WORKING GROUP ON SPATIAL FISHERIES DATA (WGSFD; outputs from 2021 meeting)

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Contents

i Executive summary

The Working Group on Spatial Fisheries Data (WGSFD) collates and analyses spatial fisheries data in order to evaluate fishing effort, intensity, and frequency in European waters.

The group was updated on several Vessel Monitoring Systems (VMS), Automatic Identification System (AIS) and Logbook related projects which are ongoing at national labs, including presentations on the use of spatial data from electronic monitoring systems to investigate behavioural changes of fishers in response to management measures, estimation of “effort” in small scale fisheries, and from the other groups which have linkages to WGSFD. Prior to the meeting, ICES had issued a data call for aggregated VMS and logbook data for the years 2009–2020.

At the request of the North East Atlantic Fisheries Commission (NEAFC), members of WGSFD produced and analysed maps of fishing activity in NEAFC regulatory areas, with a particular emphasis on fisheries around the Josephine Seamount, using the VMS and catch information provided by NEAFC. A product was once again delivered to ICES Working Group on Deep-water Ecology (WGDEC), which was used to provide advice on the impact of fisheries on Vulnerable Marine Ecosystems, and feedback given to NEAFC on potential ways to improve data and subsequent advice.

WGSFD revisited the work done at previous meetings on its terms of reference on the potential use of AIS to deliver information on D6C2, the possibilities and implications of moving to a finer spatial resolution in the data call, and the guidance provided strategic guidance to the Workshop to evaluate and test operational application of human activities causing physical disturbance and loss to seabed habitats [D6C1-C4] (WKBEDPRES2) on the use of AIS data. None of these areas had developed significantly in the subsequent years therefore the work is reiterated.

WGSFD retains its ambition to publish peer-reviewed research. One term of reference dealing with quantification and spatiotemporal variability of fishing fleets is making good progress towards this aim. A second paper on best practices for analysis of VMS data was paused whilst details surrounding protection of fishers’ anonymity were resolved. This issue has been addressed by WGSFD and work is continuing to define best practice.

ii Expert group information

Expert group name	Working Group on Spatial Fisheries Data (WGSFD)
Expert group cycle	Multiannual
Year cycle started	2019
Reporting year in cycle	3/3
Chair(s)	Neil Campbell, UK
	Roi Martinez, UK
Meeting venue(s) and dates	24–28 June 2019, Lysekil, Sweden (20 Participants)
	8–12 June 2020, by Webex (20 Participants)
	7–11 June 2021, by Webex (24 Participants)

1 Data Call

1.1 New submission procedures

In preparation to the meeting, the ICES secretariat in collaboration with WGSFD had prepared a Quality-Control document that processed submitted Member State data and generated indicators that were scrutinized by the WGSFD chairs for quality. In case concern was raised, data submitters were consulted and asked to revise and resubmit data if necessary. Changes to the data call and the system for submitting data to the Secretariat had resulted in some data providers having issues with the submission process. Due to the delays these changes caused there was not sufficient time for a subgroup of WGSFD to meet, review and quality check the aggregated data products, and as a result, although national data was quality checked by the chairs, it was not possible to review aggregated data prior to the working group. Consistent processes across submissions were lacking in some areas, and a few countries did not submit data within the required deadline, or in the correct format. Subsequently, relevant data submitters were contacted and asked to revise and resubmit data. This substantially improved our understanding of issues with the submission process and the data quality.

VMS data from Vessel Monitoring Systems, coupled with logbook data is currently the most practical and cost-effective way to describe the spatial dynamics of fishing activities. Since 2014, ICES has issued an annual data call to all ICES member countries to address requests for advice to describe fisheries activities in and in the vicinity of sensitive habitats (i.e., Vulnerable Marine Ecosystems, VMEs) and to map the aggregated distribution of fishing by different gear types.

The format of the data and fields to be provided are agreed upon by WGSFD, WGSFDGOV and ICES Secretariat and this format has evolved over time to adapt to changing needs of advisory products and to ensure the preservation of vessel anonymity.

Additional information and support on how to prepare data is provided in a guidance document (ICES, 2021) if data submitters wish to use the updated VMSdatacall_proposedWorkflow.r developed by the ICES Working Group on Spatial Fisheries Data (WGSFD).

This year's submission[1] was online through the ICES Data portal for VMS and Logbook.(https://data.ices.dk/vms) using the format specified in datsu.ices.dk/web/selRep.aspx?Dataset=145 and with an additional quality check (DATSU check) to ensure that data was in the proper format. Additionally, data submitters were able to see a quality control (QC) report of the data and could resubmit data if errors were detected. Next, the chairs of WGSFD reviewed the QC reports and highlighted potential issues to the submitter for feedback and/or resubmission.

An audit trail of the data quality is tabulated and presented as and annex (annex 3)

Data submitters encountered several issues during the submission that were solved ad- hoc by ICES Secretariat and WGSFD experts. These issues are fully documented in the following sections together with a plan for improving the submission procedures for next year.

[1] https://www.ices.dk/sites/pub/Publication%20Reports/Data%20calls/datacall.2021.VMS_LogBook_data.pdf

1.2 List of issues encountered by data submitters

- Format not specified in Table 1 and Table 2
- No clear instructions for submitters on format of data to upload (csv, others?), no header, no extra column with row.names and no quotation
- The **"Import vms/logbook data in the database"** button created some confusion: Some submitters clicked it just after submitting the data, some others after receiving the QC, others after the chairs examined the QC and, finally, some did not click it at all.
- On a few occasions there were some problems with pages of our submission portal not displaying well, some submitters lamented "white pages" or "**not found**" pages.
- **No column names**. A submitter stated: "*I also find it weird that there shouldn't be column names in the files, since datsu.ices.dk/web/selRep.aspx?Dataset=145 explicitly states the column names.*"
- **The message errors** reported by the DATSU screening process were sometimes of difficult interpretation for some submitters
- Lack of **an actual data example formatted** correctly which they can use as a template.
- Issues with following columns:
  - Country: as table in guidelines specifically says nchar(3) and 1-alpha-3 format. Also the field in table at http://datsu.ices.dk/web/selRep.aspx?Dataset=145 , says nchar(3), you need to go beyond table to find codes, no links in guideline tables)
  - LowerMeshSize, UpperMeshSize,
  - AnonymizedVesselID
  - some ICES rectangles were refused in the screening process, but the issues were usually fixed quickly by Data Centre.
- Some submitters noticed that some of the **fishing efforts maps** present in the QC report were of difficult interpretation (due to low data density levels and low contrast between the colour of the data points and the background of the map). It is also possible that for coastal fisheries the data is obscured by the coastline when the map is looked at with a low zoom
- **Disagreement of the proposed r-script**, (developed and changed in 2020, and referred to in this year's data call) and the input format to the DATSU database.
- The **screening process has been slow in the case of large files**, sometimes stopping when multiple large files were screened at the same time.
- Country code: Information **on valid missing value** code for the various fields. (Not allowed with missing values?)
- Gear width is mandatory in VE table but there are no instructions in the proposed r-flow on where to add this information (on ping level or on aggregated data gives different results) nor are there any links to existing functions to help produce this or references to the relevant BENTHIS papers and métiers lookup tables.

1.3 Suggestions from data submitters and WGSFD experts

It was suggested to create a "submission handbook" to document the different practical steps and aid future submissions. Work needed is divided in sections and subdivided further in tasks:

Datacall R script Workflow:

General: Update according to new data call requirements.

Specifics:

- Redesign the workflow in functional blocks (cleaning, analysis, delivery)
- Align Added new fields
- New fields were missing in the R script
- New fields with data cannot be provided e.g., upperMeshSize, LowerMeshSize, AverageGearWidth
- Links to VMSTools update work
- Update script to save tables without header
- Include and updated version and date of any changes in the code for traceability purposes.
- Use DATSU vocabularies (csv) for checking before uploading tables
    - Either include these checks in the proposed workflow
    - Or give hint in the description text, so that data providers know to do that beforehand
    - Explain in the Data Call text that log-in credentials to DATSU are the individual ones.
- Provide only one correct link for data upload
- Change the QC script to **use ggplot** and lower the alpha values so the coastline doesn't cover the near-shore data.

DATSU ICES Vocabulary

- WGSFD members provide expert view into values accepted via WGSFDGOV.
- Allow more gear types (MetierL4) 1. PUL, PUK (electrified beam trawls) missing – Different impact as TBB on SAR.
- TBS and other gears missing, propose a definition.
- Allow NA for missing values especially in optional fields, like gear width, mesh size – Workaround: 0 (zero)

Data submission process

- Submit directly from the R script using API services.
- Decrease response time for result/feedback (if possible) or announce those long times directly on the website
- Improve access to submission status: The link in the response mail/webpage did not inform of submission status. Instead, needed to go via overview list
- Webpage messages not synced with submission phase as sometimes told that data were o.k., although screening was still running
- Webpage gave two messages on same page 1. Data are incorrect 2. Data are correct, including button for uploading.
- Create a submission handbook to document the different practical steps and with an example of formatted data
- Create a subgroup to run pilot test prior to issuing data the call

- Change meeting structure and data call deadlines:
    - Extend data call deadline until 15 May
    - Add a 1–2-day meeting for QC of (aggregated) data set in the middle of June and feedback to submitters
    - Full meeting in autumn including QC of aggregated dataset with resubmitted data

2 Progress on Terms of Reference

2.1 In response to ToR a)

Analyse current AIS datasets available to the WG, their fitness for purpose in provision of advice, and investigate possibility of inclusion of AIS data in the annual request from ICES to its member countries to provide spatial fisheries effort data to the Data Centre ("the ICES VMS data call"); (2018-2020)

This term of reference was covered by the group in its 2019 report (ICES, 2019). Since then, the headline position has not changed – AIS is a demonstrably useful tool for analyzing the spatial distribution of fisheries in certain circumstances, however issues around access, data management and lack of a common toolbox for analysis limit its practicality for an initiative such as the ICES VMS data call.

2.1.1 Introduction

Physical disturbance from bottom-contacting fishing gear is likely to be a substantial contribution to the total extent of physical disturbance and method or methods to define this type of disturbance needs to be defined.

Two main sources of data are currently used to map the distribution and intensity of bottom-fishing activity: Vessel Monitoring System (VMS) data, which is coupled with fishing logbook data, and Automatic Identification System (AIS) data.

The Automatic Identification System (AIS) is an automatic tracking system providing detailed vessel positioning data. AIS was introduced by the International Maritime Organisation (IMO) to improve maritime safety and avoid ship collisions (International Maritime Organisation, 1974). Vessels fitted with AIS transceivers can be tracked by AIS base stations located along coastlines or, when out of range of terrestrial networks, through a growing number of satellites that are fitted with special AIS receivers, which are capable of deconflicting many signatures.

Building upon the evaluation of these data types (ICES WGSFD 2016, 2018), and considering the differences in data availability, resolution and outcomes of their processing, a comparative analysis in selected study areas is needed to assess their relative merits for MSFD purposes.

In this ToR, WGSFD compares the use of VMS and AIS data, and associated data required to determine fishing effort and type, such as fishers' logbooks, in the context of use for MSFD D6 assessments. This includes a side-by-side comparison (see section 2.1.1.1) against several parameters, including source of the data, availability, use, spatial coverage in European waters, temporal coverage, resolution, accuracy, technical requirements for processing and resources needed. The comparison includes 2 case study showing the distribution of bottom-fishing activity from the two data sources for the same period, indicating where the distribution overlaps and where not, with an associated quantification of this (see section 2.1.3.5).

The findings are summarised at the end of the chapter (section 2.1.4). A technical guidance on how, and when to use AIS to assess physical disturbance to the sea floor is provided (section 2.1.5).

2.1.1.1 Comparison of VMS and AIS against several parameters

AIS data are collected through a network of terrestrial stations. AIS data commercial providers integrate terrestrial AIS data with data collected through a network of satellites, improving data coverage and quality (multi source AIS data). Table 1 presents a summary of information on several AIS raw data holders.

Table 1. Organisations who collect and/or hold raw AIS data.

AIS (Raw) data holders	Links	Restrictions	Comments
National maritime agencies (NMA)	EMSA SafeSeaNet Project: CleanSea Project National initiatives: Denmark has made publicly available Iceland: Norway: Russian Federation: United Kingdom: United States: https://marinecadastre.gov/	EMSA provides limited access Evaluated on case-by-case basis	National coast guards collect and report to NMAs.
Regional Sea Conventions (RSCs)	HELCOM AIS network collates regionally real time AIS data streams http://www.helcom.fi/action-areas/shipping/ais-and-e-navigation	Available to Helcom member states but with limitations. Data starting from 2005	
Commercial vendors	CLS: (multisource) Marine traffic: https://www.marinetraffic.com Global fishing watch: https://globalfishingwatch.org/ Vessel finder: ExactEarth: FleetMon: ExactEarth: OrbComm: SpireMaritime: AstraPaging AIS:		Global fishing watch shares AIS data with the Research Accelerator Program.
European Commission agencies	EMODnet	Data published can be reused. Raw data cannot be shared	From January 2017 to December 2017

	JRC (courtesy of Volpe Center of the US Department of transportation, the US Navy, and MarineTraffic) Data set linked to European fleet register-MMSI.	From October 2014-September 2015. Data used in
Terrestrial networks of receivers	National maritime agencies for most of ICES member states	For further info see:

2.1.1.2 Availability and Accessibility

Different AIS datasets were considered to perform the comparison against VMS. A detailed description including the legal requirements and resolution is provided in section 2.1.1.3.
Access to raw AIS data is dependent on the organization collecting the data. AIS data are collected by the national coast guards or other organizations involved in Search and Rescue (SAR) activity, to assist with their operations. National maritime agencies can then give access to national fisheries scientists for research purposes. Some ICES member countries have started a process by which the National Maritime Authorities and/or Coast Guards provide fisheries scientists with AIS database dumps to be coupled with VMS and logbook data. Other countries (e.g., Iceland and Norway) provide marine and fisheries scientists with a harmonized VMS and AIS dataset. Alternatively, commercial providers sell AIS data.

2.1.1.3 Uses of AIS data

The initial purposes of AIS, a system imposed by Regulation 19 of Chapter 19 of the International Convention for the Safety of Life at Sea (International Maritime Organisation, 1974) include promoting the safety of navigation, collision avoidance, enabling coastal States to obtain information about ships and their cargos and as a VTS tool (EU Commission, 2009).

Because AIS data is transmitted unencrypted, over publicly available frequencies, there is nothing to prevent anyone with suitable equipment from receiving it. A few commercial companies have successfully established web-based AIS data sharing mechanisms on this basis.

Nonetheless, any data recipient/user is responsible for handling the data received appropriately and in compliance with the law. The article 24 of the Directive 2009/17/EC amending Directive 2002/59/EC for establishing a Community vessel traffic monitoring and information system (VTM Directive) that also applies to AIS, states that: "Member States shall, in accordance with Community or national legislation, take the necessary measures to ensure the confidentiality of information sent to them pursuant to this Directive, and shall only use such information in compliance with this Directive." Consequently, information contained in AIS transmissions should be considered as potentially sensitive. Data should not be combined with other data in a manner that will create data from which persons, individual vessels or enterprises are identifiable or personal data can be revealed.

In 2012, the European Data Protection Supervisor (EDPS) issued an opinion on the use of AIS and VMS data (European Data Protection Supervisor, 2012). The opinion states that: “As long as the data can be linked to identified or identifiable individuals (e.g., the master of the vessel, the owner of the vessel, or the members of the crew) such monitoring involves the processing of personal data. It is therefore important that (…) adequate safeguards are put in place and implemented to avoid that the rights of the persons involved are unduly restricted. This implies for instance a clear delimitation of the purposes for which the relevant data can be processed, the minimisation of the (personal) data being processed and the establishment of maximum retention periods for the same data.” EDPS advised to clarify *ex post* the scope and the limits of processing. Although no new rules have been implemented so far, we must be careful with the extensive use of this kind of data.

2.1.1.4 Spatial and Temporal coverage

AIS data is affected by spatial and temporal vessel coverage issues. AIS data collected using a network of terrestrial stations is affected by the power and the location of the receivers. When the fishing occurs far from the coast, the coverage of AIS signal is patchy because the vessels might be out of reach of the terrestrial network.

Satellite AIS is used to collate data for vessels far away from the coast (approximatively 20–40 nautical miles). When terrestrial and satellite AIS data are coupled coverage is greatly improved and AIS sources of uncertainty depends on temporal and vessel coverage, i.e., the number of ships covered by AIS data.

Temporal coverage is affected by spatial coverage and by vessel issues. Vessel coverage can be a direct consequence of spatial and temporal coverage (i.e., is a vessel within range of a transmitter or satellite coverage at a particular time), on an intentional decision to switch AIS on or off switching, on the level of uptake of AIS (relevant especially for the small vessels where AIS is not mandatory) and on the level of completeness of the data providers.

AIS data needs to be linked to other datasets (mainly logbooks) to be used. Other coverage issues come from the dataset used to linked AIS data.

The main field used to link AIS data is Maritime Mobile Service Identity (MMSI). A Maritime Mobile Service Identity (MMSI) is a series of nine digits, which are sent in digital form over a radio frequency to uniquely identify ship stations or coast radio stations among others. A summary of the main coverage issues for AIS data and for MMSI is shown in Table 2.

Table 2. Spatiotemporal coverage issues of AIS and MMSI.

AIS coverage issues	Maritime Mobile Service Identity (MMSI) coverage issues
On/Off	Spoofing
Vessel Coverage: proportion of the number of fishing vessels in the AIS dataset and the total number of fishing vessels required to use AIS.	One vessel may have multiple MMSIs.
Spatial Coverage	MMSI is linked to the device and not to the fishing vessel.
Temporal Coverage	Coupling with ancillary information.
	Not present in the EU Fleet Register
	Could be affected by the recent GDPR

2.1.1.5 Spatial Resolution (granularity)

Member states collect VMS data at national level with different temporal resolutions (a minimum resolution of two hours is required for EU vessels fishing in EU waters under the remit of the EU Common Fisheries Policy (CFP). In contrast with AIS data, VMS data is used for control purposes and therefore data collection, quality control and final data products are outstanding. VMS data sets have a coarser temporal resolution compared to AIS but a more reliable temporal and spatial coverage, with fewer *holes* (local variation). The imposed time granularity of two hours is however not capable to capture vessels movements at a fine scale, and it requires additional interpolation between consecutive points to produce a reliable vessel track. The coarse temporal granularity of two hours affects the spatial granularity of VMS data. Spatial granularity and confidentiality issues force VMS and logbook data products to be calculated and disseminated at an aggregated level.

AIS data on the other hand, provide considerably higher temporal granularity, which however is uneven and subject to the coverage issues linked with the different technology used. The result is that AIS data sets contain more points, with a finer temporal resolution, but with a coverage that is highly unstable and different geographically.

Assuming coverage information is provided, fishing vessels tracks based on AIS data do not need interpolation between consecutive points and AIS data products could be disseminated at a higher spatial resolution.

Member States Coast Guards, Maritime Authorities and EMSA use a harmonized VMS and AIS data set, that preserves data quality and coverage by leveraging on the proprietary technology of VMS data and allow for an improved time granularity when AIS data coverage is optimal.

2.1.1.6 Accuracy in the estimation of fishing effort

The official sources of fishing effort for EU member states are collected and disseminated through the Data Collection Framework under the Fisheries Dependent Information data call. Fishing effort is available for quarters of the years and at ICES rectangle resolution (1 x 0.5 degrees). The coarse resolution limits the use of the fishing effort dataset to for the assessment of physical disturbance on the benthos. Estimating fishing effort using AIS, VMS and logbook data can greatly improve the spatial and temporal resolution.

The accuracy of fishing effort estimation is primarily linked to the quality of the input data and to the cumulative effect of linking different datasets with difference level of accuracy together. However, individual accuracy issues aside, we can assess the different combinations of AIS, VMS, logbook and ancillary data and the information gain obtained from them. Table 3 shows a summary of the possible links between AIS datasets and other fisheries control data in relation to fishing gear, an important information when estimating fishing effort and swept area.

Table 3. Links between AIS and other fisheries control data.

Sources of Data	Gear information	Is the gear used in the fishing trip? (Yes (Y)/No(N))
AIS + VMS + Logbook	Métier (DCF level 6)	Y
AIS + Logbook	Métier (DCF level 6)	Y
AIS + Fleet register	gear type (DCF level 4)	N
AIS + Sales Notes	gear type (DCF level 4)	N
AIS	gear is inferred	Y[2]

2.1.1.7 Technical requirements for processing AIS data

Linking AIS and VMS/Logbook data requires additional technical skills and infrastructure that is mostly beyond the scope of national fisheries scientists. For example:

- Experience working with "big data"
- Spatial data analysis and modelling skills in high performance environment
- Technical knowledge of the standards for AIS and their shortcomings

However, the fisheries scientist's knowledge of the fleet behaviour and the fishery is essential in successfully using AIS and VMS data. Now, the best examples of the inclusion of AIS in fisheries science have shown that the local knowledge of the fishery is crucial in accounting for the inconsistency's due uneven temporal and spatial coverage and for the several input errors.

2.1.2 Icelandic Case Study

2.1.2.1 Data

The AIS dataset was acquired by EMODnet, and it comprises all vessels operating in waters under the remit of Common Fisheries Policy for the year 2017. The AIS dataset was filtered by country and the resulting subset constituted the AIS Iceland dataset. The Icelandic was preferred because AIS coverage is better and it includes vessels of less than 15 meters length overall, and for the concentration of the fishing activity inside the Exclusive Economic Zone. The data was imported in the statistical software R for the rest of the processing. The workflow of the analysis is documented through a series of R files. The workflow adopted for the case of Iceland was different than the North Sea case study mainly because for Iceland, detailed logbook data were made available for research by the Icelandic Ministry of Fisheries. The logbook data was linked to the AIS dataset and then aggregated at c-square and Benthis total gear level. The following paragraphs describe the main steps of the analysis and the final total effort maps.

2.1.2.2 Active fishing vessel identification

The identification of the fishing vessel was obtained through a look up table created to link MMSI, call signs and vessel identifiers. Such lookup table is also used to directly link VMS and AIS data that are provided to fisheries scientists as unique integrated dataset. This practice represents an advanced stage in the implementation of AIS data into fisheries research and exempts the researcher from the complex matching process. The look up table was joined with logbook data by using the vessel identifier variable "*vid*" and then to the AIS Iceland dataset leading to the identification of 1161 vessels of the 1164 of the active fishing fleet. An excellent result, only

[2] Subjected to accuracy of the prediction algorithm.

possible through the look up table described above, that shows how, national, or subnational level (individual fisheries organizations) is the ideal when coupling AIS data with logbook data. The vessel identifier *vid* is characteristic of the Icelandic fleet but, member states adopt similar procedures to link the different identifiers to the individual fishing vessel

2.1.2.3 Append tow times for mobile bottom contacting gears

Once identified the vessel and the gear used, mobile bottom contacting gears (MBCG) were selected and linked to the WGSFD/Benthis metier using a lookup table built on the logbook metadata.

Table 4. Gear mapping for mobile bottom contacting gear.

Gear id	Description	Gear metier	Benthis_metier	Benthis_Total	Gear Total
38	Cyprine dredge	Dredge	DRB_MOL	Benthis_total	Gear_total
40	Sea-urchins dredge	Dredge	DRB_MOL	Benthis_total	Gear_total
9	Lobster Trawl	Otter_Trawl	OT_CRU	Benthis_total	Gear_total
14	Shrimp trawl	Otter_Trawl	OT_CRU	Benthis_total	Gear_total
6	Bottom trawl	Otter_Trawl	OT_DMF	Benthis_total	Gear_total
5	Danish seine	Danish_Seine	SDN_DMF		Gear_total

Table 4 shows the gear mapping adopted in the selection of the MBCG fleet. These mappings greatly affect the maps by individual metier level. An additional arbitrary category was included to produce alternative maps, not included in the maps here presented.

Individual trips were filtered out of those records without the initial and the final tow times. For the 101 trips where the final tow time was not available, we used the average tow time for the same vessel and gear (100 records) and for the total of the fleet (1 record).

The tow times for the MBCG fleet were appended to the vessel by locating the closest points in time in the AIS track. A binary variable (0 or 1) named *fish* was created and set to 1 for all those times in the track included between the initial and the final tow times. For the remaining points the variable *fish* is set to 0. Additional checks on the consistency of the fishing activity, identified points in the track with high values of fishing speed. Such unrealistic values are caused by input errors in the logbook dataset and were adjusted by employing an algorithm that identifies and remove extreme outliers in statistical distribution of the speed values during the fishing activity.

2.1.2.4 Creation of the spatial data file at Benthis and C-square resolutions

The individual fishing vessels track point were georeferenced using the latitude and longitude coordinates and spatially joined with the polygons of the Icelandic harbours created using a buffer of 1 kilometre around the port[3]. After eliminating the points in harbour with zero speed values, the points were attributed c-square notation using the R package VMS tools (Hintzen *et al.*, 2012) and individual gear identifiers aggregated at WGSFD/Benthis metier level and several spatial data files were produced for mapping.

[3] The ports dataset was acquired from Marine Traffic.com

2.1.2.5 Comparison of temporal coverages of the VMS + AIS + logbook data

The comparison was performed on the on the entire logbook fleet of 1161 vessels. We aligned 1142 vessels with the VMS dataset and calculated the proportion by vessel of:

$$\frac{AISnumberofrecords}{VMSnumberofrecords}$$

729 out of 1142 (63.8%) have a ratio >= 1. However, the ratio is not a complete coverage indicator because coupled with the total number of points, it is also essential to inspect the mean and median differences in time. 413 remaining vessels have a ratio <1 with 13% of total number of trips affected. The limited temporal AIS coverage is:

1. clustered in time with low median differences in time (dt) and high mean *dt;* indicating that the distribution of *dt* is characterized by a majority of small *dt* with few very high *dt*
2. scattered throughout the year leading to high and close median and mean *dt* the points are distributed in the year and have high median and mean *dt;*
3. clustered with high median *dt* and a low mean value: with a majority of high *dt* with fewer smaller *dt*

The first case described is the most recurrent and shows a common pattern in commercial AIS datasets: having considerable time resolutions for most vessels but a very limited coverage in the others.

The AIS + VMS + logbook dataset has a stable distribution with high median *dt* (3360 seconds) and a 2560 median number of points per vessel (median 2560 points) resulting in a total time at sea of 7 533 396 hours. The AIS dataset has more variability with a very high median *dt* (11 seconds) and 4147 median number of points per vessel-hours which are not enough to compensate for the high median difference in times and account for a total of 931 614 hours of activity. For the comparison exercise we considered any activity the fishing is performing while moving or stopped outside the harbour.

2.1.2.6 Mapping

The final aggregated dataset at Benthis total level with c-square resolution of 0.05 decimal degrees was mapped using the fishing hours variable.

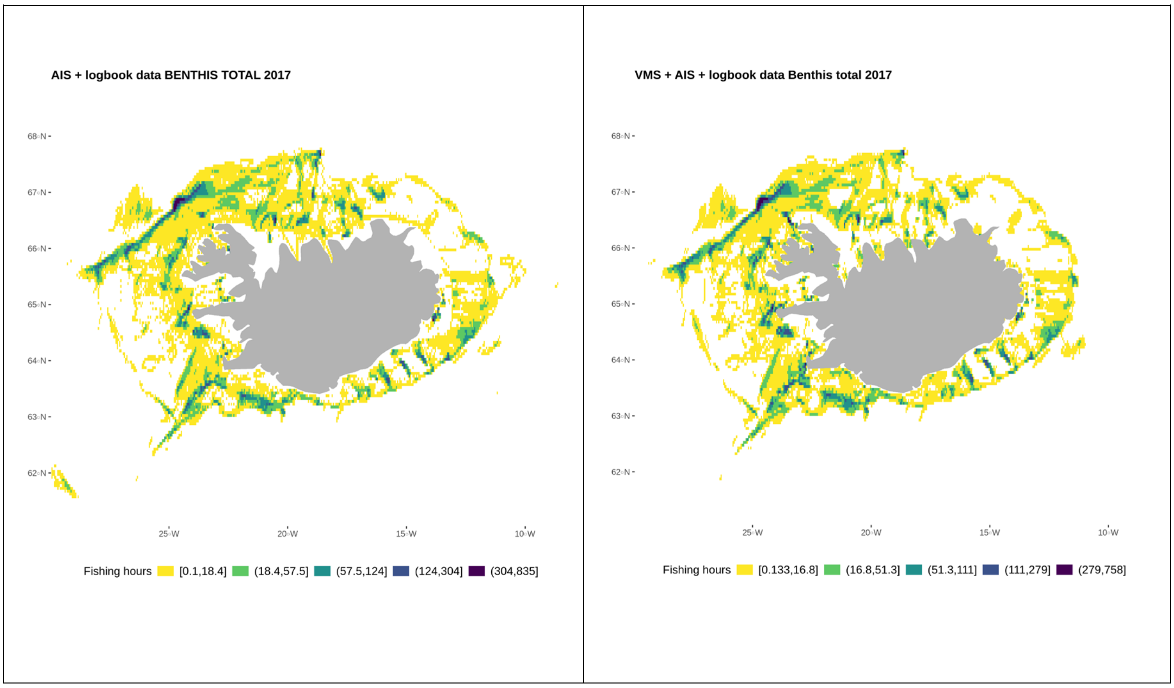

Figure 1. Comparison of spatial fishing effort maps calculated with Icelandic AIS+logbook data (left panel) and VMS and AIS and logbook data.

The maps of VMS + AIS + logbook data (Figure 2) show a better coverage and a better identification of the fishing activity, showing that high temporal resolutions in the AIS dataset have diminishing returns in terms of information gained and can lead to overestimation of the fishing hours. While the distributions are similar in maximum values, the AIS dataset presents a slightly maximum value per c-square and a corresponding total number of fishing hours that is overestimated in the AIS and logbooks map. The reason for the overestimation resides in the coverage of the AIS data. The AIS dataset has a characteristic of having higher temporal resolution for most of the vessels but when the coverage is patchy and sparse the difference in times between two consecutive points in the track are very high and if in that point is recorded fishing activity by the logbook the resulting total number of fishing hours will be artificially increased. To attenuate this issue, we limited the maximum difference in time between fishing points in the track to six hours. In addition, the high resolution of the AIS dataset will identify a greater number of points where fishing activity is recorded, sometimes including fishing speeds values not in the range of the fishing activity.

The total number of fishing hours for the AIS + logbook data is 186339 against the 179345 of the VMS + AIS + logbook dataset.

2.1.3 North Sea Case Study

2.1.3.1 Data

The AIS dataset was acquired by EMODnet[4] and it comprises all vessels operating in waters under the remit of Common Fisheries Policy for the year 2017. The AIS dataset was filtered by the fishing category (variable *aisshiptype* 30) and by the extent of the ICES North Sea Ecoregion. The resulting database stored in textual form was subdivided in 15 other files, for easier management and analysis. The files were imported in the statistical software R for processing. The processing workflow was organized in R files. Here we will briefly describe the workflow and its main outputs, the R files are available for further enquiry and for scrutiny.

2.1.3.2 Spatial join with the harbour database

The database was converted to spatial and joined spatially with squares extending 3 nautical miles from the fishing harbours. The result of this typical Geographical Information System's operation, also known as *point in polygon*, was a new field in the database table reporting if the point is in harbour or not. This information is of vital importance in the cleaning and modelling process. Fishing vessels keep the AIS devices on even when they are stationing in harbour, which increase the size of the AIS database without adding useful information to the fishing estimation process (points in harbour are excluded). For the North Sea case study, the initial database of fishing vessels was 70742839 points. The resulting database after the point in polygon operation, obtained by removing the point in harbour with zero speed contained 25825446 points, with more than 60% of the initial points filtered out.

2.1.3.3 Gear attribution

The point database was summarised by vessel and then joined with several registers ranging from the Community Fishing Fleet Register[5] to several other Regional Fisheries Management Organizations (RFMO) collecting fishing vessel's information and finally to the Global Fishing Watch[6] fishing vessels register obtained through the Research Accelerator Program of Global Fishing Watch. The result of the matching process yielded 78% of the MMSI with gear information using FAO's International Standard Statistical Classification of Fishing Gear[7] (ISSCFG) with a two/three letters code for macro gear category (i.e., OTB, DRB, TB). The aggregated maps show that the gear attribution process did not perform well mainly for the lack of a global unique identifier for the AIS fleet. While the European Fleet Register and the RFMO registers tend to use a unique identifier for a vessel (i.e., the Community Fleet Register Number), in the AIS fleet a unique vessel is identified by a combination of identifiers. The MMSI is not linked to the vessel but to the device, the ITU call sign is attributed to a vessel at national level, but it can change during the lifetime of the vessel, the International Maritime Organization (IMO) number is the only unique identifier for the lifetime of a vessel. However, due to its recent extension to fishing vessels, the presence is low in the database.

The IMO number was the first identifier used in the matching with the fleet registers; followed by a bespoke identifier obtained by combining MMSI and Callsign (total MMSI with gear attribution after this match (circa 50%), The remaining records were linked to the GFW list of fishing vessels using the MMSI (28% gain in MMSI gear attribution). Despite the good results in gear

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[4] http://www.emodnet.eu/

[5] http://data.europa.eu/88u/dataset/the-community-fishing-fleet-register

[6] https://globalfishingwatch.org

[7] http://www.fao.org/3/a-bt986e.pdf

attribution, the process is still prone to errors and to inconsistencies that are for the most part in the quality of the fleet register data and on the assumption that the gear used in the track is the most common one reported. The GFW fleet register is an attempt to reconcile such inconsistencies with the real gear identification from the fishing track and it has been used in the last stage of the gear matching process because it was preferred to use official organization's fleet registers.

2.1.3.4 Fishing estimation process

The fishing estimation process was aligned to the one used by WGSFD when exact fishing locations are not available, and it is based on the analysis of speed profiles and in the estimation of a speed interval where the fishing vessel is considered fishing. The methodology has proven to be particularly effective for mobile bottom contacting gears, which are considered in this case study. The performance of the model does not rely heavily on the gear attribution from the previous step, because speed intervals are based on the single fishing vessel's track in a year and on the analysis of the speed. Gear attribution is however essential to identify mobile bottom contacting gears.

The fishing estimation process outputs a binary variable (1 or 0) classifying a point as fishing or not. Since the classification solely on the speed, the track must be checked to exclude point classified as fishing that are in harbour and to exclude points where the fishing vessel is not fishing but still travelling at a speed estimated as fishing.

The cleaning routines employed two main arbitrary thresholds set after consulting several domain knowledge experts: firstly, a preliminary filter was applied excluding points with speeds exceeding 9 knots and with differences in time of more than six hours. Finally, the fishing speed interval is calibrated on every vessel, and it varies depending on the fishing gear used and targeted species, but in average usual speed ranges are 2–4, in some cases, 3–5 or even 5 to 7.

2.1.3.5 Creation of the aggregated geographical dataset for mapping

The point tracks were aggregated at Benthis macro-category and c-square level. Benthis metier were linked to the FAO gear information obtained from step 2. Table 5 shows how gear codes were assigned to different Benthis categories.

Table 5. Benthis gear codes used in the North Sea case study.

Gear description	Gear code	Gear category	WGSFD/Benthis gear
Beach seines	SB	Seine Nets	Seine
Boat seines	SV	Seine Nets	Seine
Seine nets other	SX	Seine Nets	Seine
Danish Seine	SDN	Seine Nets	Seine
Scottish Seine	SSC	Seine Nets	Seine
Pair Seines	SPR	Seine Nets	Seine
Bottom pair trawls	PTB	Trawls	Otter
Bottom trawls other	TB	Trawls	Otter
Multiple bottom otter trawls	OTP	Trawls	Otter
Single boat bottom otter trawls	OTB	Trawls	Otter
Trawls other	TX	Trawls	Otter
Twin bottom otter trawls	OTT	Trawls	Otter
Dredges other	DRX	Dredges	Dredges
Hand dredges	DRH	Dredges	Dredges
Mechanized dredges	DRM	Dredges	Dredges
Towed dredges	DRB	Dredges	Dredges
Mechanized dredges	HMD	Dredges	Dredges
Beam trawls	TBB	Trawls	Beam

C-square were assigned through the package VMStools (Hintzen *et al.*, 2012) and checks on the quality of the aggregated data lead to the exclusion of c-squares with only one point per Benthis metier estimated as fishing.

2.1.3.6 Mapping

The spatial data with a geographical resolution of 0.05 decimal degrees and Benthis gear level were mapped spatial data with a geographical resolution of 0.05 decimal degrees and Benthis gear level were mapped using the total estimated number of fishing hours obtained by multiplying the *fish* variable by the *dt* variable, indicating the difference in seconds between two consecutive points in the track recorded by the AIS device. An uneven coverage in the AIS dataset can result in high differences in times and unrealistic total number of fishing hours. To attenuate this temporal coverage issue we capped the maximum value of *dt* to six hours. In the Icelandic case the gear attribution was different, with a match close to 100%. Fishing effort was calculated through logbooks data, leaving the main discrepancies in the two total fishing effort maps to the coverage of the VMS AIS dataset (Figure 3).

For this case study, non-realistic fishing hours within the c-squares were analysed in relation to their geographical location. The most of these extremely non-realistic values occurred along the coastline in the North Sea ecoregion and consequently were omitted in the analysis.

The final map of total effort in fishing hours by c-square for the AIS only dataset is shown in Figure 5 with the map of total fishing hours calculated using VMS and logbooks data taken from the output of the WGSFD 2018 meeting (ICES, 2018).

The preliminary comparison shows plausible maximum values by c-square (2901 fishing hours) in the AIS only map compared to the VMS and logbook data value (4806), The differences in value are due to an incorrect coverage of the total fleet by the AIS dataset and by the gear attribution process. These effects cannot be attenuated until the entire fishing fleet is covered by AIS and until the gear attribution is improved by introducing a unique identifier for fishing vessel or perfecting the estimation of the gear used while fishing.

The coverage and gear attribution issues are affecting the total number of fishing hours: 1012319 for the AIS dataset and 1156942 for the VMS and logbook dataset, the 87.5 % Further investigation and statistical analysis is needed to validate the statically validate the results of the AIS dataset especially for the ability to estimate disaggregated gear level effort, In addition it is still to debate the use of total fishing effort maps for mobile bottom contacting gears measured in fishing hours, for the assessment of MSFD D6, were surface and subsurface maps are essential.

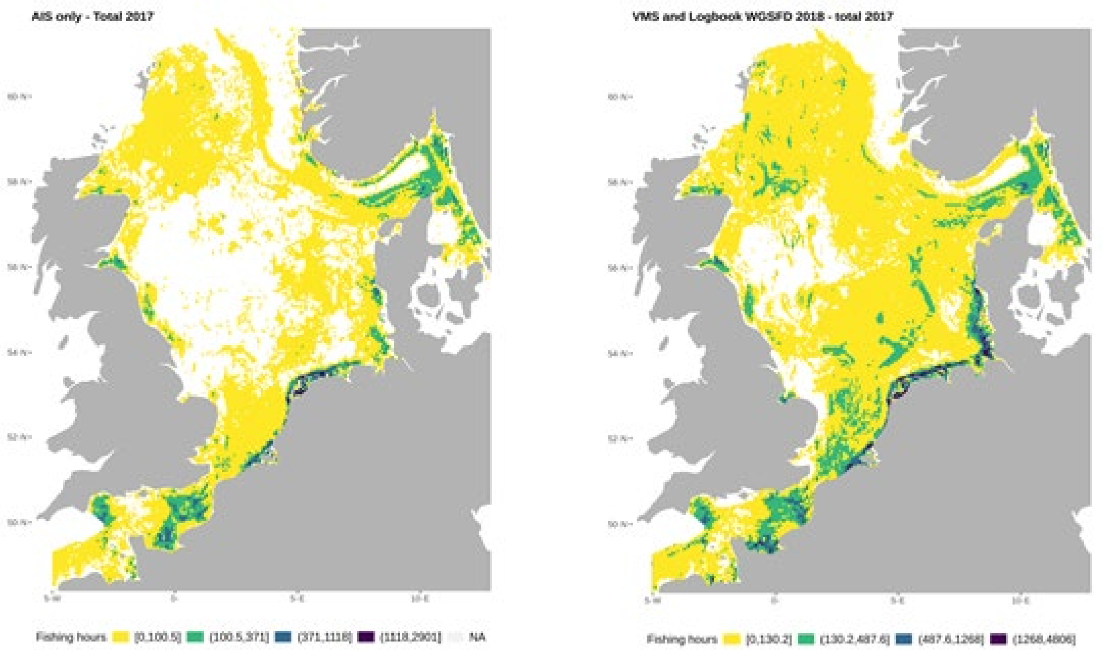

Figure 2. Comparison of spatial fishing effort maps in the Greater North Sea calculated with AIS data (left panel) and VMS AIS and logbook data (right panel).

2.1.3.7 Surface and subsurface disturbance by mobile bottom-contacting gear calculations using AIS and logbook

Surface and subsurface abrasion maps were not calculated either for the Icelandic and the North Sea case. For the North Sea case, gear attribution, obtained through data fusion of other fleet registers, was possible at DCF metier level 4. Such gear attribution, meant as an indication of the most gear mostly used by the vessel in a calendar year, was linked to every vessel's track in the AIS dataset. In the Appendix, gear maps by DCF level 4 show that the gear attribution process did not perform well in estimating fishing effort and would result in misleading surface and subsurface disturbance maps.

In the Icelandic case, where gear attribution was obtained through logbooks, the mapping of the Icelandic gear coding to Benthis metiers was performed in a similar way and VMS and logbooks surface and subsurface validation maps were not available.

2.1.4 Summary of findings

Recent studies show that AIS has been adopted by around 75% of EU fishing vessels above 15 meters of length. However, the methods developed to identify fishing activity require detailed logbook data for validation purposes in addition.

The use of AIS for MSFD D6 assessment purposes without VMS data coupled with logbooks poses several challenges: lack of gear information, irregular coverage, biased signal reception, diverse technology used to collect the data among others. Information on gear used at the trip level is contained in the logbook data. When logbook data is not available, researchers resort to coupling the AIS fishing fleet with national or supranational fleet registers (EU CFR, CLAV, IUU, IOTC, WPCFC, NPC, ICCAT) using the most used gear in a year as an average and thus not reflecting the real gear used for the fishing vessel.

2.1.4.1 Advantages of using AIS to analyse fishing effort

AIS data can be used to complement VMS data for vessels larger than 12 meters and can provide spatial and temporal information for vessels for which we have logbook but not VMS (10–12 meters vessels). It could provide information for vessels smaller than 10 meters. Table 6 summarizes the advantage of using AIS in fisheries research for different size classes of vessel:

Table 6. Advantages of the use of AIS in fisheries research.

	VMS	**Logbook**	**AIS**	**Gain from adding AIS**		**Sales Notes**
				Time	Space	
8-10 meters	Voluntary, major gap in VMS data. Mandatory if they want to fish in certain areas	Voluntary, mandatory if they want to fish in certain areas	Voluntary. Likely to be adopted by a large share of this vessel length category because it is not used for control but for safety and these vessels are usually under the range of terrestrial receivers	Time information at a highest rate (5 minute	Location/track vessel information Better definition of fishing operations for the in-shore fleet	Voluntary (Exceptions: mandatory in Norway)
10-12 meters	Voluntary	Mandatory	Voluntary	Time resolution from day to minutes. Better fishing effort estimation for D6C2 assessment purposes (gear from trip and not from fleet register)	From ICES rectangle to vessel track.	Mandatory

12-15 meters	Mandatory with exceptions	Mandatory	Voluntary	From VMS (hours) to AIS (minutes)	Better track definition and better fishing operations	Mandatory
> 15 meters	Mandatory	Mandatory	Mandatory	From hours to minutes	Better track interpolation better fishing operations for the offshore and high seas fleet	Mandatory

2.1.4.2 Disadvantages of the use of AIS for fisheries research

Conversely, there are several disadvantages posed by using AIS data as a tool in marine research and planning (Table 7).

Table 7. List of potential problems with the use of AIS data in marine science.

Issue	**Problem**
Short Time Series	AIS is a relatively new technology (circa 2000 onwards), and long-term records are infrequently kept due to the amount of physical disc space needed to store the transmitted messages.
Variability of coverage, temporally, by area and by fleet sector	Smaller fishing vessels are often equipped with AIS Class B devices. AIS-B is a non-mandatory form of AIS typically used by small commercial craft, fishing vessels and recreational vessels. To prevent overloading of available bandwidth, transmission power is restricted which can lead to a potential under representation of effort and misleading spatial use patterns.
	The technical specifications of the AIS signal influence the coverage that may change in different areas and over time. Therefore, an absence or limited AIS signal do not guarantee the absence of/limited vessels trajectories.
Data Quality	Potential sources of error exist within the data, where, for example, an AIS transponder may be switched on or off during a ship's passage or be defective, thereby not capturing the full transit. Errors with the positioning system can provide inaccurate locations. Transmitted information such as Maritime Mobile Service Identity (MMSI) numbers, vessel type or dimensions can also be incorrectly entered, thereby providing an additional degree of uncertainty.
Verification of Fishing Activity	AIS offers a high level of resolution to assess fishing activity in space and time but an essential piece of information on the catches and targeted species is missing. Reference to logbooks remains thus essential.

2.1.5 Technical guidance on the potential use of AIS to assess spatial distribution of fishing effort and physical disturbance pressures on the seabed in MSFD marine waters

In the EU, AIS has become compulsory since May 2014 for all fishing vessels of more than 15 meters of length (EU Commission, 2011) providing a potential alternative source of data to map fishing activities and impacts to the environment. The use of AIS data sets in fisheries research has dramatically increased in the last years, and several national and supranational initiatives had proven the added value of AIS data coupled with the official vessel monitoring systems in detecting large scale fishing vessel's movements (Table 3).

This document intends to report on the potential use of AIS to calculate spatial distribution of fishing effort (mW fishing hours) and surface and subsurface disturbance by mobile bottom-contacting fishing gear (average swept area ratios, SAR) similarly as for VMS (Eigaard *et al.*, 2015).

2.1.5.1 Mapping fishing effort with AIS coupled with VMS and logbook

AIS data is noisy and need a series of cleaning routines and validation by coupling of other data sets, like logbook and VMS data sets. The coupling of VMS and AIS datasets increases the temporal and spatial resolution of the fishing vessel's track and eliminates the need for interpolation of vessel trajectory from two VMS data points when using only VMS and logbook data.

However, the coupling of VMS, AIS data and logbook data is not yet a standardized product that can be used in the assessment of MSFD D6. Only a few EU countries provide fisheries scientists with AIS and VMS harmonized datasets (see section 2.1.1.2).

Further complications to the coupling of data sets are the lack of unique global identifiers for the world fishing fleet. Alternatives to this include the use of machine learning to infer fishing activity.

2.1.5.2 Spatial distribution of average annual fishing effort

Maps of spatial distribution of average fishing effort show the distribution of effort (MW fishing hours) by vessels >15 m using AIS coupled with logbook. The number of hours fished is provided with the VMS and logbook data call.

The fishing effort methodology works under the assumption that the vessel slows down while it is engaged in fishing. This is true for mobile bottom contacting gears, or, in general for those gears that when used in fishing are characterized by changes in speed and in the direction (e.g., purse seiners - Bez *et al.,* 2011).

The speed filter is calculated automatically from VMS and Logbook data. The threshold is set arbitrarily or with the help of domain expert knowledge (Eigaard *et al.*, 2015). Speed filter is calibrated on every single vessel or estimated from other vessels using similar fishing gears.

The distribution of fishing effort (mW fishing hours) by vessels > 15 m using AIS for MSFD assessments need to take into consideration both the gear used and when possible, the *metier.*

In some countries, AIS coverage extends to fishing vessels shorter than 12 m (see section 2.1.2). Gear information is not available in AIS data and when taken from the fleet register, it is just an indication of the main gear used (in the EU there are three to five gears) and not the gear used in the trip. The EU fleet register is available only for EU vessels. For other vessels: FAO Fishing Vessel Finder, Regional Fisheries Management Organization (e.g., ICATT species-based registries) or national fleet registers can be used.

Total effort calculated on AIS data is generally lower than with VMS + logbook data with varying degrees depending on the gear/metier attribution process and on the coverage. However, estimation of fishing effort using combined AIS, VMS and logbook data could greatly improve the spatial and temporal resolution. Fishing effort by vessels < 12 m may be significant, especially in the inshore areas. However, these vessels are not required to have VMS nor AIS and information on the spatial distribution of their effort is very limited.

2.1.5.3 Average annual surface and subsurface disturbance by mobile bottom-contacting fishing gear, expressed as average swept-area ratios

Swept area ratio is calculated as hours fished × average fishing speed × gear width. The gear width, expressed as surface and subsurface bottom contact, is estimated based on relationships between average gear widths and average vessel length or engine power (kW), as stated in Eigaard *et al.* (2015) and using expert input.

The swept-area ratio is calculated for all 0.05 × 0.05-degree grid cells in the ecoregion and is the sum of the swept area divided by the area of each grid cell. The resultant values indicate the theoretical number of times the entire grid cell area would have been swept if effort were evenly distributed within each cell. The swept-area ratio is calculated separately for surface and subsurface contact (Eigaard *et al.*, 2015).

AIS coupled to VMS and logbook can improve the temporal and spatial resolution of fishing effort allowing for the assessment of physical disturbance on the benthos. However, since gear information is not available in AIS data linked to a fleet register, indications of the main gear are used instead of the real gear used in the trip. Therefore, swept area ratio calculated on AIS plus fleet register data can be underestimated as compared to VMS and logbook data.

Swept area calculation should be based on logbook data and values should be estimated and only when the logbook data is not available.

2.1.6 Applicability in EU waters

Given the disadvantages of using AIS and fleet register data only listed in section 2.1.3, this method is considered less applicable to produce an indicator such as MSFD D6 on the scale of all EU waters. Particularly in the North Sea region and surrounding waters where VMS and logbook data are available and routinely analysed on member state level.

In principle any benthic indicator, including specific gear dimensions can be calculated with a (theoretical) 100% coverage of the fishing fleet (vessels >12 m). Nevertheless, in areas where routine-based VMS and logbook analysis are lacking the method (AIS + fleet register) can provide an estimate of fishing hours, albeit uncertain and subjected to the inherent disadvantages, for the most used gears. Fishing hours for a certain gear class could be used as a proxy for sea floor integrity.

There is a rapid technological development in the area and presently the control regulation is under revision and the commission proposal contains several suggestions to facilitate and increase the amount of spatial information from the fishing fleet. As an example, all vessels are suggested to be equipped with a device to collect and store geographical information. There are numerous examples throughout the member states on various technical solutions to collect spatial information from small scale fisheries. Seen in a long to medium term perspective and given the six-years cycle of the MSFD reporting it is therefore likely that spatial information on the fishing vessels could come from various technical platforms, such as VMS, AIS and/or black-box GPS solutions. In this perspective the value of an indicator builds from only one of these sources of spatial information can be questioned, especially with a weak or no direct coupling to the fishermen logbook and the total effort information. A coupling which, due to the legal protection of the logbook contents, needs to be performed at a member state level.

2.1.7 Conclusions

Using AIS in combination with VMS and logbooks will associate more pings with fishing activity, relative to VMS alone, and thereby making it possible to create SARs at more highly resolved spatial scale. However, as AIS is different to VMS in various ways, using AIS as a supplementary data source will add different uncertainties to the resulting data product: At present, VMS will usually have a temporal resolution of 1 or 2 hour depending on country. This results in a uniform uncertainty and fits well with the spatial resolution of the 0.05 C-square. The temporal resolution of AIS is generally higher but with a much more variable frequency, and often there are long gaps in the data, because either the vessel is outside range of an AIS receiver, or the vessel turns the AIS off. The result is a much more variable uncertainty, both temporally and spatially.

Furthermore, AIS is not bound to the vessel, and therefore it can be a challenge to link an AIS signal to a correct vessel. The timestamp column in the AIS data is not linked to a specific time zone. Therefore, it can be challenging to merge with VMS, as they will not align if recorded as different time zones. If the wrong time zone is implemented, time intervals between AIS and VMS pings will not be correct.

The coupling of AIS and VMS data sets is further complicated by the lack of unique identifiers for the global fishing fleet. Neither the International Maritime Organization number (IMO), nor alternative unique id's cover the entire fishing fleet. Alternative unique IDs that are provided with the AIS data are usually the Mobile Maritime Service Identity (MMSI), which is not unique to a vessel, the Callsign, a radio signal attributed by the National organizations through the International Communication Union that is also not unique. An FAO project is currently testing the use of global ids to improve the coupling and aligning of fishing vessels data and to create a global fishing fleet register where every fishing vessel has a unique global ID.

2.1.8 Recommendations

WGSFD considered the following recommendations should be considered when assessing fishing activity using AIS, VMS, and logbook data:

1. If AIS is combined with VMS and logbooks to create SARs, an uncertainty assessment for each reported SAR should be attached. This could for example reflect the average temporal intervals between pings in each cell.
2. Each member state's maritime authorities should collect AIS data for its own vessels and add vessel ID to the data and check it against the VMS, to see if the time zones are aligned, before AIS from the fishing vessels are delivered to the data submitters.
3. Data quality of linked AIS, VMS and logbook data could be greatly improved if ancillary data sources could contain a common field: for example, the MMSI.
4. The ICES VMS data set currently provides a better tool for analysis of spatial distribution of fishing effort than AIS alone can, in the waters of the CFP.
5. A proper comparison of VMS and AIS datasets can only be possible when AIS streams feed into the WGSFD workflow.
6. In the absence of ancillary data on gear type, machine learning or other analytical approaches should be used to assign an estimated fishing gear used, as opposed to, for example, assigning a main gear used during the year from a fleet register. Machine learning models, however, require a considerable amount of data to be used in the training

process. Training labels would be the vessel's fishing track with the indication from logbook data of the real gear used, the hauling times and the landings. Logbook data are kept at national, or fisheries lab level and they are available to national fisheries scientists but difficult to access to external researchers.

2.2 In response to ToR b)

Evaluating need and possibility to move towards higher spatial resolution in the ICES VMS data call

Using interpolation methods, make a voluntary test data call for a couple of countries within WGSFD on submitting data on c-squares on a 0.01-degree resolution instead of the current 0.05-degree resolution.

As with the previous term of reference, most of the progress on this was made during the 2019 meeting. There has not been a notable increase in VMS ping frequencies during 2020 or 2021, therefore the conclusions arrived at during this meeting remain valid.

The current spatial resolution specified in the ICES VMS data call was arrived at after process of extensive consultation over several years (e.g., ICES, 2011). It represents an optimum solution to the problem of gridding three-dimensional point data (latitude, longitude, and time) in a two-dimensional form. At latitudes where the bulk of fishing activity in EU waters of the northeast Atlantic takes place, the 0.05 decimal degree resolution of the grid is roughly equivalent to the distance a vessel travelling at speeds indicative of fishing activity can travel in the two-hour interval between pings mandated in European legislation (European Commission, 2011b). Using this resolution minimises the possibility that a vessel can cross one or more grid cells without being recorded, introducing artificial granularity into output data products.

A voluntary data call for national administrations to provide raw point VMS data was not carried out, and therefore no data of this nature was available to the group during the 2019 meeting. Two alternatives were explored – the simulation of VMS data through sub-sampling Icelandic AIS data at hourly intervals, and the interpolation of NEAFC VMS data, which has been used to validate putative fishing "tows" in the NEAFC Regulatory Area under previous terms of reference.

Icelandic AIS data was available within the group, with a temporal resolution of 5-10 minutes. A linear extrapolation of the data was done using a 1-minute resolution but at the same time retaining the original data by adding a variable to the data set indicating if a value is an observation or an extrapolated data point. An emulation of VMS data with hourly ping rate was created by extracting the records on the full hour.

Not unexpectedly, the number of squares containing fishing activity decreases with increasing resolution, and for any given resolution, increases with increasing ping rate (Figure 4A) while the estimates of the area swept, by law of arithmetic, is independent of both spatial and temporal resolution (Figure 4B).

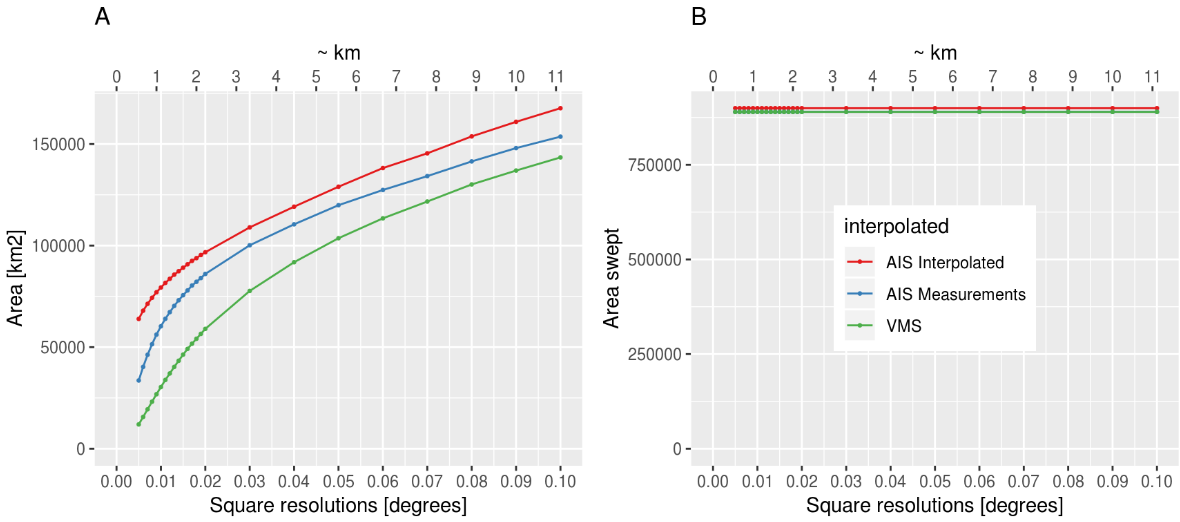

Figure 3. Perceptions of Area impacted by fishing (left) and Swept Area (right) using interpolated AIS, raw AIS, and simulated VMS from the Icelandic fleet, gridded at a range of spatial resolutions from 0.005 to 0.1 decimal degrees.

At the 0.05 decimal degree resolution that the current data call is based on, there is relatively little difference in the SAR pattern between a 1-minute interpolated resolution, a 5–10-minute measurement resolution and a simulated VMS resolution of 60 minutes (Figure 5). Of note here though is that any "erroneous points", where temporary malfunctions of VMS equipment result in reported positions considerable distances from preceding and subsequent points, in the actual AIS/VMS data can have considerable impact when it comes to interpolation. These points would need somehow to be first filtered out an initial screening of the data.

Moving to a 0.01 x 0.01 decimal resolution if the temporal resolution of the data is 1 hour or more will however results in a very patchy map, which by nature we know is continuous.

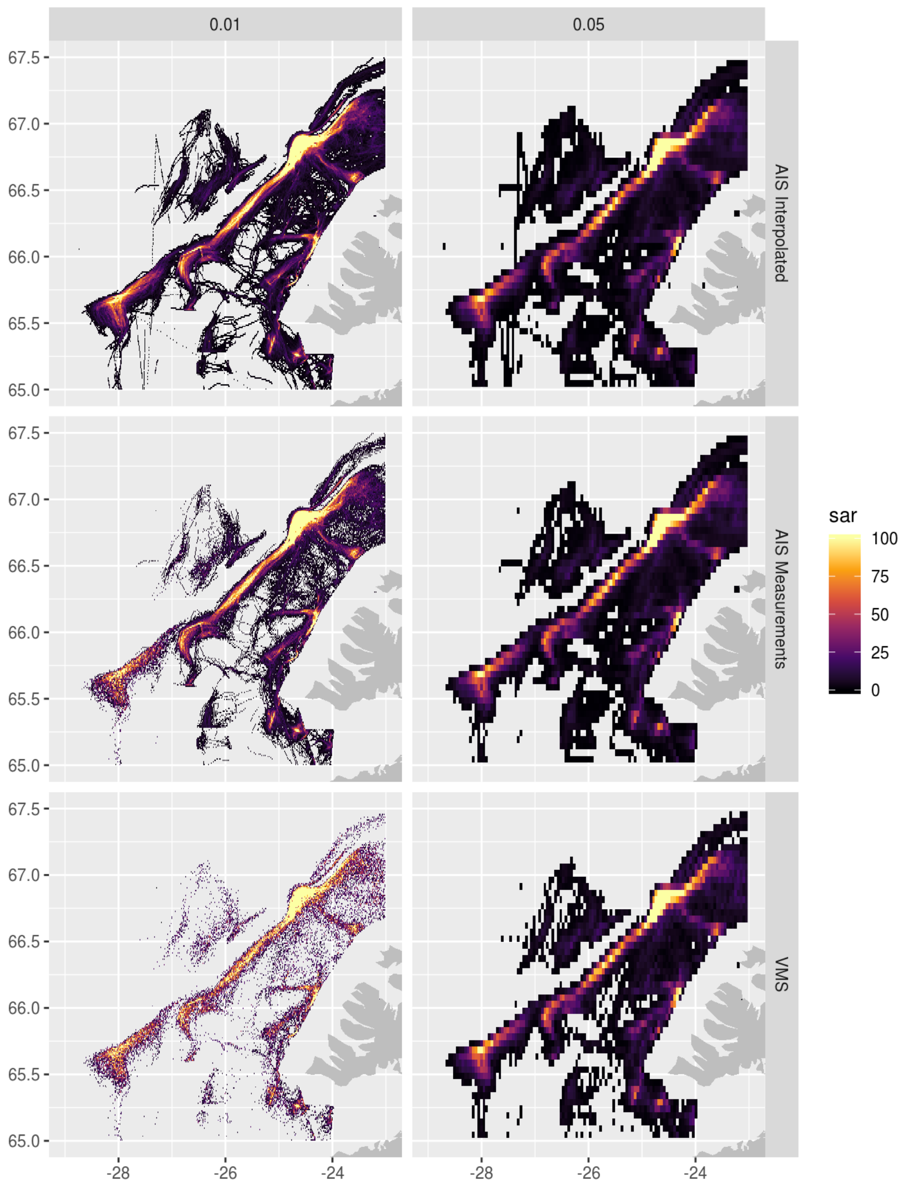

Figure 4. Maps of effort at 0.01 and 0.05 decimal degree resolutions of interpolated AIS, raw AIS, and simulated VMS data from the Icelandic fleet.

A subset of NEAFC VMS data, processed as described in ToR F, for mobile bottom contact gears on the north part of Hatton Bank was used to examine the effect of increasing spatial resolution. Examination of the maps generated shows that interpolation alone has little effect on perception of the distribution of effort (Figure 6, Figure 7). Increasing spatial resolution at which effort is gridded results in a much noisier picture (Figure 8), which can be counteracted by interpolation between points (Figure 9). This highlights that, for certain gears fishing on relatively homogenous substrates, interpolation can be used as a valid means of improving the resolution of VMS data. It should however be emphasised that there is a degree of uncertainty associated with these interpolated positions. While interpolation methods a reasonably accurate in predicting fishing behaviour for certain trawl gears (e.g., Hintzen *et al.*, 2010), their use may not be appropriate for seines and static gears, or in areas where the bathymetry is highly structured and fishing direction is determined by the need to follow a depth contour.

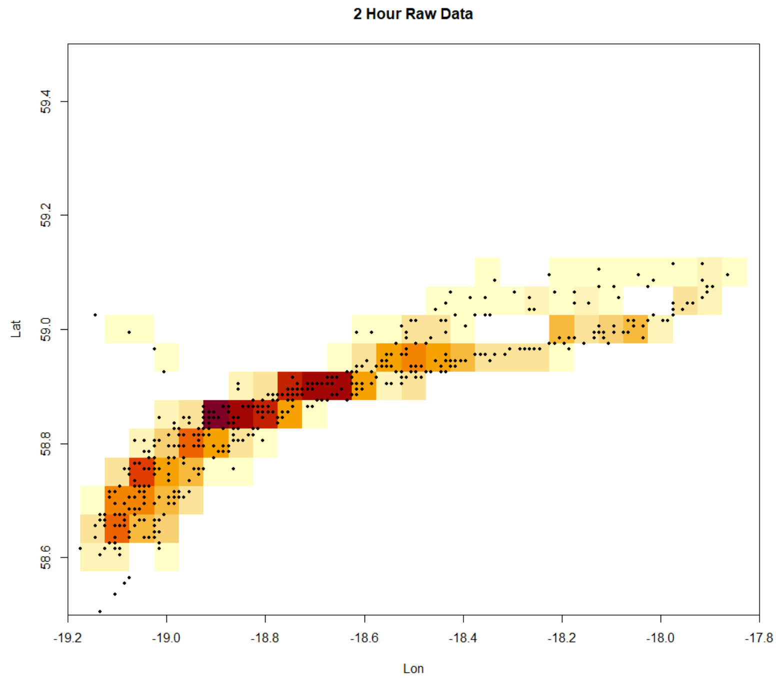

Figure 5. Two-hourly NEAFC VMS data gridded at 0.05 decimal degrees.

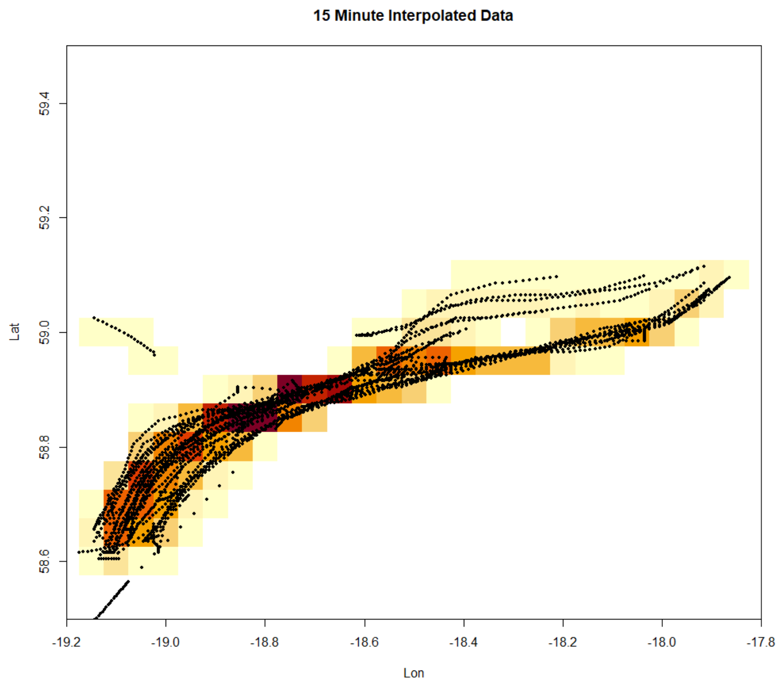

Figure 6. NEAFC VMS data interpolated at 15-minute intervals, gridded at 0.05 decimal degrees.

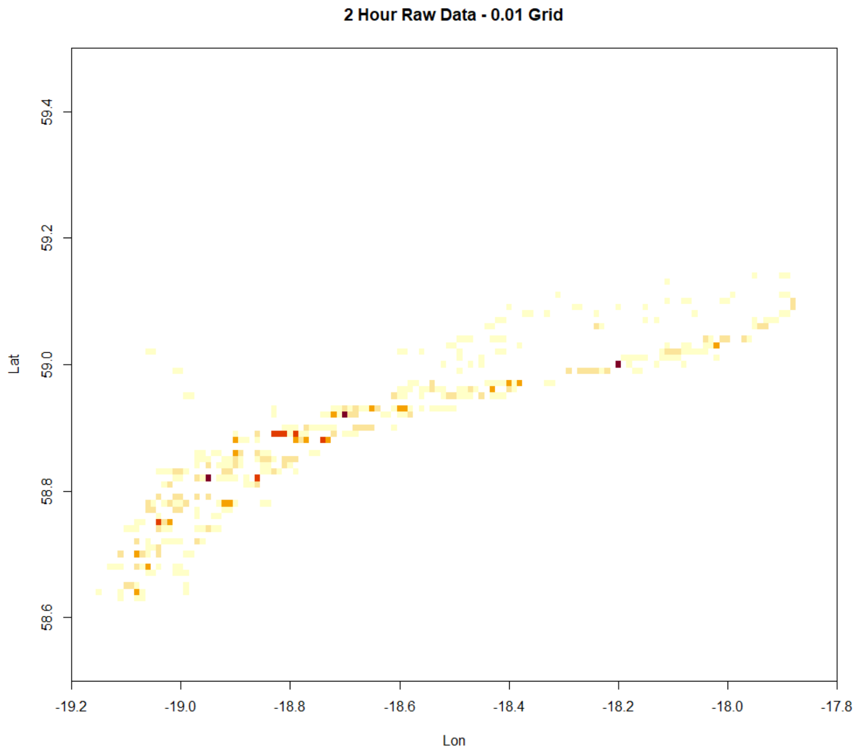

Figure 7. Two-hourly NEAFC VMS data gridded at 0.01 decimal degrees.

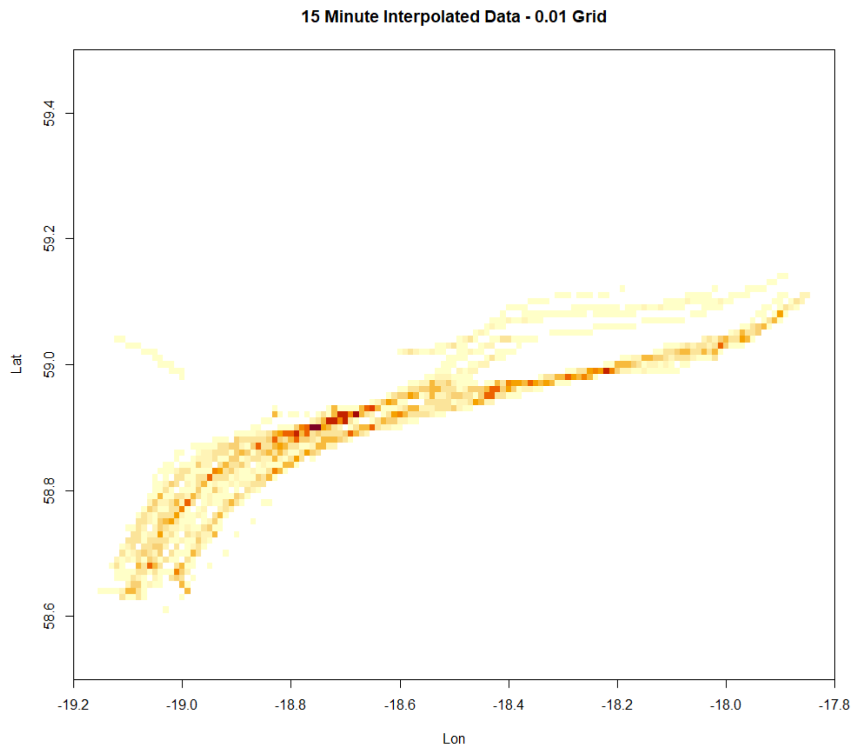

Figure 8. NEAFC VMS data interpolated at 15-minute intervals, gridded at 0.01 decimal degrees.

In conclusion, based on analysis of the Icelandic and NEAFC data, indications are that making a data call for a 0.01 x 0.01-degree resolution of VMS data that is of temporal resolution of 1 hour or more is not likely to improve the current map products generated. Interpolation between points, for some gears in some areas, can improve the situation, however, is likely to introduce its own uncertainties.

2.3 In response to ToR c)

Development of spatial effort indicators for static gears:

To estimate the effort of the passive fishing gear, other parameters (soaking time, gear length, number of hooks etc.) are needed. During the next term, WGSFD will further evaluate whether these parameters can be estimated from VMS, fleet characteristics and observer data to produce speed filter and describe typology of various fishing events for different gear categories.

The development of a consistent approach to estimation of fishing effort by vessels using static gears is a key challenge which, when addressed, will facilitate the development of comprehensive overviews of fishery activity, identification, and mitigation of areas of gear conflict and better interpretation of trends in landings data from static gear fisheries. While data on the spatial and temporal distribution of fishing activity from vessels using static gears, and the associated catch, is available through the ICES VMS and logbook data call, the additional information needed to translate this into meaningful indicators of effort has been lacking. WGSFD have investigated whether such information is available, however the overall conclusion has been that it is not, and therefore WGSFD has not been able to progress this term of reference to a satisfactory conclusion during its present term. Efforts instead have focussed on identifying shortcomings and areas where additional data is required and proposing potential solutions. A follow-up term of reference on static gears has been proposed for the next term of the group.

VMS data availability for static gear fisheries

Fishing with static gears is often an inshore activity carried out using relatively small vessels. A substantial proportion of the vessels fishing with passive gears are below the length at which vessels are required to carry VMS equipment, and in some cases the requirement to carry logbooks.

Table 8 shows a summary of VMS coverage for vessels fishing with static gears, averaged over 2018-2021 from the logbook data submitted in the ICES VMS/Logbook data call. The table can only show the coverage of VMS for vessels that have logbooks and is therefore missing the part of the fleet that does not have logbooks (<10 m, or <8 m in the Baltic). This table can assist in focusing on the development of indicators where existing VMS data are available but other key parameters for estimating static gear fishing effort are missing.

Table 8. Fishing effort (MW hours fished) for static gear groups, by ICES area, for 2019 and 2020.

ICES Area	Longlines		Nets		Traps	
	2019	2020	2019	2020	2019	2020
1.b	1937	3916	113	53	-	-
10.b	13617	7412	-	-	-	-
12.a	332	220	1575	671	-	-
12.b	172	571	7	17	-	-
12.c	961	865	-	-	-	-
14.a	2503	1911	209	-	-	-
14.b.2	30956	30203	5276	4717	6	47
2.a.2	3988	3226	-	-	-	-
3.a.20	18636	13959	5636	6941	643	114
3.c.22	66287	58138	18880	10966	-	-
3.d.26	7478	13114	67	35	16	4382
3.d.27	256	338	374	513	306	-
3.d.28.1	92	328	25	23	-	-
3.d.28.2	316	562	176	205	41	-
4.a	-	-	253	193	1	52
4.b	1	-	1490	688	8	24
4.c	79	44	8186	7747	3603	4857
5.a.1	-	-	-	-	-	5
5.a.2	-	-	2169	889	1554	3618
5.b.1.b	1043	487	-	-	-	-
5.b.2	14786	10258	2036	3335	1588	1181
6.b.2	4256	3656	4485	3951	-	-
7.b	2099	2598	4654	8472	2844	1137
7.c.2	7705	3079	6881	7639	-	-
7.d	-	3	4	238	915	193
7.e	42	190	4873	3301	987	5905
7.f	486	1639	7448	8594	5714	3033
7.g	-	46	-	186	253	24
7.h	1364	466	3349	6586	-	152
7.j.2	2002	1327	2406	2753	183	6
8.a	13388	15373	20998	15888	501	181
8.b	6056	6794	37868	27866	3312	3519
8.c	1508	1298	1655	5031	181	447
8.d.2	4875	5662	31002	19614	393	52
8.e.2	588	363	210	708	5	2
9.a	1476	3417	3183	17014	222	8

VMS data as an indicator of static gear fishing activity

Further to the issue highlighted above, VMS data is typically reported at time interval of up to two hours. Fishing with static gears is typically a two-stage process, with a vessel travelling relatively quickly while deploying gears (5-10 knots) followed by a period at slow speed (0-2 knots) while retrieving gears. The speeds observed when is shooting its gears overlap with steaming speeds, creating significant difficulties in the development and application of a speed threshold to determine the location of fishing.

Availability of Ancillary Data

WGSFD carried out a scoping exercise to assess the availability of additional static gear fisheries data through a questionnaire survey of WGSFD delegates, with a view to developing and incorporating additional data requests within future ICES data calls. Responses are summarised below and revealed that data available for static gear fisheries vary from country to country but are in no way comprehensive or uniformly available.

- Information on soaking time, is occasionally recorded in logbooks, but nowhere is it mandatory, therefore availability is patchy. As a logbook entry it is also therefore not available for smaller vessels. Soaking time is further considered a questionable metric of effort for LPUE/CPUE calculation.
- Measures of gear dimension such as net length, net height, number of hooks, pots etc. are also not widely recorded currently. For some fisheries, such as larger vivier crab vessels, number of pots used is available, but such information is not available for smaller scale fisheries.
- Observer data could be used as a source of information for some of the missing technical parameters (estimates of pot numbers, net lengths, no. hooks) but this is likely to be highly specific to fleet and fishery, variable within a fleet to some extent, and hard to generalise without wider data collection process.
- Industry interviews carried out in some countries have highlighted the variability between vessels in this regard.

These caveats notwithstanding, it is possible to map activities by vessels fishing with static gears using the data collected in the ICES VMS and Logbook data call (Figure 10, Figure 11, Figure 12). Such maps should however be seen as relative indicators of areas of high and low fishing activities, rather than absolute indicators of effort due to the uncertainties outlined above.

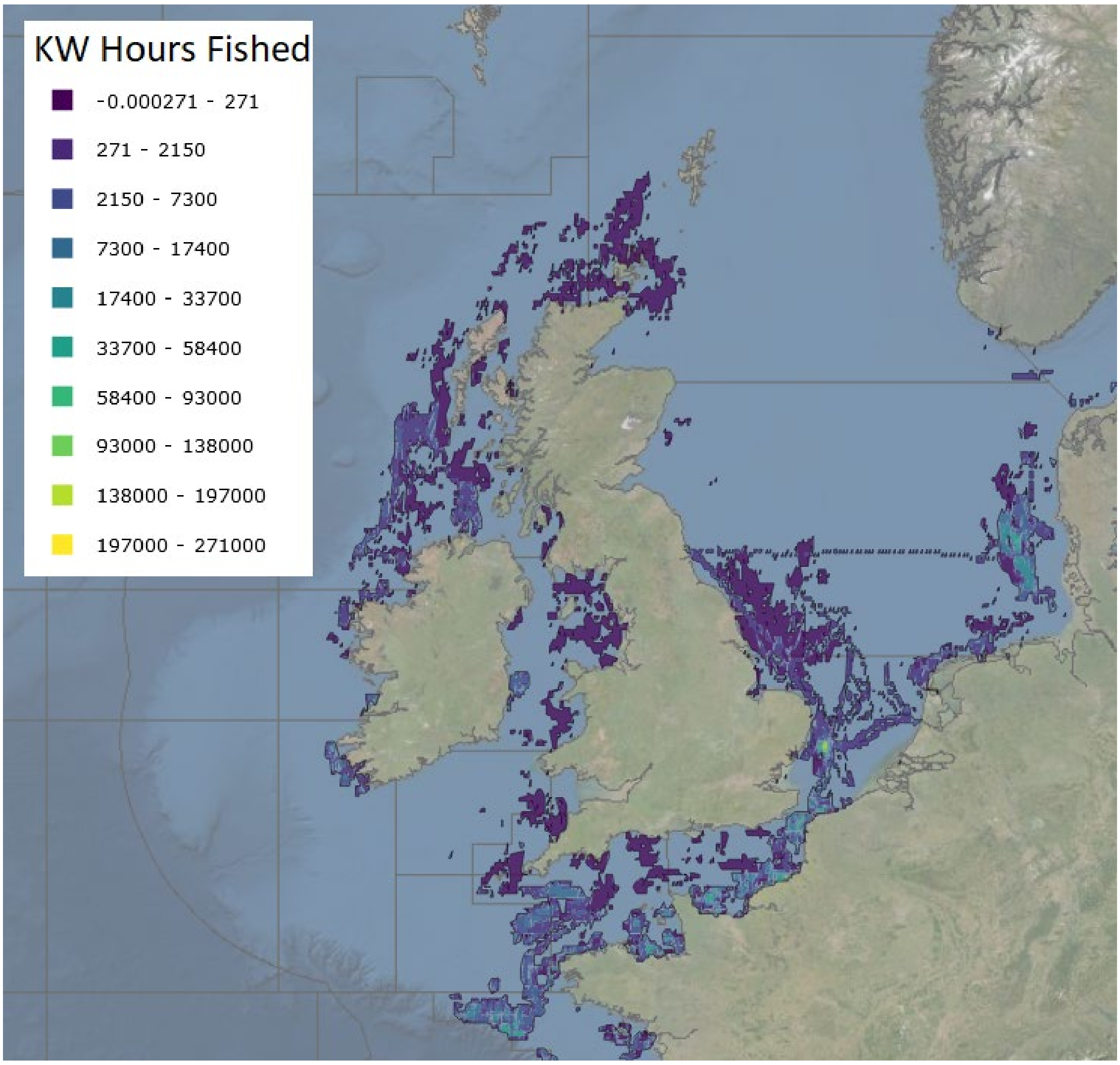

Figure 9. Fishing "effort" (KW Hours Fished) for vessels using pots & traps, 2020.

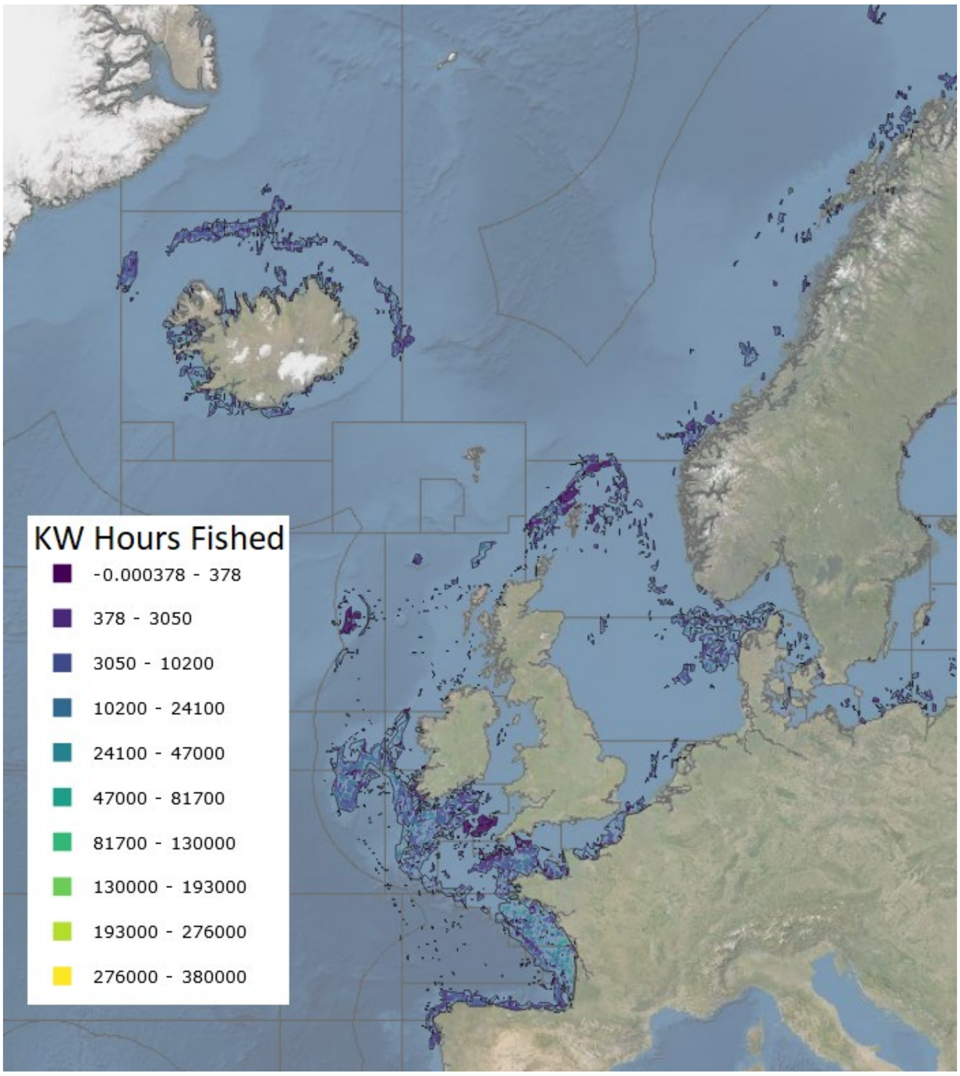

Figure 10. Fishing "effort" (KW Hours fished) for vessels using entangling nets, 2020.

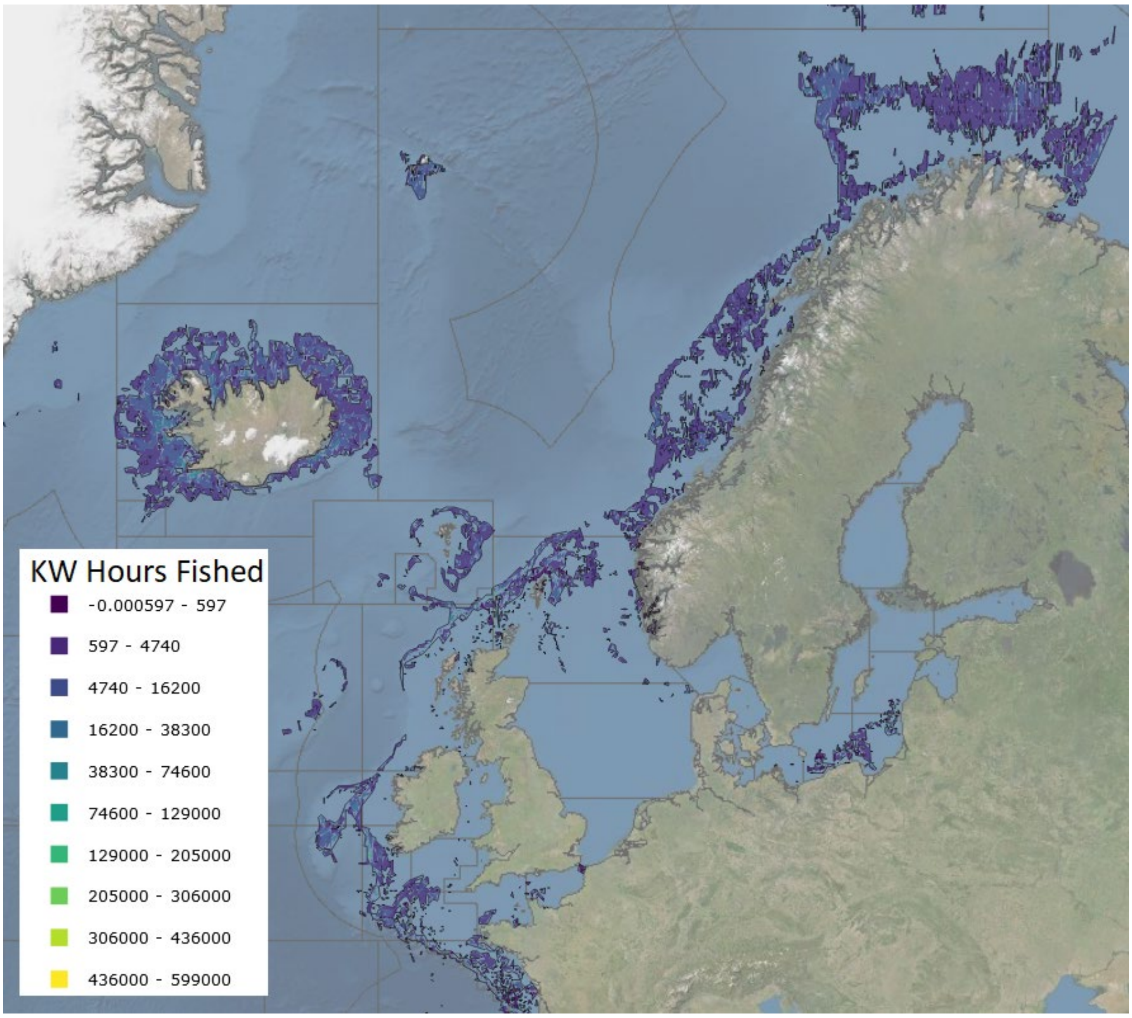

Figure 11. Fishing "effort" (KW Hours Fished) for vessels using longlines, 2020.

Conclusions

It has become apparent that although VMS data can be used to highlight locations where fishing with static gears takes place, and to perform some relative analysis of areas of higher and lower effort, its low polling frequency means is not an appropriate tool to make quantitative conclusions about effort distributions. WGSFD cannot answer questions about effort metrics for static gear fisheries with the data which is available to the group (Table 9).

Table 9. Issues identified with the use of VMS as an indicator of effort in static gear fisheries.

Problem	Solution	Benefits	Drawbacks
Polling frequency of VMS data is not high enough to capture fishing activity.	Increase the polling frequency for vessels deploying static gears, or fishing in areas of interest, and provide specific instruction to WGSFD to examine this.	Uses a mature system for data collection and provision for analysis.	Cost implications for states and fishers in increased frequency of VMS polling.
	Use alternate sources of spatial data, such as electronic monitoring "black box" systems	High frequency of data collection allows accurate estimation of fishing activity	Typically only available for specific fleet sectors, and not through the VMS system and associated data calls.
Lack of information on gear dimensions.	Arrange a "Bethis" type project to conduct the groundwork for which products such as the swept area ratio calcuations for mobile bottom contacting gears relies upon.	Required to fill the information gaps regarding static gears.	Unlikely to deliver usable advice for several years
Lack of resolution within metier	Current metier definitions are likely to cover multiple fisheries using very different gears, e.g. pots for crabs, lobsters and *Nephrops*, or gillnets for fish ranging from close inshore to the shelf slope.	Allow specific coding for these groups if distribution of their fisheries is of interest.	Introduces more complexity to the data call.

2.4 In response to ToR d)

Identifying potential drivers and describing spatial conflicts of fisheries in the past and future on dis-placement of fishing activities over various timescales

Fisheries territories are defined by operating conditions and fish availability. Changes in fish resource distribution and accessibility to fishers due to climate change, management measures and other human uses (MPA, marine traffic, gravel extraction, wind farms, oil rigs, and seismic survey) may result in displacements of effort when competition occurs for a given space.

Displacement of fishing activity from current fishing grounds could result in a reallocation of the fishing effort to more sensitive habitats or habitats which traditionally have not been fished potentially increasing the habitat damage in these areas. Displacement can also impact fisheries efficiency with an increase to the cost of the fishing operation or increasing the amount of by-catch species (Bastardie *et al.*, 2013).

During the 2019 WGSFD meeting, a dataset combining the fishing VMS and logbook data submitted by the ICES member states has been used to produce a 10-year time-series of fishing effort. This newly available dataset provides high resolution spatiotemporal fishing effort, weight landed and economic catch value parameters describing the trends in use of the European seas by different fisheries and will be used to estimate the spatial variability of these fisheries over time.

Considering the above, the overarching aim of the ToR D is to explain the spatiotemporal variability of the fishing intensity using environmental and economic explanatory variables. And consequently, be able to identify likely displacement locations of fisheries in the case of a marine space becoming occupied by another industrial activity incompatible with fishing operations. ToR D has been approached as two sections:

1. Modelling the suitable fishing habitats by fishery type using environmental and economic explanatory variables.
2. Evaluation of the spatio-temporal variability of fishing effort as result of conflict with other human activities uses of marine space and the implementation of regulatory fishing restricted access areas.

2.4.1 Modelling the suitable fishing habitats by fishery type using environmental and economic explanatory variables

The first task will carry out a decadal view analysis on fisheries distribution and variability over time which is currently lacking from the literature. This analysis is now possible because of the information now available through the ICES data-calls on VMS and logbook data, providing a valuable data source to investigate, describe and explain the spatiotemporal use of European seas by different fisheries. Under the current ToR, work started under ToR J (2016–2018 WGSFD), which aimed to quantify and explain spatiotemporal variability of fishing fleets across the ICES area, is continued. This modelling framework, once validated, can be used to predict displacement and interactions between fishing fleets. The spatial and temporal distribution of fishing fleets (gear / metier specific) will be modelled depending on several co-variates. In 2018 and 2019 effort was focussed on gathering the relevant co-variates and merging these together into one data file. A selection of co-variates was collected (Table 10), with a focus on working first on beam trawl fishing in the North Sea:

Table 10. Covariates collected as a baseline for model development.

Co-variate	Type	Description
c_square	chr	Identification of c-square location
Year	int	Year field (2009-2014, to be expanded to 2018)
Month	int	Month field (1-12)
in_shore	logi	Identifier if c-square is inshore or not
distance_coast_avg	num	Distance to coast for c-square location
bpi5	num	Bathymetric position index (range of 5km)
bpi10	num	Bathymetric position index (range of 10km)
bpi30	num	Bathymetric position index (range of 30km)
bpi50	num	Bathymetric position index (range of 50km)
bpi75	num	Bathymetric position index (range of 75km)
tac_ple	int	TAC of plaice in the North Sea
tac_sol	int	TAC of sole in the North Sea
mud_percent	num	Percentage of mud inside a c-square
sand_percent	num	Percentage of sand inside a c-square
gravel_percent	num	Percentage of gravel inside a c-square
total_d50	num	Identifier of rock content inside a c-square
Tidalvelmean	num	Mean tidal velocity
oil_price	num	Oil price by month
sea_bottom_temp	num	Sea bottom temperature inside a c-square
metier_benth	chr	Benthis metier
Totweight	num	Total weight of the catch inside a c-square
Totvalue	num	Total value of the catch inside a c-square
kw_fishinghours	num	Total kw-hours of fishing inside a c-square
fishing_hours	num	Total fishing hours inside a c-square
Lat	num	Latitudinal midpoint of the c-square
Lon	num	Longitudinal midpoint of the c-square

Exploratory GAM models were fitted but results of these are not ready for dissemination. Intersessionally, INLA models (see ICES, 2018) will be fitted to the data and investigated for goodness of fit.

2.4.2 Analysis of the spatiotemporal variability of fishing effort in areas with limited access for fishing operations

There is an increasing trend in the use of the marine environment for human activities and therefore a growing need for consideration of the cumulative impacts and interactions between these activities to manage them in a way which considers resource sustainability and ensures conservation of the ecosystem and associated services are maintained. Within European waters under the Marine Strategy Framework Directive (MSFD) directives examples of such areas include Natura 2000 and national level implementation of MPAs.

Work previously carried out by WGSFD on recent spatial and temporal distribution of fishing effort data at high resolution has shown that, for example, only 23% of the Great North ICES ecoregions area is persistently unfished by bottom contact fishing gears (ICES, 2017). This evidence demonstrates that the implementation of a protected or restricted area or use of marine space by another industrial activity is highly likely to directly affect existing fishing activities and consequently displace them to other areas or alternative gears.

Understanding the drivers and processes of displacement could contribute to more effective management, estimation of the redistribution of effort and prediction of the associated impacts (positive or negative) of future marine uses, ecosystem protections or climate change scenarios. Understanding, quantifying, and predicting the links and effects between the different human activities and their interactions will help managers to achieve the aims of the MSFD (adopted in 2008) to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.

In addition, the WGSFD have been collecting datasets related to potential fishing access restriction areas including Marine Protected Areas, areas with *in-situ* management regulations, windfarm licensed areas (and their status; operational, under construction, etc.), offshore oil and gas platforms, and marine aggregate licensed areas among others. By integrating all these datasets in a Relation Spatial Database Server (PostgreSQL/PostGIS) and using a spatial-temporal overlapping model we aim to identify and quantify which of these other activities has greater effect in the decrease or increase of fishing effort in their area of influence (Figure 13).

To deliver on the second part of the term of reference, a spatial database will be created including the location of other human activities and conservation protected areas.

However, this industrial activity varies from licensed boundaries to actual construction progress in space and in time, therefore is important achieve the highest temporal and spatial resolution available of these individual developments. As an example, the windfarm construction varies from the prior licensed area extension with the actual development over time. The location of these other human activities is evaluated by dedicated ICES working groups like the ICES Workshop on Scoping for Benthic Pressure Layers D6C2 - from methods to operational data products (WKBEDPRES) or Working Group on Marine Spatial Planning (WGMSP). There was a special request to WGSFD regarding advice on the potential to provide high-resolution fishing effort information than the current advice at -.05 degrees. This collaboration can provide us the spatial, temporal and intensity distribution of industrial activities within ICES ecoregions and related ecosystems.

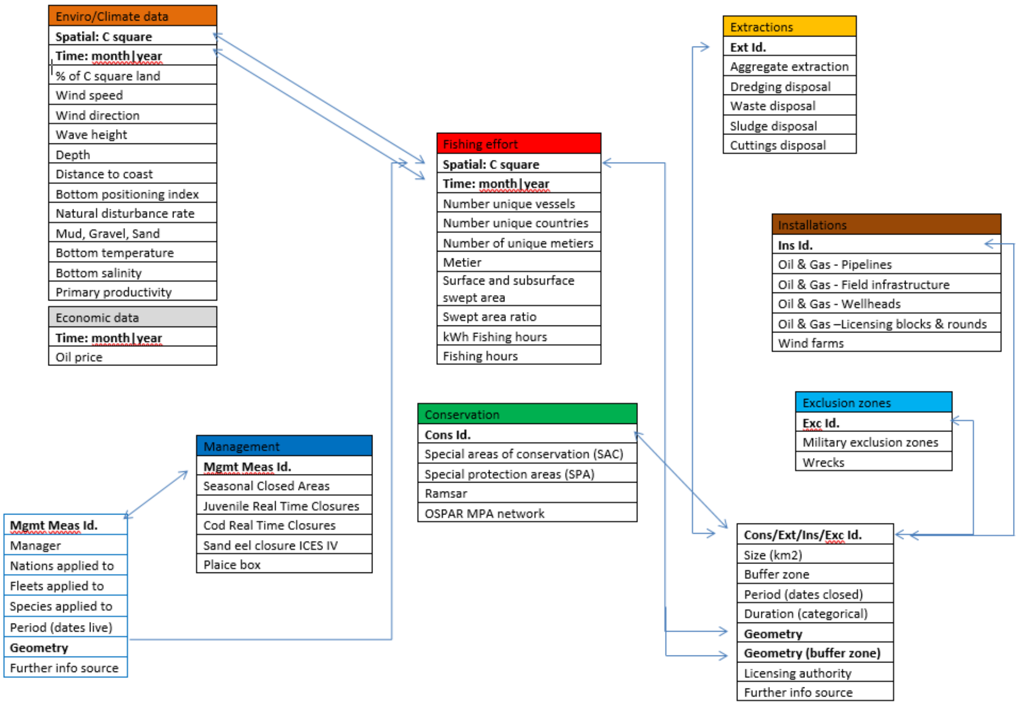

Figure 12. Diagram of the Relational Database Model designed to store and perform efficiently spatiotemporal queries over the spatial fisheries, marine regulatory areas and other human activities licensed and used areas.

A variety of displacement drivers have been assessed including implementation of regulation measures (MPA, quotas, restrictions, etc.) and other human activities occurring in the same space of existing fishing activity.

2.4.3 Greater North Sea ICS Ecoregion Case of Study

The Greater North Sea ecoregion, ICES Subarea 4, Divisions 3a and 7d, was chosen as the case study for this analysis. This is an area with large historical fishing activity using multiple gear types and a recent increase in other human activities in the area including windfarms, oil and gas platforms, marine aggregate industry, etc. Since this area has such prevalent use of marine space it is likely to be negatively affected by the impacts of these activities and it has been set conservation priorities through the implementation of an international MPA network and Natura 2000 protected areas. The establishment of these protected areas, aiming to achieve conservation objectives, could influence the fishing industry operating within and near designated protected areas.

Firstly, an analysis was run to identify the most common fishing fleets operating in the Greater North Sea, to focus on these fisheries, and quantify their effort variability, and its overlap in time and space with the other major activities using marine resources and space.

The fishing activity analysis indicates that beam trawlers targeting demersal species (TBB_DEF) are the metier with the highest fishing hours in the ICES subarea 4 (Figure 14). The effort related to this fishery increases over the 2009–2018-year period, reaching 50% of the total effort in the greater North Sea in 2018. Meanwhile the second most intense fishing fleet (up to 20% of the total fishing effort in 2018) are the vessels using otter trawlers and targeting demersal fishes. These fisheries are followed by the beam trawlers and otter trawlers targeting crustaceans (representing 10% and 2% respectively).

The TBB_DEF fishing operations are constrained to the southern North Sea (mainly area 4c and partially 4b). Whereas the OTB_DEF activity is more evenly distributed over the whole greater North Sea ICES ecoregion, although large amount of effort is concentrated in the northern North Sea (Figure 11 and 12).

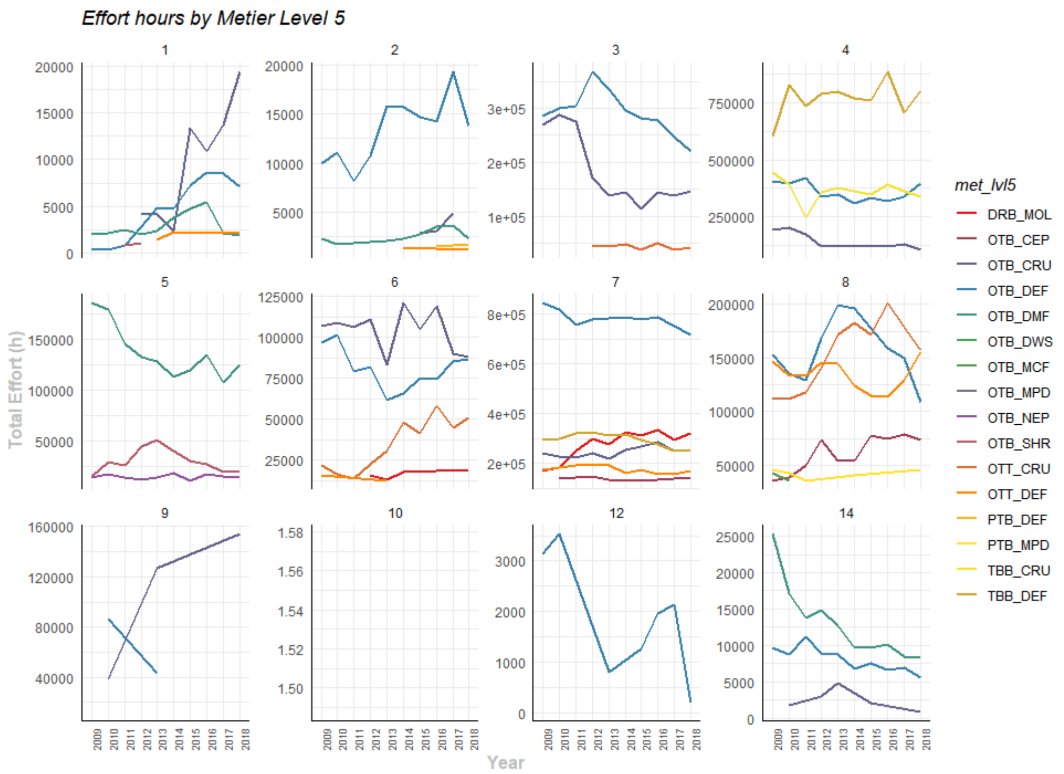

Figure 13. Graphs with the total effort hours by metiers level 5 and year within the ICES Divisions. The graphs numbers title indicates the corresponding ICES Division.

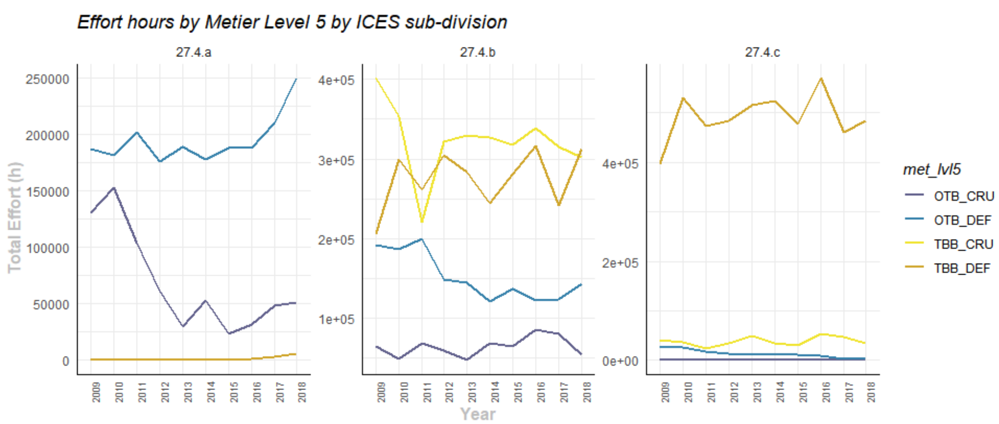

Figure 14. Fishing effort of the main fishing metiers operating in ICES Subarea 4 by year and ICES division.

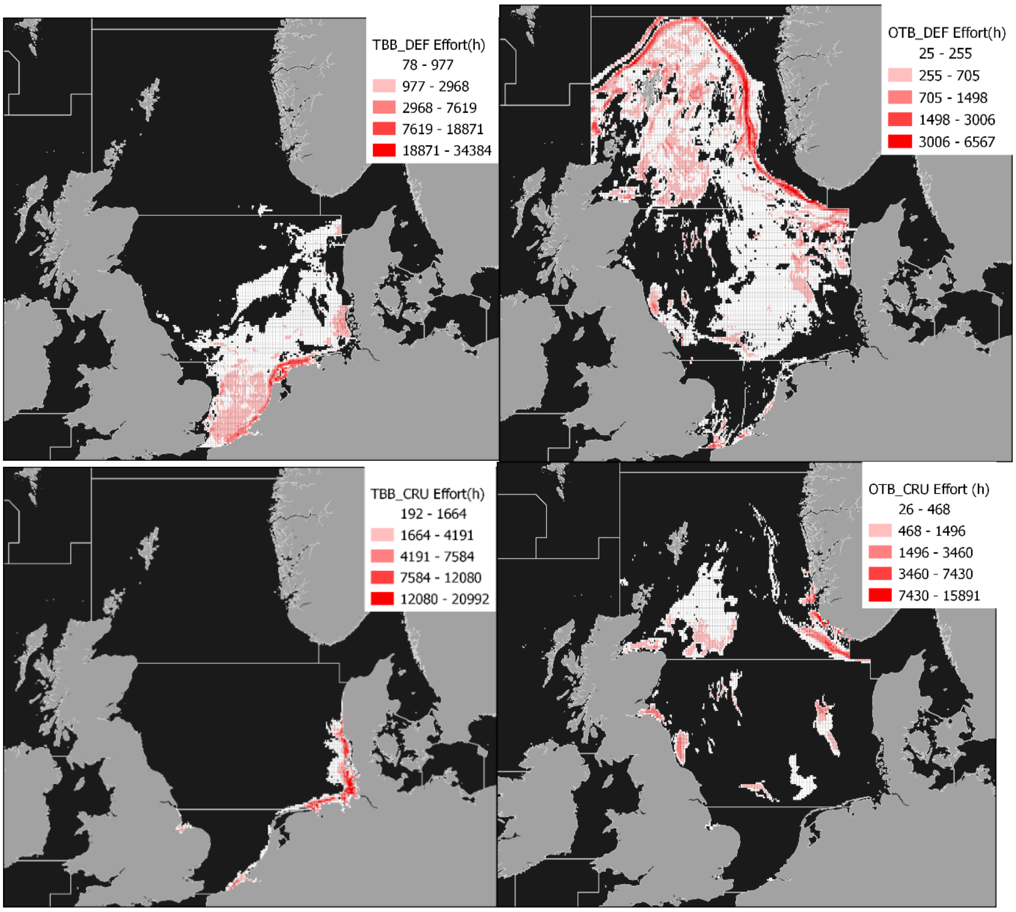

Figure 15. Maps show the spatial distribution and intensity of the fishing activities of the main four metiers operating in ICES Division 4.

2.4.4 Analysis of the fishing activity related to areas of Man-Made Structures (MMS) presence

Windfarm licensed areas

A dataset of windfarm installations in the greater North Sea was extracted from EMODnet website and integrated in the SFD_DB. The boundaries of the windfarm licensed areas are classified in four different development status: *Planned, authorised, under construction, operational or production*. These status categories were used to analyse separately the degree of fishing effort variability and assess the effect on fishing effort displacement of the different windfarm development phases. However, this dataset should be reviewed in future to increase the temporal-spatial resolution planned for further detailed analysis.

To determine the dynamics of the fishing activities within the windfarms and its area of influence, a series of spatial buffers based on a distance logarithm scale distance from the windfarm licensed boundaries was created (Figure 17). These spatial buffers were used to run an overlapping spatial query on the SFD_DB and subset the fishing activity occurring within each of the buffer distance ranges (7 and 20 Km from the licensed area). To visualize the temporal and spatial changes in fishing effort, graphs of average annual effort within the licensed area (yellow patch in Figure 18), within the area between the boundary of the licenced area and a buffer of 7 km from this boundary, and within the area between this 7 km buffer and one 20 km from the licenced area baseline were created (Figure 19). This exercise was repeated for demersal otter trawlers targeting fish (Figure 20).

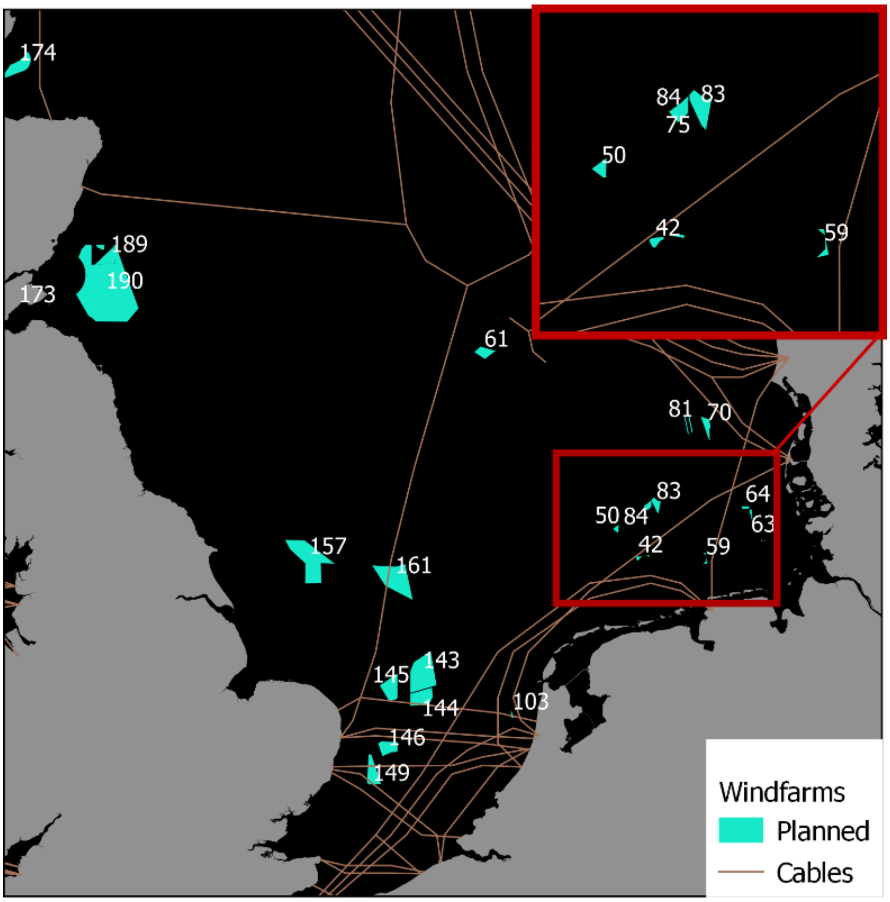

Figure 16. Map of the planned windfarms in the North Sea (source: EMODnet).

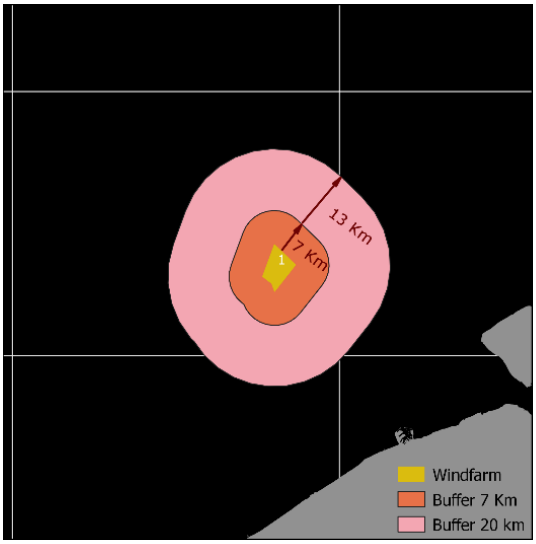

Figure 17. Spatial buffers around a windfarm licensed area used to evaluate the variability of fishing effort at different distance ranges.

This process was then repeated for areas where windfarms have been authorised (Figure 21 – Figure 23), areas where wind farms are under construction (Figure 24 – Figure 26) and wind farms which are producing electricity (Figure 27 – Figure 29). The results of this analysis can be visualized in graphs showing the annual variability by windfarm development status and by licensed area individually. Fishing activity varies depending on the phase of construction or number of turbines installed within the licensed area. This information is not collected yet and these results must validate in next year's WGSFD using ground-truthed remote sensing derived data or data provided directly from industry and using in related projects (e.g., INSITE). This highlights the need for WGSFD to establish strong connections with other ICES expert groups dealing with research topics.

Figure 18. Distribution of fishing effort of the beam trawls targeting demersal fish over the past 10 years within the planned windfarm licensed areas (red) and at 7 (green) and 20 km (blue) distance from them.

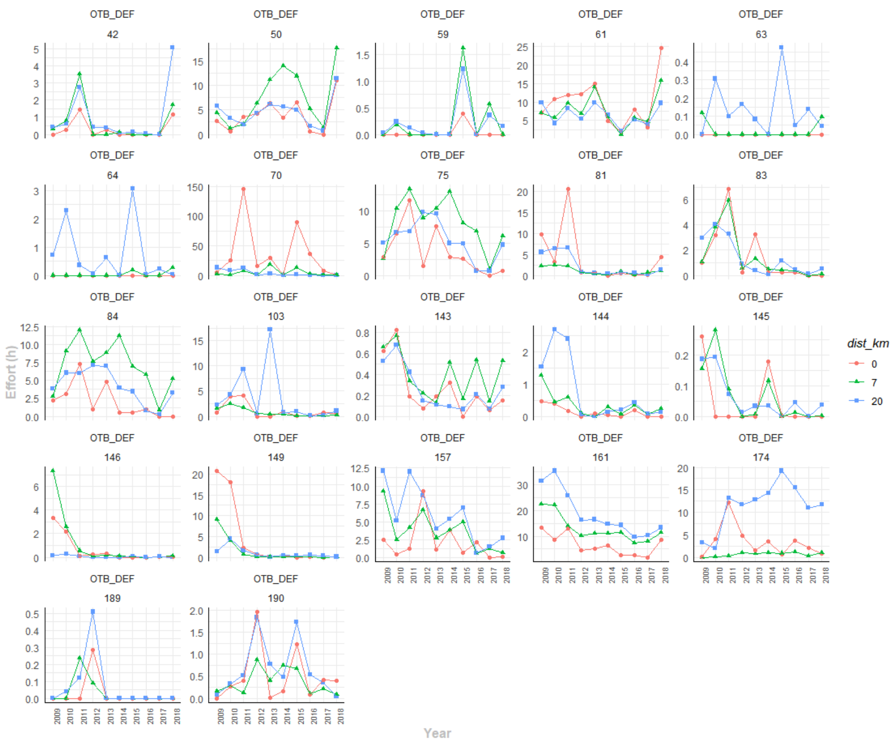

Figure 19. Distribution of fishing effort of the otter trawlers targeting demersal fish over the past 10 years within the planned windfarm licensed areas (red) and at 7 (green) and 20 km (blue).

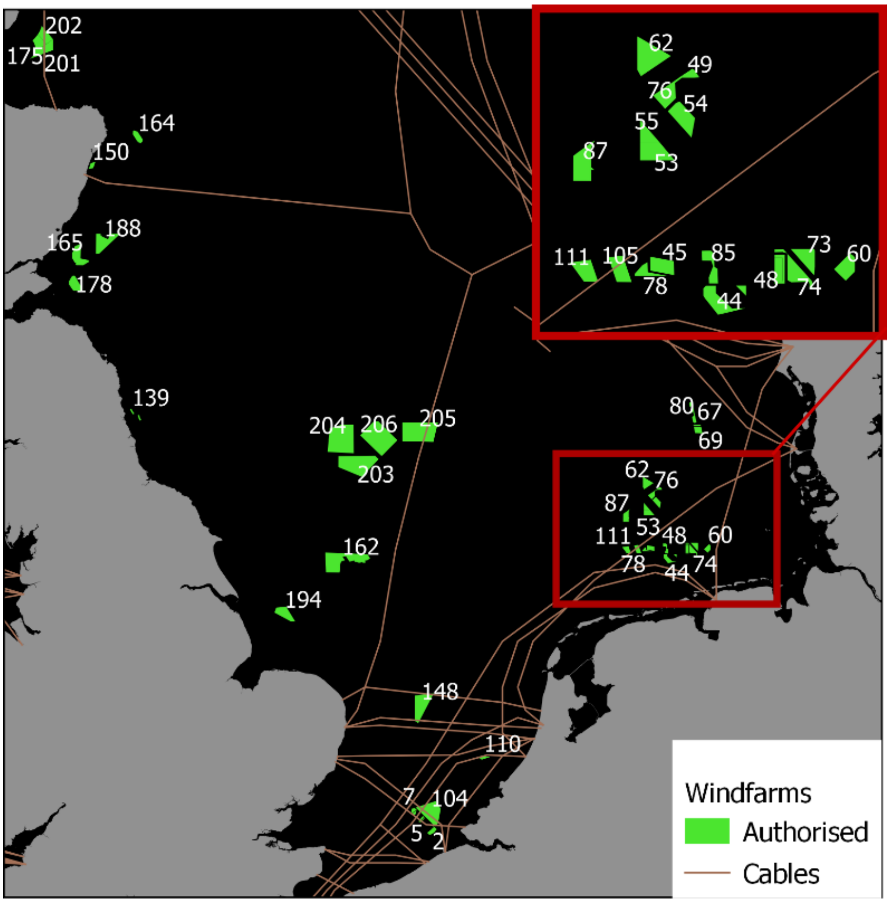

Figure 20. Map of the authorised windfarms in the North Sea (source: EMODnet).

Figure 21. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within the authorised windfarm licensed areas (red) and at 7km (green) and 20 km (blue) from them.

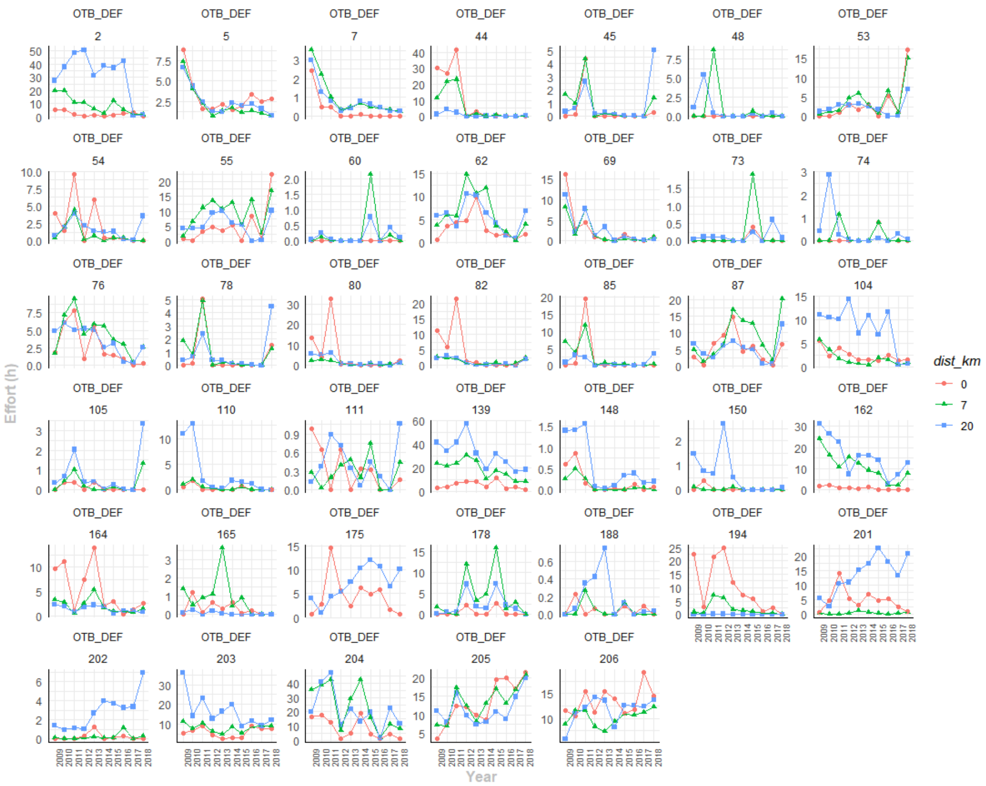

Figure 22. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the authorised windfarm licensed areas (red) and at 7km (green) and 20 km (blue) from them.

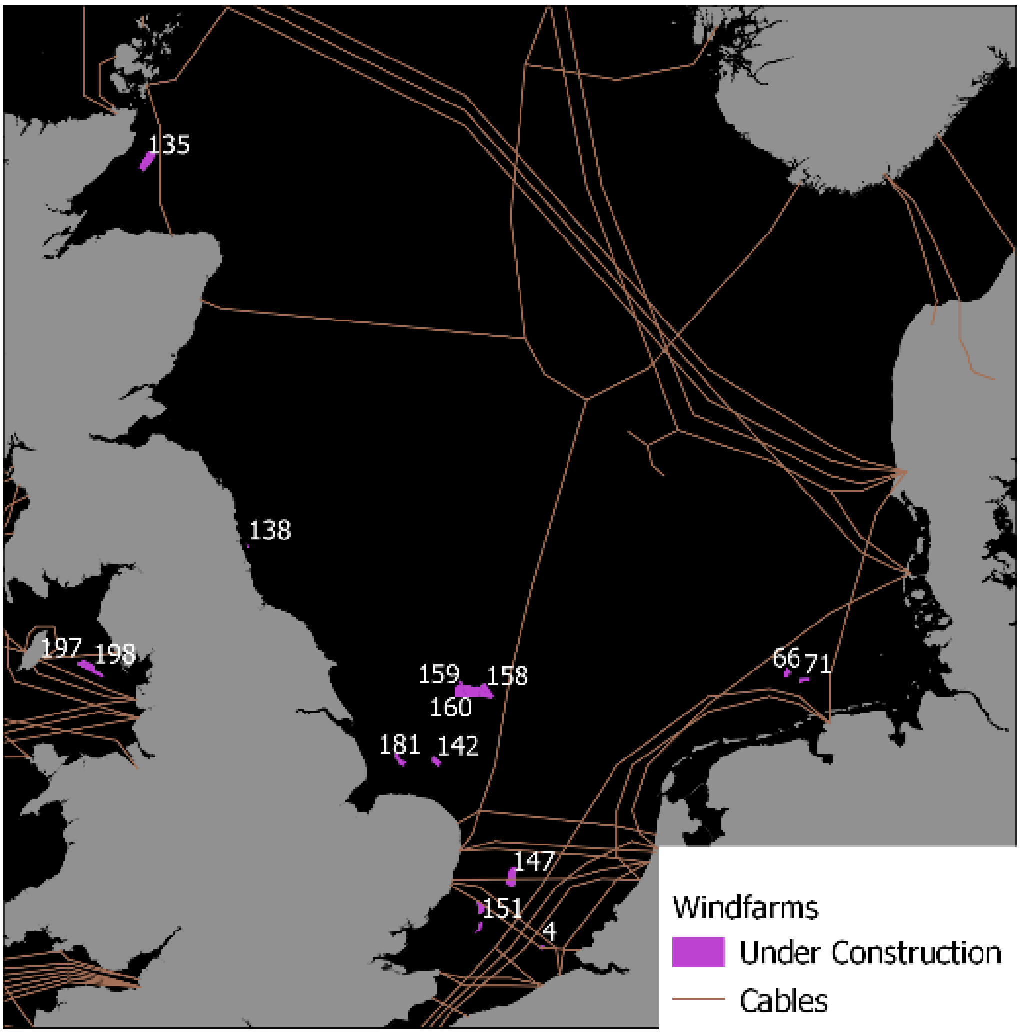

Figure 23. Map of windfarms under construction in the North Sea (source: EMODnet).

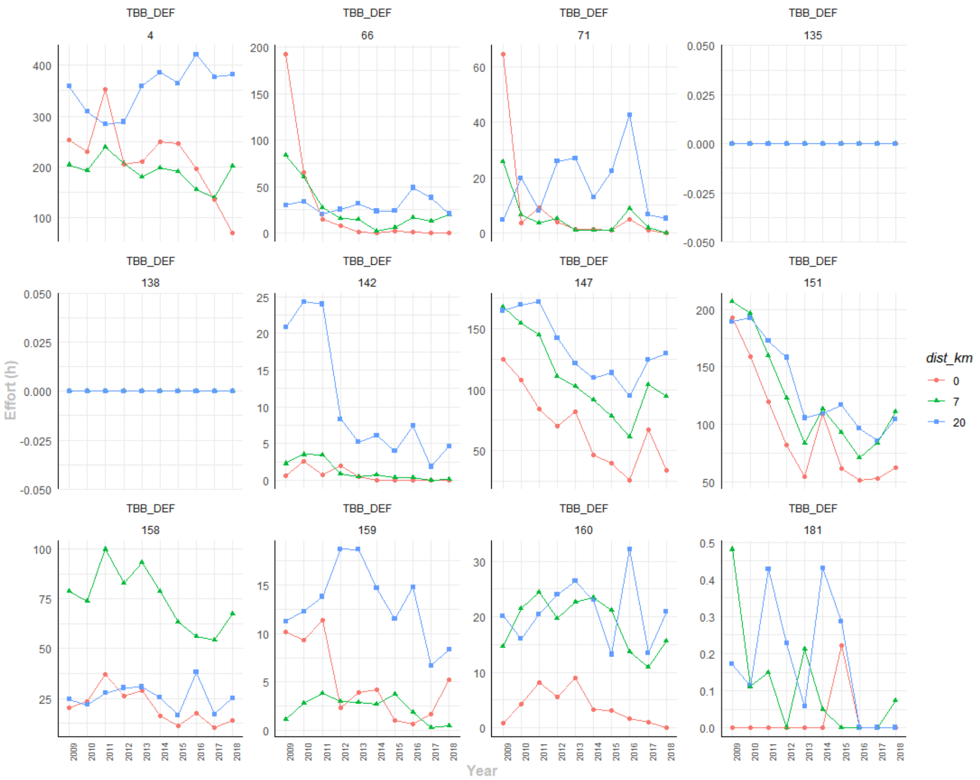

Figure 24. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within the under-construction windfarm licensed areas (red) and at 7 km (green) and 20 km (blue) from them.

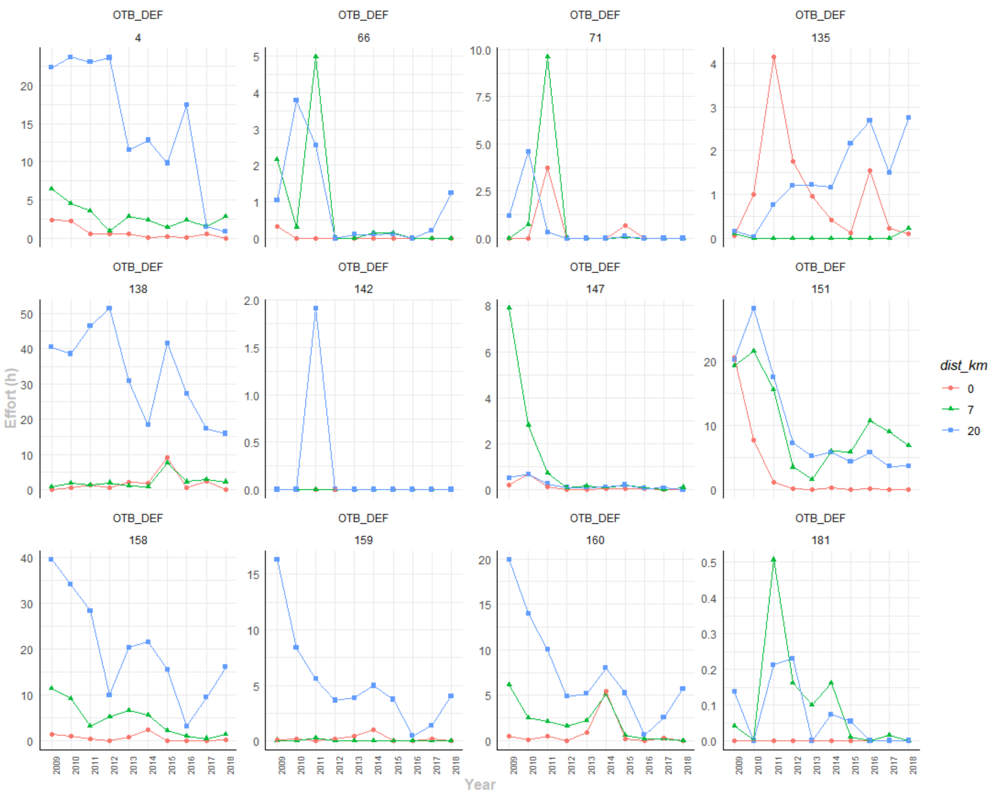

Figure 25. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the under-construction windfarm licensed areas (red) and at 7km (green) and 20 km (blue) from them.

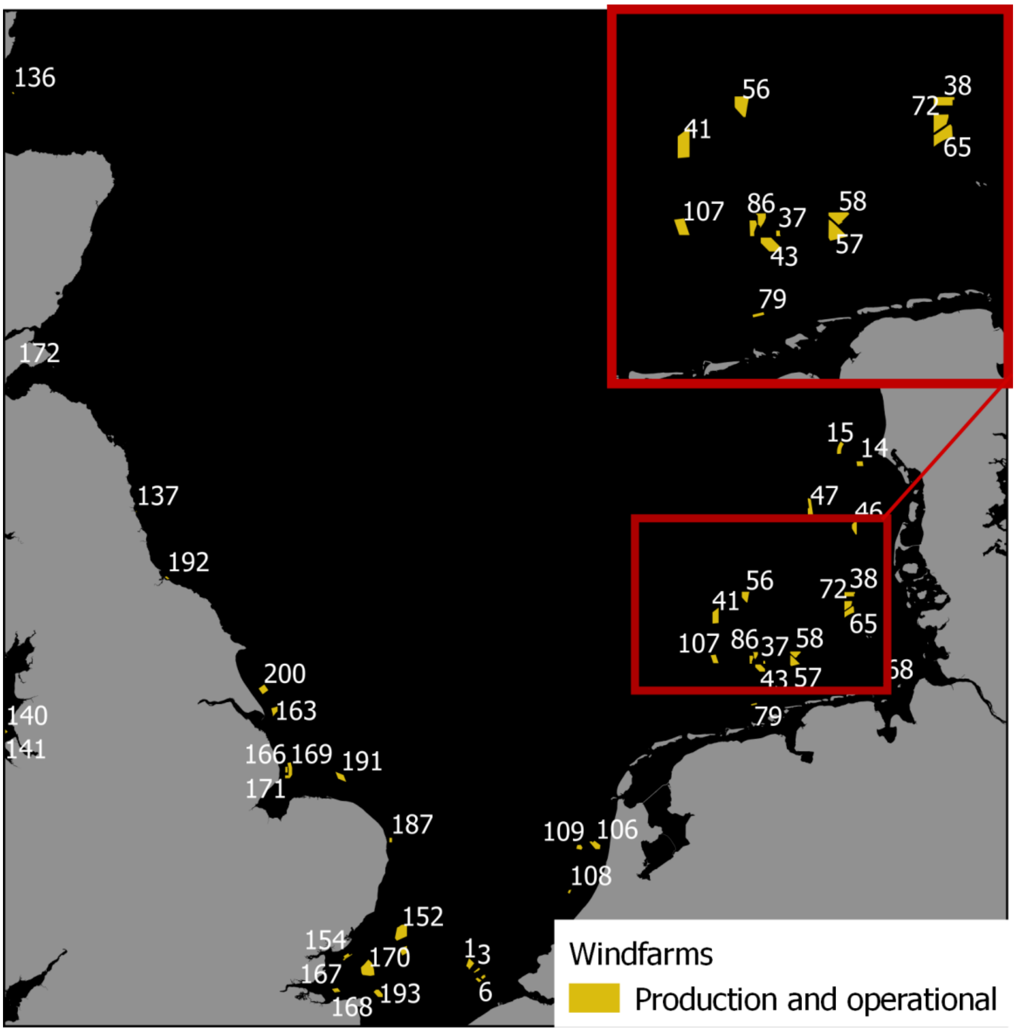

Figure 26. Map of operational windfarms in the North Sea (source: EMODnet).

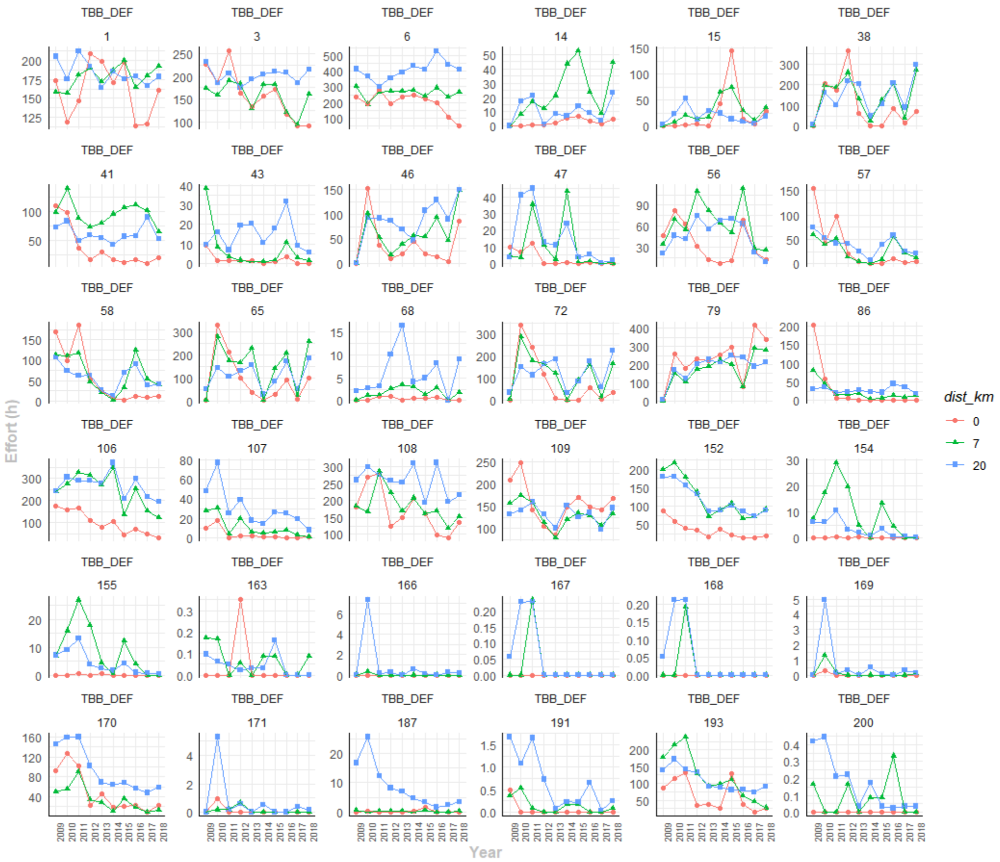

Figure 27. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within the operational and in production windfarms licensed areas (red) and at 7km (green) and 20 km (blue) from them.

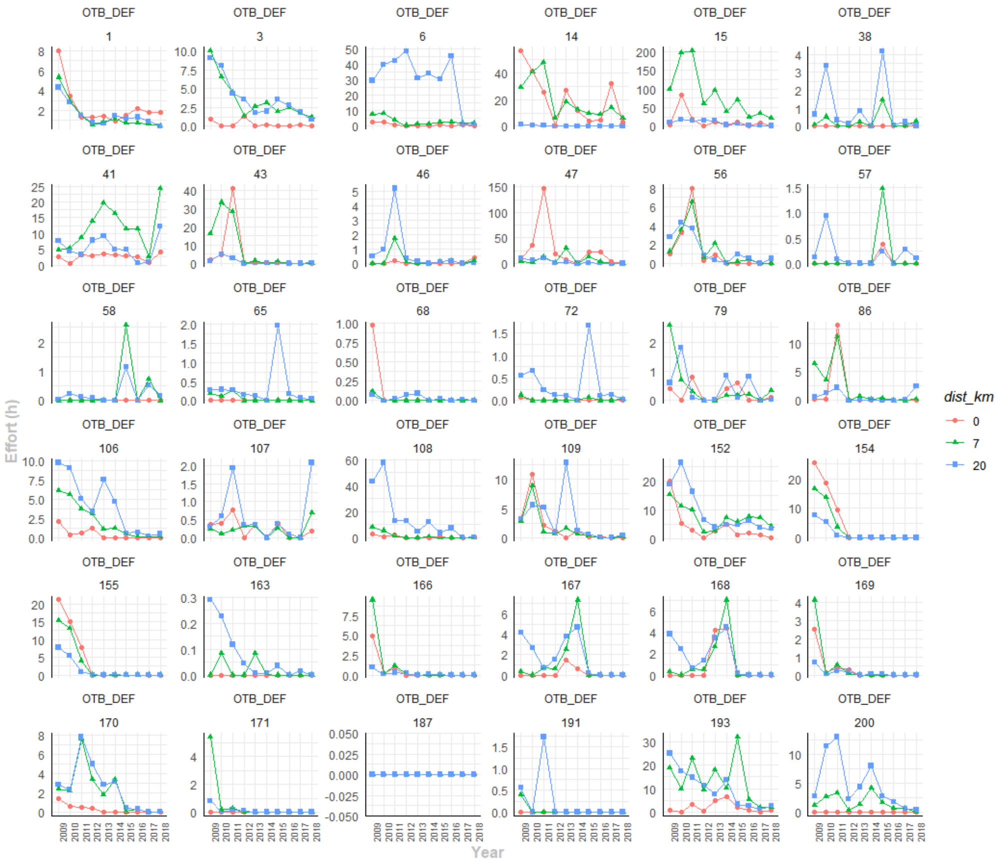

Figure 28. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the within the operational and in production windfarms licensed areas (red) and 7km (green) and 20 km (blue) from them.

2.4.5 Displacement of fishing activity by Marine Protected Areas

The implementation of management measures in marine protected areas or spatiotemporal fisheries restrictions and closures could drive the displacement of existing fishing effort occurring in the area. The existing studies on fisheries displacement suggest that this can be both spatial, temporal, or transferred to alternative gear types. Spatiotemporal displacement of existing fisheries will depend on the alternative opportunities available either within the MPA (if the management measure permits certain fishing activities) or in adjacent and along boundary areas in the case of restricted access. Therefore, in addition to the identification of potential drivers of displacement, analysis is needed to identify potential redistribution to other existing fishing grounds or suitable habitats that the affected fishery could be displaced into. Often in the case of fish conservation closures displacement will be to the closest permissible fishing area to the closure in the hopes of a 'spill-over' effect of the protected fish resource. Literature related to analysis of displacement and consequently the change on the spatial distribution of habitat impact recommends identifying the nearest existing fishing grounds targeted by similar fisheries. In a similar manner to the exercise carried out for wind farms, fishing effort was calculated for both beam- and otter trawls by year for a ten year period within protected areas, between their boundaries and a 7 km buffer, and between this and a 20 km buffer, for OSPAR Marine Protected areas (Figure 30, Figure 32), Marine Conservation Zones (Figure 33,Figure 35) and Nature Conservation Marine Protected Zones (Figure 36, Figure 38).

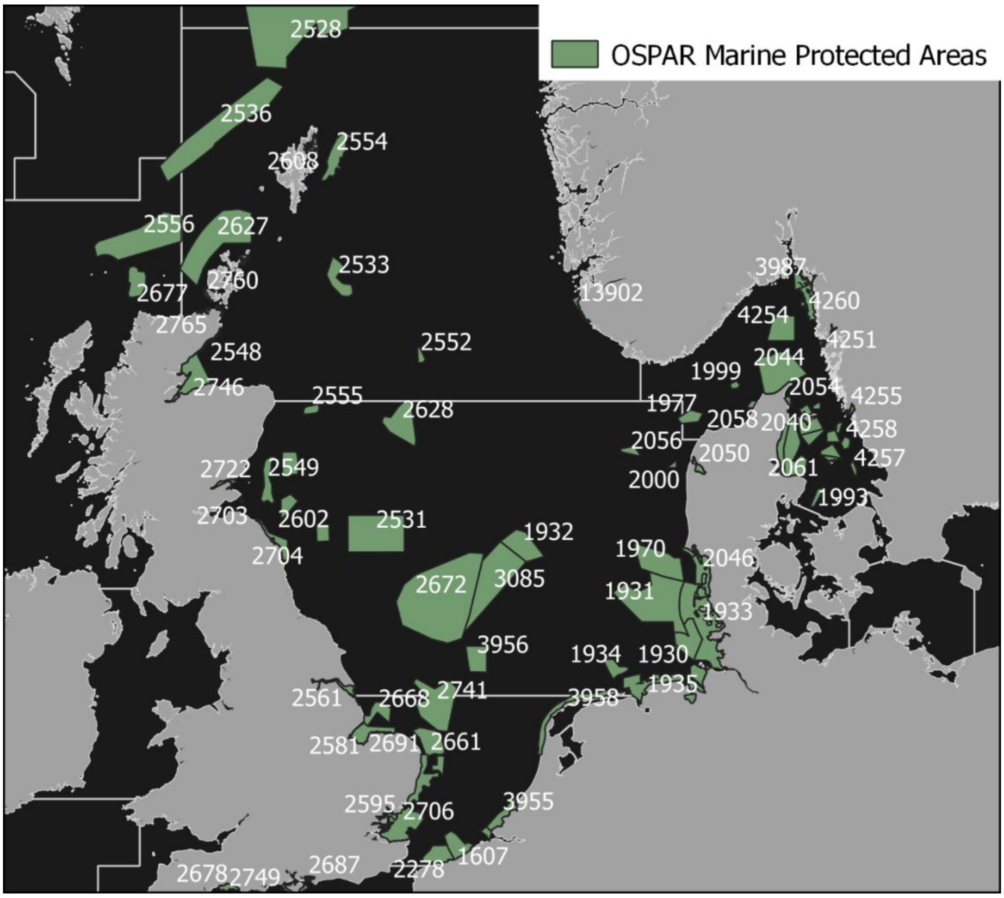

Figure 29. Map of OSPAR Marine Protected Areas in the Greater North Sea ICES Ecoregion (source: EMODnet)

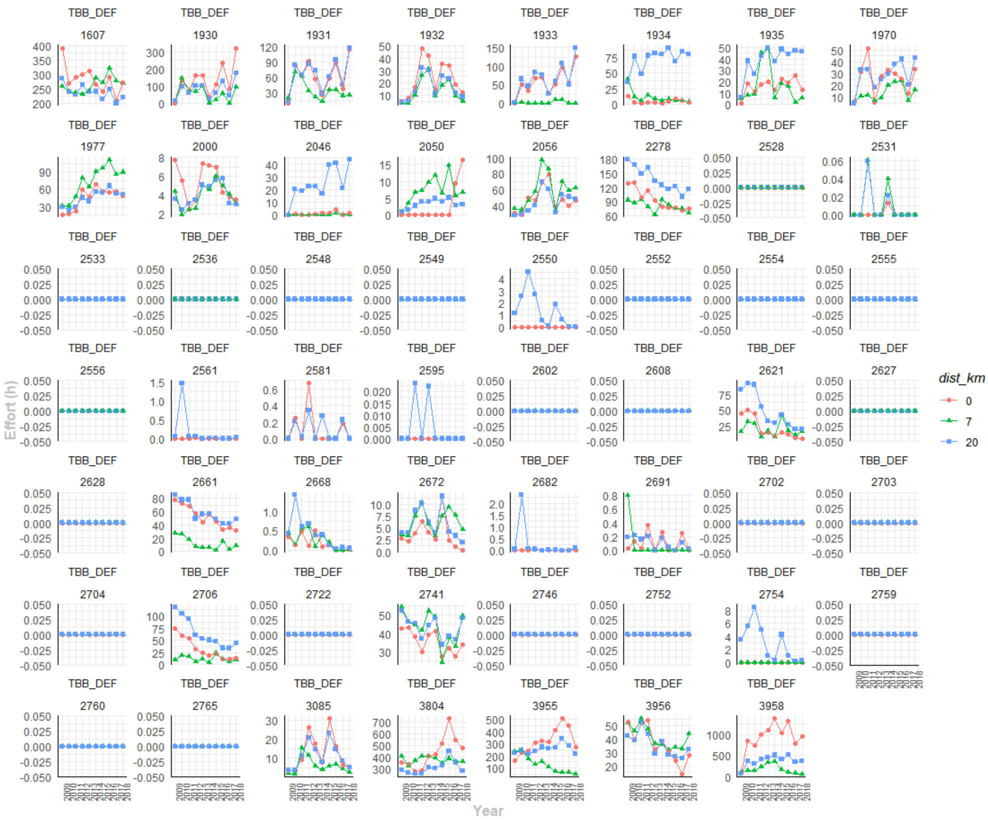

Figure 30. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within OSPAR Marine Protected Areas (red) and at 7km (green) and 20 km (blue) from them.

Figure 31. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within OSPAR Marine Protected Areas (red) and at 7km (green) and 20 km (blue) from them.

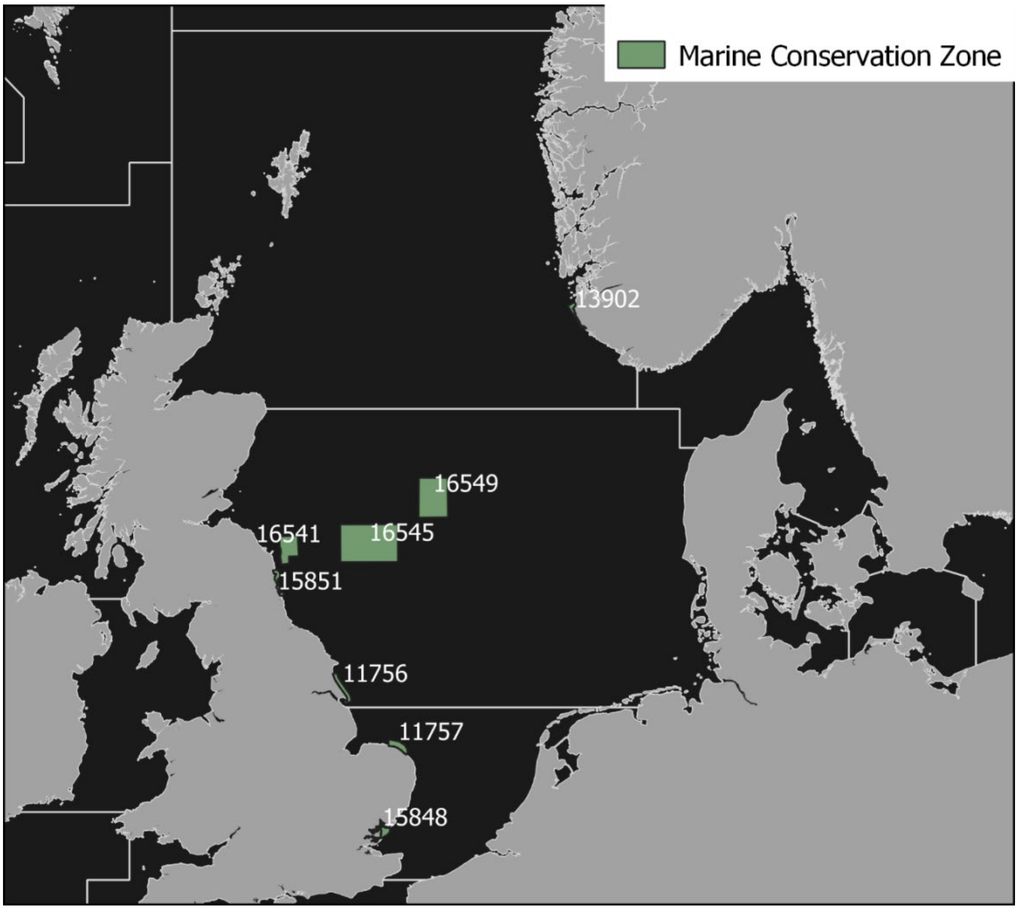

Figure 32. Map of Marine Conservation Zones in the Greater North Sea ICES Ecoregion (source: EMODnet).

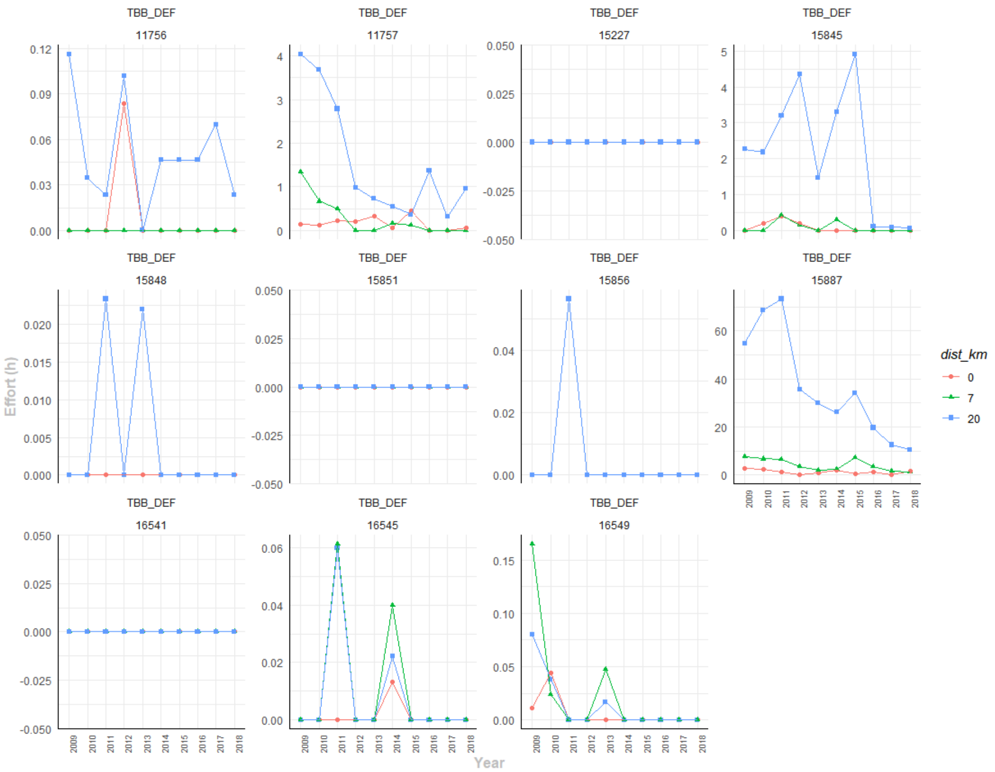

Figure 33. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within Marine Conservation Zones (red) and at 7km (green) and 20 km (blue) from them.

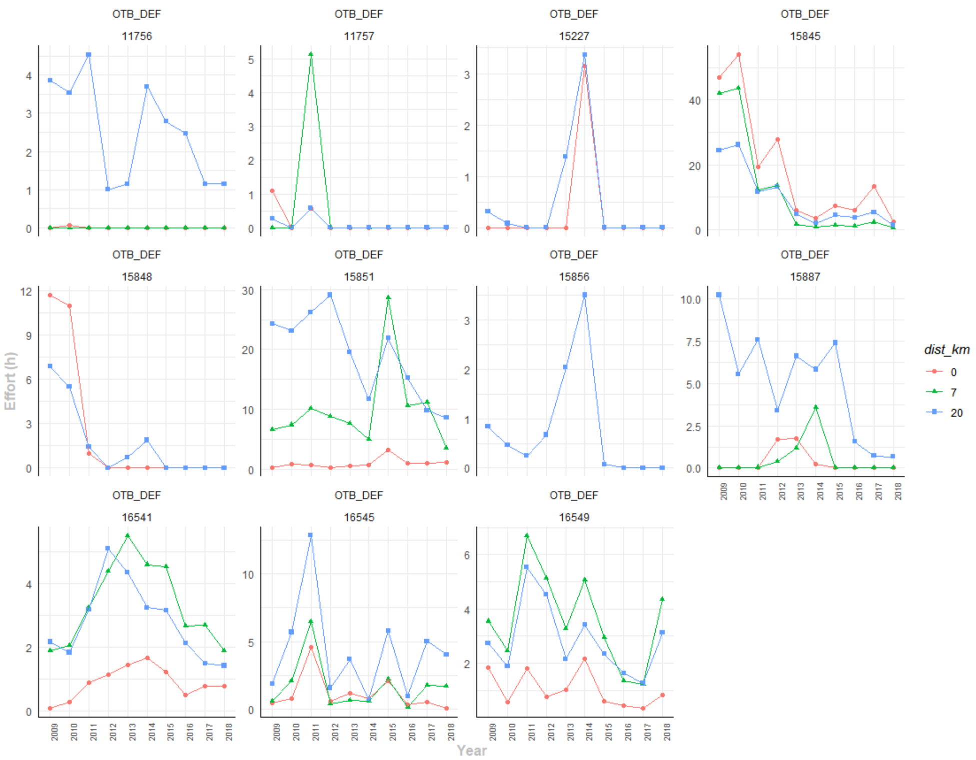

Figure 34. Distribution of fishing effort by otter trawls targeting demersal fish over the past 10 years within Marine Conservation Zones (red) and at 7km (green) and 20 km (blue) from them.

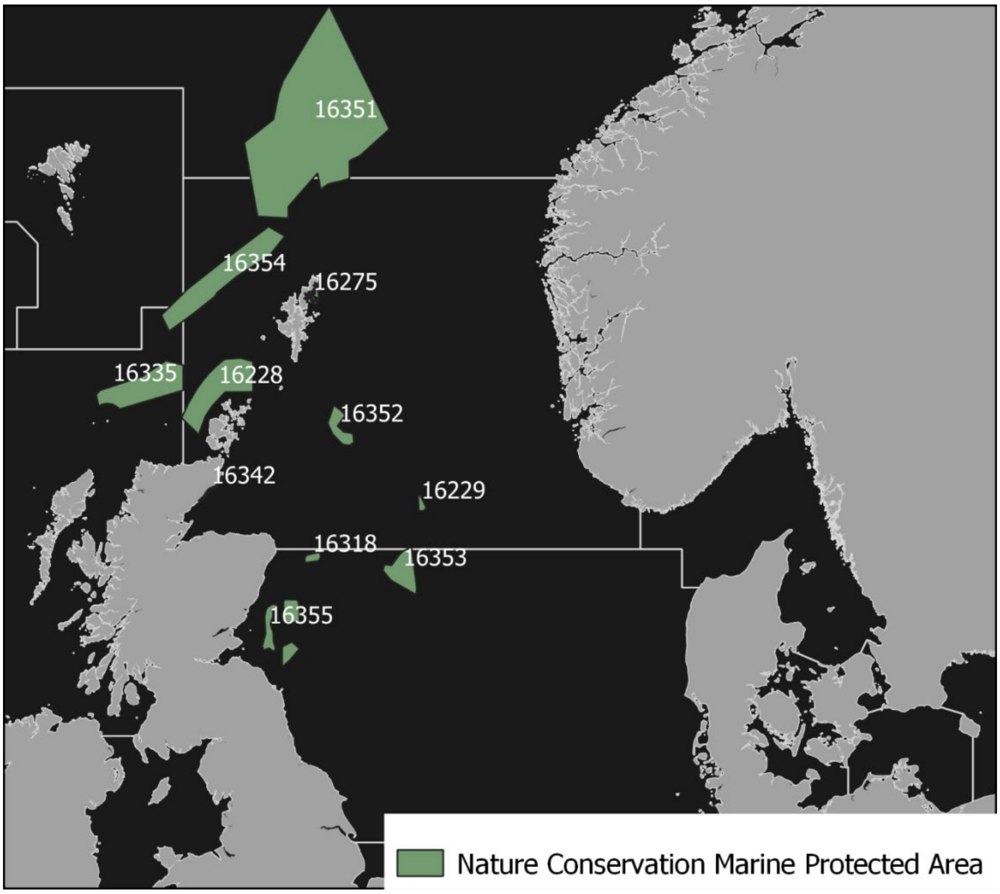

Figure 35. Map of Nature Conservation Marine Protected Areas in the Greater North Sea ICES Ecoregion (source: EMOD-net).

Figure 36. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within Nature Conservation Marine Protected Area areas (red) and at 7km (green) and 20 km (blue) from them.

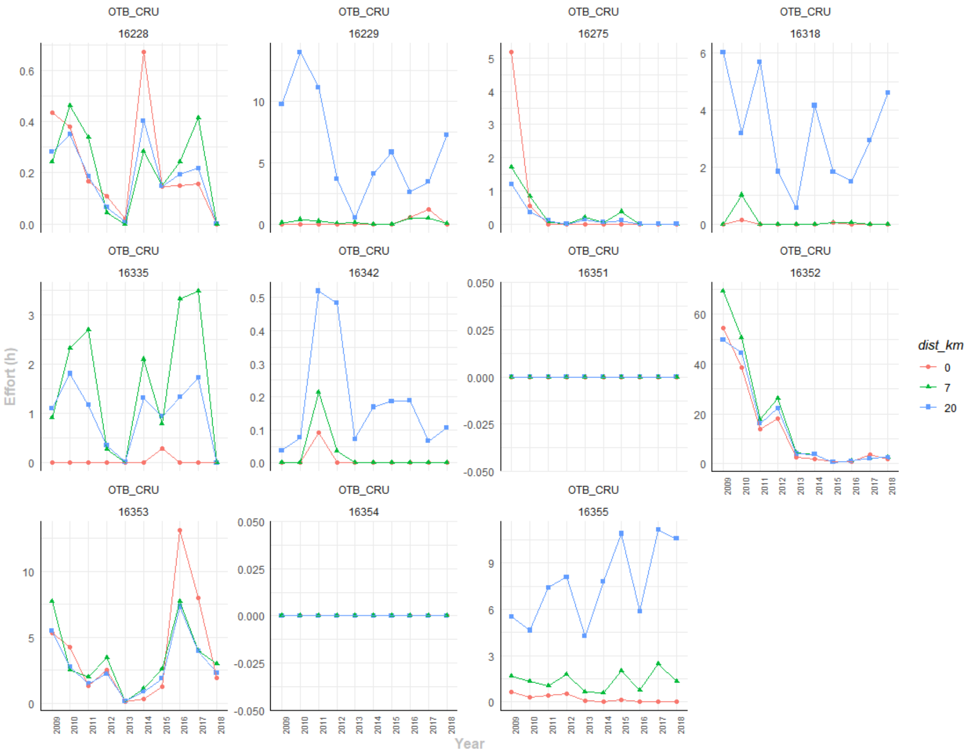

Figure 37. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the within Nature Conservation Marine Protected Area (red) and at 7km (green) and 20 km (blue) from them.

2.4.6 Displacement of fishing activity in relation to other human activities

Shipping cargo lines

The North Sea is a marine region that communicates several large cities with transport and cargo terminal harbours, therefore this sea holds high shipping activity lanes. Through EMODnet site a dataset is available with the cargo shipping footprint layer. The east entrance of the English Channel (ICES rectangles 31F1 to 34F4) concentrates much of this traffic as well the entrance to the Baltic Sea by Skagerrak and Kattegat (ICES rectangles 43F7 to 44F8). An analysis was run to identify the variability of the fishing effort over the past 10 years within the cargo shipping footprint and in the nearby area. The cargo vessel footprint has been split by ICES statistical rectangle to compare the effort inside the cargo footprint with the effort in the surrounding area within each ICES rectangle (Figure 39). Effort distribution overlapping and not overlapping with shipping lanes, by statistical rectangle, is shown in Figure 40 and Figure 41.

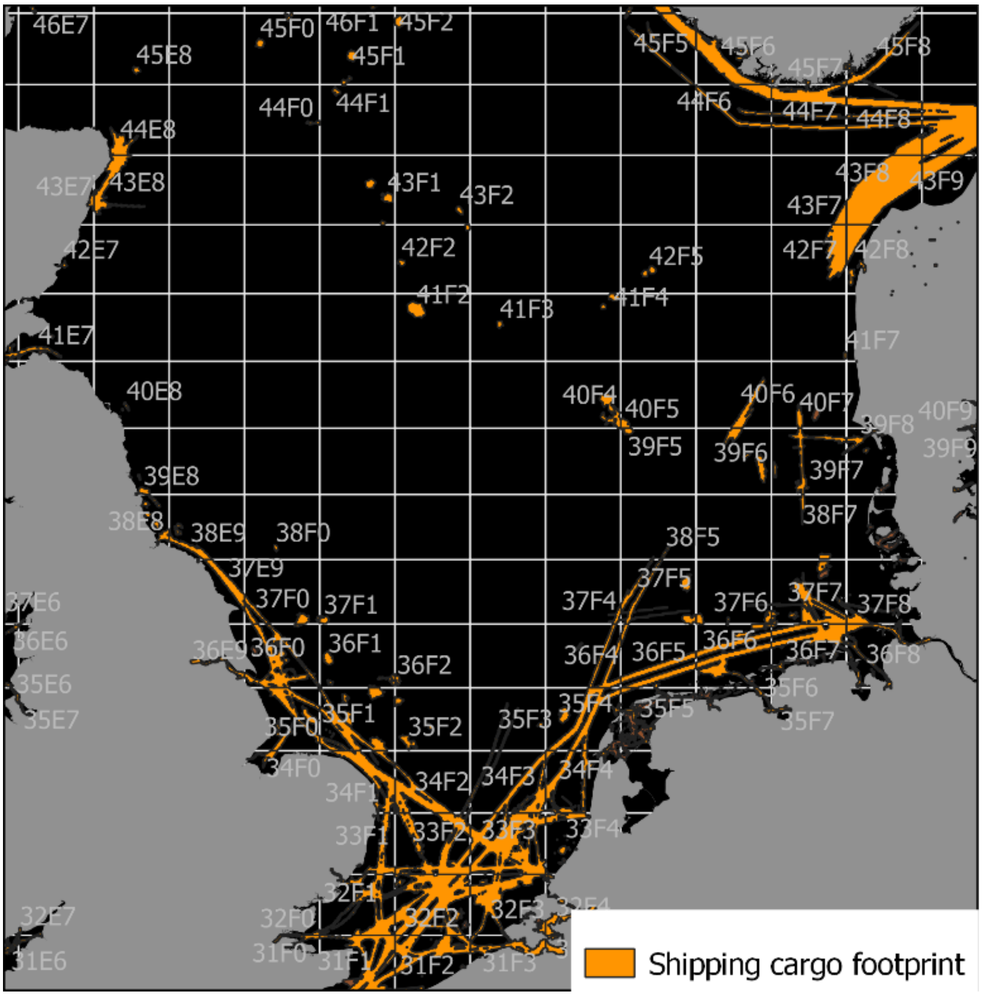

Figure 38. Map of the cargo vessels footprint split by ICES rectangle.

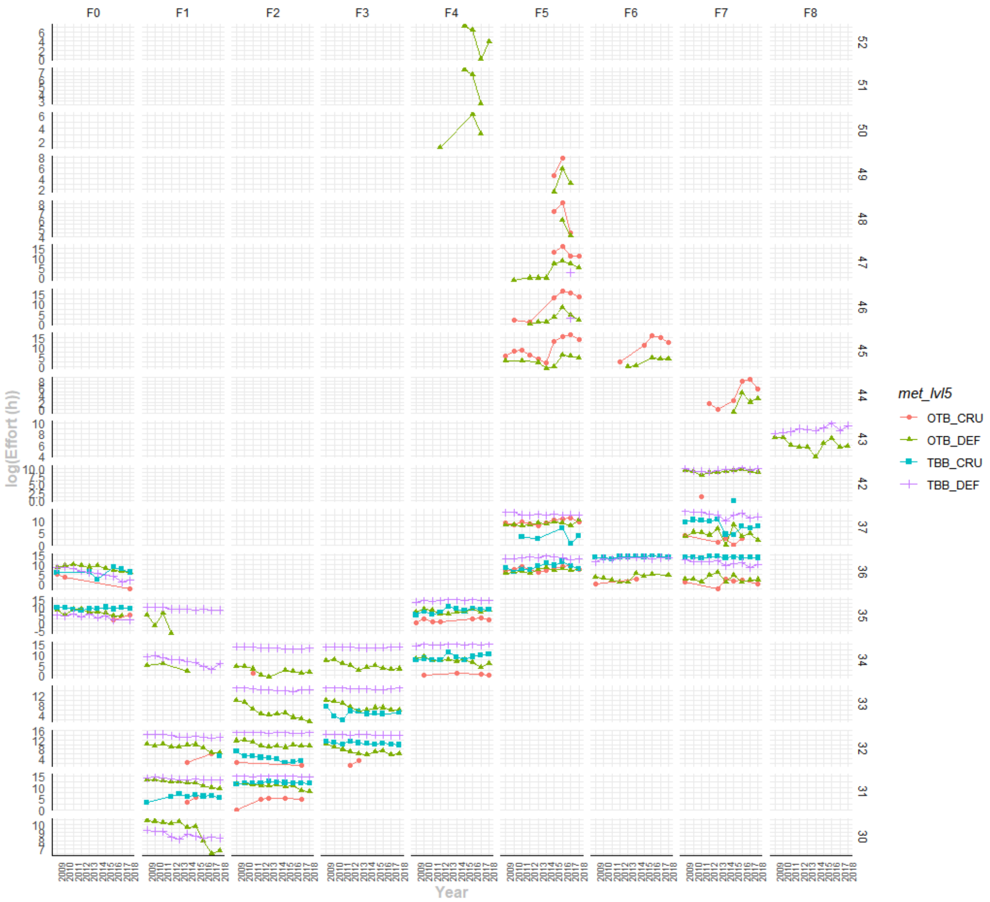

Figure 39. Effort distribution between 2009 and 2018 overlapping the cargo vessel footprint by ICES rectangle. Graphs distributed in an ICES rectangle grid.

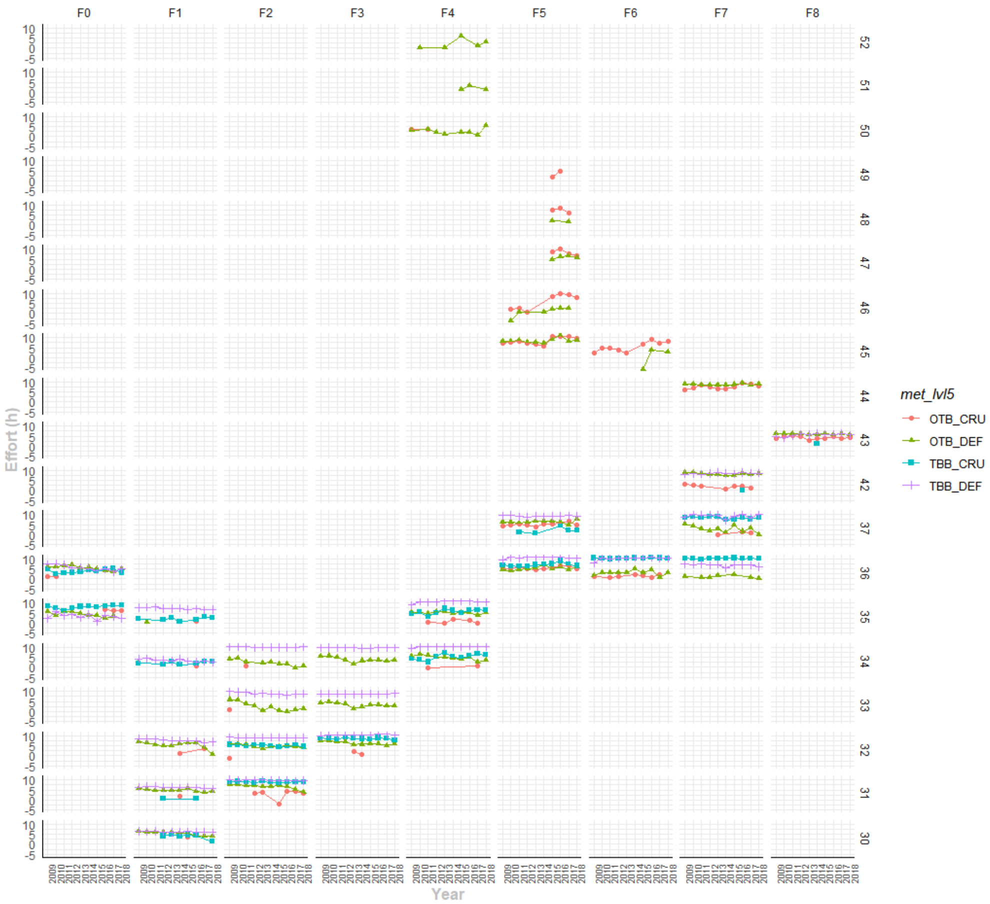

Figure 40. Effort distribution between 2009 and 2018 not overlapping the cargo vessel footprint by ICES rectangle. Graphs distributed in an ICES rectangle grid.

2.5 In response to ToR f)

Analysis of NEAFC VMS data in support of WGDEC:

WGSFD is requested to produce maps of bottom contacting fishing activity in and in the vicinity of VMEs (defined by WGDEC) and separate this into mobile bottom contacting gear and static gear in NEAFC areas including the Josephine Seamount using the VMS and logbook catch report information collected by NEAFC.

WGSFD is requested to also provide a short narrative on how NEAFC could improve data available to ICES that could facilitate the subsequent analyse of fishing gears used in the NEAFC areas, to provide a more detailed analysis of bottom gears accounting for a diversity of types of gear designs, sizes, rigging and operational methods (passive and active).

VMS data were received from NEAFC, via the ICES Secretariat, along with catch information from logbooks, authorisation details, and vessel information from the NEAFC fleet registry. These data were analysed by WGSFD, in advance of the ICES-NAFO Working Group on Deep-water Ecology meeting, to support the NEAFC request to ICES to provide information on the distribution of fisheries activities in and in the vicinity of VME habitats. The tables were linked using a unique identifier (the "RID" field) which now changes on an annual basis to protect anonymity of vessels rather than the previous six-monthly basis. As in 2020, ICES received information on the catch date and the catches were linked to vessels on the date of operation.

The VMS data were filtered in R to exclude all duplicate reports, polls outside the year 2020, and messages denoting entry and exit to the NEAFC regulatory area ("ENT" and "EXT" reports). The time interval (difference) between consecutive pings for each vessel was calculated and assigned to each position. Any interval values greater than four hours were truncated to this duration, as this is the minimum reporting frequency specified in the Article 11 of the NEAFC Scheme of Control and Enforcement. Such a scenario could occur when a vessel leaves the NEAFC regulatory area or has issues with its transmission system.

Examination of the speed field of the VMS data showed that the speed data, which has been problematic in previous years, was of usable quality. Fishing effort is inferred from VMS data based on speed, with pings at slower speeds deemed to represent fishing activity, and those at faster speeds to represent steaming and/or searching. In this instance, a speed of 5 knots or lower has been used to demarcate fishing from non-fishing pings for bottom trawl gears. Visual examination of speed profile histograms for vessels without a registered gear type suggests that this demarcation is appropriate for these too (Figure 42). For vessels recorded as using static gears, a speed of 4 knots or less was used to signify fishing activity, although care needs to be taken in the interpretation of these results, as time spent at these speeds represents the recovery of gears and does not directly translate in to measures of effort.

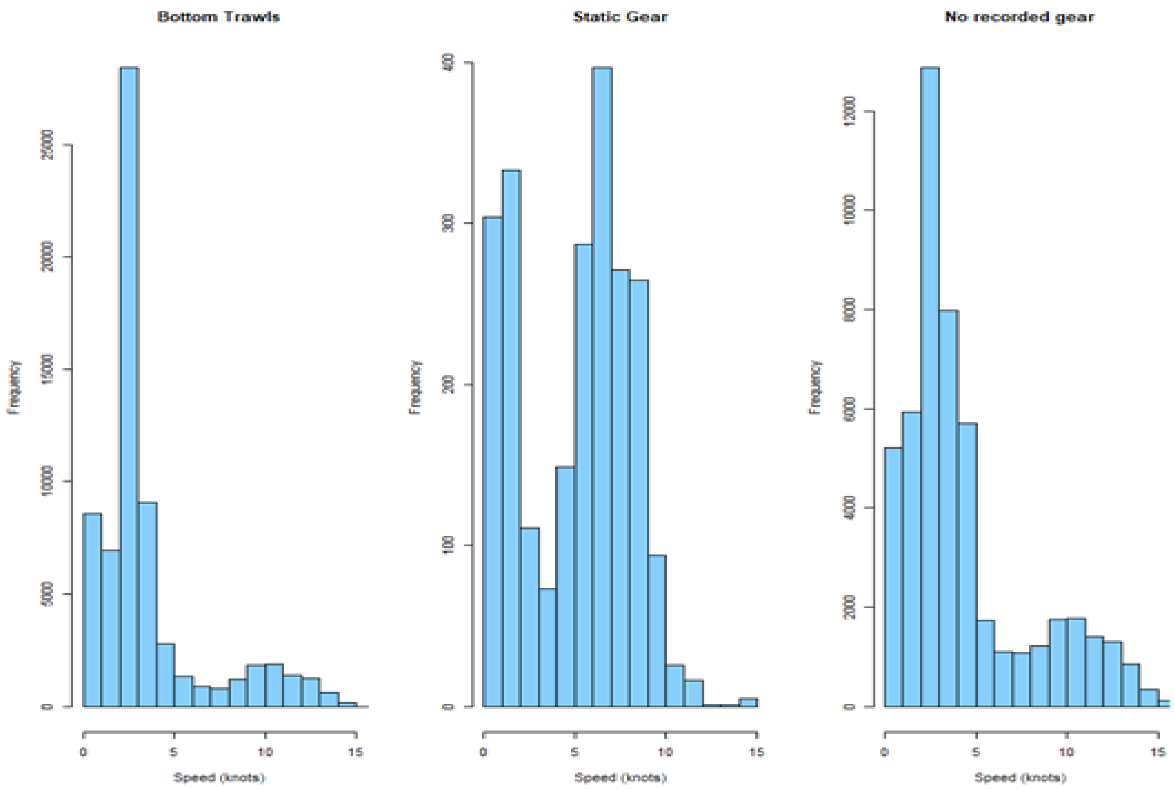

Figure 41. Histogram of derived speeds for vessels recorded as using bottom trawls, static gears, and without a specified gear type, based on position and time, conforms to expected distribution.

The speed filtered pings were presented to WGDEC in the form of a raster grid, consecutive pings at fishing speeds grouped into putative "tows" and as a set of points data, to give a range of options for display purposes. These were provided for vessels registered as using mobile bottom contact gears (otter trawl – OTB and shrimp trawl - TBS), static gear (gear codes "FPO", "LL" and "LLS"), and for vessels for which no gear code was available ("NIL") (Table 11). This year, a large proportion of the vessels had no gear specified and the number of gear types reported was very low compared to previous years.

Table 11. Number of pings registered against each fishing gear type in the speed filtered (--5 knots for mobile gears, --4 knots for static) in the NEAFC VMS data.

Gear	Description	Grouping	Number of pings
FPO	Fish pots	Static Bottom	992
LL	Long lines	Static Bottom	1294
LLS	Long lines (set)	Static Bottom	1558
NIL	No gear recorded	Unknown	1328
OTB	Bottom otter trawl	Mobile Bottom	56 378
OTM	Midwater otter trawl	Pelagic Gear	261 248
PS	Purse seine	Pelagic Gear	1232
PTM	Midwater pair trawl	Pelagic Gear	324
TBS	Shrimp trawl	Mobile Bottom	1801
UNK	Unknown	Unknown	24 832

2.5.1.1 Rockall and Hatton Banks

As in previous years, activity by mobile bottom contacting gears is concentrated on Rockall around the western edges of the haddock box, the eastern slope of the bank, and the southwest corner. On Hatton Bank, effort is spread along the western flanks, with a concentration at the northern and southern tips. Activity by vessels with no registered gear type overlaps with this effort, on the western side of the Haddock Box (Figure 43).

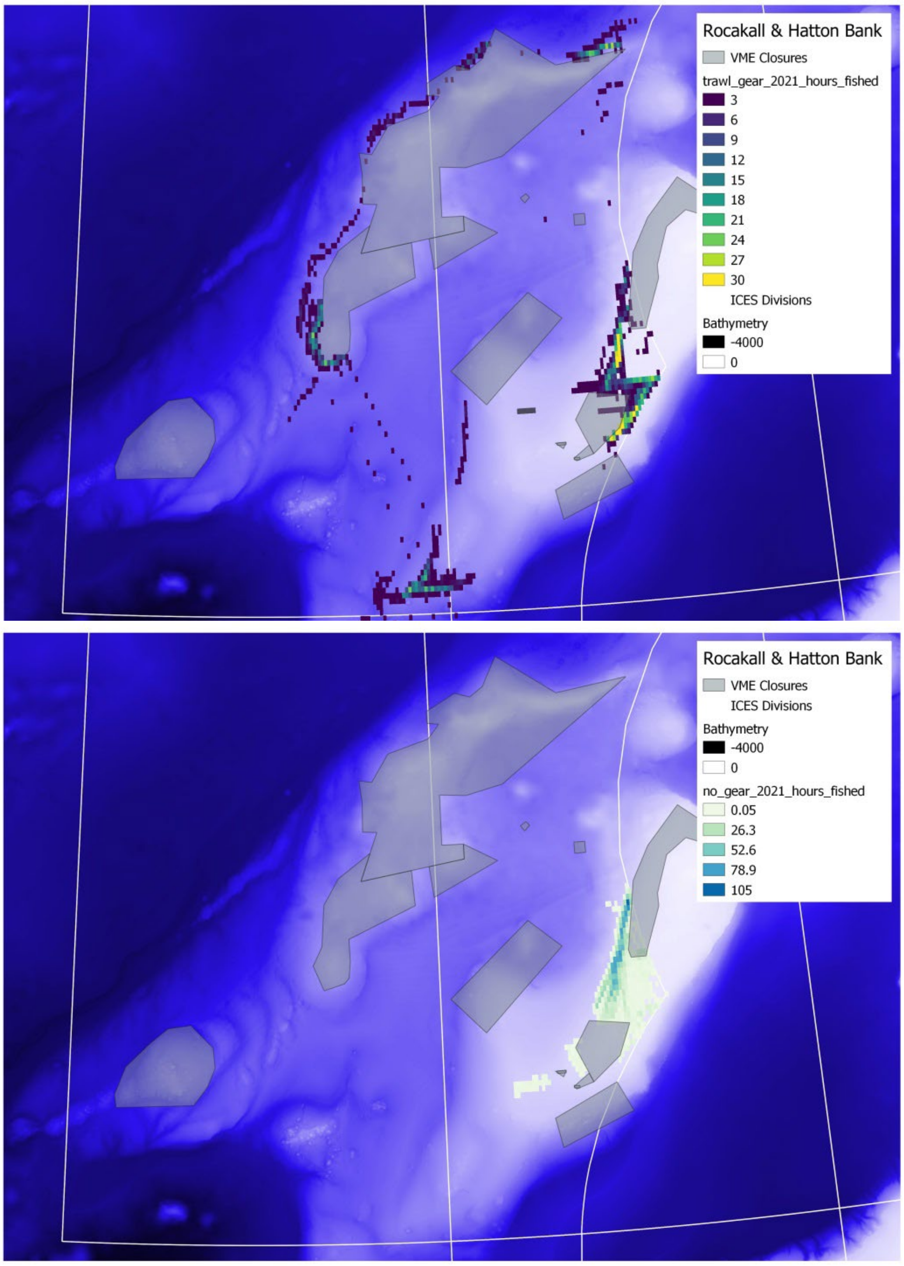

Figure 42. Fishing activity on Rockall and Hatton Banks during 2020, by vessels registered as using mobile bottom contacting gears (top), and with no registered gear type (bottom).

2.5.1.2 South of Iceland

As in previous years, fishing effort by vessels recorded as using mobile bottom contacting gears is seen in oceanic waters to the southwest of the Icelandic EEZ. This is in waters greater than 2500m deep, and therefore unlikely to truly represent bottom fishing. Catch composition reports show these vessels to fishing for pelagic redfish, therefore this is likely midwater trawling which has been miscoded due to the gear type being linked to each vessel for the year, rather than at a trip level (Figure 44).

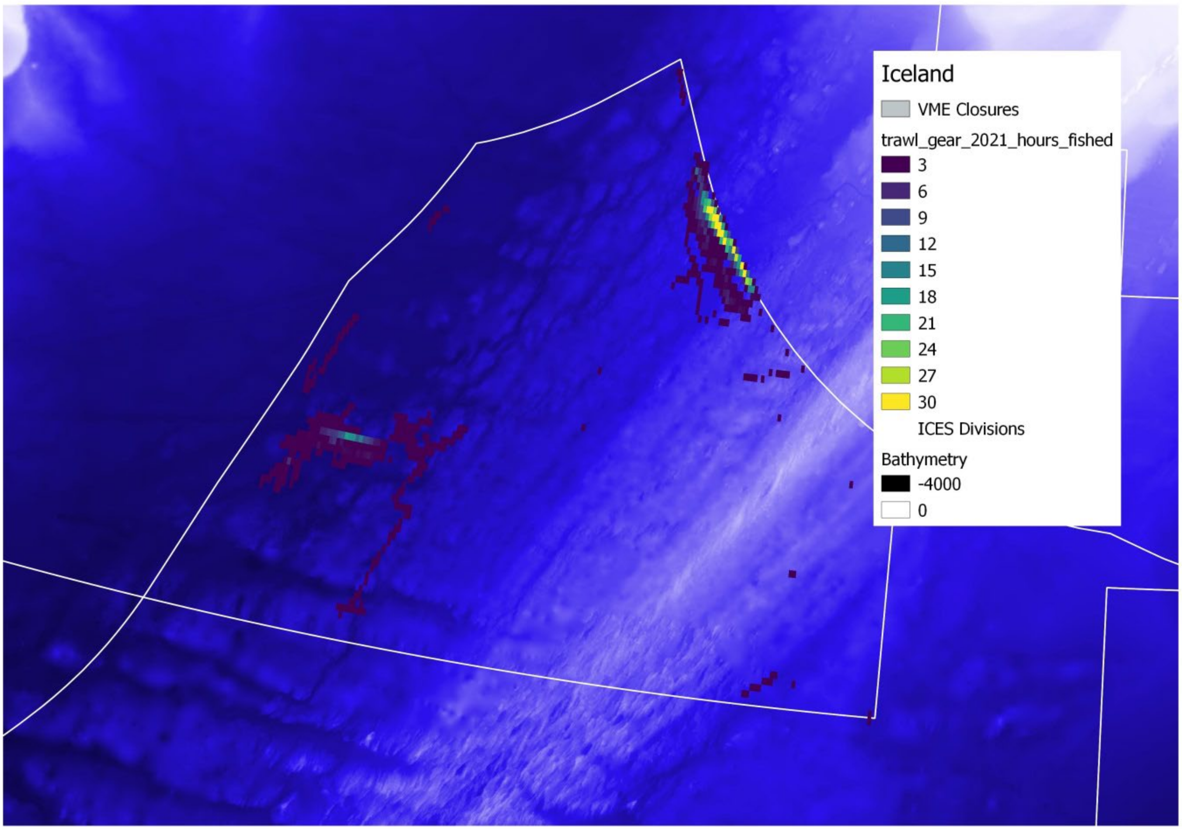

Figure 43. Fishing activity south of Iceland during 2020, by vessels registered as using mobile bottom contacting gears.

2.5.1.3 NEAFC Regulatory Area 2 and 3

This is the first-time analysis of VMS data in Regulatory Areas 2 and 3 has been presented. Although there are not VME-related closures in place for these areas at present, that does not preclude the presence of VMEs, and such information is likely to help inform discussion of areas which may be impacted by fishing.

In Area 2 vessels using both mobile bottom contacting gears and no registered gear type are mostly active to the south of the Arctic mid-Ocean ridge, with a smaller concentration of effort on the Voring plateau. Effort is also scattered over the deep waters of the Norwegian Sea, and this may represent miscoded pelagic trawling (Figure 45, Figure 46). In Regulatory Area 3 the fishery is concentrated along the Central Bank (Figure 47).

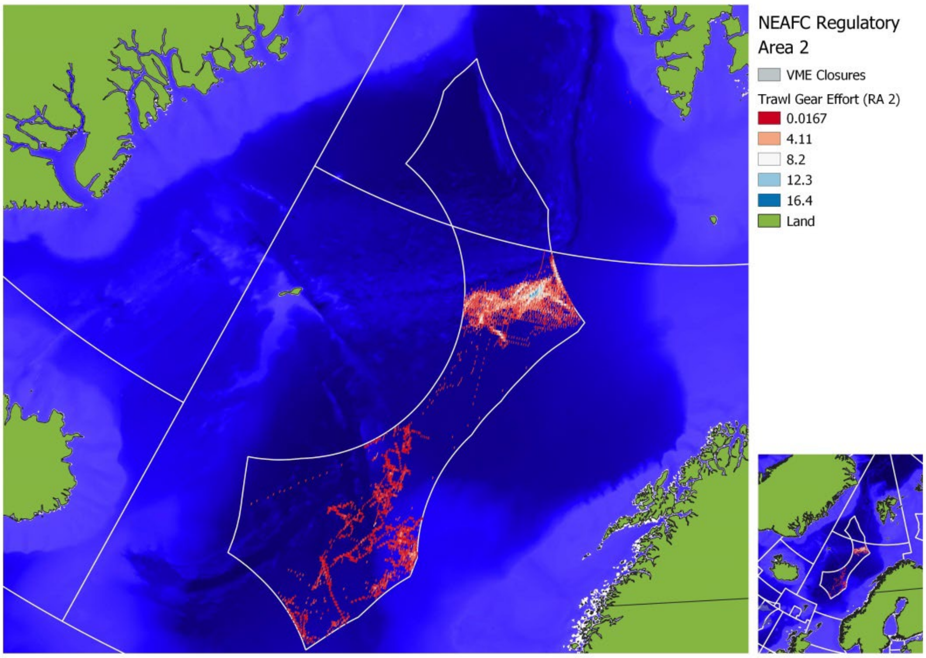

Figure 44. Fishing activity by vessels recorded as using mobile bottom contacting gears in NEAFC Regulatory Area 2.

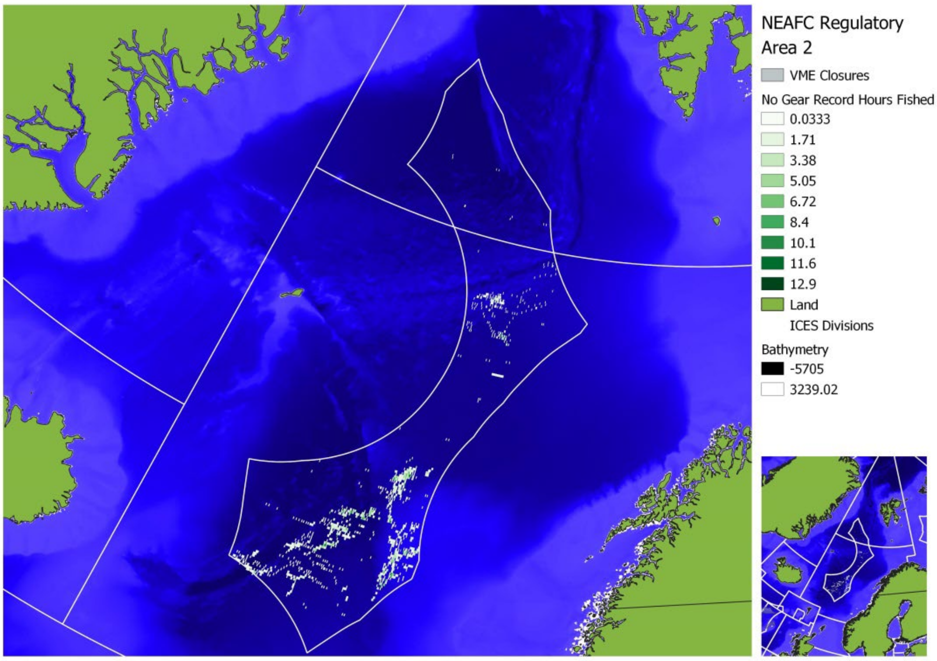

Figure 45. Fishing activity by vessels recorded as using static gears in NEAFC Regulatory Area 2.

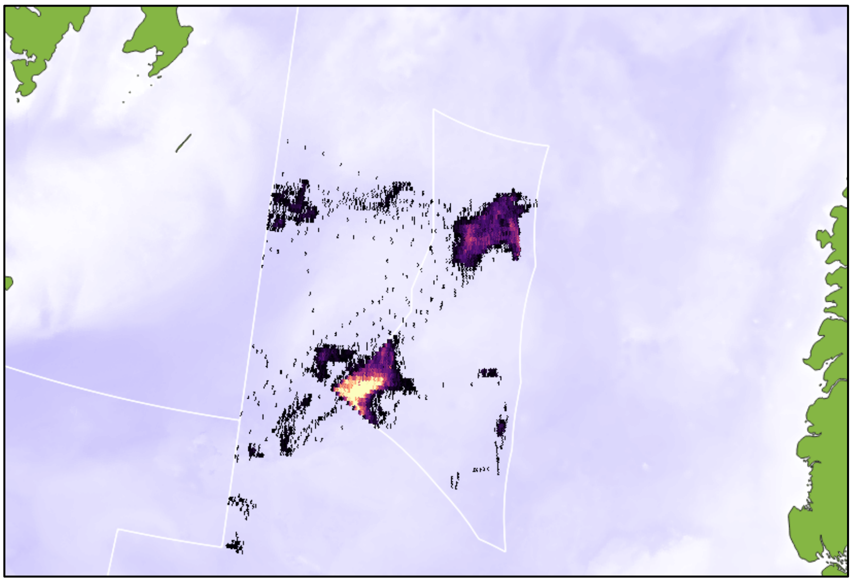

Figure 46. Fishing activity by vessels using mobile bottom contacting gears in NEAFC Regulatory Area 3.

2.5.2 Josephine Seamount

Josephine Seamount is a flat-topped, steep flanked seamount, approximately 500km west of Cape St Vincent. The plateau of the feature is at a depth of roughly 200–300m. During 2021, three vessels were recorded as fishing on the Josephine Seamount – one recorded as using bottom otter trawl gears, which made a single visit, and two recorded as using set long-lines, who made several trips to the region. All focussed their fishing activity on the top of the bank (Figure 48, Figure 49). Catch reports from the vessel using bottom trawl gears were inconclusive in determining the target of the fishery, however those of the vessels using static gears were more characteristic seamount species – wreckfish, conger eels, redfish, and alfonsino. Several trips had no associated catch reports, and these are presumed to be targeting species under ICAAT management.

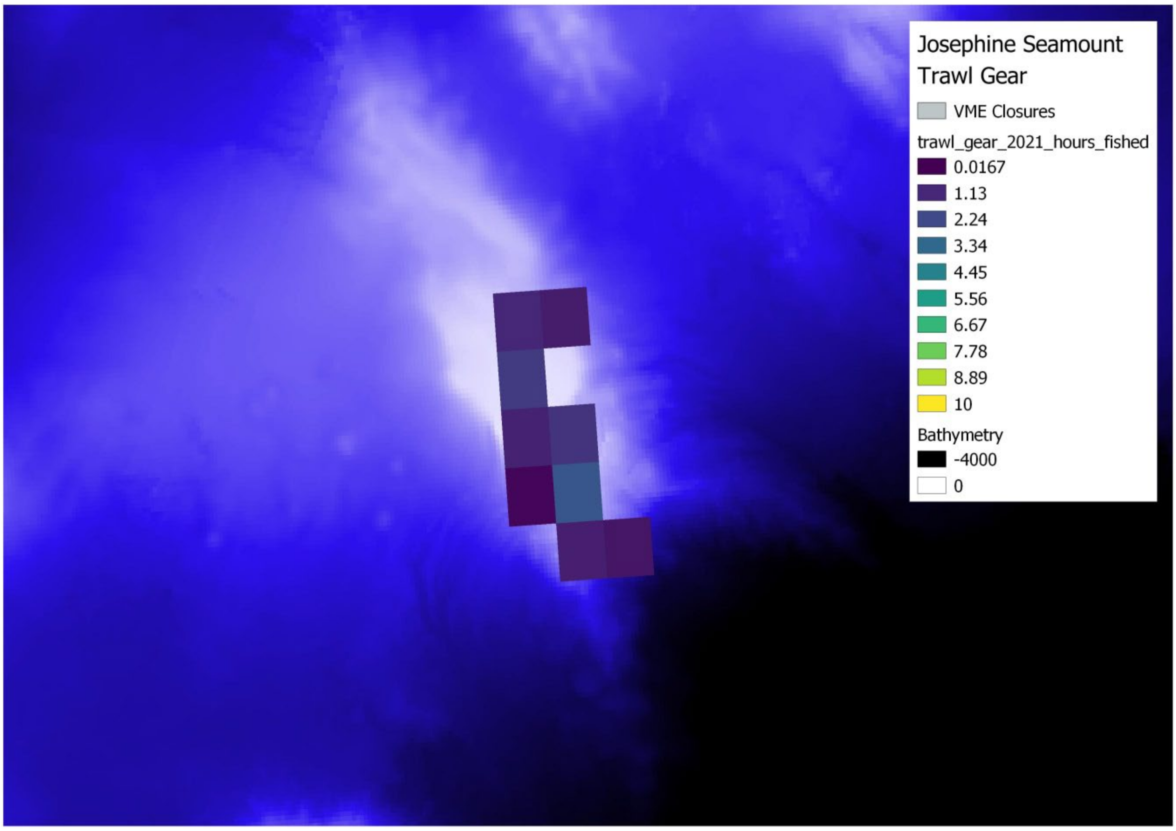

Figure 47. Fishing activity on Josephine Seamount by vessels using mobile bottom contacting gears.

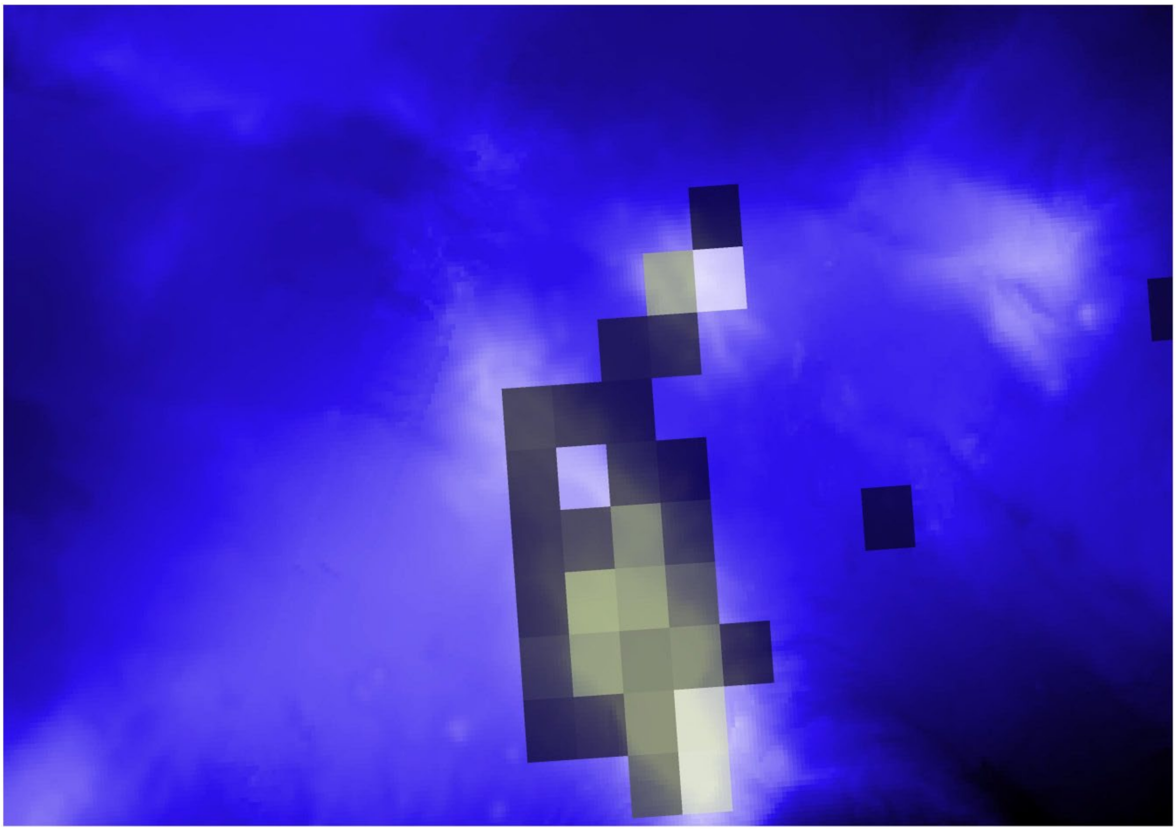

Figure 48. Fishing activity on Josephine Seamount by vessels using static gears.

2.5.3 Potential improvements to NEAFC data

The quality of the data provided to ICES by NEAFC has grown markedly in recent years enabling more precise linking of vessel catches to corresponding activities, enabling provision of better-informed advice.

Several potential changes which could improve the usability of data are suggested below:

- **Incorporate gear code in the CAT reports**

The North Atlantic Format (NAF), which is used to standardise the way in which catch reports are transmitted to fisheries monitoring centres, allows for additional information to be encoded, including gear type, beam length, the use of sorting grids, and mesh size used. At present, these fields are not used (or at least not available in the information provided by NEAFC to ICES). If such information could be made routinely available, even if at the trip level, in a similar manner to catch-on-entry and catch-on-exit messages, the utility of the data for the provision of advice would be greatly enhanced as it would be possible to calculate gear specific metrics of benthic impact such as swept area ratios.

- **Encourage contracting parties to supply gear information**

Presently there are a significant number of fishing vessels in the table provided to ICES which are active in the NEAFC regulatory area but for which no primary gear type information is provided. While the provision of such information does not appear to be mandatory, its absence is detrimental to the quality of advice which can be provided – a third category must be included in addition to static and mobile gears, the impacts of which are difficult to interpret.

- **Request comparison of NEAFC VMS with products of ICES VMS data call**

The ICES VMS and logbook data call requests data in an anonymised, aggregated, and standardised format from all ICES members fishing in the northeast Atlantic during 2009 - 2020. In theory it should receive data which is consistent with that which ICES receives directly from NEAFC. It would be an interesting exercise to request some comparison of the data from the two sources. Issues such as absent or miscoded gear information should not be a factor in the ICES data call, however the ability to drill into catch composition and to verify that tows are being conducted parallel to the prevailing bathymetry. Through such an exercise it may be possible to eliminate duplication of efforts and standardise the approach to analysis inside and outside the NEAFC regulatory area.

- **Identify gaps**

One feature which emerged during of the analysis of VMS around Josephine Seamount was the presence of trips identified from VMS data for which corresponding catch data did not exist. Presumably these trips were targeting species under the purview of other RFMOs and so working to a different set of standards, with data communicated via an alternative route. This data gap creates a risk that potential impacts on VME features could be missed or misinterpreted. While formal collaboration between RFMOs on such an issue may be a difficult task, it may be the case that this problem could be explored using existing data received through the ICES VMS data call and could be included in a request relating to the point above.

2.6 In response to ToR g)

Investigate the effect of moving to a higher resolution on anonymity in the VMS data call

In preparation for future advice requests for electronic advice outputs at higher resolution (c-square at -.05° x -.05°), WGSFD will:

1. *Analyse the extent of aggregated international VMS data subject to anonymity issues (≤ 3 number of vessels)*
2. *Discuss different procedures to preserve anonymity (gear groupings, area grouping, international grouping, …)*
3. *Approve on a method/s that optimizes the data product while preserving the anonymity.*

[To ensure vessel anonymity in electronic advice outputs at a higher resolution, aggregated international effort values of any c-squares containing three vessels or less will not be shown (see ICES VMS data call 2019). ICES Secretariat/Data centre will filter the sensitive data in the aggregated international fishing effort (3 vessels or less) and present the group with different scenarios. The agreed upon method will contain as much information as possible (spatial or as fishing effort value) while preserving the vessel anonymity.]

In its 2019 report, WGSFD considered the rules proposed by the Regional Coordination Groups (RCGs) as the basis for determining whether a system of data processing for VMS protected the anonymity of individuals within the data. These rules state:

1. When data are being published, each unit should contain at least 3 vessels.
2. Data providers should not suppress any data themselves
3. Data providers should supply the number of individual vessels in each aggregated unit
4. The authorised end user can be given access to data for an agreed purpose
5. Publication of data (including maps/charts/tables) must use one of the following techniques
    a. Suppression of data that includes less than 3 different vessels, by suppressing sensitive values.
    b. Aggregation of data so that each aggregation contains at least 3 different vessels.

ICES welcomed these practical suggestions elaborated by the RCGs and responded with changes in the implementation of ICES workflow to ensure contracting parties outside the scope of DCF were also included. The 2019 ICES VMS data call was modified to include a field showing the number of distinct vessels at the aggregation level of the data call and maps were presented to illustrate the areas for which the numbers of unique vessels in a c-square would be too low for data to be able to be presented. Removing data where there are less than 3 vessels within the data call aggregation affects the potential use of the published data. It will show main fishing grounds, used by several vessels, but removes the peripheral fisheries, particularly for smaller metiers.

An issue raised with this approach of adding the number of distinct vessels to the data call is that in ICES VMS data call, aggregation is by Country, Year, Month, C-square (-.05 degrees), Gear and Metier level 6. The number of distinct vessels can only be summed over country and vessel length category, but cannot be summed over month or metier, as the same vessel might be fishing in several metiers and months.

To provide greater flexibility in this regard, the 2020 and 2021 ICES VMS data calls went one step further, requesting the inclusion of unique identifiers for vessels fishing in cells where there are less than three unique vessels. This provides further assurances that any higher level of aggregation which allowed values to be published for a cell would indeed contain at least three unique vessels. Analysis of received data shows that the proportion of the area which must be redacted via this approach varies strongly between metiers, ranging between 4 and 97% (Table 11, Table 12). To aid with visualising the scale of the issue, these are mapped for selected Benthis metiers in Figures 51 – 56.

Table 12. C-squares with less than 3 unique vessels ('restricted') and greater than or equal to 3 ('not restricted') by Benthis categories, and the percentage of restricted c-squares to the total number of c-squares that the fishing gear reported activity for in 2020.

Benthis_metiers	Number of Restricted Cells	Number of Non-restricted cells	Percentage Restricted
DRB_MOL	3294	2846	54%
OT_CRU	12256	8865	58%
OT_DMF	27865	49952	36%
OT_MIX	3697	4116	47%
OT_MIX_CRU_DMF	3137	2360	57%
OT_MIX_DMF_BEN	1871	615	75%
OT_MIX_DMF_PEL	96	1874	5%
OT_SPF	5551	1435	79%
SDN_DMF	3768	1985	65%
SSC_DMF	7158	3224	69%
TBB_CRU	639	1624	28%
TBB_DMF	4581	9379	33%
TBB_MOL	56	7	89%

Table 13. C-squares with less than 3 unique vessels ('restricted') and greater than or equal to 3 ('not restricted') by Benthis categories, and the percentage of restricted c-squares to the total number of c-squares that the fishing gear reported activity for in 2019.

Benthis_metiers	Number of Restricted Cells	Number of Non-restricted cells	Percentage_Re-stricted
DRB_MOL	3416	3356	50%
OT_CRU	9471	9670	49%
OT_DMF	24223	49142	33%
OT_MIX	3428	4018	46%
OT_MIX_CRU_DMF	2882	2738	51%
OT_MIX_DMF_BEN	1763	590	75%
OT_MIX_DMF_PEL	64	1635	4%
OT_SPF	5059	1146	82%
SDN_DMF	4194	2113	66%
SSC_DMF	7752	2781	74%
TBB_CRU	1304	1538	46%
TBB_DMF	4608	9997	32%
TBB_MOL	74	2	97%

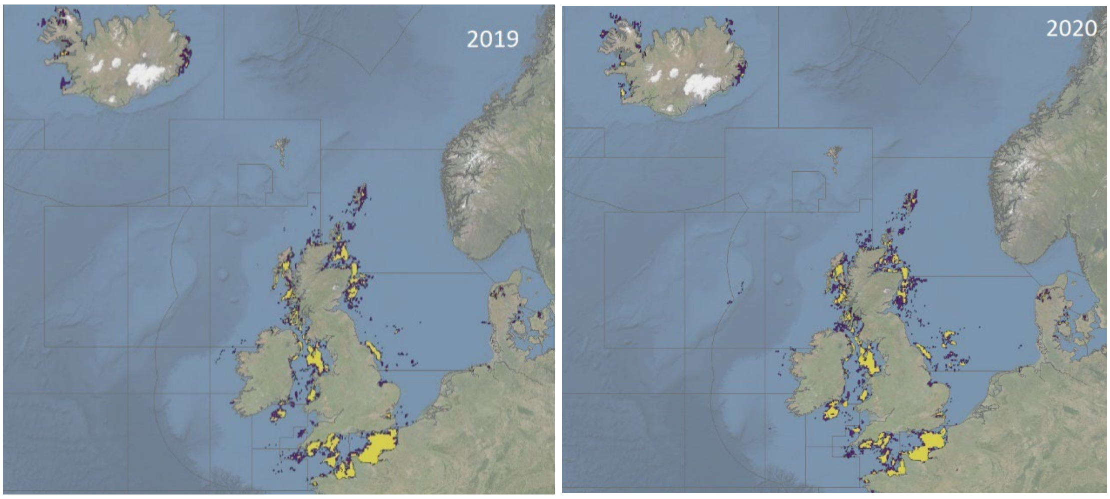

Figure 49. Areas fished by DRB_MOL gears in 2019 and 2020 which contain less than three (purple) and three or more vessels (yellow).

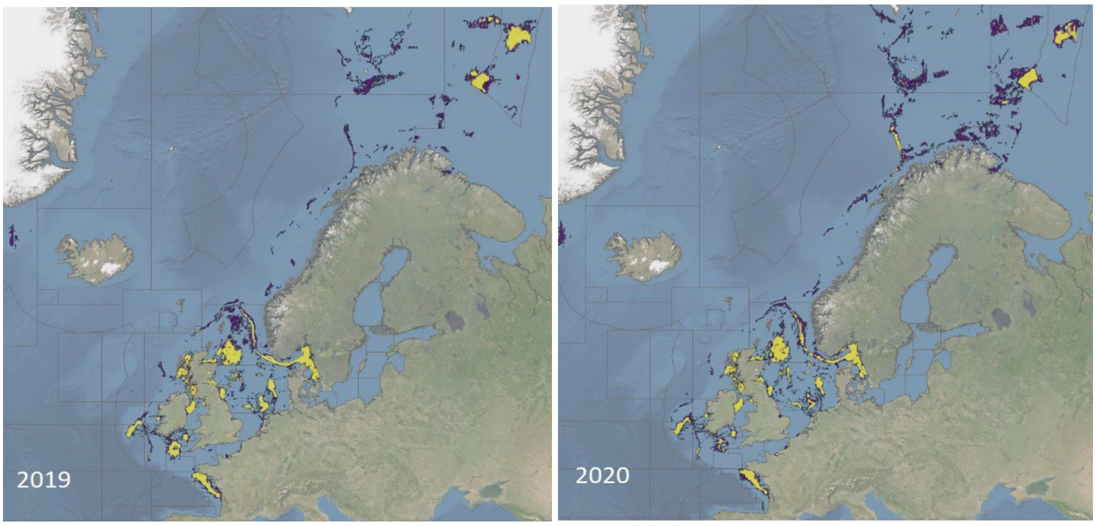

Figure 50. Areas fished by OTB_CRU gears in 2019 and 2020 which contain less than three (purple) and three or more vessels (yellow).

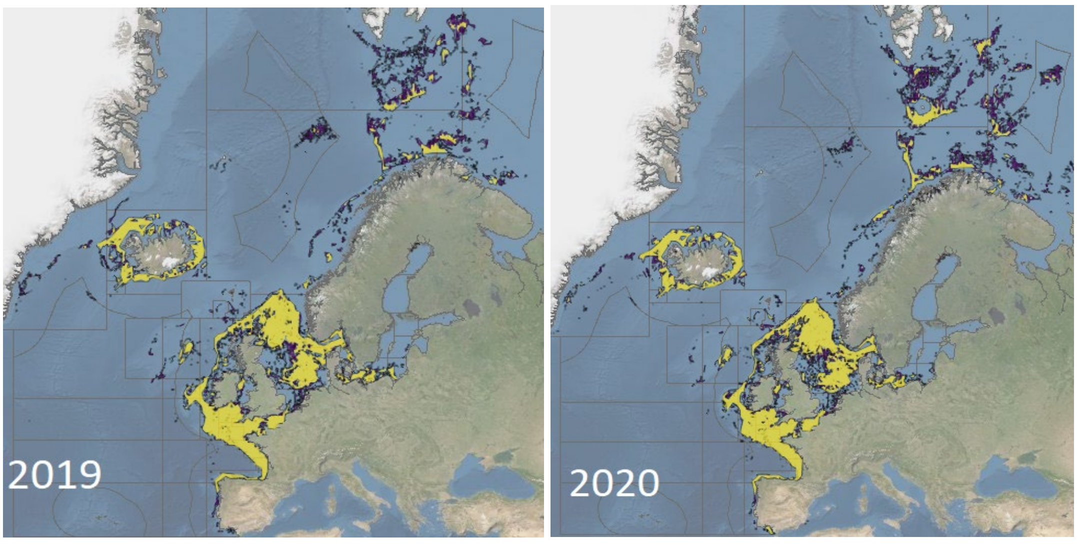

Figure 51. Areas fished by OTB_DEF gears in 2019 and 2020 which contain less than three (purple) and three or more vessels (yellow).

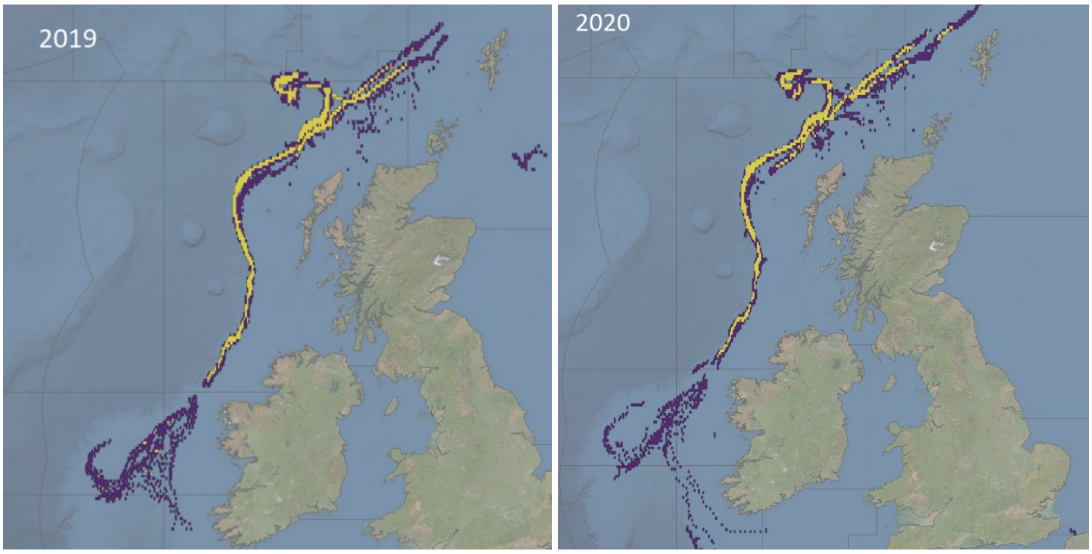

Figure 52. Areas fished by OTB_MIX_DMF_BEN gears in 2019 and 2020 which contain less than three (purple) and three or more vessels (yellow).

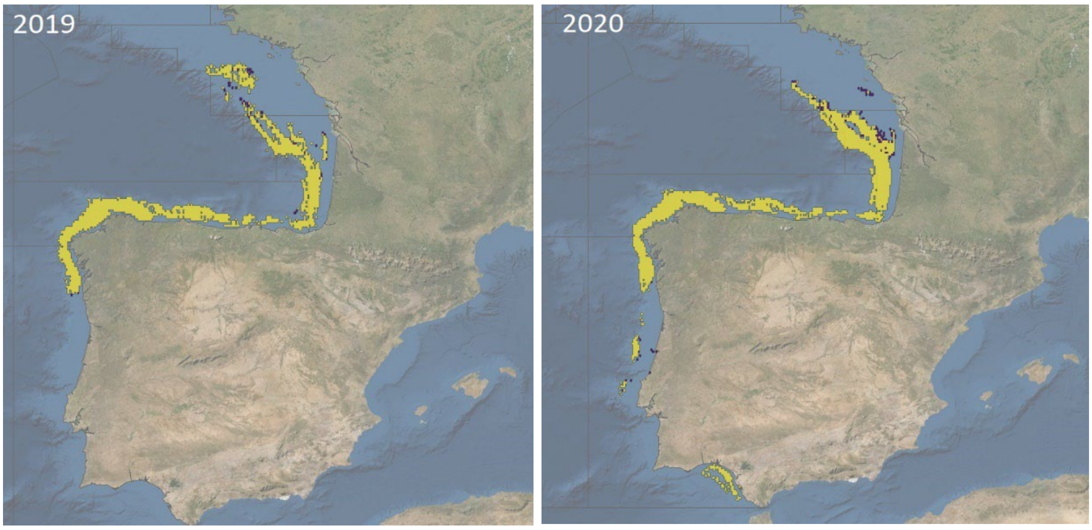

Figure 53. Areas fished by OTB_SPF gears in 2019 and 2020 which contain less than three (purple) and three or more vessels (yellow).

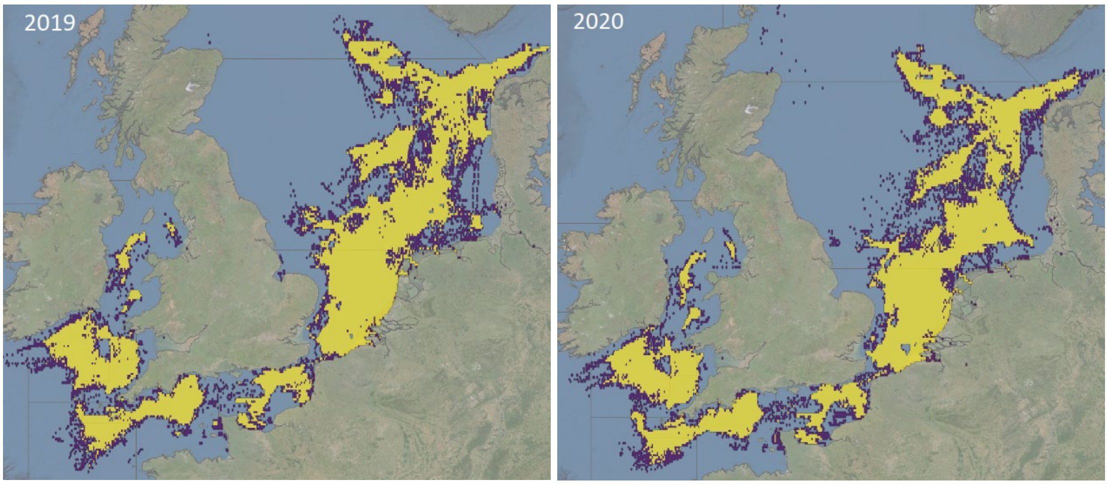

Figure 54. Areas fished by TBB_DEF gears in 2019 and 2020 which contain less than three (purple) and three or more vessels (yellow).

Recommendations

Data can be considered sensitive if the activities of individual vessels can be inferred from the data, however the perception of sensitivity is not uniform and is often dependent on the context of the request for advice for which the data is being processed. ICES WGSFD are not experts on the technicalities of data protection legislation, and to "recommend" any particular approach as being "sufficient" for suitable protection of anonymity is beyond the scope of the group. While we have presented several approaches to protect anonymity in aggregated VMS data, the onus is on the publisher of such data that the method used is appropriate.

ICES WGSFD recommends that the following guidelines are followed when publishing data:

- **Swept area ratios (SAR) and hours fished are not sensitive and can be published, even if there are less than 3 vessels within the aggregation. This information cannot be used to identify individual vessel.**
- If there is need to publish other data with less than 3 vessels within the aggregation level, the data values can be classified, so that only groups are published (e.g., Kw groups), that are wide enough that individual vessels can't be identified.
- Published data should not include information that can be used to infer the suppressed value (e.g., if the value of a single unit is suppressed but the total value is published then the suppressed value might be calculated).
- A solution for publishing the sensitive data have been mentioned in the ICES data call that data are only made public at ICES rectangle level, but it would be possible to give information on the empirical distribution of values within each ICES rectangle.
- Special requests for advice can be addressed with data calls to national labs to produce rasters from point data which can then be aggregated at an international level.

3 References

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4 Provision of new information on VMEs and fishing activities within NEAFC Convention Area and EU waters

Copy of the Joint report section with WGDEC 2021

Provide all available new information on the distribution of vulnerable habitats (VMEs) in the NEAFC Convention Area. This should also include information on the distribution of vulnerable habitats in sub-areas of the Regulatory Area that are closed to fishing for other purposes than VME protection. In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters

4.1 Areas with new, historical or resubmitted VME data

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

Areas considered within the NEAFC Regulatory Area:

- Hatton Bank
- Rockall Bank
- Charlie Gibbs Fracture Zone
- Barents Sea

Areas considered within the NAFO Regulatory Area:

- Grand Banks of Newfoundland and Flemish Cap

Areas considered within the EEZs of various countries:

- Rockall Bank
- Hebridean slope
- Faroe Shetland Channel
- Irish continental slope and Porcupine Bank and Seabight
- Bay of Biscay
- Spanish continental slope (North Spain)
- Galicia Bank
- Bay of Biscay
- Central and South West Barents Sea (Tromsø Flaket)
- North West Barents Sea (Svalbard)
- North East Barents Sea (Russia)

For each area, maps are shown of the new VME indicator and/or habitat records, the outputs of the VME likelihood index based on the VME weighting algorithm, and the associated VME index confidence layer. Details of the method for the VME weighting algorithm are reported in Morato *et al*, 2018. It should be noted that the absence records described in Section 3 are not included in the VME weighting algorithm or the ToR [b] maps.

4.2 Areas considered within the NEAFC Regulatory Area

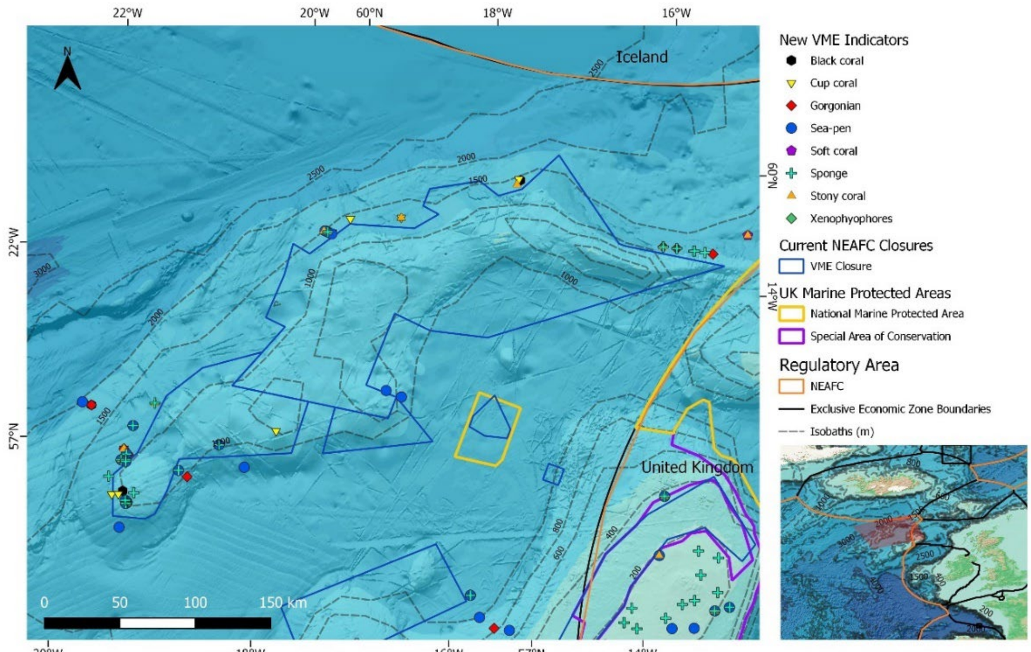
4.2.1 Hatton Bank

Hatton Bank is a large volcanic bank, situated in the Atlantic Northwest Approaches, towards the western extent of the UK continental shelf. It is an elongate, arc-shaped bank, stretching nearly 500 km in length and rising up to 1 km above the surrounding seabed.

New VME habitat data on Hatton Bank were submitted by Marine Scotland Science in the UK from the Deepwater Ecosystem survey (1420S), and the Instituto Español de Oceanografía (IEO) in Spain from fishery observers through the Spanish Observers Program (2014-2019) (Figure 4.1).

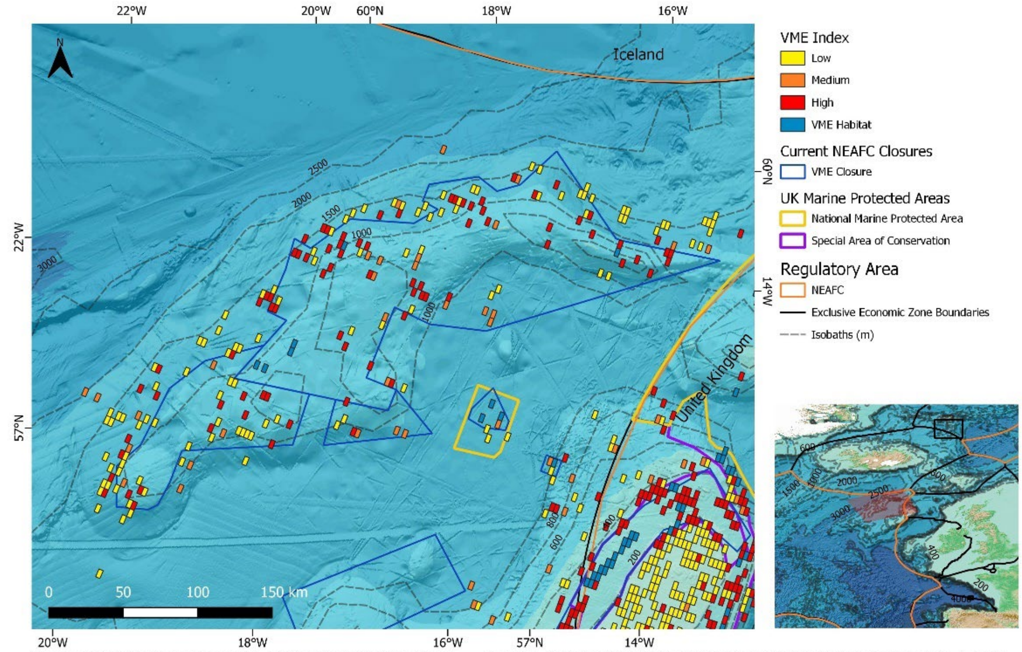
These new data have contributed to updated outputs from the VME weighting algorithm. The updated VME index for Hatton Bank is shown in Figure 4.2. The algorithm has a gridded output layer, which shows the likelihood of encountering a VME for each grid cell; either low (yellow), medium (orange) or high (red). Those grid cells containing bona fide records of VME habitat are shown in blue and were excluded from the VME weighting algorithm and confidence layer.

The confidence layer associated with the VME weighting algorithm's VME Index layer is shown in Figure 4.3. High confidence cells are shaded black, medium confidence cells are shaded grey and low confidence cells are shaded white.



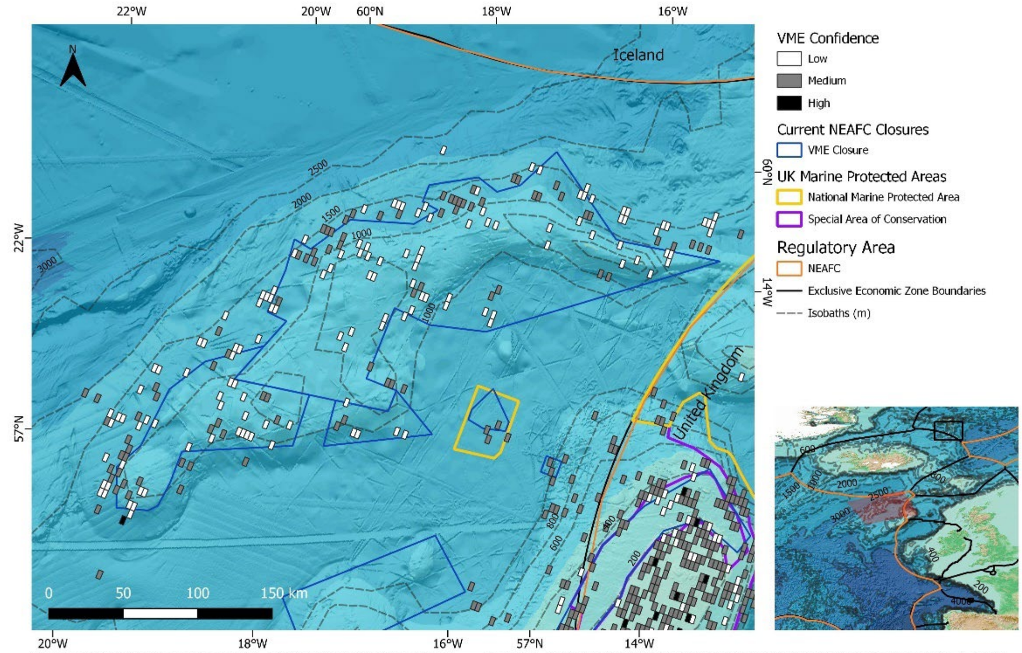
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.1 New VME records submitted in 2021 for Hatton Bank within the NEAFC Regulatory Area. Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.2 Output of the VME weighting algorithm for the area shown in Figure 4.1 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.3 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.2). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2021) records from the ICES VME database.

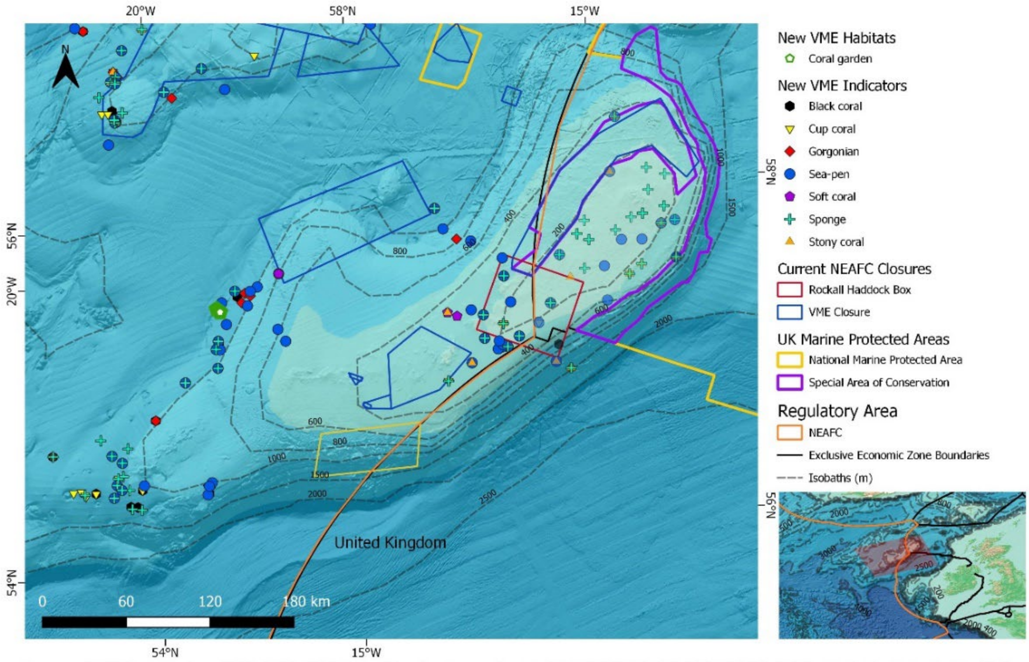
4.2.2 Rockall Bank

Rockall Bank is located off the west coast of Scotland and Ireland. The more gently sloping western side of the bank is located within the NEAFC Regulatory Area whereas the steeper, eastern side of the bank is located within the EEZs of both the UK and Ireland.

New VME habitat data (coral gardens) and VME indicator data within the NEAFC Regulatory Area on Rockall Bank were submitted by Marine Scotland in the UK from the Rockall Haddock Survey (1320S) and PINRO (Russia) from fishery observers (Figure 4.4).

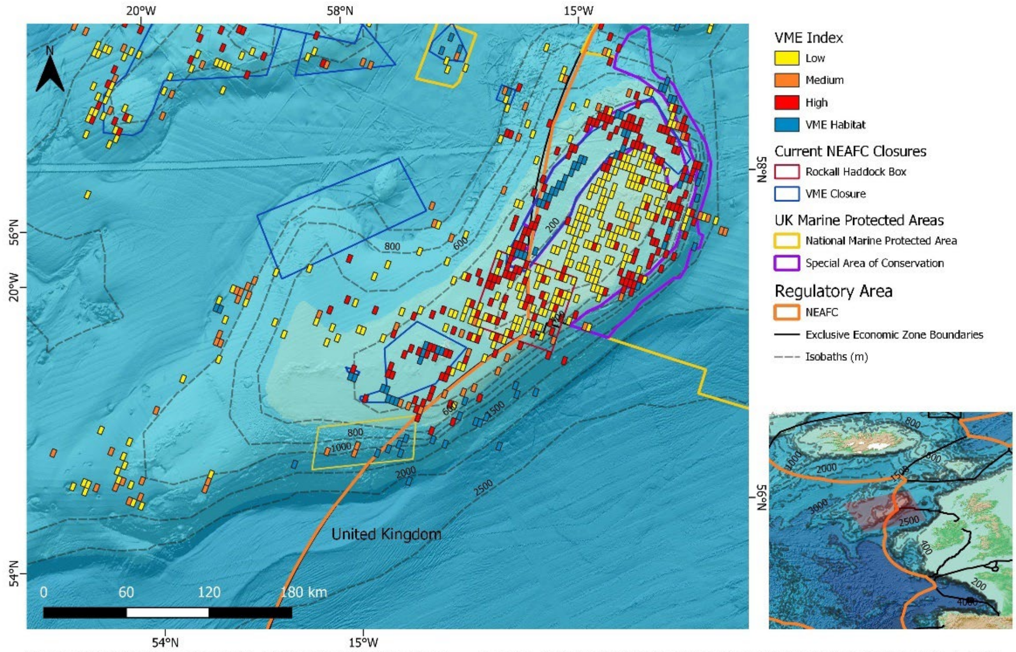
Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.5, and the confidence layer for the VME index is shown in Figure 4.6.

Fifteen new VME indicator records were submitted from within the Haddock Box closure area (Figure 4.7). This brings the total number of VME database records within the Haddock Box closure (within the NEAFC Regulatory Area) to 260 VME indicators (and to 447 including the area within the EEZs of UK and Ireland). The closure remains an important area for VMEs, as indicated by the outputs of the VME weighting algorithm shown in Figure 4.8 and Figure 4.9.



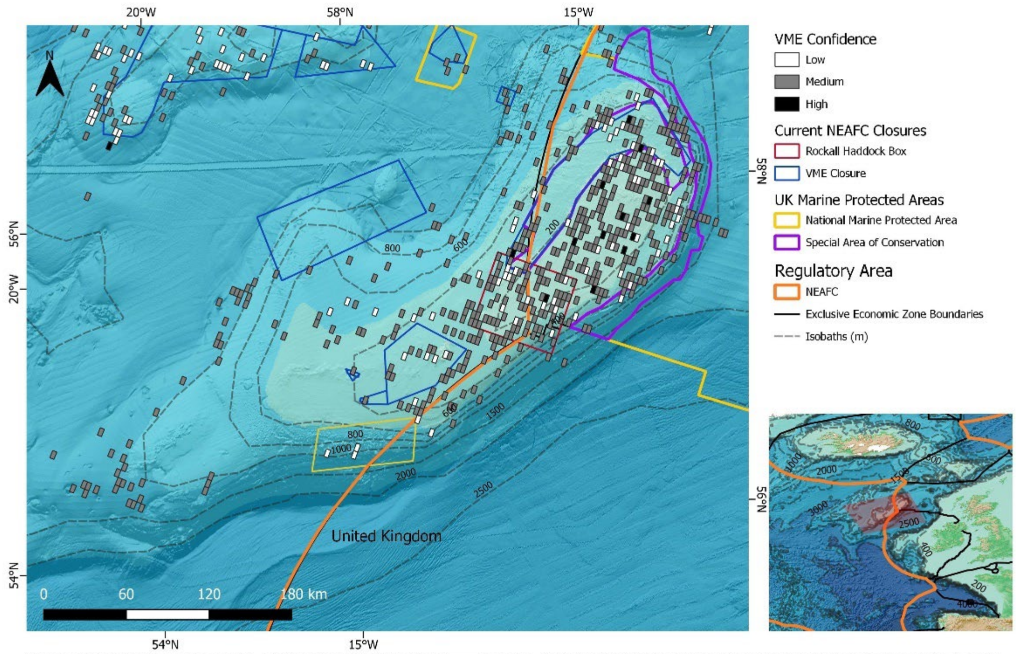
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.4 New VME records submitted in 2021 for Rockall Bank within the NEAFC Regulatory Area (new records outside the NEAFC Regulatory Area are displayed as transparent). Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.5 Output of the VME weighting algorithm for the area shown in Figure 4.4 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.6 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.5). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2021) records from the ICES VME database.

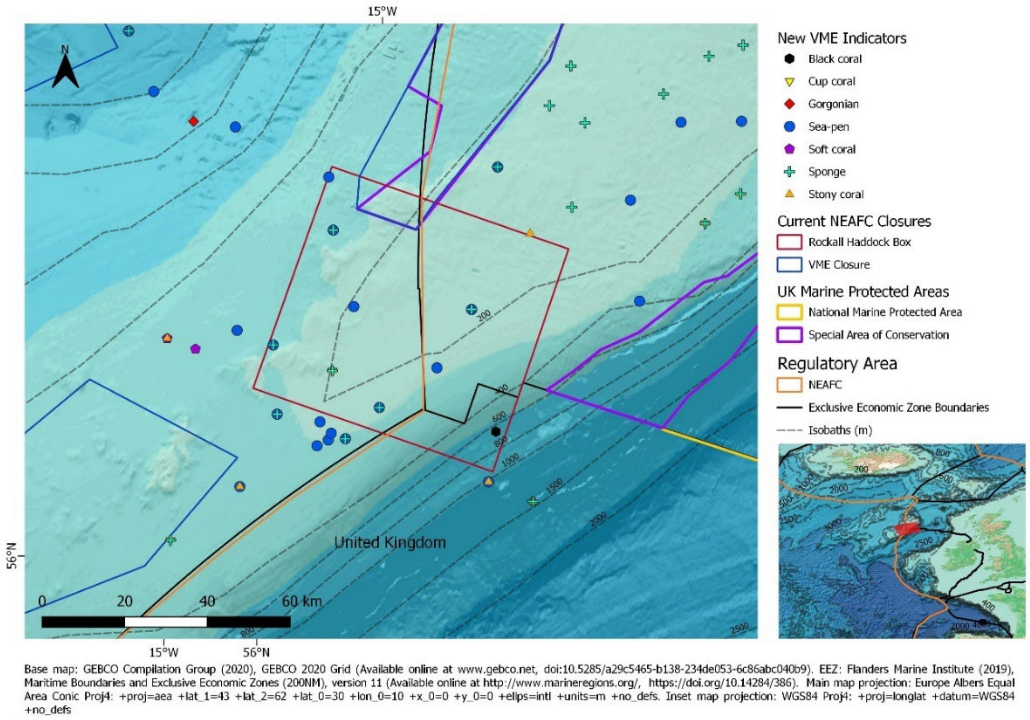


Figure 4.7 New VME indicator records submitted in 2021 within the Haddock Box closure area on Rockall Bank. Note, other VME records from the VME database for this area are not displayed.

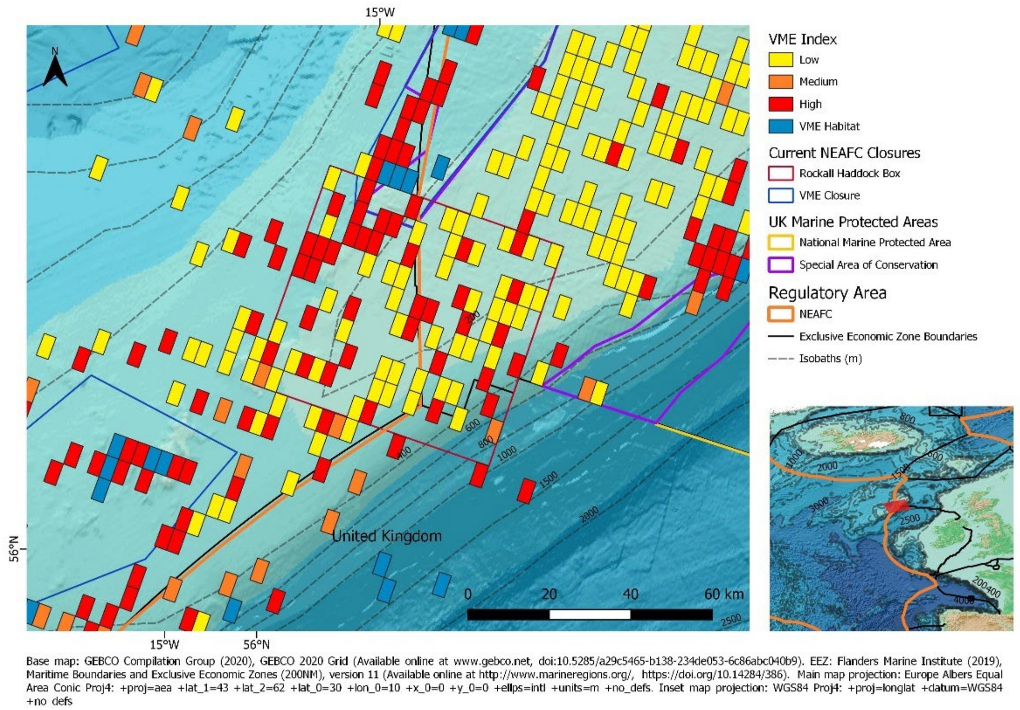
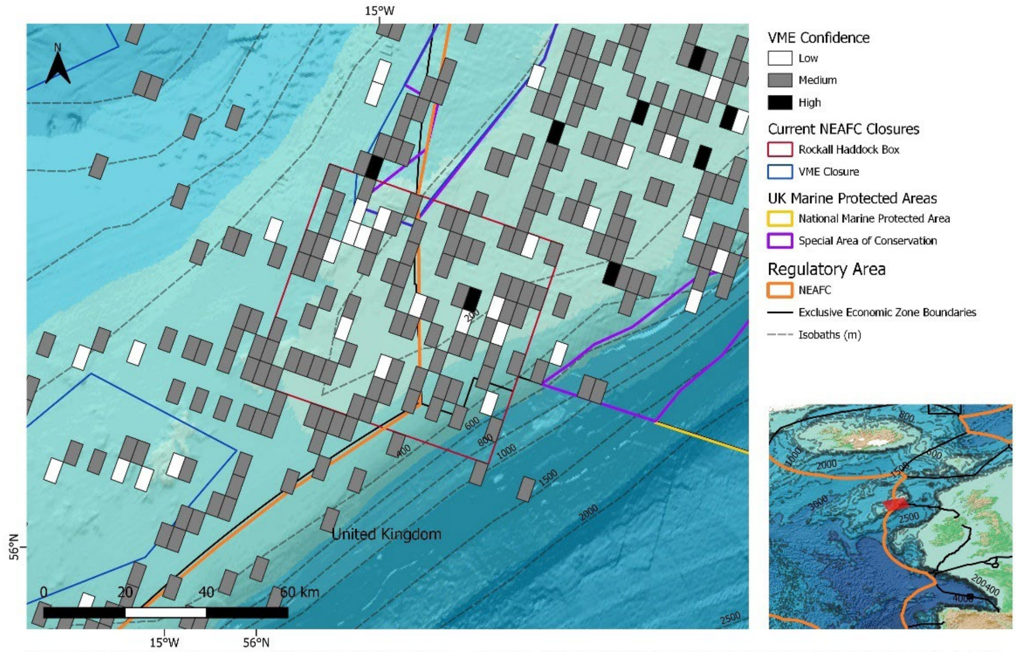


Figure 4.8 Output of the VME weighting algorithm for the area shown in Figure 4.7 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

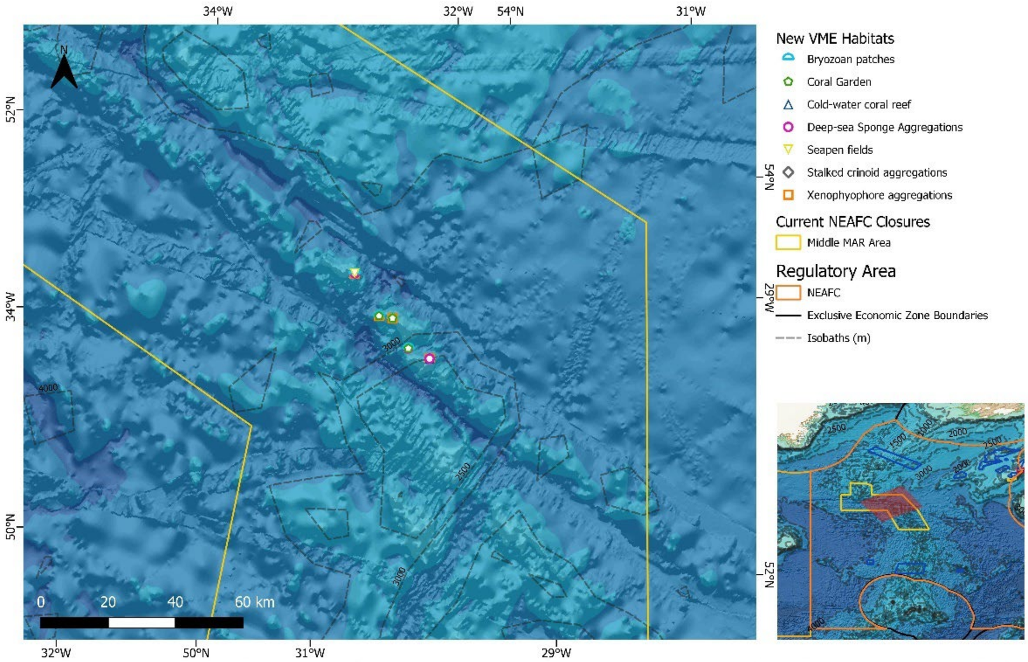
Figure 4.9 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.8). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2021) records from the ICES VME database.

4.2.3 Charlie Gibbs Fracture Zone

The Charlie Gibbs Fracture Zone is a large geological fault within the northern Mid-Atlantic Ridge between Iceland and the Azores.

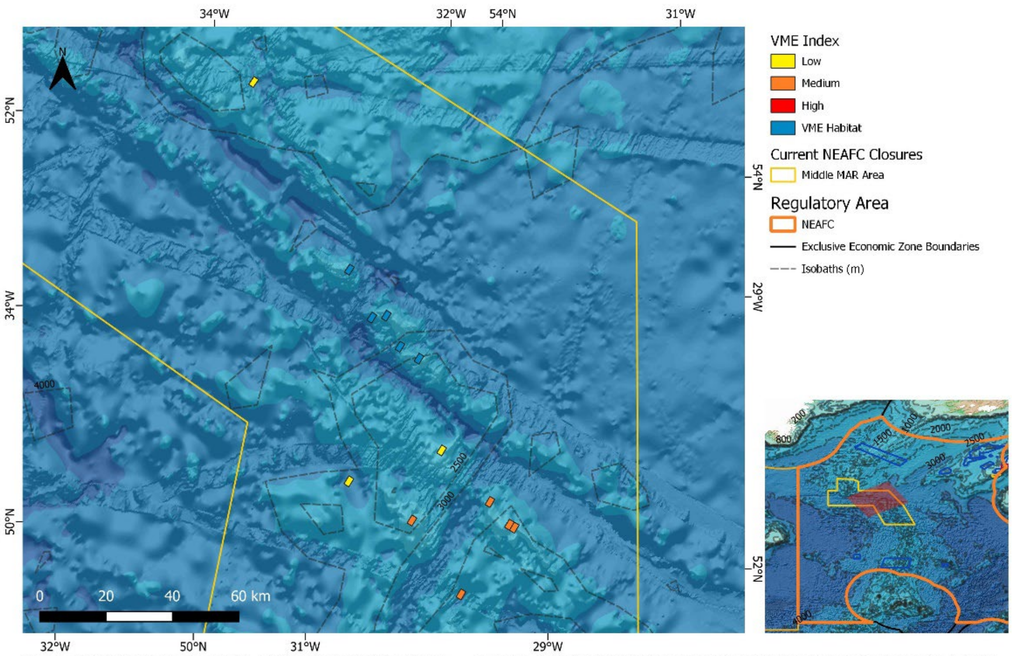
New VME habitat data within the Charlie Gibbs Fracture Zone were submitted by the Marine Institute, Ireland, from the TOSCA 2018 survey, providing important new records of VME within the existing NEAFC 'Middle MAR' VME closure area (Figure 4.10).

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



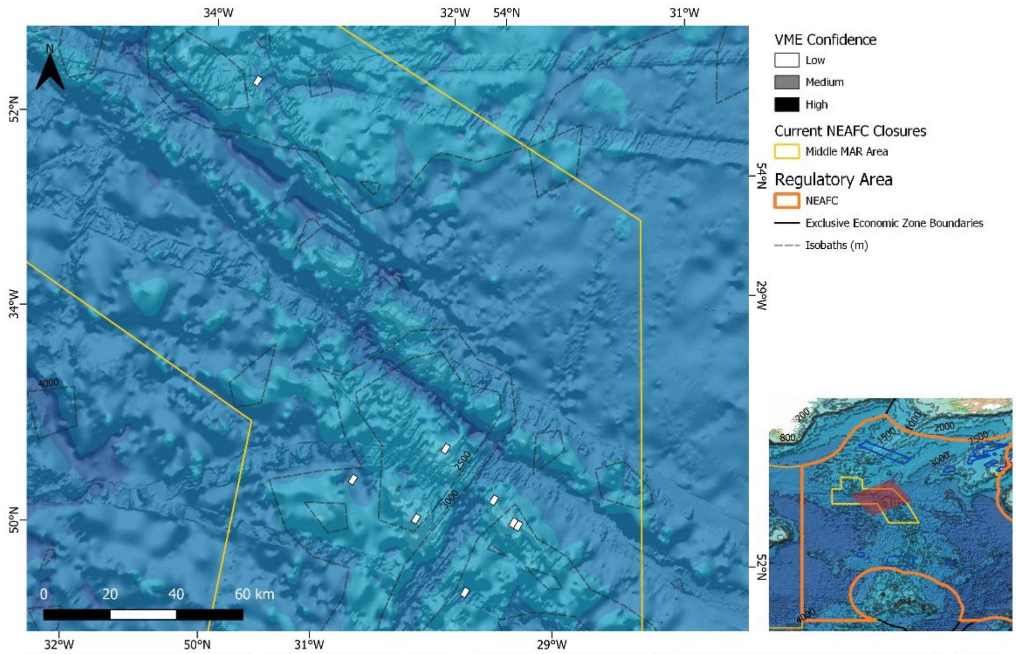
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.10 New VME records submitted in 2021 for the Charlie Gibbs Fracture Zone within the NEAFC Regulatory Area. The existing VME closure is shown in yellow. Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.11 Output of the VME weighting algorithm for the area shown in Figure 4.10 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME (blue squares). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.12 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.11). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. This includes all (not only 2021) records from the ICES VME database.

4.2.4 Barents Sea

New VME indicator data were submitted by the Institute of Marine Research (Norway) and PINRO (Russia) for the North East Barents Sea within the NEAFC Regulatory Area (Figure 4.13). Data were from bottom trawls from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS) in 2019 (Norway) and 2020 (Russia).

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

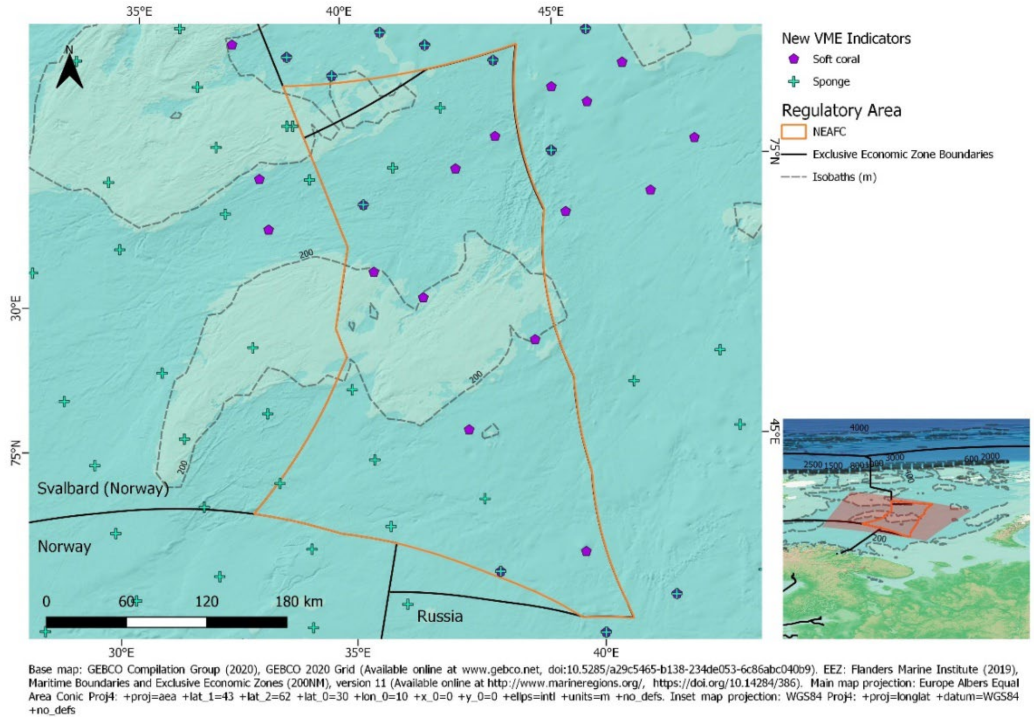


Figure 4.13 New VME indicator records submitted to the VME database in 2021 for the NE Barents Sea. The NEAFC Regulatory Area is shown as an orange line. Note, other VME records from the VME database for this area are not displayed.

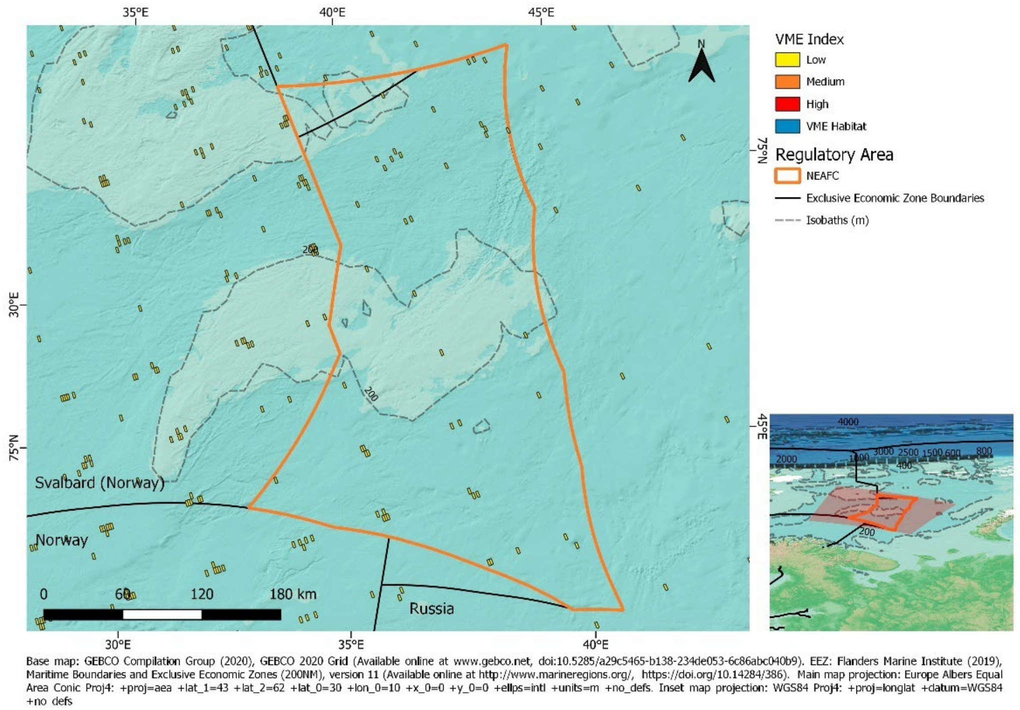
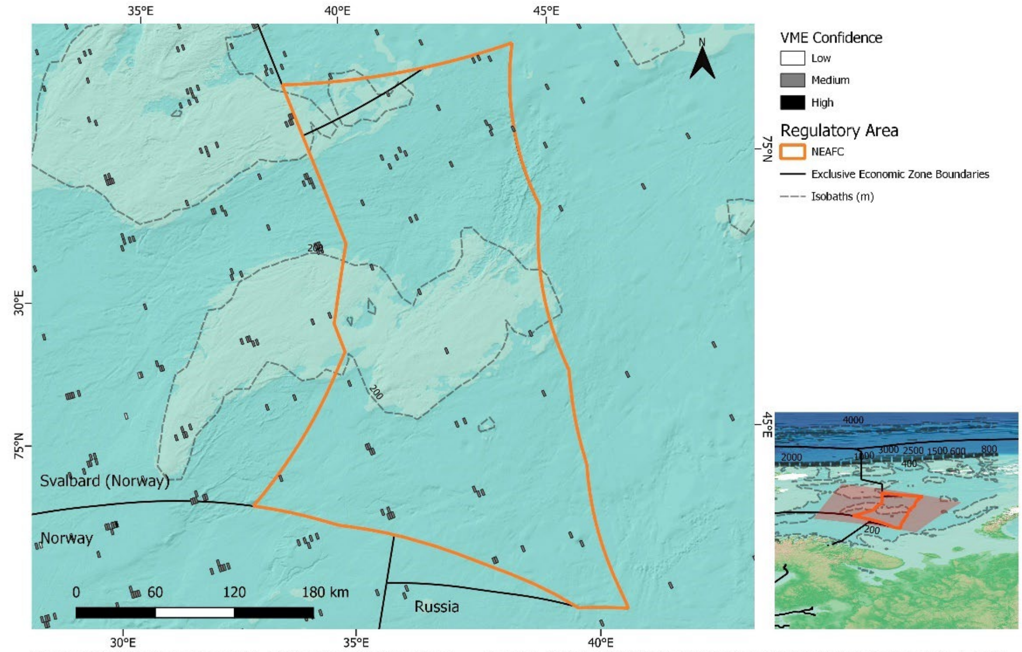


Figure 4.14 Output of the VME weighting algorithm for the area shown in Figure 4.13 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

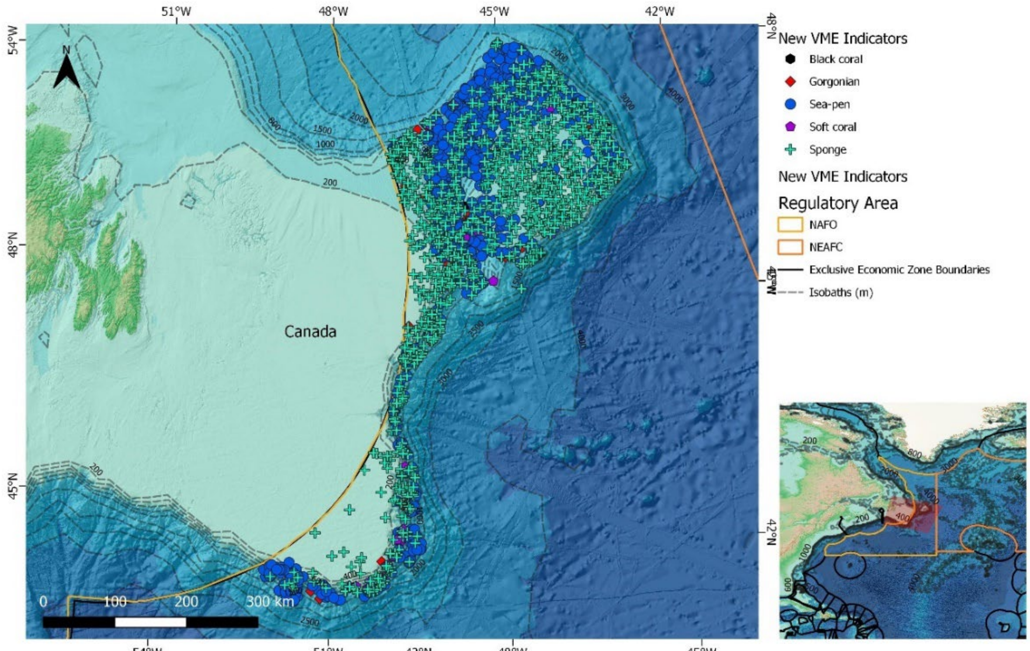
Figure 4.15 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.14) showing all cells as Medium VME confidence. This includes all (not only 2021) records from the ICES VME database.

4.3 Areas considered within the NAFO Regulatory Area

4.3.1 Grand Banks of Newfoundland and Flemish Cap

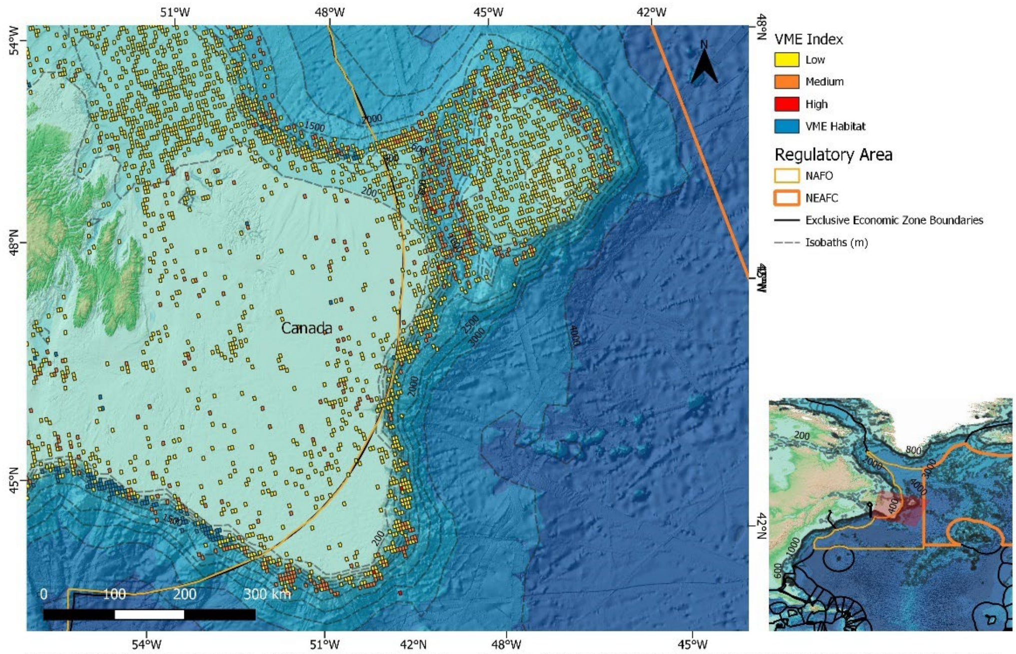
New VME indicator data for the Grand Banks of Newfoundland and Flemish Cap within the NAFO Regulatory Area were submitted by the Instituto Español de Oceanografía (IEO) in Spain (Figure 4.16). Data were from the 2014-2020 EU bottom trawl groundfish surveys in the NAFO Regulatory Area (Division 3LMNO).

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



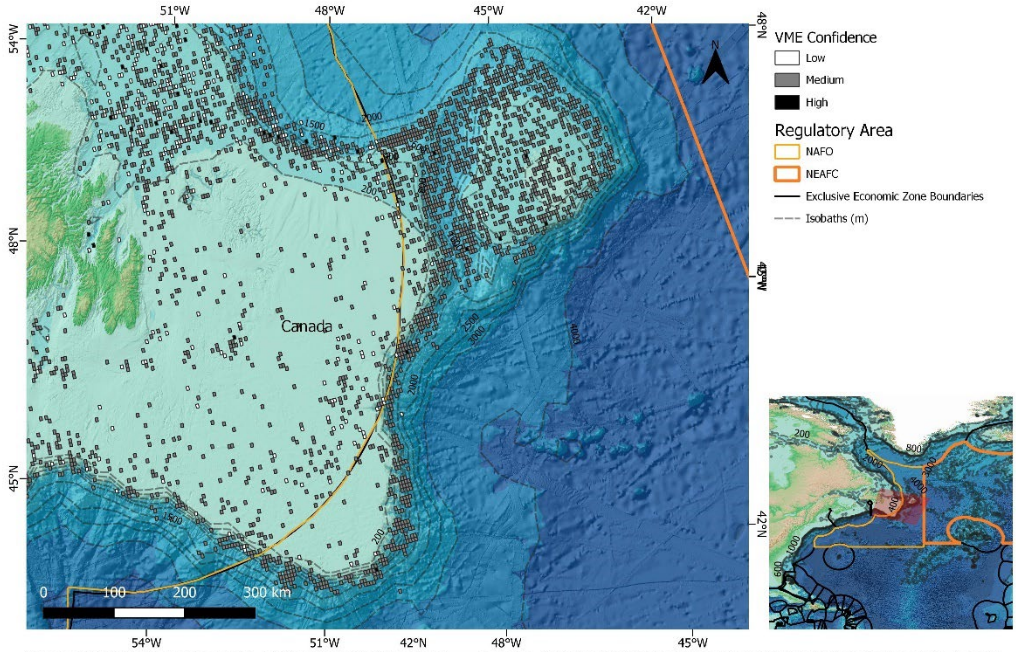
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Quebec Albers Proj4: +proj=aea +lat_1=60 +lat_2=46 +lat_0=44 +lon_0=-68.5 +x_0=0 +y_0=0 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.16 New VME indicator records submitted to the VME database in 2021 for the Grand Banks and Flemish Cap. Note, other VME records from the VME database for this area are not displayed



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Quebec Albers Proj4: +proj=aea +lat_1=60 +lat_2=46 +lat_0=44 +lon_0=-68.5 +x_0=0 +y_0=0 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.17 Output of the VME weighting algorithm for the area shown in Figure 4.16 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Quebec Albers Proj4: +proj=aea +lat_1=60 +lat_2=46 +lat_0=44 +lon_0=-68.5 +x_0=0 +y_0=0 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

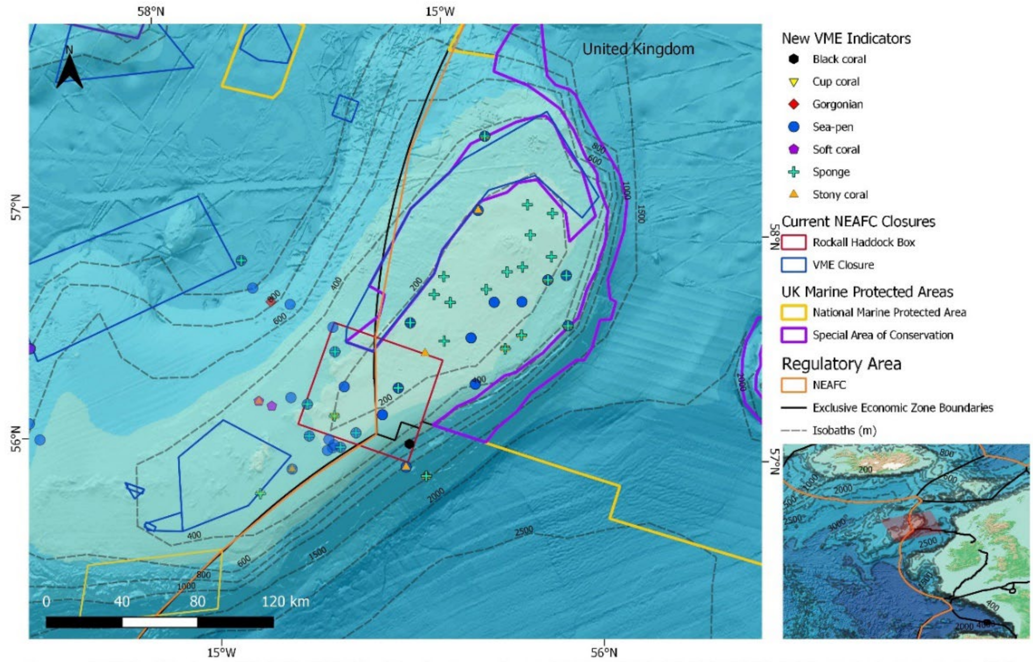
Figure 4.18 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.17). This includes all (not only 2021) records from the ICES VME database.

4.4 Areas considered within the EEZs of various countries

4.4.1 Rockall Bank

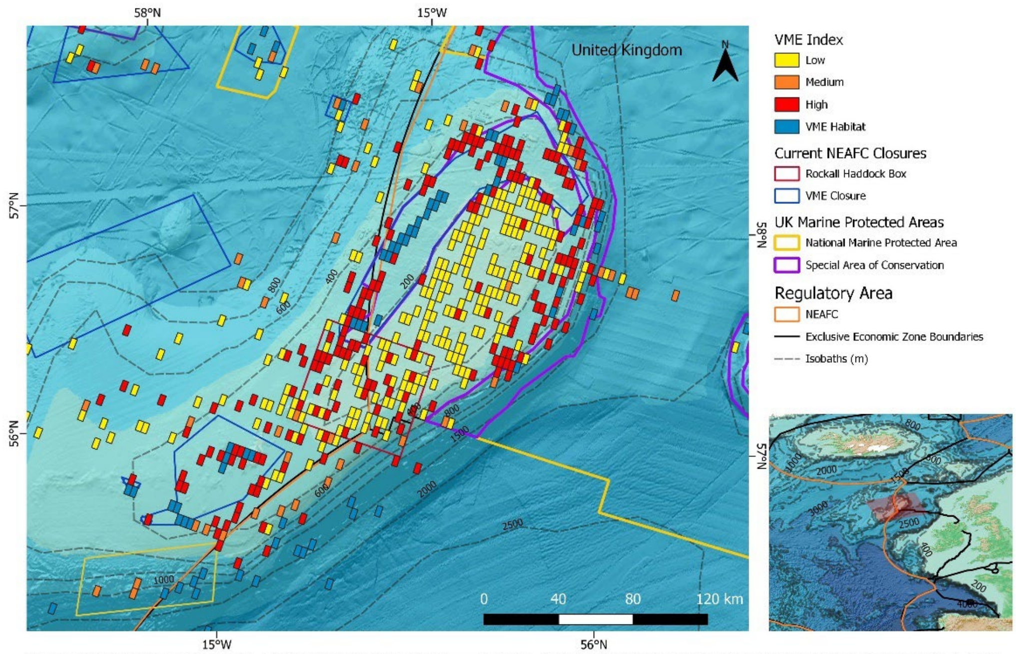
New VME indicator data for Rockall Bank were submitted by Marine Scotland Science (UK) (Figure 4.19). New data within the UK EEZ came from the Rockall Haddock Survey (1320S), and data within the Irish EEZ came from the Deepwater Ecosystem survey (1420S).

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



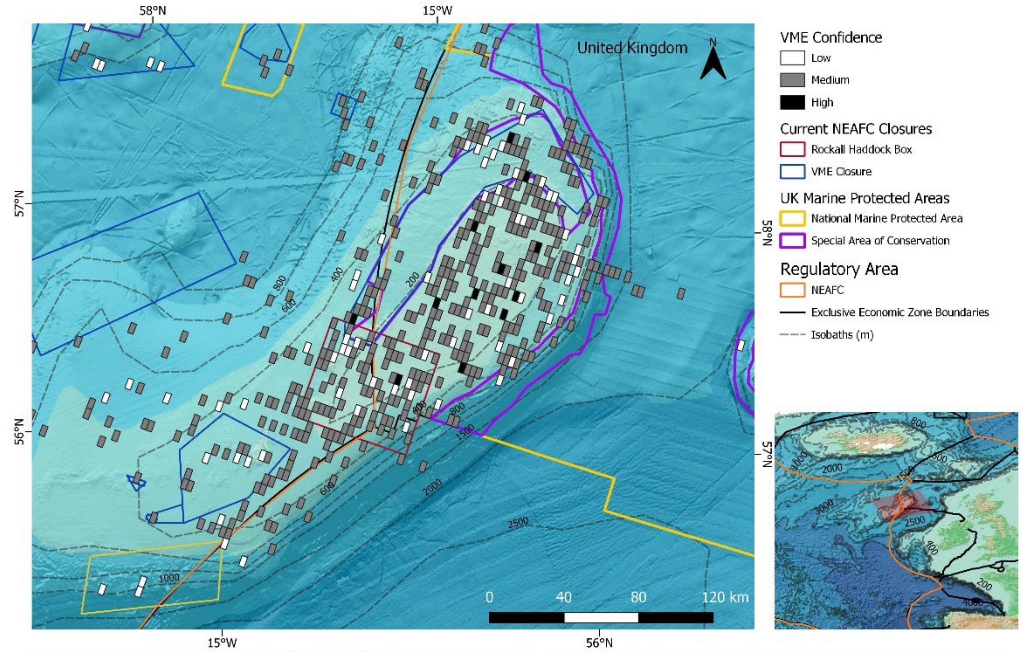
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.19 New VME indicator records submitted in 2021 for Rockall Bank within the UK and Irish EEZs (new records outside the EEZs are displayed as transparent). Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.20 Output of the VME weighting algorithm for the area shown in Figure 4.19 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



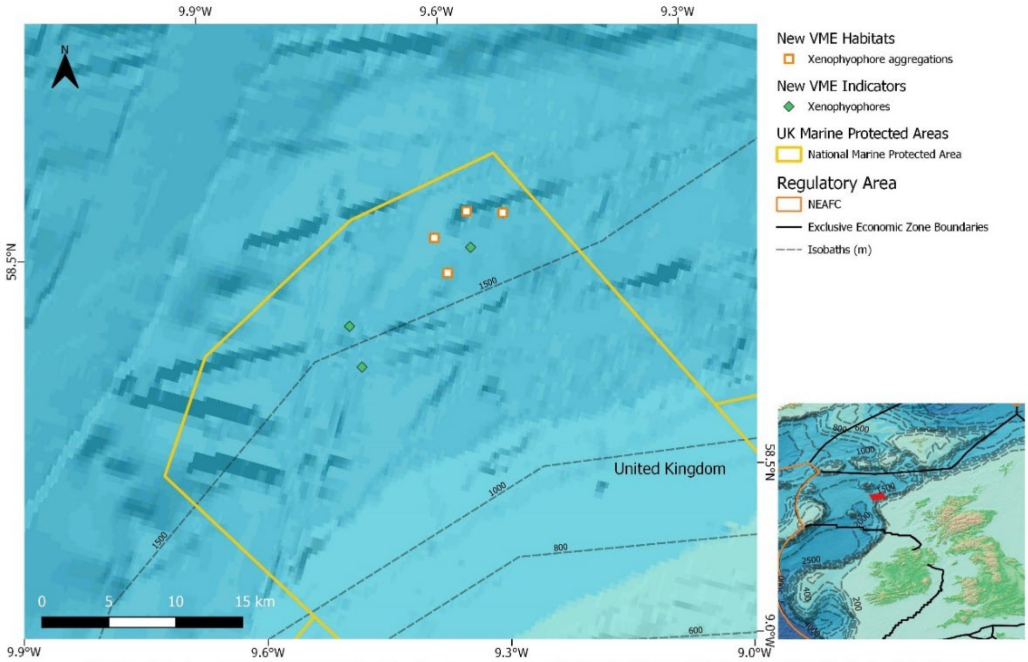
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.21 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.20). This includes all (not only 2021) records from the ICES VME database.

4.4.2 Hebridean Slope (Scotland)

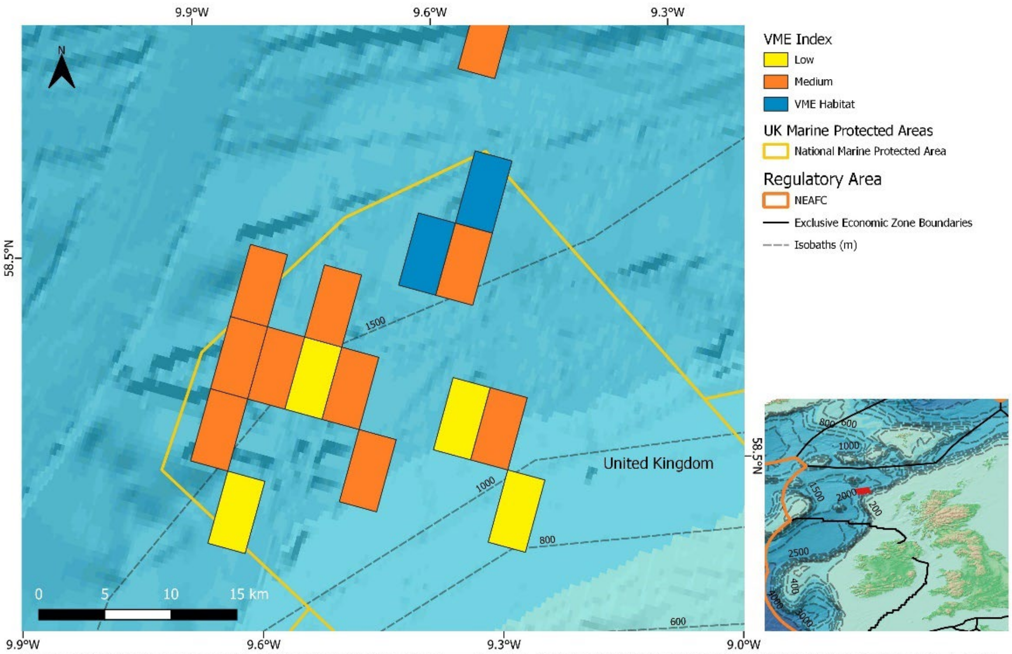
New VME habitat and Indicator data for the Hebridean Slope off Scotland in the UK EEZ were submitted by the JNCC (UK) (Figure 4.22). Data came from the joint JNCC/Marine Scotland Science research cruise (1016S), to Geikie Slide and the Hebridean Slope MPA.

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



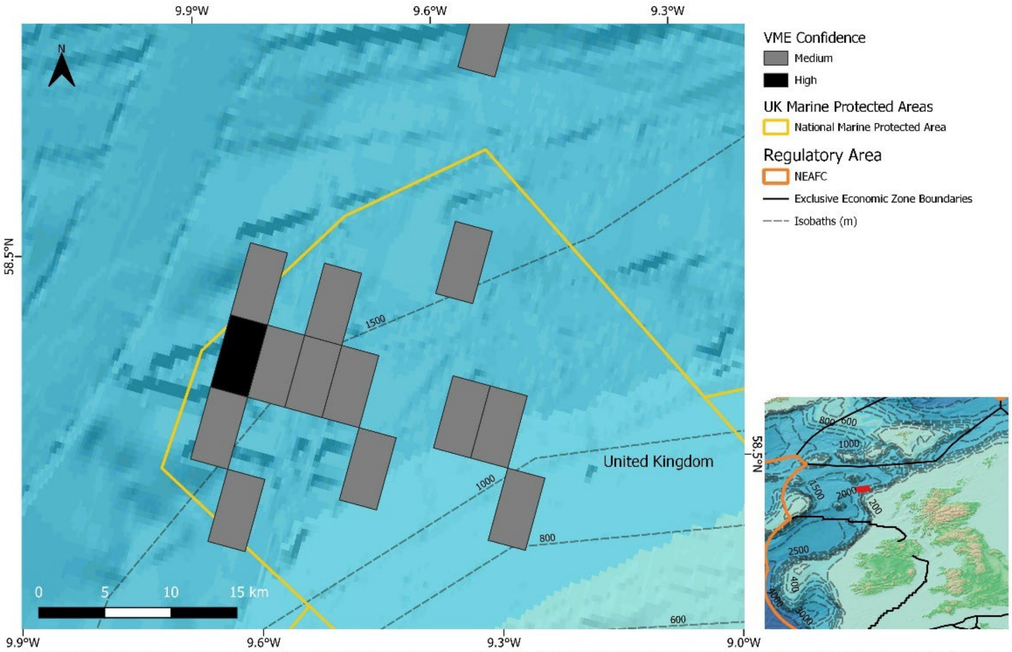
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic ProjH: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 ProjH: +proj=longlat +datum=WGS84 +no_defs

Figure 4.22 New VME records submitted in 2021 for the Hebridean Slope within the UK EEZ. Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic ProjH: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 ProjH: +proj=longlat +datum=WGS84 +no defs

Figure 4.23 Output of the VME weighting algorithm for the area shown in Figure 4.22 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

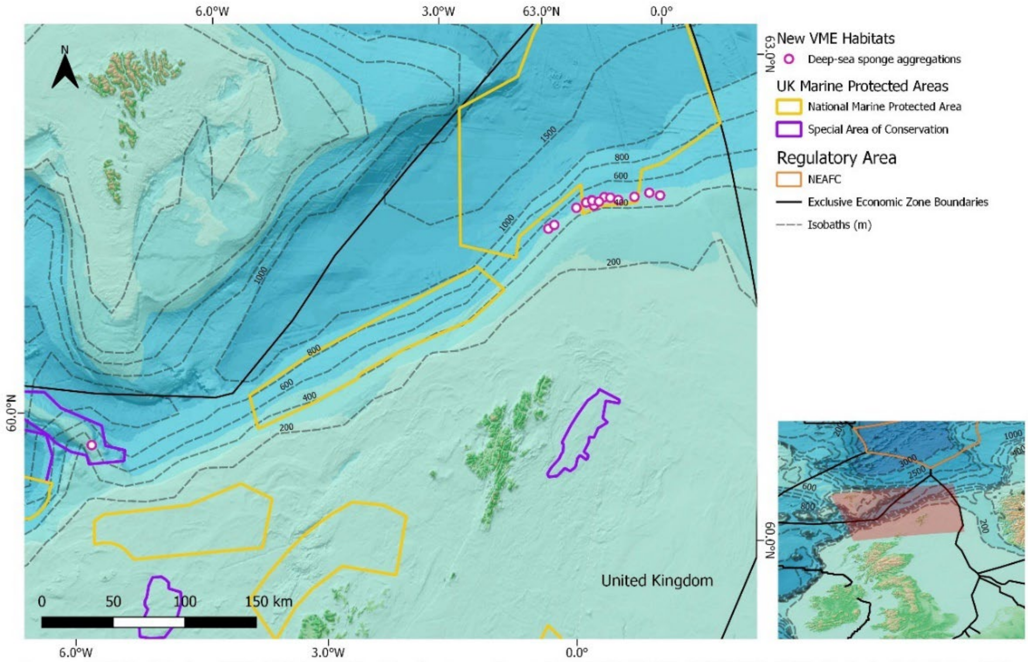
Figure 4.24 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.23). This includes all (not only 2021) records from the ICES VME database.

4.4.3 Faroe Shetland Channel

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

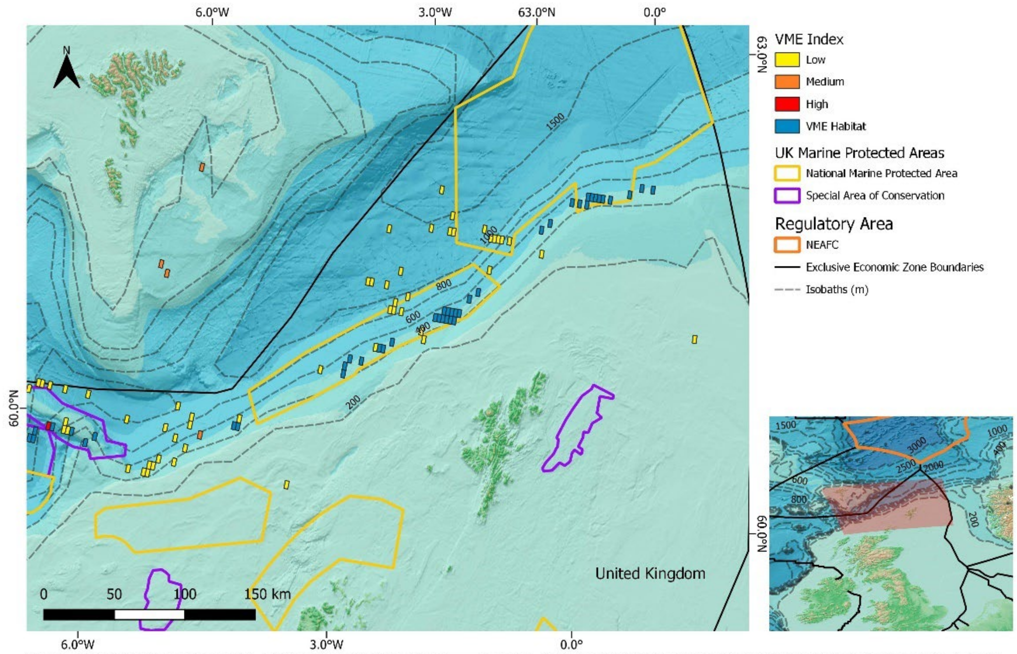
New VME habitat data for the Faroe Shetland Channel within the UK EEZ were submitted by JNCC (UK) from the joint JNCC/Marine Scotland Science research cruise (1517S) to the North-east Faroe Shetland Channel MPA, Wyville Thomson Ridge MPA and West Shetland Shelf MPA (Figure 4.25).

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



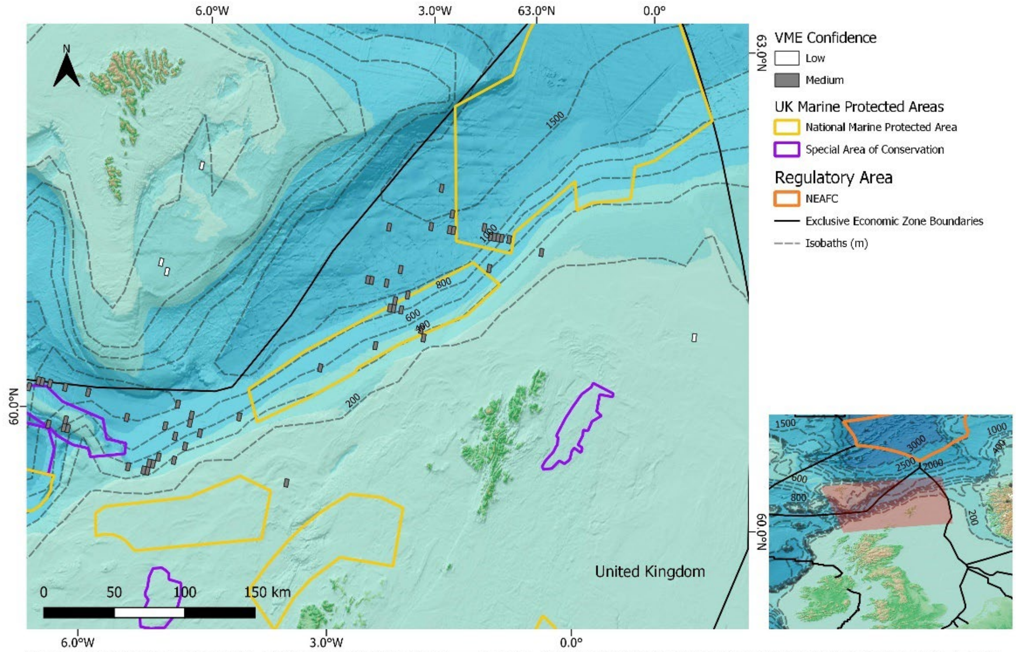
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.25 New VME records submitted in 2021 for the Faroe Shetland Channel within the UK EEZ. Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.26 Output of the VME weighting algorithm for the area shown in Figure 4.25 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



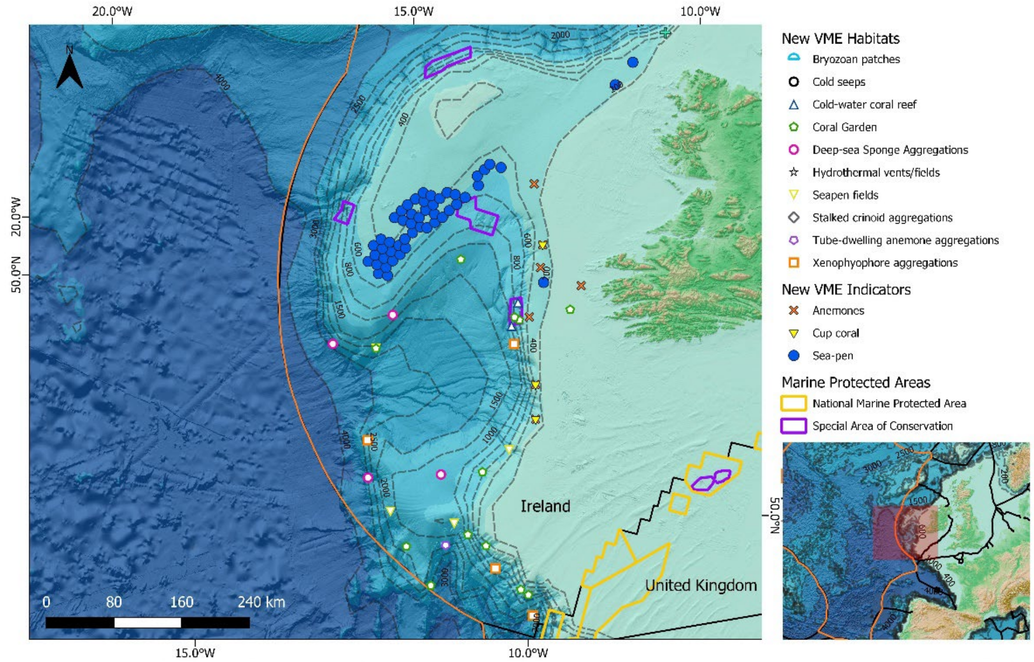
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.27 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.26). This includes all (not only 2021) records from the ICES VME database.

4.4.4 Irish continental slope and Porcupine Bank and Seabight

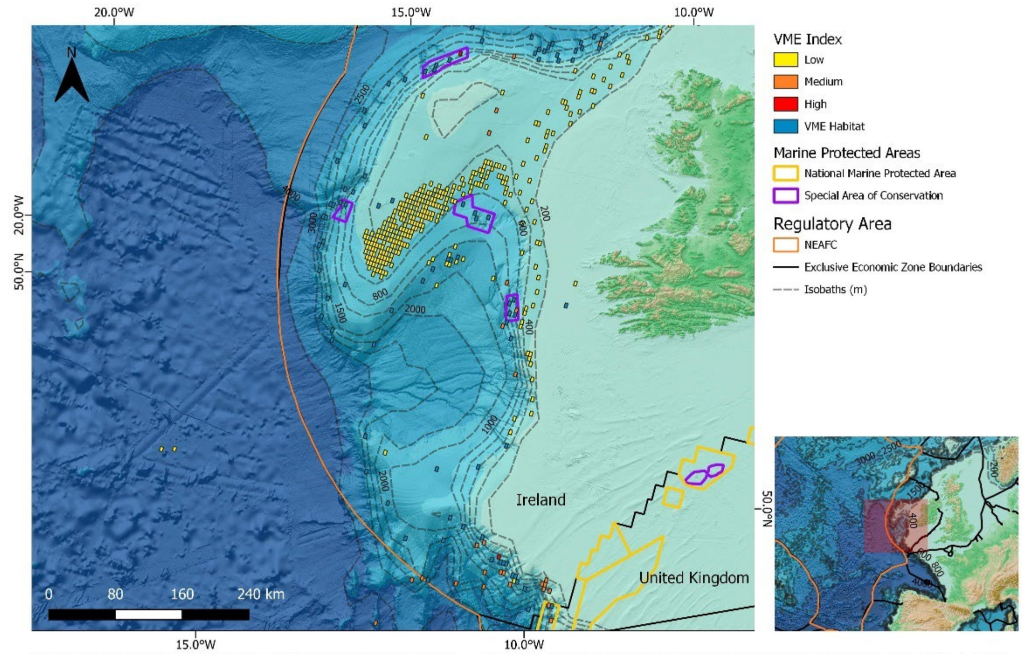
New VME habitat and indicator data for the Irish continental slope, Porcupine Bank and Seabight within the Irish EEZ were submitted by the Marine Institute Ireland (Figure 4.28). Records along the Irish continental slope came from the 2019 SeaRover survey and the Irish Groundfish Survey (IGFS). Those on the Porcupine Bank came from Underwater TV Surveys, whilst those around the Porcupine Seabight were also from the 2019 SeaRover survey.

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



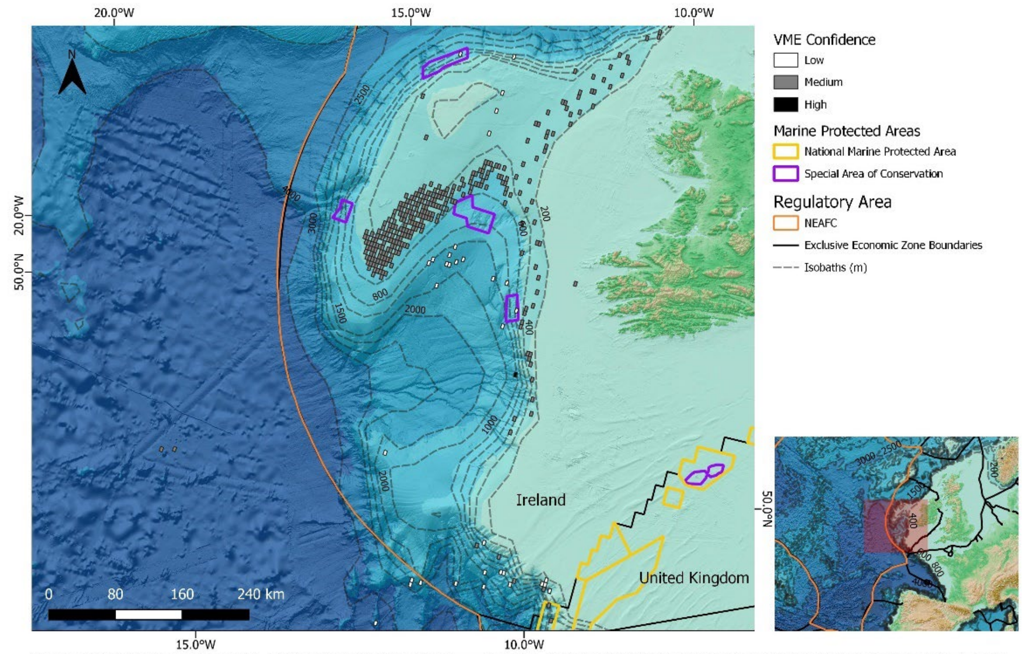
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.28 New VME records submitted in 2021 for the Irish continental slope, Porcupine Bank and Seabight within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.29 Output of the VME weighting algorithm for the area shown in Figure 4.28 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.30 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.29). This includes all (not only 2021) records from the ICES VME database.

4.4.5 Spanish continental slope (North Spain)

New VME habitat and Indicator data for the Spanish continental slope within the Spanish EEZ were submitted by the Instituto Español de Oceanografía (IEO) and Oceana. Data came from international bottom trawl surveys, the INDEMARES and ECOMARG projects, and the Oceana survey 'Expedición Atlántico-Cantábrico 2008' (Figure 4.31).

These records provide a significant amount of new data for the Spanish continental slope, where previously the VME database had very little data for this region.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.32, and the confidence layer for the VME index is shown in Figure 4.33.

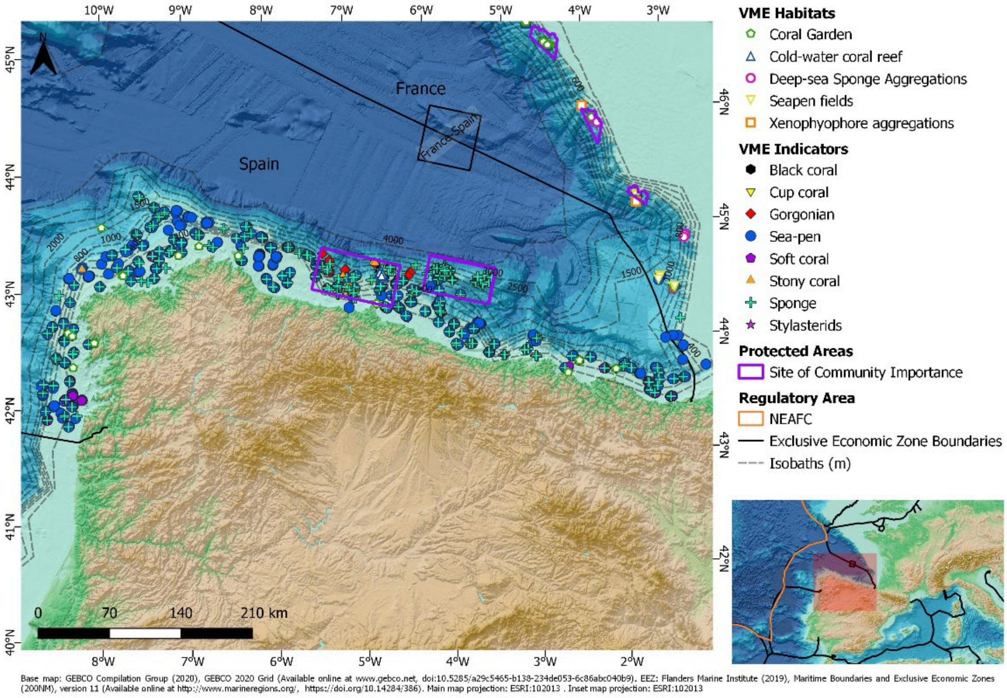


Figure 4.31 New VME records submitted in 2021 for the Spanish continental slope within EU waters. Note, other VME records from the VME database for this area are not displayed.

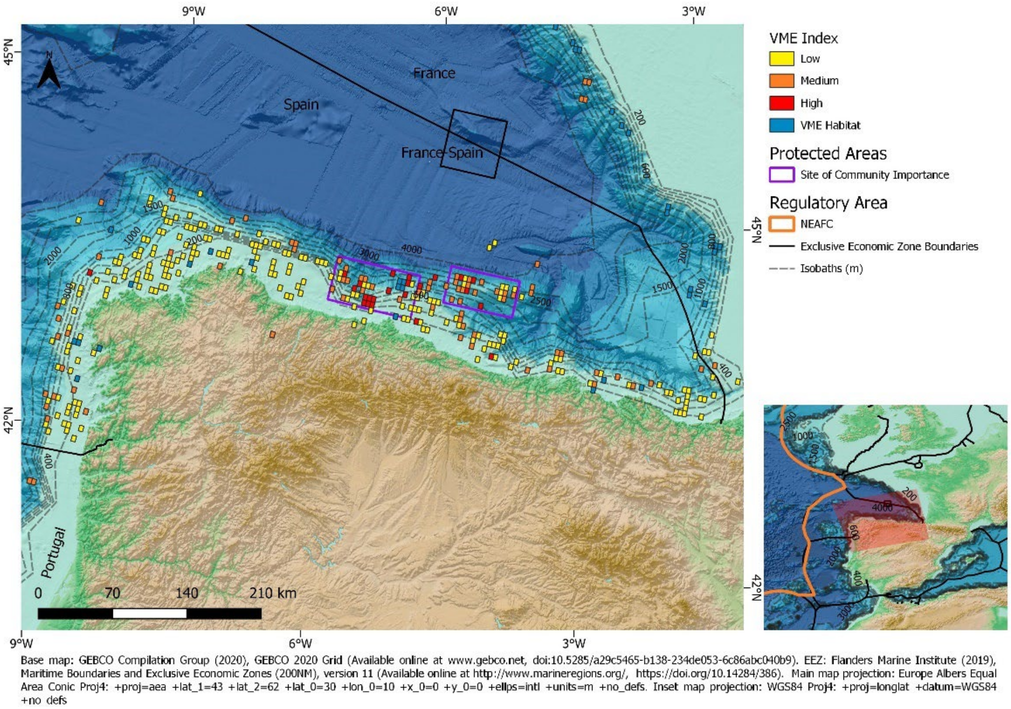
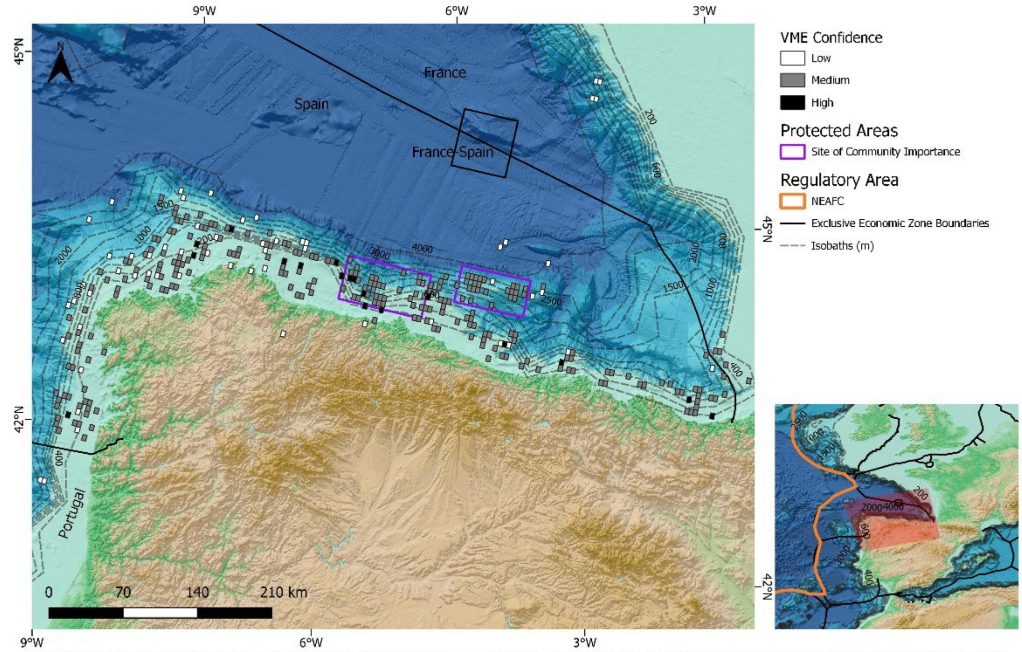


Figure 4.32 Output of the VME weighting algorithm for the area shown in Figure 4.31 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.33 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.32). This includes all (not only 2021) records from the ICES VME database.

4.4.6 Galicia Bank

New VME indicator data for the Galicia Bank within the Spanish EEZ were submitted by the Instituto Español de Oceanografía (IEO) in Spain (Figure 4.34). Data came from the ECOMARG projects.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.35 and the confidence layer for the VME index is shown in Figure 4.36.

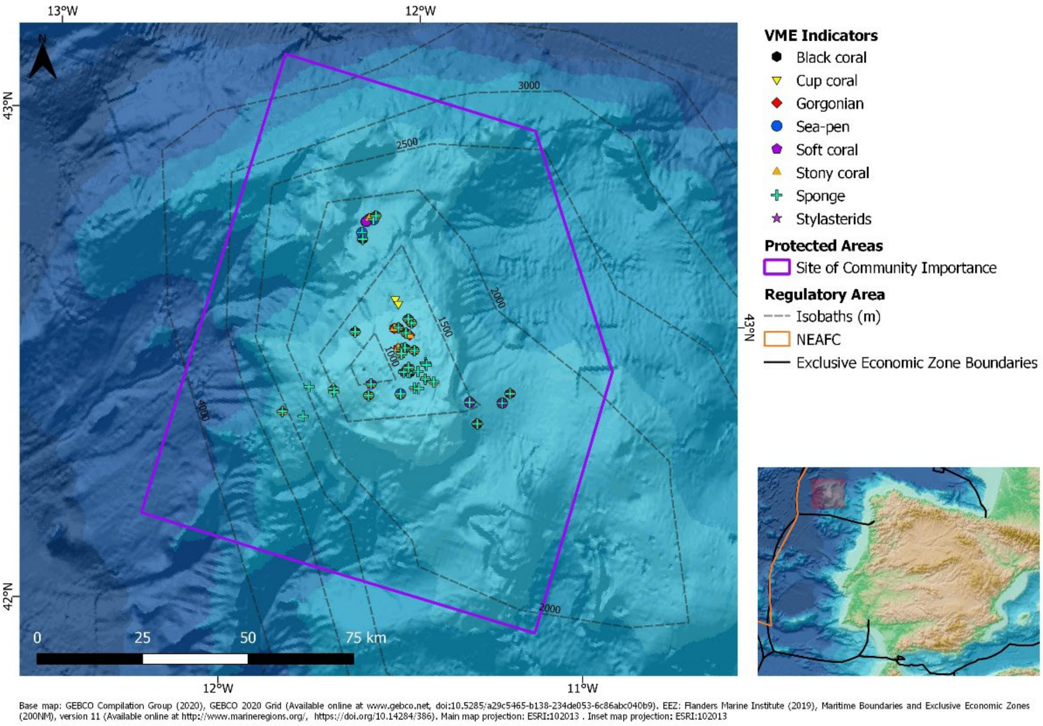


Figure 4.34 New VME records submitted in 2021 for the Galicia Bank within EU waters. Note, other VME records from the VME database for this area are not displayed.

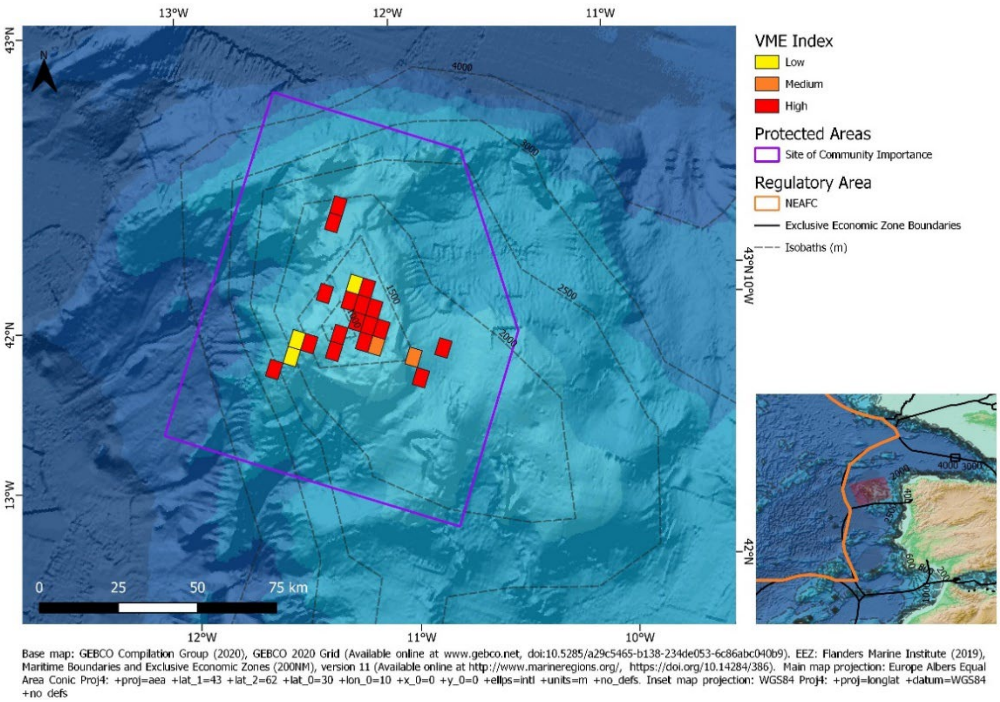
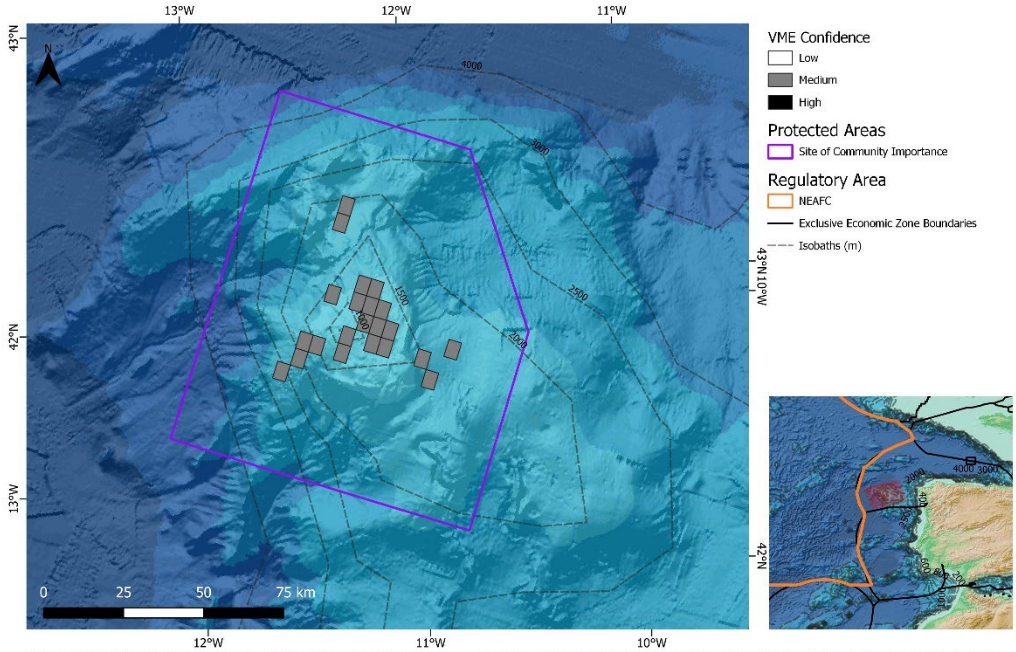


Figure 4.35 Output of the VME weighting algorithm for the area shown in Figure 4.34 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



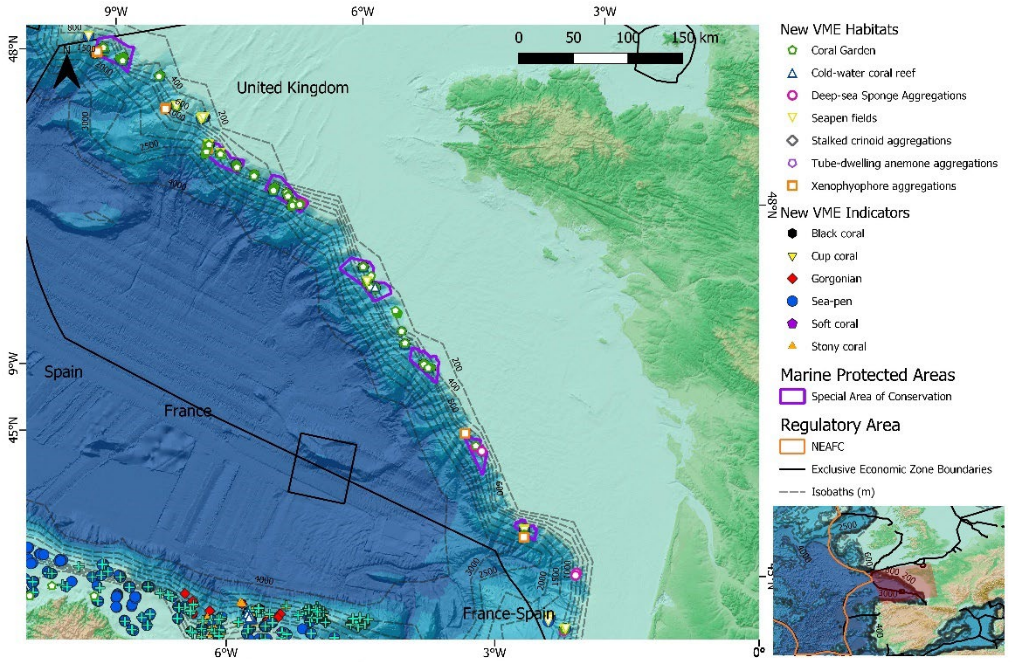
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

Figure 4.36 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.35). This includes all (not only 2021) records from the ICES VME database.

4.4.7 Bay of Biscay

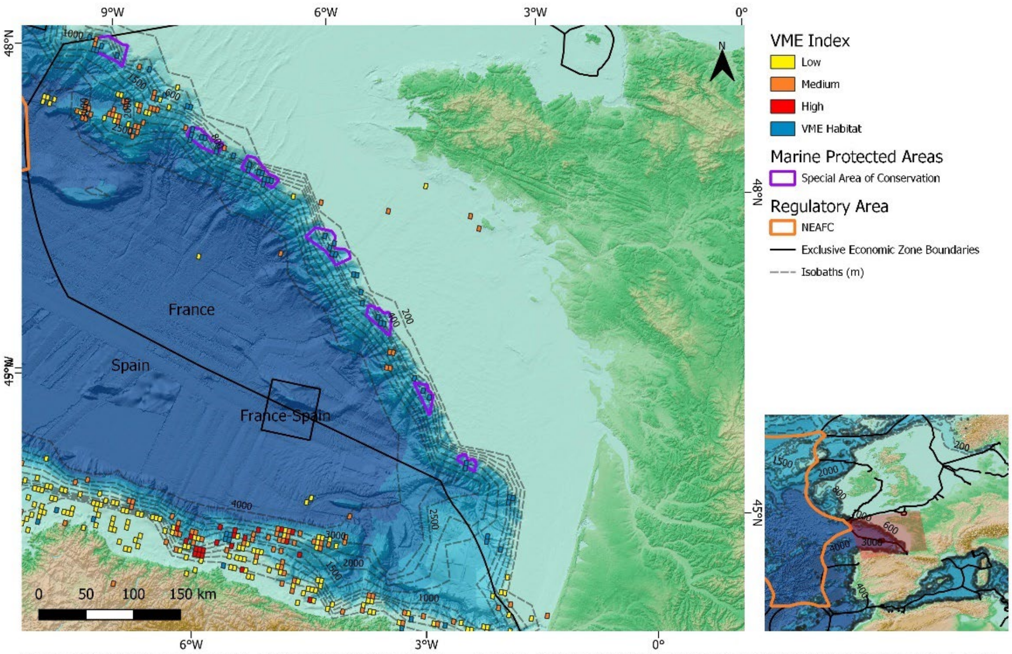
New and re-submitted VME habitat and Indicator data for the Bay of Biscay in the French EEZ were submitted by the Instituto Español de Oceanografía (IEO) in Spain and Ifremer (France) (Figure 4.37). A small number of VME indicator records came from the INDEMARES cruise, whilst the majority of VME habitat and indicator records came from the CoralFISH project.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.38, and the confidence layer for the VME index is shown in Figure 4.39.



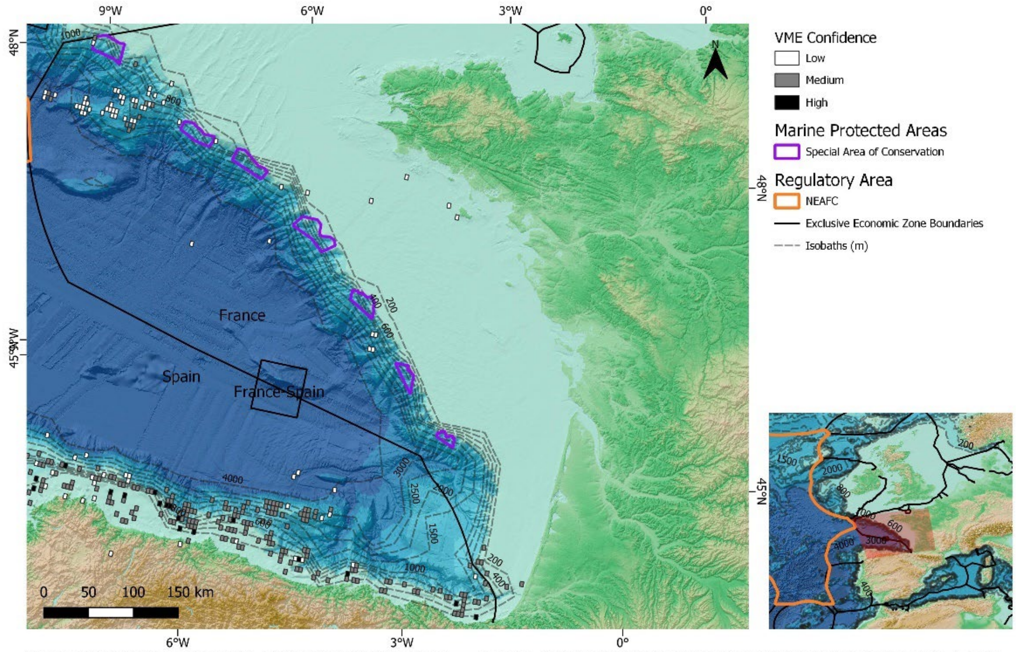
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.37 New VME records submitted in 2021 for the Bay of Biscay within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.38 Output of the VME weighting algorithm for the area shown in Figure 4.37 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high). Note, this includes all (not only 2021) records from the ICES VME database.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no defs

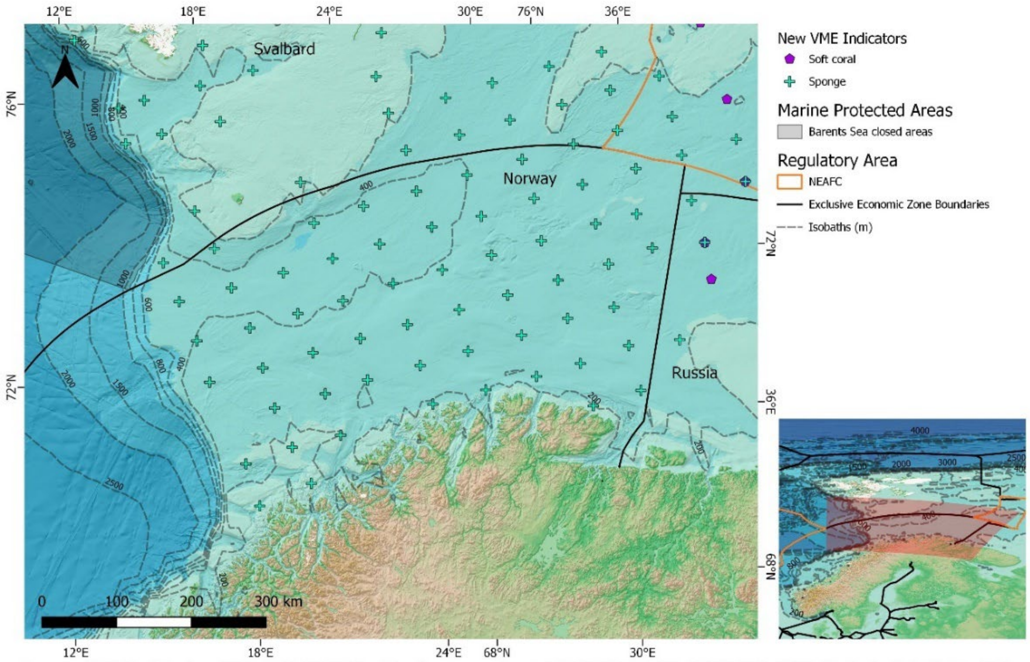
Figure 4.39 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.38). This includes all (not only 2021) records from the ICES VME database.

4.4.8 Central and South West Barents Sea (Tromsø Flaket)

New VME indicator data were submitted for the Central and South West Barents Sea (around Tromsø Flaket) from the Institute of Marine Research (Norway) (Figure 4.40). Data were from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS).

Outputs of the weighting algorithm and confidence layer with these new VME data are not presented due to the large number of new records making the scale of view too small. However, these can be viewed on the ICES VME data portal[8].

[8] http://vme.ices.dk/map.aspx



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.40 New VME indicator records submitted in 2021 for the Central and South West Barents Sea. Note, other VME records from the VME database for this area are not displayed.

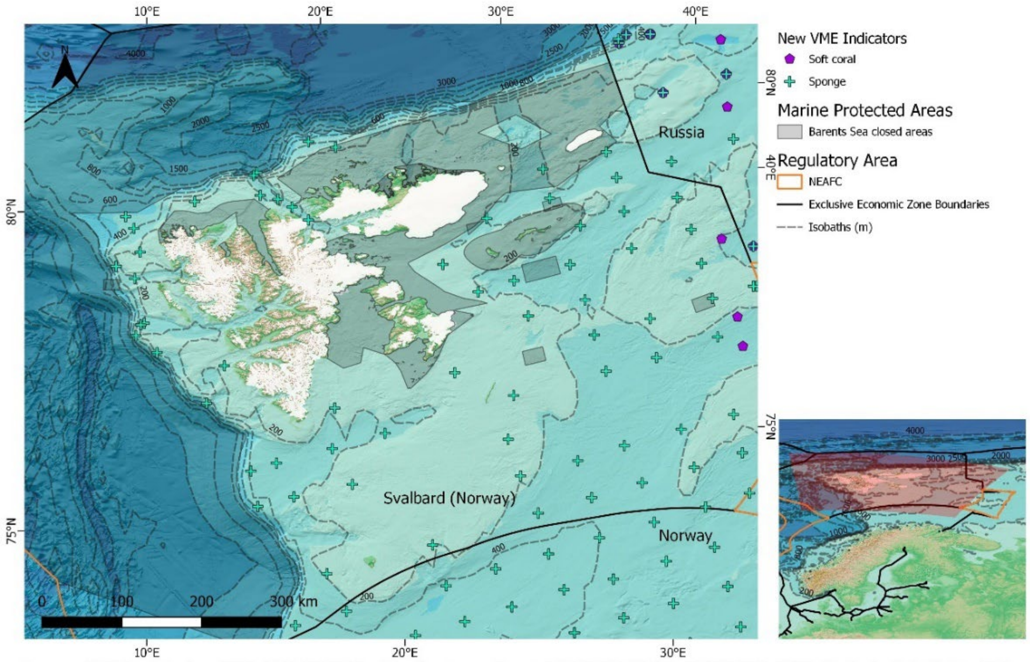
4.4.9 North West Barents Sea (Svalbard)

New VME indicator data were submitted for the North West Barents Sea (Svalbard) from the Institute of Marine Research (Norway) (Figure 4.41). Data were from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS).

Outputs of the weighting algorithm and confidence layer with these new VME data are not presented due to the large number of new records making the scale of view too small. However, these can be viewed on the ICES VME data portal.

The existing biodiversity regulation from 2011 – restricting bottom trawling deeper than 1000 m but not limiting it in shallower waters – was not sufficient to protect the shallower and more vulnerable and benthic ecosystems in the Barents Sea. To further protect vulnerable species to sustain the complexity of bottom habitats in the Barents Sea, specifically in waters around Svalbard, a new and modified fishing legislation took place July 1st, 2019 (Jørgensen *et al*., 2020). It was based on already existing long-term monitoring data of benthos in the Barents Sea, and obtained from the annual joint IMR and PINRO Barents Sea Ecosystem Survey and the SI_Arctic project (Jørgensen *et al*., 2020).

Waters around Svalbard are divided into new and existing fishing areas, and areas below 800 meter in depth are considered a new fishing area where bottom trawling requires a special license from the Directorate of Fisheries. Jørgensen *et al*., (2019) identified fauna vulnerable to trawl gear and this research was used to apply a precautionary approach to areas previously unfished. In response to the new fishing legislation, four large areas covering 442,022 km^2, within the Fisheries Protection Zone around Svalbard, are closed to all fishing (see grey polygons in Figure 4.41). Within the existing fishing areas, an additional ten closed areas covering more than 3260 km^2 are completely closed to bottom trawling, including any fishing gear likely to be in contact with the seafloor.



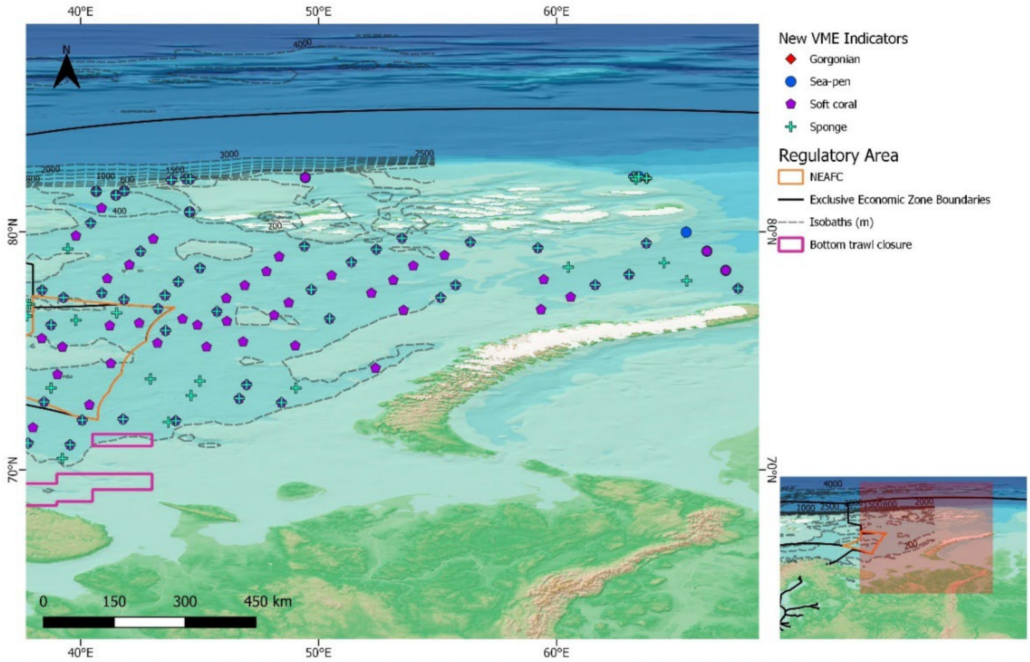
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic ProjJ4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 ProjJ4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.41 New VME indicator records submitted in 2021 for the North West Barents Sea (Svalbard). Note, other VME records from the VME database for this area are not displayed.

4.4.10 North East Barents Sea (Russia)

New VME indicator data were submitted for the North East Barents Sea within the Russian EEZ from PINRO (Russia) (Figure 4.42). Data were from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS)

Outputs of the weighting algorithm and confidence layer with these new VME data are not presented due to the large number of new records making the scale of view too small. However, these can be viewed on the ICES VME data portal.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 4.42 New VME indicator records submitted in 2021 for the North East Barents Sea in the Russian EEZ. Note, other VME records from the VME database for this area are not displayed.

4.5 Analysis of the 2020 VMS submission from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs)

4.5.1 Methods

Vessel monitoring system (VMS) data were received from NEAFC, via the ICES Secretariat, along with catch information from logbooks, authorisation details, and vessel information from the NEAFC fleet registry. These data were analysed by the Working Group on Spatial Fisheries Data (WGSFD), in advance of the WGDEC meeting, to support the NEAFC request to ICES to provide information on the distribution of fisheries activities in and in the vicinity of VME habitats. The tables were linked using a unique identifier (the “RID” field) which changes on a yearly basis to protect anonymity of vessels. This year, ICES received information on the catch date and the catches were linked to vessels on the date of operation.

The VMS data were filtered in R to exclude all duplicate reports, polls outside the year 2020, and messages denoting entry and exit to the NEAFC regulatory area (“ENT” and “EXT” reports). The time interval (difference) between consecutive pings for each vessel was calculated and assigned to each position. Any interval values greater than four hours were truncated to this duration, as this is the minimum reporting frequency specified in the Article 11 of the NEAFC Scheme of Control and Enforcement. Such a scenario could occur when a vessel leaves the NEAFC regulatory area or has issues with its transmission system.

Quality of the speed data was again much improved on previous years (Figure 4.43). It was validated against a derived speed, calculated as the great-circle (orthodromic) distance between consecutive points reported by a vessel, divided by the time difference between them. Fishing effort is inferred from VMS data on the basis of speed, with pings at slower speeds deemed to represent fishing activity, and those at faster speeds to represent steaming and/or searching. In this instance, a speed of 5 knots or lower has been used to demarcate fishing from non-fishing pings for mobile bottom gears, 4 knots for vessels using static gears, and 6 knots for vessels with undefined gear types. Consecutive pings at fishing speeds for vessels using mobile-bottom contacting gears were grouped into putative "tows", manually reviewed to remove any erroneous sequences, and plotted, as a means to validate where fishing is taking place with the vessel tracks running parallel to bathymetric contours, as would be expected. Similar to last year, a large proportion of the vessels had no gear specified and the number of gear types reported was very low compared to previous years (Table 4.51).

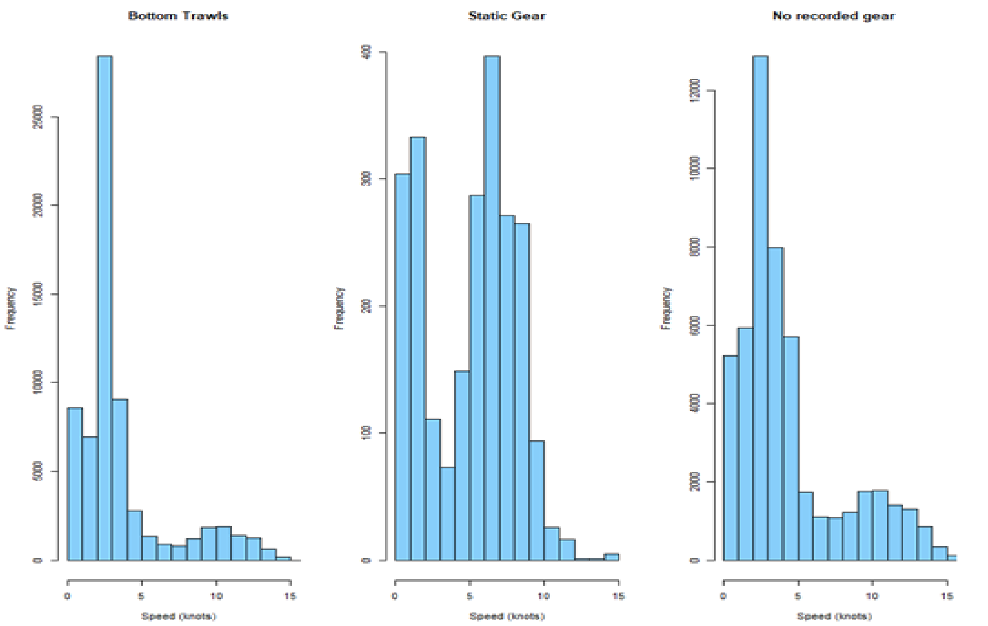


Figure 4.43 Histogram of derived speeds for all gears, based on position and time, conforms to expected distribution

Table 4.51 Number of pings (N) registered against each fishing gear type (Gear) in the speed filtered (0-5 knots) NEAFC VMS data

Gear	Description	Grouping	Number of pings
FPO	Fish pots	Static Bottom	992
LL	Long lines	Static Bottom	1294
LLS	Long lines (set)	Static Bottom	1558
NIL	No gear recorded	Unknown	1328
OTB	Bottom otter trawl	Mobile Bottom	56 378
OTM	Midwater otter trawl	Pelagic Gear	261 248
PS	Purse seine	Pelagic Gear	1232
PTM	Midwater pair trawl	Pelagic Gear	324
TBS	Shrimp trawl	Mobile Bottom	1801
UNK	Unknown	Unknown	24 832

Results

The NEAFC VMS data, VME closures and existing fishing areas were mapped along with the VME Index outputs, which show the likelihood of VME presence based on the VME weighting algorithm, to assess whether fishing activity was occurring in the vicinity of VMEs in the NEAFC Convention Area. Results of this analysis are shown for Hatton Bank, Rockall Bank, Iceland, the Mid Atlantic Ridge Seamounts and the Barents Sea. Data for the west of the Bay of Biscay, with particular reference to the Josephine Seamount, are provided in Section 5.4.

4.5.2 Hatton Bank

The closures to the northern side of the Hatton Bank continue to be generally well observed and there appears to be reduced activity in the area compared to last year (Figure 4.44). A small number of bottom trawls appear to occur to the south of the north-east existing fishing area, but these activities are very limited (Figure 4.45). There was no evidence of vessels using static bottom contact gears, or activity of vessels without a registered gear type in this area. Closures on the western side of the bank are also well observed (tow tracks: Figure 4.46 and gridded trawl data: Figure 4.47). No activity of static gears, or from vessels without a registered gear type was observed on the western side of the Hatton Bank this year

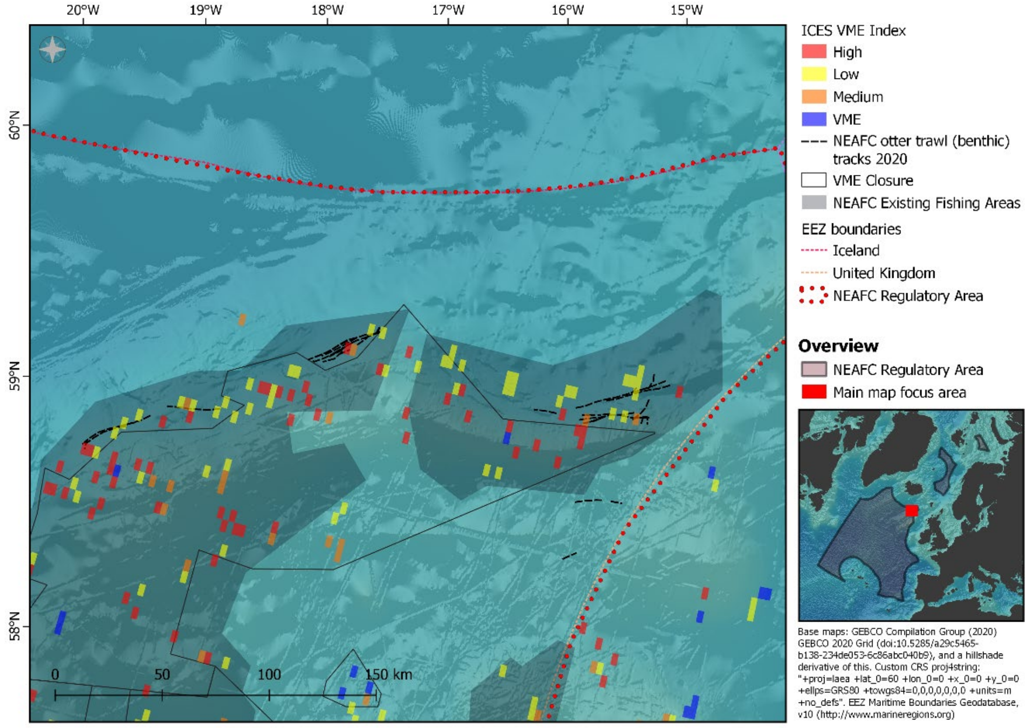


Figure 4.44 Bottom contacting otter trawl tow tracks to the north of Hatton Bank, overlain with the VME Index, VME closures, existing NEAFC fishing areas and EEZ boundaries.

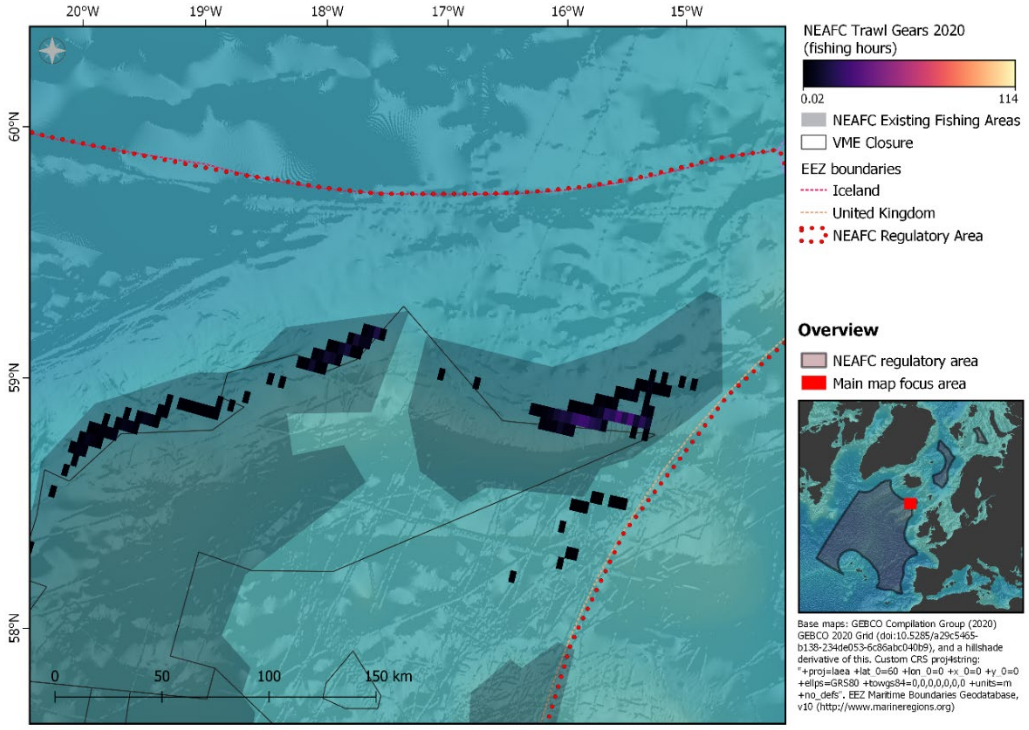


Figure 4.45 Gridded data (fishing hours) for bottom contacting trawl gears to the north of Hatton Bank, overlain with existing NEAFC fishing areas and EEZ boundaries.

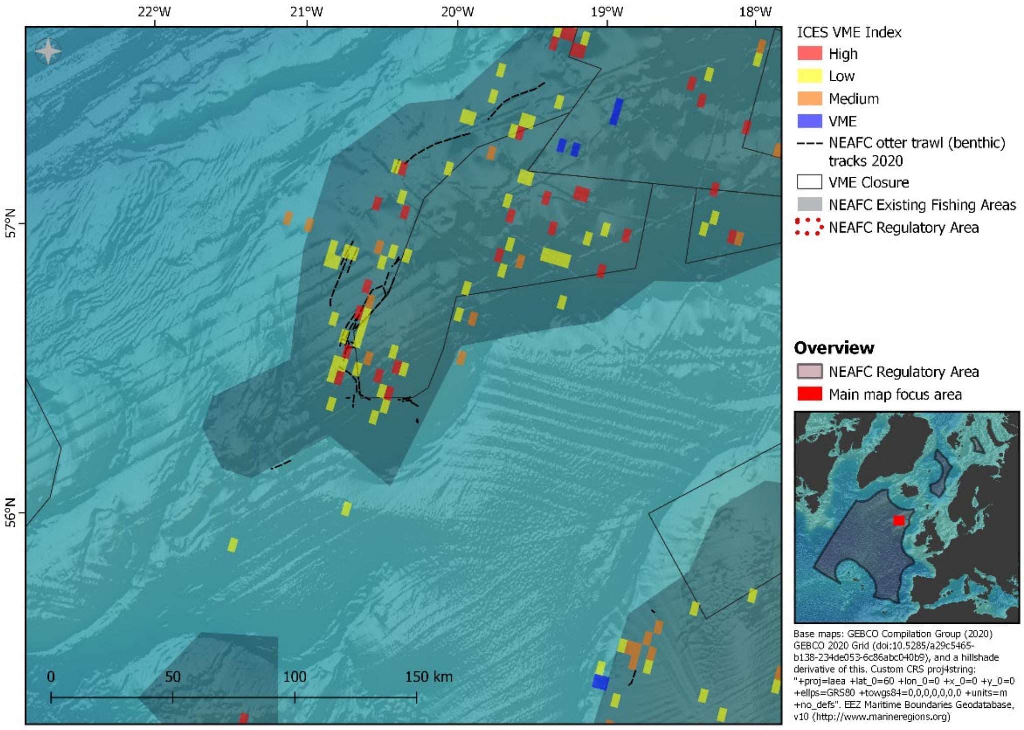


Figure 4.46 Bottom contacting otter trawl tow tracks to the west of Hatton Bank, overlain with the VME Index, VME closures and existing NEAFC fishing areas.

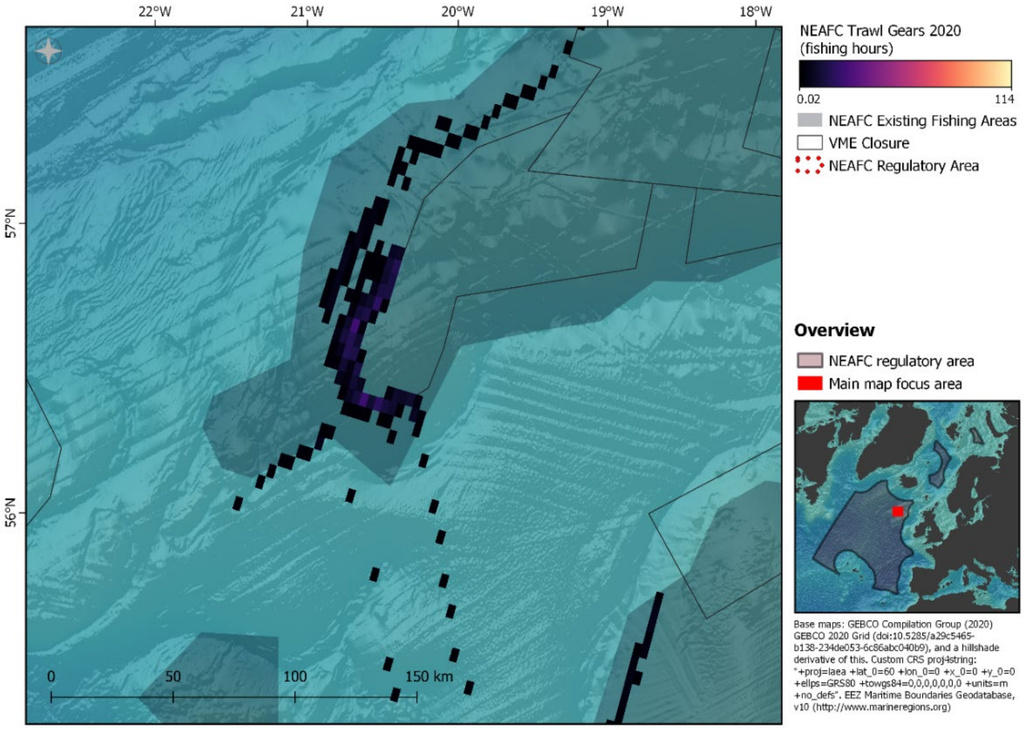


Figure 4.47 Gridded data (fishing hours) for bottom contacting trawl gears to the west of Hatton Bank, overlain with VME closures and existing NEAFC fishing areas.

4.5.3 Rockall Bank

The VME closures on the eastern side of Rockall Bank are generally well observed, with the highest intensity of fishing occurring in an area that stretches along the western boundaries of the Northwest Rockall closure and the Haddock Box (Figure 4.48 and Figure 4.49). There are a small number of tows in the larger closed area in southwest Rockall, but these are limited. Vessels registered as using static gears were active, at low levels, in the existing fishing areas on Rockall Bank outside any VME closure areas and the Haddock Box (Figure 4.50). Vessels operating with no registered gears were most active along the western boundaries of the Northwest Rockall closure and the Haddock Box (Figure 4.51). There is some evidence of low levels of activity from vessels with no registered gear type within the Haddock Box, but this may be an artefact of the high levels of activity in the area.

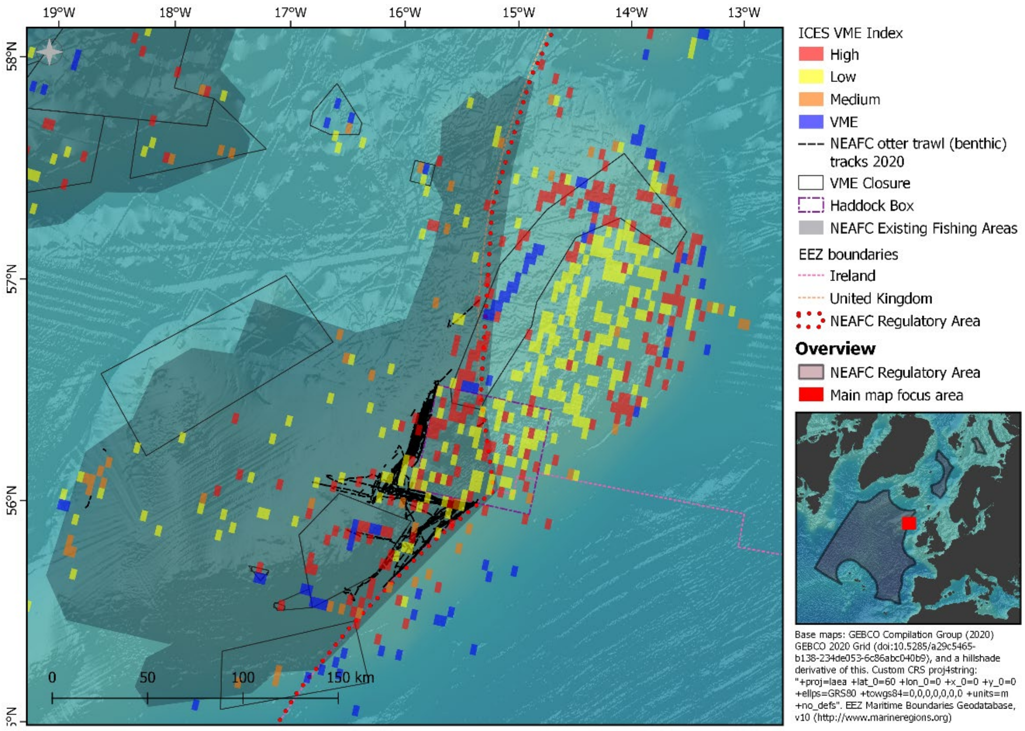


Figure 4.48 Bottom contacting otter trawl tow tracks on Rockall Bank, overlain with the VME Index, VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

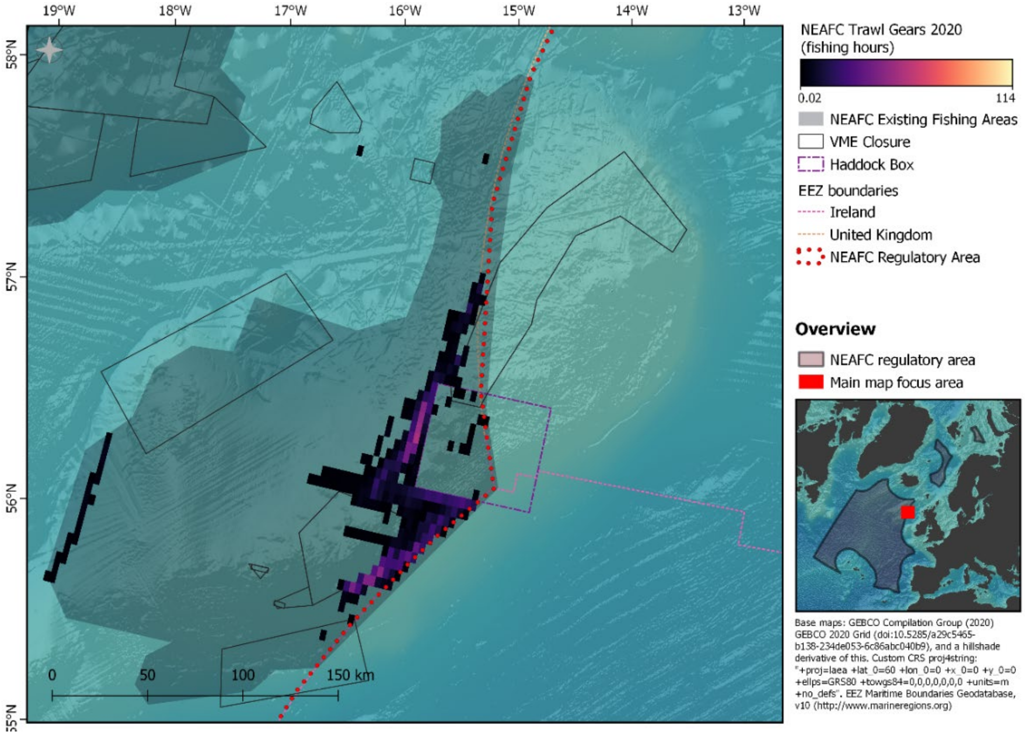


Figure 4.49 Gridded data (fishing hours) for bottom contacting trawl gears on Rockall Bank, overlain with VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

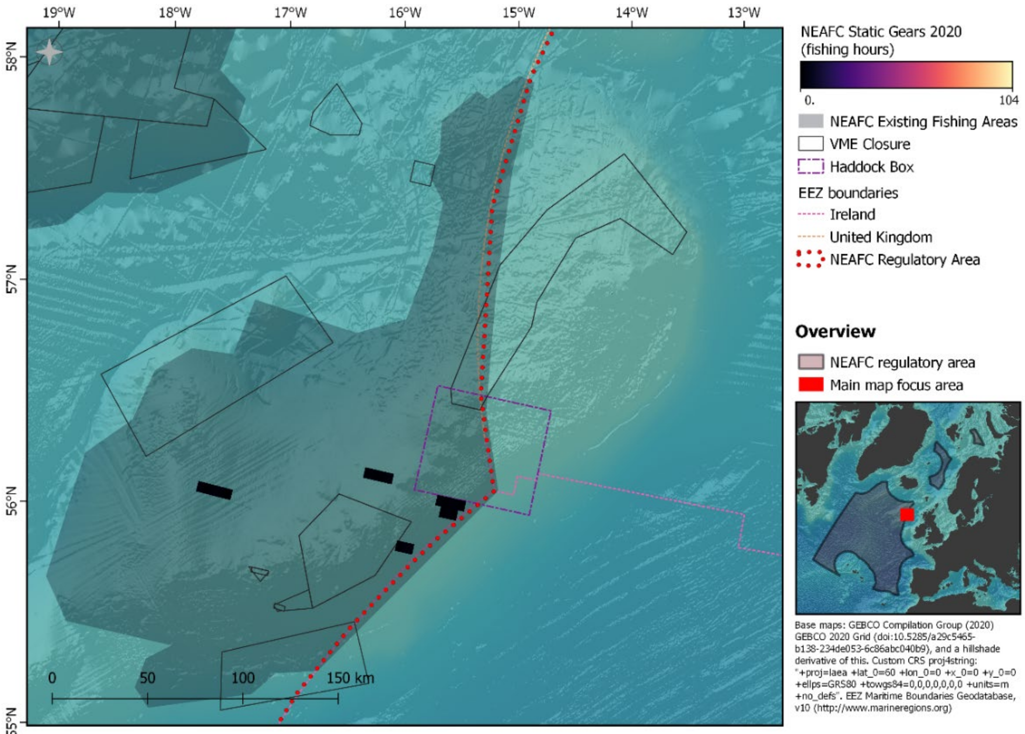


Figure 4.50 Gridded data (fishing hours) for bottom contacting static gears on Rockall Bank, overlain with VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

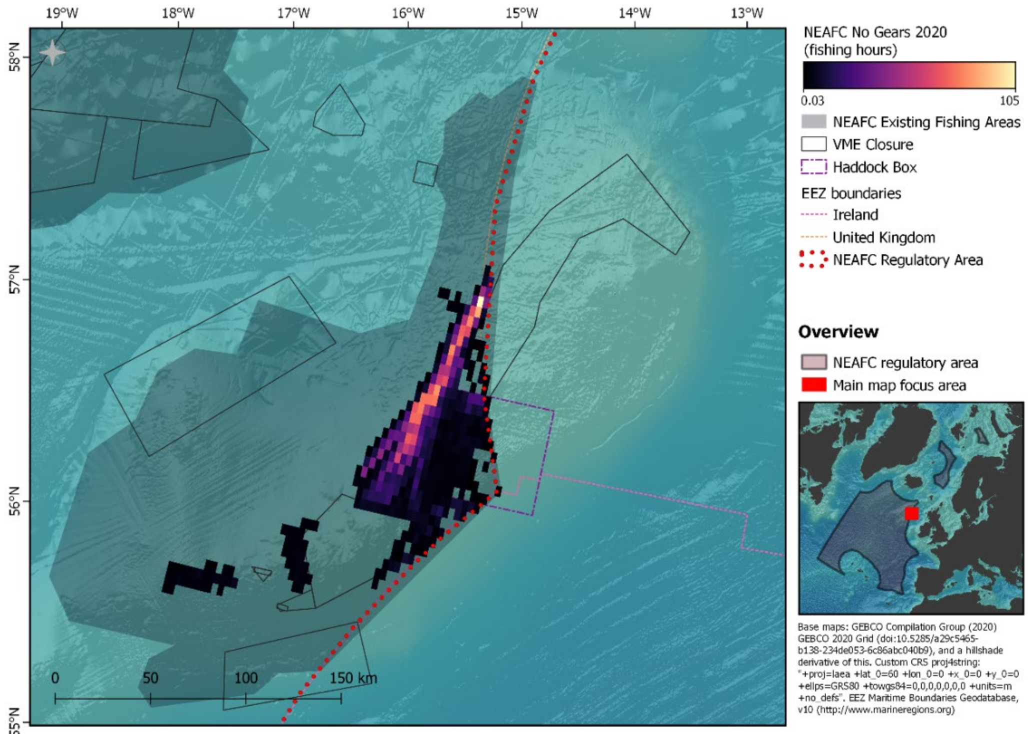


Figure 4.51 Gridded data (fishing hours) where no gear was registered on Rockall Bank, overlain with VME closures, the Haddock Box, existing NEAFC fishing areas and EEZ boundaries.

4.5.4 South of Iceland

The pattern of bottom contact fishing activity around the Reykjanes Ridge shows a similar pattern to last year (Figure 4.52). Activity is concentrated in an area to the north of the existing fishing area on Reykjanes Ridge, in water depths of around 2000 m. Further south, in depths of 2500 – 3000 m, there is also evidence of some low levels of fishing in the NEAFC area to the west of the Reykjanes Ridge and some very low activity in the north-western corner of the northern mid-Atlantic ridge VME closure area (Figure 4.52). Activity to the south of Iceland is comprised of trawling gears (Figure 4.53) and vessels with no registered gear type (Figure 4.54), with no evidence of static gears being used in the region. Due to the water depths in this area south of Iceland, the observed activity most likely relates to mid-water trawls targeting redfish and not bottom contacting trawl gears.

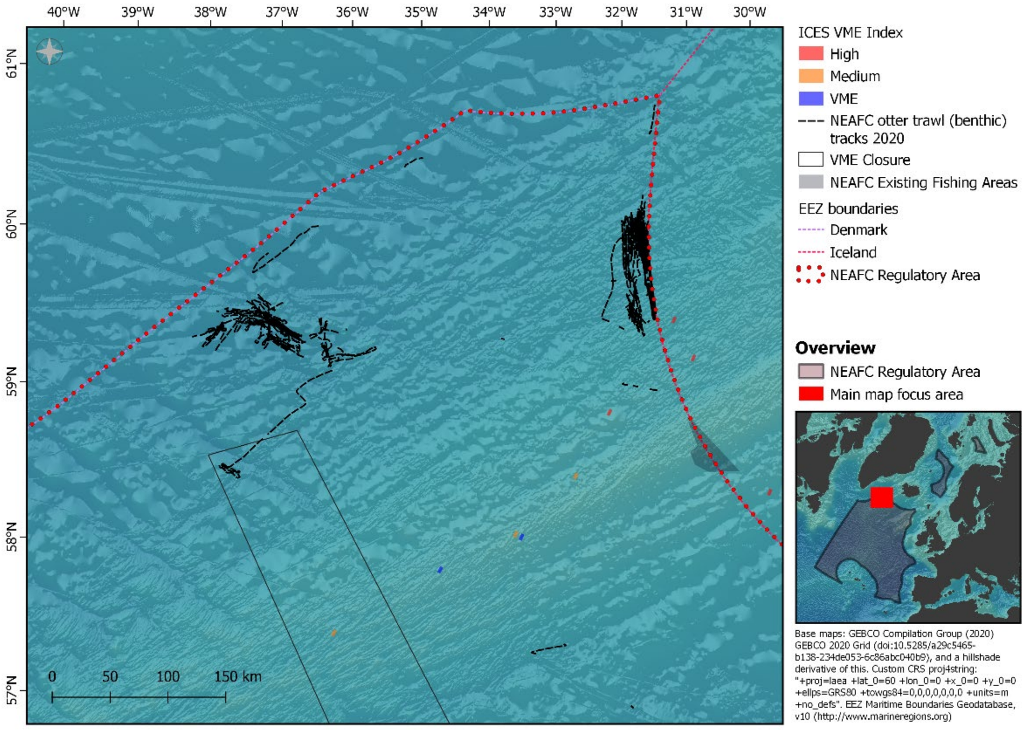


Figure 4.52 Bottom contacting otter trawl tow tracks south of Iceland, overlain with the VME Index, VME closures, existing NEAFC fishing areas and EEZ boundaries.

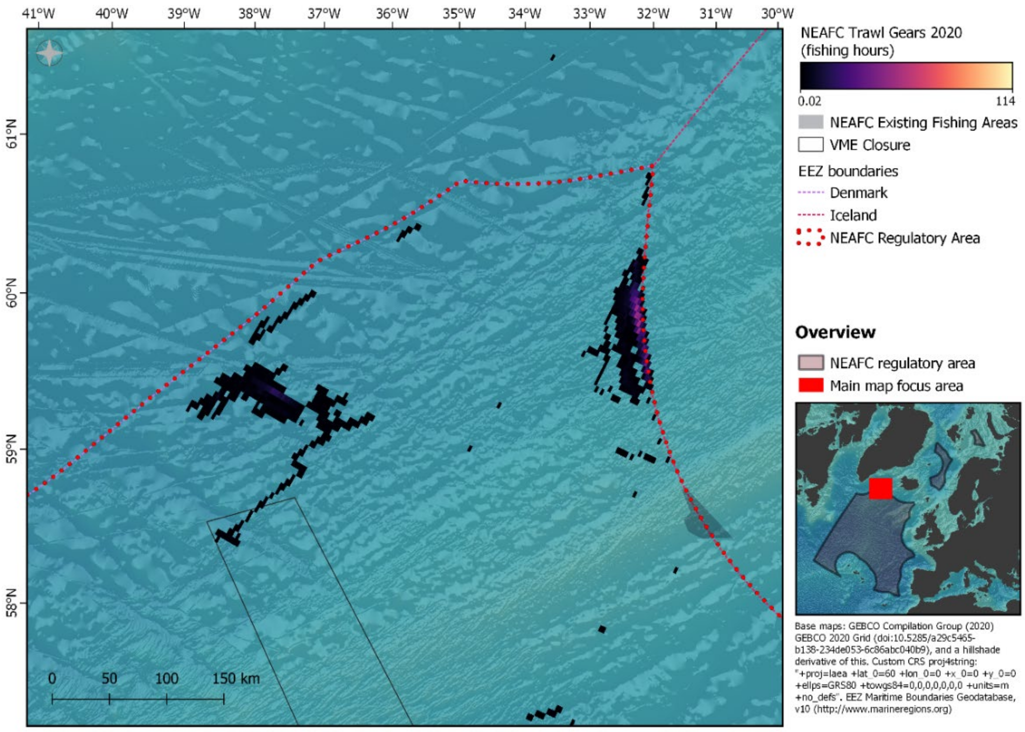


Figure 4.53 Gridded data (fishing hours) for bottom contacting trawl gears to the south of Iceland, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries.

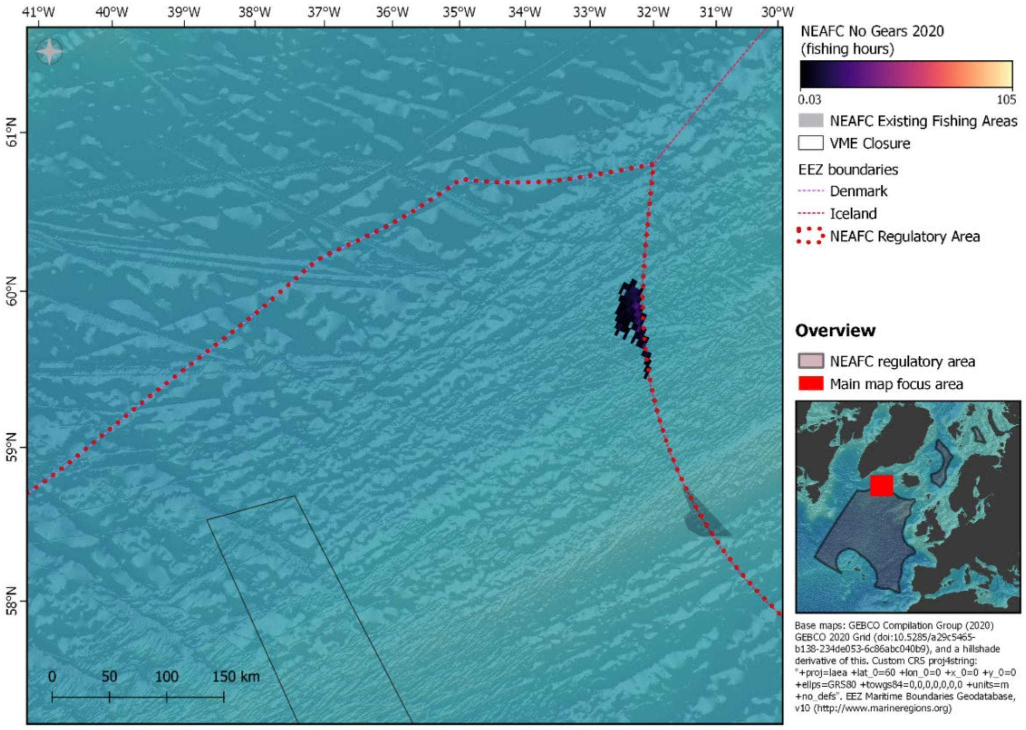


Figure 4.54 Gridded data (fishing hours) where no gear was registered to the south of Iceland, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries.

4.5.5 Mid Atlantic Ridge Seamounts

The only fishing activity observed within the mid-Atlantic Ridge Seamounts area this year was for vessels with no registered gear, outside the south-eastern corner of the Southern MAR NEAFC VME closure (Figure 4.55). This activity was extremely limited and occurred in water depths in excess of 3000 m and as such is very unlikely to be with bottom contacting gears. The bottom trawling activity noted in previous years in this area is absent and there continues to be no evidence of static gears operating in the area.

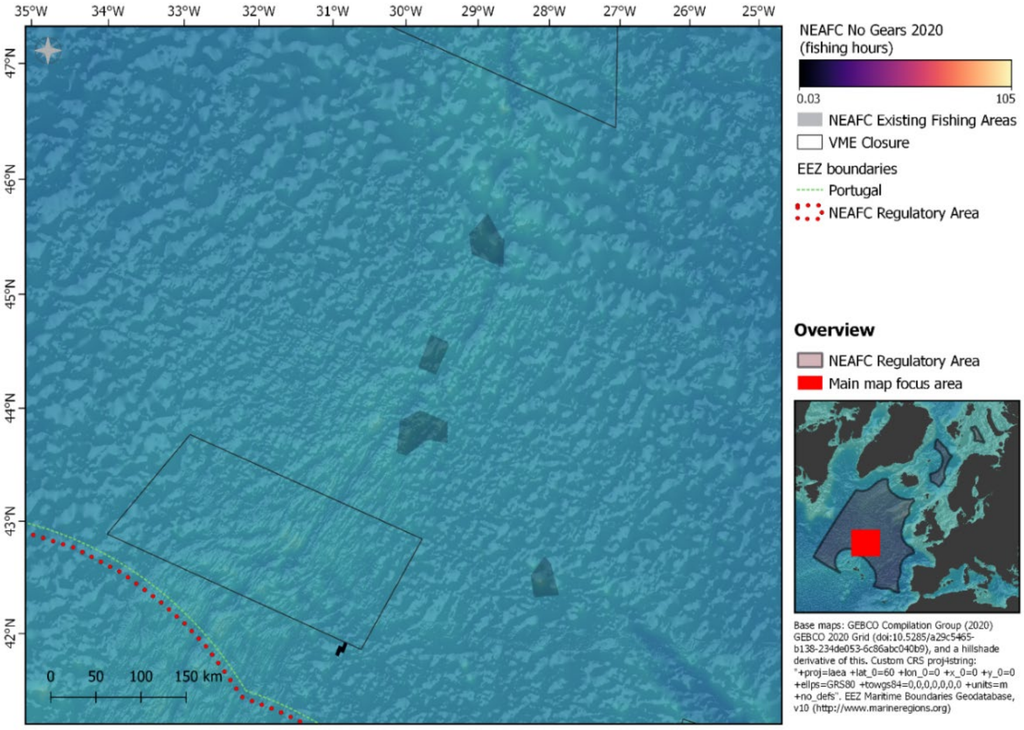


Figure 4.55 Gridded data (fishing hours) where no gear was registered on the Mid Atlantic Ridge seamounts, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries

4.5.6 Barents Sea

Fishing activity within the NEAFC regulatory area in the Barents Sea occurs entirely within the existing fishing area with the exception of a small number of bottom otter trawl "tows" in the northwest area that occur just outside (Figure 4.56). Vessels registered with bottom otter trawls are active in two main focus areas here, with higher intensities occurring in the southwest corner of the existing fishing area (Figure 4.57). Vessels with no registered gears are also active, with the highest intensities in the north of the existing fishing area (Figure 4.58). There is no indication of any activity using static gears.

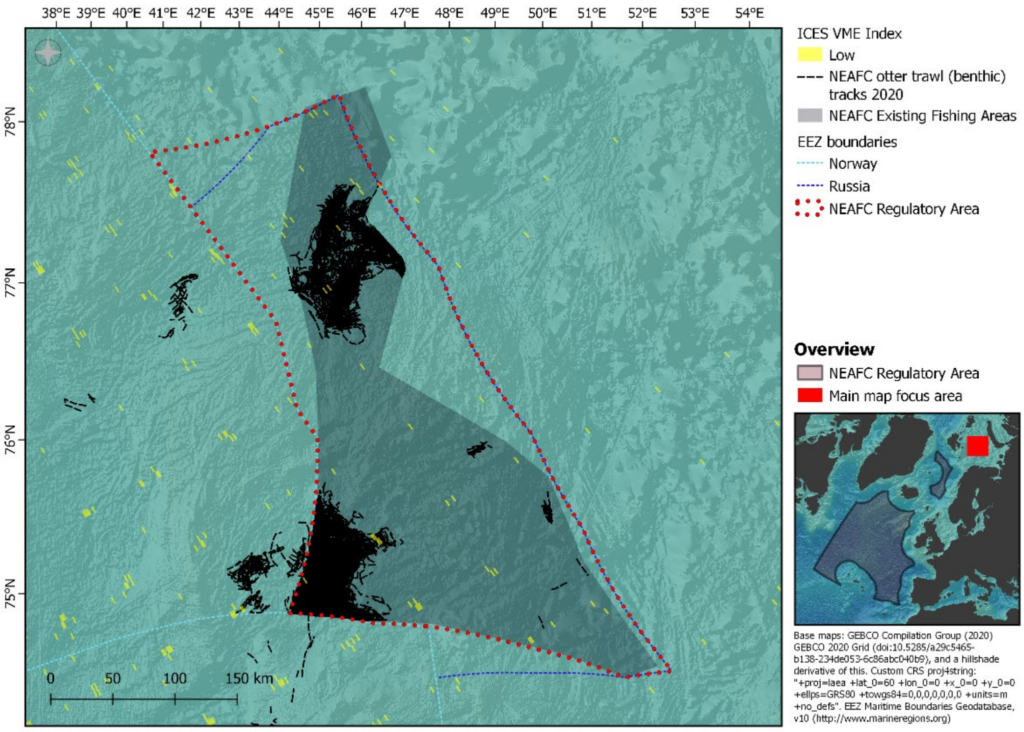


Figure 4.56 Bottom contacting otter trawl tow tracks in the Barents Sea area, overlain with the VME Index, VME closures, existing NEAFC fishing areas and EEZ boundaries.

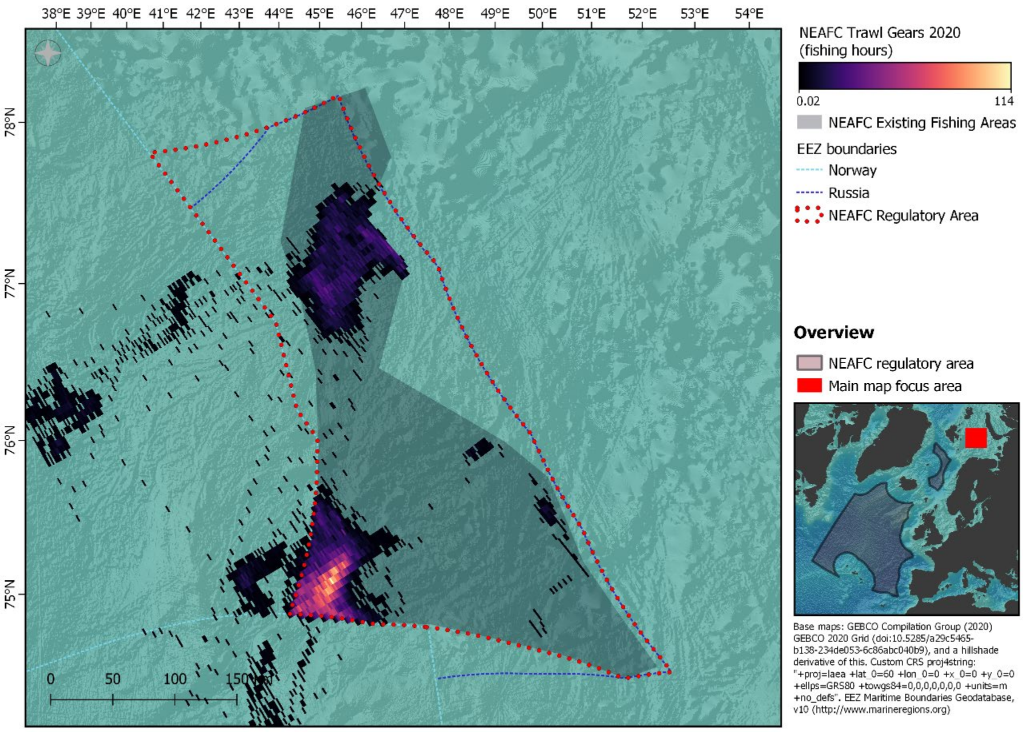


Figure 4.57 Gridded data (fishing hours) for bottom contacting trawl gears in the Barents Sea area, overlain with existing NEAFC fishing areas and EEZ boundaries.

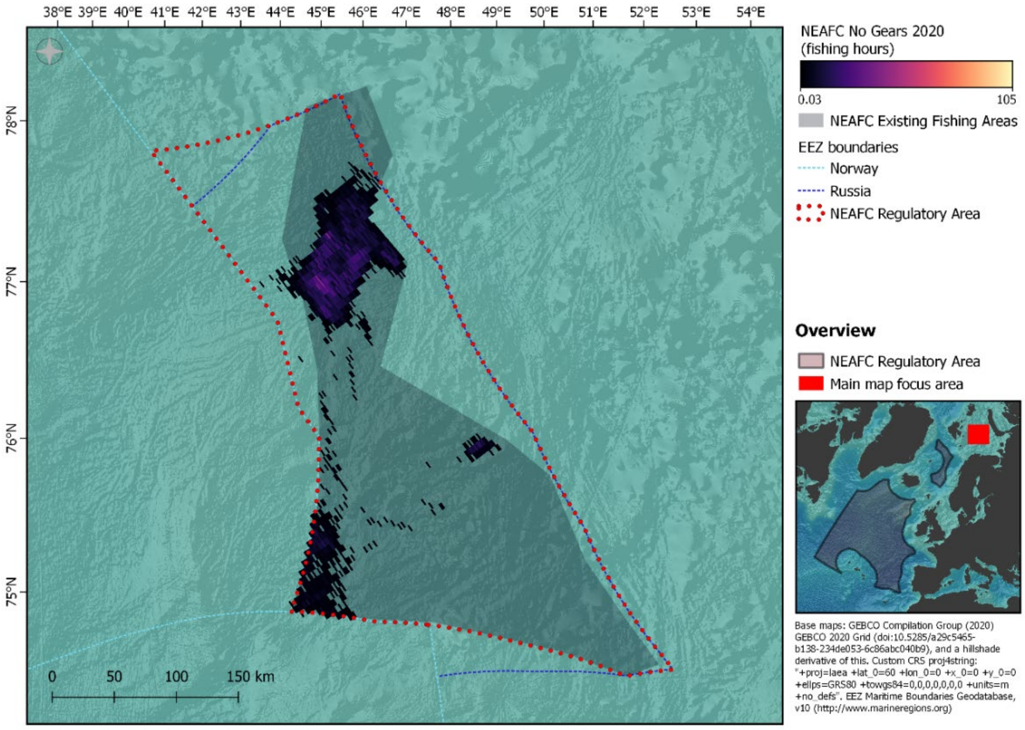


Figure 4.58 Gridded data (fishing hours) where no gear was registered in the Barents Sea area, overlain with VME closures, existing NEAFC fishing areas and EEZ boundaries

4.6 References

Jørgensen, L. L., Primicerio R., Ingvaldsen R. B., Fossheim M., Strelkova N., Thangstad T. H., Manushin I., Zakharov., 2019. Impact of multiple stressors on seabed fauna in a warming Arctic. Mar. Ecol. Prog. Ser. 608, 1-12.

Jørgensen, L. L., Bakke B., Hoel A.H., 2020. Responding to global warming: New fisheries management measures in the Arctic, Progress in Oceanography 188 (2020) 102423.

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

5 Provision of new information on VMEs and fishing activity within Josephine Seamount and surrounding seamounts

Copy of the Joint report section with WGDEC 2021

"Provide all available previous and new information on the distribution of vulnerable habitats in the Josephine Seamount areas and the surrounding seamounts, in the NEAFC Convention Area, and fisheries activities in and in the vicinity of such habitats to provide advice, relevant to the Regulatory Area, in terms of effective measures to prevent significant adverse impacts of bottom fishing activities on vulnerable marine ecosystems" – New ICES advice request 2021

5.1 Background

Josephine Seamount lies just over 200 nm north of the Island of Madeira (Portugal) and is classed by NEAFC as 'an existing bottom fishing area' on the basis of documented bottom fishing activity in the area for at least two years within the period 1987–2007. In 2011, OSPAR designated Josephine Seamount (and the five other seamounts in the immediate vicinity) as an MPA on the basis of information that included VME indicator species such as hexactinellid sponges and gorgonians.

In 2012, WGDEC reported on the presence of VME indicators on Josephine Seamount, based on historical data from a database used by Yesson *et al.* (2012), (ICES, 2012). In 2013, WGDEC reported that the presence of gorgonian corals indicated a high likelihood of VMEs on the Seamount, and that the summits and flanks of the seamounts were examples of geomorphological features that could support VME indicator species (VME Elements) (ICES, 2013a). Although no data was available to support an analysis of fisheries activities in the area, the group considered that the seamount's status as an existing bottom fishing area suggested that there was a risk of significant adverse impacts on the VME indicators. ICES therefore advised in 2013, that should NEAFC wish to protect these VMEs, a bottom fisheries closure be implemented to align with the boundary of the existing OSPAR MPA (OSPAR Decision 2010/5) (Figure 5.1). This advice stated that "such a closure would encompass the seamount, the documented locations of recent VME indicator records, and the five other nearby seamounts that are within the NEAFC RA. As a consequence of enclosing the seamounts in one protective management measure, some surrounding deep areas of high topographic relief (and thus likely to contain VMEs) would also be protected from potential impacts" (ICES, 2013b).

Following this ICES advice, in 2014 WGDEC received new VME indicator records from literature, including two species of black corals and eleven gorgonians (ICES, 2014). VMS data from 2013 was also reviewed, and this showed no records of bottom fishing activity within the proposed closure area on Josephine Seamount. In 2018, WGDEC re-reported on the VME indicator records present on Josephine Seamount, and provided an output of the VME Index which showed all c-squares as 'Medium VME likelihood' and Medium to Low confidence. However, the group still considered that Josephine was likely to have VMEs due to its status as a seamount complex, and based on historical records presented to the group, but advised further submission of VME data from past studies in the area would improve the basis for evaluations and advice (ICES, 2018).

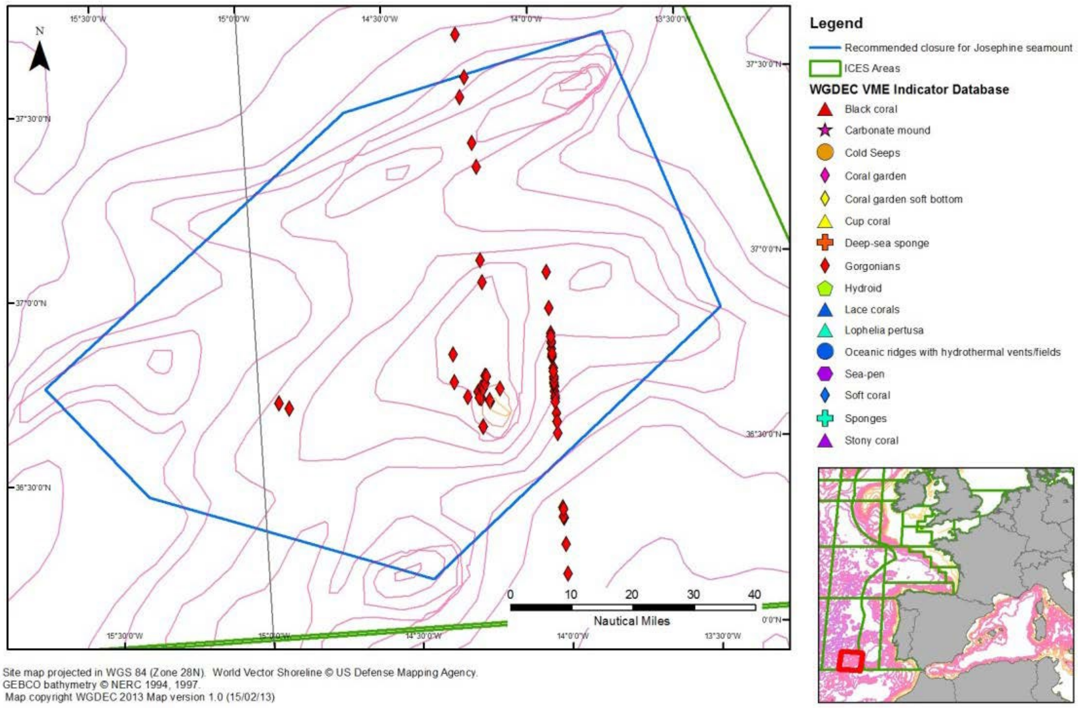
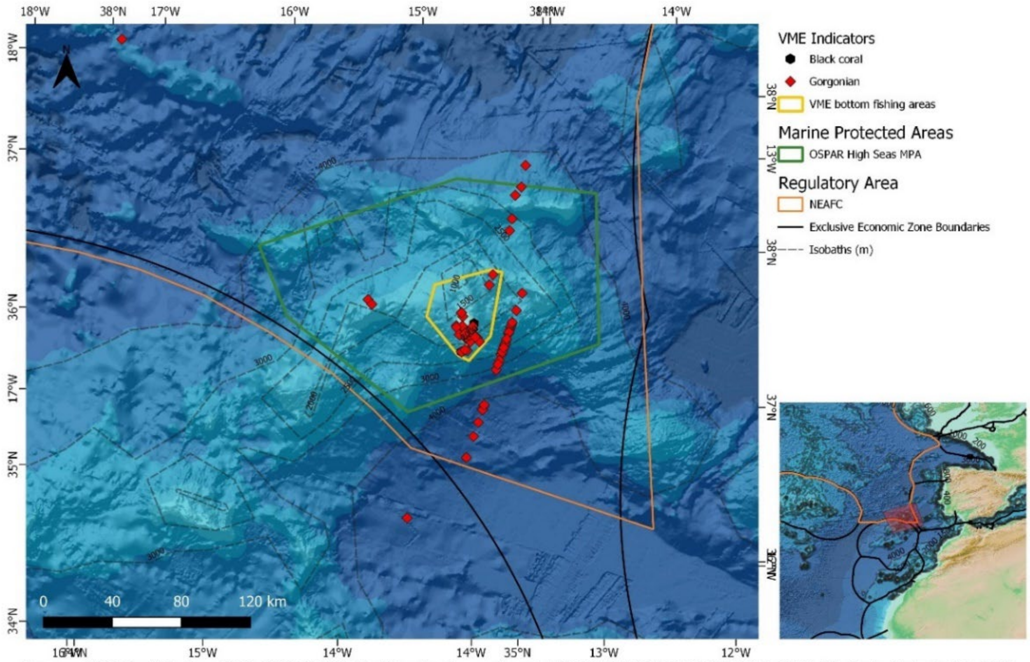


Figure 5.1 Map of Josephine Seamount showing the distribution of gorgonian corals and the proposed bottom fishing closure recommended by ICES in 2013. The proposed closure boundary corresponds precisely with the OSPAR High Seas MPA. The red square on the overview map shows the approximate location of the closure.

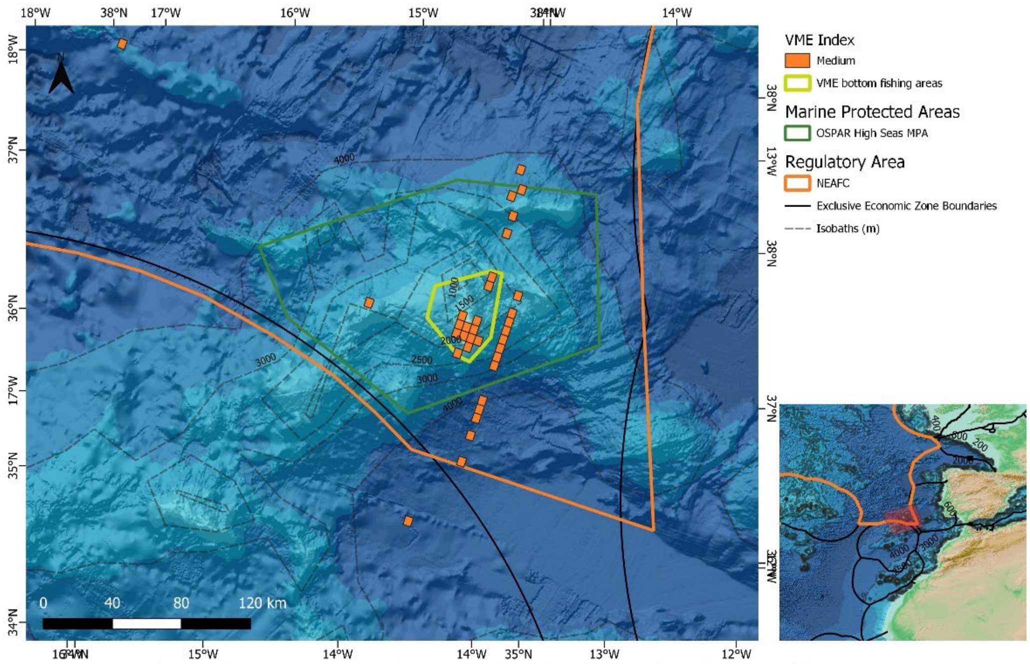
5.2 Existing VME records on Josephine Seamount

No further data were provided to the VME database in 2021, however the existing records are shown in Figure 5.2, alongside the VME Index (Figure 5.3) and Confidence (Figure 5.4) outputs.



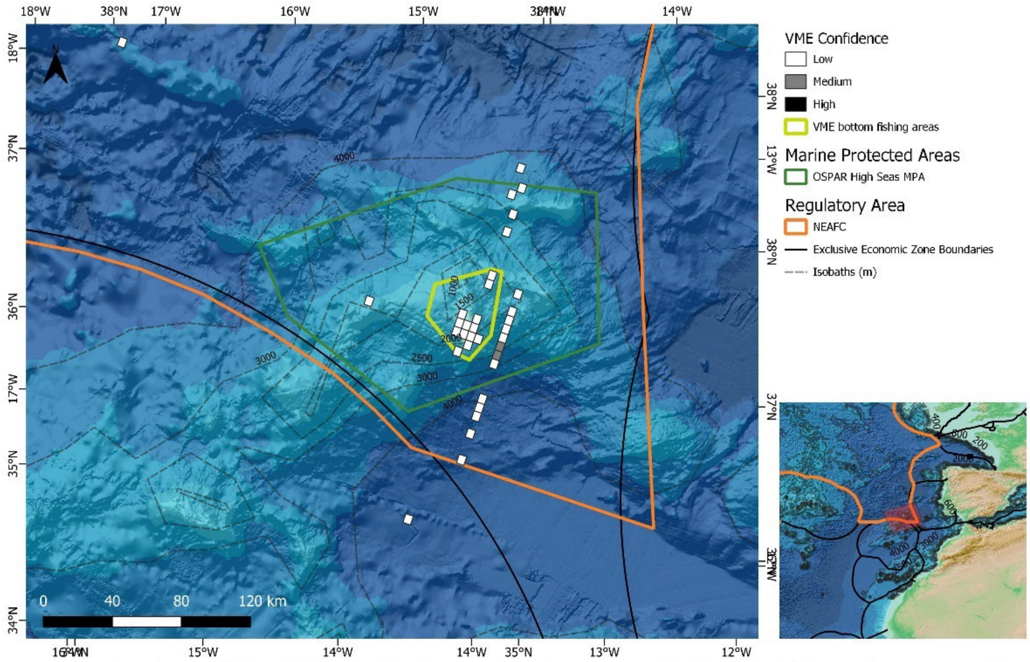
Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 5.2 VME indicator records from the ICES VME database, on the Josephine Seamount. The map shows the current OSPAR High Seas MPA boundary in green and the existing bottom fishing area in yellow.



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 5.3 Output of the VME weighting algorithm for Josephine Seamount, showing the VME Index; the likelihood of encountering a VME within each grid cell (shown as Medium for these records).



Base map: GEBCO Compilation Group (2020), GEBCO 2020 Grid (Available online at www.gebco.net, doi:10.5285/a29c5465-b138-234de053-6c86abc040b9). EEZ: Flanders Marine Institute (2019), Maritime Boundaries and Exclusive Economic Zones (200NM), version 11 (Available online at http://www.marineregions.org/, https://doi.org/10.14284/386). Main map projection: Europe Albers Equal Area Conic Proj4: +proj=aea +lat_1=43 +lat_2=62 +lat_0=30 +lon_0=10 +x_0=0 +y_0=0 +ellps=intl +units=m +no_defs. Inset map projection: WGS84 Proj4: +proj=longlat +datum=WGS84 +no_defs

Figure 5.4 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 5.3) for Josephine Seamount.

5.3 New VME evidence for Josephine Seamount

During the WGDEC 2021 meeting, the group considered the data present within the VME database for Josephine Seamount. No further data submissions have been received for this area since the 2014 meeting. However, the group were aware of some research activities within the Seamount complex area, and therefore reviewed available literature to identify any additional sources of VME data.

5.3.1 OSPAR Background Document

The OSPAR background document for the Josephine Seamount High Seas MPA states that endemic species found on Josephine Seamount include *Victorgorgia josephinae* (Alcyonacea). The document also reports that dense gorgonian aggregations, composed of *Callogorgia verticillata* and *Viminella flagellum*, cover rocky outcrops and limestones on the seamount, together with hexactinellid sponges *Asconema setubalense* (OSPAR, 2011). The background document reports on invertebrate species records on the seamount from literature (Table 5.1), including some reported by ICES (2014) (e.g. Grasshoff, 1985; Pasternak, 1985), but also including additional literature sources for Hexactinellid sponges (Tabachnick & Menchenina, 2007), solitary scleractinians (Zibrowius, 1980), and Alcyonacean gorgonians (Lopez-Gonzales & Briand, 2002). This suggests some additional VME indicator species occur on the seamount, which are not currently in the VME database. These could be submitted to the database during the VME Data Call 2022.

The OSPAR background document reports that no habitat-forming scleractinians were reported from the summit or slopes of Josephine Seamount, but that research cruises (e.g. SEAMOUNT 1 and Meteor 9c) had commonly focused on the plateau (200–400 m).

Table 5.1 List of species recorded at the Josephine seamount or its vicinity

Taxonomic group	Taxa	Position (Lat, Long)	Depth range (m)	Sources
Hexactinellid sponges	*Asconema setubalense*	36°45'N,14°15.1'W 36°45.80'N,14°17.50'W 36°45.90'N,14°20.40'W	315–380	Tabachnick & Menchenina, 2007
Alcyonacean gorgonians (10 spp.)	*Bebryce mollis*	36°40'00"N, 14°09'45"W 36°41'00"N, 14°11'45"W 36.32166667, -14 36.35027778, -14 36.69805556, -14 36.8225, -14 36.98972222, -14	170–300	Grasshoff, 1985; Pasternak, 1985
	Callogorgia verticillata	36°40'00"N, 14°09'45"W 36°41'00"N, 14°11'45"W 36.32166667, -14 36.32361111, -14 36.32416667, -14 36.55166667, -14 36.66583333, -14 36.75833333, -14 36.78, -14 36.79583333, -14 36.89111111, -14	170–500	Grasshoff, 1985; Pasternak, 1985
	Muriceides lepida	36.58333333, -14	170–300	Grasshoff, 1985
	Nicella granifera	36°40'00"N, 14°09'45"W 36°41'00"N, 14°11'45"W 36.67833333, -14	200–241	Grasshoff, 1972, 1985; Pasternak, 1985
	Paracalyptrophora josephinae[1]	36.58333333, -14 36.67833333, -14 36.68666667, -14 36.69, -14 36.705, -14 36.72, -14 36.76166667, -14	200–340	Grasshoff, 1985; Cairns and Bayer, 2004

Taxonomic group	Taxa	Position (Lat, Long)	Depth range (m)	Sources
		36°46’N, 14°07’W		
	Placogorgia terceira	36.605, -14	170–300	Grasshoff, 1985
	Victorgorgia josephinae[2]	37°48’N, 14°01’W	1500	López-González and Briand, 2002
	Villogorgia bebrycoides	36.58333333, -14	170–300	Grasshoff, 1985
	Viminella flagellum	36°40'00"N, 14°09'45"W 36°41'00"N, 14°11'45"W	196–430	Grasshoff, 1985; Pasternak, 1985
		36.70833333, -14.33666667 36.78333333, -14.33333333 36.66666667, -14.295 36.67833333, -14.25833333 36.66166667, -14.255 36.58333333, -14.25 36.69, -14.24666667 36.68666667, -14.24 36.7, -14.23333333		
	Swiftia dubia	36.58333333, -14 36.63666667, -14	170–196	Grasshoff, 1985
Scleractinians (14 solitary spp.)	*Anomocora fecunda*	36°41,4'N, 14°14,8'W	216–225	Zibrowius, 1980
	Balanophyllia (Balanophyllia) cellulosa	36°45,8'N, 14°19,2'W	310–345	Zibrowius, 1980
	Caryophyllia (Caryophyllia) smithii[3]	36°40,4'N,14°15,6'W	208–230	Zibrowius, 1980
	Deltocyathoides stimpsonii	36°48,5'N,14°12,5'W	296–417; 208–231 (nearby stations)	Zibrowius, 1980
	Deltocyathus eccentricus	~36°36,3'N,14°14'W (plus a station without position)	170–910	Zibrowius, 1980
	Deltocyathus moseleyi	36°36,3'N, 14°14'W; 36°46,8'N, 14°14,7'W	170–910	Zibrowius, 1980

Taxonomic group	Taxa	Position (Lat, Long)	Depth range (m)	Sources
	Dendrophyllia cornigera	36°36,3'N-14°14'W (plus 4 stations without position)	170–345 m	Zibrowius, 1980
	Flabellum (Ulocyathus) alabastrum	36°52,1'N, 14°37,5'W	1700	Zibrowius, 1980
	Flabellum (Flabellum) chunii	36°41,4'N, 14°14,8'W	216–220	Zibrowius, 1980
	Fungiacyathus (Bathyactis) crispus	~36°46'N, 14°07'W	418	Zibrowius, 1980
	Paracyathus arcuatus	36°46'N, 14°07'W (plus stations without position)	201–231	Zibrowius, 1980
	Paracyathus pulchellus	36°41'N, 14°11'45"W; 36°38,2'N, 14°14,2'W (plus a station without position)	195–233	Zibrowius, 1980
	Peponocyathus folliculus	36°48,5'N,14°12,5'W	296–417	Zibrowius, 1980
	Stenocyathus vermiformis	36°40'N, 14°17,7'W; 36°40,4'N, 14°15,6'W	208–430	Zibrowius, 1980
Stylasterids (2 spp.)	*Pliobothrus symmetricus*	36°42,3'N, 14°21,6'W; 36°45,9'N, 14°20,4'W	340–425	Zibrowius & Cairns, 1992
	Crypthelia sp.	~36°46'N, 14°07'W	622	Zibrowius & Cairns, 1992
Black corals (2 spp.)	*Antipathella subpinnata*	36.679, -14	229-241	Grasshoff, 1985
	Antipathes dichotoma	-	256	Grasshoff, 1985

[1]Type locality

[2]Members of this genus are known from several ocean basins, not only NE Atlantic;

[3]tiny and dead.

5.3.2 GeoMar R/V Sonne cruise SO280

In 2020 a GeoMar cruise (SO280) aboard R/V Sonne undertook high resolution bathymetric mapping of Josephine Seamount. The report and data from this cruise are not yet available, however the cruise has published a blog post[9] showing the bathymetry imagery (Figure 5.5) and a short

[9] https://www.iatlantic.eu/expedition_blog/meet-lady-josephine-beauty-of-the-high-seas/

cruise report[10]. This imagery is suggestive of the existence of habitat suitable for a range of VME indicator taxa, but this has not yet been confirmed.

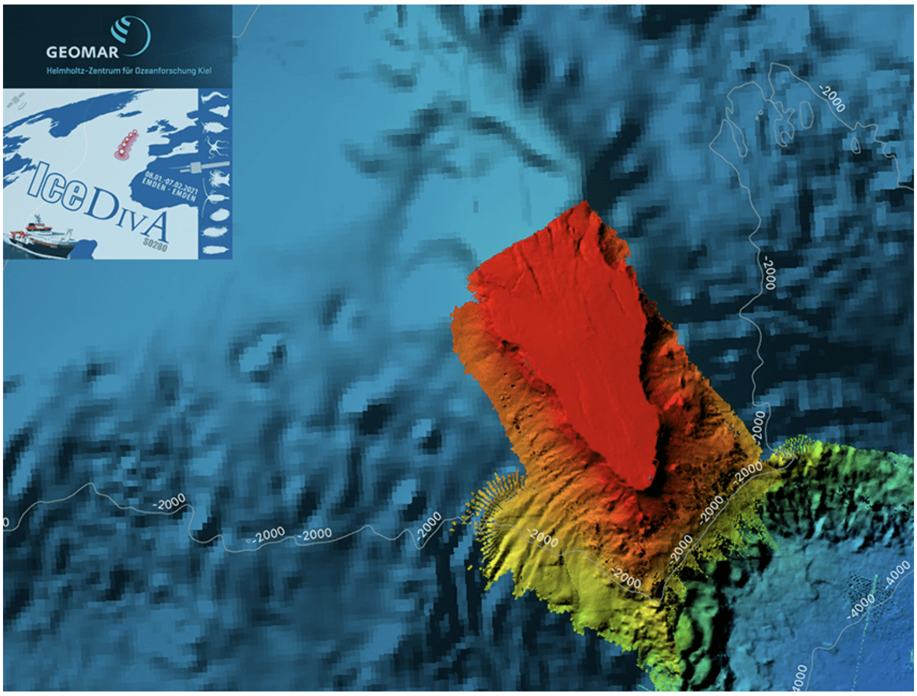


Figure 5.5 Bathymetric mapping of Josephine Seamount during the GeoMar R/V Sonne SO280 cruise. Image courtesy of Saskia Brix, James Taylor, Mia Schumacher and the IceDivA cruise participants.

This bathymetry data indicates a near-flat topped seamount with very steep south, south west and south east slopes. Seamounts of a similar shape elsewhere are known to have VME indicators occurring around the steep slope edges and ridges (e.g., Anderson *et al*., 2011). In addition, the sediments on the flat top of the nearby Great Meteor Seamount were found to be habitat to 54 new species (of 56 species found) of harpacticoid copepods (George & Schminke 2002), and Gofas (2007) found 30 new species of rissoid snails on the tops of the Lusitanian and Meteor seamounts. These latter groups are not considered as VME indicator species, but these studies show that the sands on the flat tops of seamounts can harbour considerable biodiversity.

The precipitous physiography of seamounts, rising from significant depths above the surrounding seafloor, produce topographically induced flows that increase flow rates and enhance the advection of food particles to suspension-feeding animals (Clark *et al* 2010). Flow acceleration is most pronounced along the sides near the seamount summit, but also anywhere on the seamount where there is a feature, such as a ridge, that is raised above the local topography of the surrounding seafloor. Such features, in diverse ecological settings, are characterized by high densities of corals and sponges (Genin *et al*., 1986, Tempera *et al*. 2012, Tong *et al*. 2012, Rengstorf *et al*. 2013).

Using such ecological knowledge facilitates use of the multibeam data to infer the likely presence of VME indicator species, along with the empirical observations summarized above. This is consistent with the application of the precautionary approach as addressed in UNGA 61/105 and related FAO guidance on sustainable fisheries and ecosystem principles.

[10] https://www.ldf.uni-hamburg.de/sonne/wochenberichte/wochenberichte-sonne/so279-282/so280-scr.pdf

5.3.3 EBSA proposal

Josephine seamount is also part of a proposed Ecologically or Biologically Significant Marine Area (EBSA) under the Convention on Biological Diversity CBD. The "Madeira –Tore EBSA" was proposed in 2019[11], but is not yet on the EBSA list. The CBD EBSA criteria are listed as:

7. Uniqueness or Rarity
8. Special importance for life history stages of species
9. Importance for threatened, endangered or declining species and/or habitats
10. Vulnerability, Fragility, Sensitivity, or Slow recovery
11. Biological Productivity
12. Biological Diversity
13. Naturalness

The EBSA proposal document states that Josephine seamount fulfils all the EBSA criteria except number 7 (Naturalness) due to the fishing activity occurring at the site.

5.4 Analysis of the 2020 VMS submission from NEAFC on Josephine Seamount

The Josephine seamount area shows high levels of static gear activity within the existing footprint on top of the seamount, similar to that reported last year (Figure 5.6). The static gear activity was comprised of set longlines (LLS), registered for 2 vessels. The corresponding catch data for these vessels is characteristic of seamount species, supporting the use of LLS gears on the seabed. The low intensity use of static gears in the area to the west of the Josephine seamount is reduced in extent from that observed last year (Figure 5.7) and, given the depths (3000–5000 m), are likely longline gears targeting pelagic species.

The only other registered vessel active in the Josephine seamount area reported using bottom otter trawl (OTB) gear. The vessel completed three tows on the summit of Josephine at depths of 200–250 m, within the existing fishing footprint (Figure 5.8). This activity amounts to low efforts of bottom trawl activity within the existing bottom fishing area on the seamount (Figure 5.9). There is evidence of some very low intensity bottom trawling in the most south-eastern corner of the NEAFC regulatory area, close to the Portuguese EEZ (Figure 5.8 and Figure 5.9). There was no activity of vessels without a registered gear type fishing in the area.

[11] https://www.cbd.int/doc/c/d6d3/59a9/54ec3fb193b286af9f7429e4/template-2-madeira-tore-en.pdf

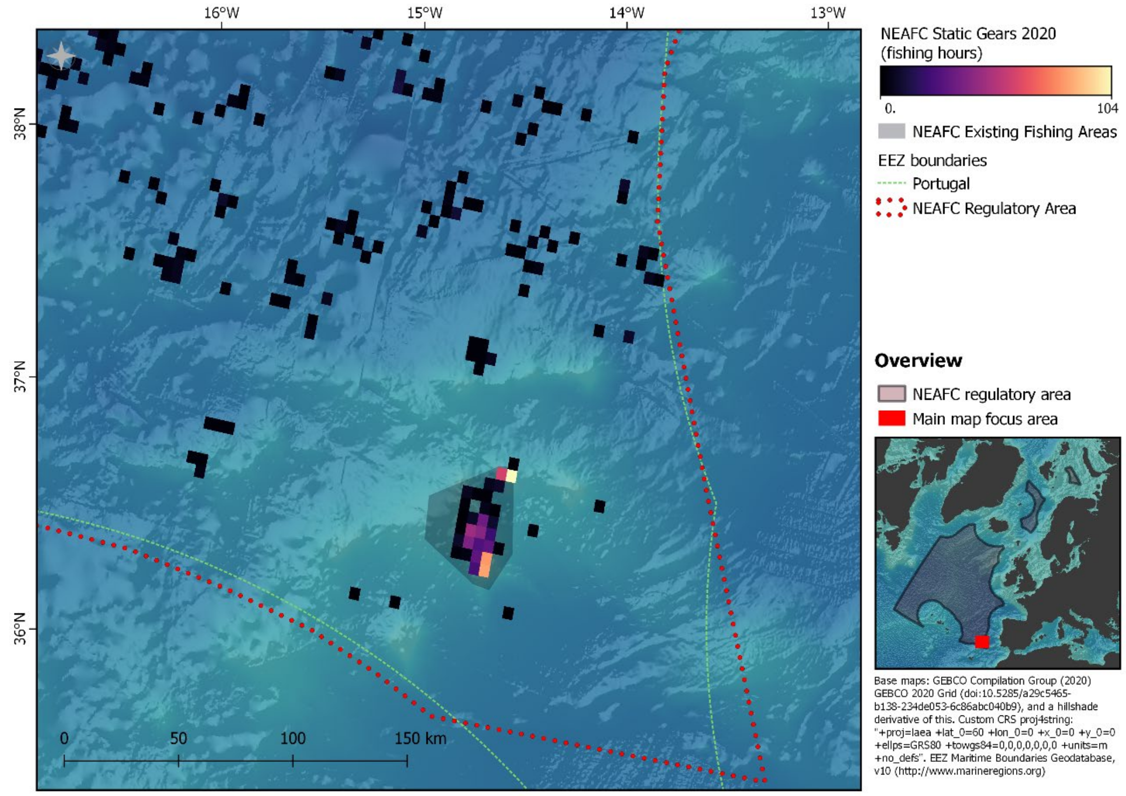


Figure 5.6 Gridded data (fishing hours) for bottom contacting static gears in the Josephine seamount area showing the existing NEAFC fishing area (grey polygon) and EEZ boundaries.

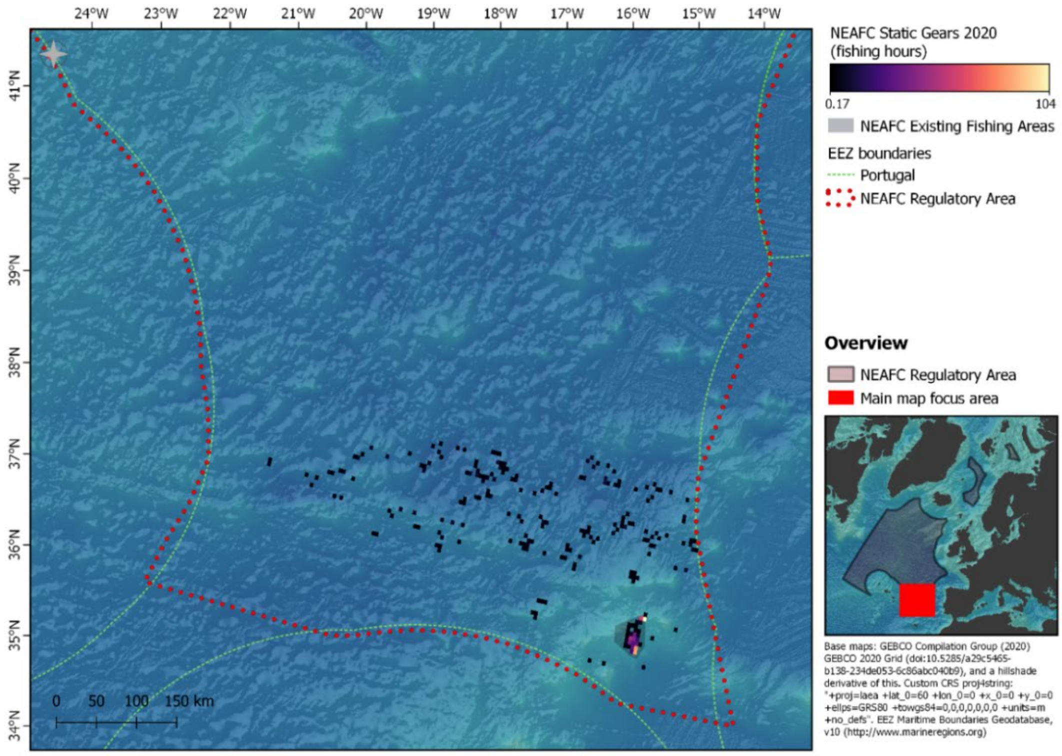


Figure 5.7 Gridded data (fishing hours) for Bottom contacting Static Gears in the area northwest of the Josephine seamount, overlain with existing NEAFC fishing areas and EEZ boundaries

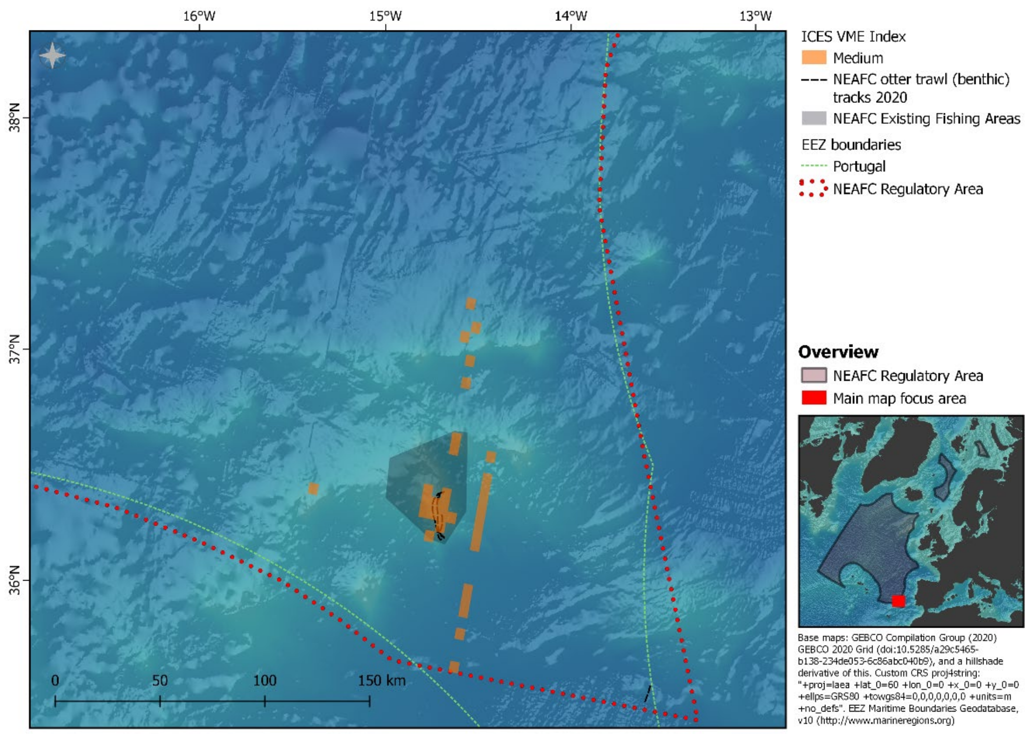


Figure 5.8 Bottom contacting otter trawl tow tracks on Josephine Seamount, overlain with the VME Index, and EEZ boundaries.

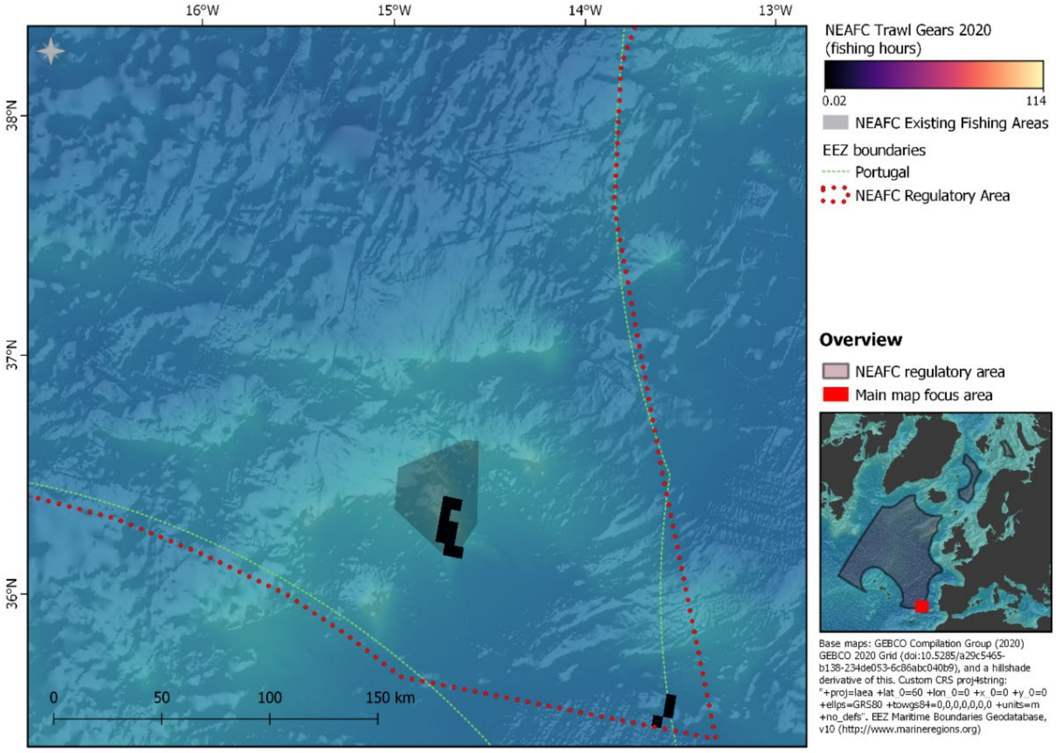


Figure 5.9 Gridded data (fishing hours) for bottom contacting trawl gears in the Josephine seamount area showing the existing NEAFC fishing area (grey polygon) and EEZ boundaries.

5.5 Potential for damage to the VMEs from mobile bottom contacting gear and static gear

Josephine Seamount is located at the crossroads of corridors of maritime traffic, from and to the Atlantic and Mediterranean basins and is also an important fishing ground for the Portuguese fishing fleet operating at seamounts of the Madeira-Tore geologic complex.

Nearly 50 vessels operated in the area for the period 2012–2014, mainly using longlines targeting wreckfish *Polyprion americanus* and the European conger, *Conger*, swordfish *Xiphias gladius* and black scabbardfish *Aphanopus carbo* (Campos *et al*., 2019).

In terms of potential damage, bottom trawling has a much larger impact on the integrity of the seafloor and associated fauna than static gears (e.g. Taranto *et al*. 2012, Pham *et al*., 2014). The effects of fishing gear on the benthic ecosystems can be direct and immediate (e.g. removal and damage of biogenic structures such as corals and sponges) (e.g. Durán Muñoz *et al*., 2012; Braga-Henriques *et al*., 2013; Vieira *et al*., 2020), persisting over time (e.g. ghost-fishing and bycatch) (e.g. Sampaio *et al*., 2012; Pham *et al*. 2013; Dias *et al*., 2020). There can also be indirect impacts caused by both short term and long-term disturbance of substrate and geomorphological features that could support VME indicator species, their occurrence, settlement and recovery (Porobic *et al*., 2019).

However, in addition to accidental/non-intended catches, static gears, such as longlines, also have potential deleterious effects to benthic fauna, which may get hooked (incidental bycatch e.g. Sampaio *et al*., 2012) or damaged through the lateral movement of the lines (see Schweitzer *et al*. 2018 and Stevens, 2021 for related studies on trap impacts). However, further investigations of the behaviour of static gears in contact with the seafloor and a risk assessment related to the fishing process are needed

While there is no specific information on potential effects of static gears on VMEs of Josephine Seamount, it can be expected these would be similar to other seamounts in the vicinity. This includes marine litter and lost and/or discarded fishing gears, which were observed at the Gorringe Bank (Vieira *et al*., 2015). Long-term impacts of lost fishing gears and other marine litter remain poorly understood but it is known they may be detrimental through clogging of filter-feeder structures by macro- and microplastics (Soares *et al*., 2020).

5.6 Recommendations

Based on the existing evidence for VME indicators on Josephine Seamount (ICES, 2014), together with potential new records from literature highlighted in the OSPAR background document (OSPAR, 2011) and expert knowledge of VME presence on seamounts similar to Josephine, **WGDEC recommend that the previous closure proposal advised by ICES in 2013 (ICES, 2013b) is re-considered.** This proposal follows the precautionary approach, as required under UNGA Resolution 61/105[12], particularly noting paragraph 80 which calls upon states to apply the precautionary approach in protecting VMEs (including seamounts) from destructive fishing practices.

This closure would protect the VME indicators occurring on the Josephine Seamount, as well as the geomorphological structure (VME element), and potential VMEs occurring on the surrounding seamounts.

The closure recommendation aligns with the OSPAR MPA boundary, as shown in Figure 5.2 and the coordinates for the closure are provided in Table 5.2.

Table 5.2 Geographic coordinates for the proposed Josephine Seamount NEAFC bottom fishing closure

LATITUDE (DECIMAL DEGREES)	LONGITUDE (DECIMAL DEGREES)	LATITUDE (DMS)	LONGITUDE (DMS)
37.460	-14.650	37° 27' 36" N	14° 39' 0" W
37.630	-13.750	37° 37' 48" N	13° 45' 0" W
36.860	-13.420	36° 51' 36" N	13° 25' 12" W
36.180	-14.450	36° 10' 48" N	14° 26' 60" W
36.450	-15.390	36° 27' 0" N	15° 23' 24" W

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Annex 1: List of participants

WGSFD 2021 meeting

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WGSFD 2020 meeting

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Annex 2: WGSFD Resolution

The **Working Group on Spatial Fisheries Data** (WGSFD), chaired by Roi Martinez, UK, and Neil Campbell, UK, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	24–28 June	Lysekil, Sweden		
Year 2020	8–12 June	by corresp/ webex		physical meeting cancelled - remote work
Year 2021	7–11 June	Online meeting	Final report by 1 August to SCICOM	

ToRs descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
a	Analyse current AIS datasets available to the WG, their fitness for purpose in provision of advice, and investigate possibility of inclusion of AIS data in the annual request from ICES to its member countries to provide spatial fisheries effort data to the data centre ("the ICES VMS datacall").	For advice processes for among others DG-ENV, it is required to analyse AIS data. To ensure a smooth transition to including AIS data in advice products, best practices and logistics need to be evaluated	3.2; 3.3; 3.5	Year 1-3	Section in WG report which can be forwarded to WKBEDPRES2 describing current best practice, data gaps and approaches to data handling
b	Evaluating need and possibility to move towards higher spatial resolution in the ICES VMS datacalls	Using interpolation methods, make a voluntary test datacall for a couple of countries within WGSFD on submitting data on c-squares on a 0.01 degree resolution instead of the current 0.05 degree resolution. The possibility of higher resolution fishing pressure data for merging with habitat data has been discussed during the ICES workshops WKFBI, WKBENTH, WKTRADE, and can provide input for the upcoming ICES WGFBIT and WKBEDPRES2.	3.2; 3.5	Year 1	Section of WG report detailing analysis of the change in fishing footprint when increasing to higher spatial resolution. A consideration of risks and other issues (e.g. confidentiality, credibility) in interpolating at finer scales than present should also be provided.
c	Develop spatial effort indicators for static gears	In order to estimate the effort of the passive fishing gear, other parameters (soaking time, gear length, number of hooks etc.) are needed. During the next term, WGSFD will	3.5; 5.4; 6.1	Year 1-3	Sections in working group reports to ICES containing: i) spatial maps of fishing activity, and ii) fishing effort maps through parameterization of soak

		further evaluate whether these parameters can be estimated from VMS, fleet characteristics and observer data to produce speed filters and describe typology of various fishing events for different gear categories.			times / gear lengths / hook number.
d	Identifying potential drivers and describing spatial conflicts of fisheries in the past and future on displacement of fishing activities over various time-scales	Fisheries territories are defined by operating conditions and fish availability. Fish resources displacement due to the climate change, management measures and other human uses (MPA, marine traffic, gravel extraction, wind farms, oil rigs, seismic survey) may result in displacements when competition occurs for a given space. Through the ICES datacalls on VMS and logbook data we now have the information available to estimate the spatial variability of fisheries over time. By this we will explore drivers of fisheries displacement and develop predictive models to infer potential fisheries reallocation in a conflicting event.	5.4; 6.1; 6.2	3 years	Peer-reviewed paper
e	Support to WKBEDPRES	To ensure compatibility with WKBEDPRES1 and WKBEDPRES2, WGSFD will provide guidance on using other data sets to assess the distribution and extent of physical disturbance to the seabed.	NA		WG Report section providing strategic guidance and criteria for the collection, management, quality assurance and reporting of non-fisheries spatial data.
f	WGSFD is requested to analyse and produce maps of bottom contacting fishing activity in and in the vicinity of VMEs (defined by WGDEC) and separate this into mobile bottom contacting gear and static gear in NEAFC areas, including the Josephine Seamount, using the VMS and logbook information collected by NEAFC. These maps should be made available to WGDEC to ensure they	In analysing and producing maps of fishing activity in NEAFC areas using the VMS and logbook information collected by NEAFC, WGSFD will ensure that WGDEC have the required fishing activity layers to produce a first draft advice sheet that address the annual advice request, "NEAFC requests ICES to continue to provide all available new information on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in and in the vicinity of such habitats, and provide advice relevant to the	NA	year 1 year 3	Maps provided to WGDEC by 30 May 2019. Maps provided to WGDEC by 30 May 2021.

	can be combined by WGDEC with new information on distribution of vulnerable habitats. WGSFD is requested to also provide a short narrative on how NEAFC could improve data available to ICES that could facilitate the subsequent analysis of fishing gears used in the NEAFC areas, to provide a more detailed analysis of bottom gears accounting for a diversity of types of gear designs, sizes, rigging and operational methods (passive and active). With the understanding that their impact on the seabed differ.	Regulatory Area and the above mentioned objectives" and the special request, "Advice on vulnerable marine ecosystems in the NEAFC Regulatory Areas, not acted on". The draft NEAFC VME advice produced by WGDEC (with input from WGSFD) will be submitted for further consideration by a review group (RGVME) and advisory committee advice drafting group (ADGVME).			
g	In preparation for future advice requests for electronic advice outputs at higher resolution (c-square at 0.05° x 0.05°), WGSFD will: 1) Analyse the extent of aggregated international VMS data subject to anonymity issues (≤ 3 number of vessels) 2) Discuss different procedures to preserve anonymity (gear groupings, area grouping, international grouping, …) 3) Approve on a method/s that optimizes the data product while preserving the anonymity.	To ensure vessel anonymity in electronic advice outputs at a higher resolution, aggregated international effort values of any c-squares containing three vessels or less will not be shown (see ICES VMS data call 2019). ICES Secretariat/Data centre will filter the sensitive data in the aggregated international fishing effort (3 vessels or less) and present the group with different scenarios. The agreed upon method will contain as much information as possible (spatial or as fishing effort value) while preserving the vessel anonimity.	3.3, 3.5	year 1	Section in the WG report which can be referred to in future advice processes.
h	Present best-practices on how to analyse and use VMS data from a world-wide perspective.	A decadal view on fisheries distribution and variability over time is lacking from the literature. This information has however now become available through the ICES datacalls on VMS and logbook data and therefore makes a valuable data source to investigate,		year 3	A peer-reviewed publication describing best practices for sharing and use of VMS data in an international context.

	describe and explain the spatio-temporal use of the European seas by the different fisheries. Analyses performed using VMS and Logbook data have been published for almost two decades. Within ICES different standardized methodology has been developed, but worldwide many scientists have undertaken similar activities. To improve the activities within ICES we review literature and describe best practices in analysing VMS and logbook data.	

Summary of the Work Plan

Year 1	Continuing WGSFD work from 2016–2018 on improving methods and ensuring high quality of VMS/logbook data processing from data request formats, quality checks and processing data to be implemented by the ICES data centre. Address the ToRs- Identification of best practices for the standardization of AIS VMS data/Logbook. Quality Assessment and Harmonization of the available AIS data Evaluation of the comparative advantage of integrating AIS and VMS in the calculation of indicators.
Year 2	Address ToRs with aim to provide methodological guidance in analysing VMS/Logbook/AIS data and showcase results of interest to a wider audience. Invite ICES states to provide AIS + VMS + Logbook aggregated data. Further evaluation of the comparative advantage of integrating AIS and VMS in the calculation of indicators.
Year 3	Address ToRs with aim to provide methodological guidance in analysing VMS/Logbook/AIS data and showcase results of interest to a wider audience. Extension of the AIS data submission to all countries. Quality Assessment of the AIS data provided.

Supporting information

Priority	WGSFD work in 2013-2018 has proven that there is a demand for fine scaled spatial fisheries information. Outputs on fishing intensity from WGSFD have been requested by OSPAR and HELCOM for work on MSFD descriptor 6. Outputs can also be used for ecoregion advice as well as in descriptions of fisheries activity. WGSFD will in 2019-2021 focus on showcasing the value of the information in terms of understanding fisheries behaviour, applicability for fisheries management and advance methodology development to best analyse the spatial datasets at hand. ToRa: as physical disturbance from bottom-contacting fishing gear is likely to be a substantial contribution to the total extent of physical disturbance, particular attention is needed to define an appropriate method or methods for this type of disturbance. Two main sources of data are currently used to map the distribution and intensity of bottom-fishing activity: Vessel Monitoring System (VMS) data, which is coupled with fishing logbook data, and Automatic Identification System (AIS) data. VMS data have been used by ICES, FP7 Benthis project and others; AIS data have been used by JRC (JRC Blue Hub) and EMODnet. Building upon the evaluation of these data types (ICES WGSFD 2016), and considering the differences in data availability, resolution and outcomes of their processing, a comparative analysis in selected study areas is needed to assess their relative merits for MSFD purposes. TORa should thus compare the use of VMS and AIS data, and associated data required to determine fishing effort and type, such as fishers' logbooks, in the

	context of use for MSFD D6 assessments. This should include a side-by-side comparison against a number of parameters, including source of the data (who holds the raw data), availability (e.g. legal requirements, including vessels to be covered), ac-cessibility (including any costs, restrictions such as due to data sensitivity, ease of access), use (e.g. restrictions on its release), spatial coverage in European waters, temporal coverage (his-toric, and within year), resolution (spatial granularity), accuracy, technical requirements for processing (to define when vessels are physically disturbing the seabed), resources needed (e.g. technical expertise, time per unit area). The comparison should include maps showing the distribution of bottom-fishing activity from the two data sources for the same time period, indicating where the distribution overlaps and where not, with an associated quantification of this (e.g. number/proportion of grid cells per subdivision for AIS only, VMS only and both) and explanations for any differences. It should be noted that other electronic monitoring systems (e.g. GPS and cell-phone based systems) are being developed in some regions, for use by smaller vessels. The work should be carried out in close collaboration with EMODnet and JRC.
Resource requirements	VMS/Logbook/AIS data requested in ICES data calls
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	Assistance from ICES Data Centre in hosting VMS/logbook/AIS data as well as quality checking and implementation of methods developed by WGSFD. Possibly meeting facilities.
Financial	Resources for ICES Data Centre to host and process VMS/logbook/AIS data.
Linkages to ACOM and groups under ACOM	ACOM
Linkages to other committees or groups	WGDEC, DIG, WGBYC, WGECO, WGMHM, BEWG, WGHIST , WKBEDPRES
Linkages to other organizations	OSPAR, HELCOM

Annex 3: Audit trail of VMS processing and quality check

Description of QC process (31 March- 8 June 2021)

This year's submission[13] was online through the ICES Data portal for VMS and Logbook.(https://data.ices.dk/vms) using the format specified in datsu.ices.dk/web/selRep.aspx?Dataset=145 and with an additional quality check (DATSU check) to ensure that data was in the proper format. Additionally, data submitters were able to see a quality control (QC) report of the data and could resubmit data if errors were detected. Next, the chairs of WGSFD reviewed the QC reports and highlighted potential issues to the submitter for feedback and/or resubmission.

Data which failed quality control were referred to the submitting country for correction and resubmission (correction). In some cases, issues were acknowledged, and no resubmission was required (annotation). Not all the countries from which data were received passed the quality control this year and could be used in ICES advisory products.

An additional quality control was run on the full VMS dataset with all the countries combined to calculate and check the most important variables (number of submitted records, fisheries effort, landings, etc.) for each year, so that any questionable deviations could be identified. A summary of encountered issues and how they were resolved is listed below:

Issue detected during quality checking	**Correction**	**Annotation**
30% decline in VMS records		The decline in records was confirmed as real reduction in activity by the data submitter
Sharp increase in VMS records in 2011-2012		Data submitter confirmed the increase in VMS records between 2011 and 2012 is due to a change in regulation on the minimum vessel length to include VMS from 15m to 12m.
Small number of vessels with high fishing days and low catches and others with the opposite relationship		The plots form the QC report were prepared separately for each target assemblage that includes data from big vessels (with high catches and low effort) and small vessels (low catches and high effort). If plots were prepared separately for each metier level 5 (gear type combined with assemblage) big and small vessels would be separated by active and passive gears respectively and the catch-effort plots would look more stable. Additionally, the number of vessels covered by a single dot in the plot in unknown.

[13] https://www.ices.dk/sites/pub/Publication%20Reports/Data%20calls/datacall.2021.VMS_LogBook_data.pdf

Sharp increase in VMS records from 2014 onwards corresponding to CRU in the Barents Sea. Please confirm type of fishery		Data before 2014 could not be retrieved. WGSFD chairs agreed to keep note of the issue when comparing the data across the years.
Spike in: • LPUE of CAT in 2016, • ANA landings per Kwh in 2018	Acknowledged at national level and data resubmitted	
Records from statistical rectangles over the mid-Atlantic-Ridge and central Atlantic that do not match the VMS data submitted	Acknowledged at national level and data resubmitted	
Sharp decrease in VMS records in 2019		Data submitter confirmed that the decrease is related to the implementation of complete cod fishery ban in the Eastern part of the Baltic Sea. In 2020 there is an increase in number of records by increased quota for Gulf of Riga herring.
VMS data outside of ICES area reported. Corresponding logbook entries have not been submitted	Acknowledged at national level and data resubmitted	
Spike in 'MIS' LPUE and values per Kwh in 2011 and not corresponding drop in any other main metiers.	Acknowledged at national level and data resubmitted	
Sharp decrease of different metiers in 2020 (but particularly CRU and DEF) in landings and values of landings		Acknowledged by data submitter and confirmed it was due to a Brexit and Covid effect.
Spatial extent of VMS records outside ICES areas	Acknowledged at national level and data resubmitted	
Difference about the data in 2013 and 2017 detected: The furthest east points in these years are 94° and 123°E, which seems out of line with the other years. The spatial range of the logbooks does not extend this far.		Acknowledged by data submitter. It is part of the long-distance fishery and the format of the data call regarding the logbooks does not match, hence the divergence. These points are outside the geographical scope of the data call and will be deleted in future uploads.

Annex 4: Technical minutes from the Vulnerable Marine Ecosystems Review Group

- RGVME
- By correspondence August 2021
- Participants: Emanuela Fanelli (Chair, Italy), Peter Hopkins (Belgium); Malcolm Clark (New Zealand) and Sebastian Valanko (ICES Secretariat)
- Working Group: WGDEC and WGSFD

In response to the two advice requests (EU, NEAFC), the report reviews the collection of (i) new information on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in, and in the vicinity of, such habitats, and provide advice relevant to the Regulatory Area, and ii) new information regarding the impact of fisheries on other components of the ecosystem including small cetaceans and other marine mammals, seabirds, and habitats. This should include any new information on the location of habitats sensitive to particular fishing activities.

The review group (RG) worked by correspondence during the period indicated (from 14th July to 20th August 2020). A first email exchange among the participants took place on 12nd of July in order to agree on the review approach. Participants decided to work simultaneously, providing separate reviews that have been revised and integrated in a single document, then the chair organized a teleconference on 20th August 2021, to agree on a final review of the advice provided in this report.

The review document is structured according to some general remarks, the two requests and a recap of recommendations for complying with this year's requests and future improvements of the WGDEC activities.

1. General remarks:

A total of 11,160 new VME presence records and 3,985 absence records were submitted and uploaded into the VME database since May 2020 (UK, Ireland, Norway, France, Spain, Russia, and data from the NGO Oceana for Spanish waters), which increases the total number of presence records in the database to 72,370. However, this count consists of all individual records in the database, and thus some VMEs will be represented by more than one record. Of the newly submitted presence records, 273 are within the NEAFC Regulatory Area, 2,500 are within the NAFO Regulatory Area, and the remaining 8,387 are within the Exclusive Economic Zones of North Atlantic ICES/NAFO member states.

Records provided by France are resubmissions, with the exception of new records for tube-dwelling anemone aggregations and stalked crinoid aggregations (as these were not recognised as VME habitats at that time). Data were originally submitted in 2014 as VME indicator records and have been further analysed to identify VME habitats.

a) The RG is very pleased with the high number of new records uploaded this year that significantly improve the dataset (indicator and habitat records) that were collected in the past and that were analysed by WGDEC. This large amount of data increases the confidence in the distribution of VME indicator species and identification of VME habitats. It also demonstrates a collaborative commitment by all countries and a valuable approach by ICES, which could be of inspiration also for other RFMOs and International commissions.

b) In response to the request of the Review Group in 2020 (ICES, 2020), the WGDEC established a Vulnerable Marine Ecosystem (VME) data quality assurance sub-group to undertake quality assurance and quality control checks on VME data submissions made by ICES member countries. The process followed by the VME Data QA sub-group looks to be appropriately rigorous and it has the power to reject submissions if significant errors are detected; errors can be flagged to the data provider, who can rectify the issues before repeating the submission process. Once approved by the QA sub-group, VME data can be released for use by WGDEC. The RG notes that this process has been applied only to the new data submitted in 2020. Similar checks applied to the earlier data are recommended to ensure that the database is as accurate and consistent as possible to support VME analyses.

c) Also in response to the last two years recommendation, absence data were provided and recognized as of equal importance as presence data, particularly from a predictive habitat suitability modelling perspective. For this reason, guidance around the submission of absence data was revised following WGDEC 2020, and formed part of the 2021 ICES VME Data Call. Therefore, for the most recent data call, absence data were only accepted for scientific trawl surveys (both current and older/historical records) and where presence of VMEs has been recorded on the same survey (i.e. if no VMEs seen throughout the survey, do not record absences). While the first condition seems reasonable to RGWGDEC, reasons for the second are not so clear. Even if a survey does not record any VMEs, as long as the survey sampling is regarded as adequate, absence records will be important for signaling that there are no VMEs in that survey area. If the absences are not recorded, then the database cannot inform modelling that the area is devoid of VME taxa or habitats. That said, the RG also agrees on the value of further discussion on the terms of inclusion of absence records in the WGDEC2022, considering the large number (3,985 records) reported after the 2021 data call.

d) The RG accepts that currently VME identification may need to rely upon presence/absence data, but agrees strongly with the recommendations made by the WGDEC 2021 that quantitative information on VME indicators is important. However, the agreement (on page 10 of the report) that submission of more quantitative information on VME indicator occurrence should be "encouraged" and that data providers "decide" on whether they submit just presence data, seems too weak. Advancing the identification of VMEs from simple likelihood of some individuals occurring (even given the weighting method of Morato *et al.* 2018) to approach something at a community or ecosystem level requires more quantitative data. With an increasing number of records from camera surveys the provision of abundance data at least should be required. As the WG has noted in the executive summary of its report, quantitative VME identification from images is a current priority for many deep-sea scientists and institutes around the world, and hence the submission of data that can support quantitative assessment is strongly recommended.

e) As for last year's report suggestion, the RG still considers that in future years the WGDEC should focus on the definition of thresholds for the range of VME taxa and sampling types (trawl and imagery).

f) As reviewed in the last three years, the use of indicator species as criteria to identify VMEs, and thus calculate the weighted VME index (with the associated confidence level) provides useful supporting information for interpreting the distribution of potential

VMEs. We consider this aspect as an appropriate way to go forward in the short-term (but noting point (d) above).

2. NEAFC request–– "NEAFC requests ICES to continue to provide all available new information on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in and in the vicinity of such habitats, and provide advice relevant to the Regulatory Area and the above mentioned objectives. Specific NEAFC requests are to:

i. Summarize all available information on VMEs on the Josephine Seamount area and the surrounding seamounts, as well as provide information on fishing activity with all bottom contacting gear and then separate this into mobile bottom contacting gear (MBCG) and static gear in the areas (based on data provided to ICES by NEAFC).

ii. Provide a commentary on the potential for damage to the VMEs from MBCG and from static gear. ICES has previously advised that "any bottom fishing on VME habitats will result in damage to these habitats".

iii. Advise on effective measures to prevent significant adverse impacts from bottom fishing activity on VMEs on Josephine Seamount areas and the surrounding seamounts areas.

Four areas were considered within the within the NEAFC Regulatory Area (Hatton Bank, Rockall Bank, Charlie Gibbs Fracture Zone and Barents Sea), two in the NAFO Regulatory Area (Grand Banks of Newfoundland and Flemish Cap) and 13 within the EEZs of various countries (including bank, channel and slope habitats), and several new records were reported for all of them. In particular, numerous records were provided by the IEO and the NGO Oceana for the Spanish continental slope, where previously the VME database had very little data for this region. New VME records were mapped and contributed to the updated outputs from the VME weighting algorithm.

The RGVME was asked to review information on new VME records and the fisheries footprint in relation to VMEs, in particular for Josephine seamount and surrounding seamounts. VMS data from 2020 were received from NEAFC via the ICES Secretariat, along with catch information from logbooks, authorization details, and vessel information from the NEAFC fleet registry. Data were analysed by the WGSFD, to support the NEAFC request to ICES to provide information on the distribution of fisheries activities in, and in the vicinity of, VME habitats. ICES received information on the catch date and the catches were linked to vessels on the date of operation. Quality of the speed data was much improved on previous years, and therefore it was possible to distinguish mobile bottom contacting gears, static gears and other gears (undefined). These were investigated separately and consequently individual speed profiles were calculated, based on the fishing speed. Unfortunately, similar to last year, a large proportion of the vessels had no gear specified and the number of gear types reported was very low compared to previous years (not possible to evaluate as the graphs are missing at the time of the review). The RG hopes that gear recording can be improved in future.

The NEAFC VMS data, VME closures and existing fishing areas were mapped along with the VME Index outputs, which show the likelihood of VME presence based on the VME weighting algorithm, to assess whether fishing activity was occurring in the vicinity of VMEs in the NEAFC Convention Area. Results of this analysis are shown for Hatton Bank, Rockall Bank, Iceland, the Mid Atlantic Ridge seamounts and the Barents Sea. The maps indicate that the closures are generally well observed, with few tows extending into closed areas. The RG notes that it is useful to compare the extent of fishing activities in the current year with previous years. However, the maps shade the "NEAFC Existing Fishing Areas" as a single polygon which presumably encompasses all historical fishing effort. While this is useful in a high-level sense, it gives little information on any trend in the extent of the fishing footprint. Some comments are made in the text that the footprint has reduced from last year, but the reader cannot visualise how it has changed in density or area without referring back to previous reports. We suggest that an indication of the footprint in the previous 2-3 year period be mapped as well, so that recent changes can be evaluated as well as the larger historical change.

The maps in the report illustrate that trawling often concentrates along the border of closed areas. Although vessels usually comply with measures, it would be very useful to get a quantitative estimate, such as the number of pings (identified as fishing), inside closed areas in comparison to the surrounding reference area. This could provide a numerical measure of compliance (although very coarse due to the low polling frequency of 4h). In addition, the temporal development of fishing intensities in the different areas can be investigated. Unfortunately, the data are not yet available, but the RG suggests that the values should be estimated in the future (and if useful also applied retrospectively to earlier years).

Several maps also show 2020 fishing activity overlying areas of high VME Index location (e.g., Rockall Bank, Fig 4.47). This may simply reflect that the VME index is based on older data, but it raises the issue that if fishing has occurred in that area in several recent years, then an impact on any VME will have been occurring. There is no evaluation of the overlap of fishing activity and the status of VME potential (recent VME data, old assignment) that can help appreciate the current level of risk from fishing to an area with VME potential.

Specific requests:

i. The 2021 Report summarize all available information on VMEs, present in the VME database, on the Josephine Seamount dating back to 2014, as no further data were provided to the VME database in 2021. However, as the WGDEC were aware of some research activities within the Seamount complex area, therefore reviewed available literature to identify any additional sources of VME data. Such review allowed to highlight the occurrence of an endemic gorgonian species, *Victorgorgia josephinae*, and the presence of dense gorgonian aggregations of *Callogorgia verticillata* and *Viminella flagellum* together with hexactinellid sponges *Asconema setubalense*. The occurrence of several other alcyonaceans and black corals was found during the literature review and such data could be submitted to the database during the VME Data Call 2022. In addition, the bathymetry images provided by the GeoMar cruise (SO280) carried out in 2020 aboard R/V Sonne (data not yet available) suggest the existence of habitat suitable for a range of VME indicator taxa, although not yet confirmed.

   a. The available information is summarized in Table 5.1. This is a good list of taxa that have been recorded but lacks any quantitative information. If a reader is wanting to assess what is so special (whether unique, representative, hotspot) about Josephine Seamount they would need to go back to the sources listed. While listing source reports is an advance over previous generic comments attributed to the OSPAR report, when the source of "dense aggregations" of several coral species needs someone to go back to original German voyage reports, it is not particularly helpful to a manager. The RG suggests that this table gets revised and presents more complete information relevant to deciding if Josephine Seamount warrants protection.
   b. The overall recommendations made by WGDEC about Josephine Seamount could apply to any seamount in the North Atlantic. The existence of VME Indicator species with a medium VME weighted index (but with low confidence), the fact it is a seamount with inferred roles as stepping stones or a high produc-

tivity area, and has topography suitable in places for VME indicator species (especially the flanks), are possibly quite valid reasons for Josephine warranting protection, but are not convincing without more specific information.

c. It is noted that Josephine Seamount has a strong guyot shape, with most of the fishing effort appearing to be on the large flat summit. The flanks appear steep from the GeoMar bathymetry. Hence there is potentially a separation between the fishing effort on the summit and the most likely sites of elevated VME species distribution and abundance on the flanks. There is no discussion of the vulnerability of the VMEs on the seamount (as requested by NEAFC) apart from the general issues raised for all fishery impacts in section 5.5.

ii. The updated fishing description is good. According to VMS data, fishery pressure was highest on the top of the Josephine seamount, where high levels of static gear activity was reported by two vessels. The corresponding catch data for these vessels is characteristic of seamount species. On the west side of the Josephine seamount, longline gears targeting pelagic species operate, but with low intensity. In addition, there is only one registered vessel active in the Josephine seamount area using OTB gear and there is evidence of some very low intensity bottom trawling in the most south-eastern corner of the NEAFC regulatory area, close to the Portuguese EEZ. There was no activity of vessels without a registered gear type fishing in the area. However, previous studies showed nearly 50 vessels operated in the area for the period 2012–2014, mainly using longlines (Campos *et al.*, 2019). Therefore, considering secondary deleterious effects caused by longlines to benthic fauna, that may be damaged through the lateral movement of the lines, the RG agrees that further investigations will be necessary to assess the actual impact of these gears in the area.

iii. The RG consider that the information here provided are not sufficient to simply reconsider the previous closure proposal advised by ICES in 2013 (ICES, 2013). The RG suggest that more detailed and quantitative information is required to make an informed decision. Based on the considerations, reported above (a, b and c), the RG strongly suggests the WGDEC collect quantitative data before re-visiting the application.

iv. Finally, surrounding seamounts were not covered in the report. The focus of the evaluation was simply Josephine Seamount. It could be that there were no data available to WGDEC, but as part of the argument for closure is to protect “potential VMEs occurring on the surrounding seamounts” there should be some additional consideration given to the area and features around Josephine.

3. EU request- Provide any new information regarding the impact of fisheries on other components of the ecosystem including small cetaceans and other marine mammals, seabirds, and habitats. This should include any new information on the location of habitats sensitive to particular fishing activities.

In particular, the EU requests ICES to:

i. Provide information regarding the impact of fisheries on the ecosystem including marine mammals, seabirds, and habitats impacts (including incidental catches). This should include information on the location of habitats sensitive to particular fishing activities;

ii. Give warnings of any serious threats from fishing activities alone or in conjunction with any other relevant activity to local ecosystems or species as soon as ICES is aware of such threats

Altogether, 7 areas were considered within the EEZs of EU countries and wider: the Charlie Gibbs Fracture Zone, the Irish continental slope, Porcupine Bank and Seabight within the Irish

EEZ, the Spanish continental slope and the Galicia Bank within the Spanish EEZ, the Bay of Biscay in the French EEZ. Records from Faroe Shetland Channel were provided from the UK EEZ, so were not considered for the EU request.

As in the rest of the report, the Working Group concentrated on the distribution of VMEs in these areas, without any mention of other components of the ecosystem that might be impacted by fisheries. Moreover, whilst trawl tracks in the vicinity of VMEs were mapped, these were restricted to bottom contacting gears (which are likely to have the greatest impact on the VMEs). No mention is made of the potential impact of fisheries on marine mammals or seabirds, nor on incidental catches, as specifically requested by the EU. This may be because such information is not readily available in the area of interest, but globally there has been a large effort by some nations and RFMOs to estimate bycatch and address interactions between fishing gears (longline as well as trawl) on marine mammal and seabirds. This deserves clarification in the report, if possible with suggestions on how to rectify the situation for future advice.

Although Norway is not part of the EU, of note is the large bycatch of *Geodia* species mainly recorded in the south of the Barents Sea at Tromsøflaket, for a total of more than 1100 kg, which deserves some attention for future management measures.

4. Recommendations

<u>Suggestions for 2021 report:</u>

Concerning the NEAFC requests, the RG considers there is insufficient information on the Josephine seamount to reconsider its protection and suggests that the WGDEC would need to collect more comprehensive and quantitative data before re-visiting the request. The information on the surrounding seamounts is absent and needs to be included or at least deserves some clarification. Hence the RG recommends the WGDEC reconsiders its recommendation concerning the previous closure proposal at this time.

Concerning the EU request, the RG recommends the WGDEC clarifies in the report why they did not address the EU request to provide information on impact of fisheries on the ecosystem including marine mammals and seabirds; and to suggest how to rectify the situation for future advice. The RG notes that this may involve expansion of analysing fisheries data to surface and midwater gears.

<u>Suggestions for next year:</u> Concerning the analysis of the fishing footprint in the NEAFC area, the RG suggests that the footprint in the previous 2-3 year period be mapped, so that recent changes can be evaluated. Concerning the Q/A sub-group, the RG recommends applying a similar data check to the earlier data to ensure that the database is as accurate as possible. The RG also recommends that the request for provision of quantitative VME data (abundance, biomass, etc.) be strengthened.

Based on this review, RGVME is content that the Working Group has enhanced our knowledge of VME distribution. The RGVME considers that the VME vulnerability indices and habitat observations represent the best available current means of representing the likely distribution of VMEs, but in future must shift to a more quantitative assessment to provide a more suitable evidence base for ICES to provide the requested advice to the EU and NEAFC. This starts with strengthening the data requirements for the VME database. In terms of the distribution and extent of fishing, the RGVME considers that the VMS data were analysed adequately and the output of the analyses was sufficient to indicate the distribution of fishing activities with bottom contacting gears in the vicinity of VMEs. However, the RGVME is concerned that the request from the EU to provide information on the impact of fisheries on other

components of the ecosystem, inter alia on marine mammals and seabirds was not addressed. The reasons for this deserve explanation in the report. The RGVME was also not satisfied with the response to the request to review available VME data from Josephine Seamount. The presentation and detail of data examined were insufficient to advance the recommendations put forward.

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