EU Request to advise 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)

Advice summary

There are two parts to ICES advice:

1. ICES advises that the *"Existing Deep-Sea Fishing Areas"* for the reference years 2009–2011 are based on the VMS and logbook data submitted to ICES in 2019 and shown in the accompanying Interactive Maps and PDF maps. The coordinates are provided in CSV files. *"Existing Deep-Sea Fishing Areas"* for the reference years are limited to the 400–800 metre depth range and are separated into three fishing footprints based on the gear type used. These are the combined static and mobile bottom-contacting gear (MBCG) footprint, the static gear only footprint, and the MBCG only footprint.
2. ICES advises that the list of areas where VMEs are known to occur or likely to occur is based on the VME data submitted to ICES in 2020. These areas are shown in the accompanying interactive maps. The coordinates are provided in CSV files. The list of habitat types, indicators, and physical elements used to define these VME areas is provided, along with the criteria used to translate the quantity and quality of data into the likelihood of VME occurrence, known as a VME Index.

This data-driven advice was developed through an iterative three-year process and is modeled on the approach taken by *"NEAFC Recommendation 19- 2014: Protection of VMEs in NEAFC Regulatory Areas".* It involves combining two data streams, VMS/logbook data to quantify the fishing footprint and data on where VMEs are known to or are likely to occur. To demonstrate how these two data layers can be used in practice to protect VMEs from fishing impacts, ICES developed and describes two scenarios, each with two options; ICES considers these to be consistent with the relevant United Nations General Assembly (UNGA) Sustainable Fisheries Resolutions and the Food and Agriculture Organization of the United Nations (FAO) International Guidelines for the Management of Deep-sea Fisheries in the High Seas with regard to the protection of VMEs. The two scenarios place different emphasis on the dual aspects of the UNGA policy and EU Regulation 2016/2336, that is, protection of VMEs with and without consideration of bottom-contacting fishing activity.

Request

The European Commission requests ICES to advise 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). This advice should deliver the following in view of completing the implementation of Regulation (EU) 2016/2336:

- Provide a description of the existing deep-sea fishing areas based on the reference years 2009-2011 in EU waters of the North-East Atlantic. This description should be translated into static coloured maps and their specific coordinates entitled "Existing Deep-Sea Fishing Areas" and listed in map and tables on the model of Annex 1 of the "NEAFC Recommendation 19- 2014: Protection of VMEs in NEAFC Regulatory Areas".

- Provide a list of areas where VMES are known to occur or likely to occur. This list should be translated into static coloured maps and their specific coordinates entitled "List of areas where VMEs are known to occur or are likely to occur" and listed in map and tables on the model of Annex 2 of the "NEAFC Recommendation 19-2014: Protection of VMEs in NEAFC Regulatory Areas".

- Make the updated interactive map available until February 2021

Elaboration on the advice

This ICES advice must be read in conjunction with Interactive Maps 1 and 2 (Annex 1), showing the fishing footprints for the reference years, 2009 to 2011; the areas where VMEs "are known to occur" or "are likely to occur"; fishing closure scenarios to demonstrate approaches for the protection of VMEs; and the fishing activity for the most recent years for which quality controlled data is available, 2015 to 2018. Interactive Map 2 has been produced to give an impression of the potential consequences of the closure scenarios on recent fishing activity.

Geographical range

EU Regulation 2016/2336 (EU, 2016) sets out specific requirements for the protection of VMEs from fishing operations that use bottom-contacting gears below a depth of 400 metres. It also stipulates that no authorisation shall be issued for the purpose of fishing with bottom trawls at a depth of below 800 metres. As ICES does not collect information on fishing authorisations, this advice considers all vessel monitoring system (VMS) and logbook data submitted by Member Countries between the depths 400 and 800 metres.

ICES uses ecoregions (ICES, 2020a) when providing advice. Most of the EU waters between depths of 400 and 800 metres fall into either the Celtic Seas ecoregion or the Bay of Biscay and the Iberian Coast ecoregion (Figure 1). Small areas within the 400–800 metre depth range occur in the North Sea ecoregion, but these see either limited or no fishing activity. There are also a number of VMEs within the Azores ecoregion that occur within the 400-800 metre depth range, mainly along the steep island slopes and offshore seamounts. The "Basis of the advice" section provides further information on the North Sea and Azores ecoregions.

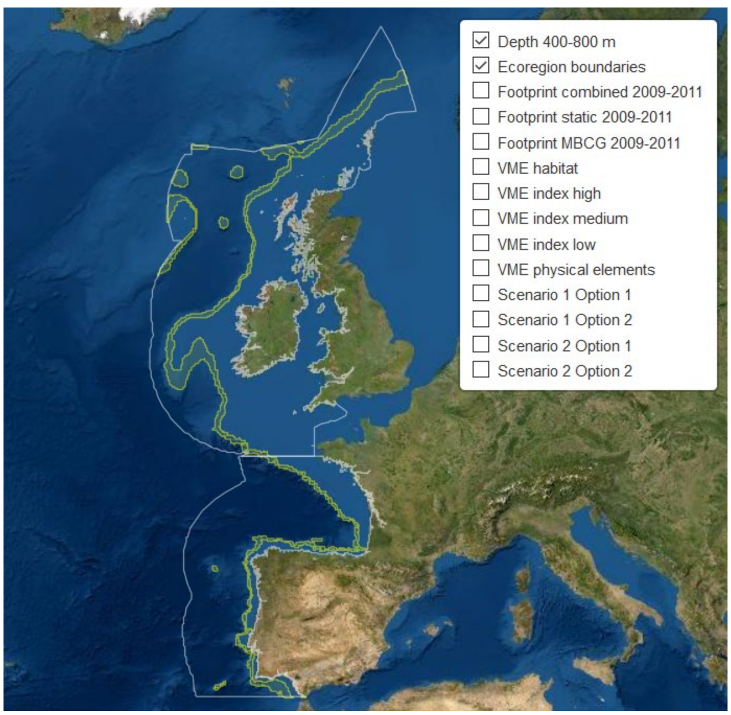


Figure 1 All waters between the 400–800 metre depth range (outlined in yellow) in the Celtic Seas ecoregion and Bay of Biscay and the Iberian Coast ecoregion (outlined in white), see accompanying Interactive Map 1.

Fishing footprints between 400–800 metres for the Reference Years 2009–2011

ICES was tasked with providing a description of the existing deep-sea fishing areas based on the reference years 2009–2011 (hereafter referred to as the "fishing footprint") in EU waters of the north east Atlantic. To do this, ICES based its analyses on all fishing activity data submitted in response to the ICES 2019 data call from EU Member States that used bottom gears at depths of between 400 and 800 metres for the period 2009–2011. The data submitted are at a C-square level resolution of 0.05° latitude × 0.05° longitude (approximately 15 km², hereafter termed "C-square"). Using the available data, ICES developed the fishing footprints for the reference period while retaining the same C-square spatial resolution.

Three footprints are shown in Interactive Map 1 (coordinates also provided): one footprint for both MBCG and static gear together, one for static gear only, and one footprint for MBCG only. Each of these can be visualized in Interactive Map 1 by turning on and off the relevant layers. As an example, Figure 2 shows the footprints for an area in the Celtic Seas ecoregion. A fishing footprint is defined as the C-squares in which each individual square with active fisheries has at least one neighbouring square also with active fisheries. Single isolated active squares are omitted. Thus, Interactive Map 1 is based on the qualitative information of presence or absence of MBCG and/or static gear – regardless of the gear's use intensity – within a particular C-square during the reference period.

Based on data currently available, it is possible to determine the presence or absence of fishing activity within a C-square for both MBCG and static gears. For MBCG, fishing intensity can also be quantified as the area swept per unit area, or "swept-area ratio" (SAR), i.e. the proportion of the area of the seabed which is contacted by the fishing gear in relation to the total surface area of the C-square. SAR can therefore be used to estimate the extent of MBCG impact on VMEs and the consequence of closures on MBCG fishing activity. For static gears, a SAR equivalent is not available and therefore the fishing intensity could not be assessed.

ICES notes that EU Regulation 2016/2336 (EU, 2016) does not differentiate between static gear and MBCG and that by using the combined footprint presented in this advice to determine the "existing deep-sea fishing areas" could potentially result in changes to the spatial distribution of fishing activities with either type of gear from that which occurred during the 2009–2011 reference period. For instance, MBCG gears, which have a far greater impact on VMEs when compared to static gears, may be able to fish in areas previously only fished by static gears during the reference period. To illustrate this, Figure 2 shows that the footprints for MBCG and static gears are different. Using the combined footprint could result in MBCG fishing activity being permitted in large areas that were only fished with static gears during 2009–2011, for example to the north and west of the Porcupine Bank. Conversely, static gears could be used in areas previously unfished in the reference period such as the shelf slope to the north of the Porcupine Seabight (Figure 2). Implementation of closure scenarios and options may lead to displacement, which could increase the likelihood of MBCG or static gears changing their gear-specific distribution within the combined footprint.

ICES also notes that under the annual VMS data call, EU Member States have the option to resubmit data for all years including the reference period (2009–2011) and that this may have implications for the fishing footprints provided in this advice.

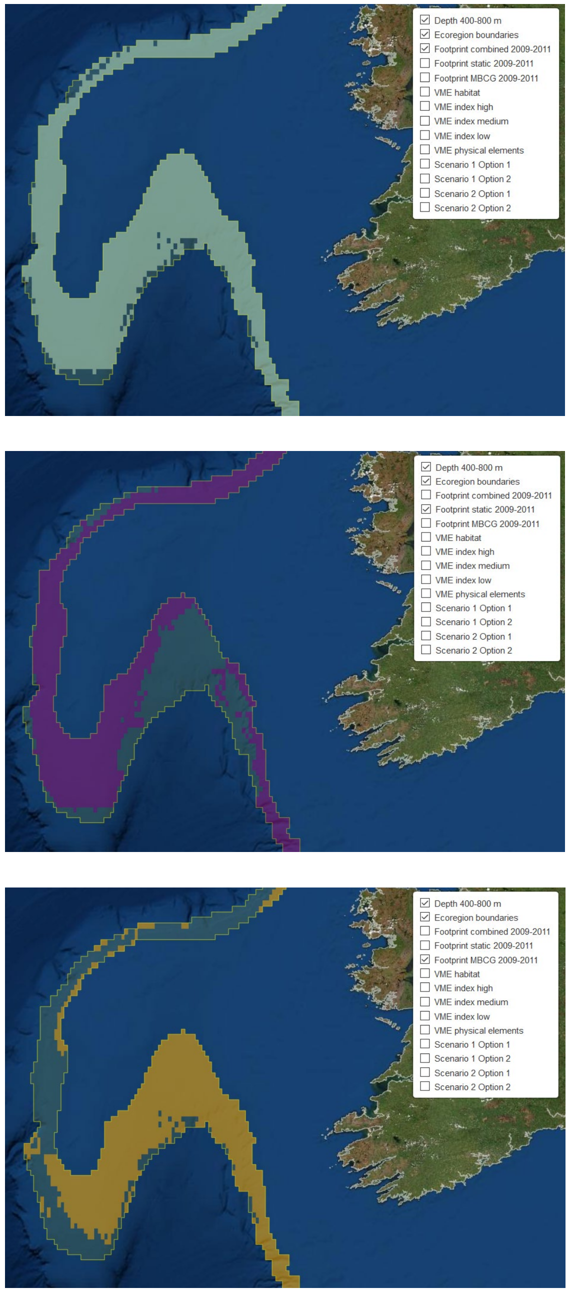


Figure 2 The 2009–2011 fishing footprints for an area in the Celtic Seas ecoregion based on VMS and logbook data submitted in response to ICES 2019 data call. The upper panel is the combined static and MBCG fishing footprint, the middle panel is the static gear footprint only, and the lower panel is the MBCG footprint only. See accompanying Interactive Map 1.

Identifying C-squares containing or likely to contain VMEs

ICES used data contained in its VME database[1] to identify C-squares that contain or are likely to contain VMEs. The VME database contains quality-controlled data submitted by ICES Member Countries and is regularly updated following annual VME data calls from ICES. Data contained in the VME database up to and including those submitted in 2020 are included in this advice.

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). Identification of what species/habitats qualify as VME indicators is based on five criteria established by FAO in 2009 (see Annex 2 for the ICES VME list that will be used from 2021 onwards), these 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.

There are two types of data submitted to the ICES VME database. The first type is data that without doubt confirm the actual presence of a VME on the seabed, for example high-quality video observations of cold-water coral reefs or deep-sea sponge aggregations (see Table 5 below) from dedicated deep-sea surveys. ICES VME database records these cases as VME habitats. These VME habitats are *bona fide* records and represent where VME “are known to occur”. C-squares where VMEs are known to occur are shown in purple in Interactive Map 1 (see Figure 3).

The second type of data consists of records that do not provide the same certainty of VME presence, often because they were remotely sampled and not directly observed on the seabed. For these records, ICES developed a method to combine individual records within a C-square using FAO criteria and any available abundance data into a “VME Index” with high, medium, and low likelihood of a C-square containing an actual VME habitat. The VME Index is applied at the C-square level and indicates squares where VMEs “are likely to occur”. C-squares where there is a high likelihood of VMEs occurring are shown in red, medium likelihood in orange, and low likelihood in yellow in Interactive Map 1 (Figure 3).

VME physical elements are defined in the FAO Deep-sea Fisheries Guidelines (FAO, 2009) as “topographical, hydrophysical or geological features, including fragile geological structures, that potentially support” VMEs. ICES used the presence of VME physical elements to indicate the likely presence of VMEs in a particular C-square.

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

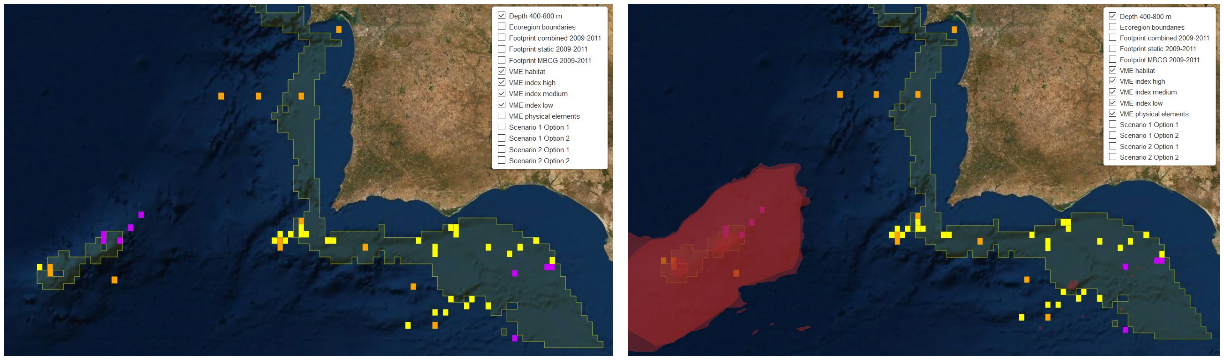


Figure 3 Both panels show C-squares containing known VME habitats (purple), C-squares with a medium likelihood (orange) of containing VMEs, and C-squares with a low likelihood (yellow) of containing VMEs. (Squares with a high likelihood of VMEs occurring are shown in red on the interactive maps, although there are none in this figure.) The right panel also includes areas with VME physical elements. Both maps can be recreated with Interactive Map 1.

Possible management approaches identified

Consistent with the UNGA Resolutions and FAO Deep-sea Fisheries Guidelines, ICES has constructed two scenarios, each with two options, which place emphasis on different aspects of the UN Resolutions. These scenarios are described in Table 1.

Table 1 Possible management approaches presented by ICES with associated management implications for the protection of VMEs and general impacts on fisheries. Interactive Map 1 is the reference for the spatial distribution of the closure polygons resulting from the implementation of the scenarios and options and how they overlap with each of the combined, static gear, and MBCG footprints. Interactive Map 2 shows the same information for MBCG only, and also the spatial consequence of the closure polygons on the MBCG fishing activity for the years 2015–2018. Mapped closures are polygons produced by the combining and buffering rules set out in the “Basis of the advice” section.

Scenario	Option	Description of C-square closures	Management implication
1	1	C-squares between 400–800m depth with VME habitats as well as C-squares with high and medium VME indices, regardless of fishing activity. C-squares with a low VME index only included if adjacent to C-squares with medium to high VME indices.	Prioritizes protection of VMEs where they “are known to occur”, and where they “are likely to occur”, regardless of fishing activity.
1	2	Scenario 1–Option 1 + C-squares that contain selected VME physical elements (banks, seamounts, coral mounds, mud volcanoes) associated with any VME indicator species records.	Prioritizes protection of VMEs where they “are known to occur” and “are likely to occur”, as well as elements that are known to frequently contain VMEs, regardless of fishing activity.
2	1	As Scenario 1–Option 1 but includes low VME index C-squares if MBCG fishing pressure is also low (SAR < 0.43).	Prioritizes protection of VMEs where they “are known to occur” or “ are likely to occur”, and includes C squares with low VME index where fishing activity is also low and significant adverse impacts (SAIs) by past fishing are less likely, this therefore offers VME protection at low cost to the fisher and highest protection of VMEs in the fishing footprint.
2	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 intensely fished and where VMEs are therefore potentially damaged by past trawl fishing. By leaving heavily fished areas open, there is reduced impact on fishing activities.

Scenario 1 prioritizes protection of VMEs, irrespective of the fishing activity and is consistent with paragraph 83c of UNGA Resolution 61/105, (UNGA, 2006) for the identification of VMEs, while Scenario 2 prioritizes protection of VME but incorporates a threshold for the level of permissible fishing activity that is empirically linked to significant adverse impacts (SAI), consistent with Resolution paragraph 83a (UNGA, 2006). All four options identified, as a minimum, C-squares where VMEs are known to occur (VME Habitats) and C-squares where there is a high and medium likelihood of VMEs occurring (i.e. high and medium VME Index).

Scenario 1–Option 2 is the most precautionary of the two options as it also includes VME physical elements and some low VME Index squares as areas where VMEs "are likely to occur" in addition to VME Habitats and high and medium VME Index squares. For Scenario 2, fishing activity is considered, but the assessment of fishing activity is limited to MBCG only. The reasons for this are: 1) MBCG is currently the only gear type for which ICES has information on the intensity of fishing activity; and 2) in most situations, MBCG has a far greater impact on VMEs when compared to static gear, a point recognised in the preamble of Regulation 2016/2336 (EU, 2016) itself. Under Scenario 2, the key phrase in the Resolution are identification of whether bottom fishing activities "*would cause* significant adverse impacts to such ecosystems". The implication is that the VMEs in the C-squares that have been more intensely fished may already be damaged and further fishing would not cause further SAIs; it must be remembered, however, that fishing activity with MBCG and the presence of VMEs within a C-square may or may not spatially overlap (and that this cannot be resolved with the data available). Where there is a significant overlap, there may be limited benefit to be gained from closing these C-squares, whereas, where there is little or no overlap (even if intensively fished), closure to prevent fishing in hitherto unfished parts of the C-square also containing VMEs could result in a significant benefit to VME protection.

To that end, the two options in Scenario 2 use a threshold for fishing activity (SAR = 0.43, or 43% of the C-square fished, applying a uniform fishing distribution) above which SAI is likely to have occurred. This threshold was estimated as the fishing intensity at which the biomass of the VME indicator that was found to be least sensitive to bottom trawling, sea pens, was reduced to low levels of abundance (Figure 4). This threshold is therefore precautionary for the more sensitive VME indicator species.

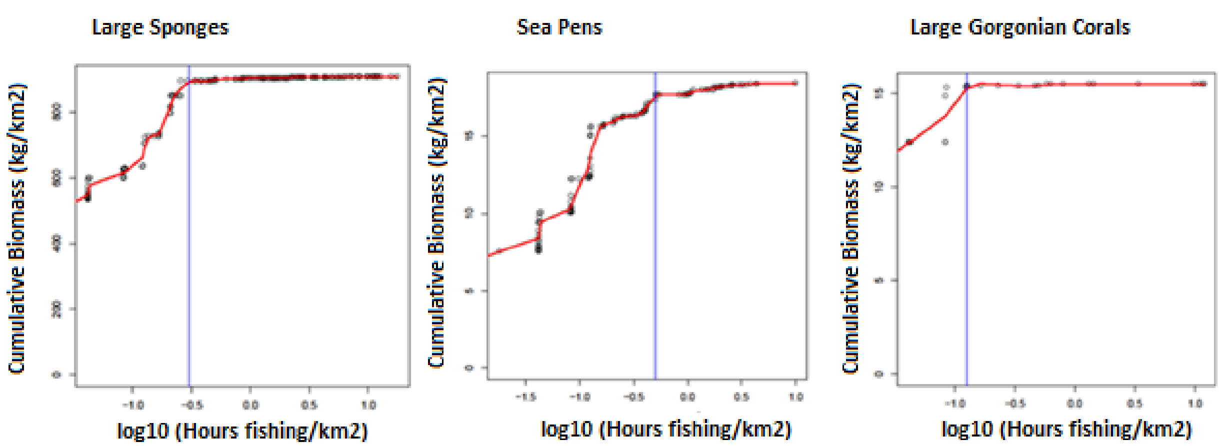


Figure 4 Cumulative plots of sponge (left), sea pen (middle), and gorgonian coral biomass against fishing effort per year in the Northwest Atlantic Fisheries Organization (NAFO) area (NAFO, 2016). The inflection cut-off values (blue lines) show the intensity above which the VME indicator species is found in low levels of abundance in bottom trawls. The inflexion cut-off value of the least sensitive VME indicator, sea pens (0.5 hours/km^{-2} per year, $0.05 < p < 0.1$), was used to define a threshold for fishing activity. This threshold is therefore conservative for the more sensitive VME indicator species. To apply the threshold value, it was necessary to convert the 0.5 hours/km^{-2} fishing effort per year to a SAR value. Using fishing gear dimensions for the halibut trawl fishery in the NAFO area, this became a mean annual value of 0.43 SAR. Figure taken from NAFO (2016, Fig. 4.2.5.3.6).

Because of the different characteristics of the VME indicators, and the way the Index has been calculated, some VME indicators such as sea pens rarely score a medium or high VME Index. Scenario 2 enhances the protection of sea pens and other VMEs that have a low index by protecting low indices where SAI from past fishing is less likely. Scenario 2–Option 1 further includes all VME habitats as well as C-squares with high and medium VME indices and gives the highest protection of VMEs in the fishing footprint. Scenario 2–Option 2 protects all VME C-squares (habitat as well as and high, medium, and low VME indices) in areas where further fishing could cause SAI.

There is no explicit reason why the selection of scenario and option needs to be the same for each ecoregion or subregion. Given that each ecoregion has very different quantity and quality of VME and fishing effort data, as well as different presence of VME physical elements, it would be reasonable for the selection of scenario and option to reflect those realities. A combination of scenarios and options can also be used. For example, if Scenario 1–Option 2 (closure of areas with VME physical elements) is combined with Scenario 2–Option 1, the areas closed give maximum protection to VMEs where they are known to or likely to occur.

ICES notes that in both the North East Atlantic Fisheries Commission (NEAFC) and Northwest Atlantic Fisheries Organization (NAFO) identification of areas closed to protect VMEs has been an iterative process and that, to date, they have closed areas to protect VMEs based only on information under Scenario 1 and have not considered directly incorporating an assessment of SAI (although this is underway in NAFO).

Spatial consequences of the possible management approaches on MBCG fishing

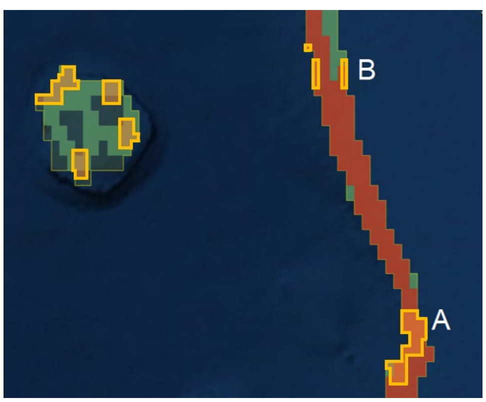
Interactive Map 2 shows polygon closures resulting from each of the scenarios and options set out in Table 1, along with the areas that were most intensely fished by MBCG based on the swept-area ratio. Table 2 shows the areas closed within the 2009–2011 footprints for both static gears and MBCG combined, for static gear only, and for MBCG only under each of the scenarios and options. The table further shows how the closure options affect MBCG fishing activity for the years 2015–2018 within the MBCG footprint. This is subdivided into 1) core MBCG fishing areas, which is the cumulative area that contains over 90% of the effort for the years 2015 to 2018, 2) MBCG fished areas outside the core areas, and 3) the unfished areas during 2015 to 2018.

As seen in Table 2, the percentage of area closed of the combined footprint varies from 16.5% to 27.6% in the Celtic Seas ecoregion and from 13.8% to 17.0% in the Bay of Biscay and the Iberian Coast ecoregion for the different closure options. Scenario 2–Option 2 has the lowest impact on MBCG activity, both in terms of the total footprint as well as of the core MBCG fishing area. Only 3.5% of the core fishing area is closed in the Celtic Seas ecoregion (relative to 9.5% to 12.1% for the other options) and 7.4% of the core fishing area is closed in the Bay of Biscay and the Iberian Coast ecoregion (relative to 9.4% to 10.3% for the other options). There are areas in the MBCG footprint that were unfished with MBCG in 2015–2018; 25% to 47% in the Celtic Seas ecoregion and 20% to 21% in the Bay of Biscay and the Iberian Coast ecoregion of these unfished areas fall within closure areas (see Table 2).

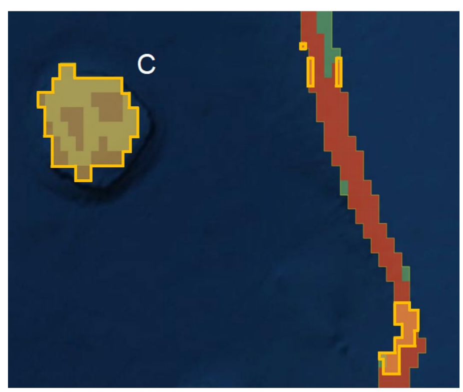
The spatial extent of these footprints and closures can be explored using Interactive Map 2. Figure 5 provides an example of spatial overlap between closures and MBCG footprint and core fishing area for part of the Celtic Seas ecoregion. Any area can be explored in more detail using the Interactive map.

Table 2 Area closed from within the 2009–2011 fishing footprints due to the various closures.

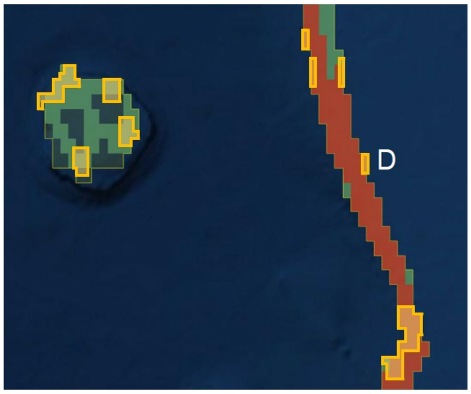
Footprint and fishing areas (in 1000 km^2)	Area closed in 1000 km^2 and as % (in brackets) from footprint due to the various closure scenarios (Sce) and options (Opt)				
	Sce 1–Opt 1	Sce 1–Opt 2	Sce 2–Opt 1	Sce 2–Opt 2	Sce 1–Opt 2+ Sce 2–Opt 1
Celtic Seas ecoregion					
Combined footprint area (static + MBCG) 2009–2011. Total footprint area = 72.50	13.42 (18.51)	17.15 (23.65)	16.24 (22.40)	11.99 (16.54)	20.02 (27.61)
Static gear footprint area 2009–2011. Total footprint area = 53.70	11.02 (20.52)	14.45 (26.91)	13.51 (25.16)	10.16 (18.92)	17.00 (31.65)
MBCG footprint area 2009–2011. Total footprint area = 55.07	9.02 (16.38)	10.23 (18.58)	11.73 (21.30)	7.54 (13.70)	12.96 (23.54)
a) Core MBCG fishing area (most fished 10–100% by SAR 2015–2018) within MBCG footprint	2.10 (9.51)	2.10 (9.51)	2.68 (12.14)	0.77 (3.50)	2.68 (12.14)
b) Areas outside the core MBCG fishing area (least fished 10% by SAR 2015–2018) within MBCG footprint	5.16 (19.86)	5.33 (20.54)	6.82 (26.24)	4.63 (17.82)	7.01 (26.98)
c) Unfished with MBCG in 2015–2018 within MBCG footprint	1.76 (25.05)	2.80 (39.83)	2.24 (31.77)	2.14 (30.45)	3.27 (46.55)
Bay of Biscay and the Iberian Coast ecoregion					
Combined footprint area (static + MBCG) 2009–2011. Total footprint area = 38.98	5.47 (14.02)	6.08 (15.59)	6.03 (15.47)	5.37 (13.77)	6.64 (17.04)
Static gear footprint area 2009–2011. Total footprint area = 33.19	5.10 (15.37)	5.72 (17.22)	5.47 (16.47)	5.05 (15.22)	6.08 (18.32)
MBCG footprint area 2009–2011. Total footprint area = 29.50	4.17 (14.15)	4.17 (14.15)	4.47 (15.17)	3.84 (13.00)	4.47 (15.17)
a) Core MBCG fishing area (most fished 10–100% by SAR in 2015–2018) within MBCG footprint	1.13 (9.40)	1.13 (9.40)	1.23 (10.23)	0.89 (7.36)	1.23 (10.23)
b) Areas outside the Core MBCG fishing area (least fished 10% by SAR in 2015–2018) within MBCG footprint	2.44 (16.88)	2.44 (16.88)	2.62 (18.12)	2.33 (16.09)	2.62 (18.12)
c) Unfished with MBCG in 2015–2018 within MBCG footprint	0.60 (20.10)	0.60 (20.10)	0.62 (20.81)	0.62 (20.81)	0.62 (20.81)



In **Scenario 1–Option 1** there is substantial overlap between one closure and the core MBCG fishing area (left of A). The thin closures (left of B) are buffers that protect VME habitat and/or medium and high VME index cells outside the 400–800 metre depth boundary.

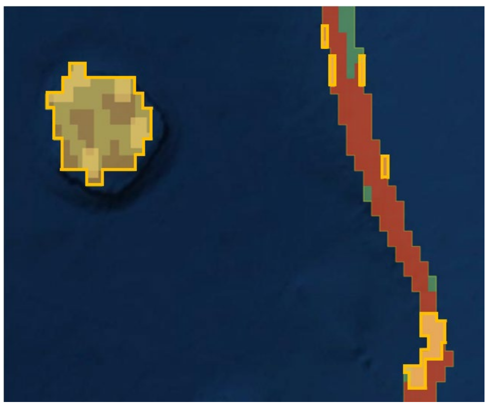


In **Scenario 1–Option 2** VME physical elements, such as seamounts, are part of the closure. The closure of the seamount in the figure (the entire area left of C) does not overlap with the core fishing area and has, as such, a limited impact on the MBCG fisheries.



In **Scenario 2–Option 1** low VME index C-squares are part of the closure when average SAR ≤ 0.43 per year. The thin closure (left of D) is a buffer that protects a low VME index C-square outside the 400–800 metre depth boundary.

In **Scenario 2–Option 2** VME habitat and index C-squares are part of a closure when average SAR ≤ 0.43 per year. This removes the closure (compare A with E) that has substantial overlap with intensive fishing in the core MBCG area.



This option combines **Scenario 1–Option 2** and **Scenario 2–Option 1** and results in the largest area closed.

Border of closure within 400 - 800 metre range

Core MBCG fishing area 2015-18

MBCG footprint area 2009-11

Figure 5 Illustration of overlap of core MBCG fishing area (10–100% of SAR) in 2015–2018 with MBCG footprint and closure consequences as shown in Interactive Map 2. Note that the core MBCG fishing area in 2015–2018 overlaps 100% with the MBCG footprint in 2009–2011 in the area selected in the figures above.

Most of the areas intensively fished with MBCG in 2015–2018 align with the MBCG footprint (Table 3). Only 5% of the core MBCG fishing area in 2015–2018 is outside the MBCG footprint for the Celtic Seas ecoregion and 1.6% for the Bay of Biscay and the Iberian Coast ecoregion. Of the fishing activity outside the core MBCG fishing area in 2015–2018, 23.6% in the Celtic Seas ecoregion and 42.3% in the Bay of Biscay and the Iberian Coast ecoregion is outside the MBCG 2009–2011 footprint. These less intensely fished areas are therefore not well aligned with the MBCG footprint.

Table 3 Fishing areas (2015–2018) outside MBCG footprint (2009–2011) in 1000 km² and as % (in brackets) relative to the total fishing area (in- and outside the MBCG footprint).

Celtic Seas ecoregion	Area outside footprint in 1000 km² and as % (in brackets)
Core MBCG fishing area (most fished 10–100% by SAR in 2015–2018)	1.16 (4.98)
Outside the core MBCG fishing area (least fished 10% by SAR in 2015–2018)	5.48 (23.56)
Unfished with MBCG in 2015–2018	22.16 (73.26)
Bay of Biscay and the Iberian Coast ecoregion	
Core MBCG fishing area (most fished 10–100% by SAR in 2015–2018)	0.19 (1.58)
Outside the core MBCG fishing area (least fished 10% by SAR in 2015–2018)	5.17 (42.27)
Unfished with MBCG in 2015–2018	12.80 (81.11)

Spatial consequences of management approaches on the protection of C-squares where VMEs either occur or are likely to occur

Each of the scenarios and options have different outcomes for degrees of protection afforded to the VMEs. These are summarised in Table 4, which shows the number of C-squares with VME habitat and high, medium, and low VME indices that would be closed under each of the options. For both regions, the number of C-squares in the column for Scenario 2–Option 1 and the numbers in the column for Scenario 2–Option 1 combined with Scenario 1–Option 2 are identical. This is because the numbers in the table refer to VME records, and adding areas with VME physical elements does not equate to adding any new VME records. The combined option (Scenario 1–Option 2 together with Scenario 2–Option 1) is nevertheless more precautionary, because it includes VME physical elements even though there are no VME records in the database. Scenario 2–Option 2 provides the least protection to C-squares with VME habitat and with high and medium VME indices, whereas both options in Scenario 1 provide less protection of the low VME index C-squares. More detailed information on the degree of protection afforded to the various VME indicator species (in terms of the number of indicator records in the VME database that would be within the closures) are shown in Annex 3.

Table 4 Number of VME habitat and index C-squares in the Celtic Seas and the Bay of Biscay and the Iberian Coast ecoregions, and within each closure scenario (Sce) and option (Opt).

	400–800 m depth	Sce 1–Opt 1	Sce 1–Opt 2	Sce 2–Opt 1	Sce 2–Opt 2	Sce 1–Opt 2+ Sce 2–Opt 1
Celtic Seas ecoregion						
VME habitat	78	78	78	78	65	78
VME index – high	41	41	41	41	36	41
VME index – medium	30	30	30	30	20	30
VME index – low	246	27	27	88	61	88
Bay of Biscay and the Iberian Coast ecoregion						
VME habitat	25	25	25	25	25	25
VME index – high	0	0	0	0	0	0
VME index – medium	18	18	18	18	15	18
VME index – low	21	6	6	13	13	13

Suggestions

ICES notes that data exist on fishing activity during the reference period; there are also data on VMEs that have not been submitted to ICES or have recently been submitted but not yet undergone quality checks. Through this advisory process, a number of VME data sources that were not in ICES 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.

ICES recommends that when these new VMS and VME data are supplied they should be incorporated in future advice on the fishing footprint 2009–2011, on the distribution of fishing in later periods, and on the C-squares where VMEs "are known to occur" or "are likely to occur".

Basis of the advice

Precision of the advice

C-square is a grid system. ICES uses a C-square resolution of 0.05° longitude by 0.05° latitude (about 15 km² (3 km × 5 km) at a latitude of 60°N). This resolution is a practical scale to collate, explore, and assess data relating to fishing activities in the marine environment. This was the system used by ICES in responding to this EUVME request.

ICES defined the depth range of 400–800 metres at the C-square level. All C-squares with any depths that overlapped within 400–800 metres were included using modeled EMODnet bathymetry data[2]. Accordingly, some C-squares that are part of the fishing footprint may have some parts of them with depths below than 800 metres. ICES provided the polygon boundary of 800 metres in previous advice (ICES, 2018a).

The aggregation of data in C-squares is suitable for the broad-scale delineation of VME occurrence and overlap with fishery activity. However, this places important limitations on the potential consequence of subgrid scale separation between VME occurrence and overlap with fishing activity that may be particularly important in development of the advice on closures for Scenario 2–Option 2. NAFO (2019) found, using highly spatially resolved VME and VMS data, that areas of high VME occurrence were often separated from areas of high fishing activity by distances that would represent subgrid scales. Accordingly, within a grid cell, fishing effort and VME occurrence cannot be assumed to be evenly distributed. Subgrid scale variation in fishing activity is something that cannot be resolved with the data available and will require fundamental changes to the ICES VMS data call and/or fine-scale analysis by individual EU Member States.

Geographical range – deep-sea areas not considered in the advice

Within the North Sea ecoregion, the Bratten is a large area in the Swedish Exclusive Economic Zone (EEZ) on the shelf slope with depths of between 100 and 560 metres towards the Norwegian Trench. The area has been surveyed extensively. It is cut by canyons and depressions where hard bottoms are exposed that host VME habitats with coral gardens and deep-sea sponge aggregations; records of these VMEs will be incorporated into ICES VME database. These habitats are surrounded by soft seabed with sea pen fields. There is also a small area of the Danish EEZ with water depths of between 400 and 800 metres on the edge of its boundary, (ICES, 2020b). Within this region, only one C-square is recorded as having VMEs occurring or likely occurring; in this case it is a known VME habitat, representing a cold seep. Based on available information, no fishing activity was recorded in this C-square in the 2009–2011 reference years; it would therefore appear not to be within an area where targeted fishing authorisation would be issued.

Within the Azores ecoregion a small number of VME C-squares occur within the 400–800 metre depth range. ICES is aware that additional data on VME habitats and indicators for the region are available but have not yet been submitted to ICES. A description of the known VMEs in the Azores ecoregion is provided (ICES, 2020b). Fishing activity is patchy across a wide area around the Portuguese archipelago but is mostly below 800 metres and mainly related to static gear (ICES, 2018a).

[2] www.emodnet-bathymetry.eu/.

Fishing footprint 2009–2011 and fishing effort 2015–2018

VMS and logbook data are received by ICES in response to ICES VMS/logbook data call and are quality controlled. For mobile gears, the speed of a vessel, calculated using the distance travelled between each two-hour reporting event (known as a "ping") is used to determine whether or not the vessel is likely to be fishing at each ping location. This information, coupled with the gear recorded in the vessel logbook for that particular trip, is used to assign a fishing ping, and this fishing ping is linked to the particular C-square. For static gears, the presence of fishing in a C-square is also determined based on the speed of vessels, visual inspection, and the removal of travelling lines.

It is, for the moment, only possible to reliably infer presence or absence of static gears. The key parameters needed to estimate static gear fishing effort such as soaking time, length of nets, and number of hooks are often not provided. The benthic impacts of these gears are also largely unknown.

For the definition of the fishing footprint 2009–2011, ICES applied the criteria that for a C-square to be included in the fishing footprint it must share at least one corner with another fished C-square. A detailed description of the identification of the fishing footprint is contained in the report of the Workshop on EU regulatory area options for VME protection (WKEUVME; ICES, 2020b) and in the 2019 report of the Working Group on Spatial Fisheries Data (WGSFD; ICES, 2019). This method retains some 99.7 % of all fished C-squares as part of the fishing footprint for the Bay of Biscay and the Iberian Coast ecoregion and the Celtic Seas ecoregion and thus is considered appropriate to define the footprint.

To explore the stability of fishing effort, the most recent distribution of MBCG fishing effort data from 2015–2018 was analysed with regards to the SAR, indicative of the impact in a C-square, and SAR values that were cumulatively aggregated for all C-squares, indicative of concentrations of fishing activities. For the cumulative effort, areas with little total SAR effort (0–10%) were distinguished from those areas where the effort is highly concentrated (90% of all SAR effort) for 2015–2018.

To develop the Scenario 2 closure options, C-squares with an annual SAR of 0.43 or less (on average for 2009–2018) and C-squares with a higher fisheries effort were identified.

Identifying C-squares containing or likely to contain VMEs

Data on the location of VME habitats and indicators are submitted to ICES as point or line data. To collate this information, ICES uses a VME weighting algorithm, an assessment system with many criteria that follows a series of transparent steps to come up with a VME score and a confidence score. 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. A detailed description of the identification of C-squares containing or likely to contain VMEs is presented in the WKEUVME workshop report (ICES, 2020b) and in the 2018 report of the Working Group on Deep-water Ecology (WGDEC; ICES, 2018b)

The list of ICES VME habitats includes six of the seven listed in Annex III of Regulation 2016/2336 (EU, 2016; mud- and sand-emergent fauna has been removed) as well as four additional ones: cold seeps, hydrothermal vents/fields, stalked crinoid aggregations, and xenophyophore aggregations, the last two of which replaced mud- and sand-emergent fauna (Table 5). It should also be noted that data on bryozoan patches have not yet been submitted to the ICES VME database, and that, while ICES VME habitats for mud- and sand-emergent fauna and anemone aggregations no longer exist, older records of these are currently in the database and were used in this advice along with the habitats that replaced them (Table 5 and Annex 3).

Table 5 Details of VME habitats listed in Annex III of Regulation 2016/2336 (EU, 2016) with the equivalent ICES VME habitat type and associated VME indicators.

VME habitat type (EU, 2016)	Equivalent ICES VME habitat type	Representative taxa (VME indicators; EU, 2016)	ICES VME indicators
Cold-water coral reef • *Lophelia pertusa* reef • *Solenosmilia variabilis* reef	Cold-water coral reef*	*Lophelia pertusa* *Solenosmilia variabilis*	Stony coral*
Coral garden • Hard bottom garden a) Hard bottom gorgonian and black coral gardens	Coral garden*	*Anthothelidae* *Chrysogorgiidae* *Isididae, Keratoisidinae* *Plexauridae* *Acanthogorgiidae* *Coralliidae* *Paragorgiidae* *Primnoidae* *Schizopathidae*	Black coral* Gorgonian* Stony coral* Stylasterids* Soft coral* Cup coral*
b) Colonial scleractinians on rocky outcrops		*Lophelia pertusa* *Solenosmilia variabilis*	
c) Non-reefal scleractinian aggregations		*Enallopsammia rostrata* *Madrepora oculata*	
• Soft-bottom coral gardens a) Soft-bottom gorgonian and black coral gardens		*Chrysogorgiidae*	
b) Cup-coral fields		*Caryophylliidae* *Flabellidae*	
c) Cauliflower coral fields		*Nephtheidae*	
Deep-sea sponge aggregations • Other sponge aggregations		*Geodiidae* *Ancorinidae* *Pachastrellidae*	
• Hard-bottom sponge gardens		*Axinellidae* *Mycalidae* *Polymastiidae* *Tetillidae*	
• Glass sponge communities		*Rossellidae* *Pheronematidae*	
Sea pen fields	Sea pen fields*	*Anthoptilidae* *Pennatulidae* *Funiculinidae* *Halipteridae* *Kophobelemnidae* *Protoptilidae* *Umbellulidae* *Vigulariidae*	Sea pen*

VME habitat type (EU, 2016)	Equivalent ICES VME habitat type	Representative taxa (VME indicators; EU, 2016)	ICES VME indicators
Tube-dwelling anemone patches	Tube-dwelling anemone aggregations* (formerly anemone aggregations*; tube-dwelling anemone patches)	*Cerianthidae*	Anemones*
Mud- and sand-emergent fauna	Stalked crinoid aggregations*; xenophyophore aggregations* (formerly mud- and sand-emergent fauna*)	*Bourgetcrinidae* *Antedontidae* *Hyocrinidae* *Xenophyophora* *Syringamminidae*	Stalked crinoids Xenophyophores*
Bryozoan patches	Bryozoan patches		Chemosynthetic species
	Cold seeps*		
	Hydrothermal vents/fields		

* VME habitat/indicator identified in the Celtic Seas and/or the Bay of Biscay and the Iberian Coast ecoregions.

VME physical elements are defined in the FAO Deep-sea Fisheries Guidelines (FAO, 2009) as "*topographical, hydrophysical or geological features, including fragile geological structures, that potentially support*" VMEs. The VME physical elements listed in the guidelines include:

- Submerged edges and slopes (e.g. corals and sponges);
- Summits and flanks of seamounts, guyots, banks, knolls, and hills (e.g. corals, sponges, xenophyphores);
- Canyons and trenches (e.g. burrowed clay outcrops, corals);
- Hydrothermal vents (e.g. microbial communities and endemic invertebrates); and
- Cold seeps (e.g. mud volcanoes for microbes, hard substrates for sessile invertebrates).

ICES includes two VME physical elements from the guidelines, hydrothermal vents and cold seeps, as VME habitats (Table 5).

ICES used EMODnet sea floor geology[3] for the identification of VME physical elements in Scenario 1–Option 2. These data are publicly available and provide 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. In particular the VME physical element 'banks' was an important feature in linking VME data records in the Bay of Biscay and the Iberian Coast ecoregions. The VME physical elements used for Scenario 1–Option 2 were limited to topographic highs (seamounts, banks) as well as small elements that were 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; this is because the list of cold seeps provided by EMODnet is incomplete. Other VME physical 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.

Spatial buffers around closed C-squares

Modern navigation systems provide a very accurate location of fishing vessels at sea. However, when fishing at depths of between 400 and 800 metres, the location of the fishing gear can differ substantially from the location of the vessel. ICES considers that a buffer of half of a C-square around each C-square would be appropriate to ensure

[3] https://www.emodnet-geology.eu.

the protection of VME habitats distributed along the edge of the C-square. The choice of a half C-square buffer rather than another distance was made primarily for the ease of implementation (ICES, 2020b). Previously, ICES advised (ICES, 2013) that for VMEs occurring 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. Given the complexity of applying this advice in the current advice, ICES opted for a half C-square buffer around each C-square.

Formation of closure polygons from C-squares identified under scenarios and options in Table 1

For each option in Table 1, ICES provides detailed steps of how the closed areas were produced, with associated figures (ICES, 2020b). For every option, the same general principles were followed with respect to how C-squares were joined together. For each option, all C-squares that included the relevant VME data (VME habitats, VME Index, and VME physical elements) were selected and a buffer the size of half of a C-square was drawn around them (see Figure 4.21 in ICES, 2020b). 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 (ICES, 2020b). This reduces the number of polygons in a data layer but does not change the protected area. Any holes with one or two C-squares inside the larger VME closures (ICES, 2020b) were included in the larger closures. This was done because 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 7 nautical miles in a typical two-hour haul, which is equivalent to between about two and three C-squares. Open areas of less than three C-squares were therefore not considered practical. Further, these areas are more likely to contain VMEs than other cells without records since they are surrounded by VME C-squares, and they may just represent a lack of data. Any single, isolated VME C-square was retained as an individual VME closure with an associated half C-square buffer (ICES, 2020b). This is because many VME types can naturally consist of patches of the size of about one C-square or smaller.

The R-scripts, which produced the closed area options and data summaries (including closure .shp files) are available on the open-source WKEUVME GitHub platform[4]. For each closure option, a script for creating the closures, a map displaying the closures, and a table of the coordinates has been produced. The table indicates the VME habitat, VME indicator, and VME physical element data present in each closed area option. The tables and maps are available as a data product (Annex 1).

Additional information

The policy framework for the protection of VMEs sits within a series of Sustainable Fisheries Resolutions regarding Responsible Fisheries in the Marine Ecosystem adopted by UNGA. Subsequently FAO developed its Deep-sea Fisheries Guidelines (FAO, 2009). These provide definitions of relevant terms, examples of characteristics that assist with the identification of VMEs, and a more expansive list of the vulnerable species groups, communities, and habitats as well as topographic features (the VME physical elements) which are known to support VMEs. They also elaborate on how significant adverse impacts (SAI) by bottom-contacting fishing gears should be evaluated.

Under the European Deep-sea Fisheries Regulation 2016/2336 (EU, 2016), bottom contact fishing conducted by EU vessels within EU waters will be confined to the existing bottom-fishing footprint based on bottom-contacting 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 EU Member States and based on best scientific information and advice, will list and annually review areas where VMEs “are known to occur” or “are likely to occur” [Article 9(6)]. The Commission will decide on the closure of these areas between depths of 400 and 800 metres in order to protect the VMEs found there. These measures will contribute to achieving the objectives of the UNGA Sustainable Fisheries Resolutions, particularly resolutions 61/105 (A/RES/61/105) and 64/72 (A/RES/6472), which call for adoption of conservation and management measures to prevent significant adverse impacts on VMEs.

[4] https://github.com/ices-eg/wk_WKEUVME.

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Annex 1 Data product and interactive maps

This annex describes the data product. The complete set of data outputs has been published electronically: https://doi.org/10.17895/ices.data.7506.

These electronic data outputs include the following:

- Maps in a PDF file and coordinates in a CSV file of three fishing footprints: 1) combined static and mobile bottom-contacting gear, 2) static gear only, and 3) mobile bottom-contacting gear only;
- Maps in a PDF file and coordinates in a CSV file of the closure scenarios and options. Each CSV file also indicates the VME habitat, VME indicator, and VME physical element data present in each closed area scenario and option, as well as VME habitat and index C-squares.
- Two interactive maps (Interactive Map 1 and Interactive Map 2) and a read-me PDF file that explains how to open and use these maps.

The PDF maps in a) and b) contain numbers for each separate polygon. These polygon numbers correspond to the polygon numbers in the CSV file. As such, the data outputs can best be used in a step-wise approach: 1) use the interactive maps to select an area of interest, 2) obtain for the area of interest the polygon numbers of each footprint and closure from the PDF maps, and 3) obtain the coordinates of the polygon numbers from the CSV files.

The R-scripts, which produced the closed area options, fishing footprints, and data summaries (including closure .SHP files) are further available on the open-source WKEUVME GitHub platform[5].

[5] https://github.com/ices-eg/wk_WKEUVME.

Annex 2 Updated list of VME habitat (sub)types and associated representative taxa

ICES updated its list of VME habitat types, VME habitat subtypes, and associated representative taxa in 2020 (ICES, 2020c). The proposed changes are provided in Table A5.9 of the 2020 WGDEC report (ICES, 2020c) and are shown below as Table A2.1, highlighting where changes to Annex III of EU Regulation 2016/2336 (EU, 2016) would be required. Some of these changes reflect changes in species nomenclature, while others are new taxa that have been evaluated against the FAO guidelines (FAO, 2009) and added to the list. Representative taxa are detailed at family level only, unless only specific species are relevant, in which case these species are listed. A full revised taxa list for use with ICES VME database is provided in Annex 6 of the WGDEC report (ICES, 2020c). The updated ICES VME list will be used from 2021 onwards.

Table A2.1 Proposed list of VME habitats/subtypes and representative taxa. Suggested changes to Annex III of EU Regulation 2016/2336 (EU, 2016) are denoted in bold text.

Proposed VME habitat type	Proposed VME habitat subtype	Representative taxa
Cold-water coral reef	***Lophelia pertusa/Madrepora oculata* reef**	*Lophelia pertusa*
		Madrepora oculata
	Solenosmilia variabilis reef	*Solenosmilia variabilis*
Coral garden	Hard-bottom coral garden	
	Hard-bottom coral garden: hard-bottom gorgonian and black coral gardens	Acanthogorgiidae
		Alcyoniidae
		Anthothelidae
		Antipathidae
		Chrysogorgiidae
		Coralliidae
		Ellisellidae
		Isididae, keratoisidinae
		Leiopathidae
		Paragorgiidae
		Plexauridae
		Primnoidae
		Schizopathidae
	Hard-bottom coral garden: colonial scleractinians on rocky outcrops	*Lophelia pertusa*
		Madrepora oculata
		Solenosmilia variabilis
	Hard-bottom coral garden: non-reefal scleractinian aggregations	*Enallopsammia rostrata*
		Lophelia pertusa
		Madrepora oculata
		Dendrophyllia cornigera
		Dendrophyllia ramea
	Hard-bottom coral garden: stylasterid corals on hard substrata	***Pliobothrus* spp.**
		***Stylaster* spp.**
		Errina dabneyi
	Hard-bottom coral garden: cup coral fields	***Caryophylliidae***
	Hard-bottom coral garden: cauliflower coral fields	***Nephtheidae***
	Soft-bottom coral garden	
	Soft-bottom coral garden: soft-bottom gorgonian and black coral gardens	***Alcyoniidae***
		Antipathidae
		Chrysogorgiidae
		Isididae
	Soft-bottom coral garden: cup coral fields	*Caryophylliidae*
	Soft-bottom coral garden: cauliflower coral fields	*Nephtheidae*
	Soft-bottom coral garden: non-reefal scleractinian aggregations	***Eguchipsammia* sp.**

Proposed VME habitat type	Proposed VME habitat subtype	Representative taxa
Deep-sea sponge aggregations		*Ancorinidae*
		Axinellidae
		Azoricidae
		Bubaridae
		Coelosphaeridae
		Corallistidae
		Demospongiae
		Geodiidae
		Hexactinellida
		Hyalonematidae
		Macandrewiidae
		Mycalidae
		Petrosiidae
		Pheronematidae
		Polymastiidae
		Rossellidae
		Tetillidae
		Theneidae
Sea pen fields		*Anthoptilidae*
		Chunellidae
		Funiculinidae
		Halipteridae
		Kophobelemnidae
		Pennatulidae
		Protoptilidae
		Scleroptilidae
		Umbellulidae
		Veretillidae
		Virgularidae
Tube-dwelling anemone aggregations		*Cerianthidae*
Stalked crinoid aggregations		***Rhizocrinidae***
		Bathycrinidae
		Septocrinidae
		Phrynocrinidae
		Isselicrinidae
		Hyocrinidae
Xenophyophore aggregations		***Syringamminidae***
		Psamminidae
Bryozoan patches		***Eucratea loricata***
Hydrothermal vents/fields	**Active vents**	***Kadosactinidae***
		Mytilidae
		Alvinocaridae
		Bythograeidae
		Bythitidae
		Zoarcidae
	Inactive vents	**See ‘coral gardens’ and ‘deep-sea sponge aggregations’**

Proposed VME habitat type	Proposed VME habitat subtype	Representative taxa
Cold seeps		***Lucinidae***
		Vesicomyidae
		Thyasiridae
		Mytilidae
		Solemydae
		Siboglinidae
		Zoarcidae

Annex 3 VME habitat and indicator species observation within each closure

Table A3.1 VME habitat and indicator records from the VME database within the 400–800 m depth band in the Celtic Seas ecoregion and an estimation of the records that are within each closure scenario (Sce) and option (Opt).

	400–800 m depth	Sce 1–Opt 1	Sce 1–Opt 2	Sce 2–Opt 1	Sce 2–Opt 2	Sce 1–Opt 2 + Sce 2–Opt 1
VME habitat						
Anemone aggregations	22	22	22	22	5	22
Cold-water coral reef	230	230	230	230	210	230
Coral garden	1042	1042	1042	1042	898	1042
Deep-sea sponge aggregations	635	635	635	635	508	635
Sea-pen fields	374	374	374	374	357	374
Tube-dwelling anemone aggregations	21	21	21	21	18	21
Xenophyophore aggregations	7	7	7	7	4	7
VME indicator						
Anemones	531	514	514	515	416	515
Black coral	194	194	194	194	180	193
Cup coral	130	116	116	116	65	116
Gorgonian	96	96	96	96	70	96
Sea-pen	810	365	365	463	386	463
Soft coral	71	55	55	67	58	67
Sponge	1332	1156	1156	1208	595	1208
Stony coral	743	743	743	743	650	743
Stylasterids	14	14	14	14	12	14

Table A3.2 VME habitat and indicator records from the VME database within the 400–800 m depth band in the Bay of Biscay and the Iberian Coast ecoregion, and an estimation of the records that are within each closure scenario (Sce) and option (Opt).

	400–800 m depth	Sce 1–Opt 1	Sce 1–Opt 2	Sce 2–Opt 1	Sce 2–Opt 2	Sce 1–Opt 2 + Sce 2–Opt 1
VME habitat						
Cold-water coral reef	988	988	988	988	984	988
Cold seeps	1	1	1	1	1	1
Coral garden	1944	1944	1944	1944	1903	1944
Deep-sea sponge aggregations	7	7	7	7	7	7
Mud and sand emergent fauna	4	4	4	4	4	4
VME indicator						
Anemones	928	928	928	928	883	928
Black coral	438	438	438	438	435	438
Cup coral	51	51	51	51	50	51
Gorgonian	528	528	528	528	523	528
Sea-pen	490	472	472	481	404	481
Soft coral	26	21	21	22	22	22
Sponge	171	171	171	171	168	171
Stony coral	871	871	871	871	868	871
Stylasterids	1	1	1	1	1	1