Advice on areas where Vulnerable Marine Ecosystems (VMEs) are known to occur or are likely to occur in EU waters

Advice summary

This ICES advice must be read in conjunction with the EU VME Advice Data Products (in a zip file) published together with this advice: https://doi.org/10.17895/ices.advice.22643356

ICES presents five spatial management scenarios for vulnerable marine ecosystems (VMEs) protection in EU waters based on new and updated information from 2022 on areas where VMEs are known to occur or likely to occur, as well as on new and updated information on mobile bottom-contacting gear (MBCG) fishing activity up to and including 2021. Four of the five scenarios are updated from previous ICES advice (ICES, 2021a), while the fifth is new.

In this advice, the total number and areal extent of VMEs protection polygons ranged 102–115 and 9 752–14 885 km^2 among scenarios. Relative to existing EU closures for VMEs protection, management scenarios based on 2022 data result in a 15–17% increase in the total area identified as VMEs protection polygon in EU waters of the Celtic Seas ecoregion and a 49–62% increase in the Bay of Biscay and Iberian Coast ecoregion.

Changes to VME polygons relative to previous advice (ICES, 2021a) include additions, expansions, and reductions in the number, size, and shape of VME polygons. These changes are based on new/updated evidence of VME occurrence and/or on new/updated evidence of MBCG fishing intensity, resulting in a change in risk of further significant adverse impacts (SAIs) to VMEs where they co-occur with fishing activity.

For this advice, ICES was requested to use the VME habitat and indicator taxa listed in Annex III of the EU Deepsea Access Regulation (DSAR), Regulation (EU) 2016/2336 (EU, 2016), on fishing for deep-sea stocks. ICES suggests that Annex III be updated to include the VME habitats, subtypes, and VME indicator taxa identified in ICES 2021a to ensure consistency with the criteria for identifying VMEs in the FAO guidelines (FAO, 2009).

ICES advises that, once an area has been closed for VMEs protection, this area should remain protected until reliable evidence of VMEs absences is available and/or bottom fisheries can be managed to prevent further SAIs on VMEs.

Request

ICES is requested to carry out an annual assessment of areas where VMEs are known to occur or are likely to occur in EU waters*. This recurring advice should be based on the advice provided on 5 January 2021, which established a list of VMEs occurrences and likely occurrences for regulatory purposes. Revision or update of this advice shall be made in light of new data reported to ICES*.

Elaboration on the advice

This ICES advice must be read in conjunction with the tables and maps available in the EU VME Advice Data Products[1] (ICES, 2023), which show available evidence on the spatial occurrence of VMEs in 2022; the distribution of recent MBCG fishing activity in 2018–2021; the location of existing EU closures to protect VMEs, as per Regulation (EU) 2022/1614 (EU, 2022); and spatial management scenarios to reduce the risk of future SAIs from MBCG fishing activities to VMEs.

The available evidence on areas where VMEs are known to occur or likely to occur includes C-squares[2] with confirmed VMEs (VME habitat), C-squares with VME indicator taxa (high, medium, or low VME index), and seabed topographic features potentially supporting VMEs (VME physical elements). The VME habitat and indicator taxa considered in this advice are those listed in Annex III Regulation (EU) 2016/2336 (EU, 2016).

ICES presents spatial management scenarios for VMEs protection that consist of VME polygons resulting from five assessment scenarios based on new/updated data from 2022. These VME polygons are presented and compared against

[1] EU VME Advice Data Products zip file: https://doi.org/10.17895/ices.advice.22643356
[2] 0.05 × 0.05 degrees (Rees, 2003)

Published 18 April 2023

existing EU closures and outcomes from previous advice (ICES, 2021a), which included four of the five management scenarios.

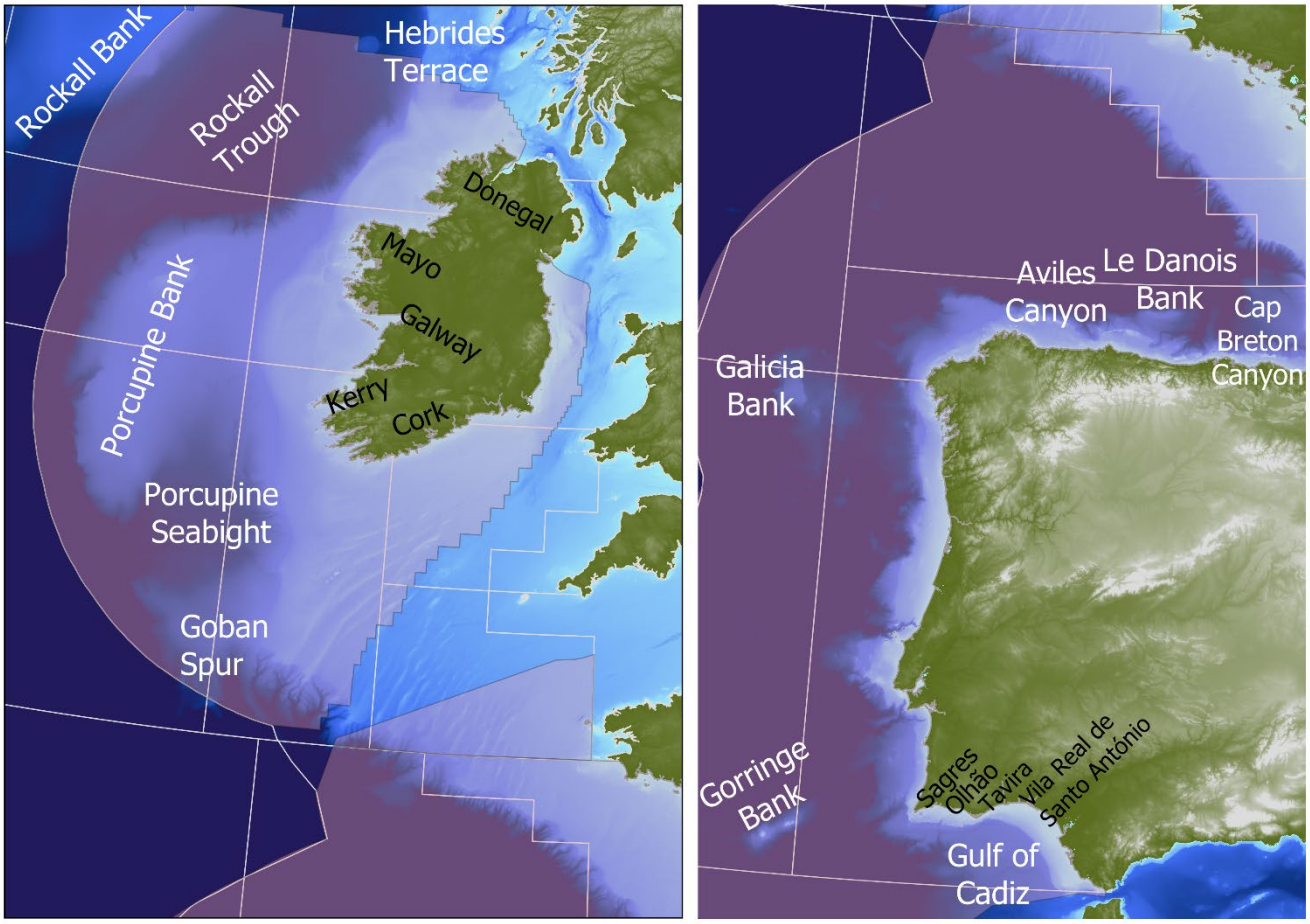

Figure 1 Locations referred to in this advice. EU waters in the Celtic Seas ecoregion (left) and in the Bay of Biscay and Iberian Coast ecoregion (right) are highlighted by the pink polygon.

The assessment area comprises C-squares that overlap the 400–800 m depth zone in EU waters where fishing operations using bottom-contacting gear can occur within the legislative footprint area (EU existing deep-sea fishing areas) as per Regulation (EU) 2022/1614 (EU, 2022). ICES uses ecoregions (ICES, 2022) when providing advice, and most EU waters between the depths of 400 m and 800 m are within the Celtic Seas ecoregion and the Bay of Biscay and Iberian Coast ecoregion. EU waters in these two ecoregions are therefore considered in this advice. The rationale for not including deep-sea areas in the Swedish and Danish EEZs in 2021 (limited fishing) still applies, and outermost regions of the EU (e.g. Azores) are not included.

The management implications associated with each spatial management scenario are detailed in Table 1. The different scenarios prioritize protection of VMEs where they are known to occur and likely to occur, with and without consideration of the risk of further SAIs from MBCG fishing activity. For the entire assessment area and among scenarios based on 2022 data, the total number of VME polygons ranges from 102 (in scenario B) to 115 (in scenario C), and the total area identified as VME polygons ranges from 9 752.4 km^2 (in scenario D) to 14 885.1 km^2 (in scenario E). ICES notes that VME habitat and indicator records occurring at depths shallower than the 400 m C-squares and deeper than the 800 m C-squares in the assessment area are not considered in the delineation of VME polygons in this advice; however, these are represented on the maps.

Celtic Seas ecoregion

The most notable change in 2022 from the existing EU closures for VMEs protection and the 2021 VME polygons is the contraction (in scenarios C, D, and E) of a large VME polygon (and existing EU closure) on top of Porcupine Bank (Figure 1 and map CS1[3]). This VME polygon is associated with low VME index C-squares, and its contraction in 2022 is linked to the updated vessel monitoring system (VMS) data and average swept area ratio (SAR) values exceeding 0.43. Additionally, in all scenarios, there are minor contractions and a few additions and extensions of VME polygons to the north of the ecoregion, along the Irish continental shelf margin and around Porcupine and south Rockall. New additions and extensions reflect the inclusion of new VME data in the assessment, while small contractions are linked to updated and resubmitted evidence of VME occurrence in response to the 2022 VME data call. In the area to the west of Donegal, Mayo, and Galway, this results in some of the existing EU closures and previous VME polygons no longer being supported by the evidence base (one polygon for all scenarios and an additional polygon for scenarios A and B). Off the southwest coast of Ireland and west of the northwest coast of France, there are additions and extensions to the 2021 VME polygons, with limited loss or contraction. Scenario D results in further contractions of the 2021 VME polygons due to increases in SAR values above 0.43 to the north of the ecoregion (along the Irish continental shelf margin north of Porcupine and southeast of Hebrides Terrace).

Between 7.6% (scenario D) and 11.5% (scenario C) of existing EU deep-sea fishing areas in the Celtic Seas ecoregion were identified as VMEs protection polygons in 2022 (Table CS2[3]). The total areal extent of new/updated VME polygons ranges from 3 895 km^2 (scenario D) to 5 587 km^2 (scenario C). Between 83% (scenarios A and B) and 85% (scenarios C, D, and E) of the updated VME polygons area overlaps with the existing EU closures for VMEs protection. This indicates a 15–17% increase in the total area identified for VMEs protection in the ecoregion based on data up to and including 2022.

Scenarios C and E, based on evidence of both VMEs and MBCG fishing, result in higher total VME polygons area (5 587 km^2 and 5 514 km^2, respectively), higher average areal extent of large polygons (405 km^2 and 460 km^2), and higher proportion of existing deep-sea fishing areas identified as VME polygons (11.5% and 11.4%). Scenario C generates one fewer polygon (53) compared to scenario E (54) and has the largest average polygon areal extent (105 km^2) among scenarios. Both scenarios C and E protect all VME habitat records observed in C-squares overlapping the 400–800 m depth zone within the ecoregion (cold-water coral reef, coral garden, deep-sea sponge aggregations, sea pen fields, and tube-dwelling anemone aggregations) and identical (highest) proportions of VMEs indicator records. Scenarios C and E would also maximize protection of sea pen records relative to other scenarios (Table CS3[3]).

Scenarios A and B, which are based solely on evidence of VMEs, result in comparable outcomes due to the limited occurrence of physical VME elements in C-squares overlapping the 400–800 m depth zone within EU waters of the Celtic Seas ecoregion. Scenario A generates fewer (50) and, on average, larger (96 km^2) VME polygons than scenario B (51 and 93 km^2, respectively) and yields a slightly larger total polygons area (4 804 km^2, compared to 4 730 km^2 in scenario B). Both scenarios protect all VME habitat records and identical proportions of VMEs indicator records in C-squares overlapping the 400–800 m depth zone within the ecoregion. However, scenarios A and B would protect a lower proportion (39%) of sea pen records compared to other scenarios.

Scenario D, which is based on evidence of both VMEs and MBCG fishing, results in smaller-on-average (78 km^2) as well as large (265 km^2) VME polygons and yields the smallest total area identified as VME polygons (3 895 km^2). Scenario D has the lowest proportional overlap with existing deep-sea fishing areas (8%) and the lowest proportions of protected VME habitat and indicator records in the EU waters of the ecoregion. Scenario D, based on 2022 data, would generally reduce proportions of VME habitat and indicator records currently protected under the existing EU closures.

Bay of Biscay and the Iberian Coast ecoregion

The most notable change in 2022 from the existing EU closures for VMEs protection and the 2021 VME polygons is the addition, in all scenarios, of a large number of polygons along the northern Iberian margin (including Galicia Bank), which incorporates the new VME evidence (Figure 1 and map BI1[3]). With the exception of scenario D, all scenarios would protect all VME habitat records and similar proportions of VME indicator records (Table BI3[3]). Scenarios C and E would protect the largest proportions of sea pen, soft coral, and sponge indicator records relative to the other scenarios. Scenarios C and D

[3] Interactive Maps file in zip file: https://doi.org/10.17895/ices.advice.22643356

no longer support three existing EU closures identified off the southern Iberian coast in the Gulf of Cádiz (off Sagres, Olhão, Tavira, and/or Vila Real de Santo António). This occurs as a result of the updated VMS data, which was known to be incomplete for this region at the time of the 2021 assessment. No new/updated evidence of VME occurrence was submitted for the southern Iberian coast in 2022.

Scenario E in 2022 would increase the size of nine existing EU closures in the Bay of Biscay and five in the Iberian coast. It would also add 16 new VME polygons: 13 along the Iberian coast and three along the Bay of Biscay. Scenario D in 2022 would increase the size of eight existing EU closures and create three new VME polygons in the Bay of Biscay, while three existing closures would be either reduced in size or no longer supported. Along the Iberian coast, scenario D would increase the size of two existing closures and create 10 new VME polygons, while 12 existing closures would be either reduced in size or no longer supported. Under scenarios A and B, eight existing EU closures – one in the Bay of Biscay, one in the northern Iberian margin, and six in the Gulf of Cádiz – are no longer supported by the evidence base.

Between 10.9% (scenario D) and 18.3% (scenario E) of existing EU deep-sea fishing areas in the Bay of Biscay and Iberian Coast ecoregion were identified as VMEs protection polygons in 2022 (Table BI2[3]). The total areal extent of new/updated VME polygons ranges from 5 857 km^2 (in scenario D) to 9 371 km2 (in scenario E). Between 37.8% (scenario B) and 51.3% (scenario D) of the total polygons area currently overlaps with the existing EU closures for VMEs protection. This indicates an increase of 49–62% in the total area identified for VMEs protection in the ecoregion, based on data submitted up to and including 2022.

Scenarios C and E, which are based on evidence of both VMEs and MBCG fishing, result in a higher total number of VME polygons (62 and 60, respectively), higher total polygons area (8 757 km^2 and 9 371 km^2), and higher proportions of existing deep-sea fishing areas identified as VME polygons (17.8% and 18.3%).

Scenarios that include VME physical elements without and with fishing information (scenarios B and E, respectively) result in the highest average areal extent of individual polygons (166 km^2 and 156 km^2, respectively) and large polygons (777 km^2 and 759 km^2). Three VME physical elements contribute to increasing the total area of VME polygons in scenarios B and E: Le Danois Bank, Galicia Bank, and Gorringe Bank. Differences in the criteria for the inclusion of low VME index C-squares in VME polygons among scenarios explain that 10 polygons protected under scenario E are not protected under scenario B, including two polygons in the Bay of Biscay, three in northern Spain, and five in the Gulf of Cádiz. These differences also explains that the three large polygons, encompassing each of the Le Danois, Galicia, and Gorringe Banks' VME physical elements in scenarios B and E, are split into five smaller polygons in scenario C.

Scenario A, which is based solely on evidence of VMEs, results in intermediate outcomes in terms of number and size of VME polygons. Scenario D, which is based on evidence of both VMEs and MBCG fishing, results in the lowest average size of polygons (109 km^2), lowest average size of large polygons (323 km^2), lowest total area identified as VME polygons (5 857 km^2), and lowest fraction of existing EU deep-sea fishing areas identified as VME polygons (11%). Scenario D reduces the size of six polygons in the Bay of Biscay and seven in the Iberian coast compared to ICES 2021 advice and fully excludes a total of 11 polygons, including six along the Iberian coast.

Suggestions

ICES reiterates that there are important regional and area-specific differences in the quantity and quality of VMEs and fishing effort data within EU waters, as well as differences in the occurence and spatial extent of VME physical elements among and within ecoregions. For this reason, ICES suggests undertaking finer-scale assessments of VMEs in relation to MBCG fishing activity for areas within ecoregions where higher-resolution data are available. Finer-scale assessments will serve to relax homogeneous distribution assumptions and minimize spatial mismatches between VMEs and MBCG fishing data.

ICES has updated the list of VME habitat types, VME habitat subtypes, and associated representative taxa in 2020 (ICES, 2020), highlighting where changes to Annex III of Regulation (EU) 2016/2336 (EU, 2016) are advised. ICES considers the updated (2020) list to be the best available evidence of where VMEs are known to occur or likely to occur in EU waters. The list of ICES VME habitats includes six of the seven listed in Annex III of Regulation (EU) 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 replace mud- and sand-emergent

fauna. 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 (ICES, 2021a; ICES, 2021b).

Bottom fishing in existing EU deep-sea fishing areas includes fishing with MBCG and fishing activity using static gear. At present, fishing with static gear is not included in the assessment scenarios. The determination of static gear fishing activity is less precise, i.e. missing information on the location of small vessels fishing with static gear and effort information such as soaking time, gear length, number of hooks or pots, net lengths, etc. The interaction between static gear and the seabed is variable among gear types (e.g. gillnets, pots, longlines) and is generally not well understood. The available evidence suggests that static gears have a lower impact on seafloor integrity compared to bottom trawling. Further investigations are required to understand the risk of significant adverse impacts from static gear fishing on VMEs.

ICES is aware that new data on VME occurrence exists for some areas within EU waters of ICES ecoregions. ICES encourages member states to submit data obtained in the framework of monitoring/research projects, as this will strengthen the evidence base for future VME advice.

Basis of the advice

Background

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 the United Nations General Assembly (UNGA). When providing advice on VMEs, ICES generally follows the FAO "International Guidelines for the Management of Deep-sea Fisheries in the High Seas" (FAO, 2009) (ICES, 2022b). These guidelines 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) that potentially support VMEs. They also elaborate on how significant adverse impacts by bottom-contacting fishing gears should be evaluated. For the purpose of this advice, ICES limits its use of VME habitat and indicator taxa to those listed in Annex III of Regulation (EU) 2016/2336 (EU, 2016).

Regulation (EU) 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 m. It also stipulates that no authorization shall be issued for the purpose of fishing with bottom trawls at a depth of below 800 m. As ICES does not collect information on fishing authorizations in EU waters, this advice considers all VMS and logbook data submitted by Member Countries in C-squares overlapping the 400–800 m depth zone.

The existing deep-sea fishing areas used in this advice are those established in Annex I of Regulation (EU) 2022/1614, which are based on bottom fishing information from the reference period 2009–2011 (ICES, 2021a). ICES 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).

Results and conclusions

In 2022, ICES received a total of 7 811 new and resubmitted/updated VME occurence records within EU waters, including 6 526 records in C-squares overlapping the 400–800 m depth zone. Within the 400–800 m depth zone, these records correspond to 164 new C-squares where VMEs are known to occur (VME habitat) or are likely to occur (high, medium, and low VME index). The new/updated VME data bring total numbers of VME habitat and VME index C-squares to 42 and 229 (respectively) in the EU waters of the Celtic Seas ecoregion and to 39 and 158 (respectively) in the Bay of Biscay and Iberian Coast ecoregion.

In the EU waters of the Celtic Seas ecoregion, new/updated evidence of VME occurrence includes nine new VME habitat C-squares and 18 new VME index C-squares (one medium and 17 low) (Table CS1[3]). The new/updated VME habitat C-squares occur to the southern portions of the ecoregion, from the southwest tip of Ireland (Cork/Kerry) to the northwest of France. The new/updated medium VME index C-square occurs to the north of the ecoregion, southeast of Rockall Bank. The new/updated low VME index C-squares occur on the Porcupine Bank to the west of Ireland. The majority (89%) of the

new/updated VME C-squares in the ecoregion overlap with recent (2018–2021) MBCG fishing activity, including eight of the nine new/updated VME habitat C-squares and 16 of the 17 new/updated low VME index C-squares.

VME habitats observed within the 400–800 m depth range in the Celtic Seas ecoregion include cold-water coral reefs, coral gardens, deep-sea sponge aggregations, sea pen fields, and tube-dwelling anemone aggregations. All available records (100%) of deep-sea sponge and tube-dwelling anemone aggregations are currently protected under the existing EU closures, as well as 99.6% of sea pen fields, 94% of coral gardens, and 85% of cold-water coral reefs records. VME indicator taxa observed between 400 m and 800 m depth include (by order of decreasing number of records) sea pen, stony coral, black coral, gorgonian, sponge, cup coral, soft coral, and stylasterids. Between 52% (sea pen) and 100% (stylasterids) of VME indicator records are currently protected under the existing EU closures for VMEs protection (Table CS3[3]).

In the Bay of Biscay and Iberian Coast ecoregion, new/updated evidence of VME occurrence includes 16 new VME habitat C-squares, 58 new high and medium VME index C-squares, and 63 low VME index C-squares (Table BI1[3]). The new VME C-squares are distributed along the continental margin in the Bay of Biscay, and most are found off the northern Iberian coast. In the Bay of Biscay, VMEs are associated with the many canyons incising the continental slope, and new VME C-squares in 2022 (13 VME habitat, one medium VME index, and three low VME index) are found north of the Cap Breton Canyon. Off the northern Iberian coast, VME habitat and medium-to-high VME index C-squares are found on the Galicia Bank or within a topographically complex area ranging from the El Cachucho (also known as Le Danois Bank) to the Avilés Canyon. Just under half (48%) of the new/updated VME C-squares in the ecoregion overlap with recent (2018–2021) MBCG fishing activity, including 44% of new VME habitats, 38% of new high and medium VME index C-squares, and 59% of low VME index C-squares. New VME C-squares that do not overlap with MBCG fishing activity in 2018–2021 are located at Le Danois Bank and Galicia Bank.

VME habitats observed in C-squares overlapping the 400–800 m depth zone in the Bay of Biscay and Iberian Coast ecoregion include cold-water coral reefs, coral gardens, deep-sea sponge aggregations, mud- and sand-emergent fauna, sea pen fields, and tube-dwelling anemone aggregations. All available records (100%) of mud- and sand-emergent fauna and sea pen fields are currently protected under the existing EU closures, as well as 92% of deep-sea sponge and tube-dwelling anemone aggregations, 74% of coral gardens, and only 12% of cold-water coral reef records. VME indicator taxa observed in C-squares overlapping the 400–800 m depth zone include (by order of decreasing number of records) sponge, gorgonian, stony coral, black coral, sea pen, cup coral, soft coral, and stylasterids. Between 1% (sponge) and 71% (stony coral) of VME indicator records are currently protected under the existing EU closures, while none (0%) of the stylasterids records are currently protected (Table BI3[3]).

Relative to the 2021 process, the ICES VMS and logbook data call and workflow used in 2022 changed only in minor ways, facilitating aggregation of data across years while complying with the "3-unique vessels" confidentiality rule. This change does not impact the MBCG fishing data used here because this advice uses SAR values, which are not subject to this aggregation rule. Because of this change, the data call was issued for all years (2009–2021), and countries were requested to resubmit previously provided data, including this extra field. The data call relies on linking VMS and logbook data from individual vessels at a national level, after which anonymized tables of fishing activity at a C-square level are submitted to ICES for aggregation. In 2022, a new approach to making the link between VMS and logbooks was applied in Spain, greatly increasing the quantity of effort and landings captured within their submission. The VMS data submission from Portugal was not completed in time to be included in the aggregated product used in this advice.

Methods

The VME assessment methodology is described in ICES (2022b), and all input data are described in Annex 1. For the purposes of this assessment, data on VMEs and fishing activity are aggregated at the scale of 0.05 degrees latitude × 0.05 degrees longitude C-square cells, where they are assumed to be uniformly distributed. The EU assessment area boundary and depth zone 400–800 m boundaries were aligned with the C-square resolution of 0.05 × 0.05 degrees. For the 400 m and 800 m depth boundaries, this was done by selecting those C-squares where minimum depth in the square is ≥ 400 m and maximum depth is ≤ 800 m. All C-squares with any depth values within this 400–800 m depth range, based on modeled EMODnet Bathymetry Consortium (2018) data, were included. For the EU assessment boundary, only C-squares with centroid coordinates located within EEZ boundaries were included as part of the assessment area.

ICES uses data contained in its VME database[4] 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 ICES VME data calls. Data submissions can include new and updated/revised VME information. Data contained in the VME database up to and including those submitted in 2022 are included in this advice. Two types of data are submitted to the ICES VME database. The first type is data that confirm the presence of VMEs on the seabed. These are referred to as "VME habitats" and include e.g. video observations of cold-water coral reefs or deep-sea sponge aggregations from dedicated deep-sea surveys with accurate positioning. VME habitats represent C-squares where VMEs "are known to occur". The second type of data consists of presence records of VME indicator taxa, without full certainty of VME presence. These include e.g. records of soft coral or sea pen bycatch in trawls. For these data, ICES developed a method to aggregate records of VME indicator taxa at the C-square level into a "VME index", using FAO criteria and available abundance information. The VME index indicates C-squares where VMEs "are likely to occur" and distinguishes between high, medium, and low likelihood of VME occurence (ICES, 2022b). VME habitats and indicator taxa considered in this assessment are limited to those listed in Annex III of Regulation (EU) 2016/2336 on deep-sea access. 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 uses the presence of VME physical elements to predict the likely occurence of VMEs in a particular C-square. It is important to note that these numbers represent the number of C-squares that intersect with elements. Hence, one seamount or other element may be represented within multiple C-squares, as their areal extent often crosses several C-square boundaries.

ICES uses VMS data to determine the presence or absence of MBCG fishing within a C-square. VMS data are submitted by ICES Member Countries in response to the annual ICES VMS data call. Annual submissions can include new data as well as error corrections and resubmissions. For C-squares where MBCG fishing occurs, an SAR is calculated using vessel speed and métier and vessel length–specific gear width (Eigaard *et al.*, 2016). The SAR expresses the proportion of the seabed in each C-square that is assumed to have come in contact with MBCGs. Average SAR values calculated for each C-square, using VMS data from 2009–2021, are used in the assessment. A threshold SAR value of 0.43 is used to distinguish C-squares in which the risk of further SAI from MBCG fishing is considered low (SAR ≥ 0.43) or relatively high (SAR < 0.43) (van Denderen *et al.*, 2022). The evidence basis for the SAR threshold value is available in ICES (2022b).

Broad-scale spatial management scenarios consistent with UNGA policy, FAO Deep-sea Fisheries Guidelines, and Regulation (EU) 2016/2336 are considered in this advice. Five assessment scenarios were applied using different types of VMEs data and emphasizing different aspects of the UN Resolutions (Table 1). VMEs protection polygons are determined based solely on evidence of VMEs occurrence (scenarios A and B) or on evidence of both VMEs occurrence and MBCG fishing intensity (scenarios C, D, and E). In all scenarios, VME polygons are created by selecting C-squares according to a set of criteria (Table 2). A buffer rule is also applied to account for uncertainties in the exact location of MBCG relative to vessels position. The buffer includes half of all C-squares adjacent to those included in the VME polygons to ensure VMEs protection around the edge of each polygon. Note that the buffer rule does not apply to C-squares identified as VME physical elements.

Table 1 Description and management implications of spatial management scenarios* to identify VMEs protection polygons

Scenario	Description of VME polygons	Management implication
A	• Includes C-squares with VME habitats and C-squares with high and medium VME index • C-squares with low VME index are only included if adjacent to C-squares with VME habitat or medium-to-high VME index	Prioritizes protection of VMEs where they are known to occur and likely to occur, regardless of fishing activity
B	• Includes C-squares with VME habitats and C-squares with high and medium VME index • In addition, includes C-squares that contain selected VME physical elements associated with any records of VME indicator taxa or VME habitat	Prioritizes protection of VMEs where they are known to occur and likely to occur, as well as physical elements with evidence of VMEs, regardless of fishing activity
C	• Includes C-squares with VME habitats and C-squares with high and medium VME index	Prioritizes protection of VMEs where they are known to occur and likely to occur, including C-C-squares with low VME index where the risk of

[4] https://ices.dk/data/data-portals/Pages/vulnerable-marine-ecosystems.aspx

Scenario	Description of VME polygons	Management implication
	• C-squares with low VME index are included if MBCG fishing intensity (SAR) is below 0.43 • C-squares with low VME index and SAR ≥ 0.43 are also included, but only where adjacent to C-squares with low VME index with SAR < 0.43, or C-squares with VME habitat, high or medium VME index	further SAI from MBCG fishing is high, and C-squares with low VME index adjacent to those prioritized for protection
D	• Includes C-squares with VME habitats and C-squares with high, medium and low VME index, only if SAR < 0.43	Prioritizes protection of VMEs where they are known to occur and likely to occur, only where the risk of further SAI from MBCG fishing is high
E	• Includes C-squares with VME habitats and C-squares with high and medium VME index • C-squares with low VME index are included if SAR < 0.43 • C-squares with low VME index and SAR ≥ 0.43 are also included, but only if adjacent to c-squares with low VME index with SAR < 0.43 or C-squares with VME habitat, high or medium VME index • In addition, includes C-squares that contain selected VME physical elements associated with any records of VME indicator taxa or VME habitat	Prioritizes protection of VMEs where they are known to occur and likely to occur, including C-squares with low VME index where the risk of further SAI from MBCG fishing is high, C-squares with low VME index adjacent to those prioritized for protection, and physical elements with evidence of VMEs

* For concordance with previous ICES advice (2021a), scenario A = scenario 1 option 1; scenario B = scenario 1 option 2; scenario C = scenario 2 option 1; scenario D = scenario 2 option 2.

Table 2 Criteria for delineating VMEs protection polygons in the different spatial management scenarios considered in this advice. The half C-square buffer applies in all cases, with the exception of C-squares identified as VME physical element (green)

Scenario	Known VME occurence		Likely VME occurrence						Potentially supports VME
	VME Habitat		VME Index						VME Physical Element
			High		Medium		Low		
	SAR < 0.43	SAR ≥ 0.43	SAR < 0.43	SAR ≥ 0.43	SAR < 0.43	SAR ≥ 0.43	SAR < 0.43	SAR ≥ 0.43	
A									
B									
C									
D									
E									

Included in VME polygon (primary selection).
Included in VME polygon if adjacent to primary selection.
Included in VME polygon if associated with VME habitat or indicator record.

Management considerations

Due to data confidentiality concerns, VMS/logbook data are anonymized and aggregated in a 0.05 × 0.05 degree grid prior to submission to ICES, using the C-square geocode system (see Rees, 2003). ICES considers this spatial grid resolution appropriate to map MBCG fishing activity, given the minimum frequency of VMS pings and average fishing speeds of vessels towing MBCG (i.e. the chosen cell-size is such that it is unlikely that a vessel could fish across a square without effort being recorded). This constraint currently determines the spatial resolution at which the VMS and VME data can be brought together to explore spatial management scenarios for ICES advice.

The area of a single 0.05 degree C-square increases from 17 km^2 at the north of the EU fishable domain to 25 km^2 at the south. When establishing protection polygons, ICES uses a half C-square buffer around a C-square containing or likely to contain a VME. This is to account for the uncertainty in the location of a bottom trawl on the seabed at 400 m to 800 m depths and the uncertainty around the location and size of the any VMEs present within the C-square. The size of a single

C-square and buffer is 68 km^2 in the north and 100 km^2 in the south. ICES recognizes the need to minimize these differences and to improve spatial resolution by, for example, using equal area nested grids.

Quality of the assessment

The scenarios that include fishing activity use a SAR threshold of 0.43. This threshold is based on evidence from the NAFO area indicating that a threshold of that scale was ecologically relevant for sea pens, which are the least sensitive (i.e. most resilient) taxa to bottom trawling. ICES uses this value in the absence of alternative evidence for these ecoregions and has not examined the sensitivity of the analysis to this threshold value.

ICES assumes that for VMEs within C-squares fished above the 0.43 SAR threshold, the risk of future SAI to VMEs is low. ICES recognizes that, at the spatial resolution of the assessment, the risk of SAI cannot be assumed to be nil, while VMEs and/or VME indicator species may still co-occur with MBCG fishing within a C-square.

Several limitations of the VME index (ICES, 2022b) apply to the current advice. The VME index combines information on the presence of 'ranked' VME indicator groups and measures of abundance, making it difficult to provide evidence on the indicator(s) to managers and stakeholders. The process of ranking the VME indicator groups against the FAO criteria (FAO, 2009) in terms of vulnerability has also met with some criticism, and there are concerns that the index is a measure of perceived vulnerability rather than likelihood of occurrence. The current VME index also lacks a measure of confidence. The VME confidence index previously used by ICES is no longer considered a good proxy for evaluating the reliability of the VME data used in the calculation of the VME index (ICES, 2022b). ICES will continue to improve the index to ensure consistency with new FAO guidelines. This may result in changes to the index and to the quality of future assessments.

The VME assessment results are sensitive to updates and corrections in the VMS data (for scenarios including MBCG fishing information) and to new/updated VME data (for all scenarios). In 2022, some ICES member states resubmitted VMS data with corrections for some of the years used in previous (ICES, 2021a) advice, while some data received for the most recent period (2019–2021) were not included due to time constraints to complete quality checks. The accuracy and completeness of the VME data is dependent on ICES member states' data submission, and the number and extent of VME records is increasing over time as new information from scientific surveys and monitoring programmes is received. In 2022, there were some revisions to previously submitted VME records, which impacted on the selection of C-squares for inclusion in VME polygons under the different scenarios. ICES is aware that other sources of data on VME occurrence exist for the northeast Atlantic that are not yet included in the ICES VME database.

Additional information

A description of the data outputs provided with this advice is provided in Annex 2.

Sources and references

Eigaard, O. R., Bastardie, F., Breen, M., Dinesen, G. E., Hintzen, P. L., Laffargue, P., Mortensen, L. O., *et al.* 2016. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science, 73: i27–i43. 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).

FAO. 2009. The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas. Food and Agricultural Organization of the United Nations, Rome, Italy. 73 pp. http://www.fao.org/fishery/topic/166308/en

ICES. 2020. ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 2:62. 188 pp. https://doi.org/10.17895/ices.pub.7503

ICES. 2021a. 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.). *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, eu.2021.01. https://doi.org/10.17895/ices.advice.7507

ICES. 2021b. Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 3:89. 162 pp. http://doi.org/10.17895/ices.pub.8289

ICES. 2022a. Advice on ecosystem services and effects. *In* Report of the ICES Advisory Committee, 2022. ICES Advice 2022, section 1.1.2. https://doi.org/10.17895/ices.advice.19551433

ICES. 2022b. Benchmark Workshop on the occurrence and protection of VMEs (vulnerable marine ecosystems) (WKVMEBM). ICES Scientific Reports. 4:55. 99 pp. http://doi.org/10.17895/ices.pub.20101637

ICES. 2022c. EU request for a Technical Service to provide data output of the ICES 2021 advice on the deep-sea access regulation (ref. (EU)2016/2336) as coordinates for EU waters area only. *In* Report of the ICES Advisory Committee, 2022. ICES Advice 2022. sr.2022.02. https://doi.org/10.17895/ices.advice.10039

ICES. 2022d. ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 4:75. 68 pp. http://doi.org/10.17895/ices.pub.21196066

ICES. 2022e. Working Group on Spatial Fisheries Data (WGSFD; outputs from 2021 meeting). ICES Scientific Reports. 4:92. 151 pp. https://doi.org/10.17895/ices.pub.21630236

Rees, T. 2003. "C-squares," a new spatial indexing system and its applicability to the description of oceanographic datasets. Oceanography, 16: 11–19. https://doi.org/10.5670/oceanog.2003.52

EU. 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/eng

EU. 2022. Commission implementing regulation (EU) 2022/1614 of 15 September 2022 determining the existing deep-sea fishing areas and establishing a list of areas where vulnerable marine ecosystems are known to occur or are likely to occur. http://data.europa.eu/eli/reg_impl/2022/1614/oj

van Denderen, P. D., Holah, H., Robson, L. M., Hiddink, J. G., Menot, L., Pedreschi, D., Kazanidis, G., *et al*. 2021. A policy-based framework for the determination of management options to protect vulnerable marine ecosystems under the EU deep-sea access regulations. ICES Journal of Marine Science, 79: 34–49. https://doi.org/10.1093/icesjms/fsab237

Recommended citation: ICES. 2023. Advice on areas where Vulnerable Marine Ecosystems (VMEs) are known to occur or are likely to occur in EU waters. *In* Report of the ICES Advisory Committee, 2023. ICES Advice 2023, vme.eu https://doi.org/10.17895/ices.advice.22643356

Annex(es)

Annex 1 Description of data inputs/layers used in the assessment, including their origins and how and why they were modified/updated from those used in ICES (2021) advice

Layer	Data	Spatial resolution	Source	Taxa used to identify VMEs	Updated since 2021	Justification
VME index	VME habitats and index	C-square (0.05° × 0.05°)	ICES 2021 and 2022 VME data call, and QC by WGDEC	Only VME taxa as described in Annex III DSAR† (not taxa advised by ICES in 2021)	Yes	The most recent and updated (Note: Annex III DSAR filtering out of VME taxa)
VME observations	VME indicator and VME habitat observations	Coordinates	ICES 2021 and 2022 VME data call, and QC by WGDEC	Only VME taxa as described in Annex III DSAR (not taxa advised by ICES in 2021)	Yes	The most recent and updated (Note: Annex III DSAR filtering out of VME taxa)
VME physical elements	Seamounts, mounds, coral mounds and banks	Polygons	Compiled by WGMHM 2022	Only VME physical elements as described in Annex III DSAR (not taxa advised by ICES in 2021)	Yes	The most recent and updated
MBCG fishing activity	Mobile bottom fishing activity as average SAR based on VMS and logbook data for the 2019–2021 period	C-square (0.05° × 0.05°)	ICES 2022 VMS and logbook data call, and QC by WGSFD 2022		Yes	The most recent and updated
SAR	Average SAR based on VMS and logbook data for the 2009–2021 period	C-square (0.05° × 0.05°)	ICES 2022 VMS and logbook data call, and QC by WGSFD 2022		Yes	The most recent and updated
Existing EU deep-sea fishing areas	Presence of bottom contacting gear (static and mobile) based on VMS and	C-square (0.05° × 0.05°)	ICES 2019 VMS and logbook data call, and QC by WGSFD 2019		No	DSAR legislative footprint polygon

Layer	Data	Spatial resolution	Source	Taxa used to identify VMEs	Updated since 2021	Justification
	logbook data for the 2009–2011 period					
EU closures	Areas where fishing with bottom gears is prohibited under the Regulation (EU) 2022/1614	Coordinates	Regulation (EU) 2022/1614 coordinates translated into polygons		Yes	Regulation (EU) 2022/1614
Previous polygons	VME polygons resulting from spatial management scenarios A, B, C, and D[‡] in 2021	Polygons	EU request for a Technical Service to provide the data outputs of ICES 2021 advice on the deep-sea access regulation (ref. (EU)2016/2336) as coordinates for the EU waters area only. Available at https://doi.org/10.17895/ices.advice.9457		No	
Depth zone 400 m – 800 m	Bathymetry as minimum, maximum, and average depth per C-square	C-squares overlapping the 400–800 m depth zone	EmodNet Bathymetry Consortium, 2018		Yes	Area south of ICES Ecoregion Bay of Biscay and Iberian Coast has been added as part of the ICES technical service (2022). No further update as depth data from EMODNET 2020 is incorrect for parts of the area.
EU Assessment Boundary	EU waters of the North East Atlantic (sub set "ICES ecoregions")	Polygons	Flanders Marine Institute in the 2020 Union of the ESRI Country shapefile and the Exclusive Economic Zones (version 3). Available at https://doi.org/10.14284/403	EEZ of France, Spain, Portugal and Ireland	Yes	The most recent and updated ICES ecoregions do not cover all EU waters (EEZ of France, Spain, Portugal and Ireland). Ecoregions have thus been adjusted to fit into larger area.

[†] DSAR (deep sea access regulation): Regulation (EU) 2016/23.
[‡] For concordance with previous ICES (2021a) advice, scenario A = scenario 1 option 1 ; scenario B = scenario 1 option 2; Scenario C = scenario 2 option 1; scenario D = scenario 2 option 2.

Annex 2 Key/Description of data product describing VME polygon .csv, .xlsx and .shp file column headers released with ICES advice**.**

Column header	Description
Polygon_Number	The unique polygon ID number that corresponds to the VME polygon in the pdf map
Coordinate_Order	A unique coordinate number for each polygon vertex which can be used to connect the individual coordinates in each polygon.
Coordinate_ID	A unique reference string identifying each individual vertex, following the format Polygon_Number_Coordinate_Order
Longitude	Longitude in decimal form according to the WGS84 coordinate system, the coordinates are rounded at 3 decimal places (note that the trailing zeros are removed in the csv file)
Latitude	Latitude in decimal form according to the WGS84 coordinate system, the coordinates are rounded at 3 decimal places (note that the trailing zeros are removed in the csv file)