food, shelter and egg-laying (skates and rays). Closed areas might give a net positive effect to the fish if the habitat is being protected, potentially increasing catches in adjacent areas. Some of these issues are being addressed in the CoralFISH EU project (http://eu-fp7-coralfish.net/)

Following the presentation and discussions, the participants split into two breakout groups, one for each of the Ecoregions, to discuss in more detail the implications of each of the scenarios and options (see Annex 3 and 4 for scenarios and questionnaires).

Following the breakout groups, the plenary resumed with a short demonstration of how the interactive maps could be used to explore additional options not covered by the Workshop (for example adding VME elements to the closures under Option 2.1).

The leads of the breakout groups then presented summaries of their discussions:

Celtic Sea Breakout Group

Preferred Options

2 of the 4 participants preferred Scenario 1 option 2 (one of whom preferred this option to be combined with Scenario 2 option 1), and one participant preferred either of the options in Scenario 2 because the explicit account taken of fishing activity is easier to defend. The protection of VME elements in large areas was generally considered to be desirable.

Scenario 2 option 2 was controversial. It has the advantage is that it limits the economic impact, but the approach assumes that the VMEs in high fishing intensity squares are damaged beyond recovery. Some of the participants felt that the use of a SAR threshold did not consider the fact that VMEs may be able to recover in some cases. The assumption that heavy fishing would remove all VME was also questioned, and it was noted that they may not be absent even if they are not collected in trawl bycatch. It was explained that the threshold was established to distinguish areas where significant adverse impacts (from the UNGA Resolutions) may have occurred, and such areas are not expected to recover in a 15 year timeframe according to the FAO guidelines.

Missing Data

Outcomes could be strongly driven by absence of VME records in areas that are not surveyed so species distribution models should be used in future

Fraction of Area Closed

Approximately 20% of the area closed and between 3% and 11% of fishing effort affected were considered by all participants to be reasonable. These percentages may overestimate the real impact of the closures on the fisheries if there is significant activity in waters shallower than 400 metres, which is not taken into account by the Workshop. Nevertheless local fish stocks, fishing vessels or ecological features may still be strongly affected.

Spatial Patterning of Closures

The closures resulting from each of the scenarios would result in a large number of small closures. Modern navigation systems should be able to cope with this easily, but 2 hourly VMS signals could make enforcement difficult, and fishers do not want to make detours around closed areas with the time and fuel costs this would entail. Considerations might be given to allow innocent passage of fishing vessels within VME closed areas through a combination of MCS measures, such as reducing VMS signal frequency reporting from 2 to 1 hour, and gear sensors to ensure the vessel is navigating and not fishing between grounds. This has proven to be successful in a technical measure related to seasonal closure of Porcupine Bank (FU16) for *Nephrops* included as a footnote in the EC Regulation on Fishing Opportunities for the Atlantic.

It was noted that the degree of ecological connectivity between VME clusters is unknown, for example the locations of source and sink populations of VME indicator species.

Other Observations

Differences between the scenarios and the resulting closures are quite subtle, so clear communication is important

There should be periodic reviews of closed areas as new information becomes available. This should include the lifting of closures as well as the addition of new closures as appropriate.

Observer coverage needs to be implemented to improve VME observation records and provide better information on the locations of VMEs and VME indicator species as well as interactions of various gear types with VMEs and indicator species.

Bay of Biscay and Iberian Coast Breakout Group

All the opinions expressed were stated to be provisional.

Preferred Options

Three participants were inclined towards Scenario 2 option 1, with the aim of protecting more VMEs. Two participants provisionally favoured Scenario 1 option 1 or Scenario 2 option 2, because they are knowledge-based and offer the most balanced options between preservation and socio-economic interests. One participant preferred a mix between scenario 1.2 (including VME elements) and scenario 2.1 (including Low index VME) on the basis that this will provide better protection of VMEs as required under Regulation 2016/2339 on the basis of the precautionary approach in light of current limitations of the available data.

Missing Data /Information

The occurrences of VMEs: data are incomplete. The situation can be improved by approaching data owners, improving data flow for observers at sea and training observers.

The Commission will review the VME closures annually as new information becomes available.

For more information on the location of the VME (co-ordinates) and the type of VME present in each closed area, Member States and managers can refer to the data in Github using the following link: https://github.com/ices-eg/wk_WKEUVME/

It is difficult to determine a preference, as the socio-economic impacts are unknown. Some fisheries go to some places on a regular basis which might be important for them, even though effort is not very high.

Implementation

None of the participants foresaw issues for offshore vessels, but it some considered that could be difficult nearshore where small vessels with no VMS are operating (this mostly concerns longliners). However this would require further investigation.

Day 3

Rationale for the Selection of Scenarios

The Technical Workshop considered that the United Nations General Assembly (UNGA) resolutions are a key point in setting the options. The two options presented for Scenario 1 prioritize protection of VME, irrespective of the fishing activity (Table 4.6). These are consistent with the UNGA resolutions, specifically UNGA 61/105, paragraph 83:

> *(c) In respect of areas where vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, are known to occur or are likely to occur based on the best available scientific information, to close such areas to bottom fishing and ensure that such activities do not proceed unless conservation and management measures have been established to prevent significant adverse impacts on vulnerable marine ecosystems (UNGA, 2006).*

The two options presented for Scenario 2 prioritize protection of VME but incorporate a threshold for the level of fishing activity that is linked to significant adverse impacts (Table 4.6). These are consistent with the United Nations General Assembly (UNGA) resolutions, specifically UNGA 61/105, paragraph 83:

> *(a) To assess, on the basis of the best available scientific information, whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems,*

> *and to ensure that if it is assessed that these activities would have significant adverse impacts, they are managed to prevent such impacts, or not authorized to proceed (UNGA, 2006).*

Why Aren't Canyons Included in the VME Elements?

Canyons are not included in the elements as we do not have a good source of information. Bathymetry data does not provide the small canyons. EMODNET data provides canyon systems that include multiple canyons that result in large closures when one canyon head overlaps with one VME. This was seen as too conservative. For ridges, banks and so on, it was easier to find the elements based on topography.

How Were the Average SARs Calculated?

For establishing the 0.43 threshold, the average of the SAR over each of the years 2009 – 2019 was used. To assess the impact of the closures on the fishing activity, the average SAR for each of the periods 2009 -2011, 2012 -2015 and 2016 – 2019 were used.

Difference in Treatment of Mobile and Static Gears

It was noted that the closures that would result from Scenario 2 would be based on the fishing intensity of mobile bottom contacting gears only. This is because the Workshop had no measures of fishing intensity for static gears. Nevertheless, static gears are included in the definition of the footprint, and according to the legislation would also be prohibited from fishing in the closed areas. It would be up to managers to decide whether or not to treat static and mobile gears differently, for example by prohibiting mobile gears in a closed area but allowing the use of static gears.

WGSFD are currently investigating how to develop fishing intensity measures for static gears which could be incorporated into future advisory products.

Annex 1: Working Document for WKEUVME: Draft Workflow in Response to TORa

The draft workflow produced by the WKEUVME Planning Committee (Annex 3) in response to TORa is detailed below. This workflow was reviewed by the ICES WGECO at their 2020 meeting and their comments and subsequent changes to the workflow that were implemented by the May meeting of WKEUVME are summarized in Section 3.1. It should be noted that in operationalizing the workflow WKEUVME **further improved the approach to determining regulatory options (Section 4)**. Therefore the draft workflow serves to document the process leading up to the May meeting of WKEUVME which provided the core of the response to the EU request (TORb), but does not represent the workflow that was implemented; that is detailed in Section 4.

Background

In April 2019, the European Commission sent a request to ICES to deliver "**advice on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas (ref. (EU)2016/2336)".** ICES informed the Commission that it would provide an interim technical service by the end of 2019 leading to final advice in 2020. The output of the technical service was finalised and reported in November 2019 and outlined a framework whereby a range of closed area options could be identified to managers and stakeholders so as to facilitate consideration under different protection and management scenarios, (ICES, 2019). The workflow set out below is being undertaken by ICES, in collaboration with the managers and stakeholders, to collate, analyse and present a range of potential options to protect VMEs within EU waters at depths between 400 and 800m5 (Figure 1).

ICES has well established protocols to ensure only the best available data and science is used. To this end VME and fisheries data governance groups (WGDEC and WGSFD), as well as WGECO will provide input and review the outputs of the workflow prior to the workshop. In addition, operational data products developed by the ICES Data Centre will be used to ensure consistency across various data sources (e.g., NEAFC VME closed areas) and to enable clear and traceable provenance of information for decision making. Regulation (EU) 2016/2336 includes the requirement for an annual review of any VME closed areas and it is therefore essential that the workflow can accommodate *future updates of the assessment* in accordance with established ICES VME and VMS data and data calls and associated ICES data policies. This will also ensure that ICES advice (current and future) is evidence based and conforms to the ICES FAIR principles.

The workflow incorporates a high degree of iteration with managers and stakeholders but maintains ICES' independence of advice and is consistent with the need for such approaches when providing ecosystem advice as set out in the ICES Advisory Plan.

5 Bottom trawling at depths > 800 metres is prohibited in all areas, (EU)2016/2336.

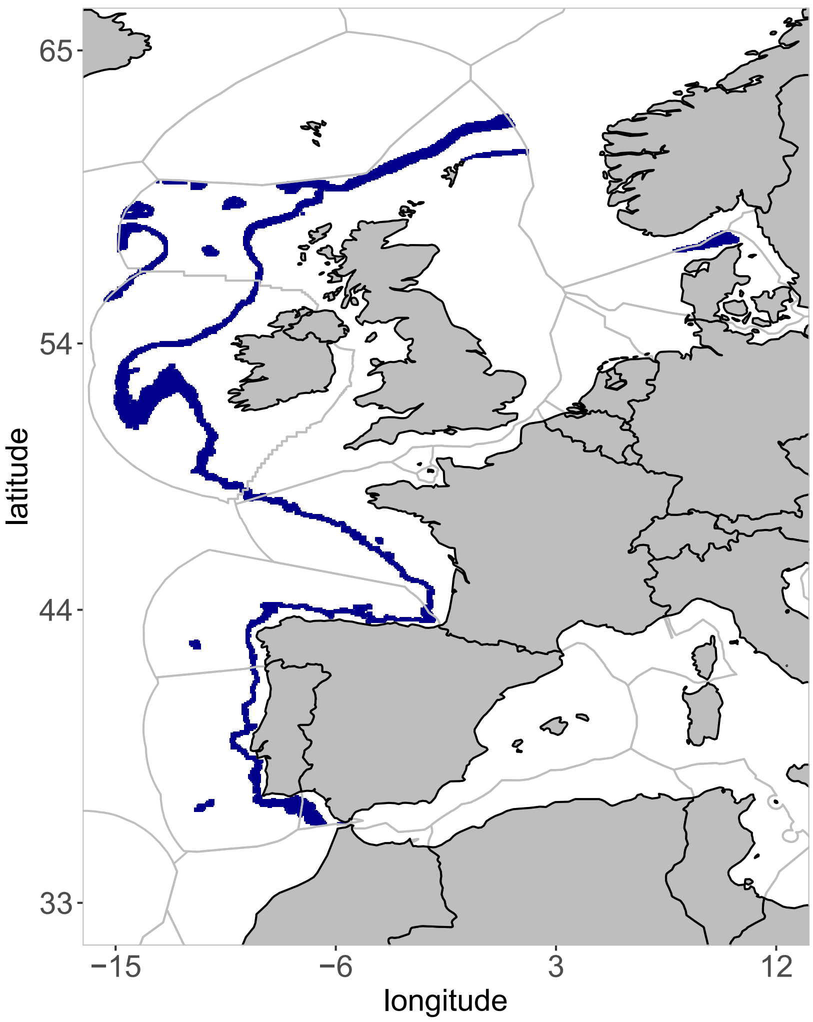


Figure 1. Northeast Atlantic with area between 400 m and 800 m depth (blue shades) for different national exclusive economic zones (UK, Ireland, France, Spain, Portugal and Denmark, grey lines) that constitute EU waters within the depth range of this request. Depth is extracted from bathymetry data of ETOPO1 Global Relief Model with sea ice cover. Areas within the EEZ of the Azores are not shown. All C-squares with modeled observations within 400-800 metres are included in the blue shaded area. For the final data product, we will use EMODnet bathymetry data (ICES, 2018).

Workflow for the delivery of advice options and their potential to protect VMEs versus restrictions on fishing activities within the 2009-2011 fishing footprint (23-24 March 2020)

Clear and transparent options are required to better understand the potential of measures to protect known areas or areas where VMEs are likely to occur from impacts of fishing activities versus the effect (distribution/landings/value) of these measures on fishing activities. Figure 2 describes a 4-step workflow to identify these options and their impact on fishing activities in order for decision makers to agree on an acceptable delineation of closed areas to protect VMEs from some of the physically damaging effects of bottom-contact fishing gears.

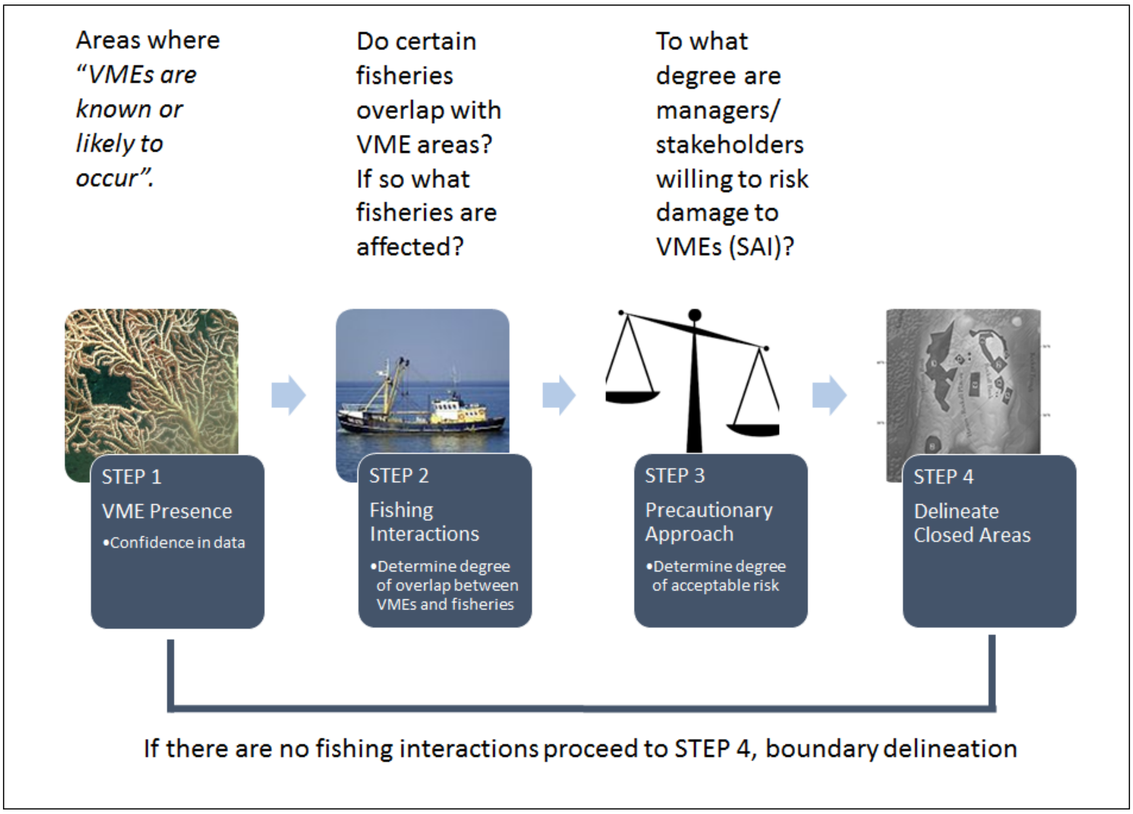


Figure 2. Workflow leading to the delineation of closed areas to protect vulnerable marine ecosystems.

These 4 steps can be subdivided as follows in order to operationalize the workflow:

1.1 Identification of VME habitats and indicators, their quality and degree of confidence;

1.2 Display of point data showing the VME types;

1.3 Aggregation of the information to display at C-square6 resolution;

2.1 Estimates of swept area ratios per C-square by métier;

2.2 Overlay fishing intensity maps with maps of VME occurrence;

3.1 Identification of C-squares with high, medium and low fishing intensities and their overlap with C-squares with high, medium and low confidence of VME presence;

3.2 Present criteria for closed areas (for example low fishing intensity overlapping with high VME quality might have a high priority for closure, high fishing intensity and low VME quality, a low priority for closure). The final choice of criteria would be left to managers based on the weights they choose to give to VME protection and the cost to the fishing activities.

4.1 Based on the criteria chosen after Step 3.2, identify C-squares that could be closed;

6 The C-square resolution used here is a 0.05 x 0.05 degree grid, equivalent to approximately 15 km² at 60°N latitude, using the approach detailed in Rees (2003). For more details see http://www.cmar.csiro.au/csquares/spec1-1.htm

4.2 Provide higher resolution information for the C-squares identified in 4.1 for fine-tuning the decisions on whether or not all or part of the C-square could remain open;

4.3 Provide expert knowledge concerning the likelihood of VME occurrence in nearby C-squares for which there is no other information;

4.4 Consult with stakeholders before final delineation of closed areas, including e.g., buffer zones.

In order to aid decision-making, trade-off analyses can often be useful. Trade-off analyses generally begin with defining the alternatives available, determining the criteria that are needed to make a final decision, weighting the criteria and analysing the results. ICES has previously held a workshop to evaluate trade-offs between the impact of fishing on seafloor habitats and provisions of catch/value (WKTRADE; ICES, 2017). They proposed an "Assessment Information Sheet" that provides illustrations of the pressure, seafloor status, impact and on the trade-off between impact and landings or value supplemented with a short accompanying text. Pressure from bottom-contacting fishing gears in the assessment year, estimated as the swept area ratio per C-square (SAR), was presented in a map together with a map of the seafloor habitats as proposed here for the special case of VME habitats. The sheet further presents the temporal development of the areal extent (footprint) in region and habitats, the degree of aggregation of the trawling activities within the footprint, the temporal development in the average status of the seafloor in the region and main seafloor habitats, the temporal development of the impact in region and habitats of a selection of métiers. Finally, information is presented about the relation between the status and the value or landings per unit of impact. A modification of this sheet specific to VMEs could assist in trade-off discussions in future.

Data Layers to Address Step 1 of the Workflow

The required input data on VMEs (or parameterization) that will operationalize this or a similar workflow will be based on the available VME data from ICES (link). This data flow, as well as the underlying analysis that this workflow will establish, will be fully documented using the ICES Transparent Assessment Framework (TAF).

Areas where Vulnerable Marine Ecosystem (VME) are Known or Likely to Occur

Data on vulnerable marine ecosystems (VMEs) in the ICES VME Database includes point and line data on individual VME indicator and habitat records, where available. In addition, data on the potential location of VME habitats (e.g., where VME *are likely to occur*) has been determined by WGDEC, using a published multi-criteria assessment method (Morato *et al.*, 2018). This collates VME indicator point records within a C-square and determines whether a VME is likely to be present, based on an evaluation of the vulnerability of the indicator species present and their abundance (where this information is available). It also assesses the confidence placed in the data (low, medium or high), based on four criteria: data collection method, number of samples within the C-square, time span of data (between first and last record) and time since last survey. The VME likelihood and confidence scores collectively provide an evaluation of the certainty of the VME habitat being present. Binary evaluations of the VME (e.g., High quality - High confidence; Medium quality - High confidence; Low quality - High confidence; High quality - Medium confidence; Medium quality - Medium confidence; Low quality - Medium confidence; High quality - Low confidence; Medium quality - Low confidence; Low quality - Low confidence) using this method are provided for each C-square where data are available. These data can be presented as the original point data, which provides the scientific name of the VME indicator and the habitat types, and as VME presence at the scale of the C-square.

However, it should be noted that in applying the multi-criteria assessment method, cells can have a high index classification score whether they have just one, or multiple, high ranking (e.g., high vulnerability and high abundance) VME indicators present. Consequently, it will be important to review the type of VME that is being considered for protection once areas of interest are identified. Further, the location of valid null records (areas where surveys have been done and no VME indicator taxa and/or habitats have been found) would be valuable information for the current exercise and ICES is currently assessing how to incorporate such information into its database.

To address these knowledge gaps we propose to draw on the Food and Agriculture Organisation of the United Nations' (FAO) International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO, 2009; para. 21, 45):

> *ii. identify areas or features where VMEs are known or likely to occur, and the location of fisheries in relation to these areas and features;*

and

> *45. Where site-specific information is lacking, other information that is relevant to inferring the likely presence of vulnerable populations, communities and habitats should be used.*

Drawing on the advice in the Annex "Examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them" of those guidelines (FAO, 2009) a number of VME elements (that is supporting features) are exemplified:

> *Examples of topographical, hydrophysical or geological features, including fragile geological structures, that potentially support the species groups or communities, referred to above:*
>
> *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).*

Species distribution models (SDMs) can also be used to provide an evaluation of whether a VME or VME indicator is `*likely to occur*' (Figure 3). These models use a range of environmental predictors, including oceanographic and topographic variables, to approximate distribution of particular VME species (e.g., cold-water corals, sponges) based on species' abiotic preferences. These models can be verified with groundtruthing data where available. Furthermore, more broad-scale habitat features ('VME elements') such as canyons, seamounts and hydrothermal vents can be mapped using bathymetric data and used as a proxy for VME presence, since these areas are commonly known to support VMEs (Figure 3). NEAFC recognizes isolated seamounts, steep-slopes and peaks on mid-ocean ridges, knolls, canyons and steep flanks > 6.4° (NEAFC, 2014). Use of SDMs and VME elements can fill in gaps between direct observations of VMEs derived from the VME Database and are a good proxy for where VMEs are *likely to occur*. This type of approach has been adopted by NAFO in the northwest Atlantic, where managers have used the location of VME elements, and SDMs showing probability of occurrence for black corals, large gorgonian corals, sponges and sea pens, to determine where to place closed areas (NAFO, 2013). However, due to the predictive nature of SDMs and VME element mapping, there would be lower confidence in these datasets for determining VME presence than with observational data from the VME Database and multi-criteria assessment method outputs.

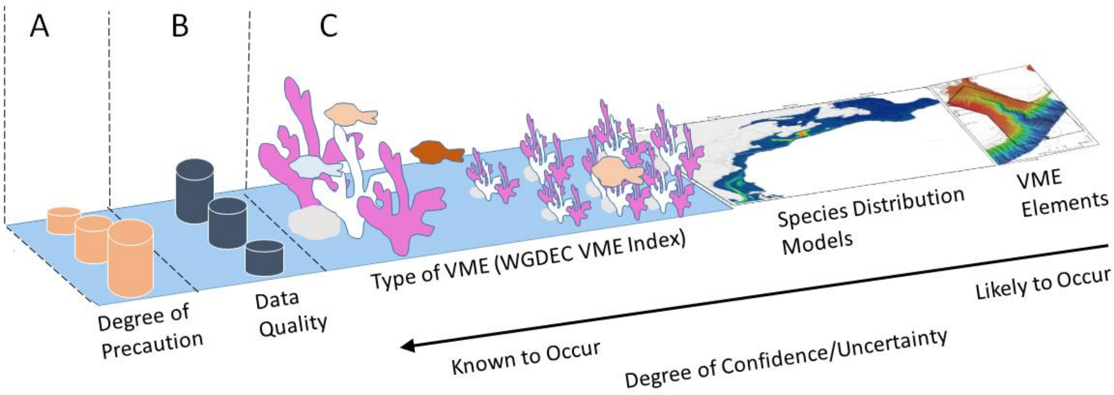


Figure 3. Illustration of the elements required for decision making. A) Increasing application of the Precautionary Approach is associated with B) decreasing data quality and C) degree of confidence in the presence of the VME habitat.

Consequently, we propose to add a new dimension over that discussed in WKREG (ICES, 2019) which will introduce a precautionary approach into the VME designation for each C-square (Figure 3). The following categories would utilise these varying data sources in a stepwise approach, with decreasing data quality and associated confidence in VME presence moving down the categories. This would therefore increase the degree of precaution in use for management, when considering VME closures based on these categories:

- VME Known to Occur: ICES VME habitat confirmed using VME records from the ICES VME Database and mapped by C-square with the multi-criteria assessment tool (Figure 4)
- VME Likely to Occur based on VME indicator presence: ICES VME High and Medium quality with High, Medium and Low confidence using the multi-criteria assessment tool (Figure 5)
- VME Likely to Occur based on VME indicator presence: ICES VME Low quality with High, Medium and Low Confidence using the multi-criteria assessment tool (Figure 6)
- VME Likely to Occur based on Species Distribution Models of VME indicators or VMEs;
- VME Likely to Occur based on the presence of VME Elements: Presence of the VME elements listed in the Annex of the FAO International Guidelines noted above (FAO, 2009).

These categories are summarised in Table 1 and Figure 3 , to illustrate the change in degree of precaution, data quality and confidence in VME presence as you go through the categories. Table 1 also summarises the relevant data sources for each category.

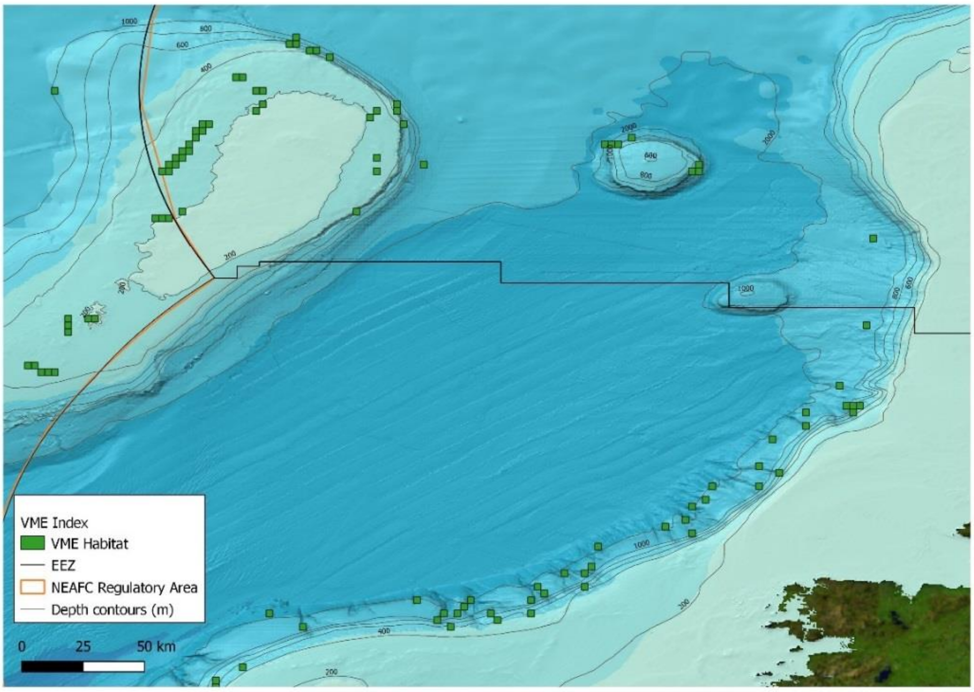


Figure 4. Example area of the continental shelf within the EEZs, showing areas of known VME (VME Habitat) mapped at the scale of C-square grids. Copyright: Base map imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2020). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Depth contours: GEBCO (2004). Map projection: EPSG:4326 - WGS 84.

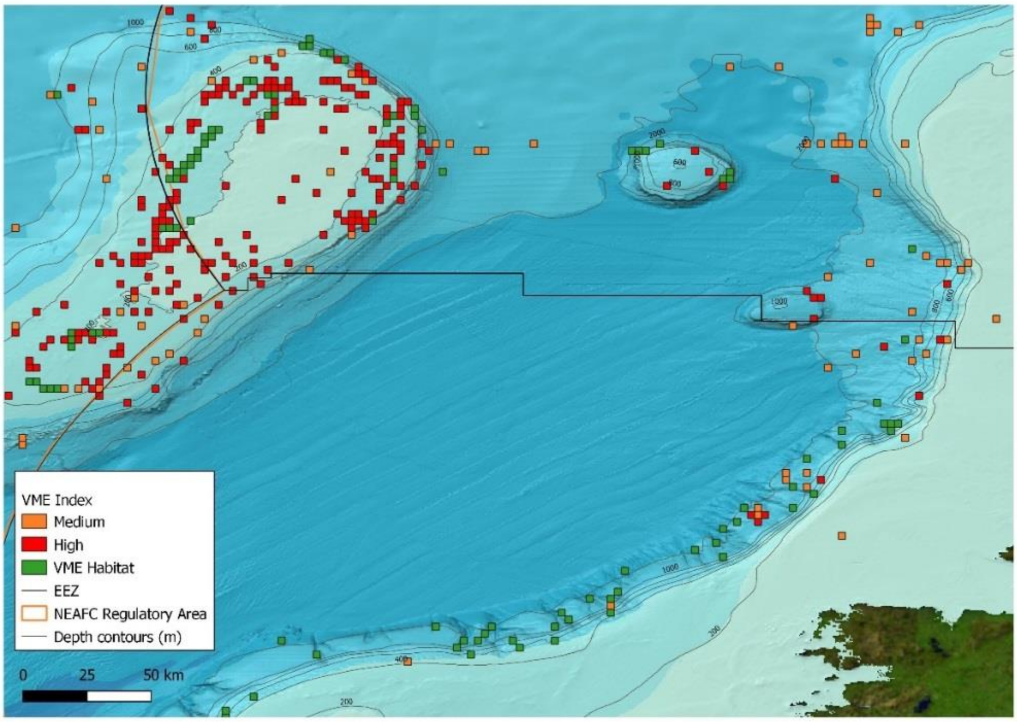


Figure 5. Example area of the continental shelf within the EEZs, showing areas of known VME (VME Habitat) and High and Medium quality VMEs from the VME Index, mapped at the scale of C-square grids. Copyright: Base map imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2020). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Depth contours: GEBCO (2004). Map projection: EPSG:4326 - WGS 84.

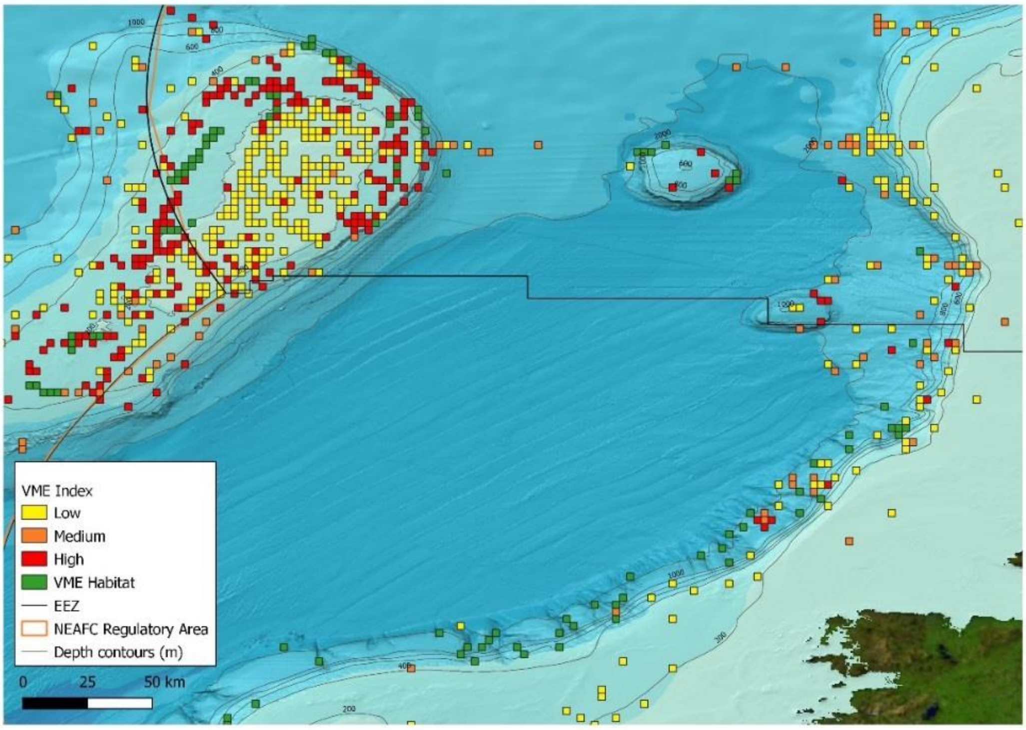


Figure 6. Example area of the continental shelf within the EEZs, showing areas of known VME (VME Habitat) and High, Medium and Low quality VMEs from the VME Index, mapped at the scale of C-square grids. Copyright: Base map imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2020). Maritime Boundaries Geodatabase, version 11. Available online at http://www.marineregions.org/. Depth contours: GEBCO (2004). Map projection: EPSG:4326 - WGS 84.

Table 1. Linking degree of precaution required to make management decisions with characteristics of the VME data (see Figure 3).

Degree of precaution	Data quality	Confidence of VME presence	Data source
Low	High	Known	VME Database
Medium	Medium	High/Medium	VME Index
High	Low	Low	VME Index
High	Low	Low	Species Distribution Models
High	Low	Low	VME element mapping

Data Layers to Address Step 2 of the Workflow

The required input data on fisheries (or parameterization) that will operationalize this workflow will be based on that available following the annual ICES data calls for VMS/logbook (link). This data flow, as well as the underlying analysis that this workflow will establish, will be fully documented using the ICES Transparent Assessment Framework (TAF).

Data on Fisheries

To understand the distribution of fishing pressure it is necessary to derive a spatially resolved index of fishing intensity. For mobile bottom-contacting gears, the most robust and easiest shared metric of such fishing intensity is the area swept per unit area, or "swept area ratio", i.e., the area of the seabed which is contacted by the fishing gear, in relation to a surface area of the grid cell. Information on fishing intensity is drawn from VMS (vessel monitoring system) and fisheries logbook data. In its raw format, VMS data are geographically distinct points, so-called "pings", providing information about the state of a vessel at a point in time: its position, instantaneous speed and heading. In EU waters VMS is transmitted at a minimum interval of approximately 2 hours, but with higher polling rates for some countries, fisheries or vessels. VMS data points can be linked to logbook data in order to get additional information about the vessel flag country, gear code (equivalent to Data Collection Framework (DCF) level 4), fishing activity category (DCF level 6), average fishing speed, fishing hour, average vessel length, average engine power (kW), total landings weight and total value of all species caught. Following some analytical steps to identify for example, misreported pings (ICES, 2015), the vessel state (steaming, fishing or floating) is identified using the speed information. Only data which are assumed to represent fishing activity are then assigned to a 0.05 x 0.05 degrees grid, about 15 km^2 at 60°N latitude, using the C-square approach (Rees, 2003).

In order to convert from a gridded sum of points to fishing intensity values, certain assumptions about the spread of the gear, the extent of bottom-contact and the fishing speed of the vessel need to be made (ICES, 2015). Submitted VMS datasets usually contain information on the gear based on standard DCF métiers (from EU logbooks, usually at the resolution of métier level 6) and the gear-specific fishing speed, but not on gear size and geometry. Therefore, vessel size - gear size relationships developed by the EU FP7 project BENTHIS project (Eigaard *et al.*, 2016) are used to approximate the bottom-contact (e.g., gear width). To do this, it is necessary to aggregate métier level 6 to lower and more meaningful gear groups (so-called "Benthis métiers"), for which assumptions regarding the extent of bottom-contact were robust. Following this, fishing effort (hours) is aggregated per C-square for each métier and year. Fishing speeds are based on average speed values for each métier and grid cell submitted as part of the data call, or, where missing, a generalized estimate of speed is derived. Similarly, vessel length and engine power are submitted through the data call but where missing, average vessel length/engine power values are taken from the BENTHIS survey (Eigaard *et al.*, 2016).

Defining the fishing footprint

A fishing footprint for EU waters is required for the regulations. One of the goals of WKEUVME will be to propose such a footprint in this advice stream. One option is to adopt the process employed by both NAFO and NEAFC, in establishing their fishing footprint. The fishing footprint in these organisations is referred to as "existing bottom fishing areas" which is defined as the portion of their Regulatory Area where bottom fishing has historically occurred, based on information concerning bottom fishing activities in the period 1987-2007 (NAFO, 2009; NEAFC, 2014), reflecting the range of years which Contracting Parties held detailed spatial records. The process undertaken in NAFO, including data sources, validation and approaches taken in developing a footprint polygon is detailed in NAFO (2009). The history of how NEAFC conducted the mapping of bottom fishing areas is outlined in Ásmundsson *et al.* (2016) starting from 2008, when NEAFC adopted a resolution that led to NEAFC's first general measures on bottom fishing in its Regulatory Area (Recommendation 13/2009):

> *"This resolution defined the terms "bottom fishing activities", "existing bottom fishing areas", and "new bottom fishing areas", and required Contracting Parties to submit, by 1 September 2009, data on their bottom fishing activities during 1987–2007, at a resolution of 5′ latitude x 10′ longitude, for the following gear categories: bottom trawls, longlines, gillnets, benthopelagic (i.e. grenadier and alfonsino fishery), and others (i.e. other gears that have bottom contact during normal operation). The Secretariat also compiled maps of bottom fishing from VMS records, although it was not always possible to identify the type of fishery from those records. The first map of existing bottom fishing areas was adopted in 2009, and improved and modified in 2010 and 2014... The current measure (Recommendation 19/2014) does not define or use the term "new fishing area", but refers to fishing "outside area closures and existing bottom fishing areas".".*

It should be noted that the data available to ICES WGSFD covers the period 2009 – 2019. Many deep water fisheries in the northeast Atlantic were closed prior to 2009 due to stocks falling below precautionary levels. Fishing activity observed in more recent times may not accurately reflect historic impacts, and conversely, recovery of these stocks may not lead to reopening of a viable fisheries if their core habitats lie outside of the defined footprint.

In the context of the EU CFP deep-sea access regime – what is possible and what is not possible to do when describing fishing activity?

Given the above process, this imposes some bounds on the possibilities when using the data collected through the ICES VMS and Logbook data call. In both NAFO and NEAFC, point data aggregated into individual fishing activity tracks has been used to refine edges of VME closures to ensure they are appropriate. Such fine-tuning is not possible with the gridded data products available here. However, other information can be used to check the appropriateness of the boundaries, such as slope direction, seabed depth or substrate.

At this time it is not possible to accurately infer activity of vessels using static gears (in the deep sea, long lines and gill nets), therefore analyses will focus solely on mobile bottom-contacting gears.

To meet this request, fishing activity needs to be described only for where the regulation applies which is limited to EU waters of the NE Atlantic (nested within the overarching ICES region, and where we have data). All countries' vessels that have submitted data in response to the ICES VMS and logbook data call are included. Disaggregation by countries' vessels is not possible, but break down by country EEZ is possible. The countries which have not thus far participated in the VMS and logbook data call (Russia and Faroes) do not have extensive interests in deep-water fisheries in EU waters, therefore their omission is unlikely to be a significant factor in interpreting patterns of activity.

Temporal stability and how representative the 2009 – 2011 reference years are for establishing a footprint?

It will be important to know if the "core" fishing grounds of the 2009 – 2011 reference years are still the same areas that are fished now, as well as information on the rate of change over consecutive years. Knowing how stable or representative the footprint is will be required so as to avoid closing areas that are currently heavily fished, or allowing fishing in areas which were formerly fished but that are not fished anymore. This could displace fishing activity to areas that contain VMEs.

WKREG noted that spatial fisheries pressure layers are needed for the years subsequent to the reference period, as up to date as possible, to identify areas where past and recent damage by bottom-contact fishing may have occurred outside of the reference period and to capture the current use of the historical footprint to include in the trade-off analysis.

What are the main fisheries (and gears) affecting the bottom and potentially impacting VMEs in the 400 – 800 m depth?

WKREG considered spatial fisheries pressure layers by gear type and métier within the fishing footprint to determine what fisheries are impacting, and what proportion of their activity is within the VME areas.

Previous work has grouped all bottom-contacting gear (mobile bottom contacting and static gears) into either presence or absence under the assumption that any contacts to VMEs will impact them. A measure of intensity (i.e., SAR) is only available for mobile bottom contacting gears and thus being able to provide a measure of intensity that also includes static gear and mid-water trawls is difficult. WGSFD is in the process of developing ways to measure intensity for static gears that could be included in future interactions of the workflow when they become available. For now, the workflow thus suggests that fishing activity is analysed at three levels:

- Use presence/absence of any potentially bottom contacting gear (MBG, static, and mid-water) (Table 2 and Figure 7);
- Use SAR intensity for mobile bottom contacting gear (Figure 8);
- For the most commonly used gear grouping (Bottom-contacting Otter trawls, OTB, Table 3) present a more detailed métier grouping, e.g., *Nephrops* otter trawling, to illustrate what the most dominant fisheries are in the 400 – 800 m depth zone.

With regard to the workflow information on gears, types and intensity of fishing will be important. This would allow demonstration of very low fishing activity areas that may still contain VMEs, and thus are worth protecting by restricting fishing, in contrast to those areas where fishing is so intense that VME occurrence is highly unlikely (already damaged) and if it were closed, there could be a high risk of displacement to previously unfished areas.

The EEZs of UK and Ireland have most C-squares within the 400-800 m depth range (Table 2). The percentage of C-squares fished in each EEZ ranges from 42% in Spain to 100% in Denmark (Table 2). A map showing the presence (SAR > 0) and absence of fishing is shown in Figure 7 (left panel). Otter trawl gears are the dominant gear grouping in the EU region within the 400-800 m depth range (Table 3). In the EEZs of Spain and Denmark, otter trawls are targeting either *Nephrops*, or demersal fish species, whereas otter trawls in Ireland, France and the UK are a mixed fishery that target mixed demersal and benthic species such as hake and monkfish.

There is little evidence for other gears being used in deep waters (Table 3), with the exception of a small amount of activity using Scottish seines to target demersal fish species along the canyon heads of the northern slopes of the Bay of Biscay.

For the final data product, we will present maps and tables with more detailed métier groupings to incorporate regional differences in otter trawl gears.

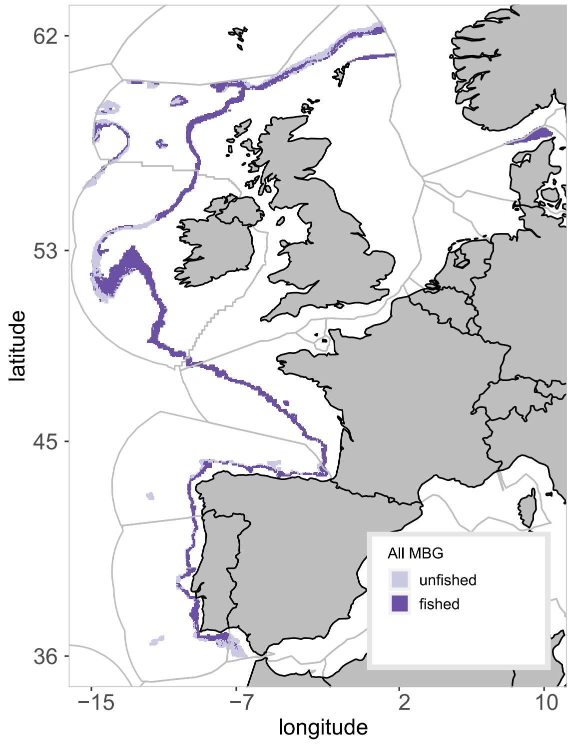
Most of the region is either unfished or fished in both the reference period (2009-2011) and the period 2012-2018 (Figure 7 right panel). Some C-squares that were unfished in the reference period have become fished in 2012-2018 (dark red C-squares in Figure 7 right panel). The increase in fished area is most visible north of Scotland and south of Portugal and Spain. Few C-squares were fished in the reference period but not thereafter (dark purple C-squares in Figure 7 right panel). An overview of the spatial distribution of the fishing intensity (i.e. SAR) is shown for otter trawl gears, the most commonly used gear grouping, in Figure 8. The intensity is categorized in unfished, low, medium and high groupings. The categories are arbitrarily chosen and will be discussed in the upcoming meeting.

Table 2. Total numbers of C-squares and numbers of C-squares fished per EEZ within 400-800 m depth range.

EEZ	Number of C-squares within 400-800 metre depth range	Number of C-squares fished within 400-800 metre depth range (% of total area per EEZ)
United Kingdom	2526	1536 (60%)
Ireland	2298	1660 (72%)
Spain	854	359 (42%)
Portugal	668	441 (66%)
France	533	515 (97%)
Denmark	258	258 (100%)

Table 3. Numbers of C-squares fished (SAR > 0) within 400-800 m depth range for the whole region (covering the EEZs of UK, Ireland, Spain, Portugal (mainland), France and Denmark).

Gear type	Numbers of C-squares with fishing (SAR > 0) within 400-800 m depth range (total region = 7173 C-squares)
Otter trawl	4759
Beam trawl	10
Dredge	13
Seine	322
Static gears	To be determined



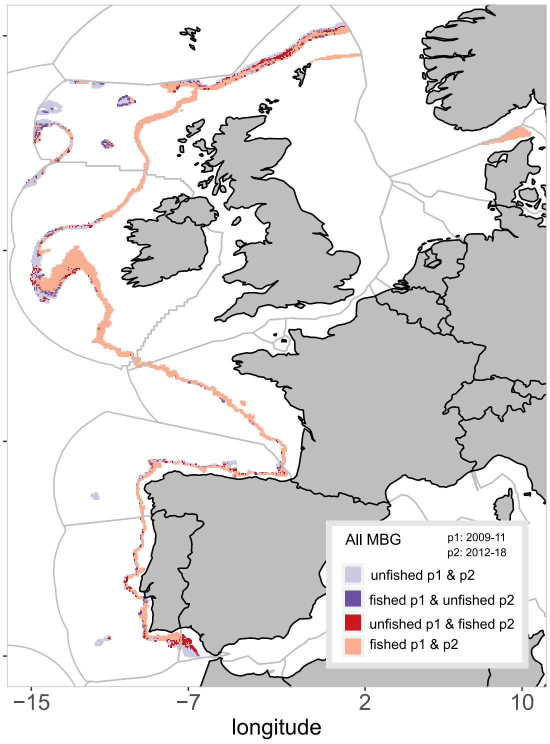
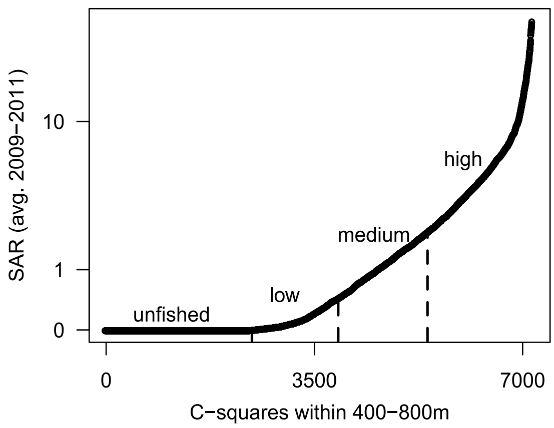


Figure 7. Left panel: C-squares within the 400-800 m range that are unfished or fished (SAR > 0) based on average fishing intensity of all mobile bottom-contacting fishing gears (MBG) in 2009-2011 (presence/absence data on static gears will be included). Right panel: Difference in fishing occurrences in C-squares between the reference period (p1: 2009-2011) and the period 2012-2018 (p2). Most C-squares are either unfished or fished in the two periods.



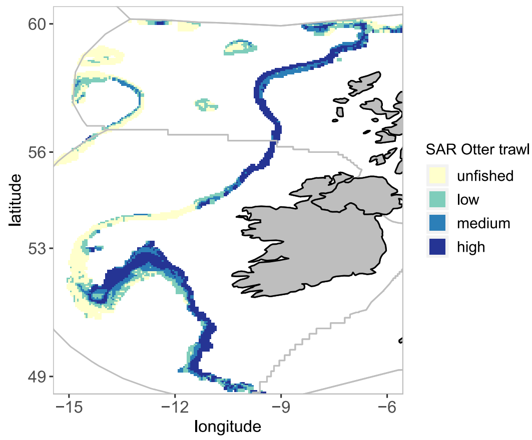


Figure 8. Left panel: Distribution of swept area ratio (SAR) from low to high SAR for otter trawl gears (average 2009-2011) for all regions in the 400-800 metre range; the dominant gear grouping in the 400-800 metre depth range (Table 3). Categories are arbitrarily chosen; unfished (SAR = 0), low (SAR 0 - 0.5), medium (0.5 – 2) and high (>2). Right panel: Example of swept area ratio (SAR) from otter trawl gears (average 2009-2011) in the EEZs of Ireland and (part of) the UK following left panel schema.

Overlap between VMEs and Fishing

WKREG (ICES, 2019) considered that the existing data products for VMEs and fisheries were useful as a decision support tool for identifying areas where VMEs could be threatened by bottom-contact fishing gears. Two scenarios utilizing the data products were summarized and modified here to include the likely occurrence of VMEs:

1. Identification of areas of overlap from existing data between fisheries and known VME or where VME are likely to occur; and

2. Identification of areas where there are known VME or where VME are likely to occur, but no current fishing.

Table 4. Number of C-squares with VME occurrence and likely occurrence within 400-800 m depth range categorized by the degree of precaution (low, medium and high, Table 1) for the total region and per EEZ. The C-square is defined as fished when the SAR > 0 (average 2009-2011). The last column shows all C-squares without a VME occurrence or likely occurrence. Note that the selection of C-squares with a high degree of precaution is only based on the ICES VME Index data; this will be updated with VME element mapping and species distribution models, where available.

Region	Precaution: low unfished/fished	Precaution: medium unfished/fished	Precaution: high unfished/fished	C-squares without VME unfished/fished
Total Region	28/49	33/62	25/90	2318/4568
United Kingdom	13/18	14/32	15/59	984/1427
Ireland	9/13	7/19	3/19	619/1609
Spain	3/0	7/5	3/0	482/354
Portugal	2/0	5/1	4/8	216/432
France	1/17	0/5	0/4	17/489
Denmark	0/1	-	-	0/257

Overlap between VME and fishing data shows that fishing occurs in most C-squares with known VME occurrence or likely occurrence (Table 4). Overlap is most pronounced in the United Kingdom, Ireland and France, whereas Spain and Portugal seem not to fish in C-squares with VME habitat. The overlap is estimated using data on all gear types but is mostly coming from otter trawl gears that are the dominant fishing gear operating in the 400-800 m depth range (Table 3). Maps illustrating overlap between VME at different levels of precaution and fishing (by all gears) are shown in Figure 9 and Figure 10. Maps illustrating overlap between VME presence (all levels of precaution) and fishing by otter trawl gears at different levels of intensity are shown in Figure 11 and Figure 12 respectively.

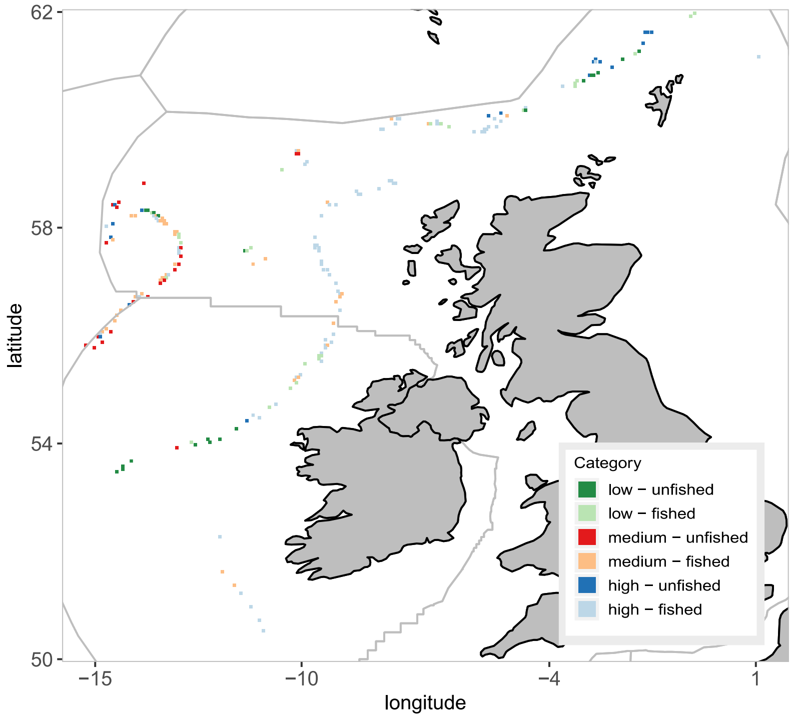


Figure 9. Plot of the Celtic Seas showing the overlap between VMEs at different levels of VME precaution (Table 1; low, medium and high) and fishing within the 400-800 metre depth range.

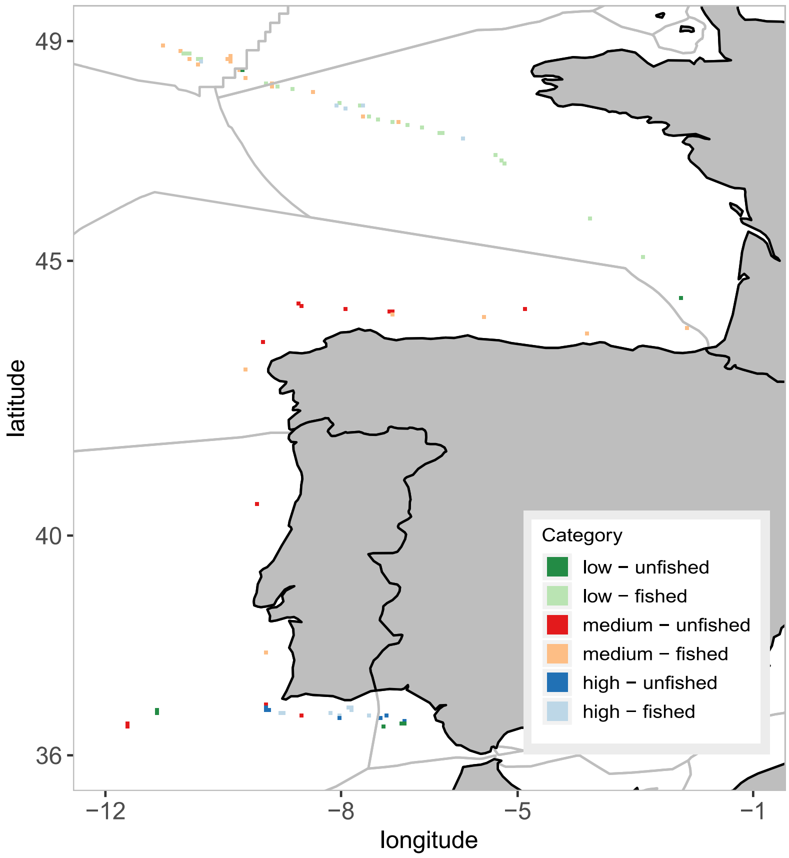


Figure 10. Plot of the Bay of Biscay and Iberian Coast showing the overlap between VMEs at different levels of VME precaution (Table 1; low, medium and high) and fishing within the 400-800 metre depth range.

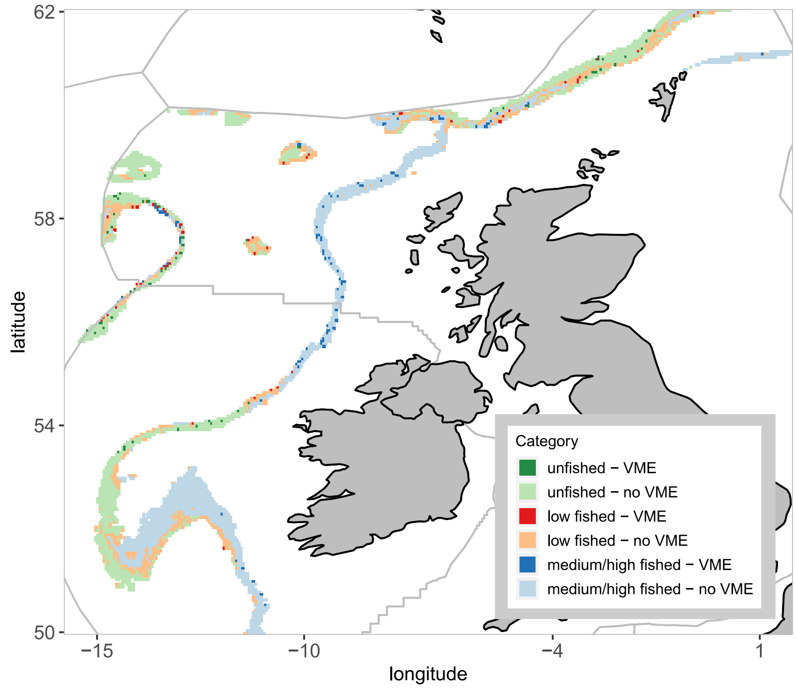


Figure 11. Plot of the Celtic Seas showing the overlap between VMEs and fishing by otter trawl gears at different levels of intensity (following Figure 8) within the 400-800 metre depth range.

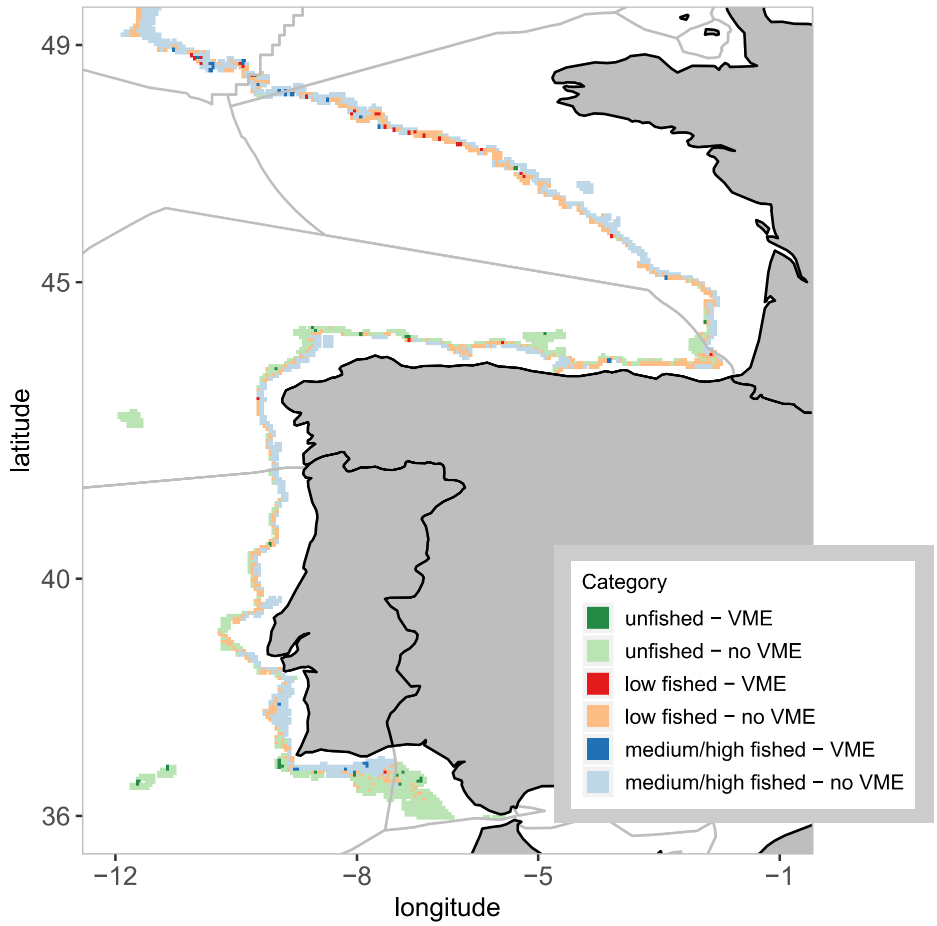


Figure 12. Plot of the Bay of Biscay and Iberian Coast showing the overlap between VMEs and fishing by otter trawl gears at different levels of intensity (following Figure 8) within the 400-800 metre depth range.

Possible Management Actions for Protecting VMEs

Using the varying qualities of data on VMEs and fisheries, a set of potential management actions have been identified for different scenarios (Table 5). These actions set out the potential options for management based on the different levels of fishing intensity and confidence in VME presence, with the resulting degree of precaution that would be applied in each case. They assume that a fishing footprint has been defined and that it contains varying levels of fishing activity, including unfished areas. These actions can be summarised as:

Action 1: Create closed areas (no fisheries conflict with VME);

Action 2: Create closed areas (high/medium confidence in VME with fisheries interaction);

Action 3: Consider closed areas (low confidence in VME with fisheries interactions - highly precautionary).

For example, in areas where there are high fishing intensity levels and where confidence in VME presence is also high, the management action proposed would be to '*create* closed areas'. Due to the higher confidence in fishing activity and VME presence, the level of precaution applied in this case would be low. Conversely, in areas where fishing intensity is high, but the confidence in VME presence is low, a higher level of precaution would be applied, with the proposed management action to '*consider* closed areas'.

Table 5. Summary of potential management actions incorporating knowledge of fishing, VME and level of acceptable risk (precaution). Actions are depicted in Figure 13. Precaution is linked to the degree of confidence in the presence of the VME (see Figure 2).

Fishing Intensity (Figure 8)	Confidence of VME Presence (Table 1)	Degree of Precaution (Table 1)	Management Action	Figure Code (Figure 13)
High	High	Low	Create Closed Area	Action 2
High	Medium	Medium	Create Closed Area	Action 2
High	Low	High	Consider Closed Area	Action 3
Medium	High	Low	Create Closed Area	Action 2
Medium	Medium	Medium	Create Closed Area	Action 2
Medium	Low	High	Consider Closed Area	Action 3
Low	High	Low	Create Closed Area	Action 2
Low	Medium	Medium	Create Closed Area	Action 2
Low	Low	High	Consider Closed Area	Action 3
Absent	High	Low	Create Closed Area	Action 1
Absent	Medium	Medium	Create Closed Area	Action 1
Absent	Low	High	Create Closed Area	Action 1

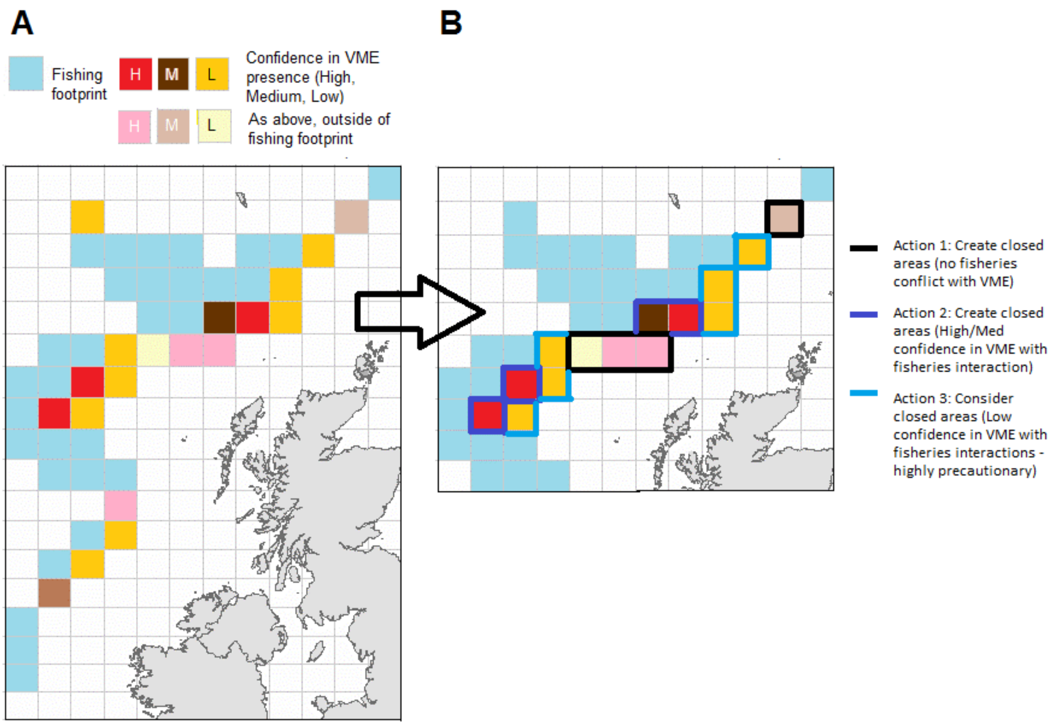


Figure 13. Illustration of hypothetical data product at the ICES rectangle scale (for visualisation), demonstrating combining the location of the fishing footprint and the occurrence of VME with first level management considerations depicted (see Table 5).

Step 4: Translating C-squares to Polygons

Following the workflow through leads to the identification of areas requiring management decisions (Step 4, Figure 2). It involves a first assessment to determine the scope of the interactions, after which managers need to make decisions on the creation of closed area polygons. VME and VMS C-square data can be used to identify initial areas for consideration, and further data can be explored to refine these as needed.

Closure only of areas of high to low confidence in VME presence within areas of no fishing activity would be the least precautionary (Action 1 in Table 5), followed by closure of areas of high to medium confidence in VME presence, with any level of fishing intensity (Action 2 in Table 5). By combining these areas together, where possible, ideally larger polygon areas could be drawn up rather than lots of small isolated C-squares.

To aid in deciding whether area closures are warranted under medium and high fishing intensity scenarios, with low confidence in VME presence (Action 3 in Table 5), where their implementation would be disruptive to the fisheries, more details on both the VME types and the fishing activity can be reviewed. For example, VME point data can be examined to assess the probability of significant adverse impacts by the fishery(s) in question (FAO, 2009), while fishing intensity can be reviewed to estimate the degree of impact on the industry.

Implementing buffer zones

In order to implement closed area polygons (Actions 1 and 2 in Table 5), some consideration is also needed of buffer zones around the VME areas. Buffer zones are often incorporated into closed area boundaries to protect VMEs from fishing activity that could stray across boundaries, and from the indirect effects of sediment plumes created by bottom-contact fishing gears. In 2013, ICES responded to a request for advice from NEAFC on the application of buffer zones to bottom fishing closure boundaries. These buffers consider the water depth and trawl warp length deployed during fishing activity, and the VME location (ICES, 2013). Two recommendations relevant here were proposed:

1) For VMEs that occur on flat or undulating seabed, a buffer zone of approximately two (> 500 m depth) or three times (< 500 m depth) the local depth is advised.

2) In some cases the presence of geomorphological features are used to define boundaries for closures on the basis that they are considered to be VME elements, in which case the VME reflects the topographic relief of the VME element without a buffer zone (ICES, 2013).

The ICES Working Group on Deep water Ecology (WGDEC) further endorsed this advice in 2017 (ICES, 2017b), for the use of buffers in recommendations for NEAFC fisheries closure areas for the protection of VMEs.

To be consistent with the NEAFC approach, these buffer zones should also be applied to proposed closure areas for the protection of VME under the EU deep-sea access regulations.

Orphaned C-squares with VME

Due to the availability of VME data at C-square grid cell scale, and the limitations on data collection in the deep sea (limited, high-cost surveys, commonly focusing on key areas such as Marine Protected Areas), it may be that in some cases the VME records are not contiguous in space (Figure 14). Therefore, managers could have difficulty in determining where to place the boundaries of the closures without creating numerous small closures. Additional information can be obtained by reviewing VME elements and SDMs which may fill in gaps between the observed VMEs. For example, in Figure 14, the location of the VME areas with high confidence in presence may coincide with seamounts, or some similar habitat feature which supports VMEs.

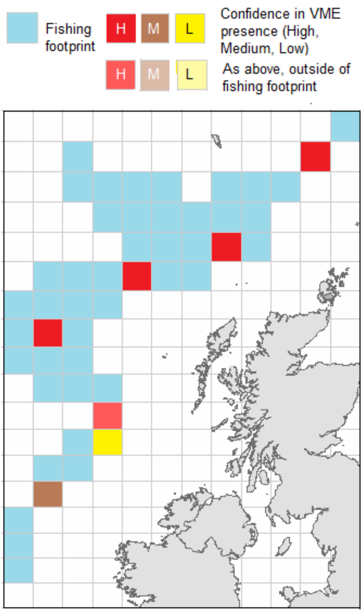


Figure 14. Hypothetical figure showing orphaned ICES statistical rectangles (for visibility purposes), in this case areas with high VME confidence of occurrence (red) but with no records from adjacent C-squares.

How the Outputs of the Workflow Meet the Requirements of the Regulations

Regulation (EU) 2016/2336 establishes the conditions for fishing deep-sea stocks in the northeast Atlantic. Specifically the following provisions apply:

- The Regulations apply to fisheries with bottom gears in EU waters operating at depths of > 400 metres (Regulation 2016/2336 Article 9);
- Deep-sea fishing authorisations to use any bottom gears may normally be granted only for fishing activities within the areas that were fished with bottom gears during the period 2009-2011 (Regulation 2016/2336 Article 7), the fisheries footprint. Outside of the fisheries footprint, deep-sea fishing authorisations to use any bottom gears may be granted only if an impact assessment demonstrates that the protection of VMEs will not be compromised (Regulation 2016/2336 Article 8);
- Bottom trawling at depths > 800 metres is prohibited in all areas (inside and outside the footprint) (Regulation 2016/2336 Article 8);
- The data layers described above provide the information on métiers needed to circumscribe the fisheries and spatial extent of the request. Figure 1 shows the area between 400 and 800 m depth in EU waters.
- Implementing acts to establish a list of areas where VMEs are known to occur or are likely to occur should have been drawn up by 13 January 2018 in order to prevent significant adverse impacts of VMEs in those areas (Regulation 2016/2336 Article 7). The list of areas is subject to annual review. This is addressed above where the data layers on VME are described.

Under the regulations, the EU fleet will be banned from bottom fishing in all waters > 400 metres depth, apart from within the existing fishing footprint. Within the fishing footprint, EU vessels will be prohibited from bottom fishing in any closed areas that might be introduced to protect VMEs.

References

Ásmundsson, S., Lobach, T. and Bergstad, O. A. 2016. Northeast Atlantic Ocean. In: FAO. 2016. Vulnerable marine ecosystems. Processes and practices in the high seas. FAO Fisheries and Aquaculture Technical Paper 595. FAO, Rome, 2016. http://www.fao.org/3/a-i5952e.pdf

Eigaard, O. R., Bastardie, F., Breen, M., Dinesen, G. E., Hintzen, N. T., Laffargue, P., *et al*. 2015. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science 73 (Suppl. 1): 27–43. https://doi.org/10.1093/icesjms/fsv099

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

ICES. 2013. General Advice. Evaluation of the appropriateness of buffer zones. Special request, Advice June 2013, 1.5.5.2 ICES Advice Book 1, 2 pp.

ICES. 2015. Report of the Working Group on Spatial Fisheries Data (WGSFD), 8–12 June 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/SSGEPI:18. 150 pp.

ICES. 2017. Report of the Workshop to evaluate trade-offs between the impact on seafloor habitats and provisions of catch/value (WKTRADE), 28–31 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:42. 109 pp.

ICES. 2017b. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 20-24 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:25 121 pp.

ICES. 2018. EU request to provide a further technical service to aid in the interpretation of ICES advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011 (sr.2018.10). ICES Technical Service North Atlantic Ecoregion sr.2018.28. https://doi.org/10.17895/ices.pub.4645

ICES. 2019. Stakeholder workshop to disseminate the ICES deep-sea access regulation technical service, and scope the required steps for regulatory purposes (WKREG). ICES Scientific Reports. 1:ISS NO. 31 pp. http://doi.org/10.17895/ices.pub.5636

Morato, T., Pham, C.K., Pinto, C., Golding, N., Ardron, J.A., Durán Muñoz, P. and Neat, F. 2018. A Multi Criteria Assessment Method for Identifying Vulnerable Marine Ecosystems in the North-East Atlantic. Front. Mar. Sci. 5:460. http://doi/10.3389/fmars.2018.00460

NAFO. 2009. Delineation of Existing Bottom Fishing Areas in the NAFO Regulatory Area, NAFO FC Doc. 09/20. Serial No. 5712. 10 pp.

NAFO. 2013. Report of the 6th Meeting of the NAFO Scientific Council Working Group on Ecosystem Science and Assessment (WGESA) [Formerly SC WGEAFM]. NAFO SCS Doc. 13/024, Serial No. N6277, 209 pp.

NEAFC. 2014. Recommendation 19:2014. Articles 2(c), 4 and 6(8). https://www.neafc.org/system/files/Rec19-Protection-of-VMEs_0.pdf

Rees, T. 2003. "C-squares", a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography 16(1): 11–19.

Annex 2: List of participants

Workshop on EU Regulatory Area Options for VME Protection (WKEUVME), 18–28 May 2020.
* *Indicates member of WKEUVME Planning Committee.*

Participant	Dept/Institute	Email	Country (of Institute)
Alberto Serrano (*by correspondence*)	Instituto Español de Oceanografia (IEO)	alberto.serrano@ieo.es	Spain
Andreia Braga-Henriques	Regional Directorate for Fisheries, Government of the Azores	Andreia.FD.Henriques@azores.gov.pt	Portugal
Andrew Kenny	Cefas	andrew.kenny@cefas.co.uk	UK
Camille Lirette (*by correspondence*)	Fisheries and Oceans Canada, Bedford Institute of Oceanography	Camille.Lirette@dfo-mpo.gc.ca	Canada
Covadonga Orejas Saco del Valle	Instituto Español de Oceanografia (IEO)	cova.orejas@ieo.es	Spain
Daniel van Denderen*	DTU Aqua, National Institute of Aquatic Resources	pdvd@aqua.dtu.dk	Denmark
David Stirling	Marine Science Scotland	David.Stirling@gov.scot	UK
Debbi Pedreschi	Marine Institute	Debbi.Pedreschi@Marine.ie	Ireland
Ellen L. Kenchington (*chair*)*	Fisheries and Oceans Canada, Bedford Institute of Oceanography	ellen.kenchington@dfo-mpo.gc.ca	Canada
Eugene Nixon*	International Council for the Exploration of the Sea	eugene.nixon@ices.dk	Ireland
Georgios Kazandis	University of Edinburgh	Georgios.Kazanidis@ed.ac.uk	UK
Graham Johnston	Marine Institute	Graham.Johnston@Marine.ie	Ireland
Helen Holah	Marine Science Scotland	helen.holah@gov.scot	UK
Jan Geert Hiddink	Bangor	j.hiddink@bangor.ac.uk	UK
Javier Murillo-Perez	Fisheries and Oceans Canada, Bedford Institute of Oceanography	Javier.MurilloPerez@dfo-mpo.gc.ca	Canada
Joana R Xavier	Interdisciplinary Centre of Marine and Environmental Research University of Porto	joana.xavier@uib.no	Portugal
José Manuel González Irusta	Instituto Español de Oceanografia (IEO)	jmanuel.gonzalez@ieo.es	Spain

Laura Robson*	Joint Nature Conservation Committee	Laura.Robson@jncc.gov.uk	United Kingdom
Lénaick Menot	Ifremer	Lenaick.Menot@ifremer.fr	France
Louise Allcock	NUI Galway	louise.allcock@nuigalway.ie	Ireland
Marcos Llope	Instituto Español de Oceanografia (IEO)	marcos.llope@ieo.es	Spain
Neil Campbell*	Marine Science Scotland	neil.campbell@gov.scot	United Kingdom
Peter Hopkins (*chair*)*		peterhopkins@skynet.be	Belgium
Phillip J Turner	Sea Scape Consultants (ATLAS)	phil.turner@seascapeconsultants.co.uk	UK
Raluca Ivanescu*	European Commission DGMARE	Raluca.ivanescu@ec.europa.eu	Belgium
Raquel López González*	Secretaría General de Pesca Ministerio de Agricultura,	rlopez@mapa.es	Spain
Sebastian Valanko*	International Council for the Exploration of the Sea	sebastian.valanko@ices.dk	Denmark

Workshop on EU Regulatory Area Options for VME Protection (WKEUVME-STAKE), 1–3 September 2020.

** Indicates member of WKEUVME-STAKE Planning Committee.*

Participant	Dept/Institute	Email	Country (of Institute)
Aare Tuvi	Ministry of the Environment	Aare.Tuvi@Envir.ee	Estonia
Alda Centeio	Directorate-General for Natural Resources, Safety and Maritime Services	acenteio@dgrm.mm.gov.pt	Portugal
Alexandre Rodriguez	Long Distance Fisheries Advisory Council	alexandre.rodriguez@ldac.eu	Spain
Ana Silva	Federação das Pescas dos Açores	asilva@federacaopescasacores.pt	Portugal
Andrea Ripol	Seas At Risk	aripol@seas-at-risk.org	Belgium
Anna Gruszczynska	Ministry of Maritime Economy and Inland Navigation	Anna.Gruszczynska@mgm.gov.pl	Poland
Benoit Caillart	Fisheries & Maritime Affairs F&S	b.caillart@fs-marine.fr	France
Caroline Alibert Deprez	European Commission	Caroline.ALIBERT-DEPREZ@ec.europa.eu	
Cristina Perdiguero Arenas	Ministry of Agriculture, Fisheries and Food	cperdiguero@mapa.es	Spain
Daniel van Denderen*	DTU Aqua, National Institute of Aquatic Resources	pdvd@aqua.dtu.dk	Denmark
Eirini Glyki	International Council for the Exploration of the Sea	Eirini@ices.dk	Denmark
Ellen L. Kenchington (*chair*)*	Fisheries and Oceans Canada, Bedford Institute of Oceanography	ellen.kenchington@dfo-mpo.gc.ca	Canada
Elsa Tudal	Directorate General of Maritime and Aquaculture Fishing	elsa.tudal@agriculture.gouv.fr	France
Eugene Nixon*	International Council for the Exploration of the Sea	eugene.nixon@ices.dk	Ireland
Gonçalo Carvalho	Pelagic AC	carvalho.gf@gmail.com	Netherlands
Helen Holah*	Marine Science Scotland	helen.holah@gov.scot	UK
Isabel Texeira	Directorate-General for Natural Resources, Safety and Maritime Services	iteixeira@dgrm.mm.gov.pt	Portugal
Jan Geert Hiddink*	Bangor University	ossc06@bangor.ac.uk	UK
Jean-Marie Robert	Les Pêcheurs de Bretagne	jmrobert@cc-sud.eu	France

Johanna Ferretti	Federal Ministry of Food and Agriculture (BMEL) - Sea fisheries management and fisheries control	johanna.ferretti@thuenen.de	Germany
Juan Antonio Espejo	Ministry of Agriculture, Fisheries and Food	jaespejo@mapa.es	Spain
Justyna Szumlicz	Ministry of Maritime Economy and Inland Navigation	Justyna.szumlicz@mgm.gov.pl	Poland
Karl-Michael Werner	Thünen Institute of Sea Fisheries	karl-michael.werner@thuenen.de	Germany
Kerstin Heck	European Commission	Kerstin.HECK@ec.europa.eu	
Laura Robson*	Joint Nature Conservation Committee	Laura.Robson@jncc.gov.uk	United Kingdom
Lénaick Menot*	Ifremer	Lenaick.Menot@ifremer.fr	France
Matthew Gianni	Deep Sea Conservation Coalition	matthewgianni@gmail.com	Netherlands
Peter Hopkins (*chair*)*		peterhopkins@skynet.be	Belgium
Raluca Ivaniescu	European Commission	Raluca.IVANESCU@ec.europa.eu	
Sandrine Polt	Seas At Risk	sandrine.polti@gmail.com	Belgium
Stavroula Kremmydiotou	European Bureau for Conservation & Development	Stavroula.KREMMYDIOTOU@ebcd.org	Belgium
Sylvaine Carteron	European Commission	Sylvaine.CARTERON@ext.ec.europa.eu	

Annex 3: Dissemination Document

EUVME

Stakeholder Input meeting

1-3 September 2020

ICES Stakeholder Workshop on EU regulatory area options for VME protection (WKEUVME-STAKE)

Chaired by Peter Hopkins (Belgium) and Ellen Kenchington (Canada)

1-3 September 2020 remotely via web conference

Approach.

This Dissemination Document has been prepared for the ICES Stakeholder Workshop (WKEUVME-STAKE), organised to provide interested parties an opportunity to input their views on the practicalities of options being developed by ICES in response to a request from the European Commission for advice on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas in accordance with the implementation of Regulation (EU) 2016/2336. It is based on the report of the ICES Technical EUVME Workshop, held in May 2020, which includes much more detailed Assessment Sheets and background information all of which are available on the ICES WKEUVME-STAKE Sharepoint site: link. The Dissemination Document cross references to the appropriate sections of the technical report to assist in navigating to the key text, tables and figures. In addition, interactive maps have been prepared which will allow participants to zoom in on areas of interest. The interactive maps are available in a zip folder on the ICES Sharepoint WKEUVME-STAKE: link. These maps contain the fishing footprint 2009-2011, VME information and closure options, and specific data layers for mobile bottom contacting fishing gears.

Background and Summary of WKEUVME work to date.

Under the European deep-sea fisheries regulations (Regulation (EU) 2016/2336), bottom contact fishing conducted by EU vessels within EU waters will be confined to the existing bottom-fishing footprint based on bottom contact fishing locations (static and mobile gears) between 2009 and 2011 [Article 7 and Article 8(2)]. Within that existing footprint, the European Commission, in consultation with Member States and based on best scientific information and advice, will list, and annually review, areas where vulnerable marine ecosystems (VMEs) are known or are likely to occur [Article 9(6)]. The Commission will decide on the closure of these areas between 400 m and 800 m depth in order to protect the VMEs found there. These EU measures will contribute to achieving the objectives of the United Nations General Assembly (UNGA) Sustainable Fisheries Resolutions, particularly Resolutions 61/105 (A/RES/61/105) and 64/72 (A/RES/64/72) which call for adoption of conservation and management measures to prevent significant adverse impacts on VMEs.

The ICES EUVME Technical and Stakeholder Workshops are part of the formal ICES advisory process in response to a request from the EU to provide "*advice on the list of areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas*". Based on input from its expert groups, ICES tasked the Technical EUVME Workshop to provide "*a set of regulatory* *area options that vary in the degree of VME protection and estimate for each of the options how it will affect bottom fisheries*". The ICES Advice is due to be released in January 2021.

Precision and Scale of the Work: Ecoregions and C-squares.

ICES uses ecoregions as the spatial units to synthesise the evidence for the ecosystem approach. The ICES network uses them to monitor, assess, address and solve regional scientific challenges and for geographical allocation and reporting of ICES advice. All ICES advice is now linked to an ecoregion, or a collection of ecoregions. Accordingly, the Technical Workshop opted to deliver its recommendations by ecoregion. Most of the EU waters between 400 and 800 m depth fall into either the Celtic Seas Ecoregion, or the Bay of Biscay and Iberian Coast Ecoregion (Figure 1). The ICES Fisheries Overviews can also be an important source of information to inform managers on the context of the fishing operations in each ecoregion: Celtic Seas ecoregion fisheries overview, Bay of Biscay and Iberian Coast ecoregion fisheries overview.

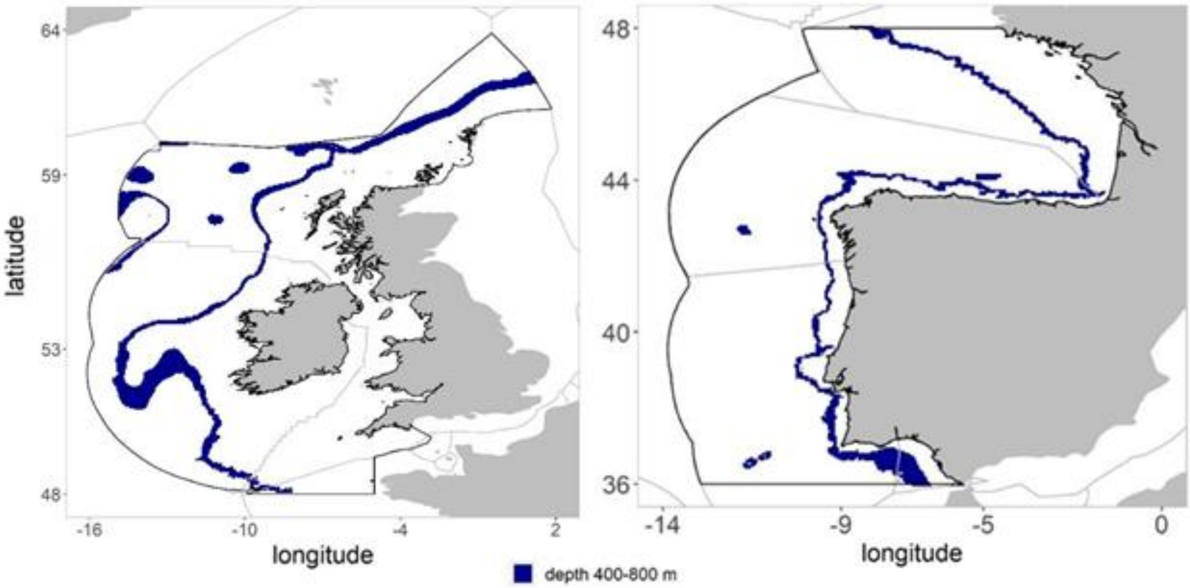


Figure 1. Celtic Seas Ecoregion (left) and Bay of Biscay and Iberian Coast Ecoregion (right) (darker outline) with area between 400 m and 800 m depth indicated (blue shade).

C-square is a grid system. ICES uses a C-square resolution of 0.05° longitude by 0.05° latitude (about 15 km² (3km x 5km) at 60°N latitude), see Figure 2. This resolution is a practical scale to collate, explore and assess data relating to fishing activities in the marine environment. Furthermore, it is the acceptable scale in terms of the confidentiality of data with respect to individual fishing vessels. This was the system used by ICES in responding to this EUVME request.

Are there VMEs in EU waters outside of these two ecoregions? In addition, a small area of **Denmark's EEZ** has water depths of 400-800 m on the edge of the EEZ boundary. This area falls in the Skagerrak which reaches its deepest point at 700 m, located within the Greater North Sea Ecoregion. Within this region, only one C-square recording VME habitat, representing a cold seep, occurs deeper than 400 m, with a maximum depth of 450 m. The location and co-ordinates are found in the Technical Workshop report (Section 4.1, Figure 4.1, hereafter referred to as the Report). Also there are a small number of VME C-squares within the Azores EEZ that occur within the 400-800 m depth zone, mainly along the steep island slopes and offshore seamounts. The Technical Workshop was aware that additional data on VME habitats and indicators for the region was available but not submitted to ICES. Inclusion of this data would support improved understanding of potential closures within the 400-800 m depth zone. As a result, the Technical

Workshop provided a description of the known VMEs in the Azores ecoregion (see Section 4.1 of the Report) and recommended that the Workshop procedures be applied to the region in future when more data have accumulated.

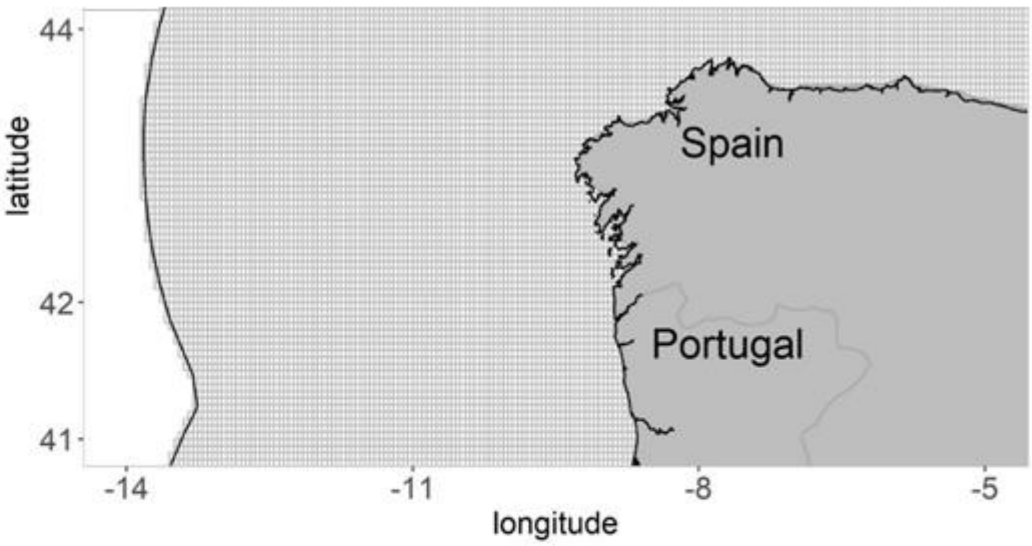


Figure 2. C-square grid system for a portion of EU waters. ICES uses a C-square resolution of 0.05° longitude by 0.05° latitude (about 15 km² (3km x 5km) at 60°N latitude) for its work on VMEs and fishing effort.

Fishing Footprint.

The legislation defines the footprint on the basis of the activity of vessels that had deep-sea fishing authorisations during the period 2009 – 2011. However, ICES does not have the information to distinguish between vessels with deep-sea fishing authorisations from those which did not. The Technical Workshop therefore based its analyses on all fishing vessels using bottom gears at depths between 400 m-800 m, because all such vessels can be assumed to have had deep-sea fishing licences. This is reasonable, given that the Technical Workshop was tasked with defining areas within the footprint with depths > 400 metres that might be closed to protect VMEs, and since bottom trawling is in any case prohibited in all areas at depths > 800 metres.

The Technical Workshop considered how best to establish a coherent fishing footprint for the reference period 2009 to 2011 based on the presence or absence of fishing with both Mobile Bottom Contact Gear (MBCG) and Static gear. This is far from a simple process and is described in detail in the Report, Section 4.3.

The determination of whether fishing has taken place within a C-square is complicated, primarily for two reasons; the frequency of data reporting from the vessel monitoring systems (VMS) of individual fishing vessels (every two hours) and the requirement to aggregate data for confidentially reasons attached to the VMS data received from ICES Member Countries. These data are received by ICES in response to the ICES VMS/Logbook Data Call. Based on the best available data and science, the fishing footprint was established at a C-square level for the reference period 2009-2011 and includes both mobile and static gears.

For mobile gears, the speed of the vessel, determined by the distance travelled between each two hour reporting event (known as a 'ping') is used to determine if the vessel is likely to be fishing or not. This information, coupled with the gear registered for the particular vessel, is used to assign a fishing event and this fishing event is linked to the particular C-square. Although a long established method, there is uncertainty associated with this process and to smooth out anomalies (vessels slowing down or stopping for reasons unrelated to a fishing event) the workshop applied the criteria that for a C-square to be selected as fished it must share at least one corner with another C-square meeting the aforementioned speed criteria.

Due to the likely impact on VMEs from MBCG and ICES' ability to examine fishing intensity for MBCG only and not static gear, the priority for the moment is placed on MBCG. Methods for measuring intensity of fishing with Static Gear are currently being developed and, should they be considered relevant, could be included at a future time.

The Technical Workshop produced a fishing footprint for all bottom contact gears, that is a combined MBCG and Static gear footprint. However in developing this document and in preparation for the Stakeholder Workshop, the footprint for MBCG and Static Gears were developed separately but using the same methodology. Consequently, the same criteria as used by the workshop was used separately for each gear type for display: WKEUVME GitHub site -> folder 5-Output -> pick the ecoregion of interest. These maps were produced in case they were of interest to stakeholders and are not meant to represent alternative fishing footprints.

Identifying C-squares Containing or Likely to Contain VMEs.

The Technical Workshop used data contained in the ICES VME Database to identify C-squares with VME. The VME Database contains data submitted by ICES Member Countries and is regularly updated following annual VME data calls from ICES. Identification of what species qualify as VME indicators is based on five criteria established by FAO in 2009. The FAO criteria in brief are:

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

For a VME indicator to qualify as a vulnerable marine *ecosystem* it should be present in significant concentrations (habitat forming), or in the case of uniqueness or rarity, be associated with an area or ecosystem whose loss could not be compensated for by similar areas or ecosystems elsewhere, such as
habitats of rare, threatened or endangered species that occur only in discrete areas (FAO, 2009).

There are two types of data submitted to the ICES VME Database, the first being data that without doubt confirms the actual presence of a VME on the sea floor, for example high quality video observations from dedicated deep-sea surveys. The ICES VME Database records these cases as **VME habitats**. These VME habitats are *bona fide* records and represent where VME *are known to occur*. However, there is a lot of valuable information on the location of VMEs that can be derived from other sources with varying degrees of confidence, e.g., trawl bycatch records or low-quality underwater imagery. For these records, ICES developed a method to combine the FAO criteria and any available abundance into a "**VME Index**" with high, medium and low likelihood of a C-square containing an actual VME. The VME Index is applied at the C-square level and indicates squares where VMEs *are likely to occur*. The UNGA resolutions and the FAO Deep Sea Fisheries Guidelines also list physical elements, such as seamounts, steep slopes, canyons etc., as VME indicators because these areas are known to host VMEs. Regional Fisheries Management Organizations (RFMOs) have closed a number of areas in the high seas to protect **VME physical elements**. ICES also identified a list of physical elements that qualify as VME indicators and the Technical Workshop included them in some of the regulatory area options as other areas where VMEs *are likely to occur*. In summary, for each C-square, the Technical Workshop considered the presence of a VME Habitat; the VME Index (high, medium or low likelihood of a C-square containing VME Habitat); and in one option, VME physical elements.

Management Options.

In order to respond to the requirement to provide "*a set of regulatory area options that vary in the degree of VME protection and estimate for each of the options how it will affect bottom fisheries*", and to focus on the priority issues, the Technical Workshop explored different approaches to using the VME information outlined above when considering areas for fisheries closures in order to protect known VME habitats or areas where there is a likelihood of VME habitats occurring. This exploration resulted in the selection of two scenarios the workshop considered appropriate for consideration by managers (Table 1). Scenario 1 prioritizes protection of VME, irrespective of the fishing activity and is consistent with the UNGA 61/105, paragraph 83c, while Scenario 2 prioritizes protection of VME but incorporates a threshold for the level of permissible fishing activity that is linked to significant adverse impacts, consistent with UNGA 61/105, paragraph 83a. Each scenario was further subdivided into two options (Table 1). Under Scenario 2, assessment of fishing activity is limited to mobile bottom contacting gear (MBCG) only. The reasons for this are: 1) MBCG is the only gear type ICES has information on of the intensity of fishing activity; and 2) in most situations, MBCG has a far greater impact on VMEs when compared to static gear. At this stage ICES only has information on the presence or absence of static gear and is therefore not able to comment on the extent of static gear impact on VMEs or the consequence of closures on static gear fishing activity. The overlap between static gear and VME is however documented.

What is the Swept Area Ratio (SAR)? SAR is the area of the seabed which is contacted by the mobile bottom contacting fishing gear in relation to a surface area of the C-square. Therefore the C-square SAR value indicates the theoretical number of times the entire grid cell has been swept in a year if effort was evenly distributed within the cell. How this effort is actually distributed across the C-square is not known. For more details see Section 4.4 of the Technical Workshop Report.

SAR therefore provides valuable insight into the potential impact of MBCG on the VMEs present by measuring the intensity over time of fishing activity within a C-square. This intensity was also used to examine the consequence of potential closures on the fisheries using MBCG.

What level of SAR is associated with significant adverse impacts on VMEs? In developing options for Scenario 2 (Table 1), ICES used an evidence-based threshold value, adapted from an approach used in NAFO, to identify areas where fishing activity using MBCG was low and therefore unlikely to have caused significant adverse impacts to the VMEs within the C-square. NAFO has a large amount of data on the biomass and abundance of VME indicators in research vessel catches. As a result, they were able to look at how the VME biomass in the catch decreased with increasing fishing activity. For three VME indicator groups (sea pens, large sponges and large gorgonian corals) the biomass in the catch decreased rapidly with increasing MBCG fishing activity and then levelled off (Figure 3). The point where the curve flattened indicates areas of VME habitats that are likely to be heavily damaged due to the fishing intensity exerted over previous years, as evidenced by little added VME biomass with increased fishing intensity. Areas where the fishing intensity was still relatively low and increasing effort resulted in high VME biomass in the catch, represented areas where continued fishing could still pose significant adverse impacts on VMEs and where, if left unfished, the VMEs may be able to recover (Figure 3). The curves for each of the three VME indicator groups were very similar in shape but the curve for sea pens was the least steep, indicating sea pens were the least vulnerable species of the indicators to be at risk of significant adverse impacts from MBCG fishing activity. If sea pens can persist, other VMEs can persist too. On that basis, NAFO chose the sea pen relationship with fishing intensity to set a conservative threshold of fishing intensity for the protection of all VME species.

Table 1. Description of management scenarios and options presented by WKEUVME with associated management implications for the protection of VMEs and general impacts to fisheries.

Scenario	Option	Description	Management Implication
Scenario 1	Option 1	C-squares between 400-800m depth with all VMEs supported by data in the VME Database, with priority to VME habitats and VME Index Medium to High 'likelihood' of occurrence, regardless of fishing activity in the 2009-11 period. C-squares with Low VME Index only included if adjacent to VME Index Medium to High C-squares.	Prioritizes protection of VMEs where they are *known* to occur, regardless of fishing activity.
Scenario 1	Option 2	Scenario 1 Option 1 + C-squares that contain selected VME physical elements (banks, seamounts, coral mounds, mud volcanoes) associated with any VME records.	Prioritizes protection of VMEs where they are *known* and *where they are likely to occur*, regardless of fishing activity.
Scenario 2	Option 1	As for Scenario 1 Option 1 but includes Low VME Index C-squares if MBCG fishing pressure is also low (< 0.43 SAR).	Prioritizes protection of VMEs where they are *known* or *likely to occur*, and includes areas where the 'likelihood' of occurrence of VME presence is lower but where fishing activity is also low and therefore any VMEs present are unlikely to be heavily damaged by trawl fishing. Gives highest protection of VMEs in the fishing footprint.
Scenario 2	Option 2	C-squares between 400-800m depth including all VME habitats, High, Medium and Low VME Index C-squares but excluding C-squares with high MBCG fishing pressure (SAR > 0.43).	Prioritizes protection of VMEs where they are *known* or *likely to occur*, but excludes areas that have been heavily fished (core fishing areas) and where VMEs are therefore likely to have been heavily damaged by past trawl fishing.

The Technical Workshop considered this evidence-based approach for protection of VME in EU waters and for incorporating it into the options for managers. Although some VME species differ on both sides of the Atlantic, they share similar size, shapes and life histories. Given the similar fishing gears used, it was agreed that in the absence of similar data in EU waters, adoption of the NAFO fishing intensity threshold of 0.5 hrs/km^2/year would be an ecologically-relevant threshold for providing management options under Scenario 2 (Table 1). In order to apply the NAFO approach to this request it was necessary to convert the NAFO fishing effort cut-off value of 0.5 hrs/km^2/year to a swept area ratio or SAR value. This value, using fishing gear dimensions for the halibut trawl fishery in NAFO, is 0.43 SAR as a mean annual value over the years from 2009 to 2016.

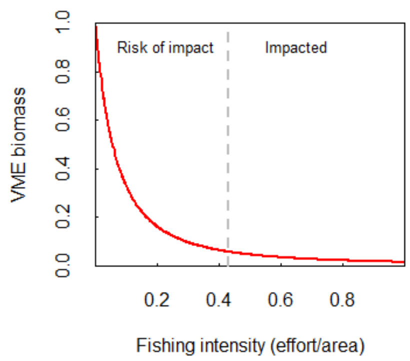


Figure 3. Example showing the relationship between cumulative biomass of VME species in the catch with increased fishing activity. The dashed line indicates the threshold separating out fishing intensity which may still negatively impact VME and fishing intensity that is so high that it is unlikely that VME are still present. Figures adapted from NAFO.

Spatial Buffers Around Closed C-Squares.

Modern navigation systems provide very accurate location of fishing vessels at sea. However, trawl gears are towed behind a vessel on wires several times the depth, and as a result the location of the actual mobile bottom contacting gear at depths of between 400 and 800 metres is much less accurately defined. The Technical Workshop considered that a ½ C-square buffer around each C-square to be closed to MBCG would be an appropriate buffer to ensure the protection of VME habitats distributed along the edge of the C-square. The choice of ½ a c-square, rather than another distance, was based primarily for the ease of implementation (see Section 4.5, Buffer Zones of the Report for more information).

How were C-squares Joined Up?

For each option in Table 1, the Technical Workshop provided detailed steps of how the closed areas were produced, with associated figures (see Section 4.5 of the Report). For every option the same general principles were followed with respect to how C-squares were joined up. For each option, all C-squares that included the relevant VME data (VME habitats, VME Index, and or VME physical elements) were selected and a ½ C-square buffer was drawn around them (e.g., Figure 4.21 of the Report). These cells are known or likely to contain VMEs and the buffer zones account for the offset between vessel positions and the position of their gear, which can be substantial in deep water, and the effects of sediment resuspension, which can have detrimental effects on VMEs. Where two or more C-squares are joined by their buffers or directly joined (in any way) they were combined into one VME closure polygon (e.g., Figure 4.23 of the Report). This reduces the number of polygons in a data-layer but does not change the protected area. Any holes with 1 or 2 C-squares inside the larger VME closures (e.g., Figure 4.25 of the Technical Workshop Report) were included in the larger closures. This was done because fishing vessels are un-likely to be able to fish effectively in very small areas without risking straying into closed areas. A trawler that fishes at 3.5 knots will cover 7nm in a typical 2h haul, which is equivalent to about between 2 and 3 C-squares. Open holes of less than 3 C-squares were therefore not considered practical. Further, these areas may contain VME since they are surrounded by VME C-squares and the areas may just represent lack of data. Any single, isolated VME C-squares were retained as individual VME closures with an associated ½ C-square buffer (e.g., Figure 4.24 of the Report). This is because many VMEs types can naturally consist of small patches of about one C-square in size or smaller.

The R-scripts which produced the closed area options and data summaries, including closure .shp files, are available on an open source platform (WKEUVME GitHub site). For each Ecoregion/Management Option/Closed Area script for creating a table of the coordinates for each closed area polygon has been produced. The table also indicates the VME habitat, VME indicator and VME element data present in each closed area option. The closed areas are also mapped and .shp files produced for each option. These will be available at the Stakeholder Workshop.

How Were the Impacts on Bottom Fisheries for Each of the Options Evaluated?

The Technical Workshop was asked to "*estimate for each of the options how it will affect bottom fisheries*". In order to do this, overviews of the fisheries were first prepared for each ecoregion. Tables of the total numbers of C-squares and numbers of C-squares fished (MBCG + Static) in each ecoregion per EEZ within the 400 m-800 m depth range were produced. This was further broken down to provide the total numbers of C-squares fished by gear type and sub-gear type within the 400-800 m depth band and within the whole region, by EEZ. This allows for an overview of which gear types are most active in each EEZ and what proportion of the activity of that gear type occurred during the reference period 2009-2011 in the 400-800 m depth band. C-squares where multiple sub-gears were active were also listed and mapped, allowing for an understanding of the different fisheries that operate in each C-square, by EEZ.

For each ecoregion a key table was produced summarizing the level of VME protection and impact on the fisheries for each of the 4 closed area options. For the Celtic Seas Ecoregion this is found in Table 9 of the Assessment Sheet for that ecoregion, and for the Bay of Biscay and Iberian Coast the equivalent table is Table 10 in its' Assessment Sheet in the Report. These tables give summaries for the depth range of the number of C-squares within the closures produced for each option and the number remaining outside the closures for: 1) VME protection; 2) VME protection above and below the SAR threshold for the fishing footprint years (2009-2011); 3) Fisheries overlap with VMEs for static and mobile gears in the footprint (2009-2011), and for MBCG only, VME overlap with areas with >10% fishing intensity; 4) Same as 3) but for the time frame 2012-2015; and 5) Same as 3) but for the time frame 2016-2019. These tables were also shown in graphical format in the Assessment Sheets.

How Effective are the Closures at Protecting Different Types of VMEs?

For each ecoregion and closed area option, the number of VME indicator and habitat records from the VME Database within the ecoregion, within the 400 – 800 m depth band as a whole, and within the depth 400 – 800 m depth band for each closure option are tabulated in the Assessment Sheets (Table 9 and Table 10 respectively in the Assessment Sheets for each ecoregion). This allows stakeholders to get an overview of the degree of protection afforded the different VME indicators and habitats under the 4 closed area options. In both the Celtic Seas (CSE) and Bay of Biscay and Iberian Coast (BBIC) ecoregions, Scenario 2 option 1 protects the largest number of C-squares containing VME inside the fishing footprint (Figures 20 and 24 respectively in the Assessment Sheets for each ecoregion). The pattern of protection under each option for the VME indicator types in the Celtic Seas ecoregion (Figure 21 in the CSE Assessment Sheet) is not consistent across VME types. For most VME types, Scenario 2 option 2 protects a smaller number of records than the other scenarios. The main exception from this pattern are the sea pens. Scenario 2 option 1 and Scenario 2 option 2 increases the number of sea pen records included in the closures by > 50%. The pattern of protection for the VME indicator types in the Bay of Biscay and Iberian Coast ecoregions (Figure 25 in the BBIC Assessment Sheet) is also not consistent across groups. Although differences are small, two patterns can be highlighted: the two options in Scenario 1 tend to under-preserve soft-corals and sea pens and Scenario 2 option 2 tends to under-preserve gorgonians and black corals.

Celtic Seas Ecoregion

Fisheries footprint and fishing intensity.

The 400 to 800 m depth band (light and dark blue) and the fishing footprint (dark blue) for the Celtic Seas Ecoregion is shown in Figure 4 and represents all C-squares with bottom-contact fishing (combined footprint for MBCG and Static), during the reference period 2009-2011. The interactive maps allow participants to zoom in on areas of interest during the workshop and Figure 4 is just meant to provide an overview of the ecoregion. For this ecoregion the combined fishing footprint is extensive, covering almost all (88%) of the 400-800 m depth band. Within the 400 – 800 m depth band, the unfished C-squares are most commonly found on the deeper edge of the depth range.

The WKEUVME Assessment Sheet for the Celtic Seas Ecoregion (Section 4.6 of the Report) provides a lot of details of the fisheries data that are not shown here. The areas of the fishing footprint that are fished by the most sub-gears, that is, different métiers (see Table 4 of the CSE Assessment Sheet in the Report for the full list), are the shelf edge south of Wyville-Thomson Ridge stopping north of the Porcupine Bank, to the south of the shelf edge surrounding Porcupine Seabight and in the Hatton-Rockall Basin.

Figure 5 shows the core MBCG fishing areas, defined as the areas where 90% of the MBCG fishing effort from 2009-2011 is found. The core fishing areas occur in less than 50% of the fished area (see also Figure 4.17 of the CSE Assessment Sheet in the Report). This core MBCG fishing area appears largely stable over time in the Celtic Seas Ecoregion (Figure 4.17 in the CSE Assessment Sheet in the Report).

Overlap with VMEs.

The Report describes details of the presence of many VME habitats and indicators in the region and stakeholders may wish to look at what protection is afforded the different VME types through the closed area options presented (see Table 10 and Figures 14, 15 and 21 of the CSE Assessment Sheet in the Report). Overlap between VME and fishing data shows that fishing occurs in 95% of C-squares with known VME occurrence or likely occurrence (VME physical elements are not considered here). The overlap is estimated using data on all gear types but is mostly coming from otter trawl gears that are the dominant fishing gear operating in the 400-800 m depth range (Table 4 of the CSE Assessment Sheet in Section 4.6 of the Report). These trawls predominantly target gadoid, *Nephrops*, and benthic fish species, and are primarily active within the Irish EEZ (highest overlap of gears: Table 5 of the CSE Assessment Sheet in Section 4.6 of the Report). However, static gears are not insignificant; pots (FPO) overlap with 12% of the C-squares with known or likely VME occurrence, whereas longlines (LLS) overlap with 49% and gillnets (GNS) 67% (Table 6 of the CSE Assessment Sheet in Section 4.6 of the Report).

Closure options for VME protection and fisheries.

The Report contains a lot of information on the various closure options and their implications for the fisheries. The closure scenarios vary in level of VME protection and full details can be found in Table 9 of the CSE Assessment Sheet in the Report. The results from Table 9 in the Report highlight that protection of all areas with a high probability of containing VMEs (Scenario 1 option 1 and 2, Scenario 2 option 1) will affect 8-9% of the total intensity of MBCG fisheries in recent years (2016-2019), while closure scenarios that avoid highly fished areas, that are therefore less likely to support viable VMEs, would reduce this to around 3% (Scenario 2 option 2). The number of closures produced under each option ranged from 69 to 89 and varied in size (Figure 6) with only Scenario 1 option 2 including large closures (> 1000 km^2) as a result of protecting VME physical elements. The location of the closures within the 400-800 metre depth range are shown in Figure 7. This map is included in the package of interactive maps which will allow participants to zoom in on areas of interest. A discussion of trade-offs among the four options and the fisheries is presented in the CSE Assessment Sheet, sub-section "Analysis of Trade-offs Between Closures and Impact on Fisheries".

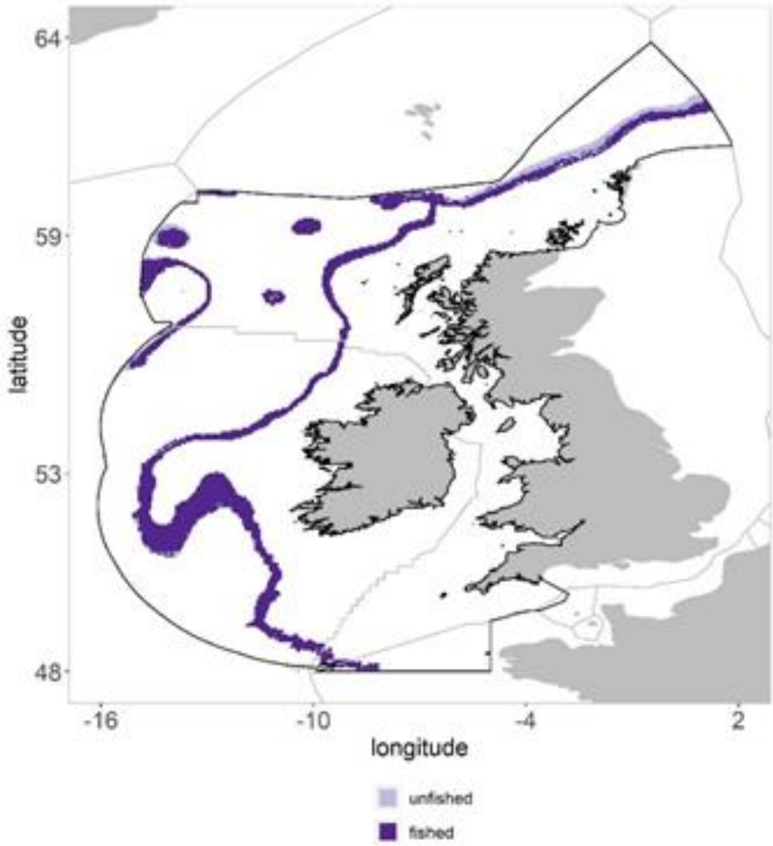


Figure 4. Fishing footprint (dark purple) between 400 m and 800 m depth (light and dark purple areas combined) of all bottom-contacting fishing gears (MBCG and Static) active between 2009-2011, highlighting fished vs. unfished areas within the depth band. This map is included in the package of interactive maps which will allow participants to zoom in on areas of interest.

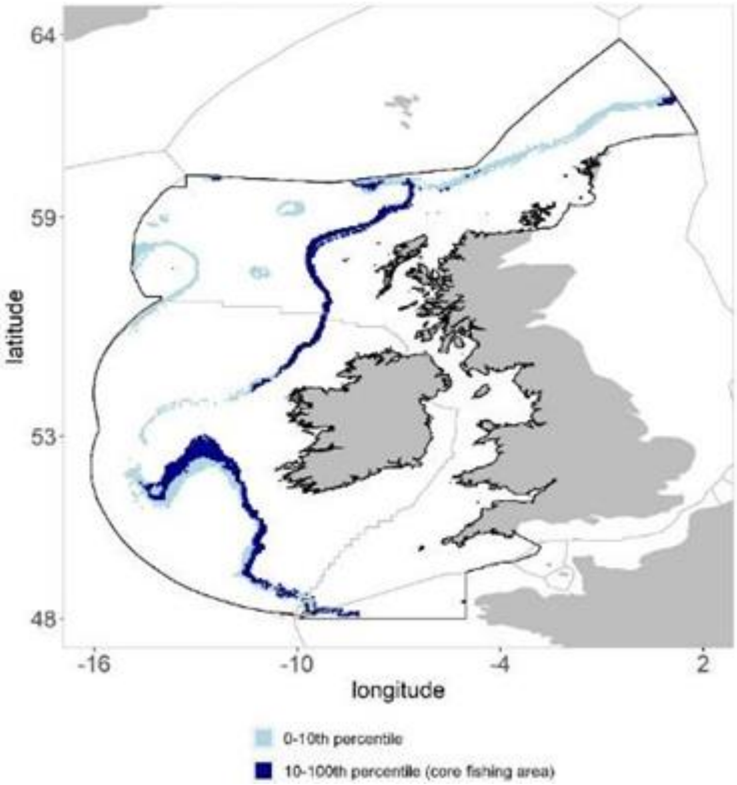


Figure 5. Fishing intensity (between 400 m and 800 m depth) of MBCG only, active between 2009-2011. Light blue area where 10% of the MBCG effort was distributed and dark blue area where 90% of the MBCG effort (core fishing area) was distributed. This map is included in the package of interactive maps which will allow participants to zoom in on areas of interest.

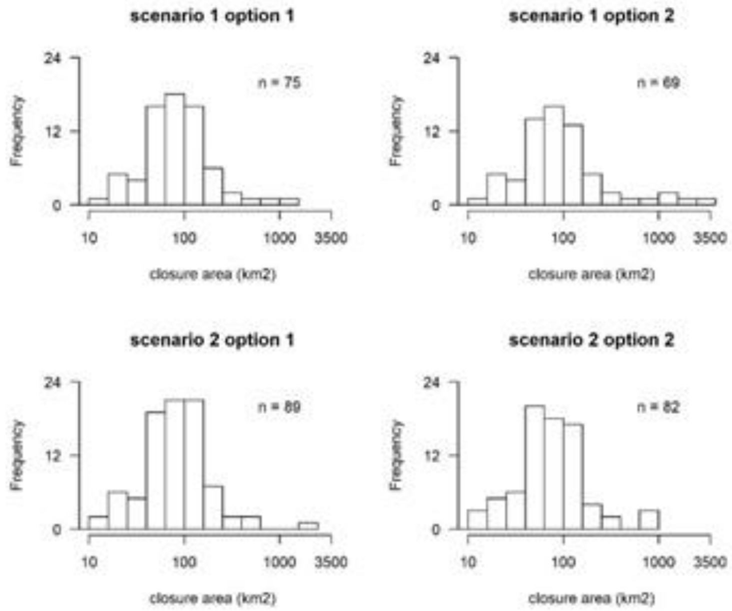


Figure 6. Histograms of the size of the closed areas that overlap with the 400-800 metre depth range following the two different Scenarios, each with two options (Table 1, also see maps in Figure 7). The total number of closure areas is in the upper right and ranges from 69 to 89.

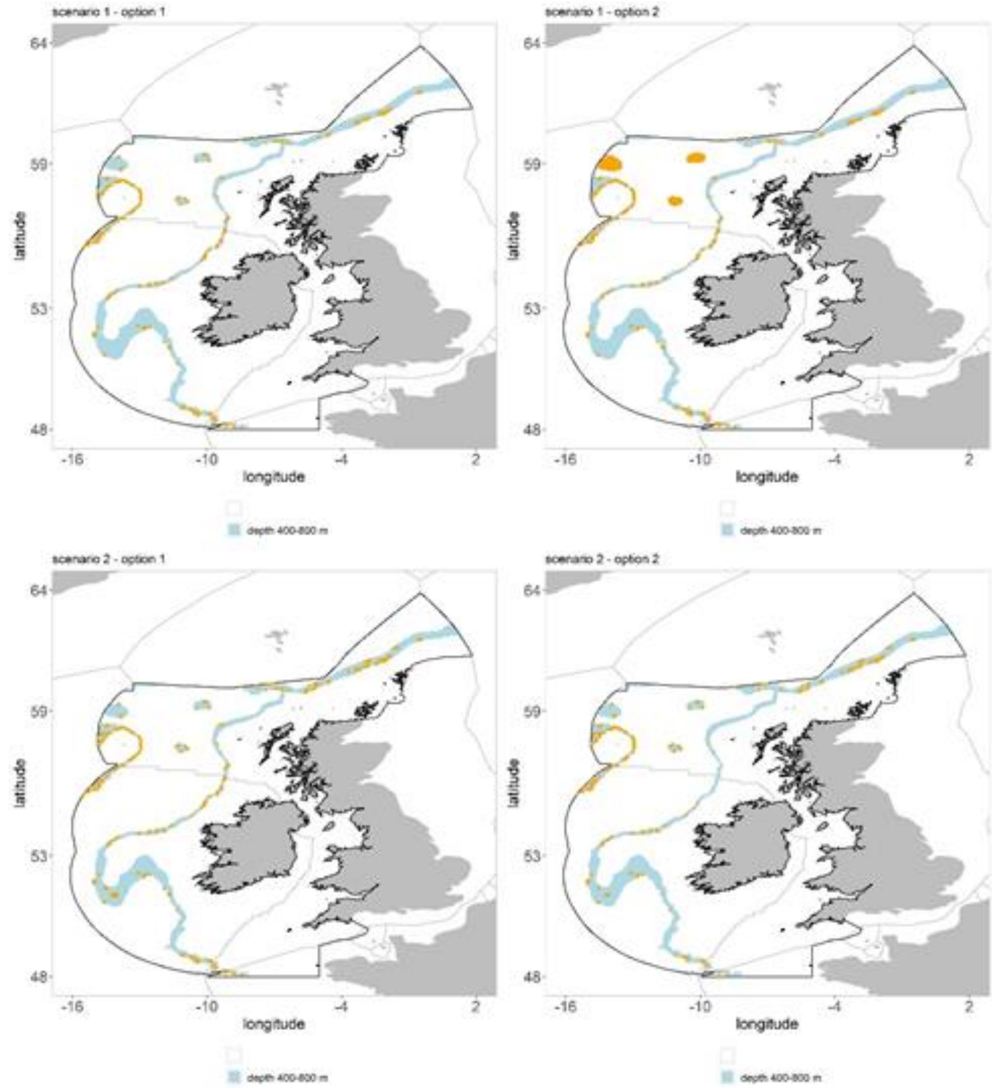


Figure 7. Maps of closures (orange) that overlap with the 400-800 metre depth range following the two different Scenarios, each with two options (Table 1). Use of interactive maps will allow participants to zoom in on areas of interest.

Bay of Biscay and Iberian Coast Ecoregion

Fisheries footprint and fishing intensity.

The 400 to 800 m depth band (light and dark blue) and the fishing footprint (dark blue) for the Bay of Biscay and Iberian Coast Ecoregion (BBIC) is shown in Figure 8 and represents all C-squares with bottom-contact fishing (MBCG and Static), during the reference period 2009-2011. The interactive maps allow participants to zoom in on areas of interest during the workshop and Figure 8 is just meant to provide an overview of the ecoregion. For this ecoregion, the fishing footprint is also extensive covering almost all (83.5%) of the 400-800 m depth band (Table 3 in the BBIC Assessment Sheet of the Report). Most of the unfished areas seems to be concentrated in Spanish waters (23% of C-squares unfished) followed by Portuguese waters (18% of C-squares unfished) whereas there are very few unfished areas in French waters (3%). Most of the unfished C-squares are concentrated in 3 areas: el Cachucho Bank, Galicia Bank and the Gulf of Cádiz (including both Spanish and Portuguese waters). However, due to the closeness of some of these deep-water areas (especially in the Cantabrian Sea) to the coast (and therefore its accessibility to small boats without VMS) and omission of a large proportion of fishing effort for the Spanish fleet (see Section 4.3. of the Report) caution is advised in assuming that all the unfished C-squares in this region are really unfished. The fishing footprint for MBCG only and that of the Static gear only which are not found in the Report are available on the WKEUVME Github Site as noted above.

The WKEUVME Assessment Sheet for the Bay of Biscay and Iberian Coast Ecoregion (Section 4.6 of the Report) provides a lot of details of the fisheries data that are not shown here. A fairly well-defined north-south gradient can be identified in the number of different fishing gears active in each fished C-square, with the northern Bay of Biscay waters accounting for the highest diversity of gear used, ranging from an average of 3 to 5 gears per C-square (reaching 6 and even 7 in some cases, see Table 4 in the BBIC Assessment Sheet of the Report) to the southernmost stretches of the ecoregion where the lowest diversity are reported, with 1 gear per C-square in the Spanish Gulf of Cádiz (but again, see caveats of fishing footprint for this region in Section 4.3 of the Report). This indicates some C-squares are fished by multiple fisheries while others are fished by a single métier. Figure 9 shows the core MBCG fishing areas, defined as the areas where 90% of the MBCG fishing effort is found. The core MBCG fishing areas occur in less than 50% of the fished area (see also Figure 4.18. of the BBIC Assessment Sheet in the Report).

Overlap with VMEs.

The Report describes details of the presence of many VME habitats and indicators in the region and managers may wish to look at what protection is afforded the different VME types through the closed area options presented (see Table 11 and Figures 18, 19 and 25 of the BBIC Assessment Sheet in the Report). Overlap between VME and fishing data shows that fishing occurs in 78% of C-squares with known VME occurrence or likely occurrence (Table 6 of the BBIC Assessment Sheet in the Report). The overlap is estimated using data on all gear types but is mostly coming from otter trawl, longline and gillnet gears that are the dominant fishing gears operating in the 400-800 m depth range (Table 5 of the BBIC Assessment Sheet in the Report).

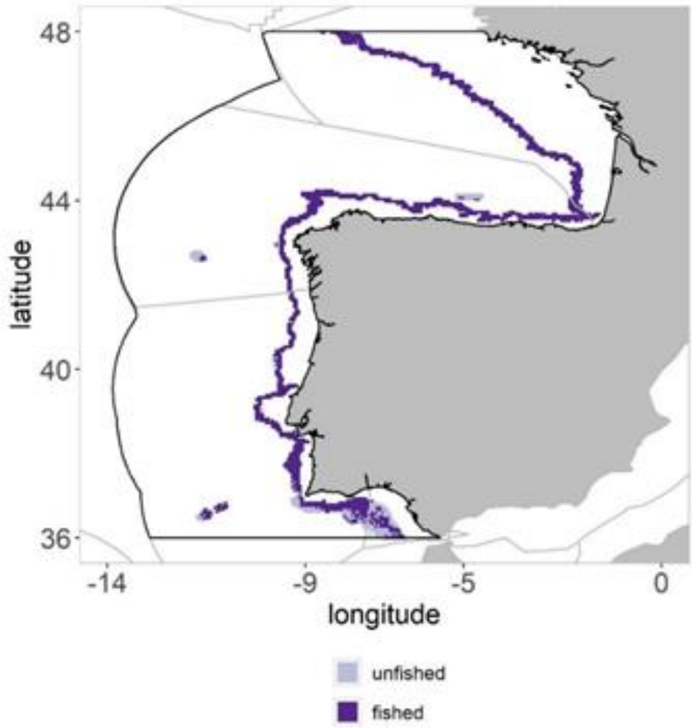


Figure 8. Fishing footprint (dark purple) between 400 m and 800 m depth (light and dark purple areas combined) of all bottom-contacting fishing gears (MBCG and Static) active between 2009-2011, highlighting fished vs. unfished areas within the depth band. This map is included in the package of interactive maps which will allow participants to zoom in on areas of interest.

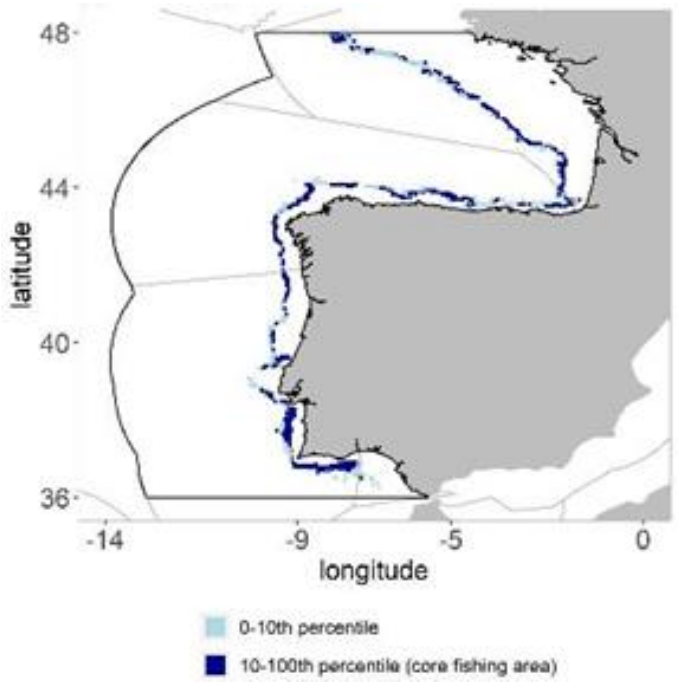


Figure 9. Fishing intensity (between 400 m and 800 m depth) of MBCG only, active between 2009-2011. Light blue area where 10% of the MBCG effort was distributed and dark blue area where 90% of the MBCG effort (core fishing area) was distributed. This map is included in the package of interactive maps which will allow participants to zoom in on areas of interest.

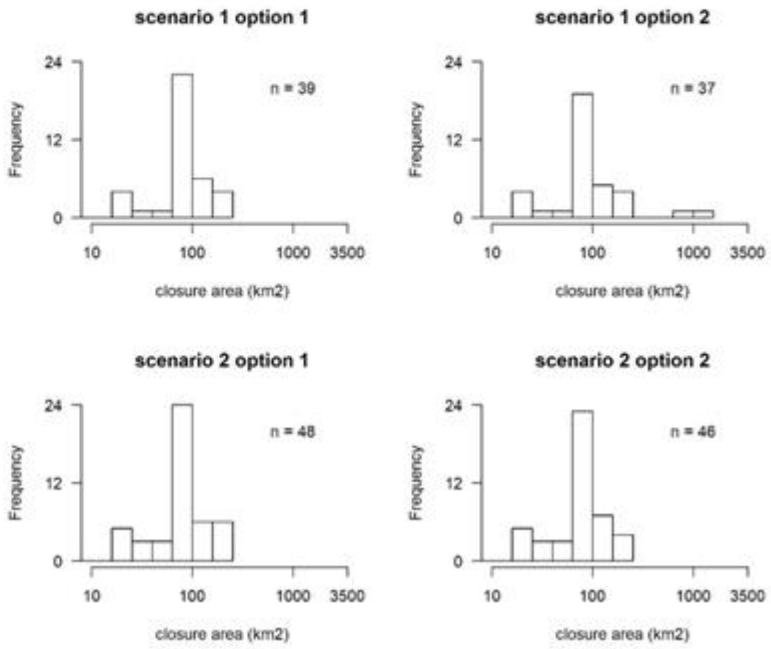


Figure 10. Histograms of the size of the closed areas that overlap with the 400-800 metre depth range following the two different Scenarios, each with two options (Table 1, see also maps in Figure 11). The total number of closure areas is in the upper right and ranges from 37 to 48.

Closure options for VME protection and fisheries.

The Report contains a lot of information on the various closure options and their implications for the fisheries. The closure scenarios vary in level of VME protection and full details can be found in Table 10 of the BBIC Assessment Sheet in the Report. The results from Table 10 in the Report highlight that full protection of all areas with a high probability of containing VMEs will affect 11% of the total intensity of MBCG fisheries in recent years (2016-2019), while closure scenarios that avoid highly fished areas, that are therefore less likely to support viable VMEs, would reduce this to around 9% (Scenario 2 option 2). The number of closures produced under each option ranged from 37 to 48 and varied in size (Figure 10) with only Scenario 1 option 2 including large closures (> 1000 km^2) as a result of protecting VME physical elements. The location of the closures within the 400-800 metre depth range are shown in Figure 11. This map is included in the package of interactive maps which will allow participants to zoom in on areas of interest. A discussion of trade-offs among the four options and the fisheries is presented in the BBIC Assessment Sheet in the Report, sub-section "Analysis of Trade-offs Between Closures and Impact on Fisheries".

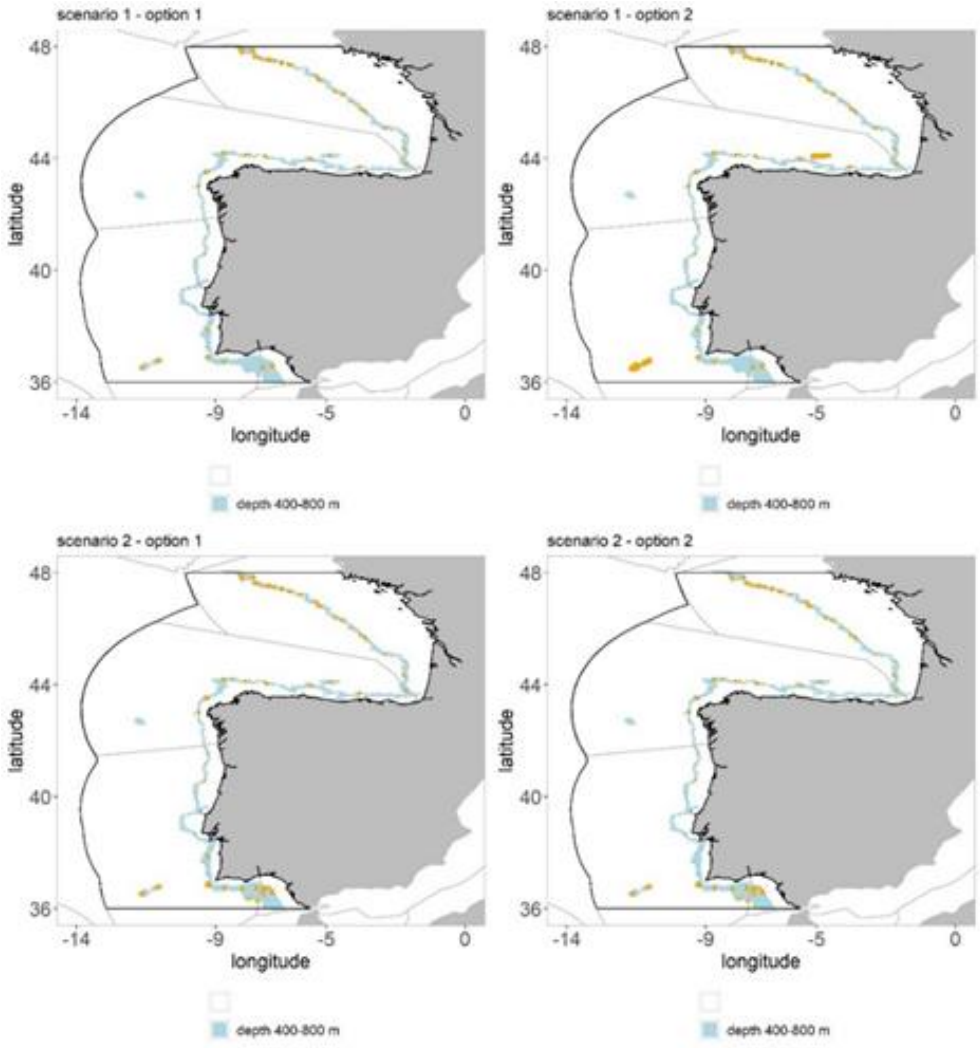


Figure 11. Maps of closures (orange) that overlap with the 400-800 metre depth range following the two different Scenarios, each with two options (Table 1). Use of interactive maps will allow participants to zoom in on areas of interest.

Stakeholder Workshop

This workshop is part of the formal ICES advisory process in response to a request from the EU. To ensure a successful workshop we encourage participants to familiarize themselves with the May WKEUVME technical report and Assessment Sheets. The May technical report embodies the scientific guidance that ICES has prepared in response to the EU request. At this workshop we seek feedback from stakeholders on the following three questions:

1) Which of the 4 management options presented do you prefer and why?

2) Do you think that the number and location of the closed areas for your preferred option is practical and implementable? If not, explain why.

3) What other information would you like to see to help you understand the options presented?

Agenda for WKEUVME-STAKE

The online workshop will start at 13.00 CET, on Tuesday 1 September and end 15.00, Thursday 3 September 2020 to address Term of Reference (ToR) c (see below). Participants will be assigned to one of two ecoregion break-out groups prior to the meeting according to their selection on the distributed questionnaire. Completed questionnaires need to be provided to the Chairs by **27 August 2020** for merging.

The work is spread out over three afternoons. On the first day, presentations will be given explaining the available data and work done during the May WKEUVME workshop and demonstrating how the interactive maps work. We will attempt to circulate those presentations (see below) prior to the meeting so that participants can review. Day 1 will close following a round table discussion to learn if anything is unclear. Day 2 will open with a review of the material requiring clarification followed by a presentation by the Chairs summarising the ecoregion-specific answers to the 3 questions that were posed above. The agenda will then move to the break-out groups where participants will review the questions posed again and explore the interactive maps in more detail. The goal is to produce a summary of the individual responses in a text form supported by examples from the interactive maps. By the end of Day 2, break-out group leads will report back on the answers to the questions and provide the Chairs with a draft set of answers to the 3 questions and any other issues that were discussed. Group leads will send the draft report to the Chairs at the end of Day 2. Day 3 will commence with a summary of the inputs received by the Chairs for inclusion in the Report and proceed to a review of the final text that will be put into the report.

	Monday 31 August	**Tuesday** 1 September	**Wednesday** 2 September	**Thursday** 3 September	**Friday** 4 September
11.00					
12.00 CET		**Day 1**	**Day 2**	**Day 3**	
13.00					
14.00					
15.00					
16.00					

Break-out group work
Plenary (All participants)

Day 1 Presentations

Background to the Request and overall approach taken (Eugene Nixon, Sebastian Valanko)

VME Data Availability (Laura Robson)

Fishing Data Availability (Helen Holah)

Technical Review and Description of Scenarios and Options (Ellen Kenchington)

Interactive Maps (Daniël van Denderen)

Management Implications of Scenarios and Options (Peter Hopkins)

Brief Outline of Workplan (Peter Hopkins)

General instructions for remote online WKEUVME-STAKE workshop

Given the present travel restrictions due to the COVID-19 outbreak, this previously planned physical meeting is now being run as a remote online WKEUVME-STAKE workshop. The online workshop will start at 13.00 CET, on Tuesday 1 September and end 15.00, Thursday 3 September, 2020. The work is intentionally spread out over the 3 day period with short plenary sessions.

Emphasis of this meeting of WKEUVME-STAKE will be on responding to the work undertaken at the May WKEUVME technical meeting. Responses will be documented and used to improve advice in future should it be requested. As such, we will avoid as far as possible lengthy discussion – debate in plenary.

Prior to the meeting, we therefore encourage all participants to read the ToRb of the WKEUVME technical report and relevant ecoregion Assessment Sheet after a first look at the Dissemination Sheets summarized above. This will likely take an afternoon (at least!) but will really help with our discussions. We ask that participants provide their pre-filled questionnaire by **27 August 2020** to the Chairs for merging in order to make the break-out groups productive.

Presentations for the first day will be done in Powerpoint and made available on the Sharepoint for viewing 9.00 CET Monday 31 August at the latest. It will be assumed that all participants have viewed and reflected on them prior to the start of first day plenary (13.00 CET, on Tuesday 1 September).

Etiquette check list for online meetings

- Test all technology (including camera/video, Wi-Fi, and screen sharing) before the meeting (we will open the meeting at least 45 min before start to allow you to do this);
- Make sure you are in a quiet area free from unnecessary distractions;
- Turn off all notifications and make sure your cell phone is on silent;
- When not speaking, always use the mute button at your site to prevent transmitting background noise;
- Read the material and come prepared;

- Do not multi-task (do other work) during the meeting;
- Use the “chat” to request speaking time;
- Don’t interrupt other people when they’re speaking (or attempt to speak over them);
- Participants are kindly invited to join the online meeting 10 minutes before the opening of the meeting once equipment is tested!

Annex 4: Questionnaire

Meeting Participants: Please fill out the questionnaire below before the meeting in anticipation of the break-out group work. Responses will be collated (namelessly) and provided to the break-out group leads to consider in the break-out sessions. **Please email your responses to the** Eirini@ices.dk **and the Chairs** by **27th August 2020**: Ellen.Kenchington@dfo-mpo.gc.ca and peterhopkins@skynet.be

Ecoregion:	Celtic Seas	☐
Ecoregion:	Bay of Biscay and Iberian Coast	☐

Question 1: Which of the 4 management options presented do you prefer and why?

If you can, please indicate what you liked and didn't like about each of the options.

Option I prefer (please check only one):

Scenario 1 Option 1 ☐

Scenario 1 Option 2 ☐

Scenario 2 Option 1 ☐

Scenario 2 Option 2 ☐

Scenario 1	Option 1	C-squares between 400-800m depth with all VMEs supported by data in the VME Database, with priority to VME habitats and VME Index Medium to High 'likelihood' of occurrence, regardless of fishing activity in the 2009-11 period. C-squares with Low VME Index only included if adjacent to VME Index Medium to High C-squares.	Prioritizes protection of VMEs where they are *known* to occur, regardless of fishing activity.

Things that I like about this option:

Things that I don't like about this option:

Scenario 1	Option 2	Scenario 1 Option 1 + C-squares that contain selected VME physical elements (banks, seamounts, coral mounds, mud volcanoes) associated with any VME records.	Prioritizes protection of VMEs where they are *known* and *where they are likely to occur*, regardless of fishing activity.

Things that I like about this option:

Things that I don't like about this option:

Scenario 2	Option 1	As for Scenario 1 Option 1 but includes Low VME Index C-squares if MBCG fishing pressure is also low (< 0.43 SAR).	Prioritizes protection of VMEs where they are *known* or *likely to occur*, and includes areas where the 'likelihood' of occurrence of VME presence is lower but where fishing activity is also low and therefore any VMEs present are unlikely to be heavily damaged by trawl fishing.

Things that I like about this option:

Things that I don't like about this option:

Scenario 2	Option 2	C-squares between 400-800m depth including all VME habitats, High, Medium and Low VME Index C-squares but excluding C-squares with high MBCG fishing pressure (SAR > 0.43).	Prioritizes protection of VMEs where they are *known* or *likely to occur*, but excludes areas that have been heavily fished (core fishing areas) and where VMEs are therefore likely to have been heavily damaged by past trawl fishing.

Things that I like about this option:

Things that I don't like about this option:

Question 2: Do you think that the number and location of the closed areas for your preferred option is practical and implementable? If not, explain why.

Question 3: What other information would you like to see to help you understand the options presented?