A review of the ICES Vulnerable Marine Ecosystems (VMEs) Advice with particular attention to the northwest of Ireland (ICES Division 6.a in the Irish EEZ)

21/06/2023

1. Introduction

On 15th September 2022 the European Commission (EU COM) published an Implementing Regulation (2022/1614) which closed 87 areas in EU waters to bottom fishing [1]. The closures were based on advice issued by ICES in January 2021 on "*areas where VMEs are known to occur or are likely to occur and on the existing deep-sea fishing areas*" [2]. This advice was updated to remove UK waters in the February 2022 ICES Technical Service [3].

Prior to the closures being implemented an online meeting was organised by DGMARE, on the 26th July 2022, in order for ICES to present and explain their advice to member states and stakeholders. At this meeting ICES attempted to explain the basis for the assessment and the identification of the proposed closed areas, referred to as polygons. Many questions were raised about the validity of the assessment and about the legality of the implementation of closures based on it, given that the VME polygons extended shallower than the 400m depth limit specified in *Article 9.1* of EU Regulation 2016/2336 "*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*" (Deep-Sea Access Regulation) [4]. Regardless, the closures were implemented and a significant impact was incurred by the fishing industry.

In 2022 the EU also requested ICES "*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"*. The resulting advice was published by ICES on the 18th April 2023 [5] and, relative to existing EU closures, indicated a 15–17% increase in the total area identified as VME protection polygons in EU waters of the Celtic Seas ecoregion and a 49–62% increase in the Bay of Biscay and Iberian Coast ecoregion. Given that this is recurring advice the area is likely to increase year on year as more records are added to the ICES VME Database. Similar to 2022 the advice was presented to stakeholders by DGMARE and ICES representatives, on the 25th April 2023, through an online meeting. Many questions were once again raised by stakeholders about the validity of the assessment, the lack of transparency of the data and inappropriate spatial scale at which the assessment input data was analysed. The answers from both DGMARE and ICES failed to provide clarity or properly acknowledge the limitations of the advice. The Scientific, Technical and Economic Committee for Fisheries (STECF) must now review the updated list at its summer plenary meeting on July 10-14th 2023 and advise the Commission whether or not the VME list should be amended.

Article 9.6 in the Deep-Sea Access Regulation [4] states:

"*By 13 January 2018, on the basis of the best scientific and technical information available and of the assessments and identifications carried out by Member States and the scientific advisory body, the Commission shall adopt implementing acts for the purpose of establishing a list of areas where VMEs are known to occur or are likely to occur.* ***The Commission shall review the list annually on the basis of advice received from the Scientific, Technical and Economic Committee for Fisheries and, where appropriate, amend the list by means of implementing acts.*** *The Commission may remove an area from the list provided that it determines, on the basis of an impact assessment and after consulting the competent scientific advisory body, that there is sufficient evidence to indicate that VMEs are not* *present, or that appropriate conservation and management measures have been adopted which ensure that significant adverse impacts on VMEs in that area are prevented. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 18.*"

The fishing industry has major concerns about the VME process and advice, regarding a number of key macro-areas:

A. Lack of Transparency and review of the ICES VME Database and assessment
B. Errors in the VME dataset and VME Portal
C. Validity of the assessment approach

Having conducted a thorough analysis of the basis of the ICES VME Advice in ICES Division 6.a these macro-areas have been fully confirmed. The issues in relation to these three macro-areas are detailed in Section 3 of the current document and for ease of reference are summarised in Section 2. The nine issues (see Section 2) illustrate significant errors and inconsistencies with the current VME assessment, which demonstrate why it is not an appropriate basis on which to delineate polygons for closure. The KFO request that these fundamental issues be addressed in the STECF review of the updated ICES advice and in the Commission's update of the VME closures. Further, in order to understand the VME Advice and resulting closures it is of course necessary to understand the development and origin of the VME assessment method. This process has evolved over many years and until recently has been largely unknown to many stakeholders. Therefore, a brief history to the background of the ICES VME Advice is provided in Annex 1 in order to show the inconsistencies that have developed over the years.

2. Summary and Conclusions

The current document presents an analysis and review of the basis of the ICES VME Advice. The primary reason for this undertaking relates to the three macro-areas of concern as set out above. During the process numerous issues were identified that fundamentally question the validity of the current closures, which were informed by the 2021 ICES VME Advice. These issues are summarised below and detailed in Section 3 where the most serious findings have been highlighted in bold:

1. A lack of transparency in the assessment process on which the advice is based.
2. Errors in ICES VME Database and VME Map Portal.
3. Lack of support for the current delineation of five out of nine polygons in the study area.
4. Inconsistencies between the VME Index layers in the 2021 and 2023 VME advice.
5. Inappropriate definition of the depth zones that are the foundation of the assessment.
6. Inappropriate delineation of VME Habitats at the c-square resolution level.
7. Potential confounding of the VME Confidence Index.
8. Questionable exclusion of the VME Confidence Index.
9. Biasing of the VME Index due to the exclusion of absence data.

The KFO requests that ICES retract its advice and perform a full and transparent review. In the interim period the European Commission should suspend the enforcement of the closed areas listed in the September 2022 Implementing Regulation (2022/1614). It is evident that the delineation of a significant proportion of the VME closed areas in ICES Division 6.a are not supported by any scientific evidence. Furthermore, there are an additional forty-six VME closed areas in EU waters that are shallower than the 400m depth specified in the Deep-Sea Access Regulation (2016/2336) [4], five of which are in ICES Division 6.a.

Finally, it is important to stress that the KFO recognises the need for conservation and restoration of sensitive marine habitats and ecosystems. This is important not only for addressing the biodiversity crisis but also for supporting sustainable fisheries which are critical for food security. The KFO acknowledge that there is a need for areas to be closed to mobile contact bottom gears but these areas need to first be identified based on robust scientific evidence, which is currently not the case. Where data is lacking then resources should be focussed on collecting real empirical data to fill those gaps. There is an increasing focus on putting significant resources into creating increasingly complex models to fill the place of real data. This often leads to vast extrapolation of underlying data, the development of inappropriate and ineffective management measures and the loss of trust and confidence in the scientific advice. This trend must be reversed and more resources focussed on basic data collection and biological research.

3. Key Issues with ICES VME Advice

Whilst taken at face value the basis of the ICES VME Advice seems to be quite clear and transparent in that polygons are identified due the presence or potential presence of VMEs. Those with a proven VME (identified through in situ observation) are automatically highlighted for closure and those with a potential VME are highlighted based on a likelihood of occurrence assessment and their proximity to other VMEs and areas that may contain VMEs. The data and advice are presented [2, 3, 5] in such manner as the reader only sees the final output and must assume that all of the underlying model assumptions and raw data are correct and appropriate. As mentioned in Section 1, a number of stakeholders have raised queries as to the validity of the approach and the underlying data, which have been ignored by DGMARE and ICES.

In the current document an analysis and review of the basis of the ICES VME Advice is presented so that it is clear and transparent to stakeholders how VME polygons are identified. Given time constraints and the fact that the complete VME dataset is not publicly available, despite ICES claims of transparency, it is not possible to review the entire dataset. Instead, the current document is focussed on key areas relevant to members of the KFO, namely ICES Division 6.a within the Irish EEZ, and the VME records and polygons therein. This document highlights significant issues which the KFO believes supports the requirement of a complete review of the VME assessment and advice processes. Publicly available data sources have been used to undertake the analyses, a full list of which is provided in Annex 2. GIS analyses were performed in the opensource software *QGIS* (Version 3.26.3 – Buenos Aires).

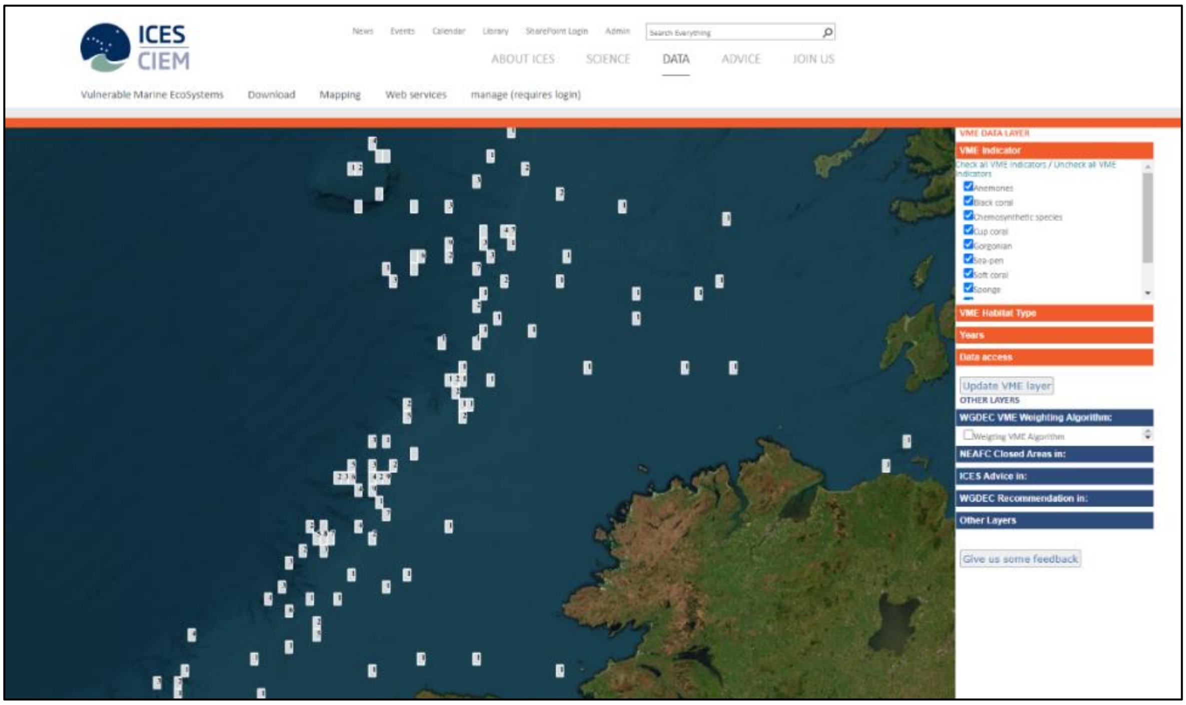

Figure 1. A screenshot of the ICES VME online map portal.

3.1. *Lack of Transparency*

One of the most significant issues regarding the ICES VME Advice is the lack of transparency concerning the data that underpins the advice and the assessment procedure used to analyse it. In order to explore this the ICES VME Database was downloaded from the ICES VME Data Portal (Annex 2). The database contains 68,865 VME records, which comprises 87% public records and 13% restricted access records. The restricted access records do not have positional data or any meta data associated with them in the public database and as such the database is not transparent as the database cannot be fully interrogated. In order to determine which records were public and which were restricted the ICES VME Map Portal (https://vme.ices.dk/map.aspx), which displays all records and enables selection of either public or restricted access records (Figure 1), was interrogated. One can also select and deselect the VME Indicator and VME Habitat type and through a process of elimination determine what the indicator species and habitat type are that support each VME c-square categorisation.

In order to compare this to the public records available in the ICES VME Database the ICES VME Index Weighting Algorithm shapefile was downloaded from the ICES VME Data Portal and the Scenario 2 Option 1 polygons and the modelled 400-800m fishing zone from the 2022 VME Technical Service (Annex 2). These were mapped together with the ICES VME Database public records on a base map with the 100m EMODnet bathymetry contours and ICES Divisions (Figure 2). It should be noted that the public records in the VME database, which are largely based on trawl data and form the basis for most of the VME Index records, contain start positions (latitude and longitude), end positions and mid-point positions. Each of these were plotted and a haul track reconstructed for each record. It was then possible to compare the GIS map with the ICES VME Map Portal and determine which were the restricted records.

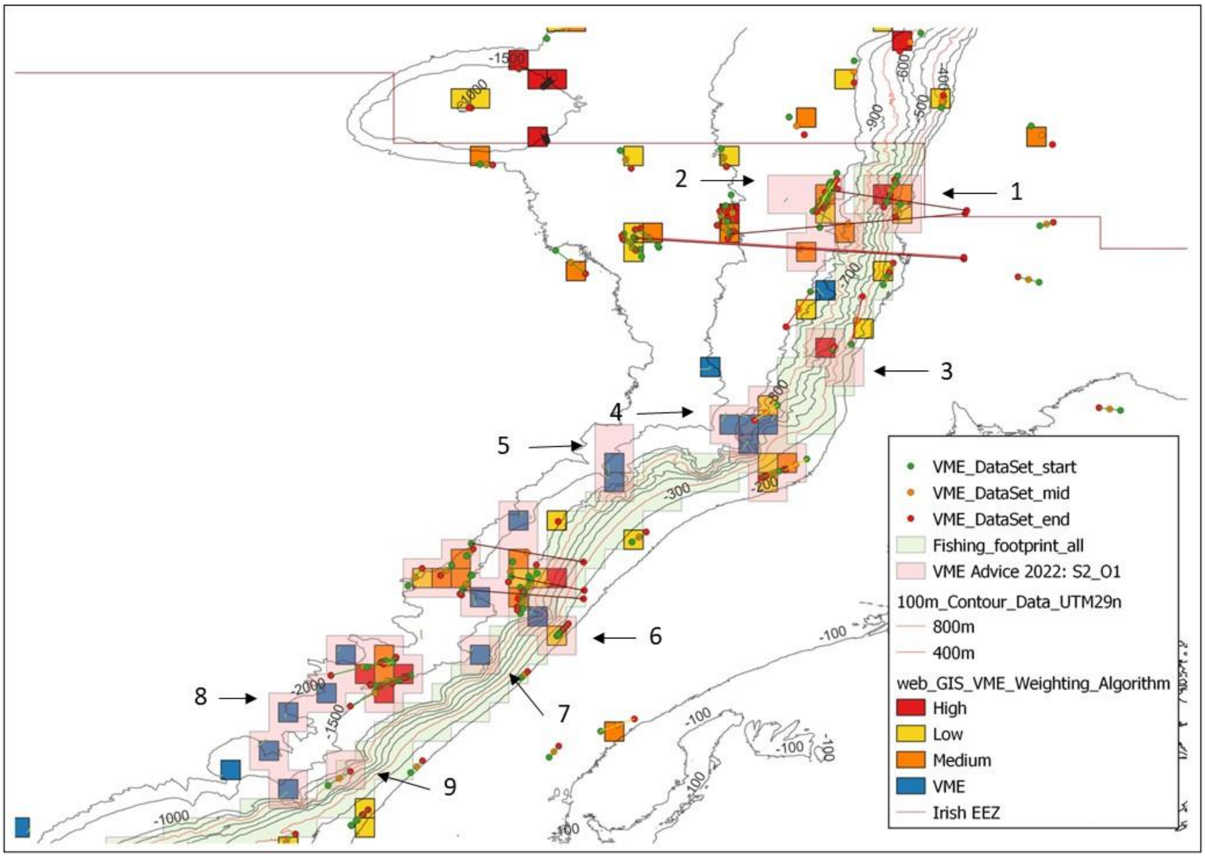

Figure 2. The start, end and middle positions of the public records in the ICES VME Database plotted with the VME Index Weighting Algorithm from the ICES VME Data Portal and the Scenario 2 Option 1 polygons and the modelled 400-800m fishing zone from the 2022 VME Technical Service. Only the area of interest in the Irish EEZ part of ICES Division 6.a is shown and the polygons have been numbered for ease of referencing.

It was immediately obvious that the VME Habitat c-squares (blue c-squares in Figure 2) did not appear to have any public record associated with them, whilst all other VME Index c-squares had at least 1 public record associated with them. When comparing this to the ICES VME Map Portal an error was detected where it was determined that the selection of public and restricted records was in fact reversed i.e. when only public records were selected the restricted records were displayed and when only restricted records were selected the public records were displayed. ICES were contacted on the 27/04/2023 to make them aware of the issue, which they rectified immediately by correcting the code underlying the map.

Regardless it was possible to identify the sites of the restricted records and through further analysis of the ICES VME database and older ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC) reports (see Annex 1) possible to determine that the restricted records were from the 2017 Sensitive Ecosystem Assessment and ROV Exploration of Reef (SeaRover) survey [6]. This survey was part of a series specifically developed to fulfil Ireland's obligation to quantify the abundance and distribution of offshore biogenic and geogenic reef habitats in Irish waters. The extensive offshore reef survey of Ireland's continental slope was commissioned by the Marine Institute in partnership with the National Parks and Wildlife Service (NPWS), funded by the European Maritime and Fisheries Fund (EMFF), and coordinated and led by INFOMAR (Integrated Mapping for the Sustainable Development of Ireland's Marine Resources). The SeaRover surveys took place annually between 2017 and 2019 and the cruise reports contain details of the sampling undertaken. A single synthesis report was also compiled by MERC Consultants Ltd. on behalf of the Marine Institute [7] and presents the results of the three surveys together along with information and discussion about the wider relevance of the surveys.

Each survey undertook transects using a Remote Operated Vehicle (ROV) to record high-definition camera footage of the transect, whilst manipulator arms were used to collect samples (physical and sediment). A very useful and constructive output of the analyses of the SeaRover series is the Marine Institute's online SeaRover GIS tool [8]. This tool makes accessible a selection of data from the surveys, including the actual ROV footage from each transect. So between the survey reports, the synthesis report and the online data portal the SeaRover data are fully publicly accessible. Therefore their categorisation as restricted in the ICES VME Database is somewhat surprising. One can only assume that **the ICES VME Database has not been updated since the data were first added after each survey i.e. whilst new records are added each year the older records in the database are assumed to be correct and are not reviewed. This situation needs to be addressed immediately.**

Whilst reviewing the ICES VME Database it was also apparent that there is a significant amount of missing meta-data for many of the VME records, particularly in the "*Dead/Alive*", "*Density*", "*Number*" and "*Weight*" columns. **This is also concerning as these categories are critically important when assessing the validity of VME Indicator records (see Annex 1).**

3.2. Errors in the VME dataset and VME Portal

Once it was established that the 2017 SeaRover survey positions were the 'missing' data these were added to the GIS map and it was clear that they corresponded to the VME Habitat records (Figure 3). Upon viewing the trawl survey tracks it was immediately apparent that there was an issue with a number of the tracks. In Figure 3 a number of very long tracks can be seen in relation to polygons 1, 2 and 6. These tracks run perpendicular to the shelf, in some instances from c. 1500m up to c. 200m. **It is physically impossible to trawl up the shelf as indicated by these tracks and as such these tracks must be incorrect.** In order to investigate further each of the records underlying the VME Index c-squares and polygons within the study area were analysed. Each public record has metadata with the survey from which it originated and in ICES Division 6.a these were primarily the Marine Institute's (MI) Irish Groundfish Survey (IGFS) and Irish Anglerfish and Megrim Survey (IAMS) and Marine Scotland Science's (MSS) West Scotland Deepwater Trawl Survey. All of the haul data for the MI surveys was available open access through ICES DATRAS (Annex 2) however the MSS data was not in DATRAS and the link in the Marine Environmental Data and Information Network (MEDIN) portal (https://medin.org.uk/) did not work. Therefore, the MSS data was downloaded as two partial datasets through the Marine Scotland Data portal (Annex 2). These included *Deepwater Elasmobranch Species Data From MSS Trawling Surveys 1996 – 2019* and *Deepwater Chondrichthyes weight-length data 2005 -2021*. Both datasets contained haul data for the majority but not all of the MSS VME records. There was also one record from an IFREMER survey that could not be confirmed as the original dataset could not be located online.

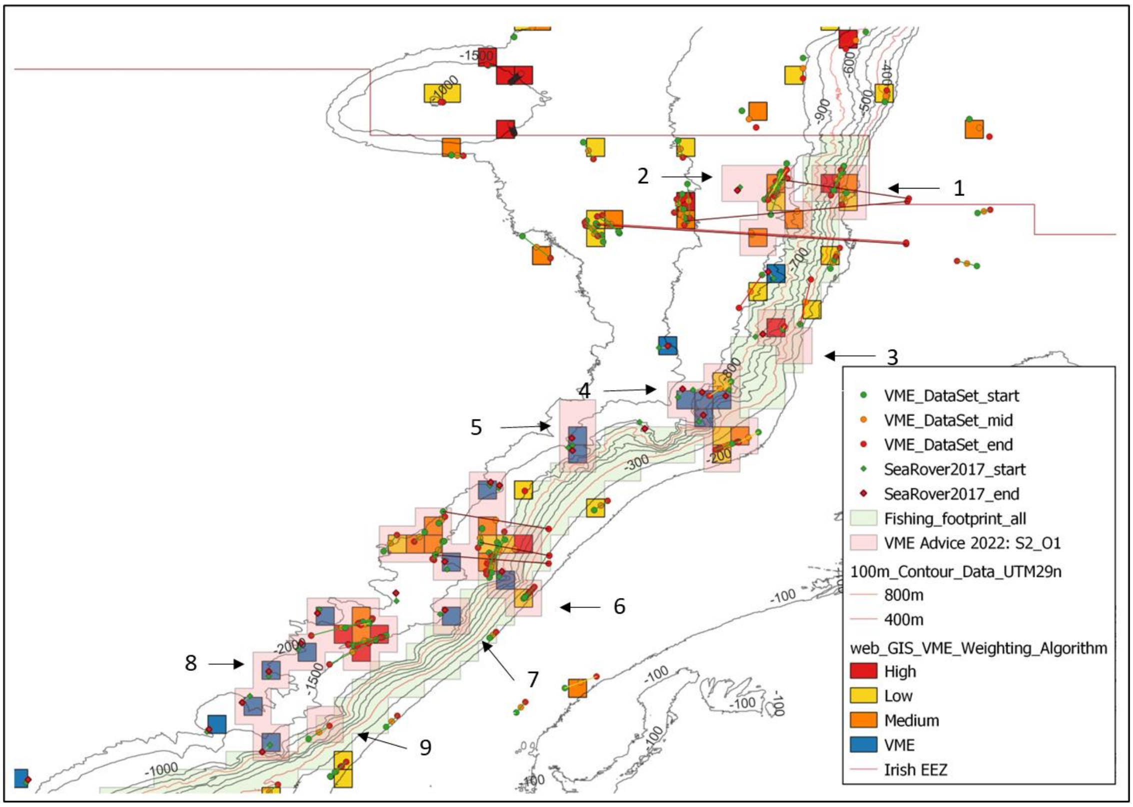

Figure 3. The start, end and middle positions of the public records in the ICES VME Database, the 2017 SeaRover start and end positions, the VME Index Weighting Algorithm from the ICES VME Data Portal, the Scenario 2 Option 1 polygons and the modelled 400-800m fishing zone from the 2022 VME Technical Service. Only the area of interest in the Irish EEZ part of ICES Division 6.a is shown and the polygons have been numbered for ease of referencing.

In total there were 202 VME Index records within the study area (Figure 3) which could be grouped into 88 survey hauls, details of which are provided in Annex 3. The start and end positions of these hauls were checked against the corresponding data in the aforementioned data sources (Annex 2), which revealed a number of errors and potential errors (Annex 3). In total 75% of the hauls had matching coordinates to the ICES VME Database and visual examination of the haul tracks in GIS indicated these were of appropriate length and orientation relative to the bathymetry and as such were considered to be likely correct. It was not possible to confirm the haul positions of 13% of the hauls (10 MSS hauls and 1 IFREMER haul) as they were not in the publicly available databases. Visual checking of these hauls did not reveal any unexpected patterns, however their data should be checked. **Seven percent of the hauls had an obvious error in position in the ICES VME Database and six percent had a likely error in position**. This error rate may appear small but it has a significant impact on the delineation and number of VME closed areas (see below).

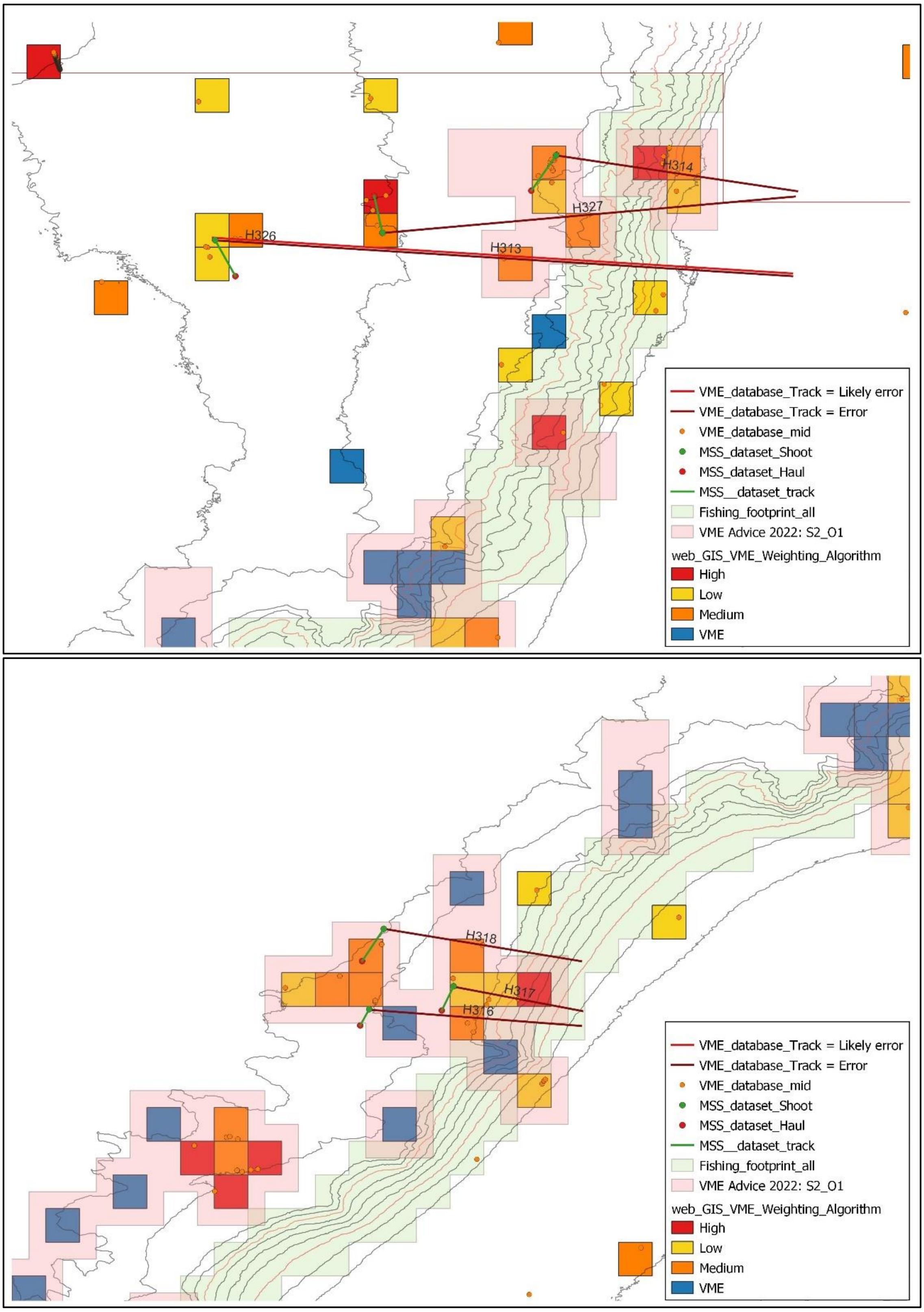

Figure 4. The 2013 MSS deepwater survey hauls showing the obvious error in position of the tracks based on the positions in the ICES VME Database (dark red and light red) and the tracks based on the positions in the MSS dataset shown in green. The mid-point of the ICES VME Database tracks are indicated by the orange points and the haul numbers for the survey are indicated.

The hauls with the obvious error in position in the ICES VME Database were from the 2013 MSS Deepwater survey. Six of the hauls had obvious errors, which are shown clearly in Figure 4 as the tracks in dark red. The tracks of the same hauls based on the MSS dataset, displayed in green, are shorter and run parallel to the bathymetric contours. A seventh track (H313) could not be confirmed as its coordinates were not in the MSS datasets available for scrutiny. It was deemed highly likely to also be incorrect given that it follows the same pattern as the hauls proven to be incorrect. Further it is interesting that Haul 313 is in an almost identical position to Haul 326, though the former took place on the 20/09/2013 and the later on the 22/09/2013. It seems unusual to repeat the same haul within the same deepwater survey. As the position of Haul 313 has not been confirmed then further analysis is required to determine its actual position as it may be in a different location.

Potential errors were also identified in four MSS hauls from 2006 (Annex 3). In the ICES VME Database these four hauls were labelled as being from survey "*SCO_1406S*". However, the plotted depths of the haul positions did not correspond to the depths listed in their associated metadata (Figure 5 and Table 1). Therefore, these hauls were checked against the MSS database but a survey with the same survey code was not found. Instead, the same haul numbers taken on the same dates were listed as being from survey "*1506S"*. In this case however when the positions were plotted the listed depths matched with plotted depths and as such one would assume that the positions were correct in the MSS database (Figure 5). In order to determine which survey code was correct the British Oceanographic Data Centre Cruise Inventory Database (https://www.bodc.ac.uk/resources/inventories/cruise_inventory/results/) was interrogated. The cruise code "*1406S*" appears to be correct as the survey type, dates and general location match the survey report (https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/1406s.pdf), whilst the "1506S" was a hydrographic survey that took place later in the North Sea (https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/1506s.pdf). **There appears to be likely errors in both datasets though the positions in the MSS dataset appear more likely to be correct given the depths listed**. Some of the haul numbers and positions also appear to be mixed up as noted in Figure 5 and Table 1.

Table 1. The four hauls from the 2006 MSS survey with the data from the ICES VME Database and the MSS database.

ICES VME Database ID	Sample	Date	Station ID	VME_DB Depth	Plotted Depth
261297	GB_WGDEC_2006_1406S_463_179	19/09/2006	1406S_463	1500	c.400-500
262089/262747	GB_WGDEC_2006_1406S_465_181	21/09/2006	1406S_465	450	c.1000
261295/261296	GB_WGDEC_2006_1406S_460_177	18/09/2006	1406S_460	500	c.1100
261630	GB_WGDEC_2006_1406S_461_180	19/09/2006	1406S_461	500	c.1500

MSS cruise number	Date	MSS Haul	MSS depth	Plotted depth	Comments
1506S	19/09/2006	463	1500	1500	At position of VME Haul 461
1506S	21/09/2006	465	450	c.350	At position of VME Haul 463
1506S	18/09/2006	460	500	c.450	
1506S	19/09/2006	461	500	c.400-500	

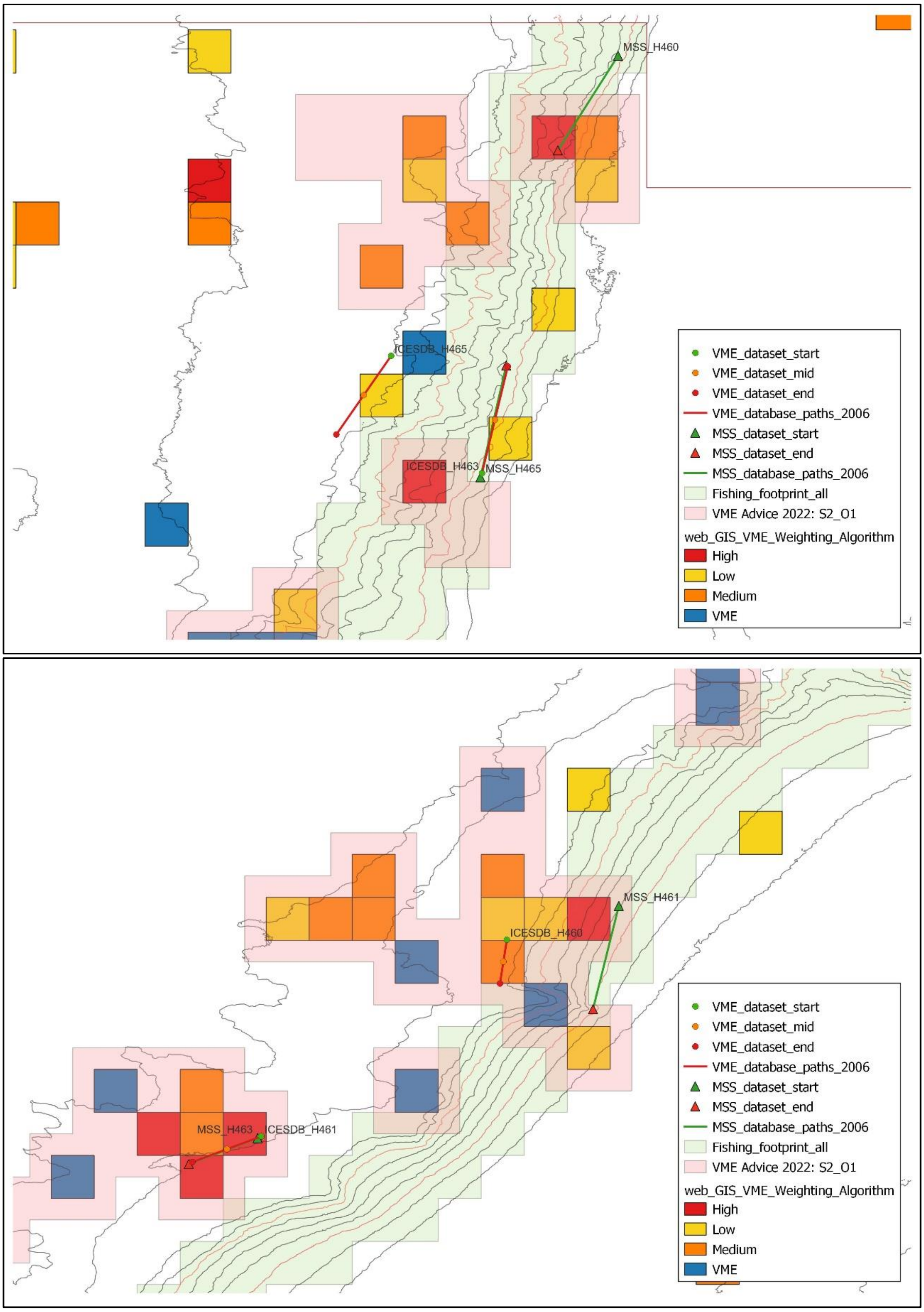

Figure 5. The 2006 MSS survey hauls showing the potential error in position of the tracks based on the positions in the ICES VME Database (red) and the tracks based on the positions in the MSS dataset (green). The mid-point of the ICES VME Database tracks are indicated by the orange points and the haul numbers for the survey are indicated.

In practical terms it is also useful to assess the impact of the erroneous records on the delineation of VME polygons and the resulting closed areas. In order to do so one must acknowledge another assumption of the VME assessment, which is not very clear within the ICES VME Advice or in the WGDEC reports (Annex 1). That is, **the catch position attributed to a VME indicator record which has been collected during a survey trawl is the mid-point of the trawl and this is the point used to identify the c-square that the record is attributed to**. This mid-point is simply the middle of a straight line between the start and end positions of the trawl. **Following standard survey protocols only the start and end positions of hauls are noted in the survey meta-data and therefore the mid-points in the ICES VME Database are not likely to be actual positions recorded on the surveys in question**. They are in fact the theoretical mid-point of the trawl if the trawl track was a perfect straight line and the 'real' middle point of the trawl transects may differ depending on the straightness of the trawled track. This issue is discussed in more detail in Section 3.3.1.

In the case of the six hauls from the 2013 MSS Deepwater survey with the clear errors in position in the ICES VME Database and the seventh haul with the likely error this issue of the mid-point has a significant impact on the designation of VME Index c-squares and on the delineation of polygons 2 and 6 (Figure 3). **If these hauls are corrected to the positions that are in the MSS dataset then one high VME Index and three low VME Index records are no longer supported by the data and must be removed (Figure 6)**. **This would remove two VME Index c-squares from each of polygon 2 and 6, which would reduce their area by approximately 122 km^2 and 68 km^2, respectively. It would also break polygon 6 into two separate polygons**.

It is also evident from Figure 6 that there are four polygons (2, 3, 5 and 9) that appear to be missing a VME Index c-square to support their delineation. In order to explore this further the *web_GIS_VME_Weighting_Algorithm* displayed in Figure 6 was visually compared with the *Weighting VME Algorithm* layer in the ICES VME Map Portal (Figure 7) and the corresponding layers in the interactive maps provided with the 2021 and 2023 ICES VME Advice (Figure 8 and 9). The 2021 ICES VME Advice included layers with the VME Habitats, Indexes and Elements so it was possible to see, at a high level, what the basis of each polygons was. This layer was not included in the interactive maps with the 2022 VME Technical Service. The 2023 advice contained 3 related layers; *Existing VME C-sqs*, *New/updated VME C-sqs*, *New/updated VME C-sqs excluded*.

The web GIS and map portal layers should be the same with the only difference being the GIS layer is more accessible as the meta data can be interrogated through offline GIS software. There appeared to be a number of differences between the datasets though, two of which concern the delineation of polygons (3 and 9). In the case of polygon 3 in the GIS layer (Figure 6) there is a single record associated with this polygon but in the map portal layer (Figure 7) there is an additional 'grey' record that does not appear to have a VME Index weighting. When the public and restricted layers are selected and deselected in the map portal, in order to try to identify this record, then this record disappears from the display and does not return. **It appears likely that this 'grey' record is an error in the ICES Map Portal and it does not actually exist in the ICES VME Database**. When polygon 3 is viewed in the 2021 advice (Figure 8) there is an additional low VME Index c-square that does not appear in either of the aforementioned datasets, which appears to support the delineation of the polygon. This low VME Index c-square is also in the 2023 advice but in this instance the resulting polygon under the same scenario and option (2_1 or C) is truncated to exclude this c-square. **This indicates that this is not a valid low VME Index c-square even though it appears in the VME Index layer**. This raises three questions, firstly has this VME record and associated c-square been removed from the ICES VME Database? Was it ever present in the database? What VME Index layer was used in the assessment for the 2023 advice? **Regardless, it appears that the delineation of polygon 3 was incorrect and as such this closure should be revised to reflect the fact that is now based on a single c-square. This results in a 43% reduction of the area of the polygon.**

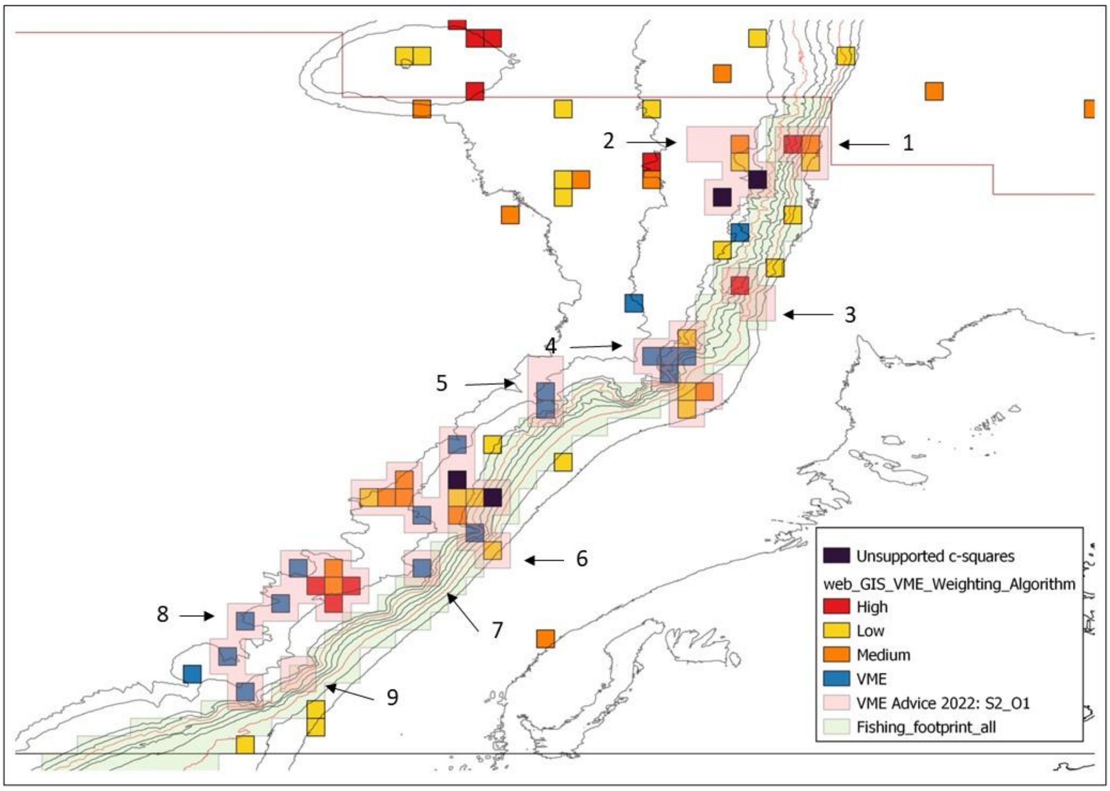

Figure 6. The VME Index c-squares, indicated in black, that are no longer supported by the data as a result of the seven erroneous 2013 MSS deepwater survey records.

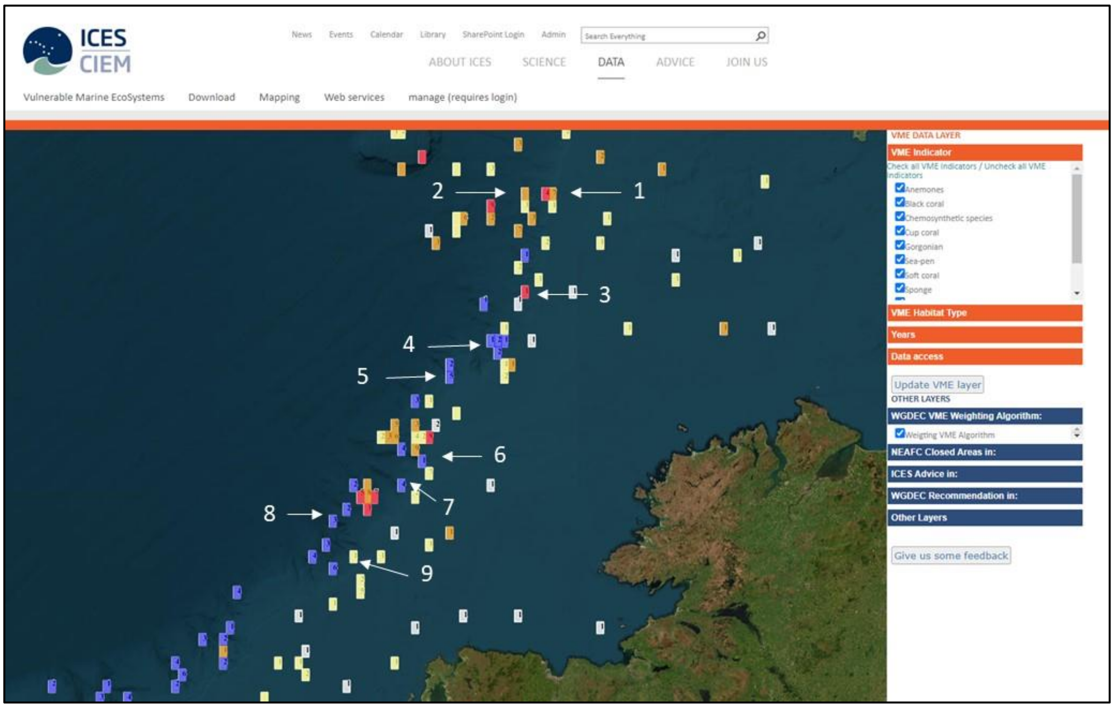

Figure 7. The ICES VME Map Portal with all public and restricted records and the VME Weighting Algorithm selected.

In the case of polygon 9 the web GIS dataset does not have a c-square associated with this polygon (Figure 6), whereas in the ICES VME Map Portal (Figure 7) and the 2021 advice (Figure 8) this polygon is apparently supported by a single low VME Index c-square. In the 2023 advice it is noted that this c-square was excluded as a VME Index c-square (Figure 9), where its states *"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)"*. **It is apparent that according to the 2023 ICES VME Advice there is no support for this polygon, which was based on the 2021 ICES VME Advice and was included in the Commission's Implementing Regulation (2022/1614). There is now no scientific basis for the inclusion of this polygon and as such it should be removed.**

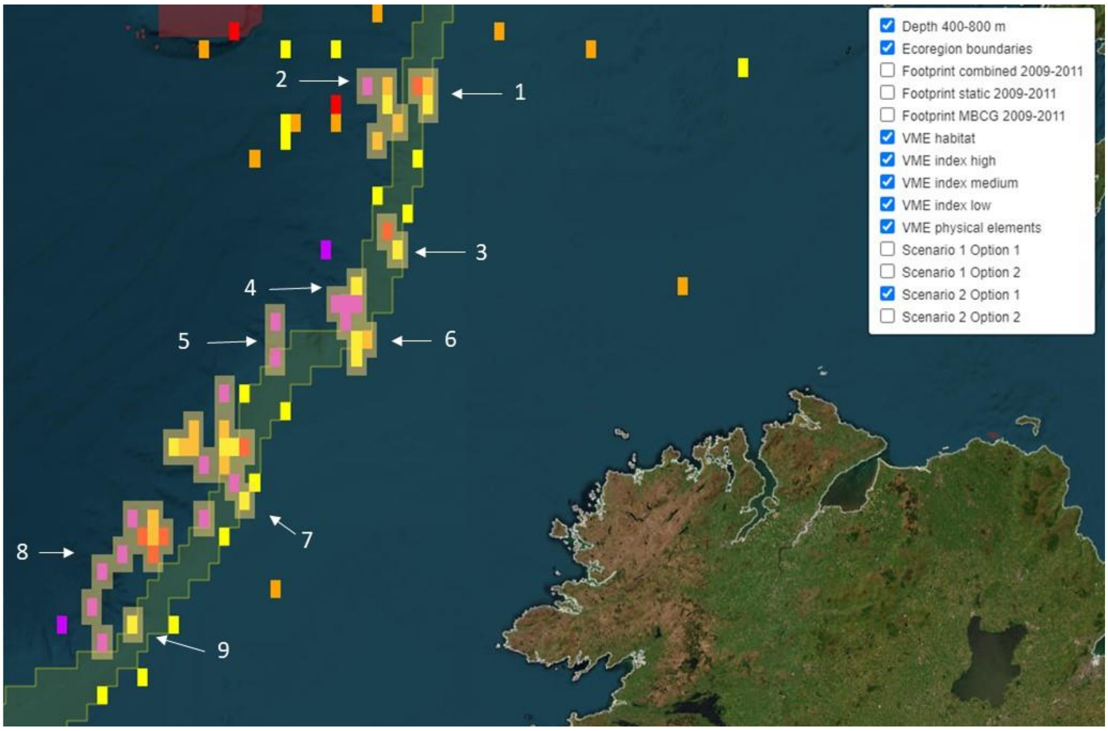

Figure 8. A screenshot of the interactive map from the 2021 ICES VME Advice showing the current study area and the VME Habitat, Index and Elements layers.

By examining Figures 6 to 9 it also becomes evident that there is an issue with polygon 5. The web GIS dataset and the map portal (Figures 6 and 7) both indicate that there are two VME Habitat c-squares in this polygon, which are adjacent to each other. This is corroborated by the positions of the SeaRover survey stations (Figure 3). In the 2021 advice polygon 5 is shown with two c-squares, which are separated by a gap of a c-square. This is also evident in the *Existing VME C-sqs layer* in the 2023 advice. However, the *New/updated VME C-sqs* layer indicated that an additional VME Habitat c-square was identified in between the other two VME Habitat c-squares and no VME Habitat c-squares were excluded. This raises the question as to what the evidence is for the most northerly VME c-square. **It is not supported by the evidence available for scrutiny in the ICES VME Database or in data displayed in the ICES VME Map Portal. If this c-square has been identified as a result of a coding error then are other c-squares also affected? This must be further analysed**.

The analyses above present a simple error checking and quality control of the basis for the ICES VME Advice in a small geographic subset of the entire VME assessment area. **This analysis has highlighted significant issues, errors, likely errors and inconsistencies in the output of the ICES VME assessment which appears to be related in a large part to errors in the ICES VME Database**. The Quality Assurance Framework as set out by ICES in the ICES Advisory Plan [9] does not appear to have been applied in the case of the VME assessment and advice process. The KFO believes that this calls into question the entire VME assessment and resulting 2021 and 2023 ICES VME Advice. **There is an urgent need for a complete review of the ICES VME Database and the VME assessment process. This should have taken place as part of the Benchmark (WKVMEBM) in 2022 [10] and each year in the twenty-two years of WGDEC meetings that led to that benchmark (see Annex 1)**.

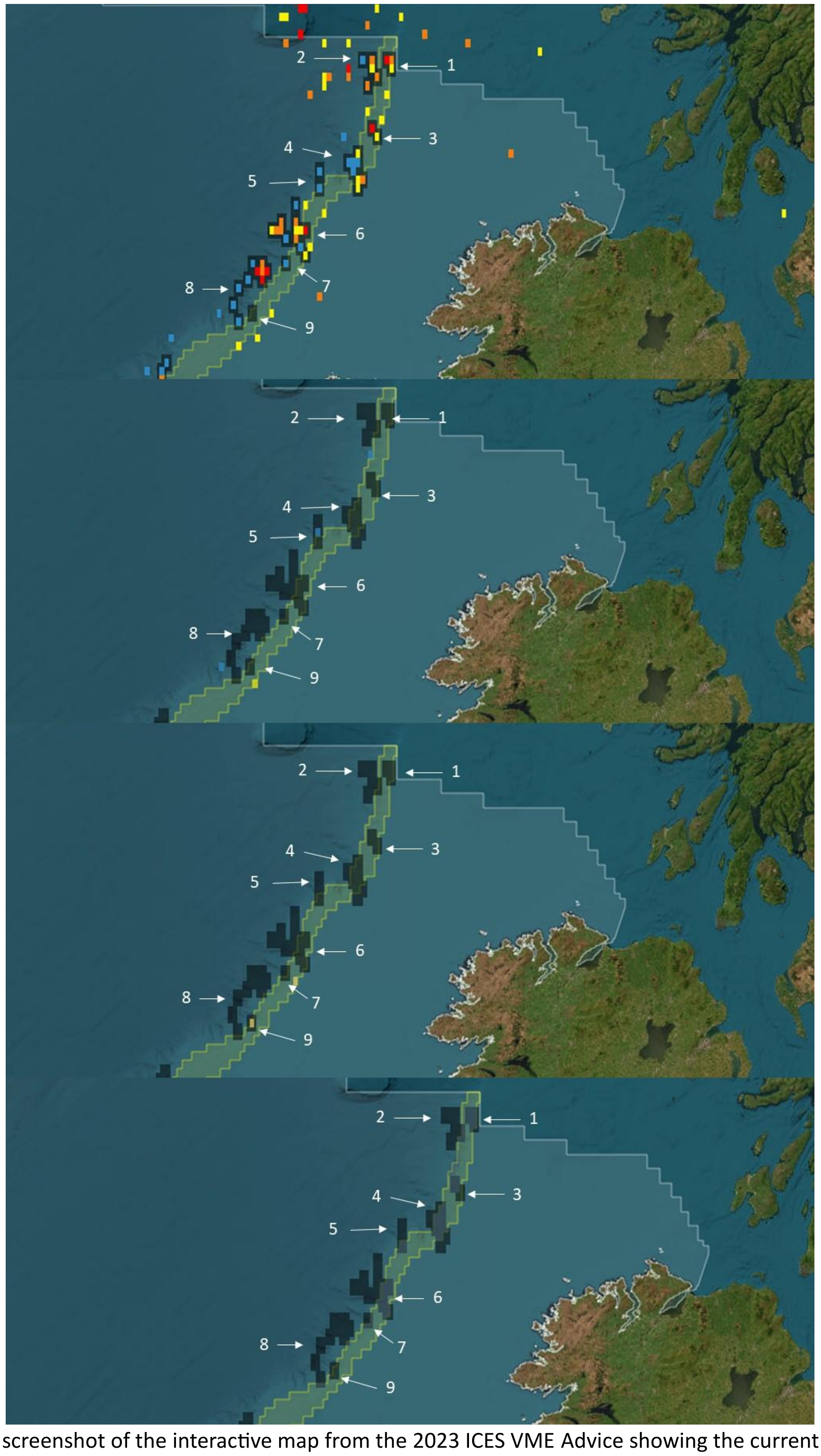

Figure. 9. A screenshot of the interactive map from the 2023 ICES VME Advice showing the current study area. The top panel includes the *Existing VME C-sqs* layer, the second panel includes the *New/updated VME C-sqs* layer, the third panel includes the *New/updated VME C-sqs excluded* and the bottom panel includes the September 2021 EU Closures (dark polygons) and the revised polygons (lighter shading on the polygons) based on the 2023 advice.

3.3. Validity of the assessment approach

In addition to the errors highlighted in Section 3.2 the KFO believes that the assessment approach used to produce the VME assessment and advice is not appropriate. The spatial scale that the data is collated and analysed is too broad, the locations of known VME Habitats are not incorporated appropriately, the confidence attributed to individual VME Index records is too high in some instances and the omission of absence data from the analysis gives a misleading impression of the prevalence of VME indicator species. Each of these is discussed in detail with accompanying examples from the study area.

3.3.1. Depth

The 2021 ICES VME Advice and 2022 Technical Service defined VME polygons which extended deeper and shallower than the 400-800m zone specified in *Article 9* of the Deep-Sea Access Regulation (2016/2336) [4]. In the European Commission's implementing act (2022/1614) which closed 87 areas in EU waters to bottom fishing [1], the entire outline of the polygons was listed rather than just the portion of the polygons within the 400-800m zone. The extension of the polygons deeper than 800m is not a concern as bottom trawling is already prohibited in this zone according to the Deep-Sea Access Regulation (2016/2336). However, the extension of the polygons shallower than 400m, and in some areas shallower than 200m, resulted in these areas becoming closed areas also. Whilst the European Commission has stated that national control authorities can account for this issue in the application of their monitoring and regulation and only apply the regulation in the 400-800m zone, **the reality is that the regulation still stands and is being enforced**. In the current study area Irish vessels that have entered the polygons, shallower than 400m, have been notified to leave the area by the Irish Navy as such these areas have been closed to bottom fishing since September 2022. It is interesting to note that in the 2023 VME Advice ICES restricted the polygons in the advice maps to the assessed 400-800m zone, which significantly changes the perception of what polygons should have actually been closed based on the advice. **However, even this modification does not account for the fact that the way the 400-800m zone is defined in the VME assessment model is fundamentally inappropriate and this is the primary reason for the extension of the polygons shallower than 400m**.

The depth layer used as the basis for the assessment to define and analyse the fishing footprint, the fishing effort and the VME Index and Habitats layers is not based on real depth but is a modelled depth. Within the model the area is divided into c-squares, which are 0.05° x 0.05° or 17 km^2 at the latitude of the study area, and each c-square is assigned a depth corresponding to the depth at its middle point. It is obvious to anyone that applying such an approach in an area like the continental shelf break is wholly inappropriate as the depth can change rapidly over a short distance depending on the steepness of the area (Figure 10). This immediately introduces large uncertainty, extrapolation and error into successive layers of the model. This is further exacerbated by the fact that adjoining c-squares or c-squares with adjoining buffer zones outside of the modelled 400-800m zone are also joined to the polygons in the assessment process (Figure 2). **The modelled 400-800m zone is in fact 100% larger than the real 400-800m zone**. Within the current study area in ICES Division 6.a the 400-800m zone as defined in the ICES VME assessment and based on c-square resolution is approximately 2,647 km^2, whereas the area actually within the 400-800m zone as defined in the EMODnet bathymetry data is approximately 1,318m^2. **As this layer is used as the starting point for the definition of the fishing footprint within the 400-800m zone, the fishing effort and the location of VME records, then the fundamental basis of the VME assessment is incorrect**.

Article 9 of the Deep-Sea Regulation (2016/2336) [4] only applies "*to fishing operations with bottom gears below a depth of 400m*". It does not state that these are modelled depths. **On this basis the entire VME assessment, subsequent advice and resulting closed polygons are based on a definition of depth which does not concur with the regulation and as such could be considered invalid**.

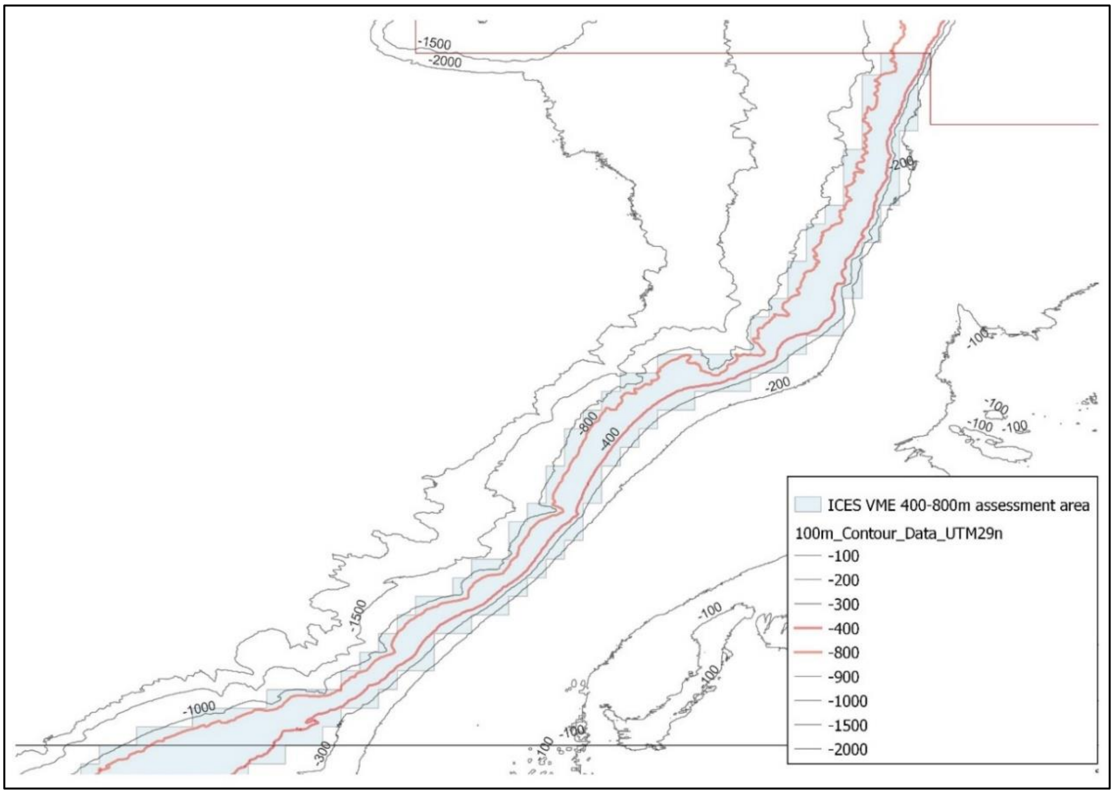

Figure 10. The 400-800m zone (in blue) as defined in the ICES VME assessment model. The 400m and 800m contours (EMODnet bathymetry) are indicated in red.

The reason ICES have taken this modelled depth approach is likely due to the fact that they only request the VMS data from member states at the c-square resolution. It is therefore easier to define the depth at this spatial scale and ignore the reality than have to subset the data based on the more accurate bathymetric data. It is possible to do this though and it was done as part of the 2018 Technical Service [11] to aid in the interpretation of the 2018 ICES VME Advice [12] (see also Annex 1).

It should be noted that the seabed in the Irish EEZ has been mapped in detail by the joint Marine Institute and Geological Survey Ireland INFOMAR programme (https://www.infomar.ie/). The bathymetric contours are well defined and the Irish data is part of the wider EMODnet bathymetric data (Annex 2). **It should be a requirement to use this best available scientific data as the starting point of the assessment process instead of artificially inflating the 400-800m zone by a factor of 100% for the sake of simplifying the approach**.

It is informative to see what the effect on the VME records would be if this step had been taken i.e. in the current study how many of the SeaRover transects and how many of the mid-points of the survey trawls which caught VME indicator species actually lie within the real 400-800m zone. In order to investigate this all of the aforementioned errors in haul positions (see section 3.2) were ignored and all records assumed to be correct. The results indicated that 1 complete SeaRover transect, 1 partial SeaRover transect and eight trawl mid-points lay within the 400-800m zone, or in simple terms 10.5% of the VME Habitat records and 9% of the survey trawls and 9% of the VME indicator records therein (Figure 11). **Had this more appropriate approach been taken there would have been significant reductions to the polygons presented in the advice which was the basis of the EU closures**.

When individual polygons were analysed the impact of the incorrect delineation of the 400-800m depth zone became even more evident. This is illustrated by zooming into polygon four in the current area of interest (Figure 12). Four of the c-squares were categorised as VME Habitats based on the observations made on the SeaRover survey. Two of these lie deeper than then 800m contour, one is partially within the 400-800m zone and one is completely within the 400-800m zone. What is also clear is that the SeaRover dives are not in the middle of the c-squares they are delineated by and in fact three out of four are on the periphery of their respective c-squares. This point is discussed in more detail in Section 3.3.2 below. Transect 33/Dive 481 is indicated by the arrow labelled number 1 (Figure 12). In order to investigate the basis for this VME Habitat classification one can go to the ICES VME map portal and through a process of elimination determine that this c-square has been categorised based on the verified presence of "Seapen fields". Through the aforementioned SeaRover resources (see Section 3.1) and by analysing the QGIS transect metadata (Figure 12) one can see that the SeaRover transect started at 964.8m and ended 684.5m with an average depth of 844m. On a straight-line basis c. 1.64km (77%) of the transect occurred in waters deeper than 800m and only c. 0.5km (23%) of the transect occurred in the 400-800m zone. **It is not transparent what point in the transect ICES used to identify the location of the VME Habitat in the assessment model.**

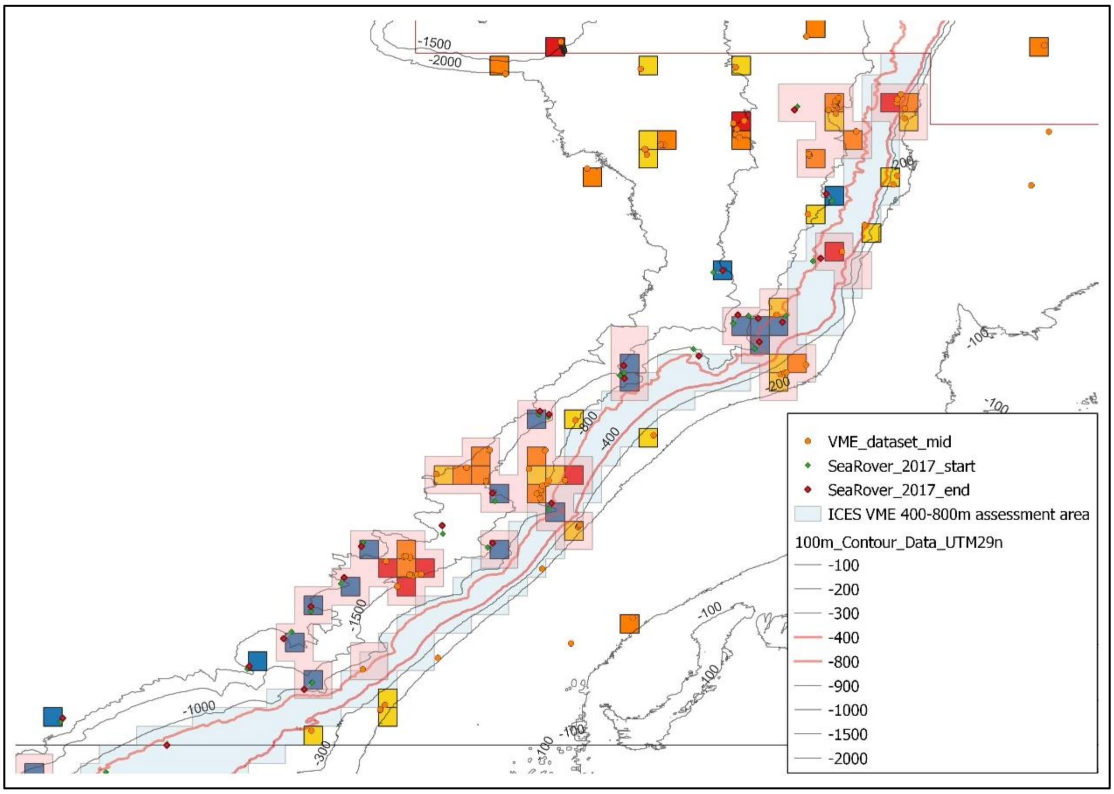

Figure 11. The location of the VME Habitat and VME Index records in relation to the 400-800m zone as defined in the ICES VME assessment model and according to EMODnet bathymetry data.

Similarly on the shallower side the majority of the low VME Index (yellow) c-square adjacent to the VME Habitat c-square is shallower than the 400m contour. **The inclusion of this c-square is due to a single record of a "sponge" collected on the IGFS in 2014 and the fact that the theoretical mid-point of that haul falls 50m inside the border of the c-square** (arrow number 2). Had this mid-point been just outside this c-square then this would have resulted in the two yellow and one orange c-squares not being included within the limits of the polygon. There is a significant level of uncertainty around the mid-point of the haul and the identification of this c-square, which is increased further by the fact that the metadata indicates the VME indicator record to be a single **dead** sponge. **Similarly the VME record in the medium VME Index (orange) c-square is located within 74 metres of the edge of the c-square, which itself is entirely outside of the real or modelled 400-800m depth zone** (Figure 12). **This example highlights the tenuous basis and lack of credibility in the approach used to identify VMEs or areas where VMEs are likely to occur. The resolution at the basis of the analysis is simply not fit for purpose**.

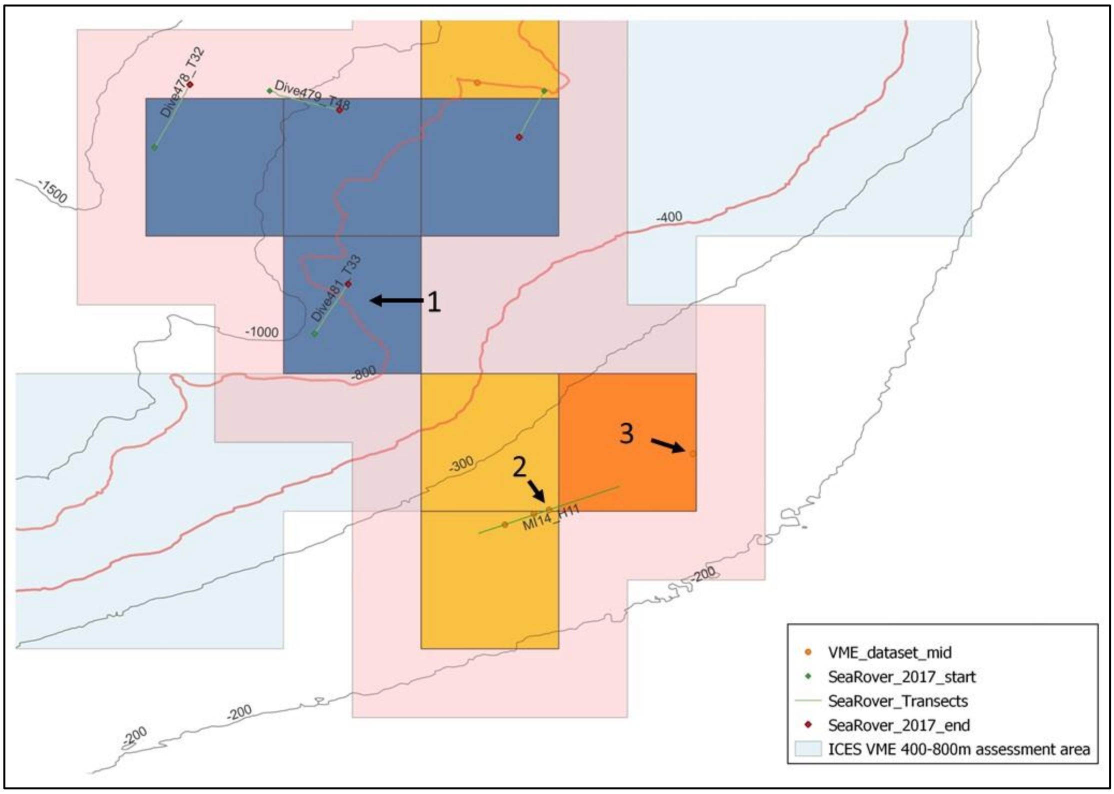

Figure 12. Polygon four in the current area of interest showing the effect of the inaccurate delineation of depth.

It should be noted that ICES acknowledged, in the 2021 and 2023 advice, that there were issues with the spatial scale of the VME Advice and suggested that finer scale assessments of VMEs are undertaken where higher-resolution data are available. **However, this acknowledgement was in relation to the spatial scale of the VMS data used to define the fishing effort and no mention was made of the impact on the assessment of the inappropriate scale at which the depth data was analysed.** Further the significant issues related to the scale of the VMS data were not included in the headline advice summary but were further down the advice sheets, which in reality means they are likely to be overlooked or not considered as relevant as the headline advice.

3.3.2. VME Habitats at c-square resolution

As shown in the example in Figure 12 the ROV transects used as the basis for the VME Habitat classifications are often on the periphery of the c-squares to which they are assigned, with parts of the transects often outside the designated c-square. In the case of VME indicators the mid-point of the survey trawls was used as the location but it is unclear what position was used for the VME Habitat designations, especially in cases where the transects started and/or finished outside of designated c-squares. Nor is it clear whether the specific location of the VME Habitat along the transect was taken into account. **In fact it appears like the VME Habitat data, which is arguably the most important data, has been forced to fit into the c-square resolution used to delineate the VME Index c-squares**. **A better approach would have been to delineate a closed area around each VME Habitat and keep them separate from the c-square basis of the VME Index.**

During the review of the ICES VME Advice development (see Annex 1) it was noted that this was actually the process put forward by WGDEC 2017 [13] to identify VME Habitats and VME Index c-squares on which recommendations of bottom fishing closures could be based (Figure 13). **It is clear to see in Figure 13 that in the case of VME Habitats the process does not appear to use the gridded c-square system to define the boundary around the Habitat record**. This makes sense as the exact location of the VME Habitat records are known and it would make sense to place them at the centre of the closed area in order to afford the greatest degree of protection. **Why this process was not subsequently followed is unclear.**

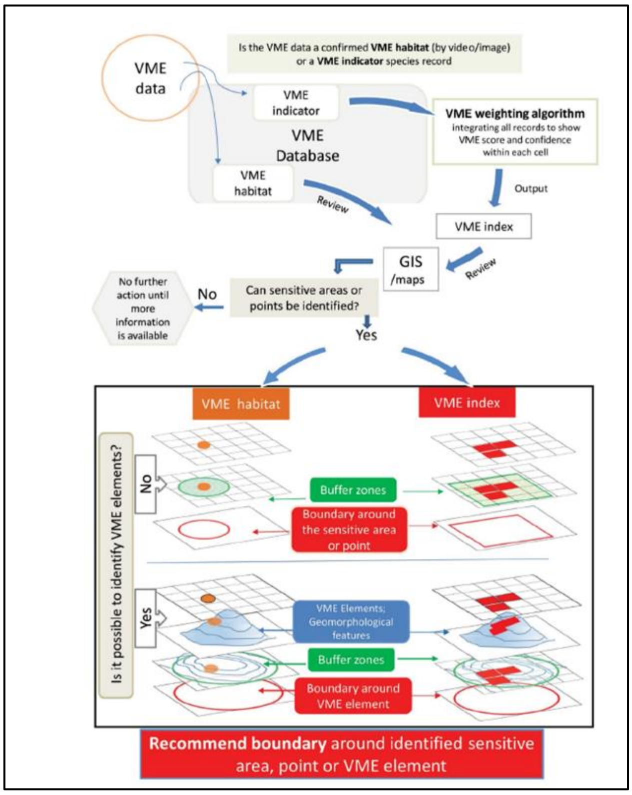

Figure 13. Process used by WGDEC (as of 2017) to delineate boundaries around sensitive areas of seabed [13].

3.3.3. VME Confidence Index

As part of the development of the VME Weighting Algorithm in WGDEC 2014 [14] and WGDEC 2015 [15] and to account for data quality issues, a data uncertainty index was developed based on the survey type, number, time span and how recent the last survey was (low uncertainty < 0.51; medium uncertainty 0.51 - 0.70; high uncertainty > 0.70). In WGDEC 2017, though not highlighted or discussed in the report, this uncertainty index appears to have been renamed as the Confidence Layer. This was actually a reversal of the previous uncertainty index i.e. high confidence = low uncertainty and low confidence = high uncertainty. In the 2018 WGDEC report [16] this was again renamed as the Confidence Index and a Table provided in Section 7.2.6 to ensure clarity. **During the review of the background to the ICES VME Advice development (see Annex 1) a significant inconsistency was noted in the translation from the Uncertainty Index to the Confidence Index**.

In the 2018 WGDEC [16] report, Table 7.3 presented the "*Measures of confidence and associated scores*", which has been recreated here as Table 2. It can clearly be seen that high confidence receives a score of 1 and low confidence a score of 0.

Table 2. Measures of confidence and associated scores. Recreated from the 2018 WGDEC report [16].

VME CONFIDENCE INDEX			
Measure of confidence	1 - High	0.5 - Medium	0 - Low
Type of survey method used	Visual survey	Fisheries data or any scientific data without visual information	Inferred from indirect methods (e.g. acoustic methods)
Number of surveys (within c-square)	> 5 surveys	3–5 surveys	<3 surveys
Time span or range of surveys undertaken	> 20 years	10–20 years	<10 years
Time since last survey	<10 years ago	10–30 years ago	>30 years ago

When this is compared to the introductory text in Section 3.2.2 in the WGDEC 2015 report [15] it appears to agree, when it was considered that low uncertainty equals high confidence, as it states

"*Data uncertainty reflects origin and nature of the collected data and was divided into three categories: low (scored as 1), medium (scored as 0.5), and high (scored as 0) data quality*". However, the text below this statement lists the four measures of uncertainty in more detail and notes the associated scores. A table (Table 3) has been created to enable easier interpretation and comparison with the WGDEC 2018 table. It appears that the scores for each of the categories have actually been reversed i.e. in 2015 low uncertainty was scored 0 and in 2018 high confidence was scored 1.

Table 3. Uncertainty Index scoring as listed in the 2015 WGDEC report [15].

VME Uncertainty Index			
Measure of increasing uncertainty	0	0.5	1
Type of survey method used	Visual survey	Fisheries data or any scientific data without visual information	Inferred from indirect methods (e.g. acoustic methods)
Number of surveys (within c-square)	> 5 surveys	3–5 surveys	<3 surveys
Time span or range of surveys undertaken	> 20 years	10–20 years	<10 years
Time since last survey	<10 years ago	10–30 years ago	>30 years ago

This confounding of scores would presumably have an impact on the output of the Confidence Index and though the Confidence Index was removed from the process of delineation of polygons following the benchmark in 2022 (see Annex 1) it was used for the provision of the 2021 advice and 2022 technical service on which the polygons listed in the European Commission's implementing act were based. **So the question is, was this error present in the model used to produce the 2021 ICES VME Advice and if so what effect did it have on the categorisation of c-squares?**

One additional error was noted, which can be assumed was a typographical error where in the 2018 WGDEC [16] report it was noted that the Confidence Index had been split into three categories using equal breaks, with scores assigned to these categories as follows:

- High confidence, for total scores >0.51;
- Medium Confidence, for scores between 0.51–0.70;
- Low confidence, for scores >0.70.

The High Confidence Category (highlighted in yellow) should obviously have a less than symbol (<) instead of a greater than symbol (>). One would assume that this error was not in the model also but it would be wise to check.

3.3.4. Lack of absence data in the assessment

In the 2023 ICES VME Advice the final two lines in the headline advice summary stated, "*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*." The inclusion of this statement is surprising as it relates to advice on a management measure that does not appear to have been part of the request to ICES, which in the summary of the advice request states, "*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.*" **Whether this additional advice was part of the original request from the EU cannot be confirmed due to the fact that as part of the "open and transparent" advice process [17] the actual advice requests made to ICES are not publicly available nor is the process by which the requests are developed between the requesters and ICES**.

Regardless, it does raise an important consideration in the form of VME absence. In the current study area the surveys used as the basis for the VME Index are considerably more extensive than is apparent from looking at the public records in the ICES VME Database (Figure 2). The surveys in question have taken place over multiple years and normally conduct hauls in the same areas (Stations) year after year as these are used as indices in various fish stock assessments. **The vast majority of the survey hauls never catch VME indicator species but this is not clear and transparent from the data in the ICES VME Database**.

The lack of inclusion of absence data has been raised numerous times at WGDEC throughout the development of the VME Index and assessment and it has largely been overlooked and deferred from one WGDEC to the next (see Annex 1). Arguments have been made about the catchability of benthic VME indicator species with trawls but this seems not to be an issue when using positive hauls or inferring that bottom trawls cause a significant impact through bottom contact. The reality is that if VME indicator species are abundant in a particular area, which may indicate the presence of a vulnerable marine **ecosystem** rather than a scattering of a few specimens, then they will likely show up in survey trawls.

In order to illustrate this point the IGFS haul data (2003-2022) were downloaded from DATRAS (Annex 2), added to the GIS map and zoomed into polygon 6 in the current study area (Figure 14). The IGFS survey station *FG108* is located in the area around the low VME Index (yellow) c-square and according to the DATRAS data was surveyed annually from 2006 to 2019 and in 2021 and 2022. This station has been trawl sampled sixteen times by the IGFS on a standardised trawl survey using the same gear. The trawl tracks are almost identical, run parallel to each other and are no more than 250m apart across the time series. **Yet VME indicator species were only encountered in four out of the sixteen trawls. What is also obvious is that none of the trawls took place within the 400-800m zone and were in fact in the 230-241m range and as such they should not have been included in the VME assessment or in the resulting polygons.** This situation is not exclusive to this polygon and is in fact replicated in the majority of polygons in the study area.

The IGFS is just one of the numerous surveys that is conducted within the study area. In order to highlight the extensive coverage, the study area was selected in the DATRAS map portal and all trawl survey records from 2000 onwards downloaded. These included the MI's IGFS (2003-2022), IAMS (2016-2022) and Deepwater survey (DWS; 2006-2009) and MSS's Scottish West Coast International Bottom Trawl Survey (SWC-IBTS; 2000-2010) and Scottish West Coast Groundfish Survey (SCOWCGFS; 2011-2023). The available MSS West Scotland Deepwater Trawl Survey data (Annex 2) were also plotted. All survey hauls were plotted as the mid-point of the hauls as this appears to be the approach used in the ICES VME Database and assessment (Figure 15 and Figure 16). It is obvious to see that in relation to polygon six, in each VME Index c-square there are significantly more hauls with absence data than there are hauls with VME indicator records. This pattern is replicated across the study area where a significant amount of absence data is available along the shelf break. This highlights the uncertainty underlying the classification of VME Index c-squares. **Though since the benchmark in 2022 uncertainty has not even been included in the VME assessment (see Annex 1) and as such almost any occurrence of a VME indicator species is concluded to be a VME. This approach biases the outcome of the VME assessment in favour of classification despite the scientific evidence supporting the opposite**.

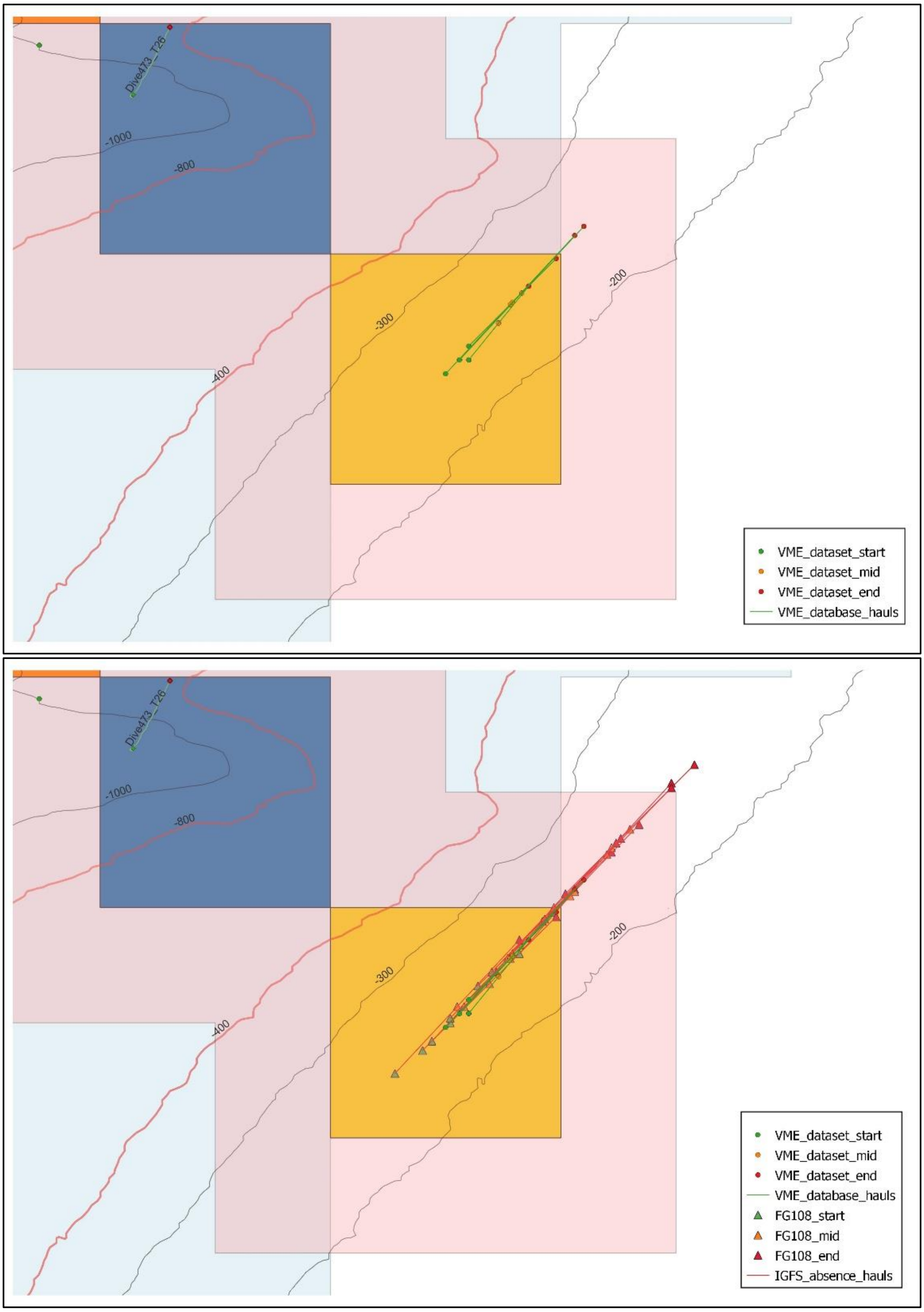

Figure 14. Polygon six in the current study area showing (top) the four hauls included in the ICES VME Database and (bottom) the twelve hauls excluded from the ICES VME Database as no VME indicator species were caught.

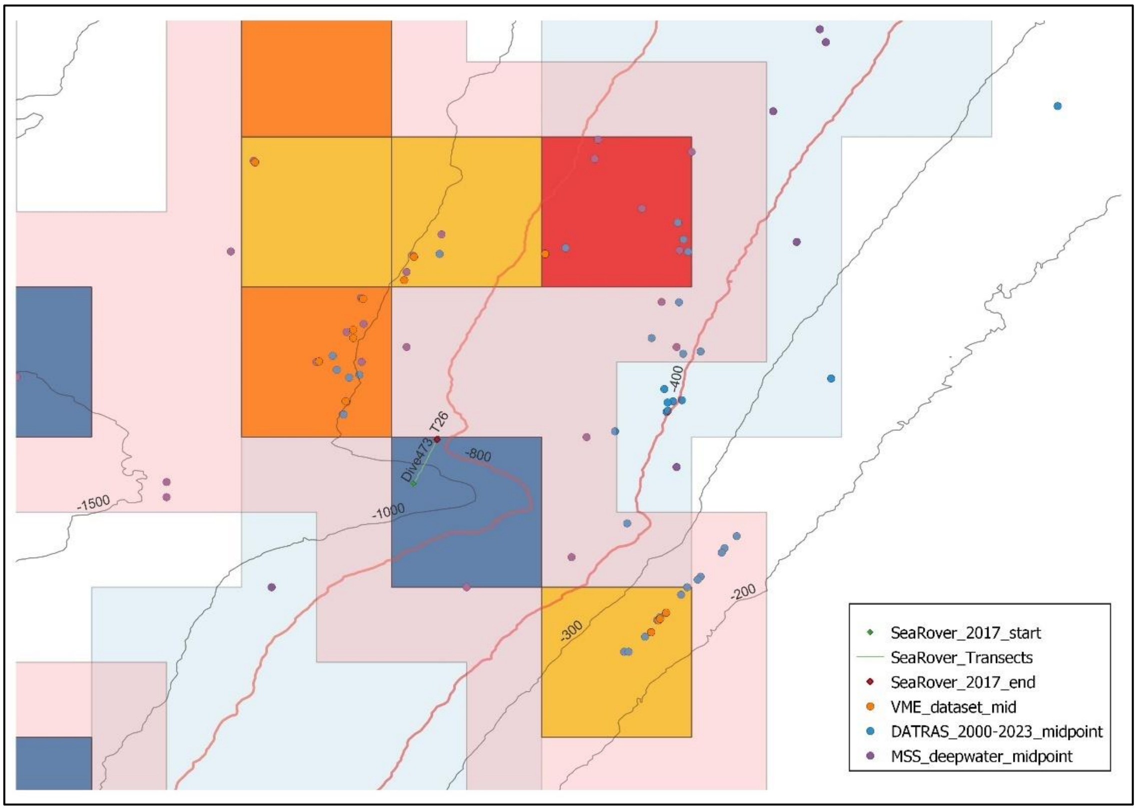

Figure 15. Polygon six in the current study area showing the mid-points of the hauls included in the ICES VME Database (orange) and the mid-points of the hauls excluded from the ICES VME Database as no VME indicator species were caught (blue and purple).

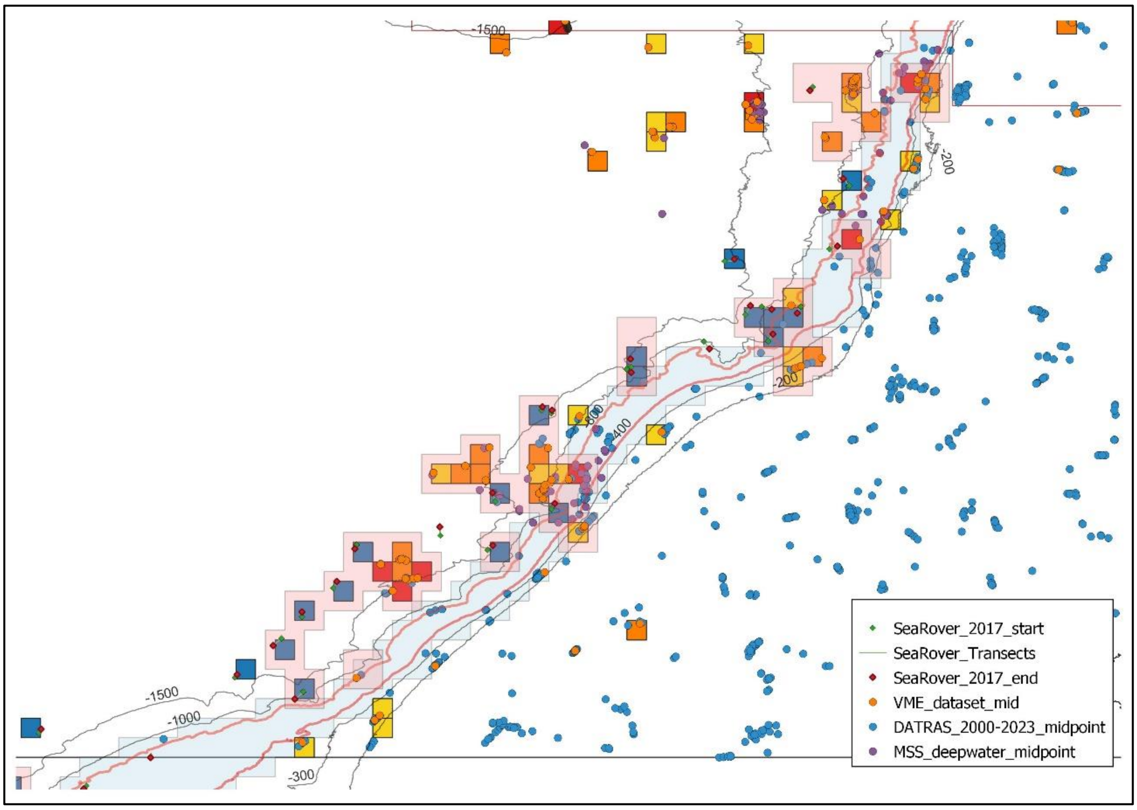

Figure 16. The mid-point of the public records in the ICES VME Database plotted with the mid-points of the trawl data available in the DATRAS database and the available MSS deepwater survey data.

4. References

1. 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
2. ICES. 2021. 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
3. ICES. 2022. 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
4. 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. Official Journal of the European Union, L 354: 1–19. http://data.europa.eu/eli/reg/2016/2336/oj
5. 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
6. O'Sullivan D., Leahy Y., Guinan J. & Shipboard Scientific Party (2017). Sensitive Ecosystem Assessment and ROV Exploration of Reef Survey Report 2017. Cruise Report prepared by INFOMAR and the Marine Institute, Galway, Ireland to the Department of Agriculture, Food and the Marine, the European Maritime and Fisheries Fund and the National Parks and Wildlife Service.
7. Picton, B.E., Morrow, C.C., Scally, L., Pfeiffer, N., & McGrath, F., 2021. Sensitive Ecosystem Assessment and ROV Exploration of Reef (SeaRover) Synthesis Report. EMFF 2014-2020. Marine Institute Report Series. Report prepared by MERC Consultants Ltd. on behalf of the Marine Institute, Galway 161 pp.
8. Marine Institute SeaRover Online GIS tool https://experience.arcgis.com/experience/a88c377603984bc8b095e02d224a5552/page/Home/?views=View-5%2CSearover-Dives
9. ICES. 2019. Advisory Plan. ICES Strategy. 19 pp. https://doi.org/10.17895/ices.pub.5468
10. ICES. 2022. 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
11. ICES. 2018. Technical Service - EU request to provide a further technical service; to aid in the interpretation of ICES advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011 (sr.2018.28).
12. ICES. 2018. Advice on locations and likely locations of VMEs in EU waters of the NE Atlantic, and the fishing footprint of 2009–2011 (sr.2018.10).
13. ICES. 2017. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 20–24 March 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:25. 121 pp.
14. ICES. 2014. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 24–28 February 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:29. 70 pp.
15. ICES. 2015. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 16–20 February 2015, Horta, Azores, Portugal. ICES CM 2015/ACOM:27. 113 pp.
16. ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 126 pp. https://doi.org/10.17895/ices.pub.7459.

17. ICES. 2020. Guide to ICES advisory framework and principles. In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, Guide_to_ICES_Advice. https://doi.org/10.17895/ices.advice.7648
18. ICES. 2005. Report of the Working Group on Deep-water Ecology (WGDEC), 8-11 March 2005, ICES Headquarters, Copenhagen. ICES Expert Group Reports, CM 2005/ACE:02. https://doi.org/10.17895/ices.pub.19267001
19. ICES. 2008. Report of the ICES-NAFO Joint Working Group on Deep Water Ecology (WGDEC), 10–14 March 2008, Copenhagen, Denmark. ICES CM 2008/ACOM:45. 126 pp.
20. ICES. 2009. Report of the ICES-NAFO Working Group on Deep-water Ecology (WGDEC), 9–13 March 2009, ICES CM 2009\ACOM:23. 94 pp.
21. FAO 2009. Report of the Technical Consultation on International Guidelines for the Management of Deep-sea Fisheries in the High Seas. Rome, 4–8 February and 25–29 August 2008.
22. ICES. 2011. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 28 February–4 March, Copenhagen, Denmark. ICES CM 2011/ACOM:27. 104 pp.
23. ICES. 2016. Report of the Workshop on Vulnerable Marine Ecosystem Database (WKVME), 10–11 December 2015, Peterborough, UK. ICES CM 2015/ACOM:62. 42 pp. https://doi.org/10.17895/ices.pub.19283945
24. ICES. 2016. Report of the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), 15–19 February 2016, Copenhagen, Denmark. ICES CM 2016/ACOM:28. 82 pp.
25. ICES. 2019. ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 1:56. 119 pp. http://doi.org/10.17895/ices.pub.5567
26. ICES. 2019. Technical Service - EU request to provide an update on the list of areas where VMEs are known to, or likely to occur, and on the existing deep-sea fishing areas for 2009–2011. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019.
27. ICES. 2020. Workshop on EU regulatory area options for VME protection (WKEUVME). ICES Scientific Reports. 2:114. 237 pp. https://doi.org/10.17895/ices.pub.7618
28. 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
29. ICES. 2021. Working Group on Deep-water Ecology (WGDEC). ICES Scientific Reports. 3:89. 162 pp. http://doi.org/10.17895/ices.pub.8289
30. ICES. 2022. 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
31. ICES. 2019. Stakeholder workshop to disseminate the ICES deep-sea access regulation technical service and scope the required steps for regulatory purposes (WKREG). ICES Scientific Reports. 1:79. 34 pp. http://doi.org/10.17895/ices.pub.5636
32. ICES. 2023. ICES Guidelines for Benchmarks. Version 1. ICES Guidelines and Policies - Advice Technical Guidelines. 26 pp. https://doi.org/10.17895/ices.pub.22316743

Annex 1. Brief Background to the ICES VME Advice

In order to understand the ICES VME Advice and resulting closures it is necessary to understand the development and origin of the VME assessment model. The ICES VME Advice is based on an assessment developed, implemented and reported on by the ICES Working Group on Deep-water Ecology (WGDEC), which deals with the biology and conservation of deep-sea habitats in the North Atlantic. The group first met in 2005 [18] with terms of reference derived from requests from OSPAR and the North East Atlantic Fisheries Commission (NEAFC) related to the potential threat to seamounts and to evaluate new information on the distribution and status of cold water corals in the North Atlantic. Additional species of interest were added to the terms of reference over the years and the spatial area of interest widened.

In 2008 the North Atlantic Fisheries Organisation (NAFO) became a co-sponsor of the group, which was renamed the ICES-NAFO Joint Working Group On Deep Water Ecology [19]. The 2008 report also contained the first mention of "*vulnerable marine ecosystems (VMEs)*" and "*significant adverse impacts (SAIs)*", in relation to ToR (b) "*review the 'Guidelines for management of deep-sea fisheries on the high seas' that will be considered by FAO COFI in 2008 and consider for reflection by ICES and NAFO*". WGDEC recommended that both ICES and NAFO utilise the draft guidelines in their ongoing work. They also considered the types of advice that clients may request in relation to VMEs and that the "*biggest constraint in the process to protect VMEs will be the uncertainties in the distribution and abundance of VME indicator species and similar uncertainties in the link between fishing effort and SAIs*". The use of VMS data was also considered to examine patterns of fishing in deep-water areas to determine where intensive fishing is occurring and evaluate the likelihood of sensitive habitats being present in those areas. It was recognised that there can be mismatches between the coarseness of available data and the management decisions that need to be made. This is particularly relevant to VMS data, which was noted to only record positions every two hours. As such it was recommended that deep-water features required a buffer zone of 6 nautical miles around them in waters up to 1000m

In 2009 WGDEC [20] considered the issue of scale in more detail and noted that "*The use of coarse scale proxies, such as predictive habitat modelling and biogeographic classifications, is becoming increasingly frequent. However their use comes with many caveats, and should not be seen to usurp the use of biological or ecological data*" and "*The results of interpolations/extrapolations and modelling (such as predictive habitat or biogeographic classifications) are not of uniform scale, with some places reflecting greater confidence (less uncertainty) than others. When this information is made explicit, better informed decisions can be made.*" A key recommendation of the group was the development of a confidence layer when using data of varying scales and quality.

In 2009 the United Nations General Assembly ("UNGA") also reiterated the need for protection of VMEs and called for a two-pronged approach: 1) to develop a protocol to minimize damage to VMEs when they are encountered ("*Encounter Clause*") and 2) to carry out assessments to determine where VMEs are known or likely to occur and to proactively protect these areas. Therefore in 2010 WGDEC [21] reviewed the science used in assessing VMEs and the "*Encounter Clause*" and also considered the state-of-the-art with regard to assessing where VMEs are known or likely to occur. In order to do so it was first necessary to define what VMEs actually are and to this end the *International guidelines for the management of deep-sea fisheries in the high seas* [21] provided a range of recommendations on how to identify VMEs and assess SAIs and proposed the following characteristics as criteria to identify VMEs subject to SAIs:

i. **Uniqueness or rarity** - an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:
    a. habitats that contain endemic species
    b. habitats of rare, threatened or endangered species that occur only in discrete areas
    c. nurseries or discrete feeding, breeding, or spawning areas

ii. **Functional significance of the habitat** - are discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.
iii. **Fragility** - an ecosystem that is highly susceptible to degradation by anthropogenic activities.
iv. **Life-history traits of component species that make recovery difficult**: ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates; late age of maturity; low or unpredictable recruitment; or long-lived.
v. **Structural complexity** - an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which depends on the structuring organisms.

Annex 1 of the FAO Guidelines [21] provided examples of potentially vulnerable species groups, communities and habitats and listed physical features which are known to host such communities (e.g. canyons, slopes, vents, seeps, seamounts). WGDEC noted the lack of data for determining encounter thresholds and recommended increased data collection and exploration of risk-based frameworks. It was recommended that NAFO and NEAFC augment their encounter and move-on rules with measures to map bottom fishing activities and the potential overlap with VMEs.

In WGDEC 2011 [22] there was significant focus on the development of the ICES VME Database, with quality assurance, security, data access and data ownership the most important issues identified. Interestingly it was stated that "*The ICES data policy states that all data held within ICES be freely available and this condition will apply to the ICES VME database. Thus submitters of data must be fully aware that the data they submit will be under this condition. Data that is not publicly available will not be considered for inclusion in the ICES VME database*". Rather confusingly though this was followed by the seemingly conflicting statement "*This is not to say that such restricted access information will not be considered by WGDEC in producing its advice*". **This seems a contradiction as if data is excluded from inclusion in the database then how could it be considered in the provision of advice**.

In 2014 WGDEC [14] took the first steps towards developing a system of weighting the reliability and significance of VME indicator records so that advice on closures could be more clearly presented and interpreted. A distinction was made between *bona fide* VMEs such as those directly observed during ROV dives and other records such as scientific trawl survey bycatch. In this case these records may indicate the presence of VMEs but are associated with a degree of uncertainty. WGDEC ranked four criteria on which to assess the confidence of VME indicator records (survey method, volume of material, date of observation, whether the specimen was dead or alive) and developed a scoring method.

The weighting approach was further developed in 2015 [15] where it was noted that an issue with the 2014 approach was likely to arise as it was based on individual records rather than an aggregate for an area that took an account of all the records present in that area. In order to resolve this WGDEC changed the basis of the approach to a spatially gridded data format (c-square), which enabled the aggregation of multiple individual records into a single grid cell with a VME Index score and would also facilitate future direct comparisons to other gridded data such as fishing effort. The final VME Index value was calculated based on a taxa dependent VME indicator vulnerability score and an abundance score and ranked out of 5 (Low <2.9; Medium 2.9 - 3.9; High >3.9). Additionally, to account for data quality issues, a 'data uncertainty' index (low uncertainty < 0.51; medium uncertainty 0.51 - 0.70; high uncertainty > 0.70) was developed based on the survey type, number, time span and how recent the last survey was. One significant concern raised about the new weighting system was that absence data was not recorded in the VME database. It was decided to address this at the next meeting. **It was clarified that the weighting system should not be applied to VME Habitats that had been confirmed**

through ROV surveys and as such a 'known VME' category needed to be included in the ICES VME Database.

An ICES Workshop on Vulnerable Marine Ecosystem Database (WKVME) was also run in 2015 [23]. The key agenda items were to review the VME Database with key data providers, add new data, perform quality checks and also to further develop the ICES online VME Data Portal. After reviewing the database the group agreed that blank cells or cells with no data/information should be populated with a 'null' value. During the review of the VME Data Portal it was noted that in 2014 almost 95% of the records were classified as restricted but this had reduced to 60% by the time of the workshop. **The chair highlighted that it was essential that the remaining records should be made public as restricted records had "*repercussions for how the data can be searched, queried and downloaded on the VME data portal*".**

In 2016 WGDEC [24] further refined the VME indicator weighting system following a review of the 2015 report by an ICES review group and comments and critiques by the Advice Drafting Group (ADG) and WGDEC members. The VME Index score ranges were adjusted as the classifications made in 2015 were considered subjective. The new ranges were; Low <2.6, Medium 2.6 - 3.7, High >3.7. The method to calculate the uncertainty score in each grid cell was also changed so that it was derived from only the records that contributed to the maximum VME score in each cell, which was the approach followed for the VME Index score. Work was also undertaken to develop a consolidated approach for the delineation of bottom fishing closures. Due to the differing levels of certainty associated with different data types (e.g. trawl bycatch of VME indicators vs in situ observations of *bona fide* VME), **it was not considered appropriate to apply one method of boundary delineation to all data types**. Instead, a number of factors including buffer zones, minimum distance spacing and geostatistical approaches were explored. Geostatistical approaches were discussed in particular in relation to the assessment of patch size for VME Habitat records. It was recommended that all three methods be included when attempting to delineate bottom fishing closures. The new ICES VME Data Portal was also launched in 2016 and for the first time, users could now view and download data on VME indicators and habitats used by WGDEC. A notable omission from the 2016 report was the issue of absence data not being included in the VME database. This was not addressed in 2016 but was listed as a proposed ToR for the 2017 meeting.

In 2017 [13], for "*the first time, and for all areas considered by WGDEC, all records from the VME database were presented as outputs from the VME weighting system, showing the likelihood of VMEs being encountered on the seabed along with an associated confidence assessment"*. Though not highlighted or discussed in the report, it should be noted that the confidence layer was actually a reversal of the previous uncertainty index i.e. high confidence = low uncertainty and low confidence = high uncertainty (See section 3.3.3). The group also developed a flow chart to explain the process used to identify VME Habitats and VME Index c-squares on which recommendations of bottom fishing closures could be based (Figure 13). Of particular interest in the figure is that in the case of VME Habitats the process does not appear to use the gridded c-square system to define the boundary around the Habitat record. This makes sense as the exact location of the VME Habitat records are known and it would make sense to place them at the centre of the closed area in order to afford the greatest degree of protection (see Section 3.3.2). What is confusing though is that in the report in the example outputs of the VME assessment for the Rockall Bank and Hatton-Rockall Basin etc. the VME Habitats were delineated as blue c-squares and mapped alongside the VME Index Weighting Algorithm output despite explicitly stating that they "*were excluded from the VME Weighting Algorithm*". There was no accompanying explanation as to why they were not delineated following the specified process in Figure 13. **This is a very significant consideration as it has major implication for the delineation of closure polygons**.

The issue of how to incorporate absence data in the ICES VME Database also received attention in 2017 where a new data submission format was developed and proposed for trial in 2018. There was however no discussion of how absence data could be incorporated into the VME Index scoring system. This was perhaps the most relevant aspect that should have been developed and discussed further as this should surely be a fundamental aspect of the confidence layer of a VME c-square.

In 2018 WGDEC [16] was also requested to provide a list of areas and spatial layers where VMEs occur or are likely to occur with respect to the EU Deep-Sea Access Regulation [4]. Though the request text was not included in the report, as ICES does not make public and transparent the full advice request process, a summary was included in the resulting advice sheet [12] and it is informative to consider it here first. It stated, "*ICES is requested to advise on a list of areas where VMEs are likely to occur and should be closed off from bottom fishing, in particular in areas deeper than 800 m. This advice should also include a footprint analysis of where bottom fishing is occurring (and has occurred), by collating and describing bottom fishing activity in the North East Atlantic 2009-2011 (or other period 2012-2016).*

In this work ICES is requested to:

> *a) Collect all relevant national VME data.* ***Building on the existing ICES VME database, prepare spatial layers and a list of areas where VMEs are likely to occur in the North East Atlantic, in particular in areas deeper than 800 m.***
> *b) Collect all relevant national VMS and logbook data 2009-2011 (or other period 2012-2016). Prepare spatial layers on the intensity of bottom fishing, that describe the fishing footprint occurring (and that has occurred) in the North East Atlantic. Issuing of a VMS and logbook data call, data collation, quality checks and analysis of data should be done in accordance with the standards developed by ICES (2017).*
> *c) Combine information from (a) and (b) above to advice on a prioritised list of fisheries closures areas, and a set of management options in line with European Commission's deep-sea access regulation (see intended use section).*

In response to this WDGEC used the outputs of the VME weighting algorithm to identify where VMEs were likely to occur but focussed only on c-squares which had a high VME Index and a high or medium confidence. They also decided to conduct the analysis across three depth bands (200-400m, 400-800m and >800m) though the reasoning and justification for this deviation from the requested advice was not clear. **The 200-400m zone is also outside of the depth range specified in the Deep-Sea Access Regulation [4], which appeared to be the basis for the Commission's advice request**.

In the resulting maps the VME Habitats were again presented as c-squares despite this not being the process as defined in 2017 (Figure 13). The reason for this became apparent in section 7.2.4 of the report where it stated "*a category in the VME weighting algorithm was added for 'VME habitat'. Records of VME habitat submitted to the database are therefore automatically assigned to this category when the weighting algorithm is run*". This does not agree with the process as defined in the 2017 report or with the previous working group reports that led to the definition in 2017 which explicitly stated that the VME Habitats were not part of the *VME weighting algorithm*. As such the delineation of the closed areas around them should not have been at the c-square resolution but should have been based on their actual location. **One may assume that having two different systems of delineating closures within a single assessment may pose difficulties as such it was deemed easier to merge the VME Habitat into the c-square resolution but this is not clear or transparent in the WGDEC reports and should have been clarified.**

Further clarification of the 2018 advice was sought by the EU and provided by ICES in the form of a Technical Service in late 2018 [11], which included a range of options particularly concerning the delineation of the 800m contour. ICES presented higher resolution options, which avoided using c-squares to resolve the 800m contour. **The EU also requested a split in the advice with a northern region of EU Atlantic waters that has good VMS/logbook and VME coverage, from a southern region,**

in which data may be missing and thus is not representative. ICES was unable to perform this split as the Spanish data was submitted late.

One surprising admission in the 2018 report was that "*WGDEC has neither adopted nor developed definitions of VMEs*" and that "*the VME database identifies VME habitats based on expert opinion following some elaboration of the FAO (2009) guidelines*". **It appears inconsistent that ICES was able to provide advice on the existence of or likely existence of something which it had not decided on a definition for**.

The issue of absence data was discussed again in WGDEC 2019 [25] where a summary of trawl and ROV survey data where no VMEs were recorded, i.e. 'absence data', was presented. The group decided that the spatial scale of the survey types was different, though this is obviously also the case for presence data, and that trawling has a low VME catchability, which hinders its usefulness as an indicator of absence. As a result the group decided to not discuss it any further and to defer it to the 2020 meeting. Instead much of the focus was on the further development of the VME weighting algorithm and the proposal of revised thresholds for VME indicators. It was noted that the abundance scores used in the VME weighting algorithm did not have a very high weighting in the index (only 10% of the final score) because at the time of development, there were very few records of VME indicators with actual biomass values (15% of the records). **As a result, the VME indicator vulnerability ranking was a bigger driver in the overall VME Index score than the abundance score**, and there were some questions as to whether updates to the VME abundance component would make any fundamental difference to the final outputs. Rather than testing a range of weighting options in the current system though it was decided to change the ToR and instead test a method being used by NAFO called kernel density estimation (KDE), to identify hotspots in either biomass or abundance. Whilst this was interesting it did not result in an improvement in the VME weighting algorithm. An updated Technical Service with a list of areas where VMEs are known to or likely to occur and on existing deep-sea fishing areas was also provided by ICES in 2019 [26]. This included the updates of the fishing footprint >800m described in the 2018 advice to include the Spanish data.

Under regulation (EU) 2016/2336 there was a requirement for a competent scientific advisory body, such as ICES, to carry out an annual assessment of areas where VMEs are known to occur or are likely to occur. In 2020 there was a series of workshops entitled, Workshop on EU regulatory area options for VME protection (WKEUVME) [27], whose focus was to define a method for identifying these areas in EU waters, specifically in the 400-800m depth zone, that should be closed for the protection of VMEs. To this end a workflow was drafted, based on the previous work by WGDEC, describing different VME protection scenarios, with criteria for area selection that could be used with relevant ICES datasets. The VME assessment area was divided into two ecoregions (Celtic Seas Ecoregion and the Bay of Biscay and Iberian Coast Ecoregion) though it was not clear what the relevance of this was to the VME assessment process and the same method was applied in each ecoregion. The closure Scenarios and Options were developed for the first time and the step-by-step process for delineating polygons defined (Figure 17). The steps for Scenario 2 Option 1, which was ultimately implemented by the EU in September 2022, are as follows:

1. ***Step 1. Select all VME Habitat, High and Medium VME Index C-squares and create a ½ C-square buffer around them****. These cells are known or likely to contain VMEs and the buffer zones account for the offset between vessel positions and the position of their gear, which can be substantial in deep water, and the effects of sediment resuspension, which can have detrimental effects on VMEs. This selection is the same as in Scenario 1 option 1 Step 1.*
2. ***Step 2. Select all Low VME Index C-squares which have a SAR < 0.43 and add a ½ C-square buffer to them****. Because they are fished at intensities that allow persistence of VME types, and because they are less important for fishing, it can be worthwhile closing these C-squares even if the presence of VMEs is uncertain. Due to the bias in the VME Index against sea pens in particular this will ensure that more sea pen habitat is protected.*

3. ***Step 3. Where Low VME Index C-squares are adjacent and joining any C-squares in Steps 1 and 2, these should be selected and a ½ C-square buffer placed around the C-square****. These cells are considered more likely to contain VMEs than other Low VME Index cells by their proximity to higher VME Index cells.*
4. ***Step 4. Where two or more C-squares from Steps 1, 2 and 3 are joined by their buffers or directly joined (in any way) they will be combined into one VME closure polygon****. This reduces the number of polygons in a data-layer but does not change the number of C-squares in the protected area.*
5. ***Step 5. All satellite VME C-squares in Steps 1 and 2 above should be defined as individual VME closures with associated ½ C-square buffer.*** *Many VME habitats naturally occur at the size of a C-square or smaller. These single C-squares can still offer meaningful protection.*
6. ***Step 6. Fill all holes with 1 or 2 C-squares inside VME closures.*** *Fishing vessels are unlikely to be able to fish effectively in very small areas without risking straying into closed areas. A trawler that fishes at 3.5 knots will cover 7nm in a typical 2h haul, which is equivalent to about between 2 and 3 C-squares. Open holes of less than 3 C-squares are therefore not considered practical.*

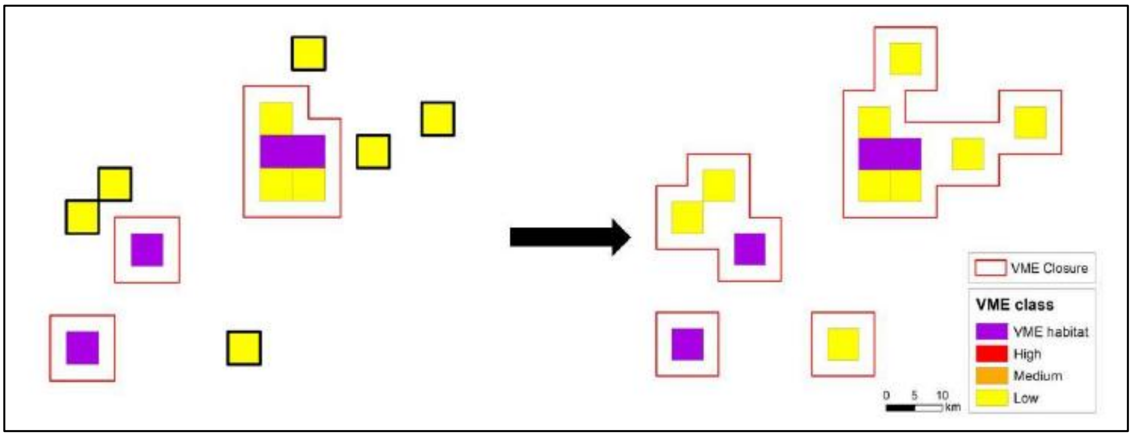

Figure 17. Scenario 2 Option 1, Steps 2 to 4 illustrating the inclusion of Low VMNE Index c-squares with fishing effort less than 0.43 SAR (yellow outlined in black on left panel). From [27].

The report also noted that the assessment procedure was fully documented using ICES TAF (Transparent Assessment Framework) principles and that the respective scripts to run the assessment were publicly available on an open source platform (WKEUVME GitHub site). **What it doesn't state is that the VME and VMS input data required to run the assessment is not publicly available on the GitHub repository so one cannot rerun the assessment independently. So in reality this is only partial transparency.**

The January 2021 ICES VME Advice [2] appears to have been based on the output from the WKEUVME workshop series and the WKEUVME report contains "assessment sheets" for each ecoregion which contain specific information about the VME and VMS data within each area. Interestingly the maps illustrating the polygon closures (Figure 18) displayed the polygons cropped to the modelled 400-800m contours. This was also presented in Interactive Map 2 of the 2021 advice, though Interactive Map 1 displayed the larger polygons, which extended shallower and deeper than the modelled 400-800m contours. The Interactive Map provided with the 2022 Technical Service only displayed the larger polygons extending shallower and deeper than the 400-800m zone and as such the implementing act was based on these larger polygons. **It is unclear why ICES did not present the cropped polygons in 2022 also and whether there was a specific request to only present the polygons in a single way.**

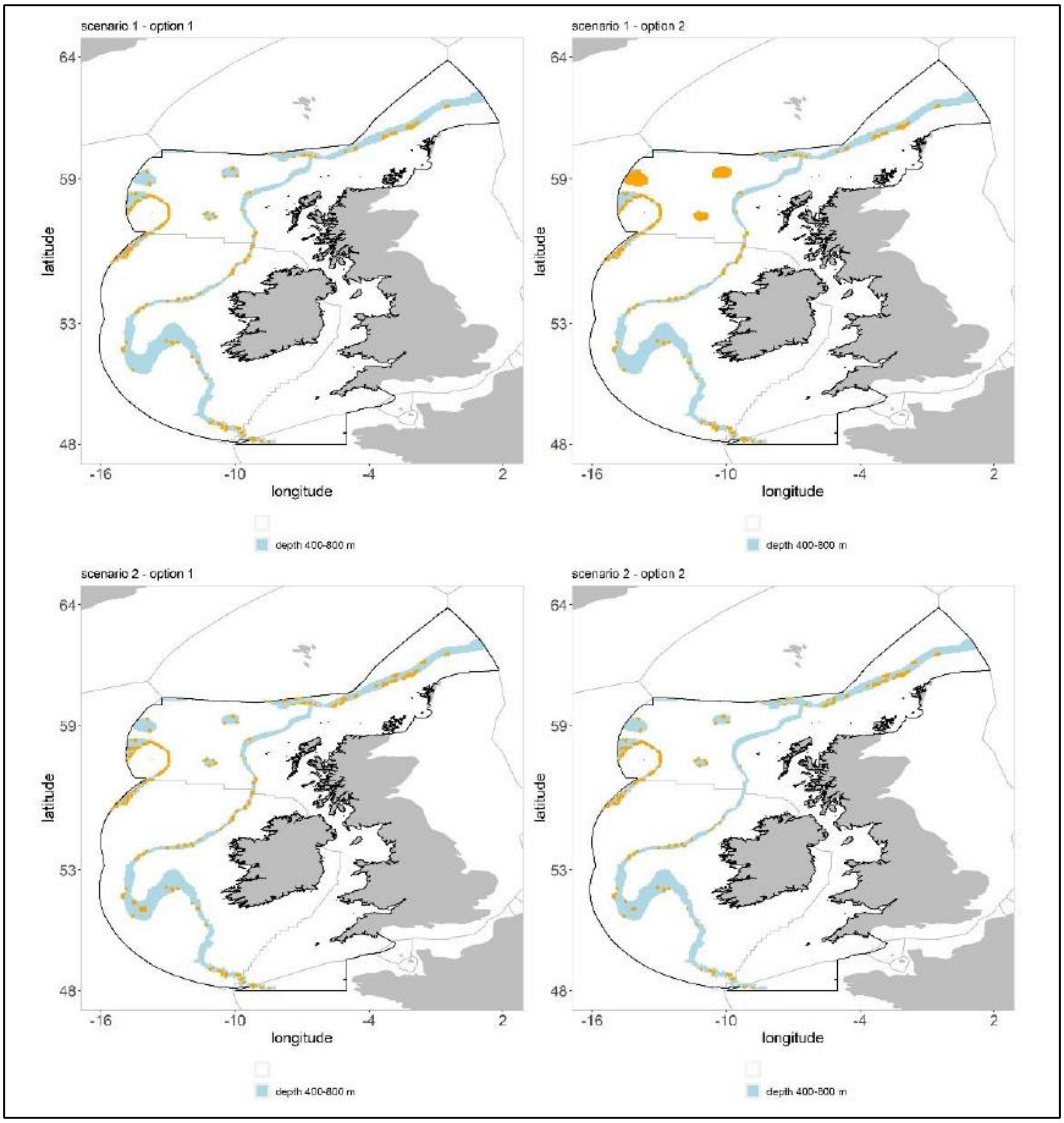

Figure 18. Map of closures (orange) that overlap with the 400-800 metre depth range following the two different scenarios, each with two options. From WKEUVME [27].

The longstanding issue of adding absence data to the VME database was included as a ToR again in WGDEC 2020 [28] however the report noted that "*prior to the start of the WGDEC 2020 meeting it was agreed by the chair of WGDEC and the ICES Secretariat, in consultation with ACOM Leadership, that this ToR would be reduced to a brief introduction on the availability and provision of absence data……*". The reasons cited were time constraints and the difficulties associated with discussing this in an online working group. It was noted however that ***"Absence data are fundamental to fully evaluating the occurrence of VME habitats and indicators, and, specifically, for the performance of species distribution models (SDMs) and habitat suitability models (HSMs) to support mapping of benthic habitats"***. So whilst the importance of absence data was noted, its use was only briefly discussed and mostly in relation to modelling of VME occurrence. It would have been more useful to discuss its use in the Confidence Index. For example if there were ten comparable survey hauls in an area and only one of them returned a small number of VME indicator species then surely this would indicate a low confidence that there was in fact a vulnerable **ecosystem** present and more likely there were a small number of scattered individuals of a particular species. Such information would appear to be important when making decisions regarding closures and protective measures. In the WGDEC 2020 report it was also noted that data from the SeaRover ROV surveys, Irish Groundfish Survey and Underwater TV surveys was submitted by the Marine Institute, Ireland to the ICES VME Database, which greatly increased the number of VMEs and potential VMEs identified in the Irish EEZ.

An objective of WGDEC in 2021 [29] was to review the VME weighting algorithm to identify potential development options. The use of the weighting algorithm outputs for the WKEUVME workshop in 2020 raised some concerns about its applicability for use within ICES VME Advice. **It had been suggested that reducing the weighting of the vulnerability ranking, or removing it altogether, would allow higher Index values to be produced for the lower ranked VME indicator taxa, such as sea pens.** Two options were discussed with a view to facilitating the wider applicability of the VME Index in ICES advice: 1) further development of the current VME Index to be less driven by the vulnerability scoring of indicator taxa and 2) development of a new complementary index of the likelihood of VME presence based on weight of evidence. Trials were undertaken during the meeting, and the preferred approach was to build a complementary index of the likelihood of VME presence based on weight of evidence, whilst maintaining the original index in its current form. This was to be further advanced in 2022.

In advance of WGDEC in May 2022 [30] the ICES VME assessment process was benchmarked for the first time in April 2022 at the Benchmark Workshop on the Occurrence and Protection of VMEs (WKVMEBM) [10]. The aim of the workshop was to "*develop and document an operational evidence-based procedure for the production of recurrent ICES advice on VMEs*". One of the most significant changes to the assessment was the removal of the VME Confidence Index from the process of defining closure polygons as it was "*not considered a good proxy for evaluating the reliability of the VME data used in the calculation of the VME Index*". It was stated that two recent ICES workshops (WKREG, WKEUVME) expressed concerns over the validity of the weighting terms applied to derive the confidence index. As described above the WKEUVME concerns related to the vulnerability ranking and did not concern the Confidence Index. WKREG [31] did express "*concerns that historic VME information was down-weighted in the multi-criteria assessment evaluation through the confidence index and given the longevity of many of these taxa, the threshold for down-weighting may not be meaningful. Hence the weighting algorithm used and its impacts on the results should be investigated further*". **This further investigation appears not to have been performed and there was no further explanation or discussion in the WKVMEBM report as to the impact of removing the Confidence Index from the assessment**.

The decision to leave the Confidence Index out of the delineation of polygons appears to have been taken at the April benchmark workshop. However, the external review of the WKVMEBM framework actually took place in February in advance of the workshop and was provided in Annex 4 of that report. The text is remarkably similar to that in the review in Annex 5 of the WKEUVME report [27] and makes reference to the VME Confidence Index. The review group highlighted that it was "*unclear how the VME confidence index is being combined with the final VME Index to demonstrate the reliability of the estimates of areas with VME occurrence*", though they agreed "*that the proposed VME Assessment Framework Benchmark is appropriate to address the request for Advice in ToR b.*". **Given this, then the subsequent exclusion of the Confidence Index during the April meeting without any elaboration is even more surprising as it appears to have occurred after the method was reviewed.** In terms of the impact on the assessment one could assume that low index VMEs with low confidence, i.e. poor supporting data, would be left out of the polygons if the Confidence Index had been included but it is not possible to deduce this as the analysis was not presented in the report. However, when this is coupled with the aim of changing the vulnerability ranking to allow higher VME Index values to be produced for the lower ranked VME indicator taxa, such as sea pens [29], then it appears like efforts are being made to increase the number of designated VME c-squares regardless of the robustness of the data. One is left to wonder if this change in direction is a result of the large increase in observations of sea-pens (low VME Index c-squares) since the increase in submission of data from the MI in 2020, which included underwater tv survey data from the Porcupine Bank.

The use of Species distribution models (SDMs) was also briefly discussed in the WKVMEBM report, as it has been done in a number of previous WGDEC reports [28, 29]. This was considered an approach that could be used in the future to "*augment the knowledge base for the assessment*" and to inform the VME occurrence layer by considering habitat suitability information. The reviewers considered that "*the overall strategy for VME protection may integrate results from species distribution models (SDMs) and habitat suitability models (HSMs) when they provide complimentary information with respect to VME elements, areas of potential occurrence and the likelihood or opportunities for recolonization*". The suggestion was that these approaches can be used where data is limited, so the likelihood is that these models will lead to further closures being identified on the basis of even more tenuous modelled data. It is useful to mention that ground-truthing of existing predictive models for coral and sponge distribution was one of the aims of the SeaRover series. To this end the models' predicted distribution was assessed relative to where actual observations were made during SeaRover. However the results were poor and it was concluded that "*If modelling of the type attempted by Howell is to be of any predictive value it needs to be much more fine-grained*", "*…….the modelled distribution of Lophelia is out of scale compared with the real world, where living reef is only in a relatively small patch on the top of carbonate mounds*" [7].

WKVMEBM also recommended that Scenario 2 Option 1 be used in preference to Scenario 2 Option 2 when considering the VME polygon results from the Scenario 2 analyses as it was the least sensitive to changes and likely to afford more protection for VMEs in the applied SAR threshold value. They also recommended that, when data are available, the combined S1O2+S2O1 was the preferred approach as it afforded the highest likelihood of protecting VMEs while also facilitating fishing with MBCG in areas where deep-sea fisheries are well established. This was the first time that a particular management option had been suggested as this was not done in the 2021 VME Advice [2] or in the 2022 Technical Service [3], where it was left up to managers to decide the best management option. **It is not clear if ICES was requested to make this recommendation on the management options or if it was proposed by individuals at the WKVMEBM**.

One of the aims of WGDEC 2022 [30] was to follow the procedure documented by WKVMEBM to provide updated information of areas where VMEs are known to occur or are likely to occur, bottom fishing footprint, and depth limits in EU waters in relation to the EU Deep-Sea Access Regulation. Whilst running the assessment it appears there was not enough time to complete the assessment during the meeting and only preliminary assessments were included in the report. The group recommended that in future the assessment should be run prior to the meeting and the results reviewed and discussed at the meeting instead. Whilst reviewing the preliminary assessments the group made a number of recommendations including to report the percentage of records left outside of VME polygons, "*this reporting on the records left outside of the polygons is a new aspect that provides some indication of what is not being protected by the management option selected*". The group also followed the example of WKVMEBM and made a recommendation on what scenario and option combination they considered optimal, "*WGDEC considers the best VME polygon option from a biological point of view is provided by the combined approach using Scenario 1 Option 2 and Scenario 2 Option 1, followed by Scenario 2 Option 1*". **Again it is not clear if the group or ICES was requested to make this recommendation**.

A subgroup of WGDEC 2022 also addressed a Tor to 1) consider known limitations, 2) explore alternative approaches to improve the VME Index method including assessment of changes to the current identification of VME Index c-squares, and 3) prepare scripts for reporting changes. The recommendations arose from WGDEC 2021 [29] and WKVMEBM who recommended to develop the current VME Index to be less driven by the vulnerability scoring of indicator taxa and also to develop a new separate index that represents the likelihood of occurrence regardless of vulnerability. Confusingly the 2022 report states that the development of the VME Index was no longer required after the benchmark "*because of clarification of what the index should represent. Those classifications should relate to the probability of VME presence only (not confounded by other factors and irrespective of*

VME indicator type) and should correspond to the amount and type of data in each c-square" and that future work would focus on the new index. **This is surprising as the benchmarked assessment was based on the "old" approach of using the ICES VME Index and it now appeared that this was not considered appropriate and a move towards an approach requiring even less data to support closures was being recommended**.

According to the benchmark process [32] significant changes cannot be made to the assessment approach without a full benchmark, so is another benchmark being planned to undertake this? It was suggested that the work would be conducted at WGDEC over "*the next year or two, with intersessional meetings and interactions with other groups such WGMHM to prepare background material for a subsequent workshop to consider a more suitable replacement for the VME Index, a means of utilizing information from habitat models (see ToR g), and developing confidence indices based on accuracy and completeness that can be used by managers for assessing risks*". An example of the potential new approach was explored in the case of the low VME Index c-squares on the Porcupine Bank and showed than these would be upgraded to medium VME Index c-squares. Under the current Scenario 2 and Option 1 these would be closed regardless of existing fishing activity. The existing closures on the Porcupine Bank are already causing significant impact on the Nephrops fishery there and any increase in this area would likely result in the closure of the fishery.

WGDEC 2022 also recognised the issue of using the mid-point of the survey trawls as the location of the VME indicator species. However instead of acknowledging the weakness of the data, the suggested solution was to explore the option of coarser nesting of c-squares i.e. classifying multiple c-squares along the trawl as VME Index c-squares. The result of this would be obvious and the likelihood is that the entire shelf edge area would become a large polygon. **There would also likely be a significant increase in the polygon areas if the Predictive Habitat Models (PHMs) are used as the basis of the ICES VME advice and as such any attempt to move in this direction should be accompanied with a robust series of ground-truthing surveys where the outputs of such models are tested through actual ROV based observations**.

As WGDEC 2022 could not complete the VME assessment during the meeting it was to be completed after in advance of the Advice Drafting Group on Vulnerable Marine Ecosystems (ADGVME), who met in November/December 2022. The ADGVME identified numerous issues with the assessment which had not been resolved in the interim period since WGDEC. It was not possible to rerun the assessment within the timeframe of the ADG so it decided that the experts were to rerun it over December and the ADG was to be reconvened in January 2023 to finalise the advice. There was a lot of discussion about what should and should not be included with the advice. The ADG did not have the time or capacity to make a judgement on the effect of scenarios and options on the fishing activity and as such this was to be removed from the advice. Further the effort data in the assessment was restricted to mobile bottom contact gear only and static gear was not included as part of the assessment therefore reference to it was removed from the advice. In January 2023 the ADG could not be reconvened as the work on the assessment had not been completed so the ADG was finally reconvened on the 14-16 March 2023 and the 2023 ICES VME Advice prepared for review by ICES ACOM [5].

Annex 2: Data sources and associated access dates as used in the analyses in the current review.

Data layers

1. VME database - accessed 10/05/2023. https://vme.ices.dk/download.aspx - Trimmed to records within 24W, 0, 63N, 34N
2. MSS Deepwater surveys - accessed 10/05/2023. Marine Scotland, Finlay Burns. 2020. Deepwater Elasmobranch Species Data From MSS Trawling Surveys 1996 - 2019. DOI: 10.7489/12326-1
3. Marine Scotland. 2023. Deepwater Chondrichthyes weight-length data 2005 -2021. doi: 10.7489/12442-1
4. VME advice February 2022 - Accessed 10/05/2023. 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 https://doi.org/10.17895/ices.data.10041.
5. ICES VME advice-Apr 2023 - Accessed 10/05/2023. Advice on areas where Vulnerable Marine Ecosystems (VMEs) are known to occur or are likely to occur in EU waters. https://doi.org/10.17895/ices.advice.22643356
6. ICES web GIS VME weighting algorithm polygon - accessed 09/05/2023. https://mapdata.ices.dk/geoserver/SQL/ows?service=WFS&version=1.0.0&request=GetFeature&typeName=SQL:web_GIS_VMEWeightingAlgorithm&maxFeatures=10000&outputFormat=SHAPE-ZIP
7. SeaRover - Accessed 10/05/2023. Ireland's Marine Atlas - https://atlas.marine.ie. https://data.marine.ie/data/SeaRover2017/metadataSeaRover2017.xlsx https://data.marine.ie/data/SeaRover2018/metadataSeaRover2018.xlsx https://data.marine.ie/data/SeaRover2019/metadataSeaRover2019.xlsx
8. ICES DATRAS data portal https://datras.ices.dk/Data_products/Download/Download_Data_public.aspx
9. ICES DATRAS map portal https://data.ices.dk/view-map?dataset=202630

Background layers

10. ICES areas - Accessed 10/05/2023. Ireland's Marine Atlas - https://atlas.marine.ie/#?c=53.9043:-15.8862:6
11. ICES ecoregions - Accessed 10/05/2023. Ireland's Marine Atlas - https://atlas.marine.ie/#?c=53.9043:-15.8862:6
12. MSP_assessment_line_shape - Accessed 10/05/2023. Ireland's Marine Atlas - https://atlas.marine.ie/#?c=53.9043:-15.8862:6
13. Designated_Maritime_Boundary_Continental_Shelf. Ireland's Marine Atlas - https://atlas.marine.ie/#?c=53.9043:-15.8862:6
14. Contour Data 100m Interval - Downloaded 03/02/2023. Data request to Infomar- Contour vector data extracted from EMODNET bathymetry (110m)
15. EMODnet_Bathymetry_2022_contours - accessed 10/05/2023. https://emodnet.ec.europa.eu/geonetwork/srv/eng/catalog.search#/metadata/4f7ab468-f4b9-4c2c-8d3b-49a375cf9964

Annex 3. The 202 VME records related to the VME Index

ICES VME Database ID	Institute	VME Index indicator species	Assessment	Comment
263171/264740/263015	MSS	sponge/gorgonian	Error	Incorrect end & mid position
263177/262735/262734	MSS	cup coral/gorgonian	Error	Incorrect end & mid position
263175/263176/262732/262733/264939	MSS	gorgonian/cup coral/sea-pen	Error	Incorrect end & mid position
264741/263173/263019	MSS	sponge/black coral/sea-pen	Error	Incorrect end & mid position
262728/262729/262730/262731/264742/263174/264744/263017	MSS	gorgonian/cupcoral/stonycoral/sponge/stylarids	Error	Incorrect end & mid position
263018/264743	MSS	cup coral/sea-pen	Error	Incorrect end & mid position
263172/263016	MSS	gorgonian/sea-pen	Likely error	Same survey as error records
261297	MSS	cup coral	Likely error	Depth incorrect (1500m). Incorrectly labelled 1506S in MSS dataset
262089/262747	MSS	sponge	Likely error	Depth incorrect 450m. Incorrectly labelled 1506S in MSS dataset
261295/261296	MSS	sponge/sponge	Likely error	Depth incorrect (500m). incorrectly labelled 1506S in MSS dataset
261630	MSS	Stony coral	Likely error	Incorrectly labelled 1506S in the MSS dataset
320868/320869/320870	MSS	Sponge/sponge/sponge	Unable to confirm	No data access
290415	MSS	Seapen	Unable to confirm	No data access
320866/320867	MSS	gorgonian/sea-pen	Unable to confirm	No data access
264957/264958/263375	MSS	gorgonian/sponge/seapen	Unable to confirm	No data access
262113	MSS	stony coral	Unable to confirm	No data access
262503	MSS	Sea-pen	Unable to confirm	No data access
270130	MSS	gorgonian	Unable to confirm	No data access
263058/263059/262617	MSS	gorgonian/sea-pen/sponge	Unable to confirm	No data access
261798	IFR	sea-pen	Unable to confirm	No data access
268217	MSS	gorgonian	Unable to confirm	No data access
270131	MSS	gorgonian	Unable to confirm	No data access
274776	MI	Sponge	Correct	
268302	MSS	Sponge	Correct	
290444/290445	MSS	stony coral/stony coral	Correct	
262560/264055	MSS	Sponge, stony coral	Correct	
262791	MSS	Black coral	Correct	
268703	MSS	Gorgonian	Correct	
262384/262385	MSS	Cup coral /gorgonian	Correct	
262188/262189	MSS	gorgonian/seapen	Correct	
262906/262907	MSS	sponge/sponge	Correct	
262610/262613	MSS	gorgonian/seapen	Correct	
262115/262770/261652	MSS	sea-pen/sponge/sponge	Correct	
274761	MI	sponge	Correct	
326671	MI	sponge	Correct	
360839	MI	sponge	Correct	
274775	MI	sponge	Correct	
274739	MI	sponge	Correct	
274737/274738	MI	cup coral/sponge	Correct	
274735/274736	MI	cup coral /sponge	Correct	

274760	MI	sponge	Correct	
362075	MI	sponge	Correct	
326669/326670/326668	MI	Hexacpralia.anemones/cup coral	Correct	
261675	MSS	sea-pen	Correct	
320854	MSS	sponge	Correct	
290423	MSS	sea-pen	Correct	
264629/262615/262616	MSS	gorgonian/sea-pen	Correct	
290449/290421/290420/290422	MSS	sea-pen/sea-pen/sea-pen/cup coral	Correct	
262114	MSS	sea-pen	Correct	
290396/290419	MSS	sea-pen/gorgonian	Correct	
320855/320856/320857/320858	MSS	gorgonian/sponge	Correct	
320860/320859/320861	MSS	sea-pen/gorgonian	Correct	
290448/290418/290476/290398/290399	MSS	cup coral/sea-pen/gorgonian/sponge	Correct	
290447/290390	MSS	soft coral/cup coral	Correct	
360838	MI	anemones	Correct	
326667	MI	anemones	Correct	
360836/360837	MI	sponge/sponge	Correct	
326666	MI	sponge	Correct	
274733/274734	MI	cup coral/sponge	Correct	
274797	MI	sponge	Correct	
274798	MI	anemones	Correct	
262252/226253/262769	MSS	black coral/sea-pen/stocy coral	Correct	
262768/262112/262768/262250/226151	MSS	black coral/cup coral/sponge/stony coral	Correct	
264626/262902/262903/262904/264628/262614	MSS	cup coral/balck coral/sea-pen	Correct	
262478/262479/262480	MSS	black coral/sea-pen	Correct	
262323/261930	MSS	black-coral/sea-pen	Correct	
261674/261676/262793	MSS	black coral/sea-pen	Correct	
261927/262833/261928/261929/262324/262834	MSS	black coral/gorgonian/sea-pen/sponge	Correct	
263057/264627/262901/263060	MSS	cup coral/sponge	Correct	
362074	MI	sponge	Correct	
362078	MI	sponge	Correct	
362127	MI	sea-pen	Correct	
362128	MI	sea-pen	Correct	
362076	MI	sponge	Correct	
362077	MI	sponge	Correct	
270160/268246/268247	MSS	cup coral/sea-pen	Correct	
269025/269026/270159	MSS	cup coral/sea-pen	Correct	
263020/264745/264938	MSS	cup coral/gorgonian	Correct	
320862/320863	MSS	sea-pen	Correct	
290446/290417	MSS	cup coral/sea-pen	Correct	
262611/262612	MSS	sea-pen	Correct	
262190/262559/264054	MSS	sea-pen	Correct	
262386/262832/262322	MSS	gorgonian/sea-pen	Correct	
290416/290397/290473/290474	MSS	sea-pen/gorgonian/soft coral	Correct	
263055/264625/262609/263056	MSS	black coral/gorgonian/stony coral	Correct	
262135	MSS	sea-pen	Correct	
320864/320865	MSS	gorgonian/sea-pen	Correct	
268704/268705/268706/268248/270161/268249/ 270162/268250/269027/269028/270215/268303/270216	MSS	black coral/soft coral/cup coral/gorgonian/sea-pen/sponge	Correct	