WORKING GROUP ON SPATIAL FISHERIES DATA (WGSFD)

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CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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i Executive summary

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

ICES had issued a data call for aggregated VMS and logbook data for the years 2009–2018.
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 carefully 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. Prior to the meeting a subgroup of WGSFD met via WebEx to review and quality check the aggregated data products. This revealed a small number of submissions had not been prepared in a manner consistent with the others. Subsequently, relevant data submitters were contacted and asked to revise and resubmit data. This substantially improved our understanding potentially outlying data and the data quality as a whole.

The group was updated on a number of Vessel Monitoring System (VMS), Automatic Identification System (AIS) and Logbook related projects which are ongoing at national labs, including presentations on the use of VMS to assist with spatial planning of measures to protect Natura 2000 sites, the changes evident in VMS data as a response to voluntary discard reduction programme, and spatial data from an experimental razor clam fishery.

Members of WGSFD analysed produced maps of fishing activity in NEAFC areas using the VMS and logbook information collected by NEAFC. A product was once again delivered to the ICES Working Group on Deep-water Ecology (WGDEC), which was used in the assessment of fishing impact on Vulnerable Marine Ecosystems.

WGSFD also addressed Terms of Reference on the potential use of AIS to deliver information on the Marine Strategy Framework Directive (MSFD) indicator D6C2 and explored means to collect the data required to parameterise the use of VMS as an indicator of effort in static gear fisheries, discussed the implications of moving to a finer spatial resolution in the data call, provided strategic guidance to the Workshop on scoping benthic pressure layers D6C2 – methods to operational data products (WKBEDPRES) on the use of AIS data.

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, which was started under the previous terms of reference, was paused whilst details surrounding protection of fishers' anonymity were resolved. This issue was addressed by WGSFD at this meeting, 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 fixed term
Year cycle started	2019
Reporting year in cycle	1/3
Chair(s)	Neil Campbell, UK
	Roi Martinez, UK
Meeting venue and dates	24-28 June 2019, Lysekil, Sweden (20 participants)

1 Data call

Standardised methods to analyse, and produce products that describe the development of fisheries in space and time is fundamental to the work of WGSFD and to downstream users of these data products. In order to deliver its core terms of reference, and in line with the aims of its work plan, WGSFD continued its work on improving methods and ensuring high quality of VMS and logbook data processing from data request formats, quality checking and processing of data implemented by the ICES secretariat.

The quality of the outputs produced by the ICES secretariat and WGSFD is highly dependent on the quality of the data provided by states, as well as the routines used to process and analyse these data. A thorough quality check process increases both, the reliability on the data used in the analysis, and the confidence of the final recipient in the advice given. ICES secretariat, ICES Data Centre and WGSFD used a multi-step approach, following a four-eye principle wherever possible, to ensure that data submissions and aggregated data are of the best quality possible. Due to the complexity of the data and different national setups for holding and extracting VMS and logbook data, the development of standardised workflows is a challenging task. To address these issues, in 2015 WGSFD developed a best practice guide, and workflow in R to help states streamline the data extraction, cleaning, aggregation and submission processes. In 2019, in order to protect anonymity of fishers, this script was amended to provide an indication of the numbers of vessels active in each C-square at the level 6 aggregation. This script was sent out to national data-submitters to be used for the combination and aggregation of fisheries data on national levels. Although not all countries used all parts of these R-routines, the quality of submitted data has continuously improved in recent years.

The status of national data submissions provided to WGSFD is given in Table 1.

Table 1. Status of data submissions in response to ICES WGSFD VMS data call, 2019.

Country	Data Submitted	Comments
Belgium	Yes	
Denmark	Yes	
Estonia	Yes	
Faroe Islands	No	
France	Yes	
Germany	Yes	
Greenland	No	
Iceland	Yes	
Ireland	Yes	
Latvia	Yes	
Lithuania	Yes	
Netherlands	Yes	
Norway	Yes	Only 2018 data available during meeting. Issues with metier assignment and statistical rectangles to be followed up. Not used in provision of advice.
Poland	Yes	
Portugal	Yes	
Russia	No	

Spain	Yes	Data submitted lacked a field containing distinct number of vessels in each aggregation unit, however data can still be used for advice.
Sweden	Yes	
United Kingdom	Yes	

Each national data submission was analysed with the help of a standardized R-script. First, summaries were calculated for the most important variables (number of submitted records, fisheries effort, landings, etc.) for each year, so that any questionable deviations could be identified. Secondly, maps were created, that show any differences for each c-square (VMS data) or ICES rectangle (logbook data) by comparing the values for the most recent year submitted against the data from the year before as well as the mean of all years. Thus, it was easier possible to identify areas that showed larger deviations, so that the underlying data could be checked in more detail. The resulting quality check reports were checked by the WGSFD chairs, commented and sent back via the ICES Data Centre to the data provider. Based on the VMS data aggregated for all submitted national data, maps for each main gear group (Benthis métiers) were produced to show any potential differences in swept area ratios for each c-square both, for the year 2017, comparing the data submitted in 2018 versus the data submitted in 2019 and between years 2017 and 2018. These maps were checked for any deviations by WGSFD experts in a WebEx subgroup prior to the meeting, no major issues were identified.

All scripts (R and SQL) used to produce the quality checks (reports and maps) are stored on the ICES GitHub, so that the routines can be checked, updated and used again for coming data calls in a standardized way. These routines will be updated, so that data submitters can download and adapt these routines to use them for own quality checks on their national data before these are submitted.

It was proposed during the meeting that, in order to reduce the workload associated with the quality assurance process, WGSFD and the ICES secretariat could begin work on developing an interactive online web application such as R-Shiny to allow data submitters to view the results of a suite of first stage quality assurance checks prior to uploading their data.

2 Progress on Terms of Reference

2.1 ToR A: An evaluation of AIS data sets available to the WG, the potential use of AIS in the VMS data call, and the usefulness of AIS for the provision of advice

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").

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 a large number of 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 a number of 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 time 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 a number of 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 2 presents a summary of information on several AIS raw data holders.

Table 2. 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 sections 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 number of 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 in order 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) in order 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 in order 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 3.

Table 3. 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.

In reality, 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 4 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 4. 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[1]

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. At the moment, 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 inconsistencies 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 over all, 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

[1] Subjected to accuracy of the prediction algorithm.

the identification of 1161 vessels of the 1164 of the active fishing fleet. An excellent result, only 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 5. 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 5 shows the gear mapping adopted in the selection of the MBCG fleet. This mappings greatly affects 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 were 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[2]. 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.

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[2] 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.

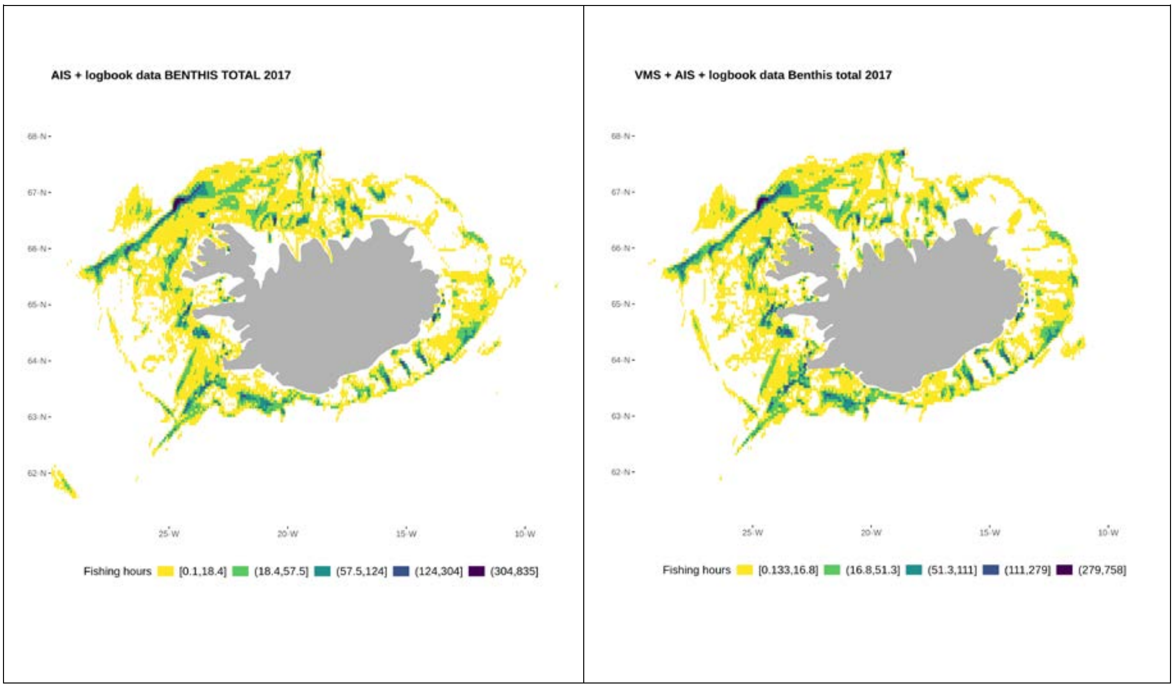

Figure 1. Comparison of spatial fishing effort maps calculated with Icelandic AIS+logbook data (left panel) and VMS and AIS and logbook data.

The maps of VMS + AIS + logbook data (Figure 1) show a better coverage and a better identification of the fishing activity, showing that really 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 reside in the coverage of the AIS data. The AIS dataset has a characteristics 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[3] 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 described 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[4] to several other Regional Fisheries Management Organizations (RFMO) collecting fishing vessel's information and finally to the Global Fishing Watch[5] 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[6] (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

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

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

[5] https://globalfishingwatch.org

[6] 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 has to 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 6 shows how gear codes were assigned to different Benthis categories.

Table 6. 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 VMS tools (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 2). 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 coast line 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 4 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.

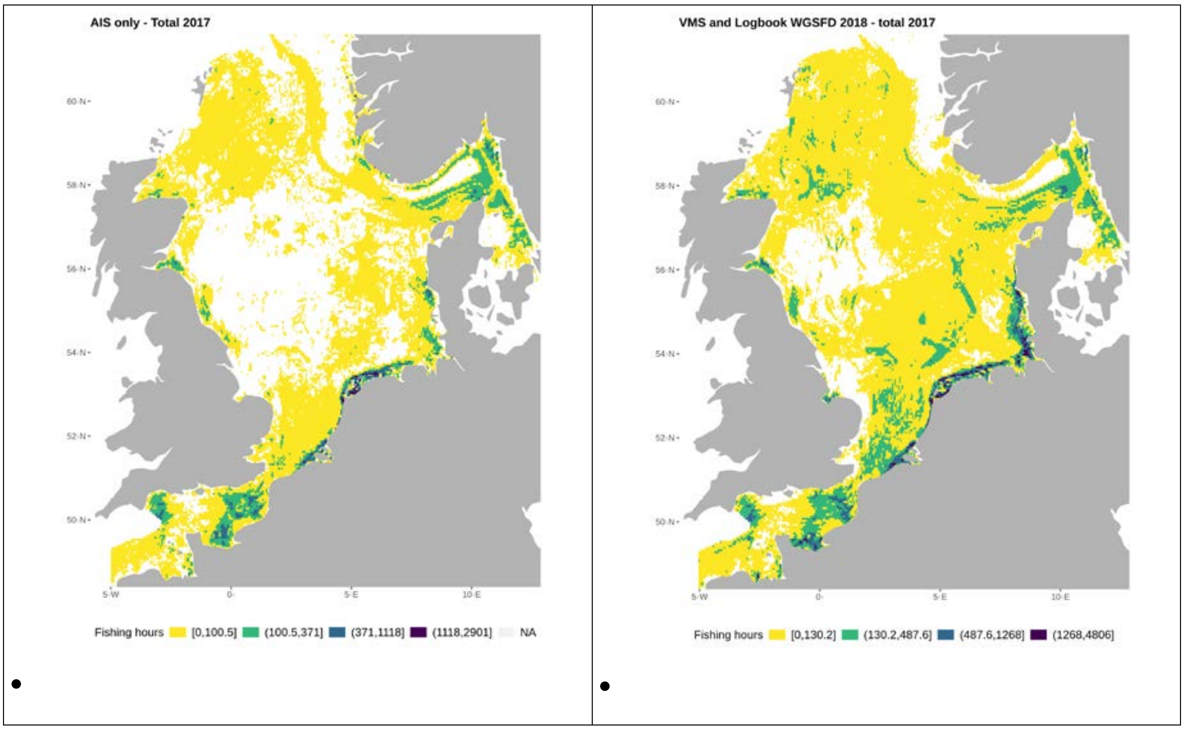

Figure 2. Comparison of spatial fishing effort maps in the Greater North sea calculated with AIS data (left panel) and VMS and AIS and logbook data (right panel).

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 a number of 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 7 summarizes the advantage of using AIS in fisheries research for different size classes of vessel:

Table 7. 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 off shore and high seas fleet	Mandatory

2.1.4.2 Disadvantages of the use of AIS for fisheries research

Conversely, there are a number of disadvantages posed by the use of AIS data as a tool in marine research and planning (Table 8).

Table 8. 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, 2011a) 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 4).

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 is 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 12m (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 is 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 commonly 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 some kind of 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 build 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 taken into account 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 improve 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 if and 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 ToR B: Evaluating need and possibility to move towards higher spatial resolution in the ICES VMS data calls

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.

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 3A) while the estimates of the area swept, by law of arithmetic, is independent of both spatial and temporal resolution (Figure 3B).

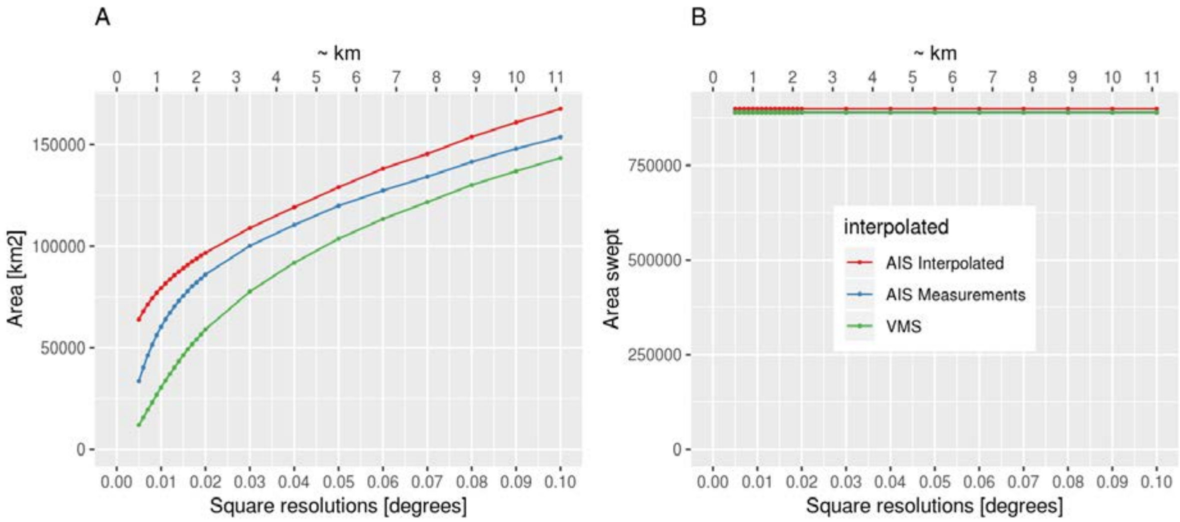

Figure 3. Perceptions of Area impacted by fishing (left) and Swept Area (right) using interpolated AIS, raw AIS and simulated VMS from the Icelandic fleet, gridded at a range of spatial resolutions from 0.005 to 0.1 decimal degrees.

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 4). Of note here though is that any “erroneous points”, where temporary malfunctions of VMS equipment results 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.

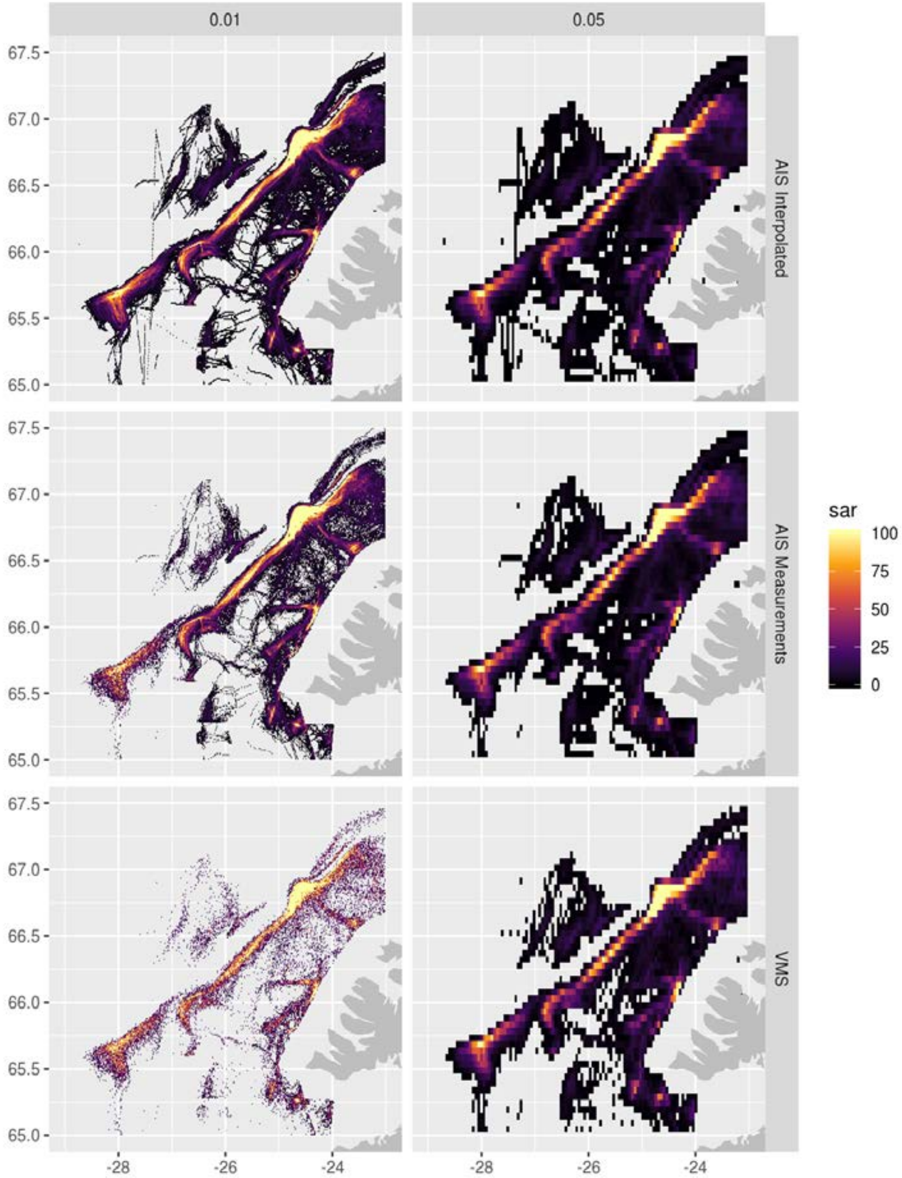

Figure 4. Maps of effort at 0.01 and 0.05 decimal degree resolutions of interpolated AIS, raw AIS and simulated VMS data from the Icelandic fleet.

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 5, Figure 6). Increasing spatial resolution at which effort is gridded results in a much noisier picture (Figure 7), which can be counteracted by interpolation between points (Figure 8). 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.

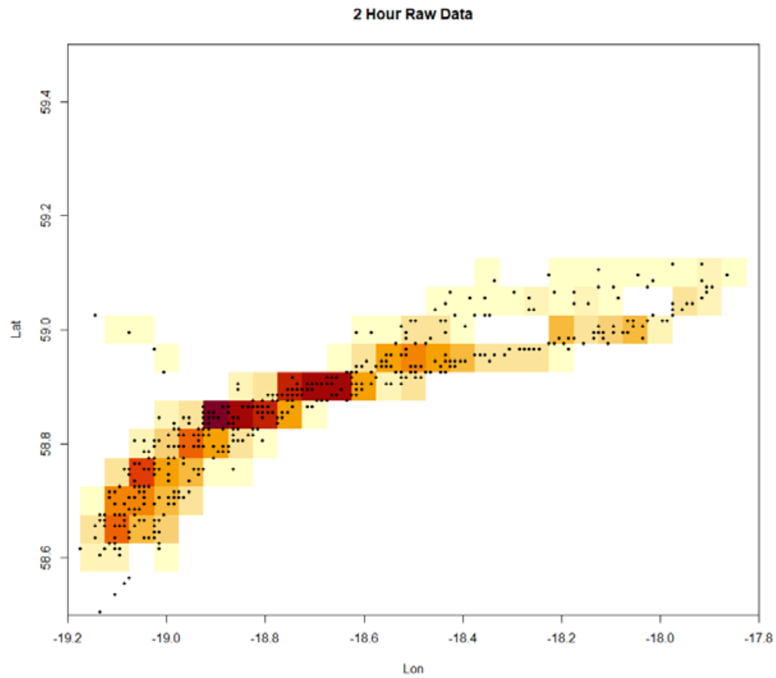

Figure 5. Two-hourly NEAFC VMS data gridded at 0.05 decimal degrees.

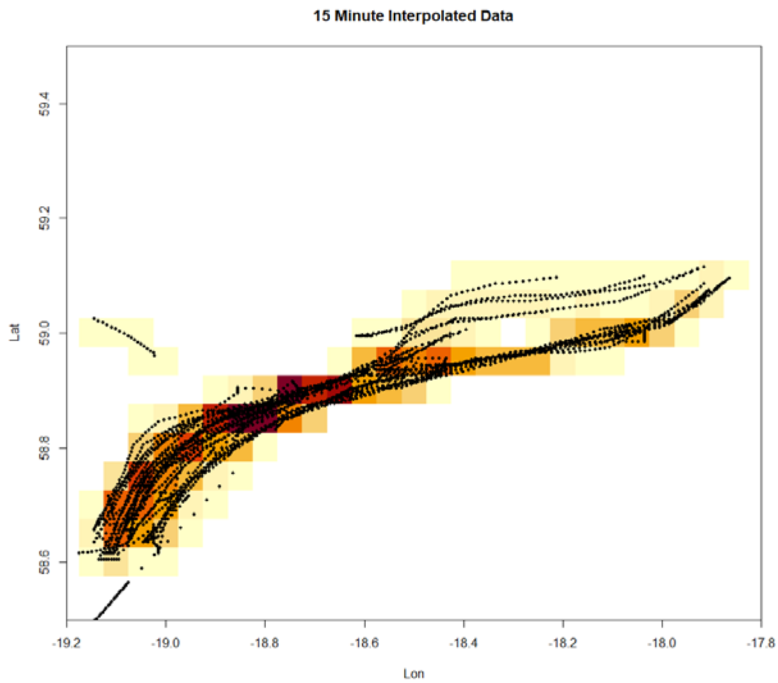

Figure 6. NEAFC VMS data interpolated at 15 minute intervals, gridded at 0.05 decimal degrees.

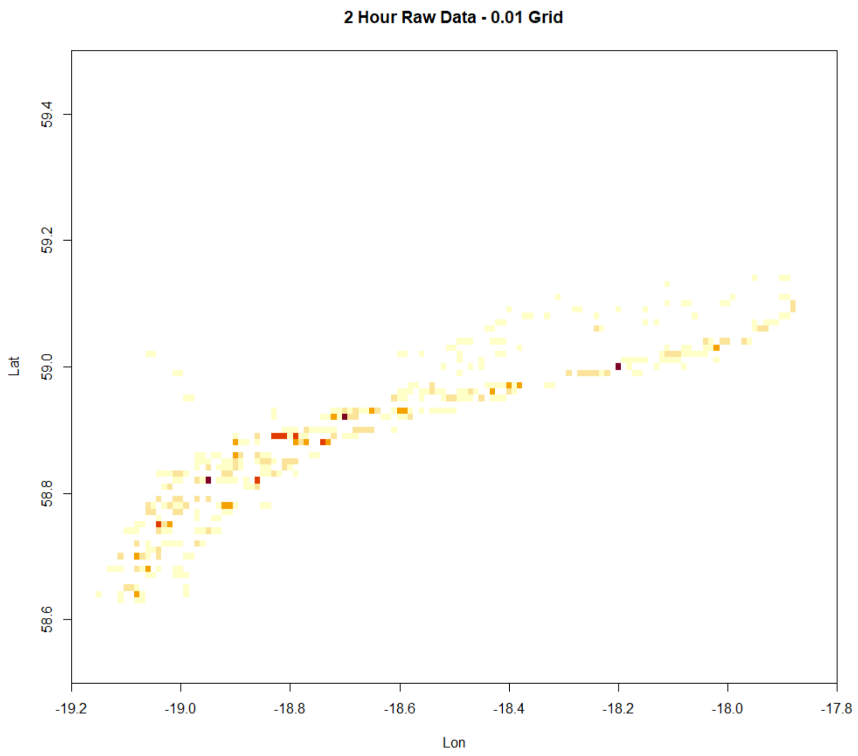

Figure 7. Two-hourly NEAFC VMS data gridded at 0.01 decimal degrees.

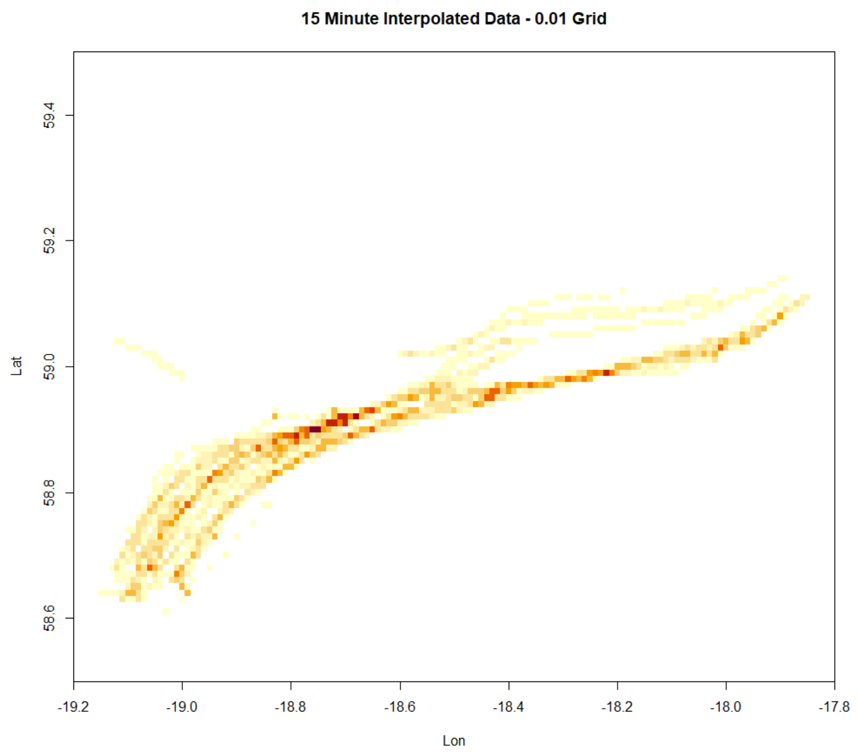

Figure 8. NEAFC VMS data interpolated at 15 minute intervals, gridded at 0.01 decimal degrees.

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 ToR C: Development of spatial effort indicators for static gears

Develop spatial effort indicators for static gears

Table 9 shows a summary of VMS coverage for vessels fishing with static gears on average from 2009-2018 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, <8 m in the Baltic). It shows that in areas like the Baltic Sea the VMS coverage is low, both in relation to effort and landing weight. This table will 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.

Because of the variation in reported details, it is not clear what the start- and stop time, and also the start- and stop position, in the logbook is representing for static gear. In some cases it seems that the start time and position is reported as the first fishing operation, that would be the first gillnet or line being either set or hauled, and similarly the stop time and position is the end of the last fishing operation. In some cases, the start and end positions are overlapping.

Due to variation in the countries submitting data these values are not directly comparable to similar summaries provided by the WGSFD in previous years.

Table 9. VMS coverage of effort and landings in 2018, for a number of static gears (active lines, nets, passive lines and pots and traps), by ICES Subarea/Division.

Area	Grouping gear	Fishing days with VMS	Fishing days without VMS	Percentage Fishing days with VMS	Total weight with VMS (kg)	Total weight without VMS (kg)	Percentage Total weight with VMS
27.1	Traps	2652		100	16 752 875		100
27.2	Active lines	29		100	18 335		100
	Nets	179	2	99	319 368	368	100
	Passive lines	24	14	63	161 998	2310	99
	Traps	3	3	45	9283	835	92
27.4	Active lines	25	11 015	0	29 877	2 119 393	1
	Nets	12 891	17 765	42	14 437 913	4 011 232	78
	Passive lines	1222	1278	49	3 358 688	952 280	78
	Traps	7399	159 178	4	15 638 477	45 853 455	25
27.5	Active lines	166 948		100	138 934 694		100
	Nets	64		100	97 304		100
	Passive lines	68 093	1	100	427 602 309	338	100
	Traps	0	4		0	54	
27.6	Active lines	13	120	10	32 490	37 624	46
	Nets	2319	93	96	6 639 669	62 903	99
	Passive lines	18 299	1955	90	47 024 858	10 131 650	82
	Traps	19 031	212 931	8	34 475 143	91 657 760	27
27.7	Active lines	6227	39 130	14	30 821 648	4 307 072	88
	Nets	27 425	87 325	24	38 518 376	26 232 161	59
	Passive lines	114 242	39 095	75	129 104 761	54 080 400	70
	Traps	36 641	362 058	9	39 339 165	181 155 485	18
27.8	Active lines	29 719	26 390	53	64 753 212	40 332 984	62
	Nets	41 227	128 091	24	38 164 487	26 011 637	59
	Passive lines	78 549	163 960	32	68 246 110	52 300 512	57

Area	Grouping gear	Fishing days with VMS	Fishing days without VMS	Percentage Fishing days with VMS	Total weight with VMS (kg)	Total weight without VMS (kg)	Percentage Total weight with VMS
	Traps	4664	116 215	4	6 279 968	13 439 659	32
27.9	Active lines	532	936	36	558 089	158 535	78
	Nets	24 965	103 934	19	6 746 160	24 864 234	21
	Passive lines	26 070	26 825	49	26 061 985	8 262 735	76
	Traps	345	145 819	0	96 110	17 156 602	1
27.10	Active lines	4371	34	99	15 604 179	168 326	99
	Nets	66	15	81	183 595	3148	98
	Passive lines	37 214	2007	95	109 301 304	12 153 824	90
	Traps	0	4			383	
27.12	Active lines	1262	1	100	3 082 395	1542	100
	Nets	3	16	17	6011	2229	73
	Passive lines	887	43	95	9 001 604	517 375	95
	Traps	165	31	84	154 539	5453	97
27.14	Active lines	31		100	39 756		100
	Passive lines	499	2	100	7 015 875	593	100
27.3.a	Active lines	20	3594	1	2160	1 018 326	0
	Nets	2999	10 326	23	2 648 549	3 677 629	42
	Passive lines	245	409	37	303 328	198 459	60
	Traps	272	10 301	3	165 172	994 775	14
27.3.b	Active lines		543			141 234	
	Nets	194	7532	3	134 211	2 730 881	5
	Passive lines	1	110	1	56	27 298	0
	Traps	1	1318	0	492	312 665	0
27.3.c	Active lines	15	142	9	393	1998	16
	Nets	704	18 878	4	392 779	3 437 937	10
	Passive lines	2	185	1	11	24 193	0

Area	Grouping gear	Fishing days with VMS	Fishing days without VMS	Percentage Fishing days with VMS	Total weight with VMS (kg)	Total weight without VMS (kg)	Percentage Total weight with VMS
	Traps		4134			804 843	
27.3.d	Active lines	1	171	1	250	11 700	2
	Nets	3820	108 292	3	3 689 043	27 804 100	12
	Passive lines	2176	10 904	17	593 932	3 230 224	16
	Traps	18	57 469	0	4168	81 627 174	0
TOTAL		12 356	38 737	24	21 367 143	14 323 926	60

A substantial proportion of the fleets fishing with passive gears is below the length at which vessels are required to have logbooks and VMS, and therefore other data sources are needed to describe the fishery. The data sources for the static gear fishery vary from country to country, whereas some have monthly reports giving a main metier and positions where the vessel were fishing during the month, while others have sales notes, and some have AIS. Some countries may have additional data collection programmes which may provide the data required to develop the necessary spatial indicators. Collation of metadata on the existence and comprehensiveness of this data across countries is an important first step in establishing a method to develop meaningful VMS-based effort metrics for static gears

The WGSFD are currently scoping the availability of additional static gear fisheries data through a questionnaire survey of WGSFD delegates (Annex 5), with a view to developing and incorporating additional data requests within future ICES data calls.

A timeline for this work was proposed, below.

Stage	Action	Due Date
1	Chairs to select respondent from each state to lead on producing response	26/08/2019
2	Answers submitted to chairs	07/10/2019
3	Answers compiled and circulated to working group members	18/10/2019
4	WGSFD teleconference to discuss and decide upon formal data call/pilot study	21-25/10/2019

WGSFD **recommends** the static gear questionnaire be circulated to data providers to assess the quantity and quality of information currently collected on effort by static gears as a precursor to the development of VMS-based effort metrics. It is anticipated that working group members will bring data underlying the responses to this questionnaire to the next meeting in order for the needs and requirements of a comprehensive static gear data call to be evaluated.

2.4 ToR D: Identifying potential drivers and describing spatial conflicts of fisheries in the past and future on displacement of fishing activities over various time-scales

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.

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 have been used to produce for a 10 year period of fishing effort. This new available dataset provides a high resolution spatiotemporal fishing effort, weight and economic catch value parameters describing the trends of uses 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:

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 as a result of 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 a number of 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 were 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 in order 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 implemented 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 9).

In order 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 are 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 in regard to advice on the potential to provide high-resolution fishing effort information than the current advice at 0.05 degrees. This collaboration can provide us the spatial, temporal and intensity distribution of industrial activities within ICES ecoregions and related ecosystems.

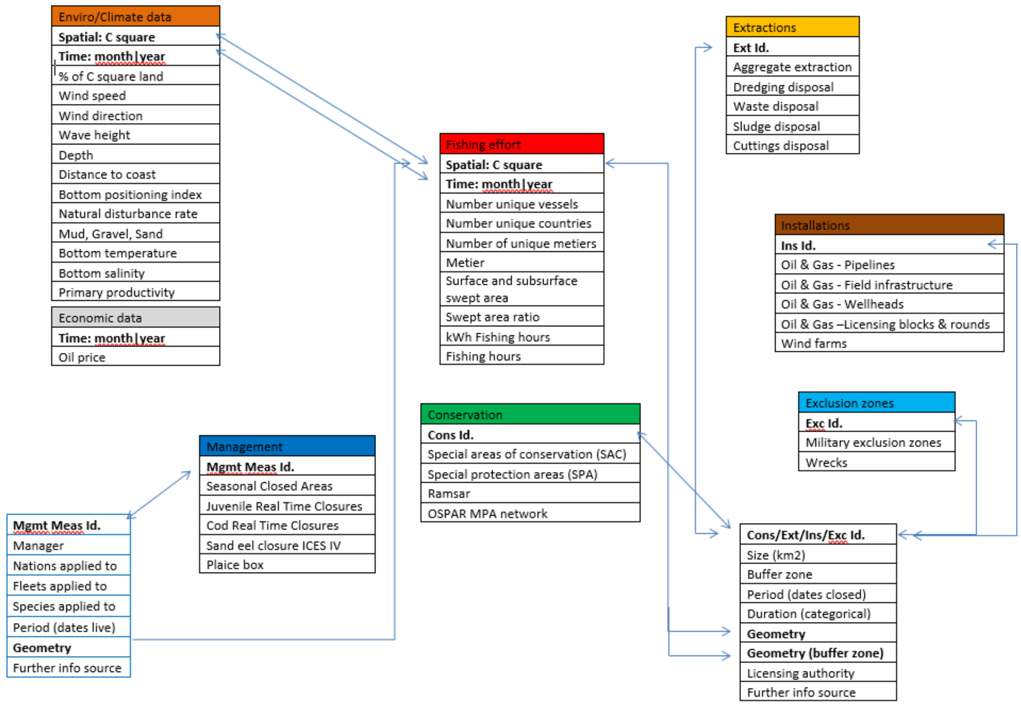

Figure 9. Diagram of the Relational Database Model designed to store and perform efficiently spatiotemporal queries over the spatial fisheries, marine regulatory areas and other human activities licensed and used areas.

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 have an effect on 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, in order 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 10). 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).

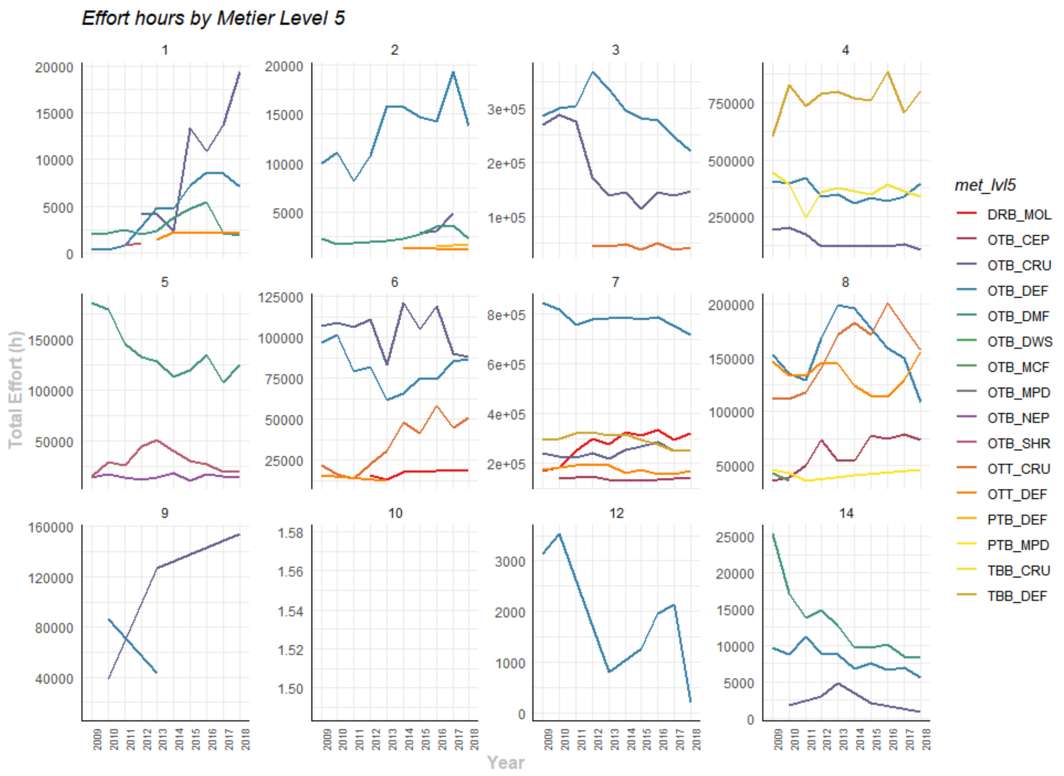

Figure 10. Graphs with the total effort hours by metiers level 5 and year within the ICES Divisions. The graphs numbers title indicates the corresponding ICES Division.

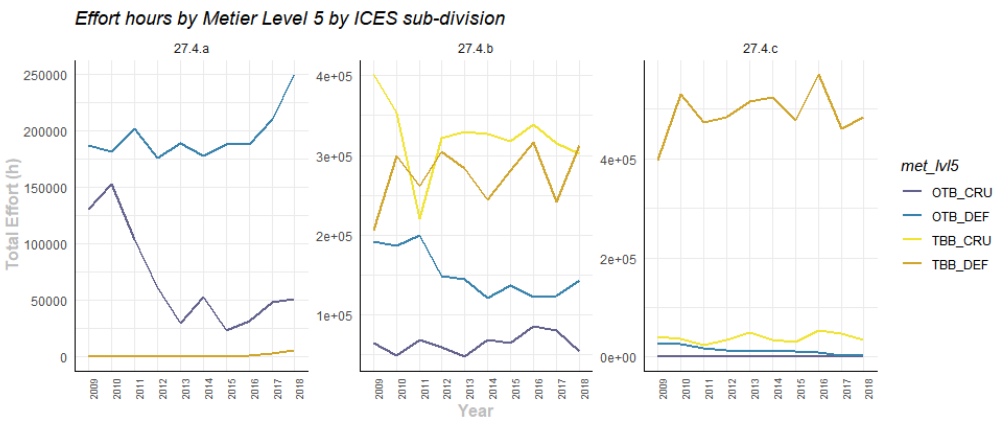

Figure 11. Fishing effort of the main fishing metiers operating in ICES Subarea 4 by year and ICES division.

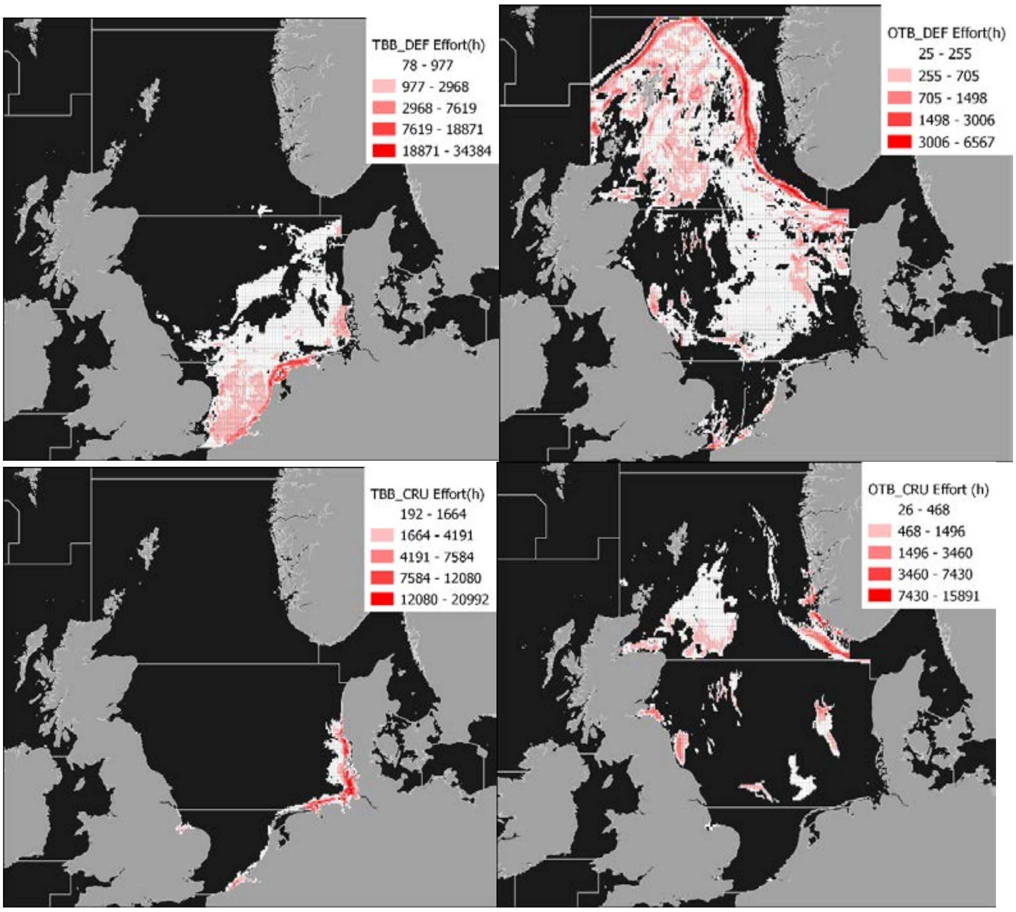

Figure 12. Maps show the spatial distribution and intensity of the fishing activities of the main four metiers operating in ICES Division 4.

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 in order to increase the temporal-spatial resolution planned for further detailed analysis.

In order 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 13). 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 14), 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 7km buffer and one 20km from the licenced area baseline were created (Figure 15). This exercise was repeated for demersal otter trawlers targeting fish (Figure 16).

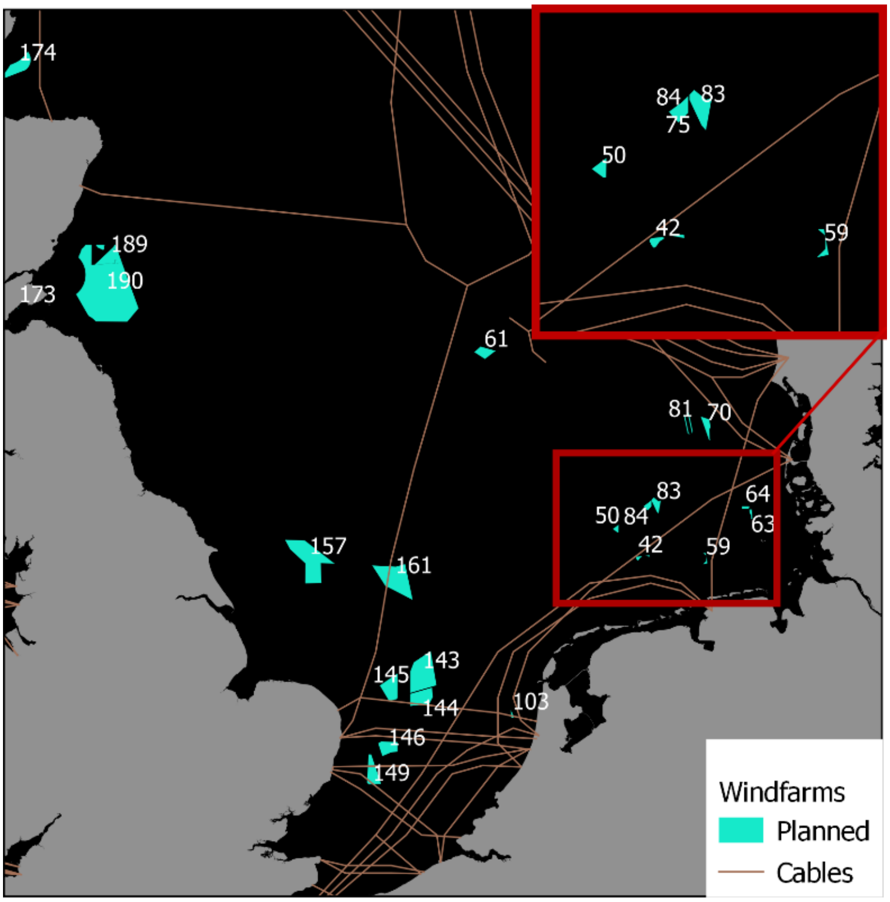

Figure 13. Map of the planned windfarms in the North Sea (source: EMODnet)

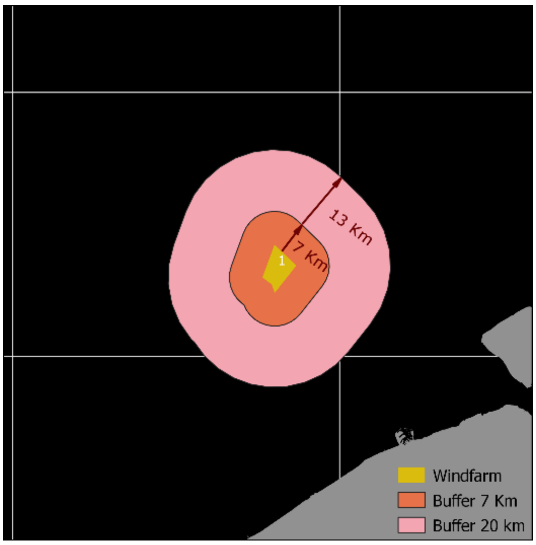

Figure 14. Spatial buffers around a windfarm licensed area used to evaluate the variability of fishing effort at different distance ranges.

This process was then repeated for areas where windfarms have been authorised (Figure 17–Figure 19), areas where wind farms are under construction (Figure 20–Figure 22) and wind farms which are producing electricity (Figure 23–Figure 25). 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 have to 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 15. 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.

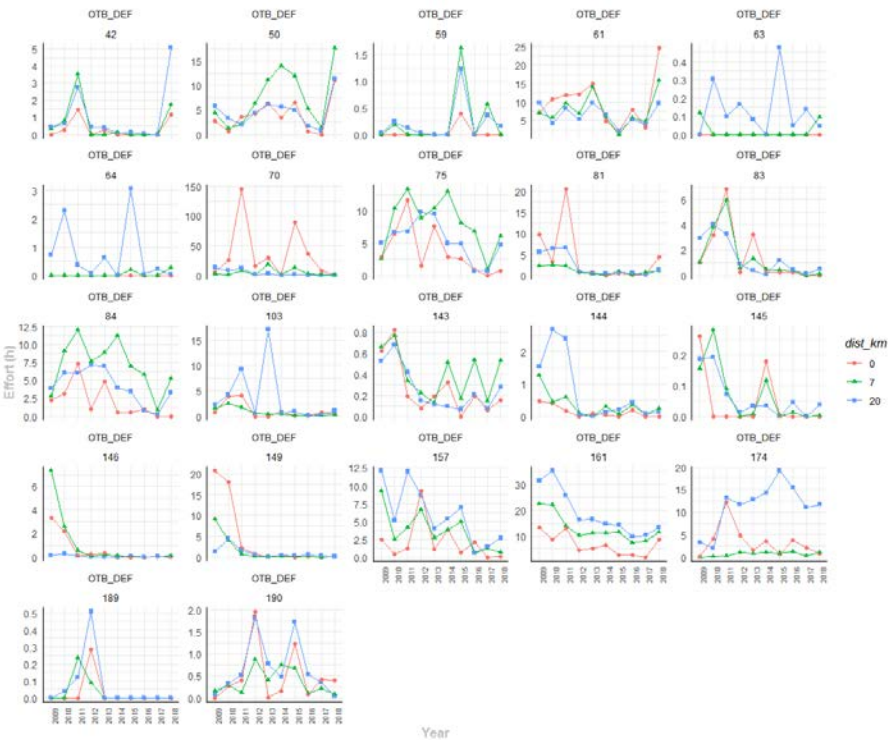

Figure 16. Distribution of fishing effort of the otter trawlers targeting demersal fish over the past 10 years within the planned windfarm licensed areas (red) and at 7 (green) and 20 km (blue).

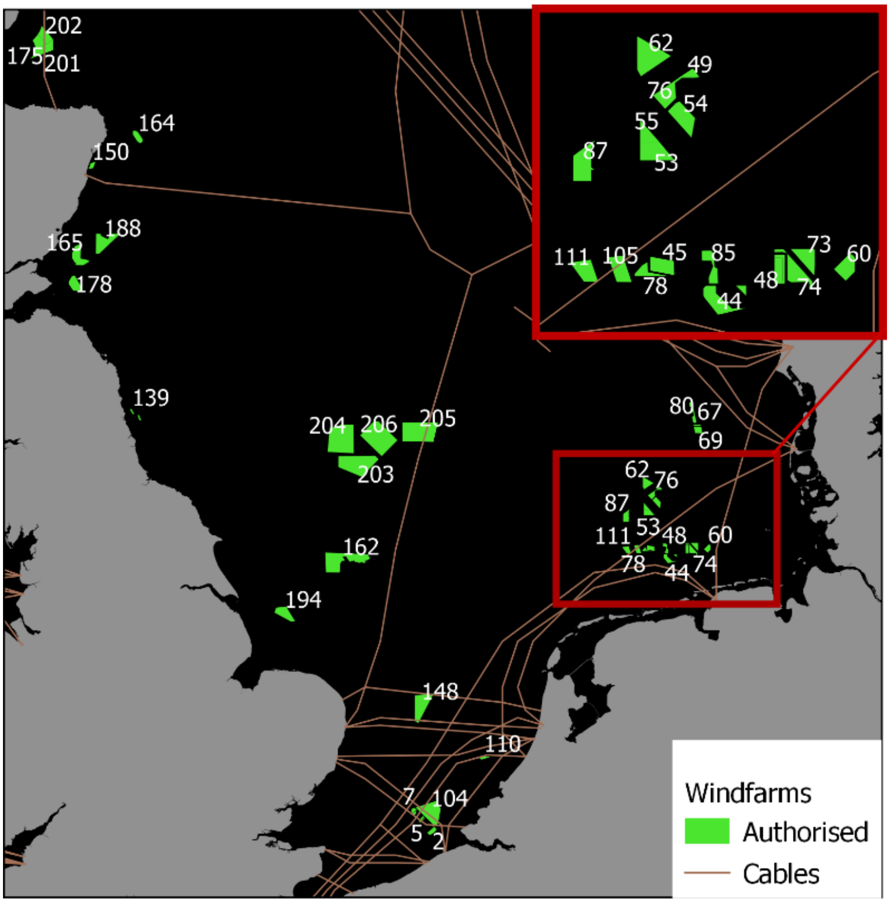

Figure 17. Map of the authorised windfarms in the North Sea (source: EMODnet).

Figure 18. 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.

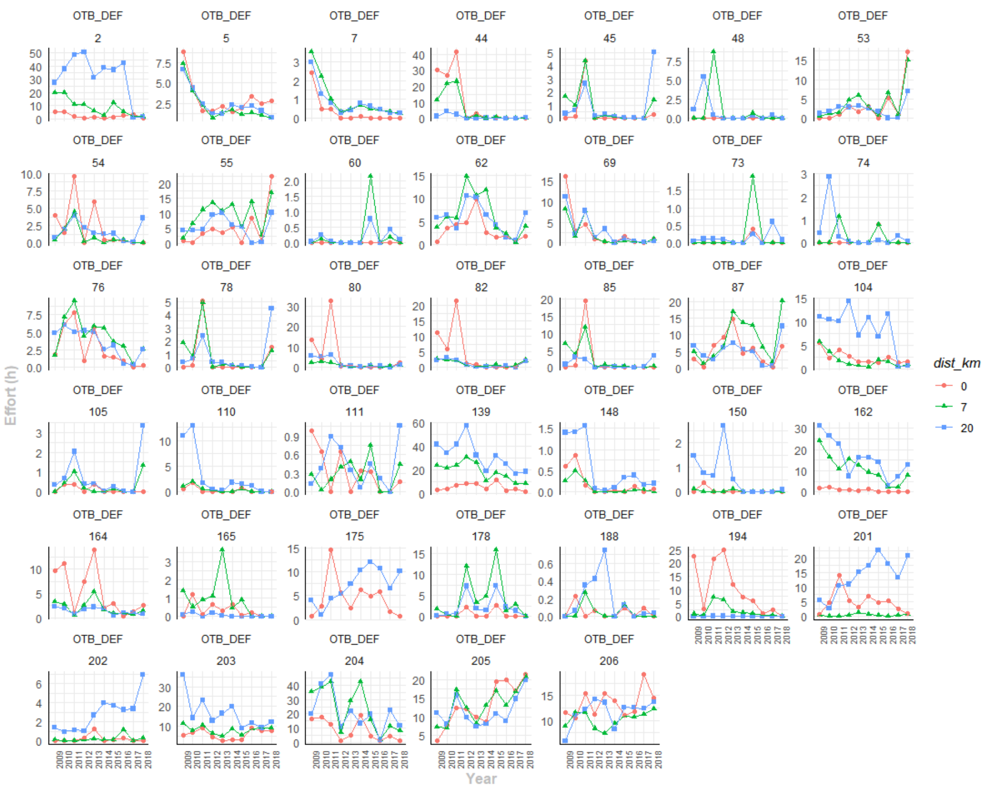

Figure 19. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the authorised windfarm licensed areas (red) and at 7km (green) and 20 km (blue) from them.

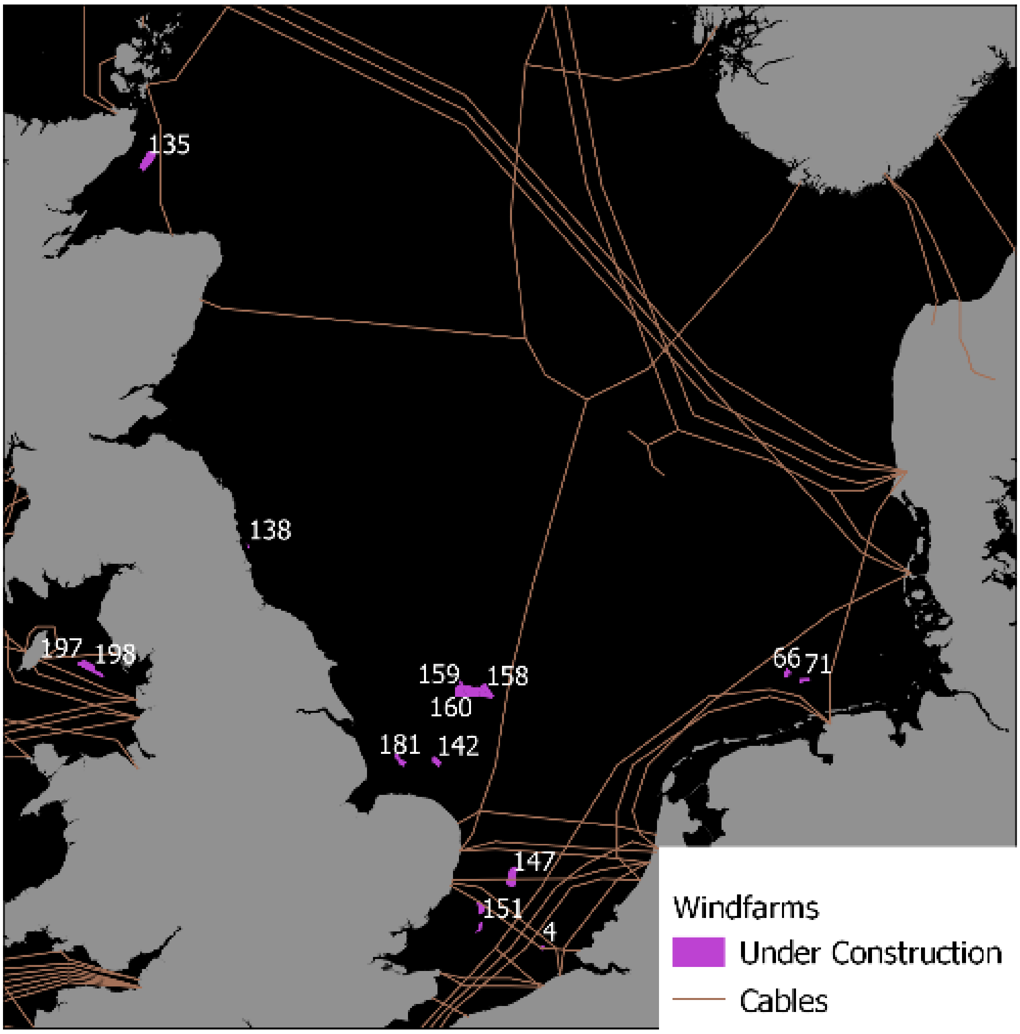

Figure 20. Map of windfarms under construction in the North Sea (source: EMODnet).

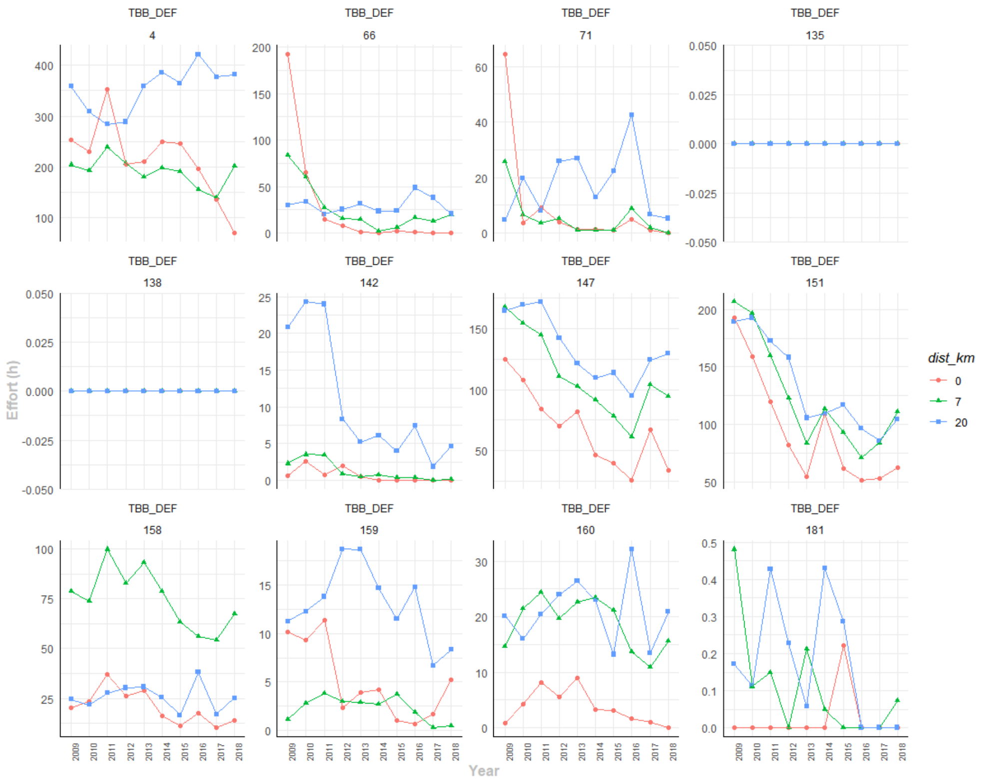

Figure 21. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within the under construction windfarm licensed areas (red) and at 7 km (green) and 20 km (blue) from them.

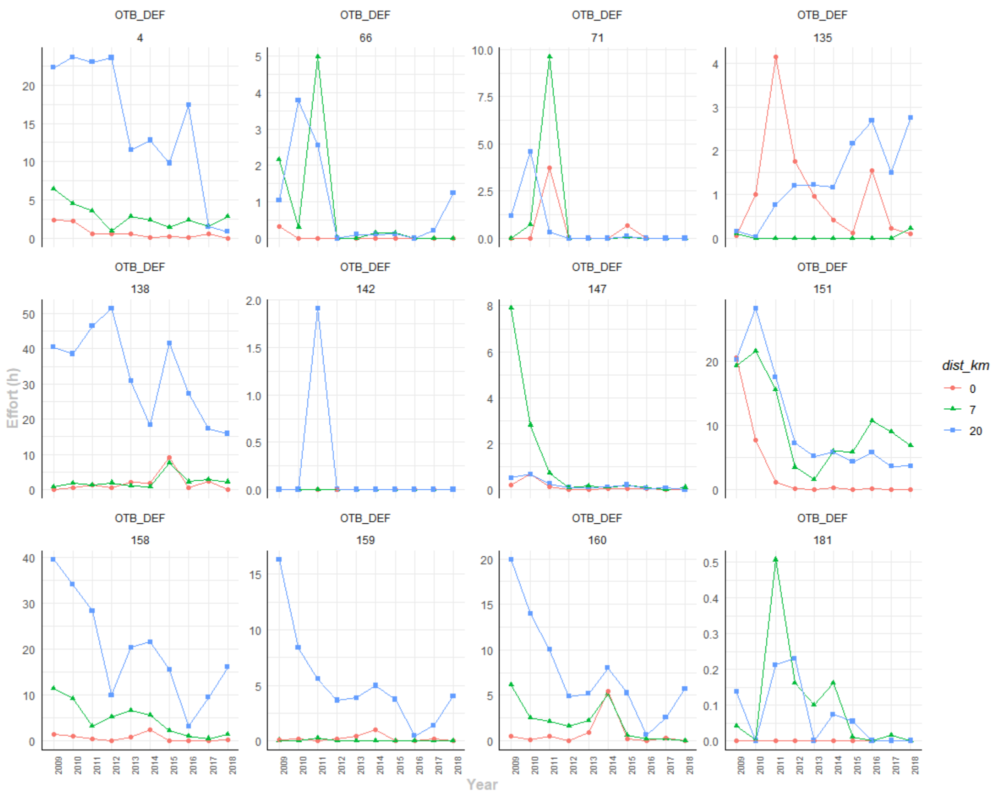

Figure 22. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the under construction windfarm licensed areas (red) and at 7km (green) and 20 km (blue) from them.

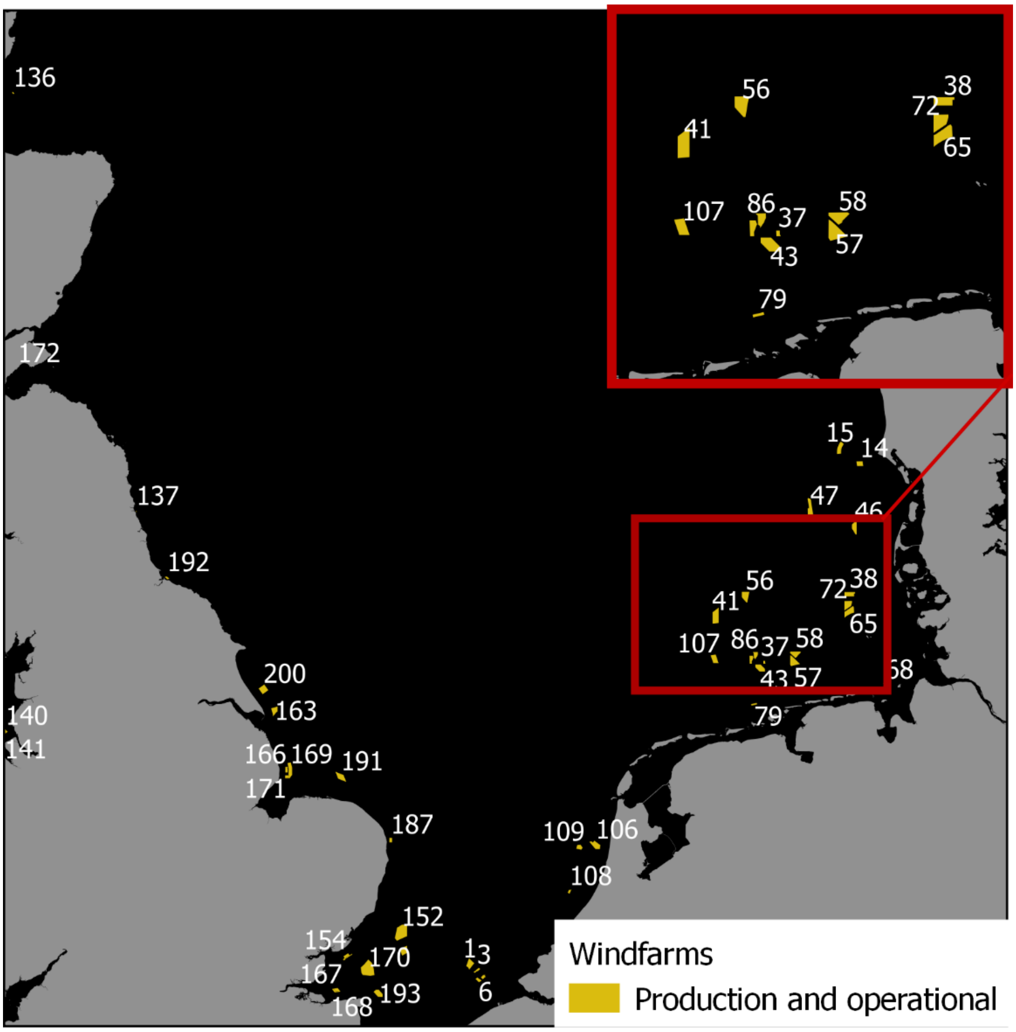

Figure 23. Map of operational windfarms in the North Sea (source: EMODnet).

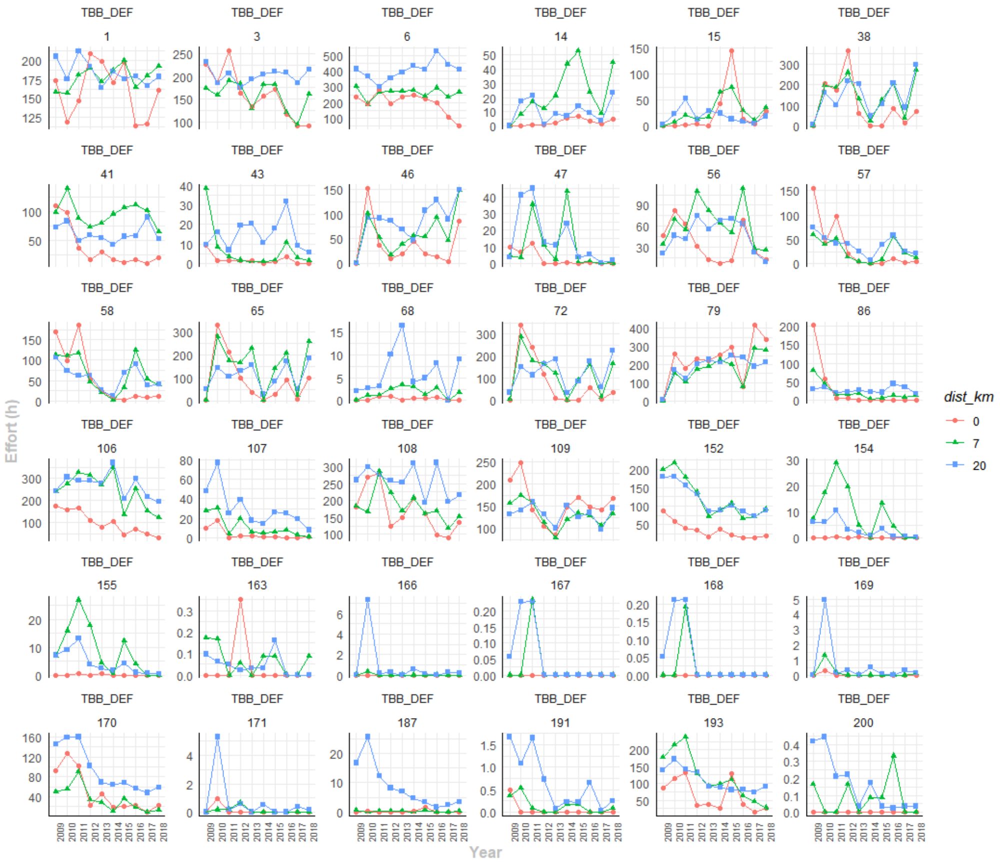

Figure 24. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within the operational and in production windfarms licensed areas (red) and at 7km (green) and 20 km (blue) from them.

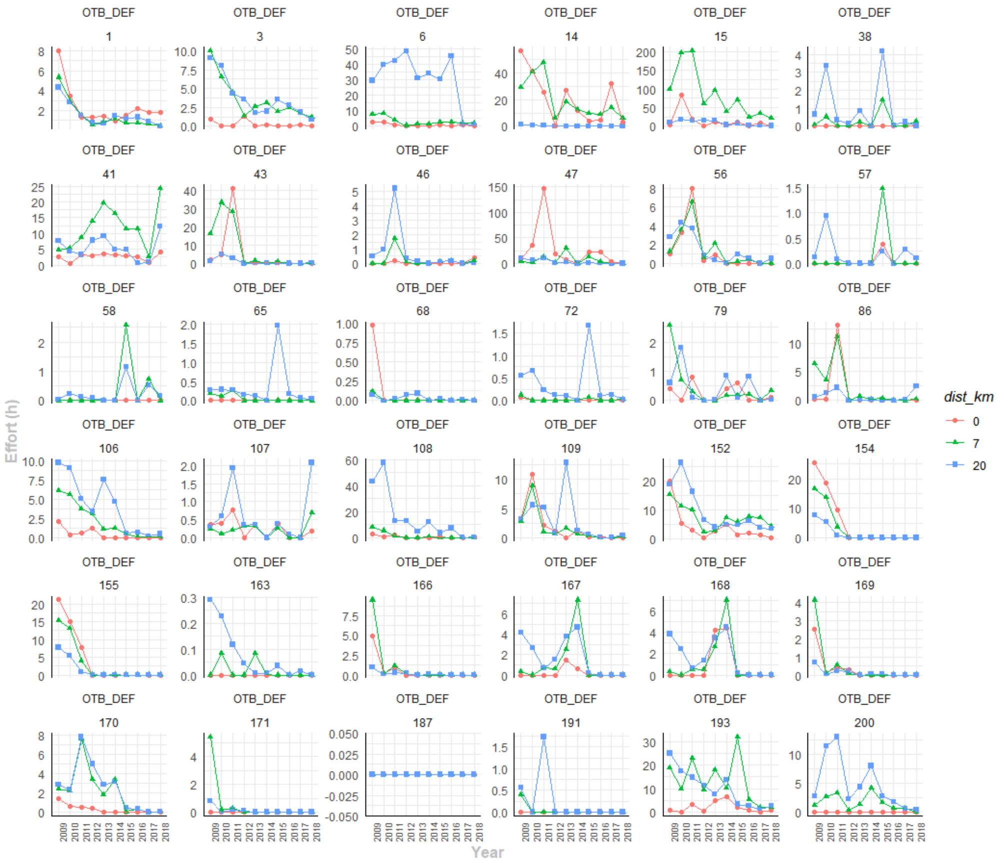

Figure 25. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the within the operational and in production windfarms licensed areas (red) and 7km (green) and 20 km (blue) from them.

2.4.4.1 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 recommend 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 7km buffer, and between this and a 20km buffer, for OSPAR Marine Protected areas (Figure 26; Figure 28), Marine Conservation Zones (Figure 29; Figure 31) and Nature Conservation Marine Protected Zones (Figure 32; Figure 34).

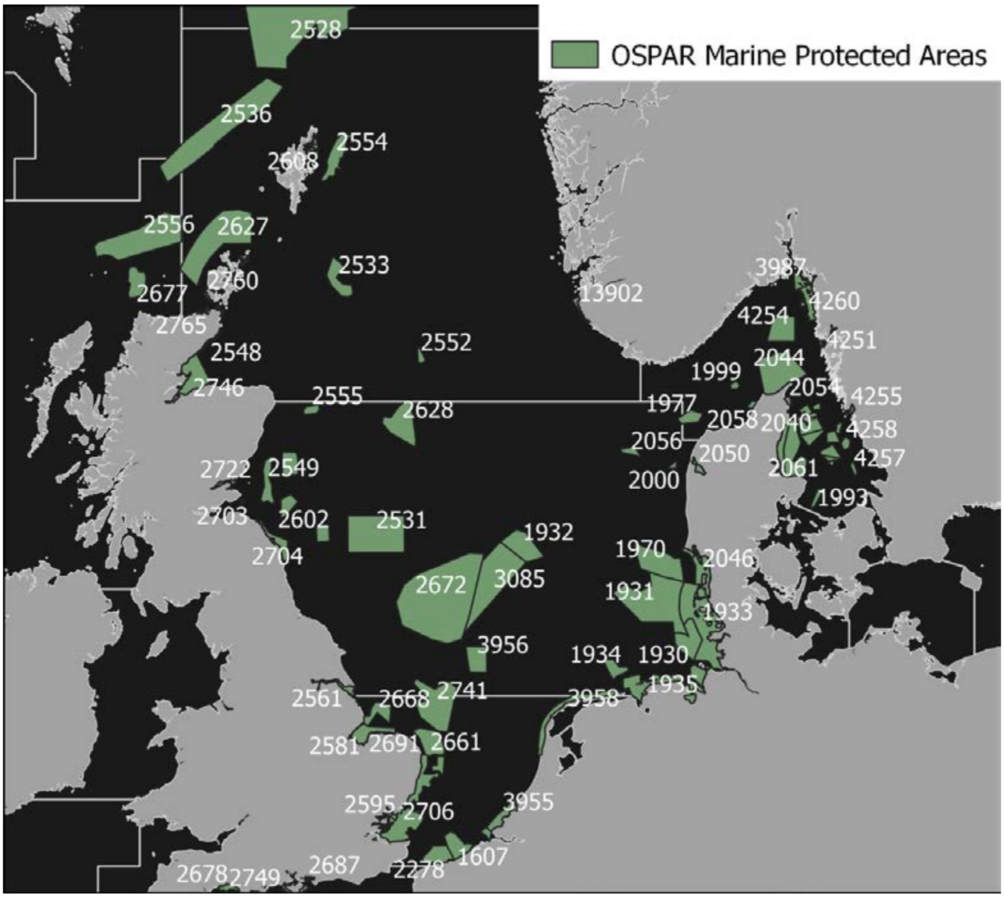

Figure 26. Map of OSPAR Marine Protected Areas in the Greater North Sea ICES Ecoregion (source: EMODnet).

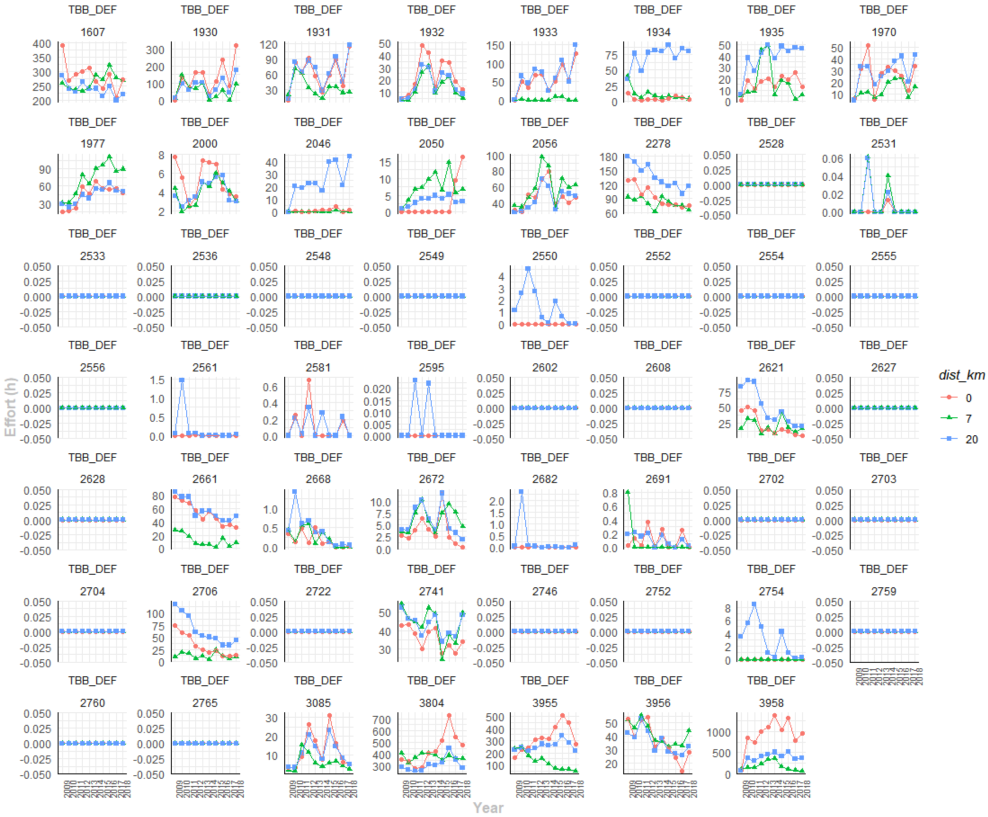

Figure 27. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within OSPAR Marine Protected Areas (red) and at 7km (green) and 20 km (blue) from them.

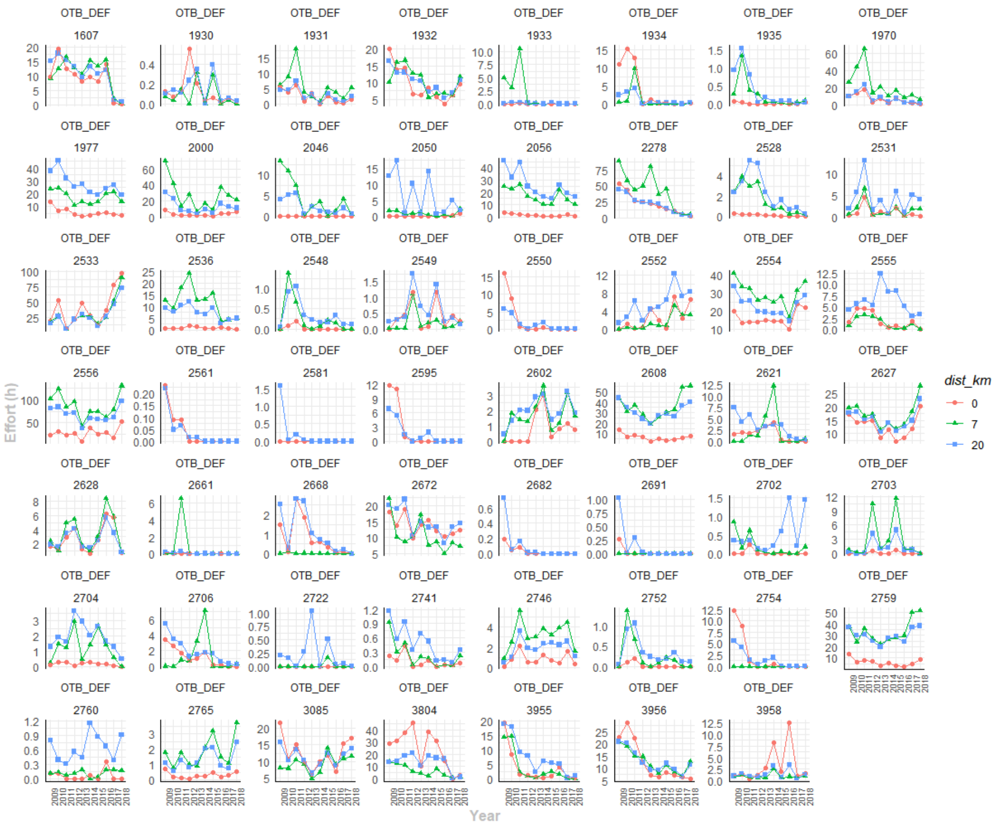

Figure 28. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within OSPAR Marine Protected Areas (red) and at 7km (green) and 20 km (blue) from them.

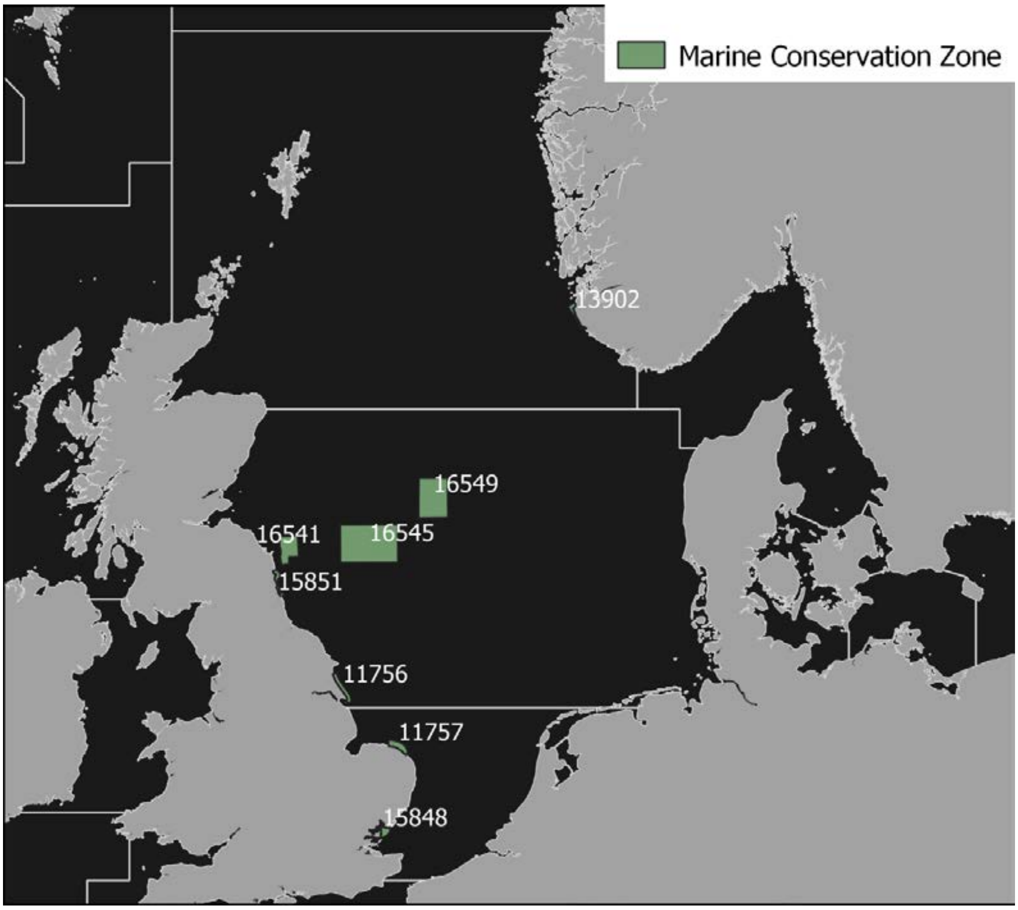

Figure 29. Map of Marine Conservation Zones in the Greater North Sea ICES Ecoregion (source: EMODnet).

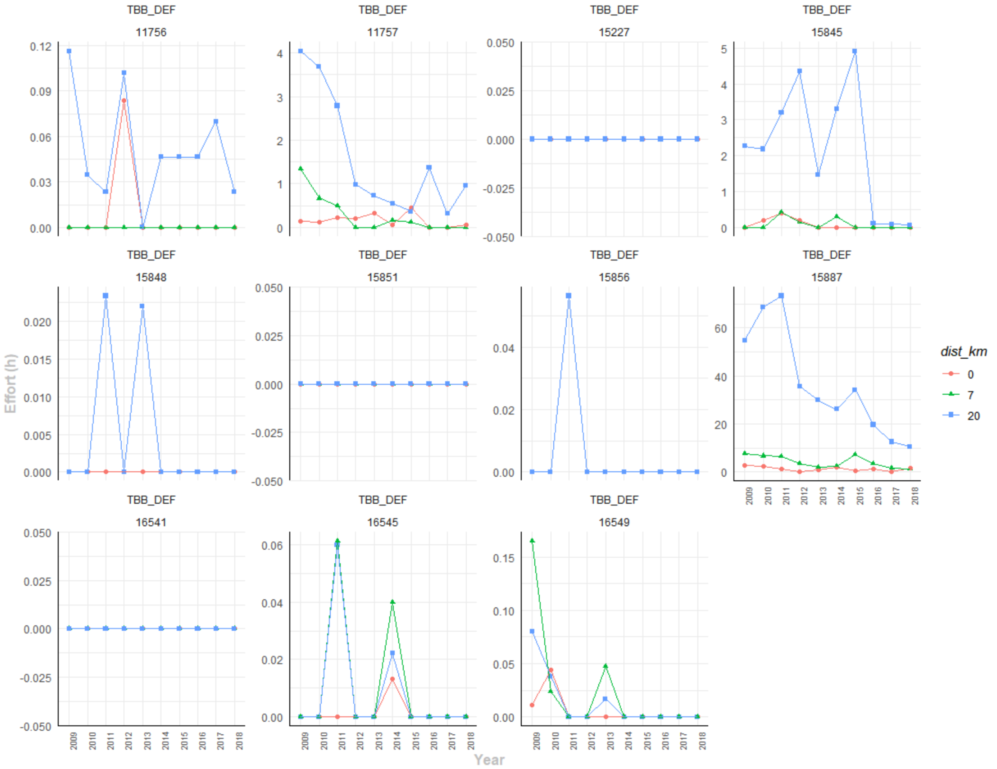

Figure 30. Distribution of fishing effort by beam trawls targeting demersal fish over the past 10 years within Marine Conservation Zones (red) and at 7km (green) and 20 km (blue) from them.

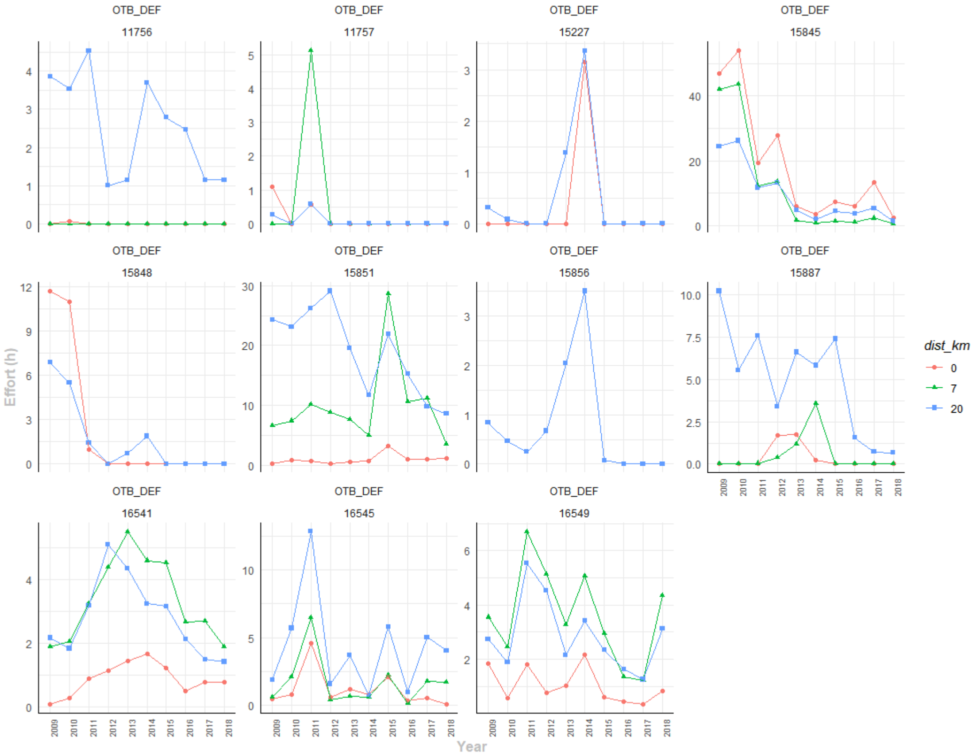

Figure 31. Distribution of fishing effort by otter trawls targeting demersal fish over the past 10 years within Marine Conservation Zones (red) and at 7km (green) and 20 km (blue) from them.

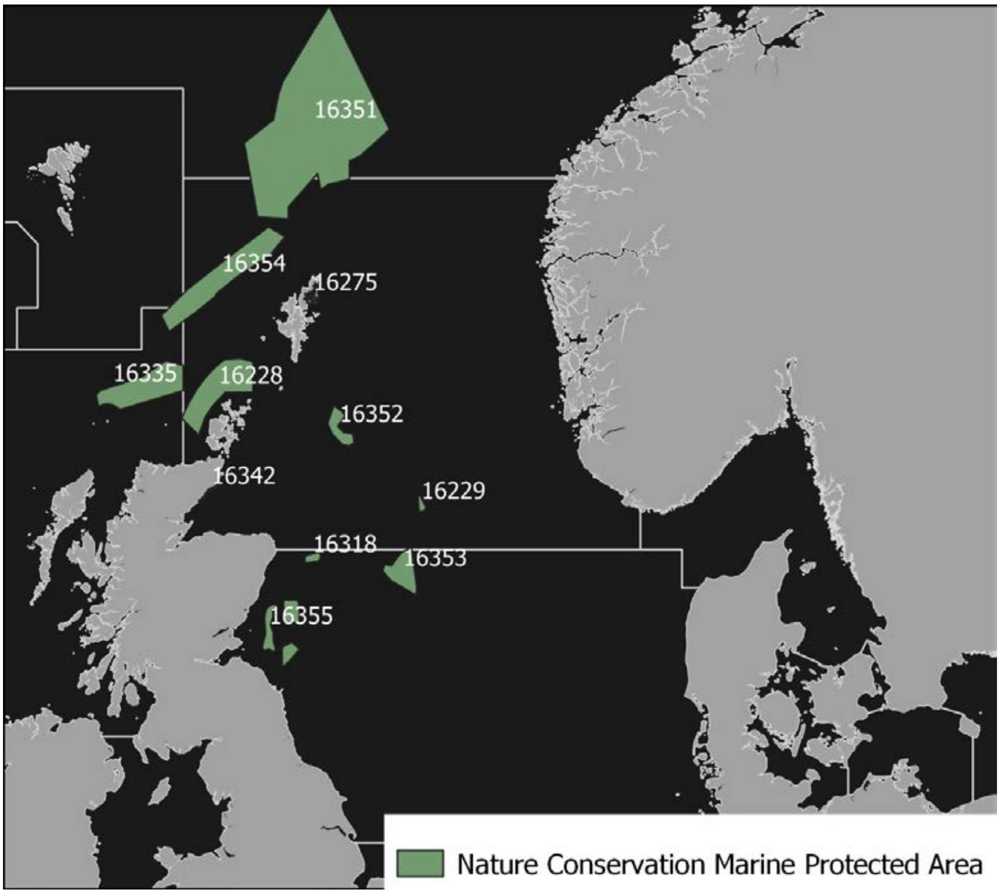

Figure 32. Map of Nature Conservation Marine Protected Areas in the Greater North Sea ICES Ecoregion (source: EMOD-net).

Figure 33. 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.

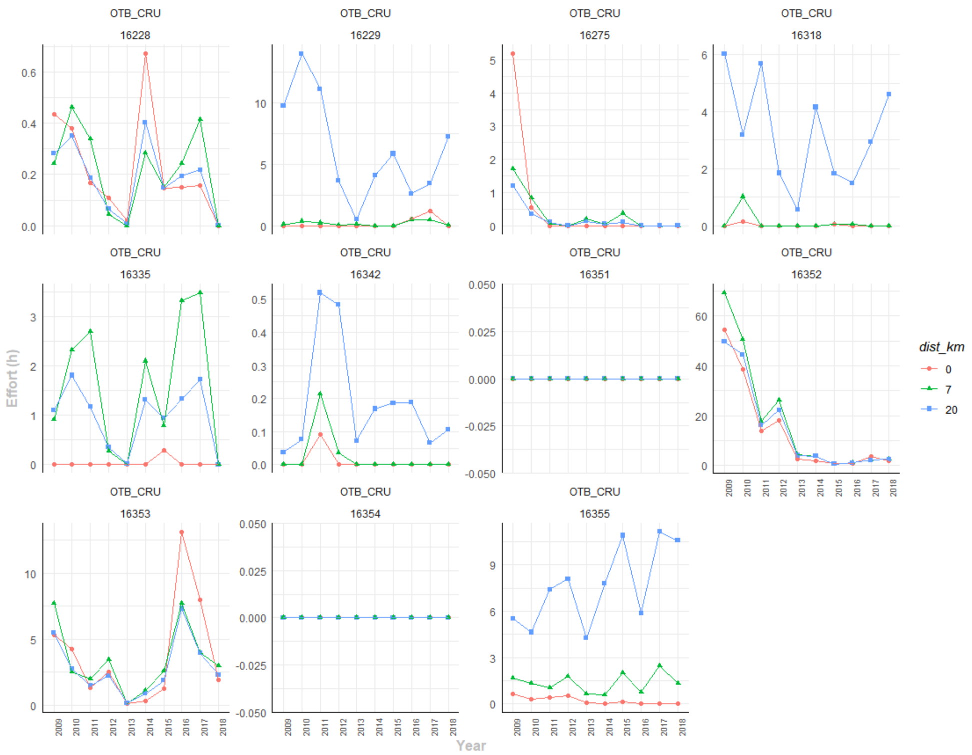

Figure 34. Distribution of fishing effort by otter trawlers targeting demersal fish over the past 10 years within the within Nature Conservation Marine Protected Area (red) and at 7km (green) and 20 km (blue) from them.

2.4.4.2 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 hold 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 the majority 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 in order to compare the effort inside the cargo footprint with the effort in the surrounding area within each ICES rectangle (Figure 35). Effort distribution overlapping and not overlapping with shipping lanes, by statistical rectangle, is shown in Figure 36 and Figure 37.

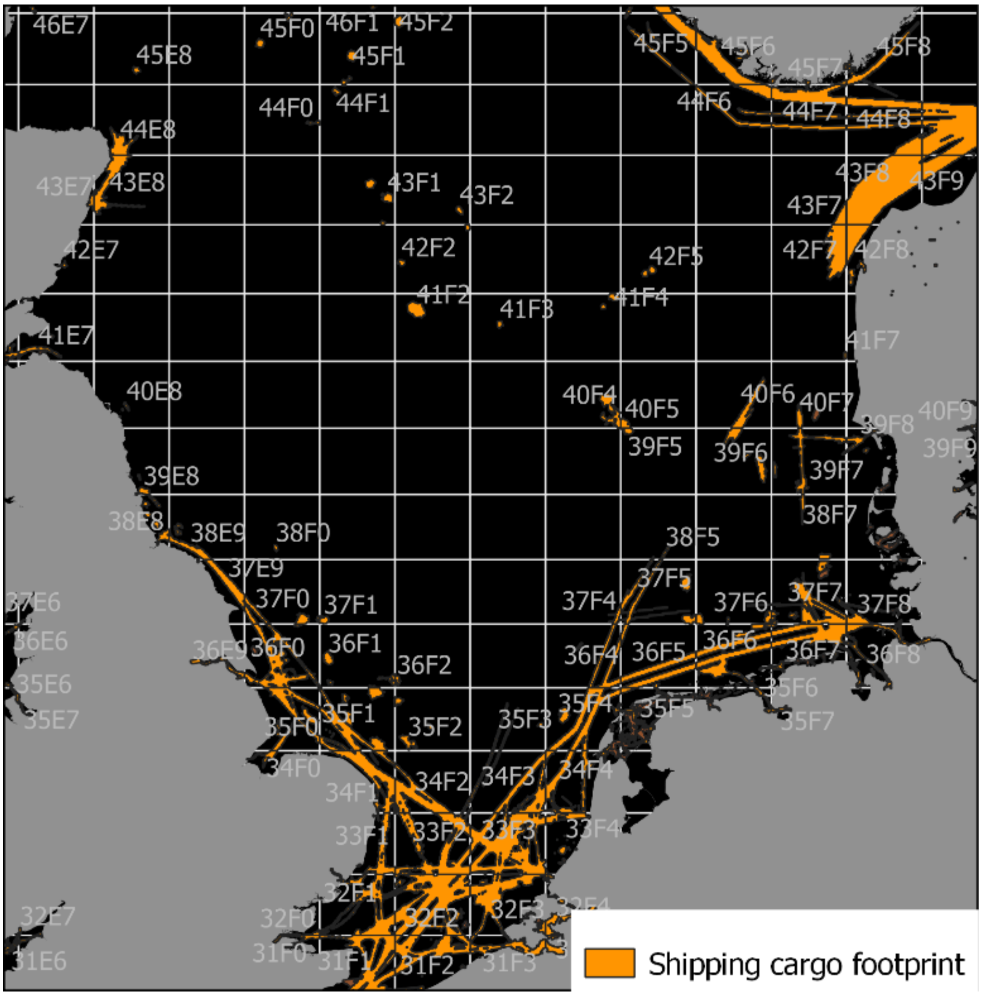

Figure 35. Map of the cargo vessels footprint split by ICES rectangle.

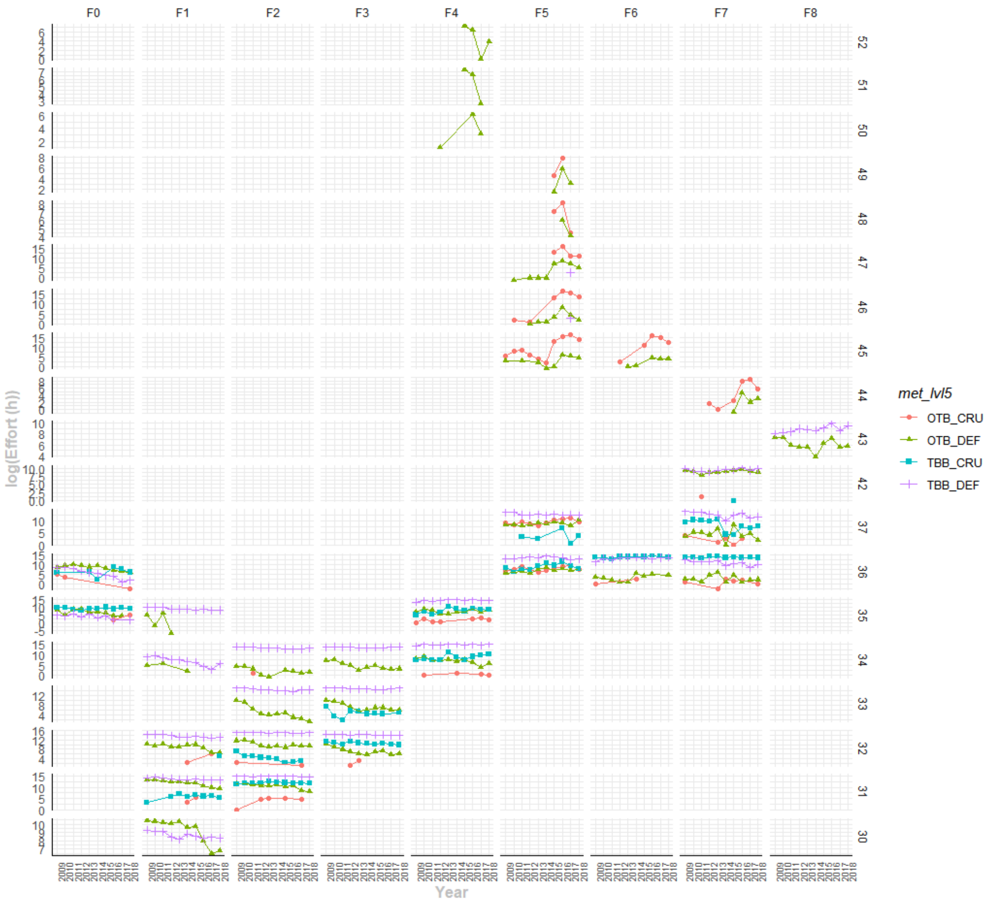

Figure 36. Effort distribution between 2009 and 2018 overlapping the cargo vessel footprint by ICES rectangle. Graphs distributed in an ICES rectangle grid.

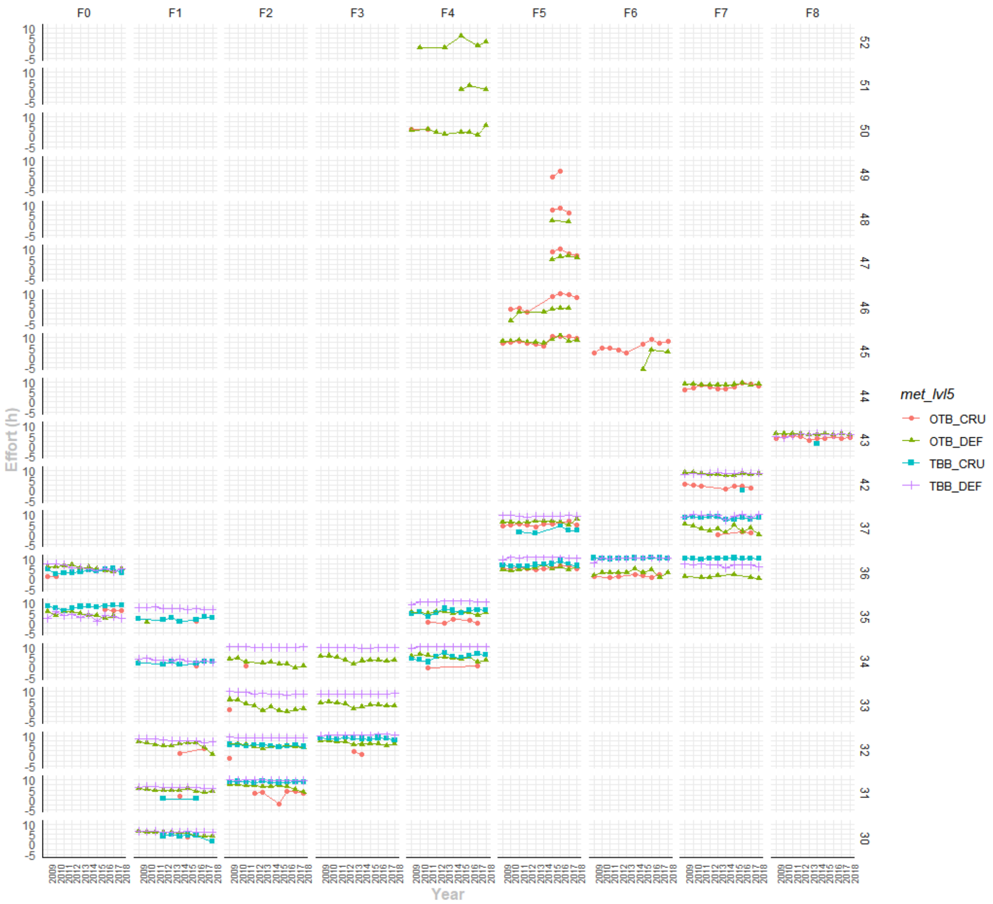

Figure 37. Effort distribution between 2009 and 2018 not overlapping the cargo vessel footprint by ICES rectangle. Graphs distributed in an ICES rectangle grid.

2.5 ToR E: Support to WKBEDPRES

VMS data products produced through the ICES VMS and Logbook data call are currently aggregated at a spatial resolution of 0.05 x 0.05 degrees by national data submitters. These national data sets are combined by the ICES secretariat to produce the combined outputs. The size of cell used for this aggregation was chosen as it represents an optimum solution given the current time interval between the polling frequency seen in the available VMS data (typically one hour, but ranging between 15 minutes and 2 hours) and the distance which a vessel travelling at speeds consistent with fishing activity will cover during this period, minimising the probability of a vessel crossing a cell without being observed.

If more finely resolved (e.g. 0.01 x 0.01 degree) fishing activity layers are required by end-users, there are a number of alternative approaches available. All involve balancing some degree of trade-off, in terms of precision, computational complexity, confidence in the comprehensiveness of the data, the degree to which logbook and positional information can be associated, and workload required for collection, processing and aggregation of the data. The costs and opportunities associated with a number of options are presented below.

Approach	Benefits	Costs	Likely availability during WKBEDPRES
As in the current data call: use data at a resolution of 0.05° x 0.05°	No changes required to current practices. Fits with temporal resolution of VMS data. Quality-assured WG-SFD time series available from 2009 onwards.	Although this approach is the most straightforward, it presents an increased risk of perceiving an impact of fishing within an area where none occurs.	Available
Grid VMS point data on a finer spatial scale	May provide a more highly resolved impression of fishing in areas of high activity.	In lower density areas, or in metiers including fewer vessels, increases the granularity of data products without really increasing accuracy, and will result in overestimate unfished areas.	Data is available, but would require a revised data call.
Interpolate between points	Improve on knowledge of footprint with a certain degree of confidence. Valid for certain towed gears types.	Appropriateness of interpolation method needs to be investigated Interpolation is not a valid approach for a number of gear types (e.g. static gears, seine nets)	Data is available, but would require a revised data call.
Include habitat type in the data call and aggregate to habitat types within grid cells	Provides information on the distribution of fishing activity at a finer scale than currently. The fishing activities will be related to the habitat type at the stage where raw VMS pings are available.	Additional effort in data call stage required to assign point data to habitat layers. Approach is not flexible beyond the point where the data call is issued Need a habitat layer as input (e.g. from WGFBIT?)	Data is available, but would require a revised data call, and agreed habitat layer.
Use AIS data	Higher frequency data. Coverage extends to parts of the fleet not subject to mandatory VMS coverage.	Increased cost associated with obtaining data, and with its interpretation Coverage is variable as it is not official data	AIS data is available, but is not currently collected and processed by WGSFD, there is no agreed, comprehensive set of data, and consider caveats detailed in response to ToR A.
Nested grids	A flexible method, can adjust to the density of data points	Years/countries data can't be combined	Data is available, but would require a revised data call.
Move to alternative data sources (e.g. electronic logging systems)	Potential for very high frequency data recording. Less costly option than increasing VMS ping frequency	Installation of new equipment required, and associated costs. No time series Requires voluntary acceptance by fishers or changes to regulatory frameworks	Unlikely to be available during WKBEDPRES other than for a very small number of fisheries.

Approach	**Benefits**	**Costs**	**Likely availability during WKBEDPRES**
Increase VMS ping rates	Existing system is reliable, provides known coverage, and has data management and quality assurance process in place. Official source of data with consequences if you turn it off	Increased costs associated with more frequent satellite transmission Potential limitation in precision and data resolution which varies between service providers – current legislative requirement is ±500m	Unlikely to be available during WKBEDPRES

It should be noted that a change in the aggregation level which results in fewer vessels being present in each category, whether spatial or using other data such as habitat type, will have the consequence of increasing the quantity of data which needs to be surprised to protect anonymity and sensitive data, therefore taking this route may be counterproductive.

As detailed extensively in section 2.1.1.2, the availability of AIS data at a national level is a grey area. Typically, AIS data is collected by commercial operations who sell access to data products. National administrations may have arrangements to access these, however their ability to submit processed data extracted from such sources is likely to be doubtful. Furthermore, this limits the potential for AIS data to be merged with logbooks, which is a requirement for swept area calculations. The costs and complexities of obtaining AIS data need to be balanced against the degree of precision which it offers.

It should be noted that VMS data represents an "official" record of positional data, its collection, use and retention are mandated and regulated in legislation, and it is routinely used as the basis of legal proceedings. AIS data is collected on a less formal basis. Limitations of AIS data relate to the quality of the received records, where potential sources of error exist within the data. For example, AIS transponders may be switched on or off, or be defective, during all or part of a voyage, thereby not capturing the full activity. In addition, errors with the positioning system can provide inaccurate locations. Voyage data is largely user-entered, and therefore has inherent limitations due to operator error or misrepresentation of information. Transmitted information such as Maritime Mobile Service Identity (MMSI); (vessel identification) numbers, vessel type or dimensions can also be incorrectly entered, thereby providing a further degree of uncertainty.

AIS-B is a non-mandatory form of AIS typically used by small commercial craft, fishing vessels and recreational vessels. Transmission power of this system is restricted to 2W in order to prevent overloading of the available bandwidth, giving a range of up to 10 nautical miles. Information regarding spatial distribution of activity by these types of craft from AIS sources alone will therefore significantly misrepresent the true frequency and use patterns.

2.6 ToR F: Analysis of NEAFC VMS data in support of WGDEC

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, in order 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 a yearly basis to protect anonymity of vessels rather than the previous six-monthly basis. 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 2018, 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 there were issues again with quality of speed data. The "estimated speed" and "vessel speed" columns contained no values, and whilst the "SP" field did contain numeric values, they ranged from zero to 500, suggesting a problem with decimal places, however not in a consistent manner across the dataset. As a means of avoiding this problem, a derived speed was 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 all gears. Visual examination of speed profile histograms for vessels registered as using trawl gears suggests that this demarcation is appropriate (Figure 38)

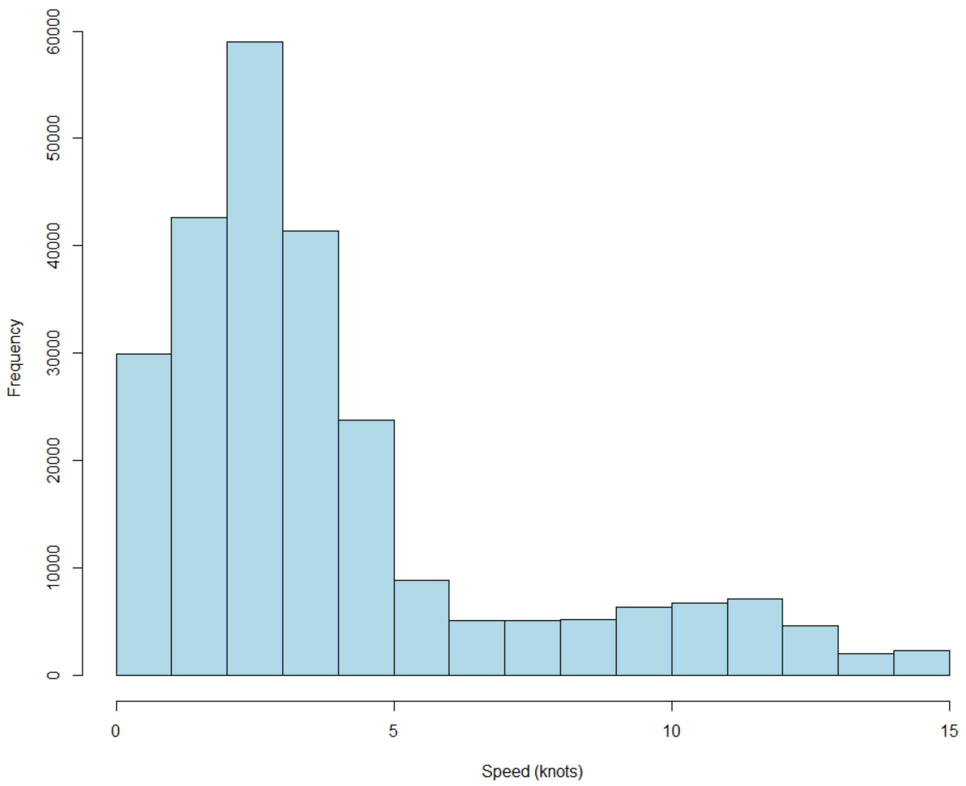

Figure 38. Histogram of derived speeds for all gears, based on position and time, conforms to expected distribution.

The speed filtered pings (0–5 knots) are 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 "LL" and "LLS"), and for vessels for which no gear code was available ("NIL"). 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).

Table 11. Number of pings registered against each fishing gear type in the speed filtered (0-5 knots) NEAFC VMS data. Gear codes: Pots (FPO), longlines (not specified) (LL), set longlines (LLS), no gear code (NIL), bottom otter trawls (OTB), midwater (OTM), purse seine (PS) and shrimp trawl (TBS).

Gear	Number of pings
FPO	1282
LL	31
LLS	831
NIL	25 364
OTB	38 649
OTM	128 252
PS	264
TBS	2056

The VMS effort data was mapped together with the NEAFC Existing Fishing Area and any VME Closure Areas to assist WGDEC in assessing 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, and the Mid-Atlantic Ridge.

2.6.1 Hatton Bank

The closures to the northern side of Hatton Bank are generally well observed (Figure 39). A small number of bottom trawl tows appear to extend into the closed area at the easternmost part and along the northernmost part of the existing bottom fishing area, however, these incursions are limited. The highest levels of fishing are closely associated with the boundary of the closed areas. There was little 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 (Figure 40).

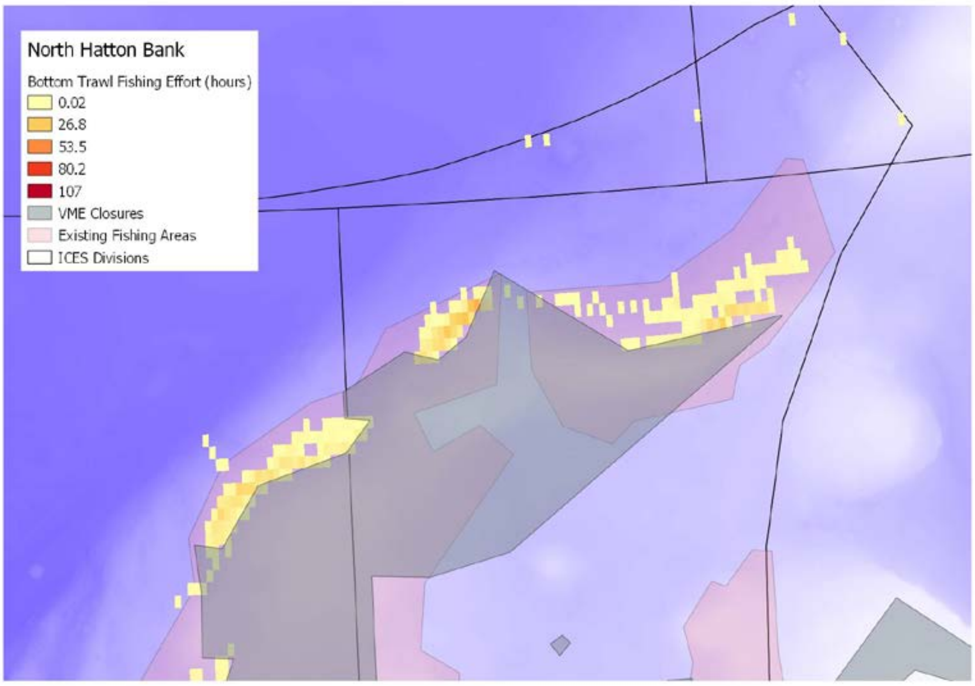

Figure 39. VMS derived fishing effort for bottom trawl gears to the north of Hatton Bank.

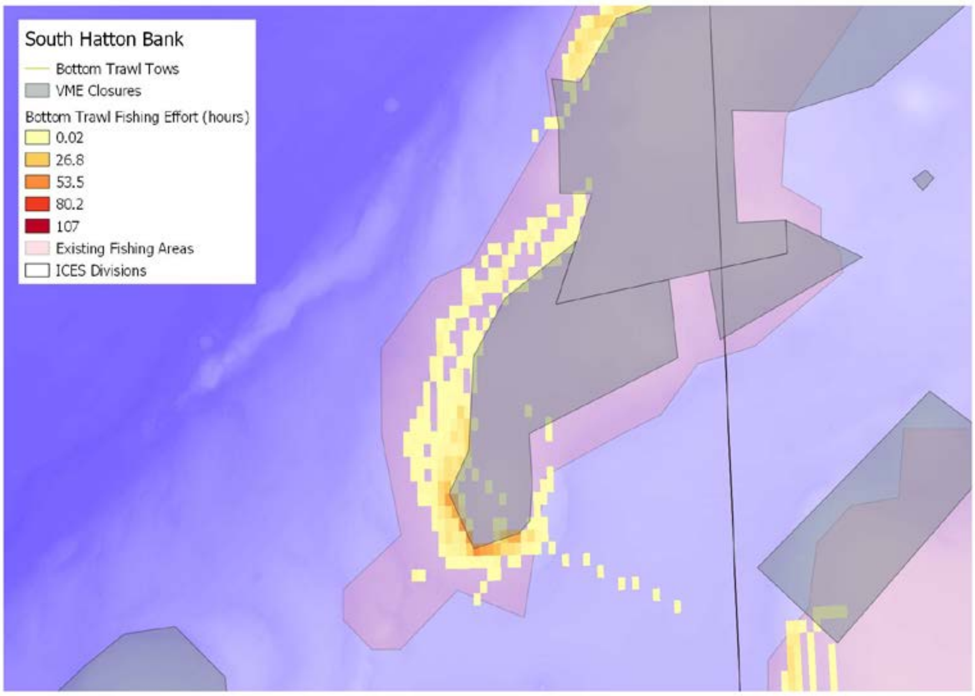

Figure 40. VMS derived fishing effort for bottom trawl gears to the south and west of Hatton Bank.

2.6.2 Rockall Bank

The VME closures on the eastern side of Rockall Bank are also generally well observed, although there is some suggestion of vessels with no registered gear type operating within the Haddock Box, particularly in the northwest quadrant (Figure 41). Vessels registered as using static gears work outside this area. To the south of Rockall Bank, trawling continues to be better confined to the “existing bottom fishing area” (Figure 42). Static gears appear to be absent from the small areas at the southerly end of the bank in which they were observed last year.

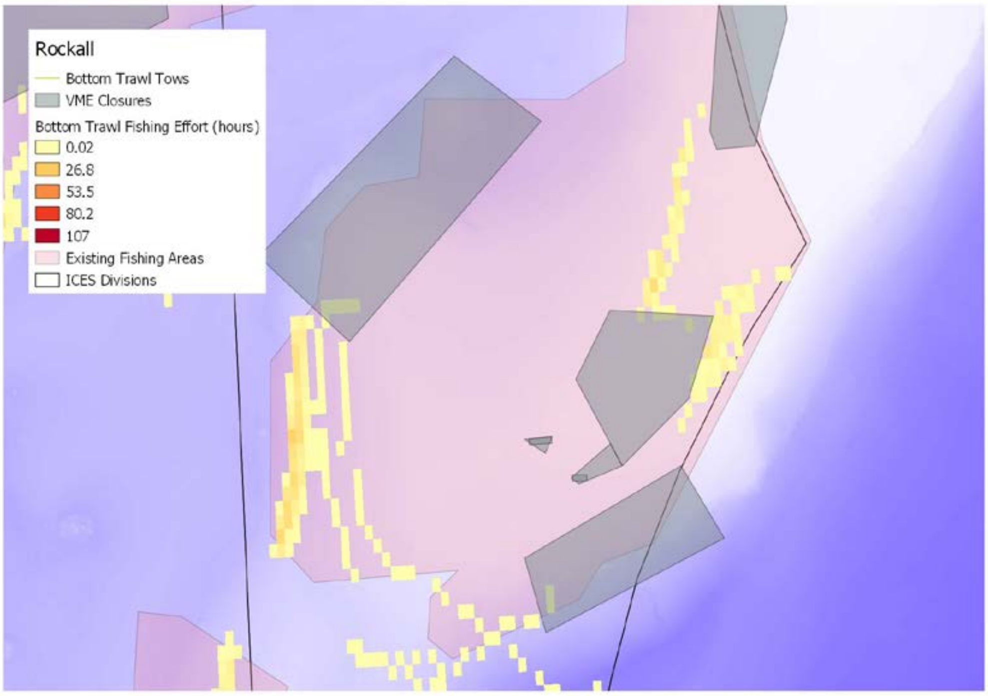

Figure 41. VMS derived fishing effort for bottom trawl gears on the northern part of Rockall Bank.

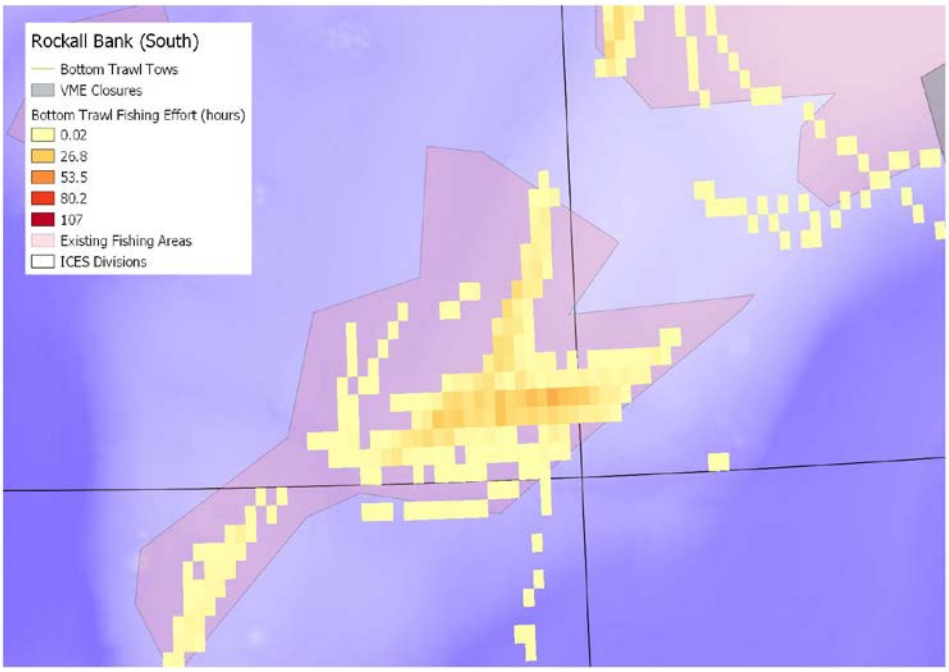

Figure 42. VMS derived fishing effort for bottom trawl gears on the southern part of Rockall Bank.

2.6.3 South of Iceland

As in previous years, the pattern of activity around the Reykjanes Ridge is somewhat confused (Figure 43). A high proportion of this activity takes place in waters over 3000m in depth – too deep to represent bottom fishing activity – and is believed to be vessels targeting mid-water redfish being miscoded in the database. One potential area of actual bottom fishing is still seen to the southeast of the mid-Atlantic ridge. The seabed in this area is at around 1300–1500m.

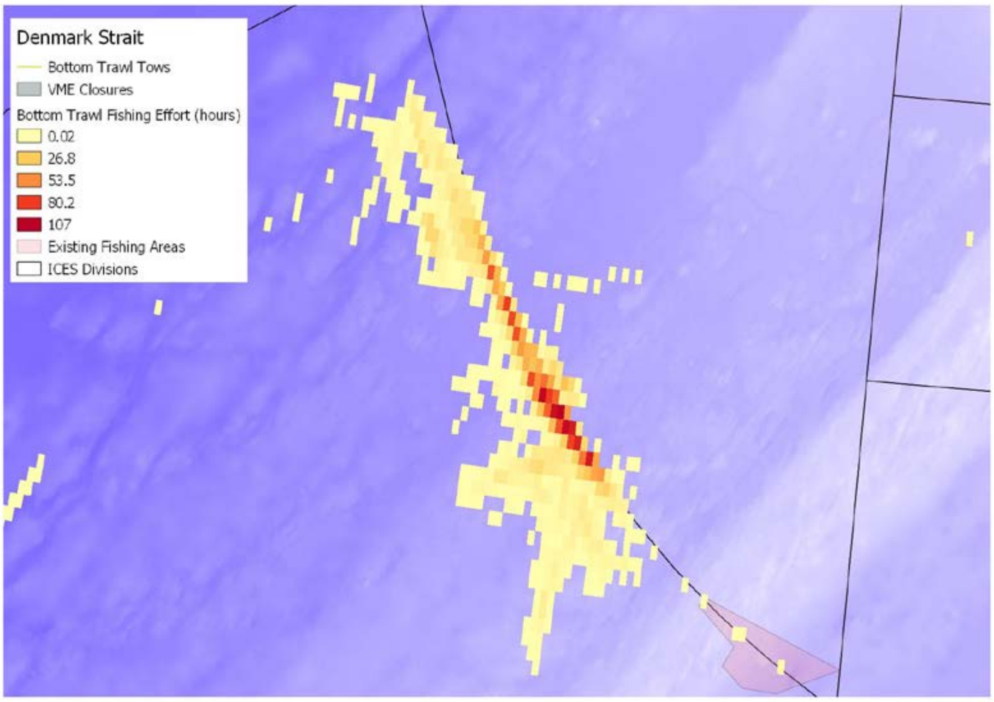

Figure 43. VMS derived fishing effort for bottom trawl gears to the South of Iceland.

2.6.4 Mid Atlantic Ridge Seamounts

As seen in the previous two years, bottom trawling activity appears to be taking place on an unnamed seamount to the south of the Mid Atlantic Ridge (MAR) closure, outside the existing bottom fishing area (Figure 44). Slightly further south, bottom trawling takes place inside the existing bottom fishing area, as well as on a seamount to the west of the Olympus knoll. The fishing observed last year on the Chaucer seamounts to the south, including within the Southern MAR (C) closure area, is not evident this year.

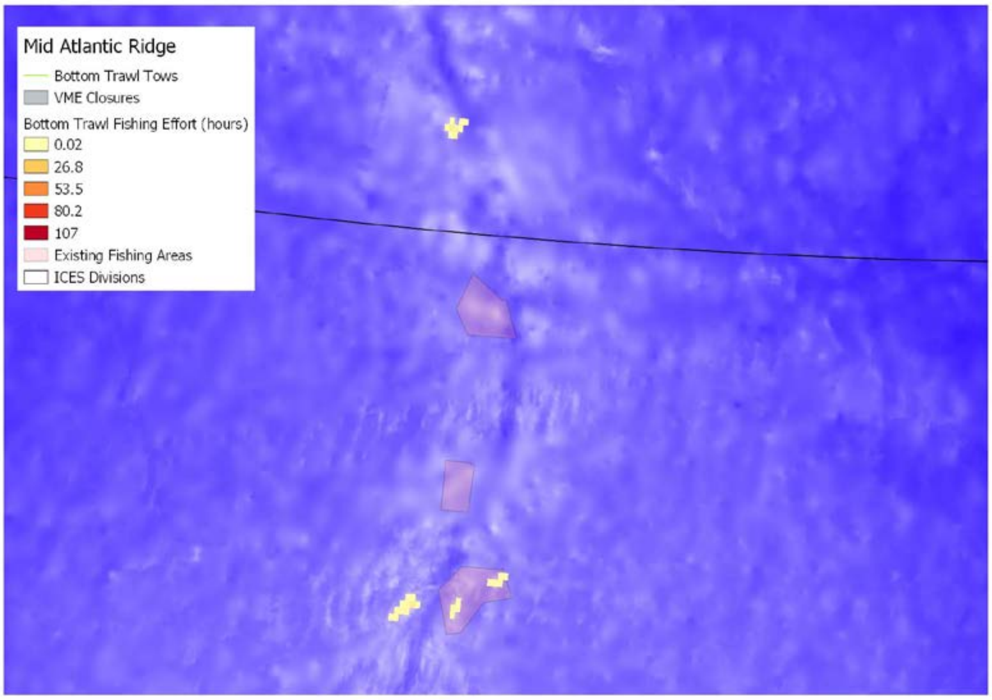

Figure 44. VMS derived fishing effort for bottom trawl gears on the Mid Atlantic Ridge.

2.7 ToR G: Investigate the effect of moving to a higher resolution on anonymity in the VMS data call

ToR 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.

After discussions on confidentiality in data calls at Regional Coordination Groups (RCGs) in 2018, there was general agreement on a set of rules to be considered when publishing VMS data products (RCG Liaison report 2018, section 2.3.1, https://datacollection.jrc.ec.europa.eu/docs/liaison).

These rules are summarized below:

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 the 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 (see Appendix 3 VMS and logbook data call February 2019).

The 2019 ICES VMS data call was changed to include a field showing the number of distinct vessels at the aggregation level of the data call. Below are maps of fishing activity by Benthis metier where cells containing fewer than 3 vessels are shown in yellow and cells containing 3 or more vessels are shown in purple. Vessel counts are accumulated across countries and vessel length but not across any other variable (see below for further explanation). Table 12 summarises the maps in terms of the number of cells containing less than 3 and greater than or equal to 3 vessels for 2018 by Benthis gear metiers. Table 12 also shows an additional row summarising the same information for static gears. 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 (e.g. Figure 45, Figure 56).

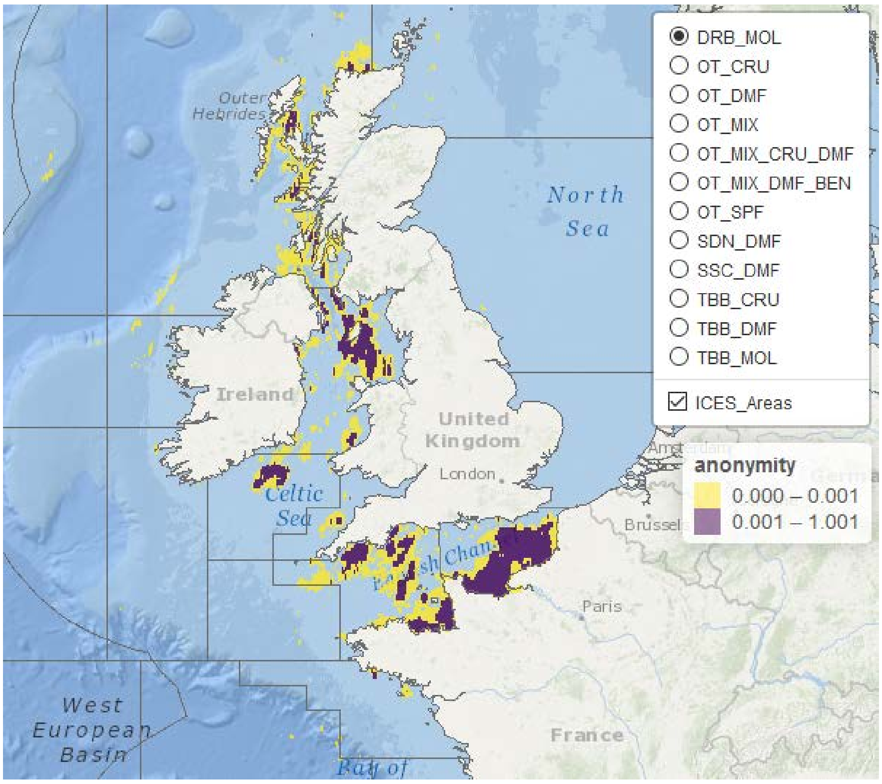

Figure 45. Map of fishing effort extent of vessels using dredges to target molluscs. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

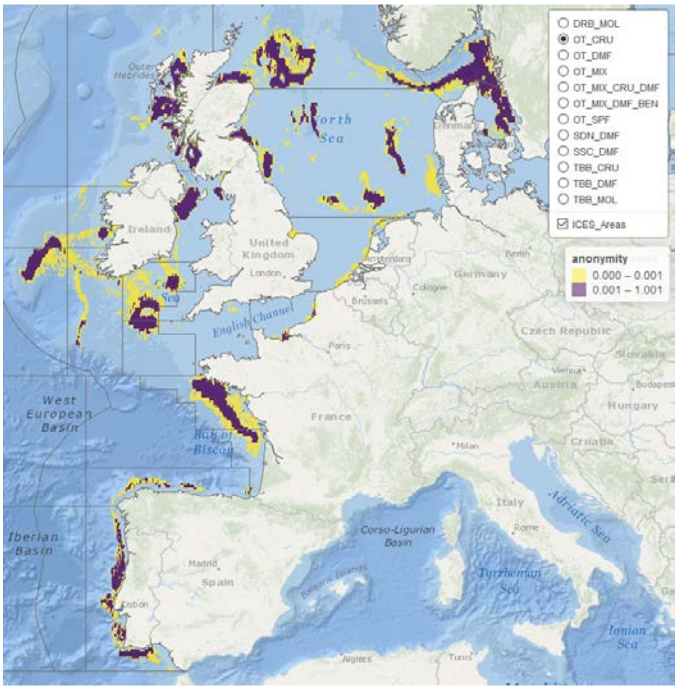

Figure 46. Map of fishing effort extent of vessels using otter trawls to target crustaceans. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

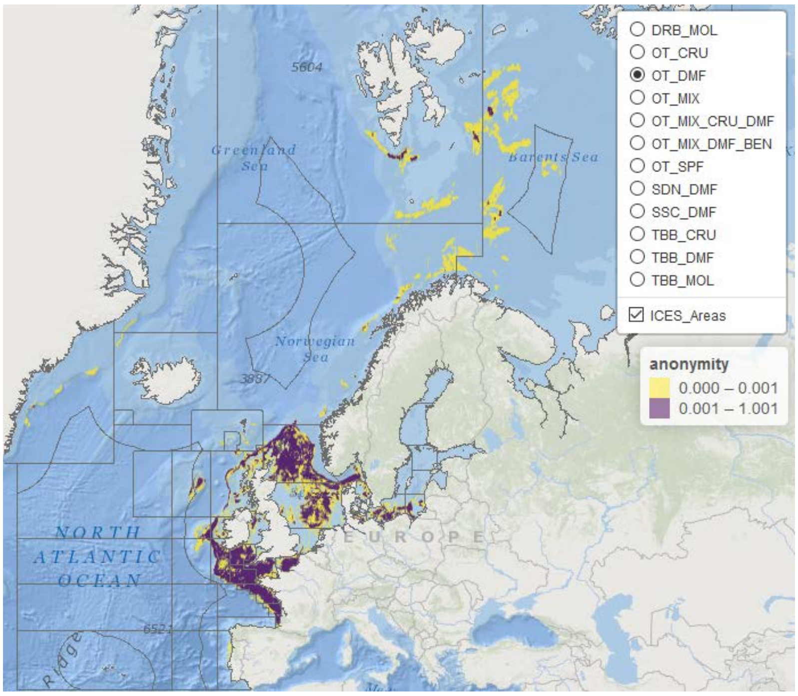

Figure 47. Map of fishing effort extent of vessels using otter trawls to target mixed demersal fishes. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

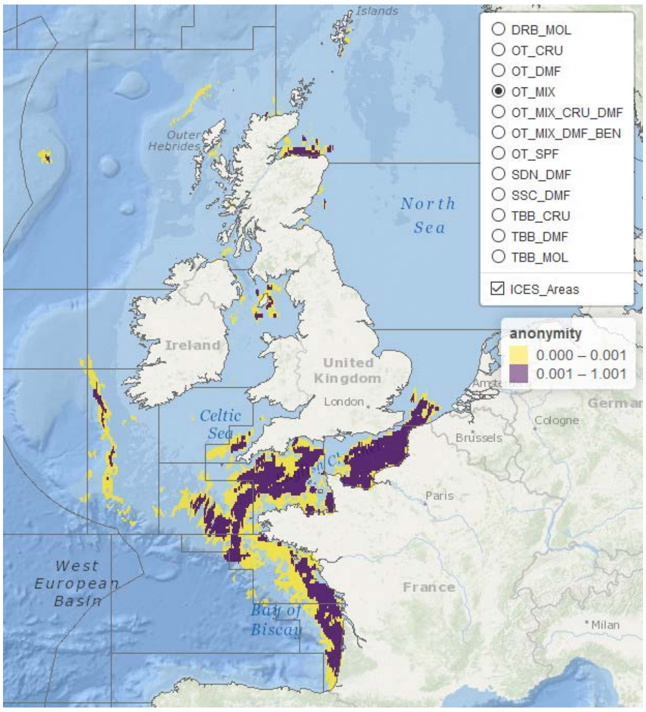

Figure 48. Map of fishing effort extent of vessels using otter trawls to target a mixed catch. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

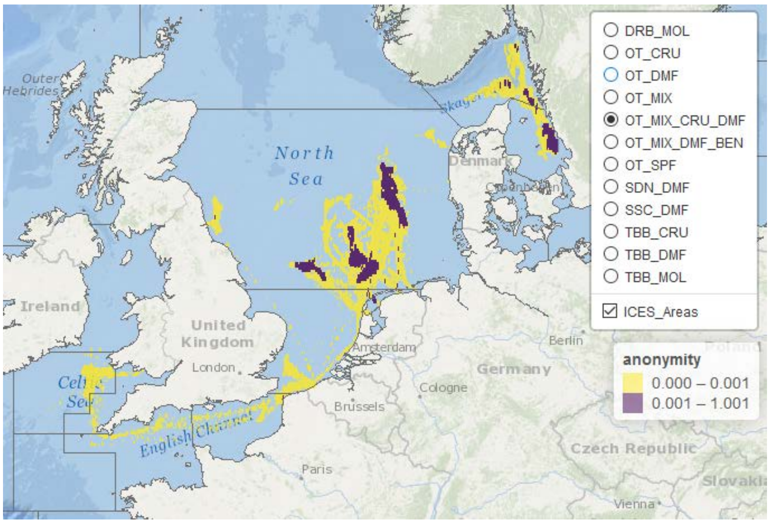

Figure 49. Map of fishing effort extent of vessels using otter trawls to target a mix of crustaceans and demersal fish. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

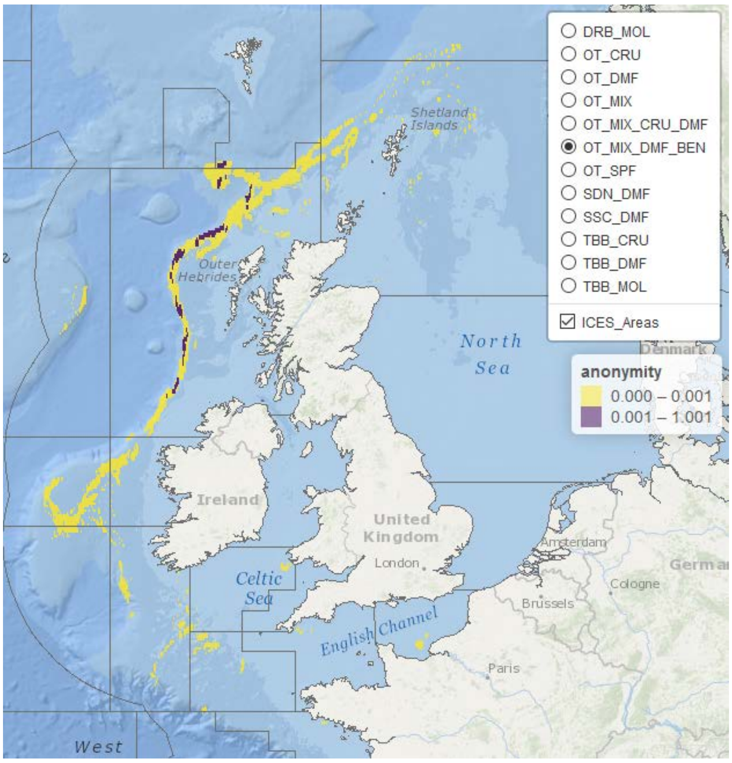

Figure 50. Map of fishing effort extent of vessels using otter trawls to target a mix of demersal and benthic fish. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

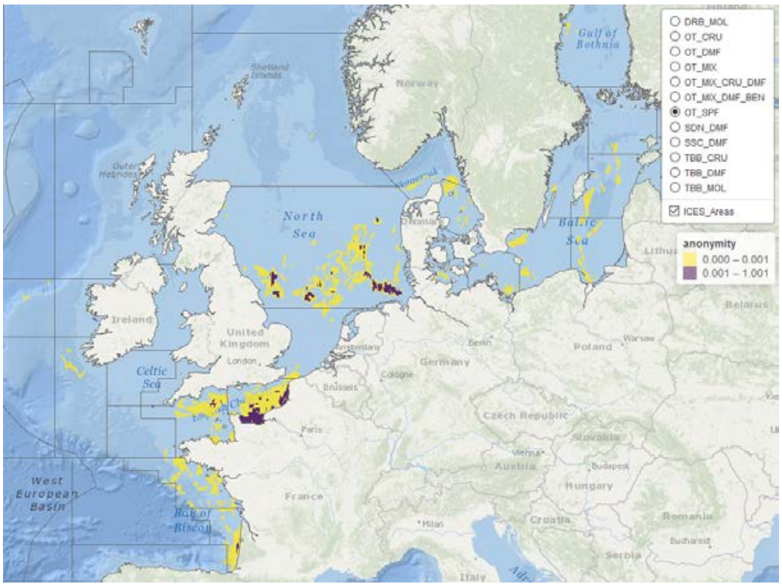

Figure 51. Map of fishing effort extent of vessels using otter trawls to target small pelagic fish. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

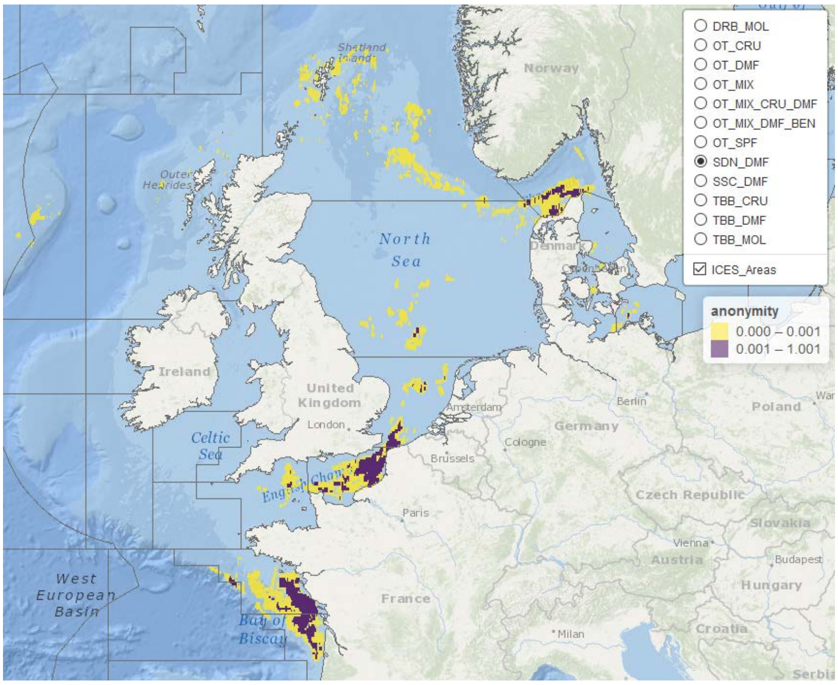

Figure 52. Map of fishing effort extent of vessels using Danish seines to target demersal fish. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

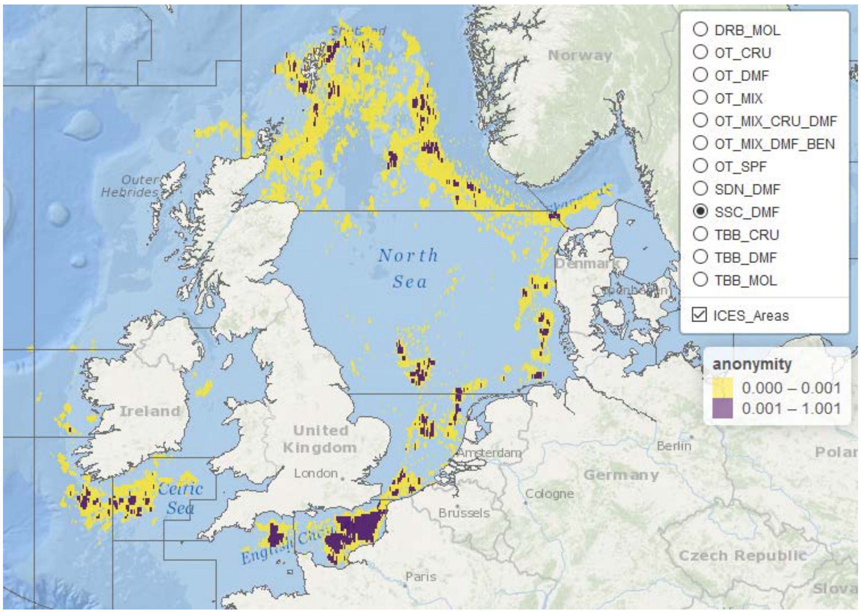

Figure 53. Map of fishing effort extent of vessels using Scottish seines to target demersal fish. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

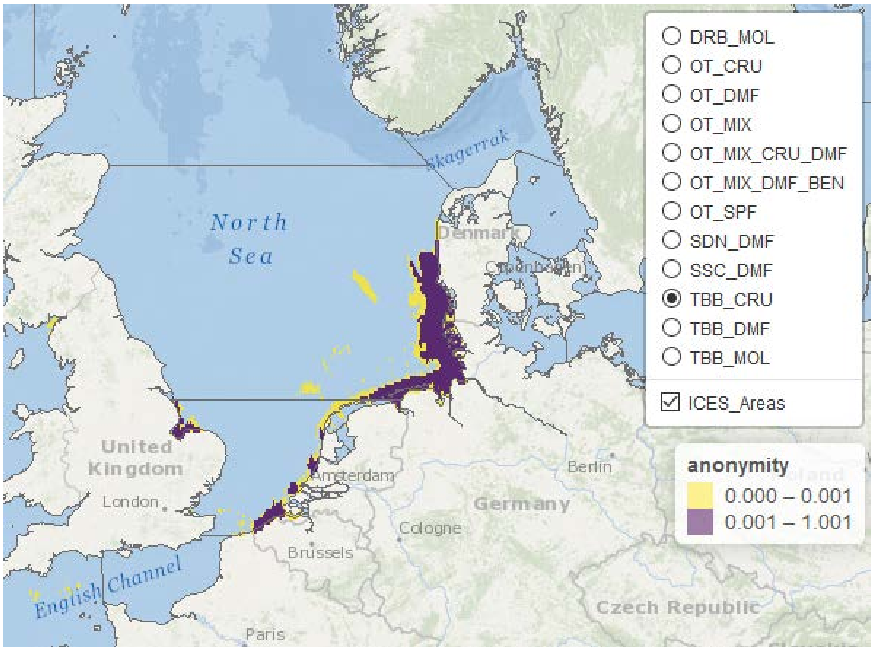

Figure 54. Map of fishing effort extent of vessels using beam trawls to target crustaceans. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

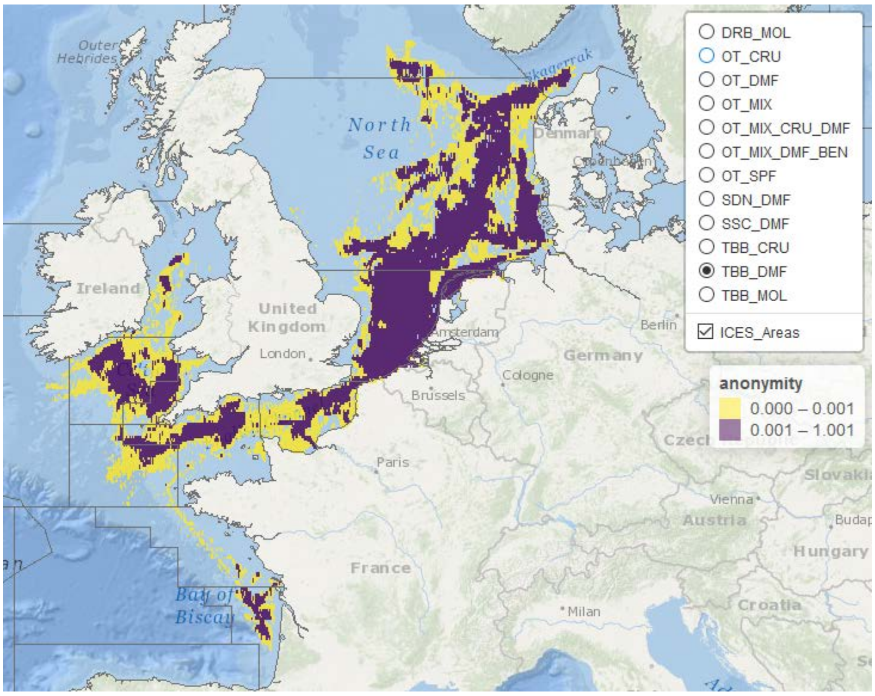

Figure 55. Map of fishing effort extent of vessels using beam trawls to target demersal fish. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

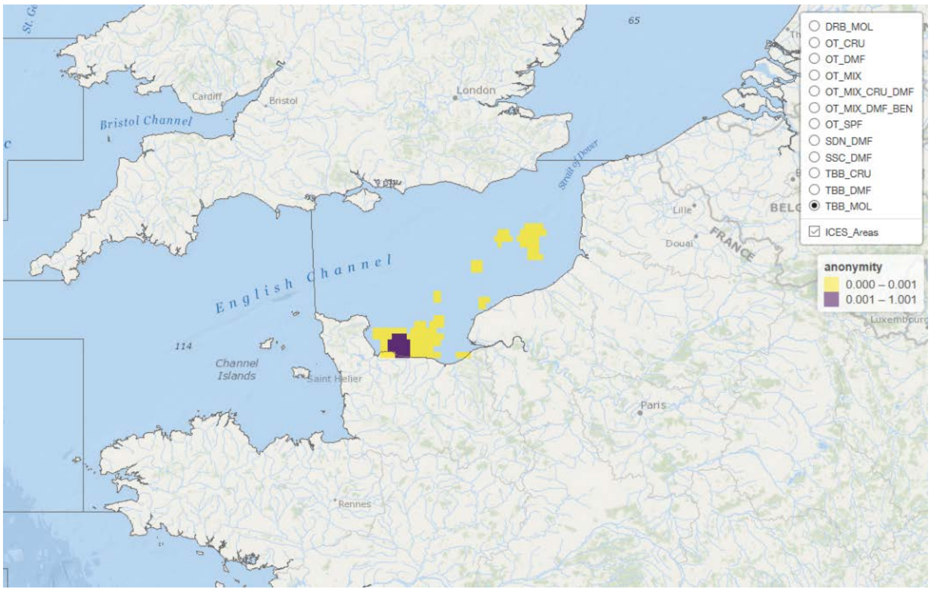

Figure56. Map of fishing effort extent of vessels using beam trawls to target molluscs. C-squares containing fewer than three vessels are shaded yellow, and containing three or more vessels, purple.

Table 12. C-squares with less than 3 unique vessels ('restricted') and greater than or equal to 3 ('not restricted') for the Benthis categories and static gears for the year 2018, and the percentage of restricted c-squares to the total number of c-squares that the fishing gear reported activity for in 2018.

Benthis_metiers	year	restricted	notrestricted	proportion_restricted
DRB_MOL	2018	1651	2302	0.418
OT_CRU	2018	6551	8821	0.426
OT_DMF	2018	22592	42090	0.349
OT_MIX	2018	2994	4386	0.406
OT_MIX_CRU_DMF	2018	2302	1141	0.669
OT_MIX_DMF_BEN	2018	1436	592	0.708
OT_SPF	2018	4204	1056	0.799
SDN_DMF	2018	2956	1778	0.624
SSC_DMF	2018	7450	2967	0.715
TBB_CRU	2018	500	1207	0.293
TBB_DMF	2018	4060	10536	0.278
TBB_MOL	2018	80	30	0.727
Static	2018	23176	13317	0.635

An issue with the 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 (0.05 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. This means that the current approach is inflexible.

Recommendations

Data can be considered sensitive if the activities of individual vessels can be inferred from the data. For example, the value of landings can in some cases be considered sensitive. Following ICES Data call, aggregated international effort values of any c-squares containing three vessels or less will not be shown. However, not all data can be considered sensitive and ICES WGSFD recommends that the following guidelines are followed when publishing data:

- Swept area ratios (SAR) 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 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, for example the current work in support of WKBEDPRES2, can be addressed with data calls to national labs to produce rasters from point data which can then be aggregated at an international level.

A more flexible solution than the current data call with the number of distinct vessels by aggregation level would be to include an extra text field in the data call with a string of anonymous vessel identifiers (Table 3). This would mean that it would be possible to know if it is the same or different vessels present at different aggregation levels. It should be noted that a move towards higher resolution data (both spatially and by vessel groupings) will lead to fewer data points in each category and increased levels of suppression.

WGSFD recommended the establishment of a VMS Governance Group within ICES to, *inter alia* provide oversight of the VMS Logbook Data Policy, guidelines for production of data products, and involvement in special requests for advice requiring use of sensitive data.

Table 13. Effects of including anonymous vessel identifier on aggregation of data products.

Aggregation level of the data call	Anonymous vessel id's	Number of reported distinct vessels	Actual number of distinct vessels
Record 1	A+B	2	2
Record 2	C	1	1
Record 3	B+D	2	2
Record 1 + 2 + 3	A+B+C+D	2	4

During WGSFD 2019, the inclusion of this text string with anonymous vessel id's in the data call format was explored. The benefits of this approach are highlighted in the tables above, where there are three records, each with fewer than 3 unique vessels. When these records are combined to form an aggregated data product, the best that can be done using the number of reported distinct vessels is 2, because it cannot be guaranteed that the vessels in these records are not the same vessels. However, given the list of anonymous vessel IDs it is possible to calculate the exact number of distinct vessels at any aggregation level. The results of this test are shown in Table 4. For this test, data was supplied by Denmark and Finland for 2018. The changes required in the workflow required for this were minimal and quick to implement; processing this data was also straightforward. Note that this example is only indicative as only two countries data were used – improvements would be expected to be greater in areas, which are fished by several countries.

Table 14. Number of c-squares for which values can be published for without suppressing c-square location (unique vessel count >= 3), based on an example dataset from Denmark and Finland. Unique Vessels Estimate is the number of c-squares identified as having fewer than 3 unique vessels using the supplied value of the number of unique vessels per c-square, month, and metier level 6. Unique Vessels IDs Estimate is the same but using the list of anonymised vessel IDs per c-square, month and metier level 6.

Gear Group	Total C-Squares	Unique Vessels Estimate	Unique Vessels IDs Estimate	Percent Improvement
Beam	957	283	303	7
Demersal seine	2179	141	474	236
Midwater	10579	1158	2363	104
Otter	13007	3850	6291	63
Static	2223	228	677	197

2.8 Update on WGSFD workplan

R scripting language (R Development Core Team, 2017) is the most common programming language used between WG SFD members. During the previous WG SFD meetings some of the members have been producing interactive maps for QC data visualization using the R Leaflet mapping and R Markdown. In addition have been proposed the integration of these already produced web interactive maps into an R Shiny web application with some additional features like the user been able to write down annotations and highlight regions in the interactive map where a potential data error was detected. This web application would be remotely accessible, and the expert's annotations and areas highlighted in the interactive map would be automatically integrated in a Spatial database used then to produce a report summarizing the regions more often selected by the experts.

This tool would support a remotely collaborative data call QC process allowing a data submitter to receive QC plots on a test dataset prior to submission, or to allow for collaborative QC tasks within an expert group after data submission allowing for the collation of reported potential errors in data sets that could be sent back to the data submitter.

For those who are not familiar with R Shiny, it is a package used to build interactive web apps that use R in the background to run the computations that are realised on the web. The developer community is active and innovative. These apps can provide an attractive web interface to almost any of the R programs already used or being developed for data exploration and analysis, as well as assessment.

Shiny servers in ICES countries

Marine labs with strong links with ICES have already successfully used the R Shiny Server platform to provide access to their science. The Centre for Fisheries and Aquaculture Science (Cefas) has a fully functional R Shiny Server with a web portal to access to the tools developed by Cefas scientists. Some of these tools are already used for industry license compliance, for example, the marine aggregate industry in UK, or for support management of marine protected areas. Access to the portal: https://openscience.cefas.co.uk/ Contact: Roi Martinez.

The Marine Institute in Ireland has an R Shiny Server hosting several tools related to stock assessment topics:

- Species Dashboard: Provides the annual review of fish stocks and the latest scientific advice that informs fishing opportunities for the following year. Makes this advice available on-line in an interactive way – for example it includes a forecasting tool that allows users to see the projected impact of different fishing scenarios. https://shiny.marine.ie/speciesdash/
- Digital Stockbook: Web application that makes biological fisheries data more available. This App allows people to explore the length, weight, and age data of commercial species that are caught around Ireland and allows the effects of factors such as year, sex, area, and gear on the fish to be investigated. https://shiny.marine.ie/stockbook/
- IGFS data explorer: The Irish Ground Fish Survey (IGFS) is part of an internationally coordinated series of demersal trawl surveys that provides data on fish stocks. This app allows users to explore the results of the survey using a number of tools. https://shiny.marine.ie/igfs/
- Cod tagging data portal: The Marine Institute, in partnership with AFBI and CEFAS, are conducting a cod tagging project in the Irish Sea. This graphical, data-driven tool allows users to look at the data collected including recaptures, tagging events and gear of tagging vessel. https://shiny.marine.ie/tagging/

Under its previous terms of reference, WGSFD made considerable progress towards defining "best practice" for the use of VMS data, and a draft paper for publication in a peer-reviewed journal was in development. This process was halted in order to ensure that a solution to the issues around protection of anonymity which did not contradict existing positions on this problem, raised by the Regional Coordination Groups in 2019, could be found. At its 2019 meeting WGSFD considered this problem and proposed a number of suggestions on how it can be best addressed. This task can therefore be revived from the previous terms of reference and addressed during the remainder of this group's mandate.

3 Summary of Presentations

3.1 Understanding the effects of electronic monitoring (EM) on fleet dynamics within the Scottish demersal fleet

Helen Holah

An analysis of historical electronic monitoring (EM) data from Scottish vessels who participated in the Scottish cod Catch Quota Management Scheme (2009–2016) is currently in progress. Participating vessels were awarded additional cod quota as well as extra days at sea in exchange for operating a cod discard ban. This work is looking for evidence to support anecdotal feedback from skippers that the conditions of the scheme led to adaptations in fleet dynamics. The behavioural changes reported included spatial displacement from known areas of juvenile cod aggregation as well as increased fuel costs as a result of more frequent/longer movements between fishing events. Preliminary exploration of VMS data for this fleet suggest that vessels who volunteered to participate in the scheme exhibited a different spatial distribution of fishing effort (more northerly and easterly) to non-participating vessels utilising the same gear types and targeting the same demersal mixed fishery prior to registering for the scheme. This has highlighted the broad spatiotemporal variability within a fleet. Further work will look to model the spatial distribution of fishing effort with surveyed cod abundance to explore the relationship between spatial use and selectivity. The aim of the project is to identify any area displacement as a result of a discard ban style management approach, considering potential contributing drivers and how this could inform the application of the landing obligation.

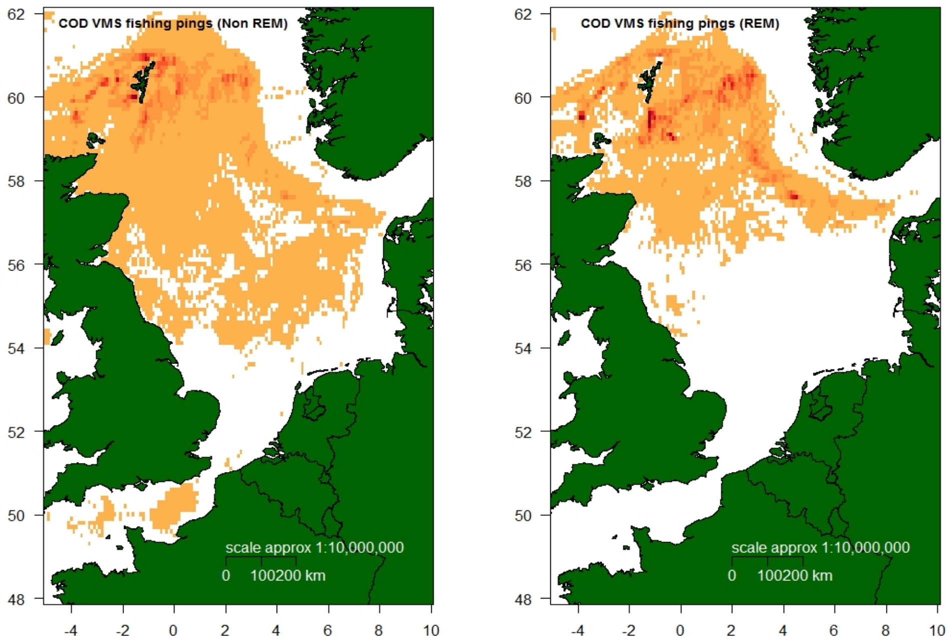

Figure 45. Location of VMS fishing activity (2006–2015) associated with cod landings for vessels in the Scottish demersal bottom-trawl whitefish fleet (left) and those vessels within the fleet operating with electronic monitoring systems during the Scottish cod catch quota management scheme.

3.2 Scottish Razor Clam Electrofishing Trials: Spatial Data Analysis

Neil Campbell

Marine Scotland is currently overseeing a trial fishery for razor clams (*Ensis* sp.). Vessels are allowed to fish in a number of "trial areas", within "production areas" in which water quality is certified for shellfish production. The fishing method used in this trial involves the use of an array of electrodes drawn behind an anchored vessel which cause the razor clams to emerge from the substrate, whereupon they are collected by divers and delivered to the surface. Vessels involved in the trial are typically small inshore boats which are too small to be required to submit VMS data. As a condition for participating in the trial, however, vessels are required to use electronic monitoring systems to record and transmit to a fishery monitoring centre their position, speed, and fishing activity status (determined through the electrical current being generated on board the vessel) every two minutes. This allows the precise determination of the fishery footprint, including the number of times a given area of seabed is crossed by the electrode array in a given period. This work is still in its infancy, however the aim is to link spatial fisheries information to ongoing work examining stock status to determine what impacts fishing may be having (e.g. sequential depletion) and may form a basis for investigating any impacts on the seabed more generally.

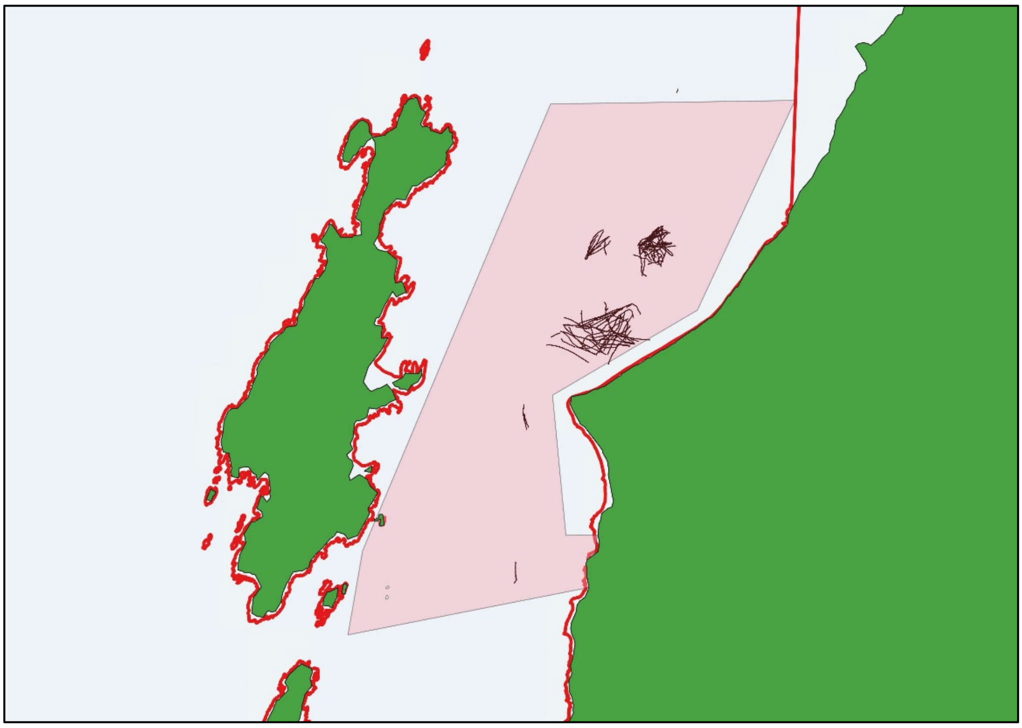

Figure 46. Location of Razor clam fishing operations within a trial area (pink polygon) and a production area (red lines). Electronic monitoring data will allow a fine scale definition of the footprint of the fishery to be determined.

3.3 The long way towards a joint recommendation for Natura 2000 fisheries management measures in the German EEZ of the North Sea

Torsten Schulze

The principal objective of sites selected as part of Natura 2000 is to achieve or maintain a favourable conservation status of habitats and species named in the EU Birds and Habitats directives. In the German exclusive economic zone, the habitat types protected by this legislation include sandbanks and reefs; while protected species include marine mammals, seabirds, and specific migratory fish species.

Assessments of fishing impacts on Natura 2000 sites require basic data on the conservation status of individual habitats and species, as well as data for fine-scale distributions of ongoing fishing activities, which can be drawn from VMS data (e.g. Figure 59). This presentation described the process used in developing fishery-management plans for each Natura 2000 site in German offshore waters, using VMS data to analyse fishing behaviour in order to address two questions:

- Where protected goods may be impacted by the fisheries?
- How does proposed management influence the fisheries sector?

The Joint Recommendation submitted to the EU Commission as a result of this process represented a compromise between protecting the sea floor, birds and marine mammals, whilst taking into account the economic consequences of management for the fisheries.

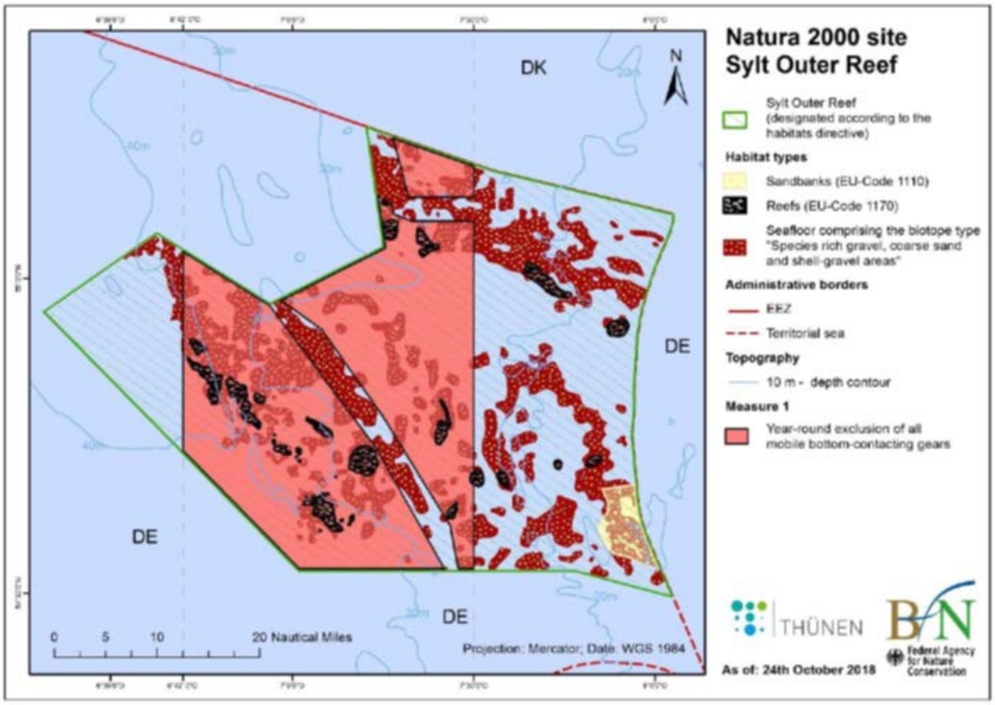

Figure 47. Measure 1 - year-round exclusion of all mobile bottom contacting gears in the three management zones within the central area of the Natura 2000 site, Outer Sylt Reef.

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Annex 2: Resolutions

2018/MA2/HAPISG03 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	Interim report by 15 August	
Year 2020			Interim report by Date	
Year 2021			Final report by Date 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 further evaluate whether these parameters can be	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

		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 NEAFC areas using the VMS and logbook information collected by NEAFC. These maps should be made available to WGDEC to ensure they can be combined by WGDEC with new information on distribution of vulnerable habitats.	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 Regulatory Area and the above mentioned objectives*." 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).	NA	year 1	Maps provided to WGDEC by 30 May 2019.

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.

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: Recommendations

RECOMMENDATION	ADRESSED TO
1. WGSFD recommends the establishment of a VMS Governance Group within ICES to develop a governance framework setting out a forward looking plan, including objectives of the VMS and logbook database, including responsibilities, processes and resources, to provide a platform for user feedback on the VMS and logbook database, to oversee and advise on the interpretation and prioritisation of recommendations and requests addressed to the VMS and logbook database and to oversee development of user data submitter guidance and training for the VMS and logbook database.	SCICOM
2. WGSFD recommends the static gear questionnaire be circulated to data providers to assess the quantity and quality of information currently collected on effort by static gears as a precursor to the development of VMS-based effort metrics. It is anticipated that working group members will bring data underlying the responses to this questionnaire to the next meeting in order for a the needs and requirements of a comprehensive static gear data call to be evaluated.	ICES Secretariat
3. WGSFD recommends to ICES Data Centre the use of an open source spatial database (PostgreSQL/PostGIS) to complement the current analysis done in SQL and R programming language. This would allow to store the data in spatial format and run spatial analysis required in task related to SFD TOR's. It would support as well the transparency framework in order to provide the SQL scripts related to the calculation of swept area ratio ready to use in an open source database.	ICES Data Centre
4. WGSFD recommends to ICES Data Centre the implementation of R Shiny Server to develop collaborative web tools using R programming language to support the data call quality control processes.	ICES Data Centre

Annex 4: Economic Questionnaire

In relation to the assignment of values to landed catches, working group participants were asked to answer the question:

- *"How was the value of landings assigned?"*

The responses received are listed below.

Country	Response
Denmark	Sales notes are merged with logbook data on trip level, and the value of landings split out on logbook data by landings weight. When coupling with VMS data, the value of landings is split out like the weight of landings by vessel and fishing day. DKK is converted to EUR using the conversion factor 7.45.
Iceland	For Iceland these statistics are not readily available and hence not reported in the data call.
Netherlands	We use average monthly prices for species and multiply these with the KG is the logbooks
Lithuania	Based on sales notes the average price by species, presentation and region is computing by dividing the total value of fish available for sale by the total weight available for sale during certain year.
Latvia	The data about prices per commercial species are collected from two data sources: Sale notes and state questionnaire form "1-Fishery" (participation of the responders is obligatory according to the Latvian legislation). The collected prices data are analysed and the most reliable prices used in the calculation of average price. Total value per species= landings per species (kg) * average price per species
Poland	Based on sales notes, we calculate the average price per species per year (EUR = PLN * average annual exchange rate), and then we multiply it with landings.
France	A specific algorithm is included into the SACROIS application to estimate the value of landings based on sales note data available (sometimes directly deducted from them) or estimation of an average price. For some fleet segment, estimated price based on expert knowledge is used to estimate the value.
Finland	The value of catches landed in Finland is calculated separately for each species by multiplying the average annual prices paid to fishermen with the quantity of the landings. The value added tax is excluded from the value of catch. The statistics of the prices for fish is annually published by the Natural Resources Institute Finland. The shares of Baltic herring landed in Finland for food and industrial purposes of the total catch are estimated on the basis of fish purchasing information received from the national central control register on commercial fishery.
Estonia	Calculations in Estonia are based on sales notes. Average price per species per year is multiplied with landings
Germany	Sales notes are merged with logbook data on trip level, and the value of landings split out on logbook data proportional to catch weight.
United Kingdom	Up to mid-2017, landing declarations and sales notes were cross referenced and the values were based solely on sales notes. This caused some problems where sales notes weren't supplied. A new system was implemented which aimed to fill in any gaps using average prices whilst sales notes were obtained, giving two potential value columns – reported value and estimated value. There are still some quality issues with this system, however in summary, we use sales notes as the primary source of values.

Annex 5: Static Gear Questionnaire

The ICES Working Group on Spatial Fisheries Data seek information on the availability of additional parameters on the use of static fishing gears to enable the development of indicators for spatial effort, habitat impact, marine litter and bycatch risk for the fishery.

Static gears can be defined as gillnets and entangling nets (GNS, GND, GNC, GNF, GTR, GTN, GEN, GN), pots and traps (FPN, FPO, FYK, FWR, FAR, FIX, FSN), passive hooks and lines (LLS, LLD, LL, LTL, LX), and active hooks and lines (LHP, LHM)

Respondents are asked to complete the questionnaire below indicating the availability of relevant data sources to assist in the development of these indicators. Any further relevant information which may help this development should be recorded in the additional comments column. If a given gear type is not present in your fishery please indicate N/A in further comments. If different information is available for different fleet segments please add another line.

Question	Yes/No	Applicable fleet segments (<8m, 8-10m, 10-12m, 12-15m, >15m, All)	Source of data (census, survey sample, expert estimation, proxy, other (please describe))	Spatial coverage (e.g. nationwide, regional project, specific fishery etc)	Timespan of data	Spatial resolution (e.g., ICES rect, lat/long/c-square	Additional comments
Q1. Quantity of gear							
Gillnets and entangling nets - total length	Yes	All	Survey samples	Nationwide	2009-2019	Lat/long	
Pots and traps-total number	No	X	X	X	X	X	
Passive hooks and lines - total number of hooks	N/A						No fishery
Active hooks and lines- total number of hooks							
Q2 Soak/Fishing time						N/A	
Gillnets and entangling nets						N/A	
Pots and traps						N/A	
Passive hooks and lines						N/A	
Active hooks and lines						N/A	
Q3 Gear dimensions							
Gillnets and entangling nets							
a) number of panels						N/A	
b) mesh size						N/A	
c) height of net in meshes						N/A	
d) deployed height of net						N/A	
Pots and traps							
a) Pot dimensions (length, width, height)							
b) Entrance diameter							

Question	Yes/No	Applicable fleet segments (<8m, 8-10m, 10-12m, 12-15m, >15m, All)	Source of data (census, survey sample, expert estimation, proxy, other (please describe))	Spatial coverage (e.g. nationwide, regional project, specific fishery etc)	Timespan of data	Spatial resolution (e.g., ICES rect, lat/long/c-square	Additional comments
c) Total length of pot strings							
Passive hooks and lines							
a) Total length of lines							
b) Size of hooks						N/A	
Active hooks and lines							
a) Size of hooks							
b) bait or lure							
Q4 Technical bycatch mitigation devices (if yes, please describe types in additional comments)							
Gillnets and entangling nets							
Pots and traps							
Passive hooks and lines							
Active hooks and lines							
Q5 Quantity of lost or abandoned fishing gear							
Gillnets and entangling nets							
Pots and traps							
Passive hooks and lines							
Active hooks and lines							

Annex 6: Audit trail of VMS data processing and quality check

Description of QC process (31 March-23 June 2019)

All received data were quality controlled. Data which failed quality control were referred back to the submitting country for correction and resubmission (correction). In some cases, issues were acknowledged and no resubmission was required (annotation). All countries from which data were received eventually passed quality control. 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
Number of distinct vessels not reported ICE,FRA,ESP,	Acknowledged at national level and data resubmitted	
Partially missing VMS records from 2009–2018	Acknowledged at national level and data resubmitted	
Global spatial extent of data submitted	Acknowledged at national level and data resubmitted	Acknowledged at the quality check of the overall dataset, the national data submitters rechecked their procedure and found that it was working as it should – no change to submission
Missing VMS records mean prevents evaluation of trends and outliers.	Acknowledged at national level and data resubmitted from missing years	
Steaming positions not filtered out at national level.	Acknowleged at national level, data was re-submitted with steaming positions filtered out.	
Higher average fishing speed than usual		Acknowledged at national level and confirmed it is correct.
Average effort lower than in previous years	Acknowledged at national level and data resubmitted	
Big increase in OTB effort and a similar decrease in TBB in VMS data not observed in logbook	Acknowledged at national level and data resubmitted	Acknowledged at national level. Confirmed it is correct and due to a shift in target species.
Average fishing speeds show 2 peaks	Acknowledged at national level and data resubmitted	

No landings by SSC in 2009		Acknowledged at national level and confirmed value is correct.
Abnormal patter of landings by DRB		Acknowledged at national level and confirmed value is correct.
Abnormal value per KW per fishing hours per year for a number of gears	Acknowledged at national level and Acknowledged at national level, detected problem and resubmitted data	
Abnormal pattern of Average price (EUR/Kg) for gear		Acknowleged at the national level that confirmed pattern.
Abnormal Kg landed data in lobgook		Acknowleged at the national level that confirmed pattern.
Abnormal value by gear by year (FIN)		Acknowleged at the national level that confirmed value.
Lack of VMS records for vessels between 12 and 15 meters		Acknowleged and confirmed at the national level. Vessels between 12-15m can request exemption to atach VMS equipment.
Abnormal logbook figures for SSC through the years (2009-2018)		Acknowleged and confirmed at the national level. Data from small scale fisheries is more precise from 2014 onwards
Drop in the number of records for 2013		Acknowleged at the national level that confirmed value. Due to a decline in number of fishermen.
Spatial extent for 2009 contains some erroneous values		Acknowledged at the national level. Data submitters rechecked their procedure and found that it was working as it should – no change to submission
Unconsistent landings across gears and years		Acknowledged at national level. To be improved in next submission
No rectangle assigned in logbook		Acknowledged at national level. Not able to correct these records
Logbook inconsistency high values in fishing days, kg landed, no value data		Acknowledged at national level. Information not available at the moment.
Lack of VMS data for a number of gears	Acknowledged at national level and data resubmitted	
Inconsistent average price and EUR/Kw for SV and LLS		Acknowledged at national level that confirmed fluctuation of these fisheries.
Only VMS records for OTM submitted in 2018	Acknowledged at national level and data resubmitted	

Transect pings detected in some VMS records	Acknowledged at national level and data resubmitted	
Abnormal drop in landings value for OTB and increase in demersal seines		Acknowledged at the national level. Data submitters rechecked their procedure and found that it was working as it should – no change to submission
Changes in average fishing speed distribution		Acknowleged at the national level that confirmed it is due to differences in the script version.
Abnormal landings/values in some gears		Acknowleged at the national level that confirmed values are based on coastal logbook
Different VMS record per length category		Acknowleged at the national level that confirmed value due to a reduction of that fleet segment
Increase in the amount of VMS records submitted		Acknowleged at the national level that confirmed that value is due to an increase in the ping rate of VMS.
Unknown gear types	Acknowleged at national level, and corrected data was resubmitted	
VMS records not in ICES rectangle	Acknowleged at national level, and corrected data was resubmitted	
Unknown gear types reported	Acknowleged at national level, and corrected data was resubmitted	
VMS records from vessels with no recorded length	Acknowleged at national level and corrected data was resubmitted	
Abnormal patter for landing/all gears	Acknowledged at national level and data resubmitted	
Abnormal trend for EUR/KWh for a number of years DK	Acknowledged at national level that confirmed value as change in gear code. Corrected data was resubmitted	
Big jump in max fishing hours recorded		Acknowleged at the national level that confirmed value.
Abnormal spatial distribution of effort by year maps		Acknowleged at the national. Data submitters rechecked their procedure and found that it was

		working as it should – no change to submission
A change in metier identification in 2012-2013 was detected.	Acknowleged at national level, and corrected data was resubmitted	
No information on value in submission		Acknowleged, and it was confirmed that member country do not use landing statistics but reports value in logbooks.

Annex 7: Final analysis of NEAFC VMS data and production of maps of bottom contacting fishing activity in NEAFC areas in support of WGDEC

Provision of new information on VMEs in the NEAFC Convention Area and EU waters, review of fishing activity in NEAFC waters and drafts of NEAFC and EU VME advice (WGDEC ToR B)

Provide all available new information on the distribution of vulnerable habitats (VMEs) in the NEAFC Convention Area. Using the most recent NEAFC spatial layers of fishing activity analysed by WGSFD, produce a first draft of the annual NEAFC VME advise for further consideration by a review group (RGVME) and advisory committees advice drafting group (ADGVME). In addition, provide new information on location of habitats sensitive to particular fishing activities (i.e. vulnerable marine ecosystems, VMEs) within EU waters; and produce a first draft of the annual EU VME advice for further consideration by a review group (RGVME) and advisory committee advice drafting group (ADGVME)

Joint report section with WGDEC 2019

4.1 Areas with new, historical or resubmitted VME data

This chapter is split according to areas within the NEAFC Regulatory Area and those areas within the EEZs of EU countries and wider. No new VME submissions were received for areas within the NAFO Regulatory Area.

Areas considered within the NEAFC Regulatory Area:

- Rockall Bank
- Hatton Bank
- North East Barents Sea

Areas considered within the EEZs of various countries:

- Faroe-Shetland Channel
- Rockall Bank
- Rosemary Bank Seamount
- Wyville-Thomson Ridge
- Irish continental shelf
- Spanish continental shelf (Gulf of Cadiz)
- Formigas Seamount
- Mid-Norwegian continental shelf
- Central Barents Sea and South West Barents Sea (Tromsǿ Flaket)
- North West Barents Sea (Svalbard)

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 Section 7 of the WGDEC 2018 report (ICES, 2018).

4.2 Areas considered within the NEAFC Regulatory Area

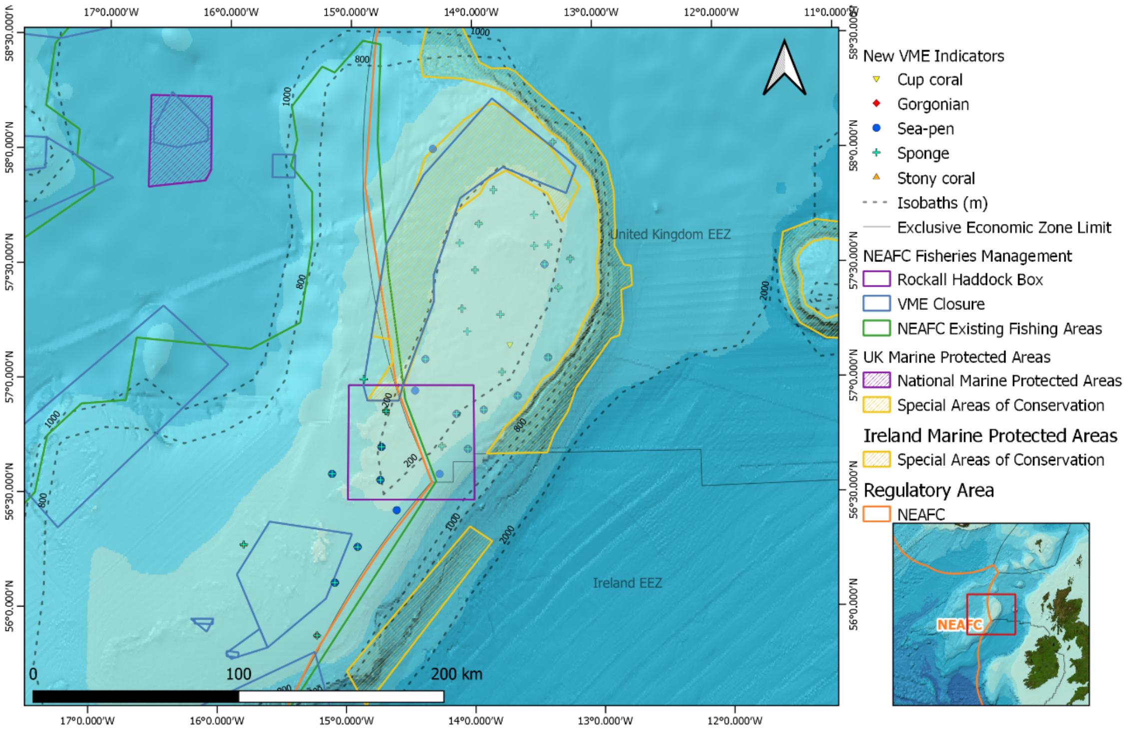
4.2.1 Rockall Bank

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 EEZ of both the UK and Ireland.

New VME indicator data within the NEAFC Regulatory Area on Rockall Bank were submitted by the UK (Figure 4.1). Records came from a Marine Scotland Science scientific bottom trawl survey (1318S) on the RV *Scotia*, as detailed in Section 3.3.1.

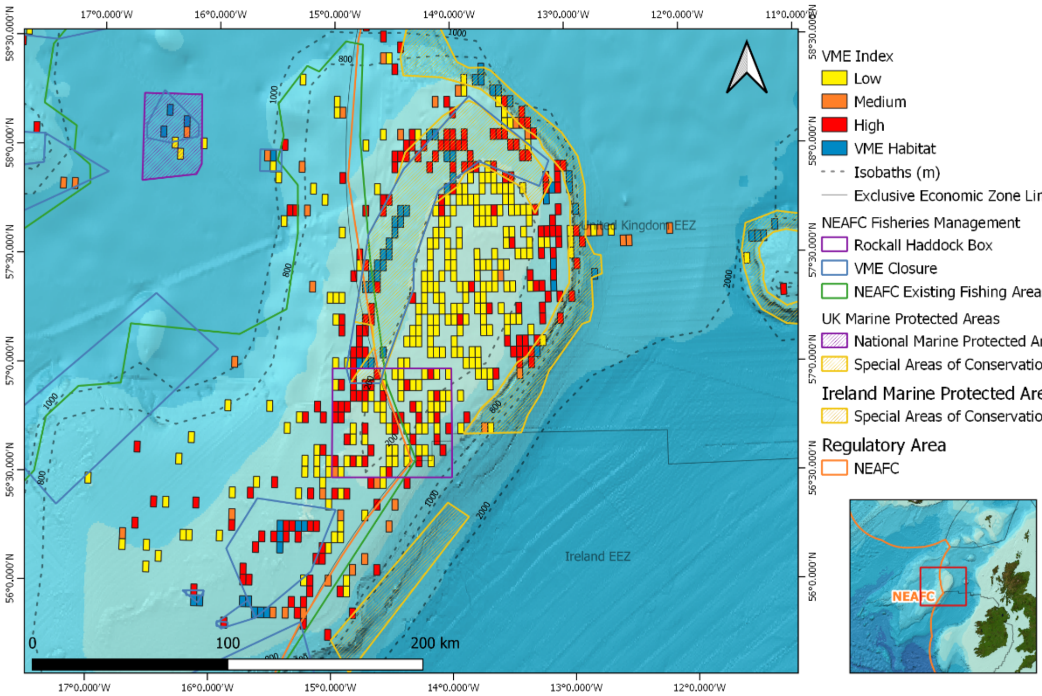
These new data have contributed to updated outputs from the VME weighting algorithm. The updated VME index for Rockall Bank (within NEAFC waters) is shown in Figure 4.2. The algorithm has a gridded output layer, which shows the likelihood of encountering a VME for each grid cell; either low (yellow), 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.



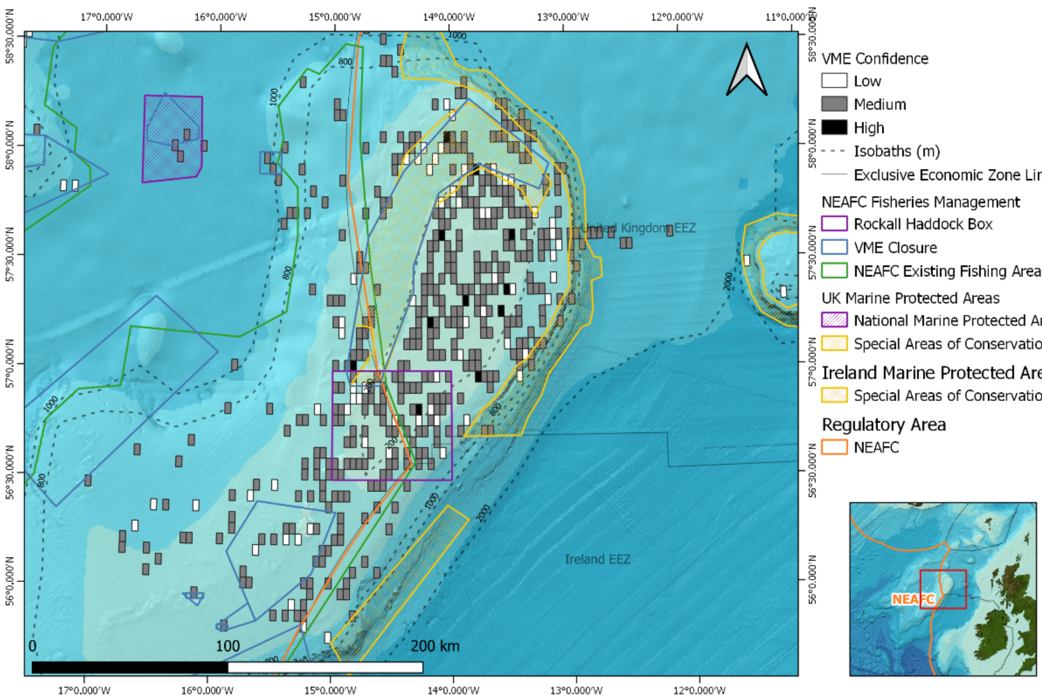
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.1. New VME records submitted in 2019 for Rockall Bank within the NEAFC Regulatory Area (new records outside the NEAFC Regulatory Area are displayed as transparent). Note, other (historic) VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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 2019) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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 2019) records from the ICES VME database.

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.

As noted in Section 3.3.8, records for Hatton Bank were re-submitted in 2019, following a review of data noted in previous WGDEC reports that did not appear in the ICES VME database. These data (Figure 4.4) were submitted by the UK for the 2019 data call from literature (Frederiksen *et al.*, 1992).

The weighting algorithm has been re-run to include these VME records, and the output is shown in Figure 4.5. The confidence layer for the VME index for Hatton Bank is shown in Figure 4.6.

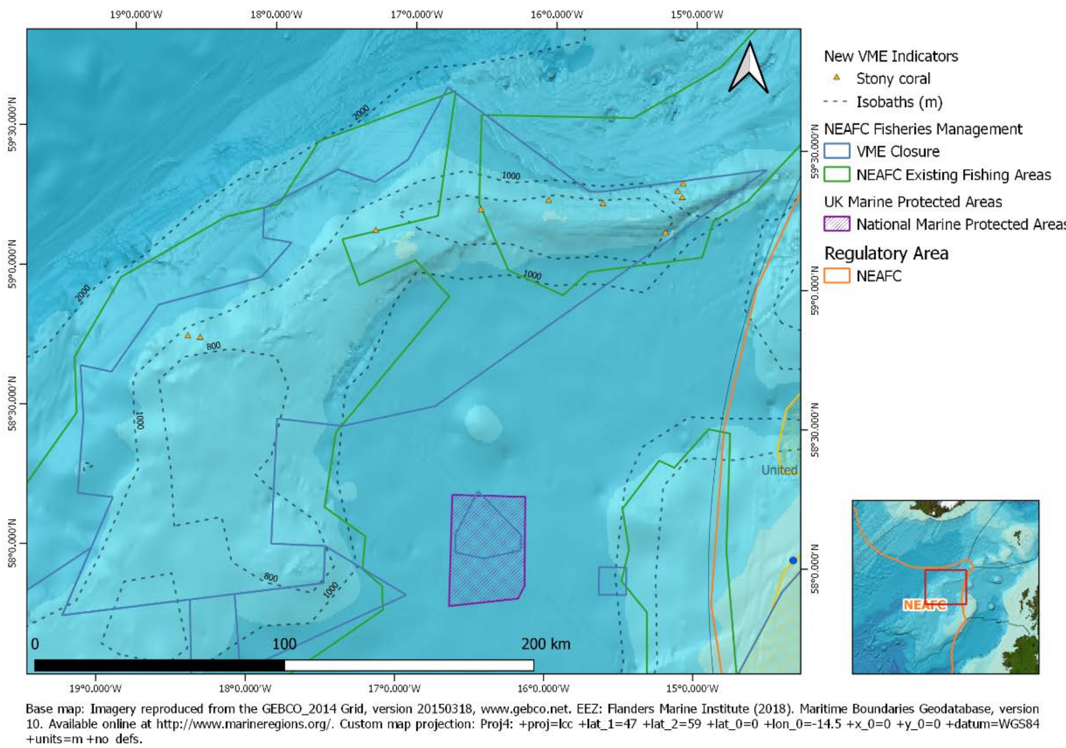
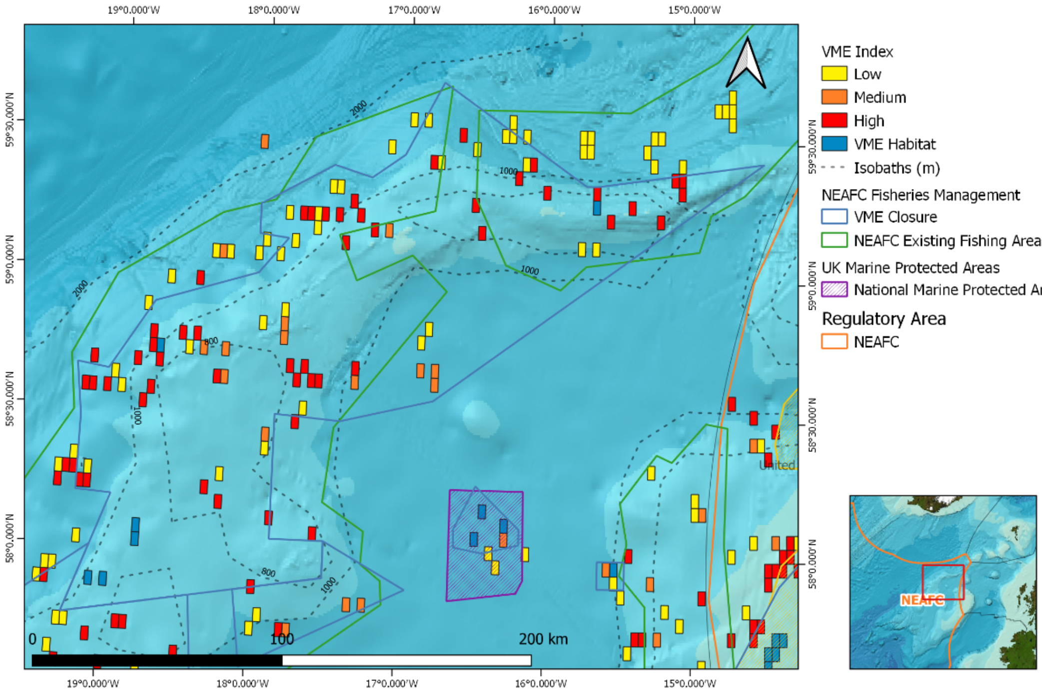
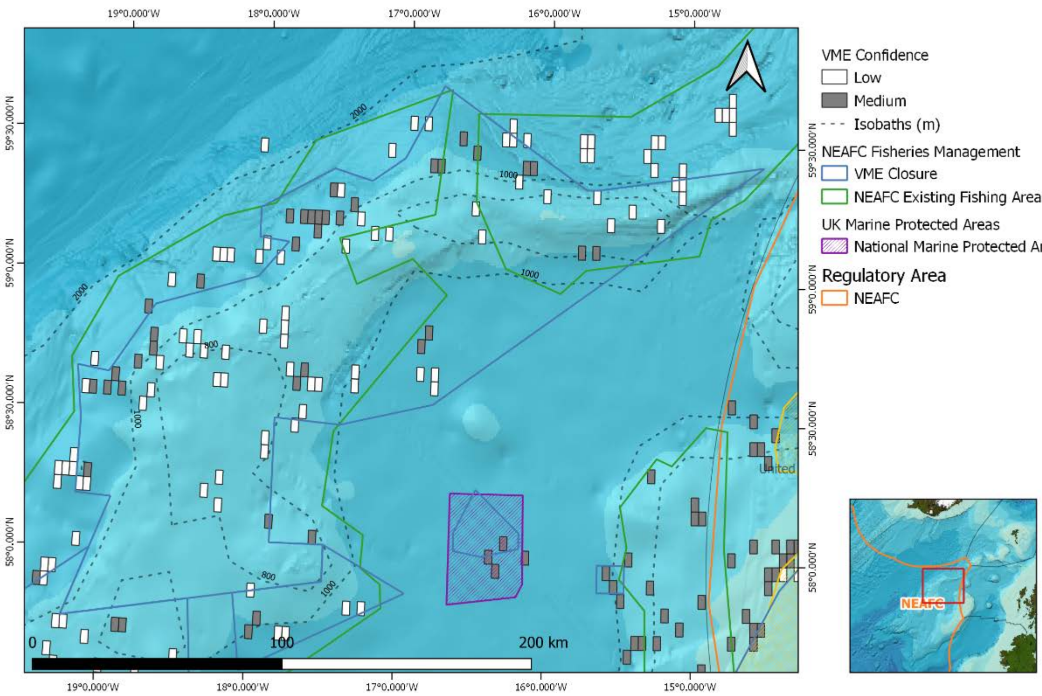


Figure 4.4 New VME records re-submitted to the VME database in 2019 for Hatton Bank within the NEAFC Regulatory Area. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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 2019) records from the ICES VME database.



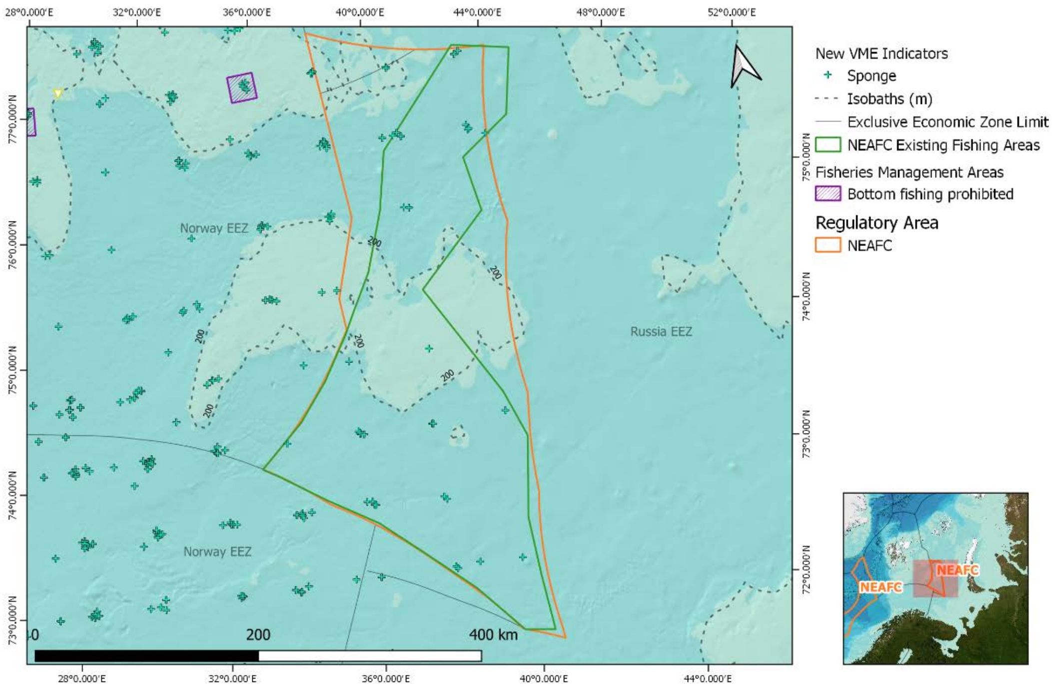
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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 2019) records from the ICES VME database.

4.2.2 North East Barents Sea

New VME indicator data were submitted by Norway for the North East Barents Sea within the NEAFC Regulatory Area (Figure 4.7). Data were from bottom trawls from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS) as detailed in Section 3.3.3.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.8, and the confidence layer for the VME index is shown in Figure 4.9.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.7. New VME indicator records (green crosses) submitted to the VME database in 2019 for the Central Barents Sea. The NEAFC Regulatory Area is shown as an orange line.

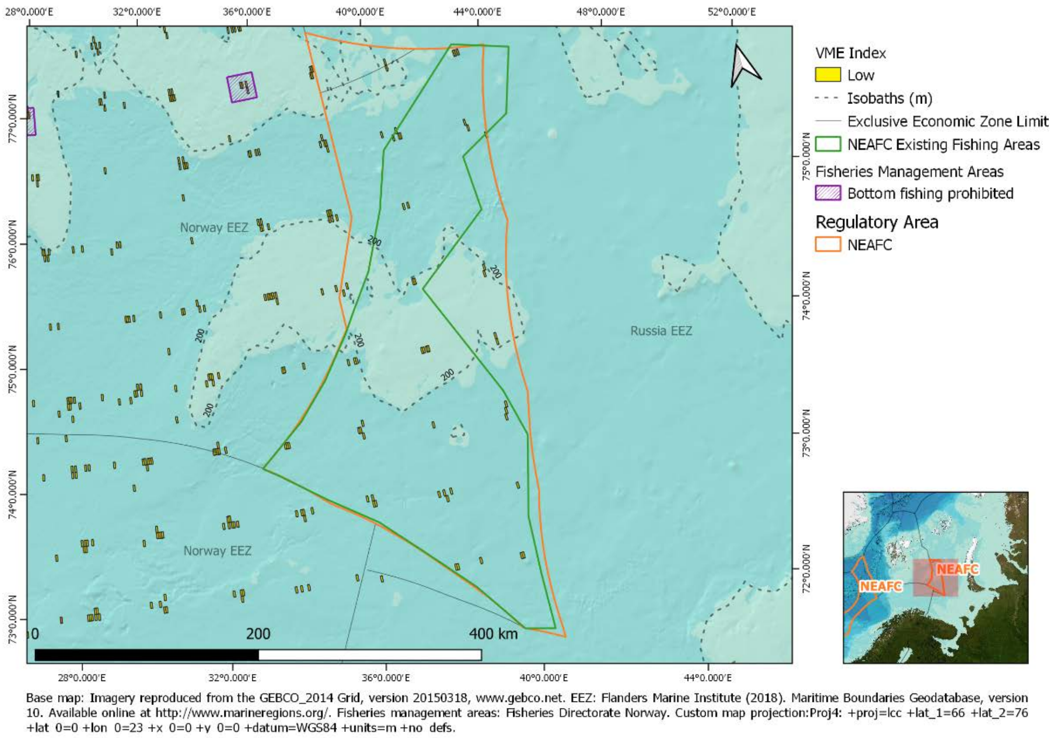


Figure 4.8. Output of the VME weighting algorithm for the area shown in Figure 4.7. Showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

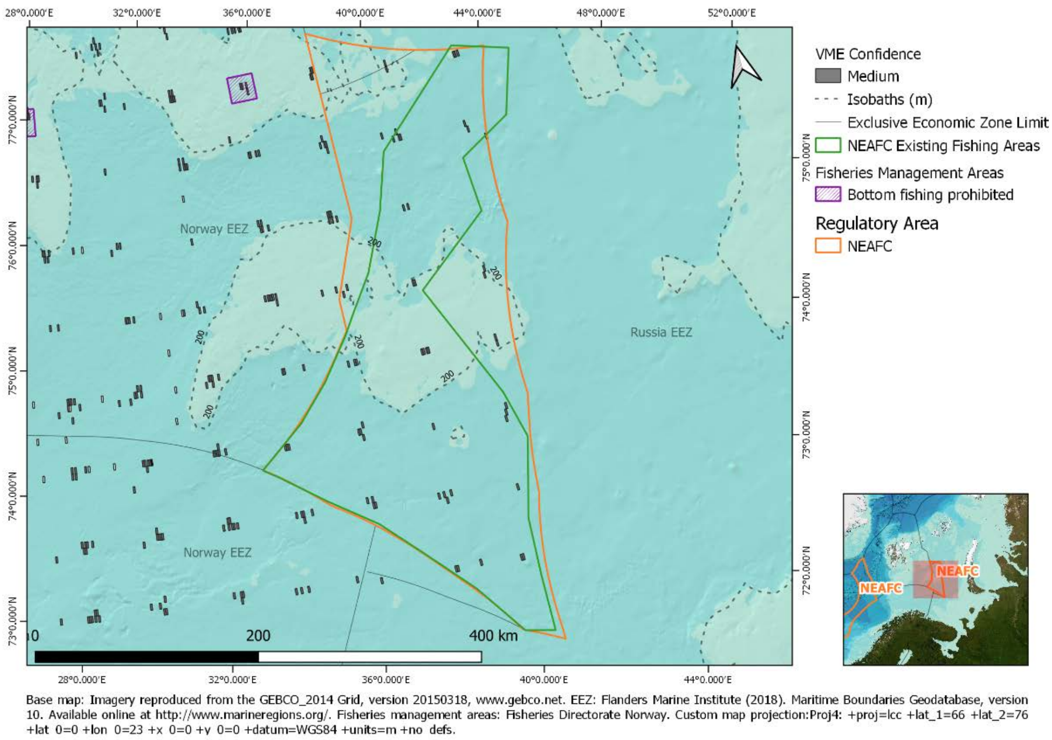


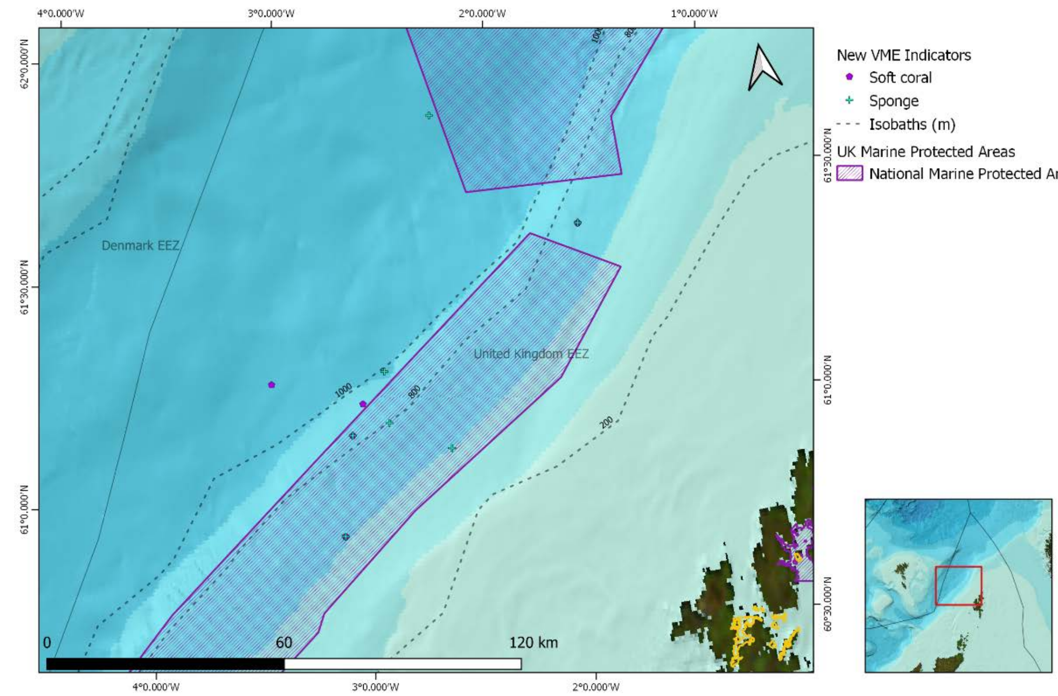
Figure 4.9. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.8). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating.

4.3 Areas considered within the EEZs of various countries

4.3.1 Faroe-Shetland Channel

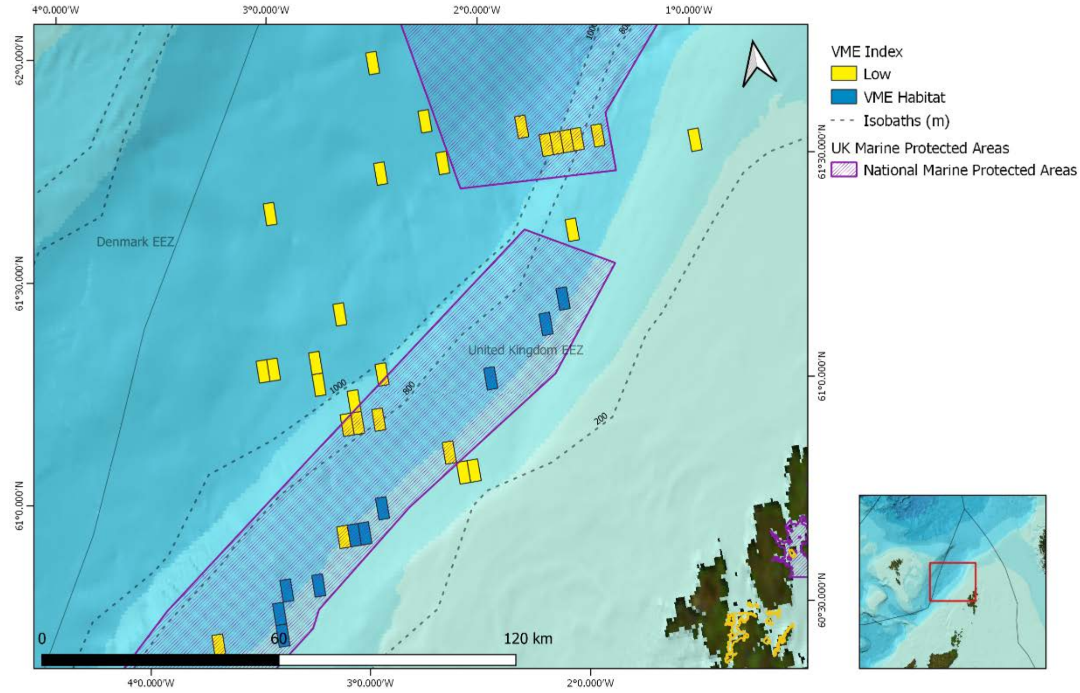
The Faroe-Shetland Channel is a deep channel located north of Scotland within the EEZ of two countries; UK and the Faroe Islands (Denmark). However, all new records submitted for this area occur within the UK EEZ (Figure 4.10). New VME indicator data submitted include sponges, soft corals, sea-pens and gorgonians, from a Marine Scotland Science scientific bottom trawl survey (1218S), as detailed in Section 3.3.1.

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.



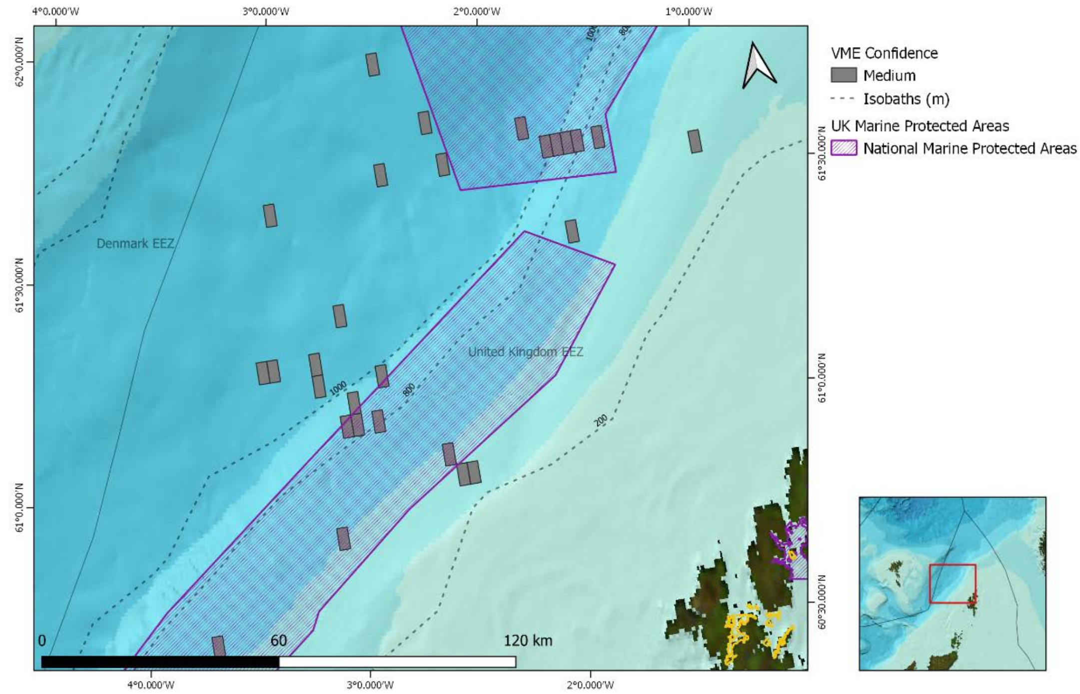
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.10.New VME records submitted to the VME database in 2019 for the Faroe Shetland Channel within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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. Note, this includes all (not only 2019) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

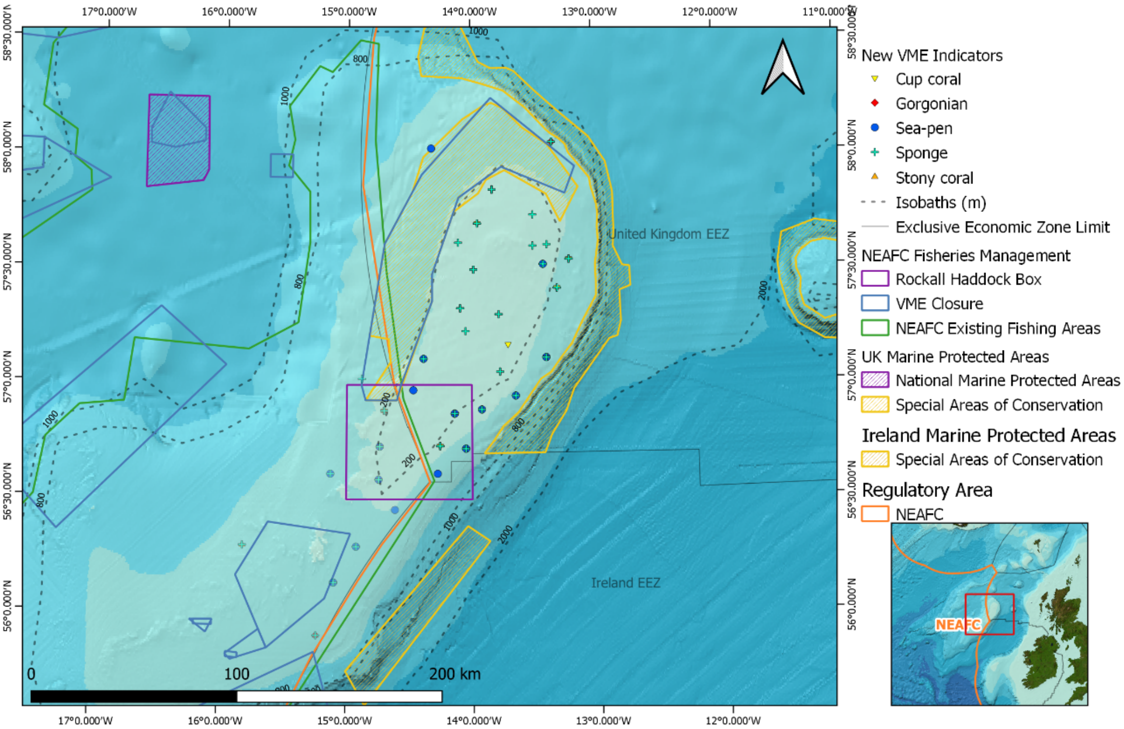
Figure 4.12. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.11). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.2 Rockall Bank

New VME indicator data was submitted during the 2019 data call for the area of Rockall Bank within the UK and Ireland's EEZ. Data was from a Marine Scotland Science survey (1318S) as detailed in Section 3.3.1.

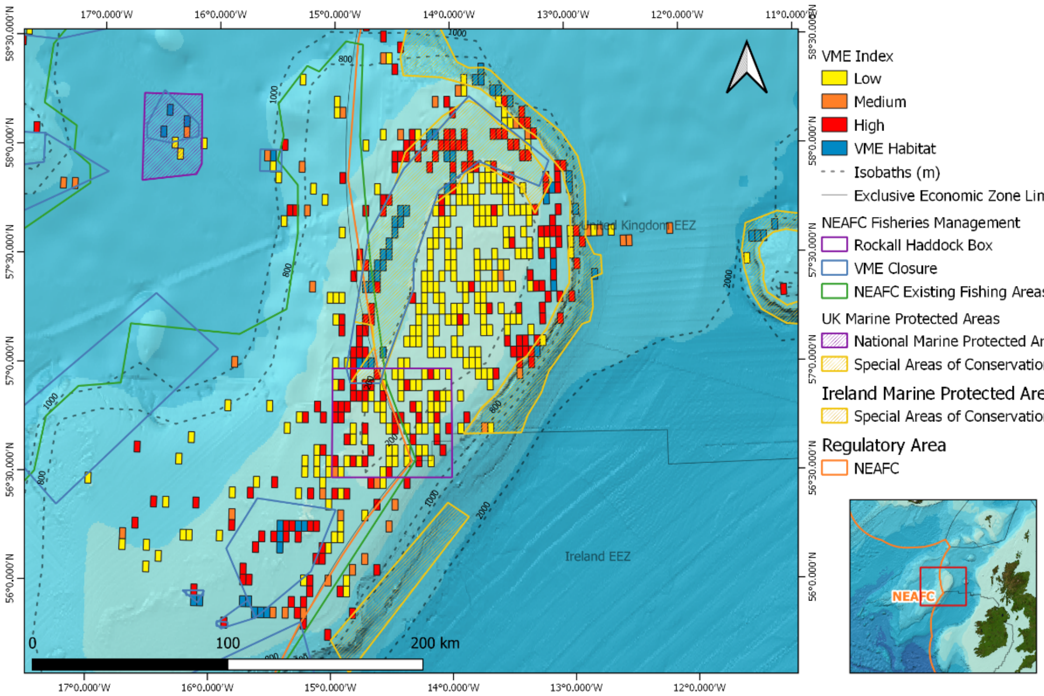
New records of cup corals, gorgonians, sea-pens, sponges and stony corals were collected from scientific bottom trawl surveys on the North East of Rockall Bank outside of the VME closure area and within the Haddock Box closure (Figure 4.13).

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.



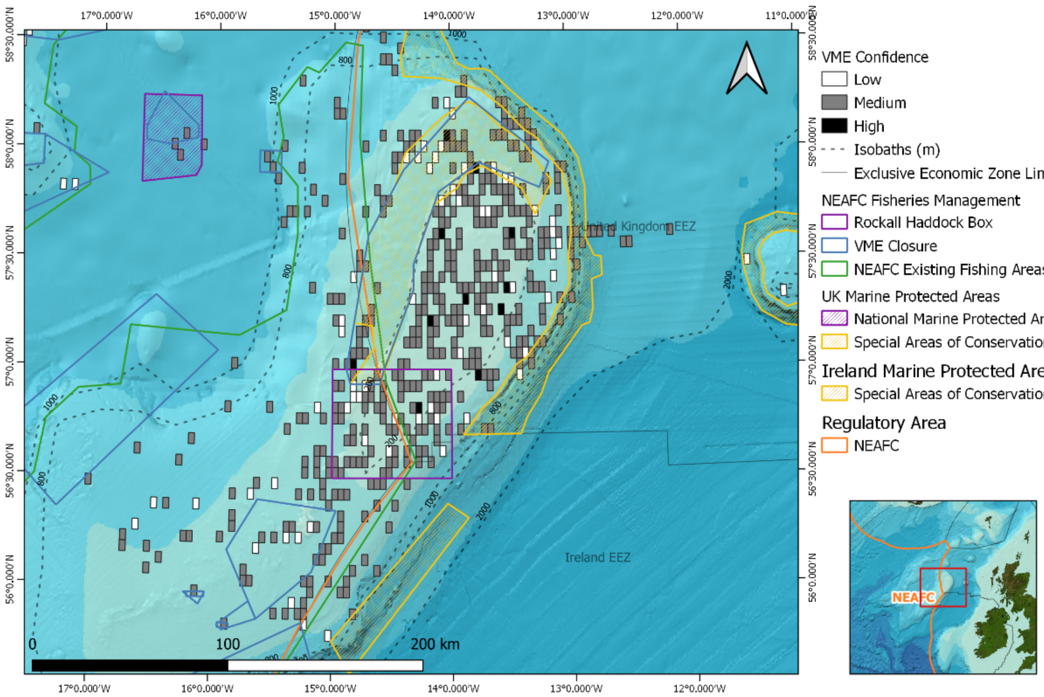
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.13. New VME records submitted to the VME database in 2019 for Rockall Bank within EU waters. Area (new records outside EU waters are displayed as transparent). Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

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); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.



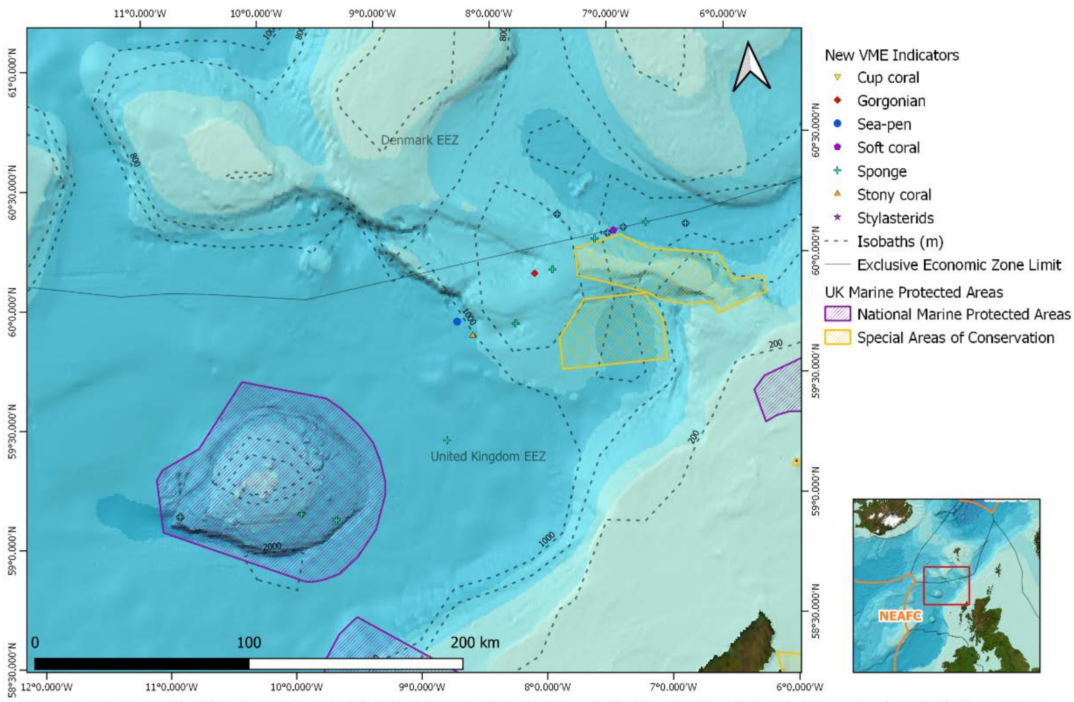
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.15. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.14). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.3 Rosemary Bank Seamount and Wyville-Thomson Ridge

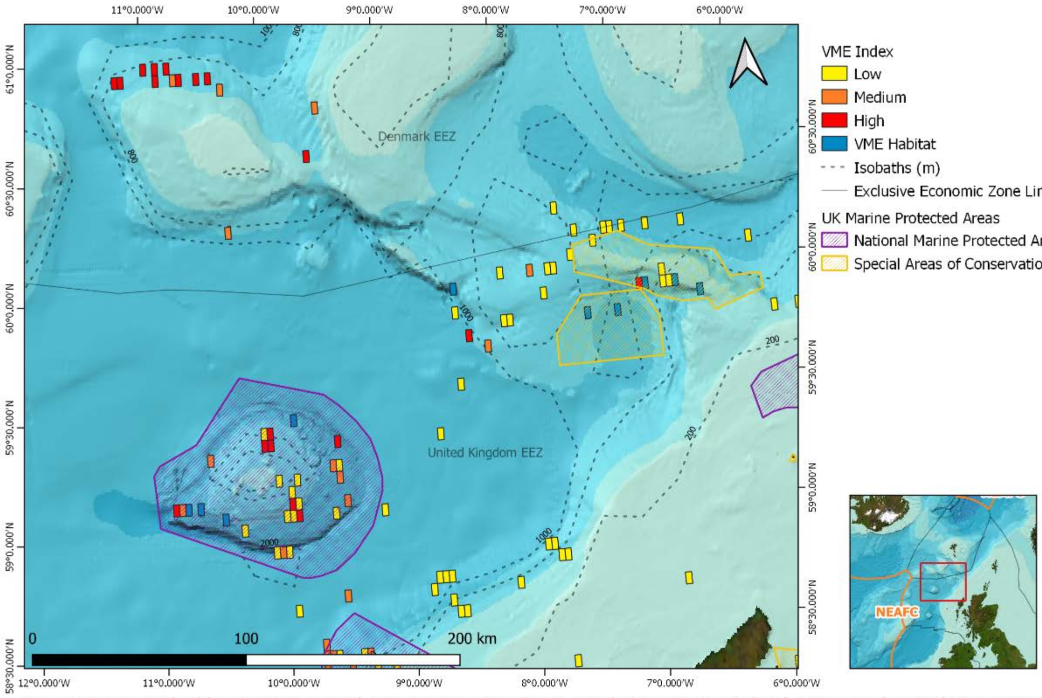
New VME indicator data were submitted by the UK for Rosemary Bank Seamount and the Wyville-Thomson Ridge, located to the northwest of Scotland within the UK EEZ. Additional records were submitted for an area to the northwest of Wyville-Thomson Ridge within the Faroese EEZ (**Error! Reference source not found.**). New VME indicator data were submitted from a Marine Scotland Science scientific bottom trawl survey (1218S), as detailed in Section 3.3.1.

Updated outputs of the weighting algorithm with these new VME data are shown in **Error! Reference source not found.**, and the confidence layer for the VME index is shown in Figure 4.18.



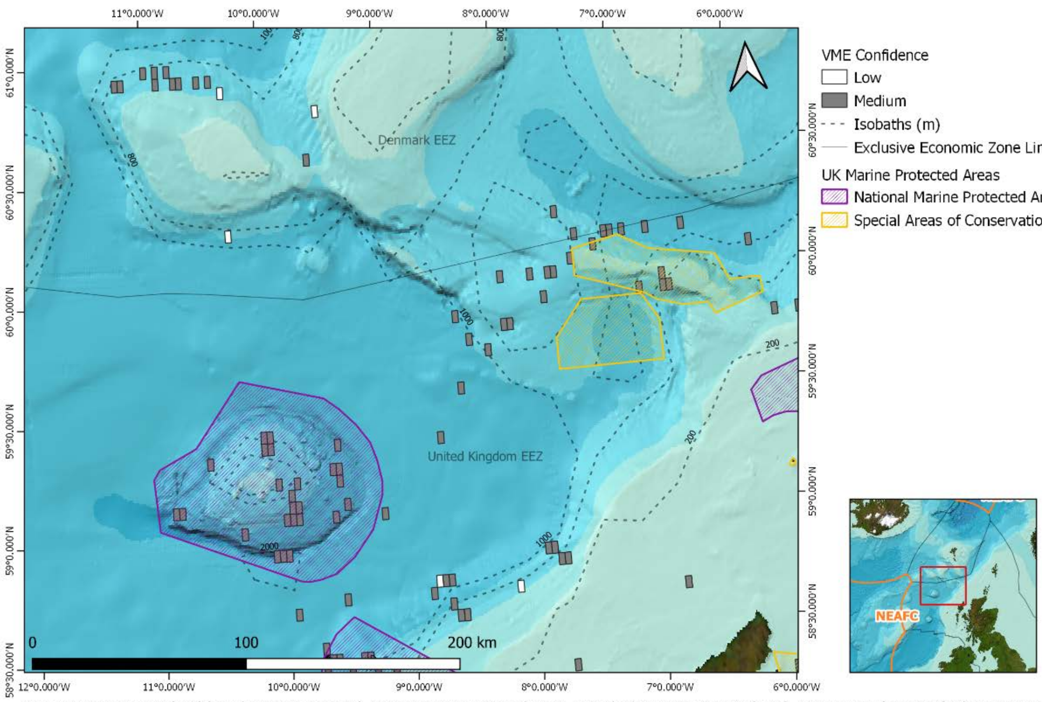
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.16.New VME records submitted to the VME database in 2019 for Rosemary Bank Seamount and Wyville Thomson Ridge within EU waters, and the Faroese EEZ. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.17. Output of the VME weighting algorithm for the area shown in Error! Reference source not found. **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 2019) records from the ICES VME database.**



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.18. The confidence layer associated with the VME weighting algorithm's VME Index layer (Error! Reference source not found.**). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.**

4.3.4 Irish continental shelf

New records of VME habitats were submitted for the Irish/Scottish Continental Shelf by Ireland's Marine Institute from the Marine Institute and INFOMAR 2017 SeaRover survey. These data were collected by ROV dives along the Irish Continental margin, see Section 3.3.4 and are shown in Figure 4.19 and Figure 4.22.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.20 and Figure 4.23, and the confidence layer for the VME index is shown in Figure 4.21 and Figure 4.24.

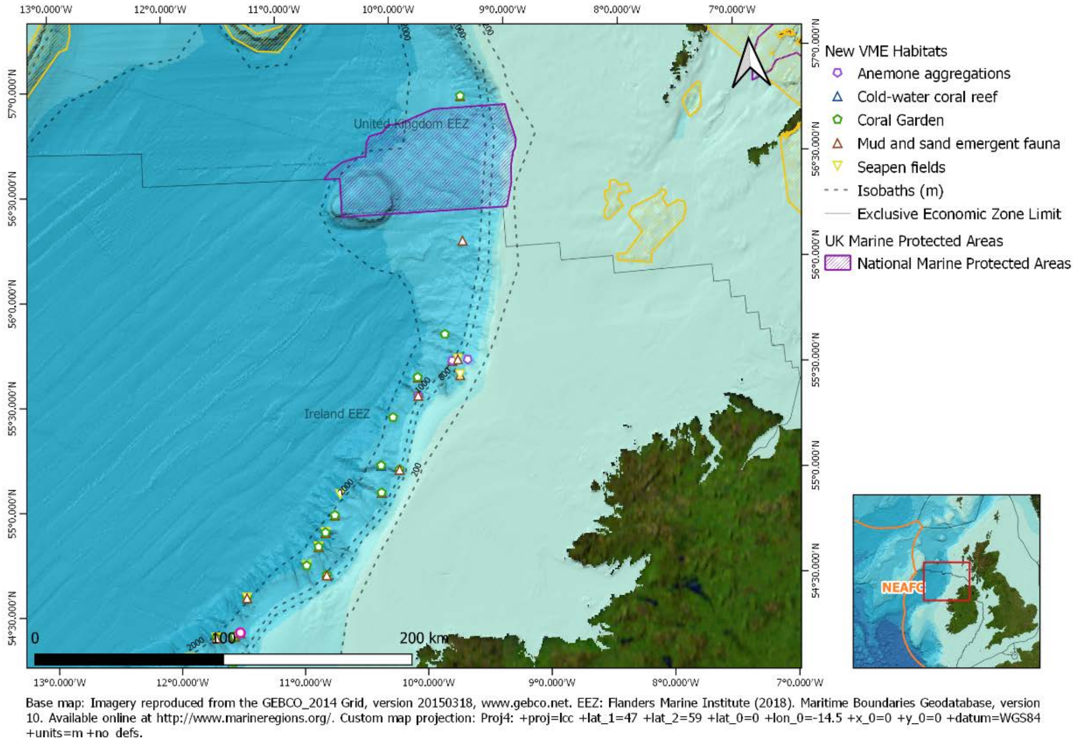
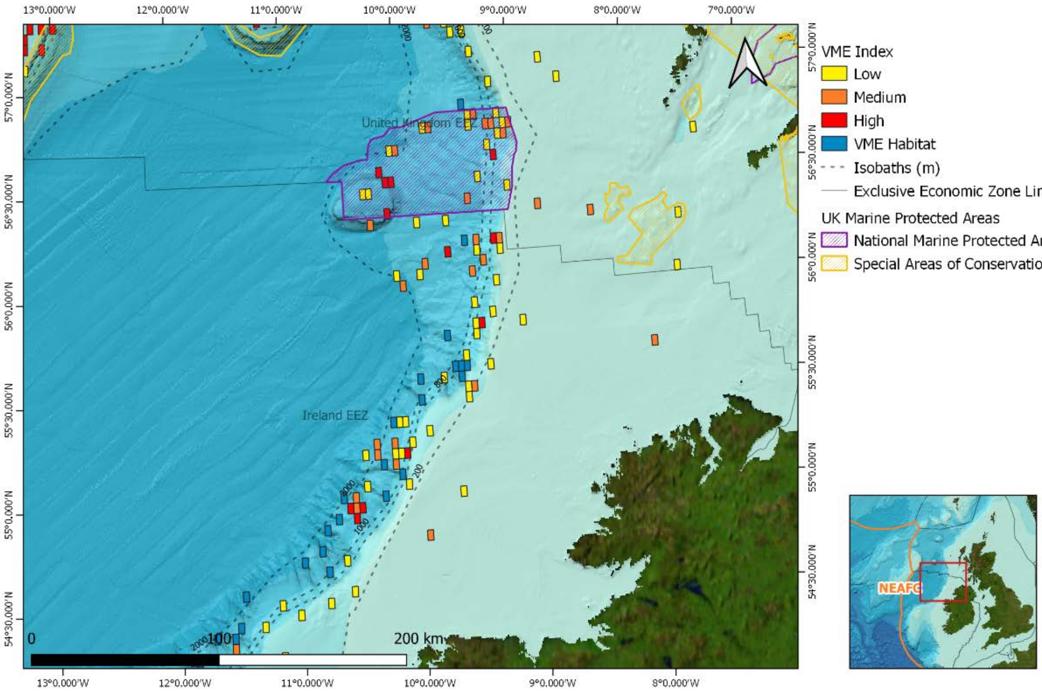
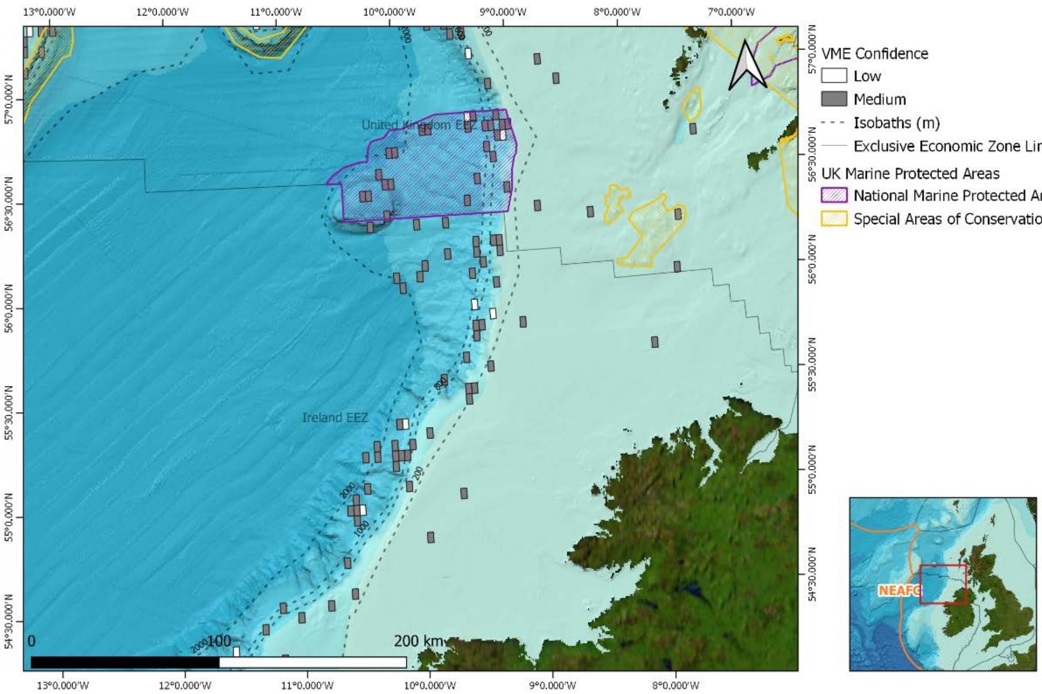


Figure 4.19. New VME records submitted to the VME database in 2019 for the Irish/Scottish Continental Shelf within EU waters (see also Figure 4.22)



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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); and presence of actual VME.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.21. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.20). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating.

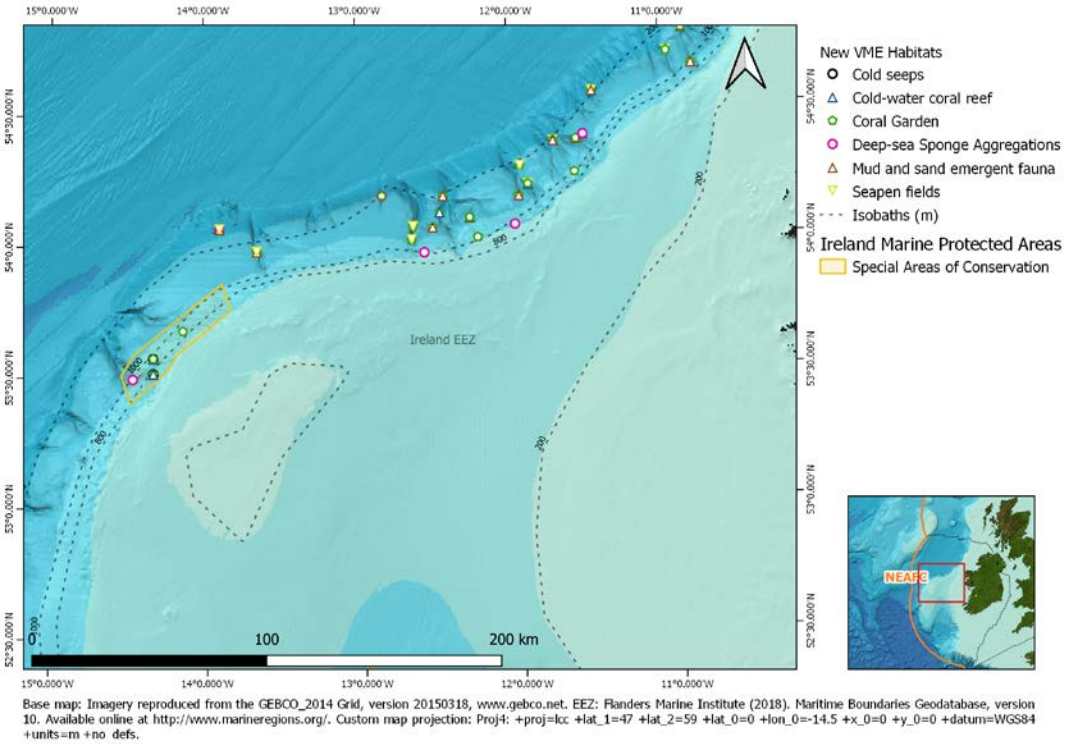


Figure 4.22. New VME records submitted to the VME database in 2019 for the Irish Continental Shelf within EU waters (see also Figure 4.19).

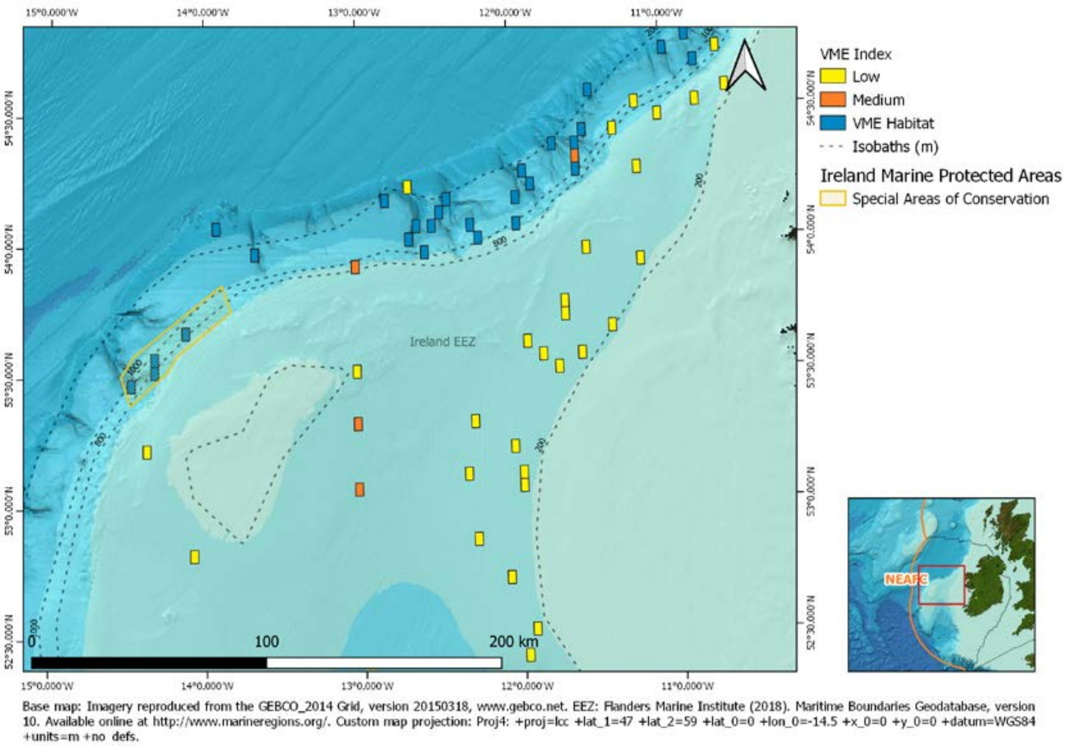
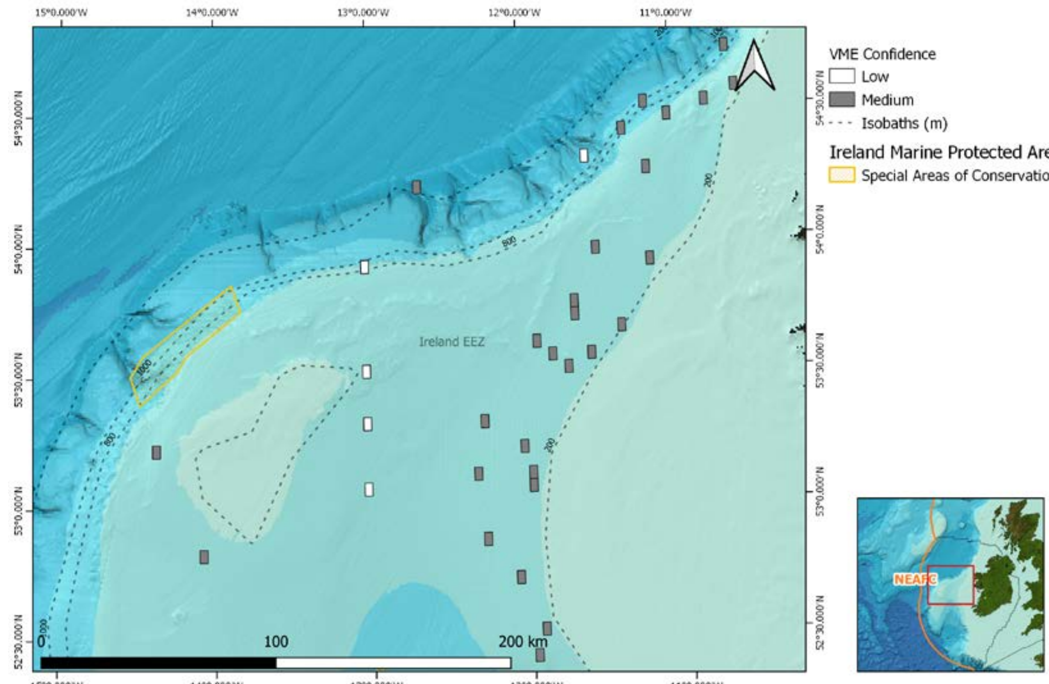


Figure 4.23. Output of the VME weighting algorithm for the area shown in Figure 4.22 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

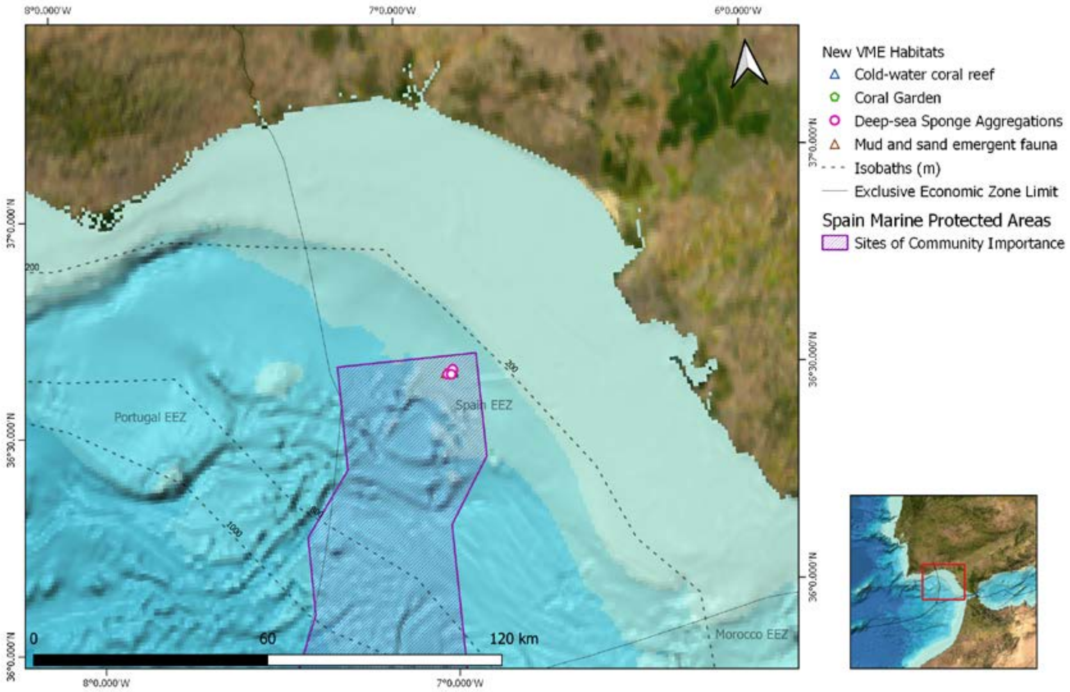
Figure 4.24. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.23). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating.

4.3.5 Spanish continental shelf (Gulf of Cadiz)

Gazul is a Mud Volcano located in the Gulf of Cádiz, approx. 33 nautical miles (nm) away from the city of Cádiz. The Gazul Mud Volcano shape is sculpted by the Mediterranean Outflow Water (MOW).

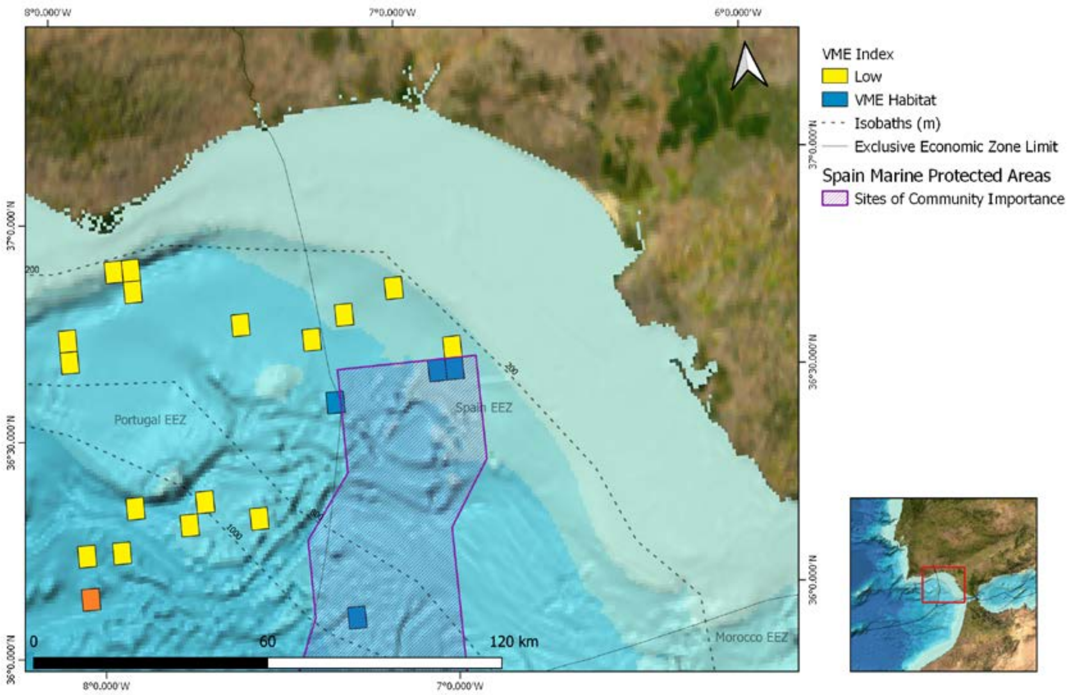
New VME habitat records for the Spanish Continental Shelf in the Gulf of Cadiz, were submitted to the VME database from the Spanish Institute of Oceanography's "Mediterranean out flow water and vulnerable ecosystems" (MEDWAVES) research cruise, see section 3.3.5. These data were from ROV footage at the Gazul Mud Volcano and included records of coral gardens, deep-sea sponge aggregations and a coral reef record (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.



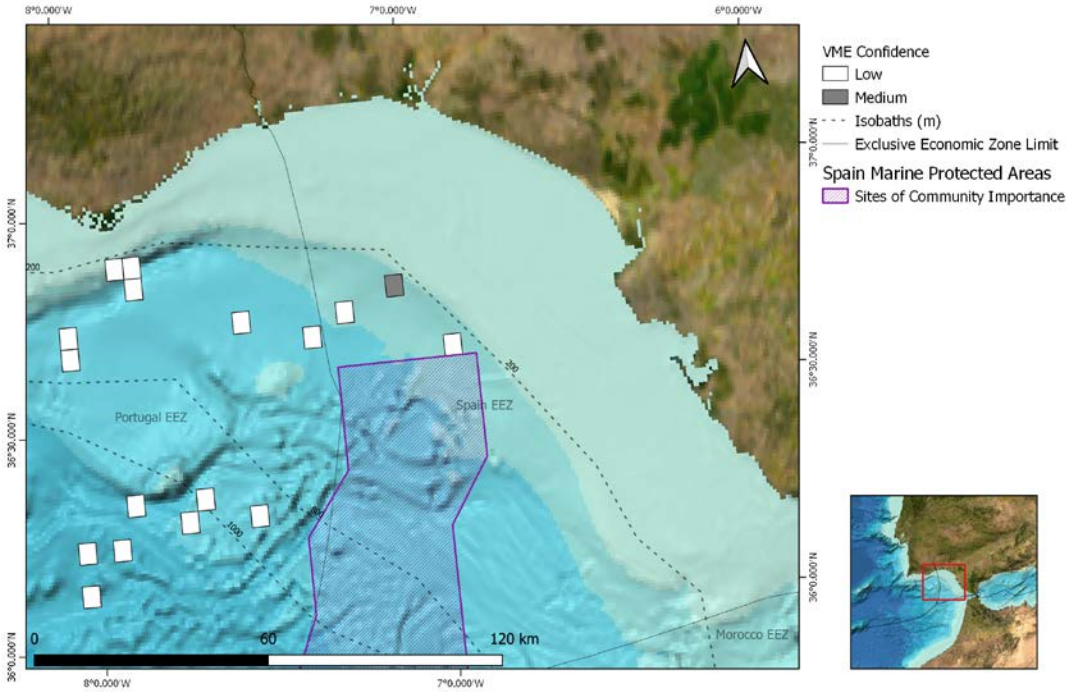
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.25.New VME records submitted to the VME database in 2019 for the Spanish continental shelf (Gulf of Cadiz) within EU waters. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +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); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no defs.

Figure 4.27. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.26). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.6 Formigas Seamount

The Formigas Islets are part of a promontory named Formigas Bank. This promontory is located next to the junction of East Atlantic Fracture Zone (EAFZ) and Terceira Rift. On the western sector a 1800 m depth flat abyssal plain extends. At the northeastern side of the surveyed area at least twenty knolls are spread on an area of 130 km^2.

New VME habitat records for the Formigas Seamount in the Azores, were submitted to the VME database from the Spanish Institute of Oceanography's "Mediterranean out flow water and vulnerable ecosystems" (MEDWAVES) research cruise, see section 3.3.5. These data were from ROV footage and included coral gardens and deep-sea sponge aggregations (Figure 4.28).

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.

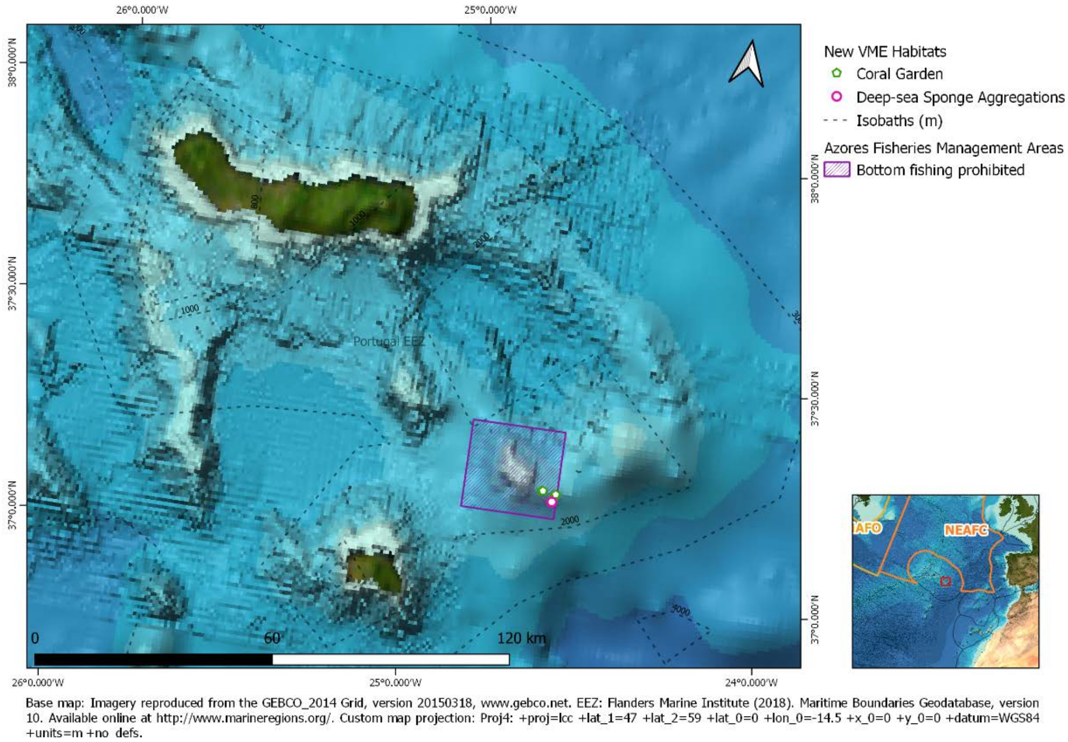


Figure 4.28. New VME records submitted to the VME database in 2019 for Formigas Seamount within EU waters. Note, other VME records from the VME database for this area are not displayed.

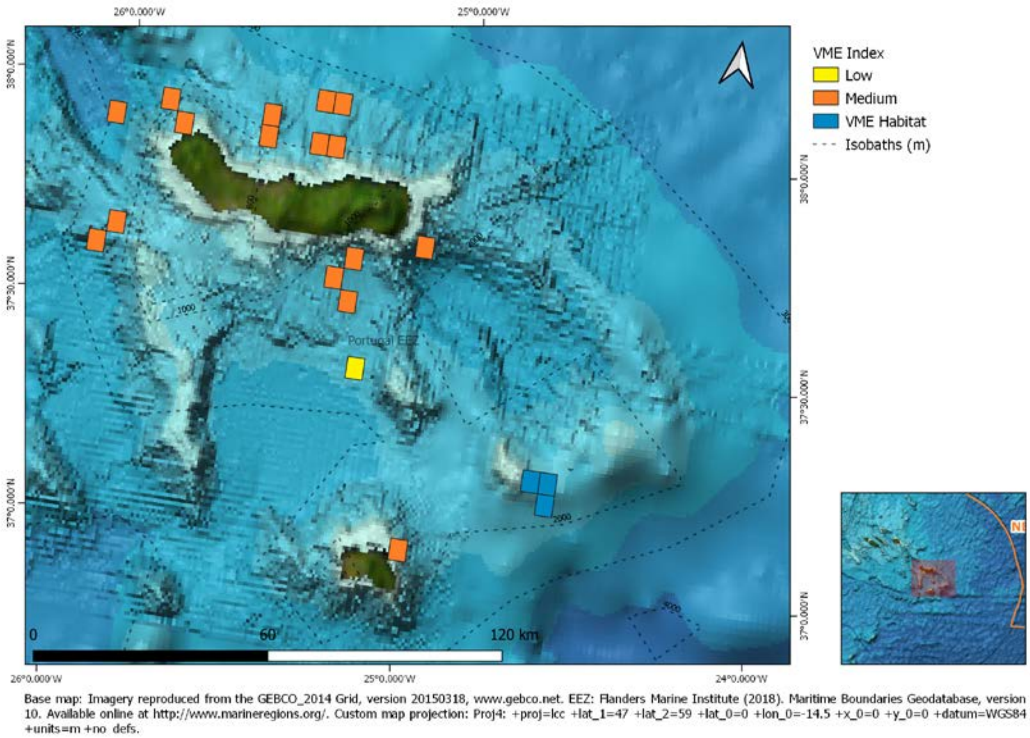
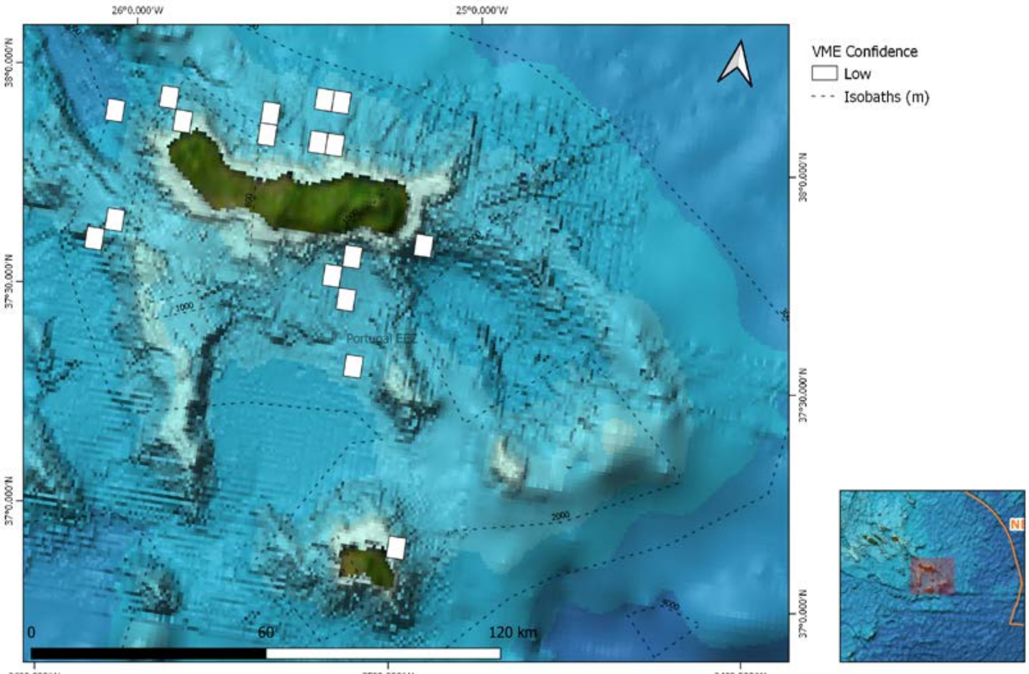


Figure 4.29. Output of the VME weighting algorithm for the area shown in Figure 4.28 showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.



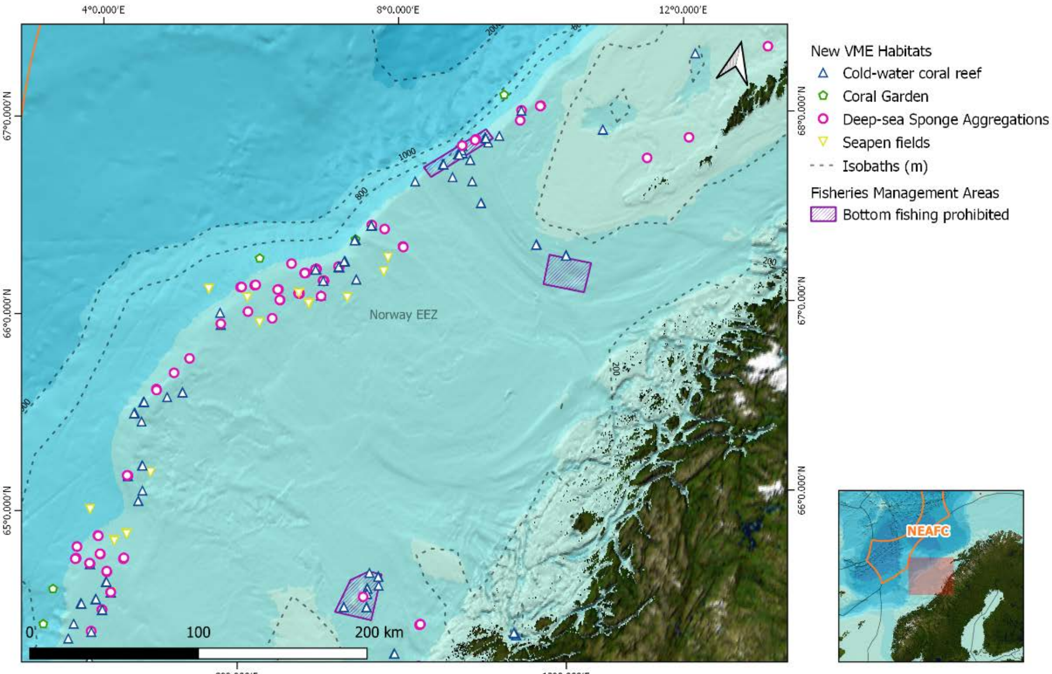
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.30. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.29). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.7 Mid-Norwegian continental shelf

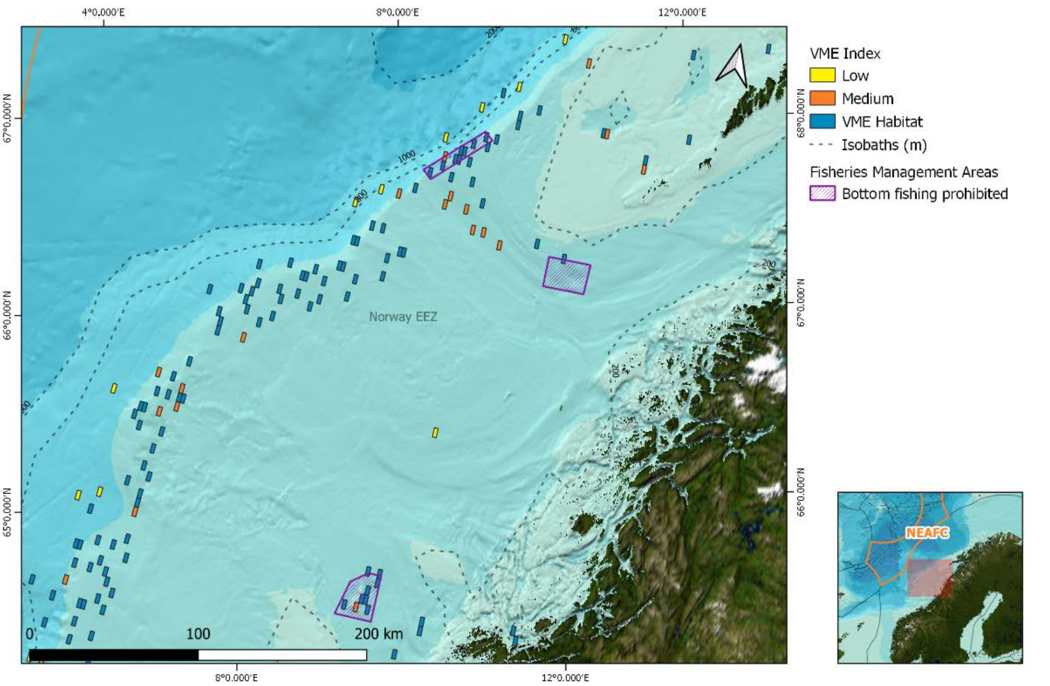
New VME data from the Mid-Norwegian continental shelf were submitted to the ICES VME database from the Norwegian National mapping programme MAREANO by the Institute of Marine Research (Figure 4.31 and Figure 4.34).

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.32 and Figure 4.35, and the confidence layer for the VME index is shown in Figure 4.33 and Figure 4.36.



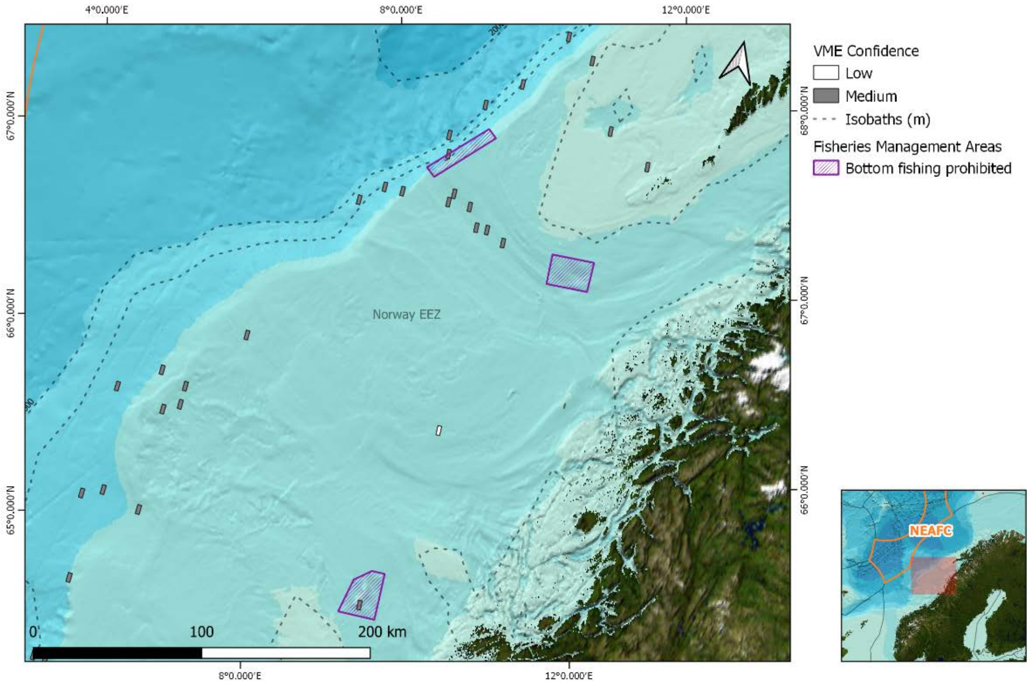
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.31. New VME records submitted to the VME database in 2019 for the Mid-Norwegian continental shelf within the Norwegian EEZ. Note, other VME records from the VME database for this area are not displayed. See Figure 4.34 for additional records in this area.



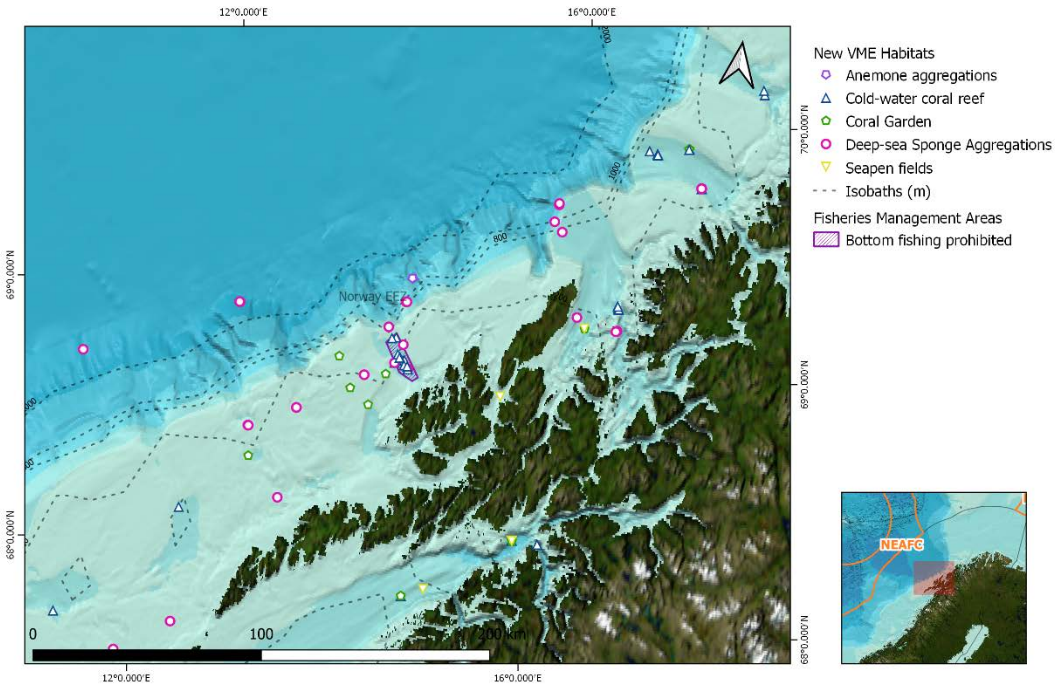
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

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); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.



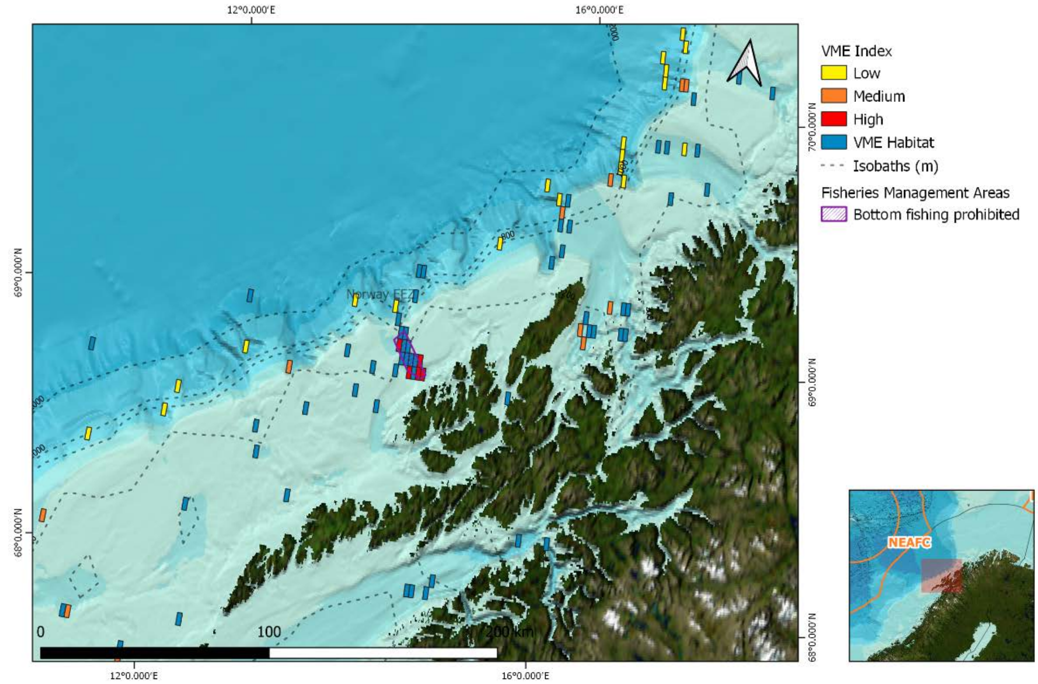
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.33. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.32). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.



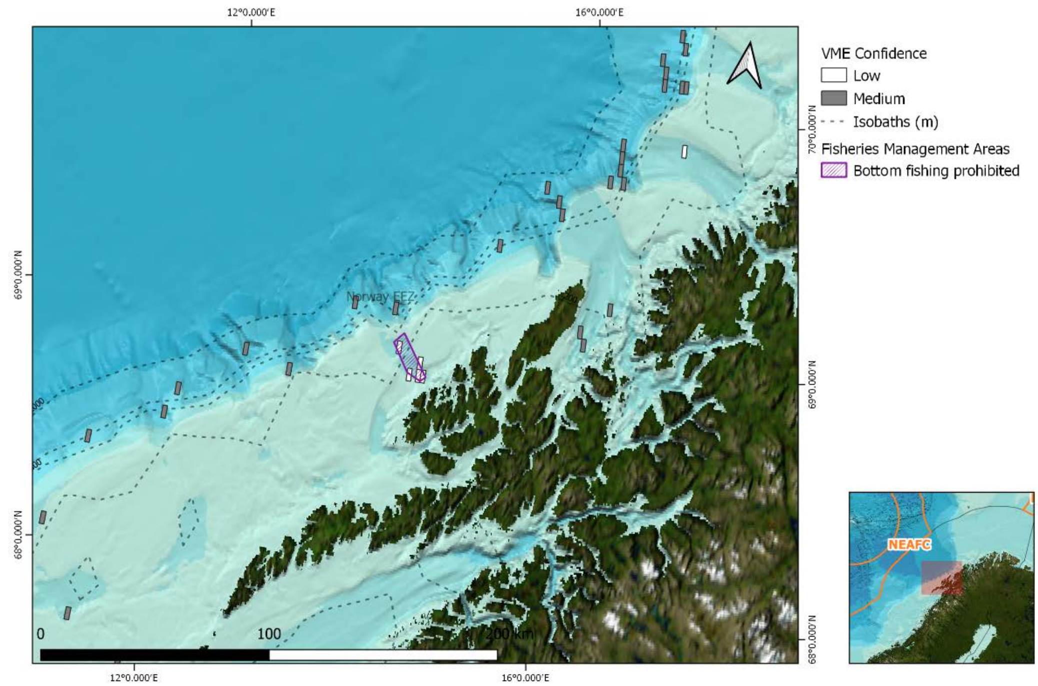
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.34 New VME records submitted to the VME database in 2019 for the Mid-Norwegian continental shelf within the Norwegian EEZ. Note, other VME records from the VME database for this area are not displayed. See Figure 4.31 for additional records in this area.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

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); and presence of actual VME. Note, this includes all (not only 2019) records from the ICES VME database.



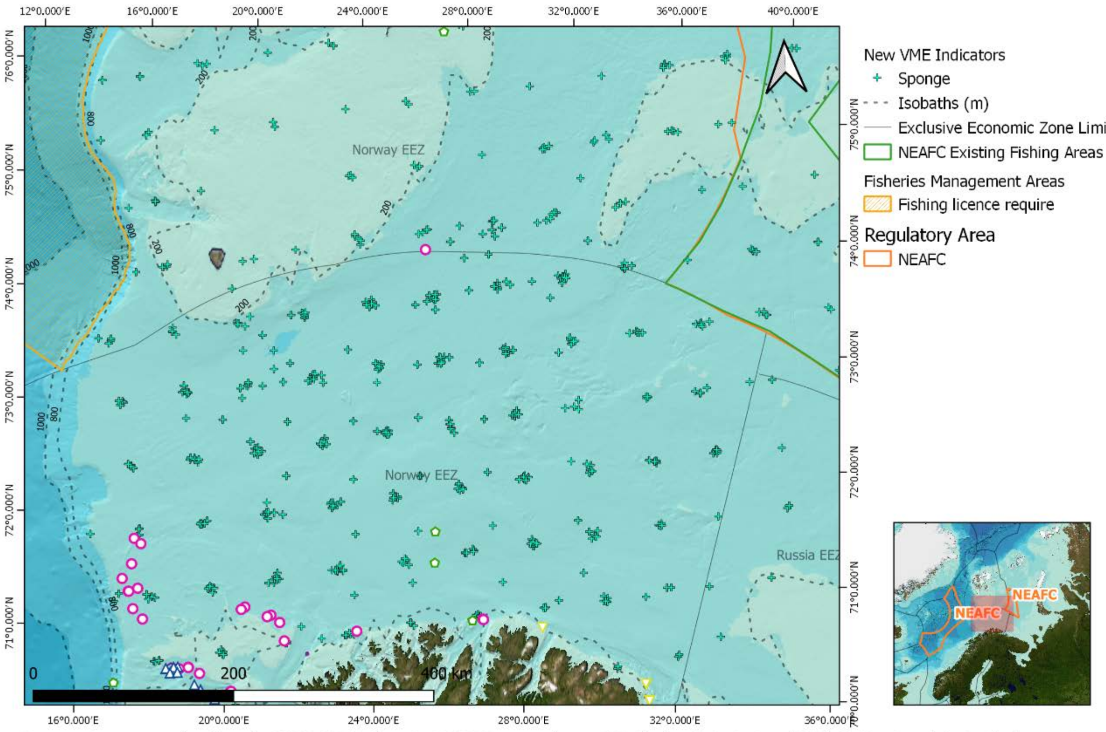
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.36 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.32). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.3.8 Central and South West Barents Sea (Tromsø Flaket)

New VME indicator data were submitted by Norway for the Central and South West Barents Sea (around Tromsø Flaket). Data were from the Institute of Marine Research bottom trawl surveys from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS); (Figure 4.37 and 4.38)

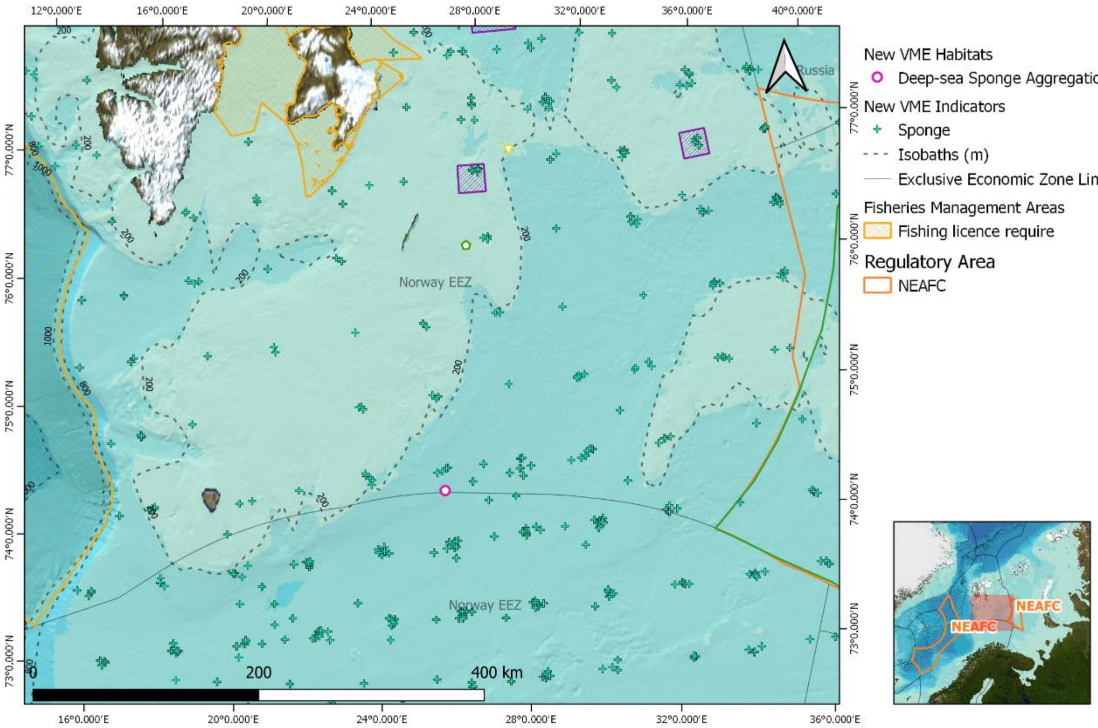
Outputs of the weighting algorithm and confidence layer with these new VME data are not presented due to the large number of new records making the scale of view too small. However, these can be viewed on the ICES VME data portal[7].



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.37. New VME indicator records (green crosses) submitted to the VME database in 2019 for the Central and South West Barents Sea. Note, records shown as a pink circles and blue triangles represent new records of deep-sea sponge aggregations and cold-water coral reefs from the Institute of Marine Research's MAREANO project (see section 4.3.7)

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



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.38 New VME indicator records (green crosses) submitted to the VME database in 2019 for the Central Western Barents Sea. Note, records shown as a pink circles represent new records of deep-sea sponge aggregations from the Institute of Marine Research's MAREANO project (see section 4.3.7)

4.3.9 North West Barents Sea (Svalbard)

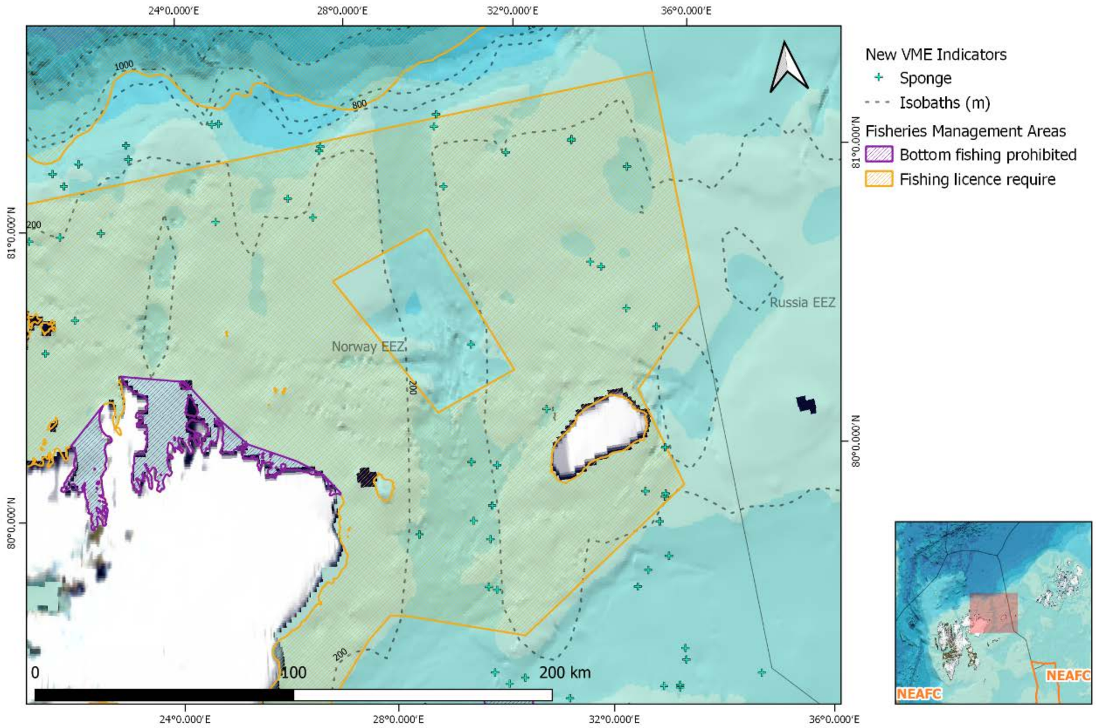
New VME indicator data were submitted by Norway for the North West Barents Sea (Svalbard). Data were from the Institute of Marine Research bottom trawl surveys from the joint Norwegian-Russian Barents Sea Ecosystem Survey (BESS) (Figure 4.39 to Figure 4.42).

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].

New legislation regarding closure of current fishing areas will take action July 1, 2019 to further protect vulnerable species and seabed habitats in the Barents Sea, specifically in waters around Svalbard. The closures have been designated based on evidence from the joint Norwegian-Russian Barents Sea ecosystem survey. There will be three types of closure;

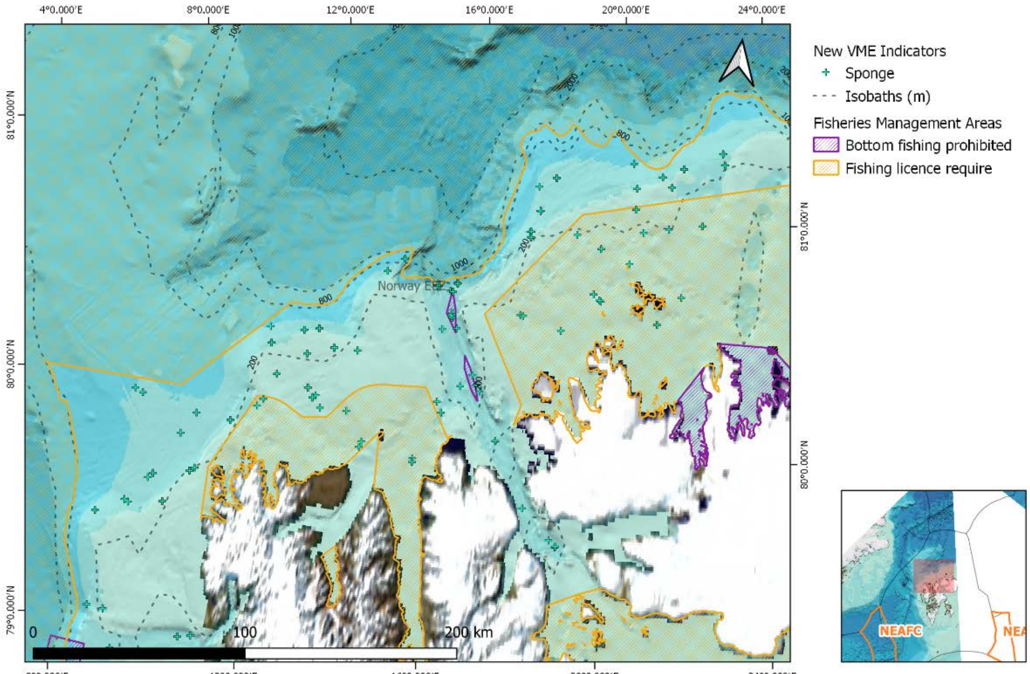
6. 10 new areas completely closed for bottom trawling, including any fishing gear likely to be in contact with the seafloor;
7. Waters around Svalbard are divided into new and existing fishing areas, areas below 800 meter in depth are considered a new fishing area;
8. Where bottom trawling requires special license from the Directorate of Fisheries.

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



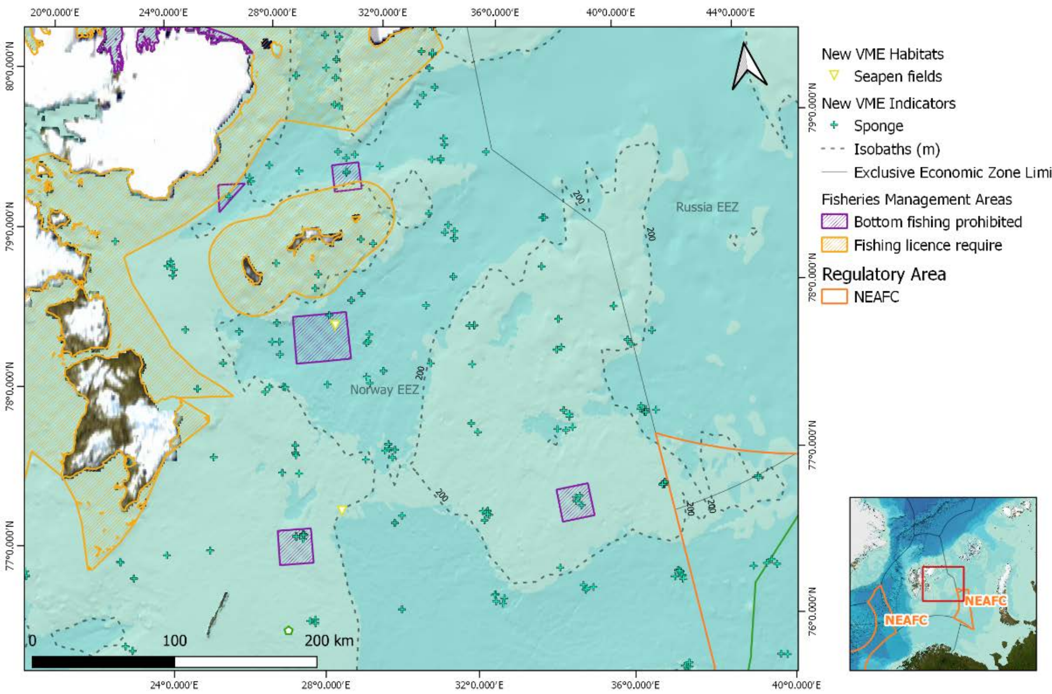
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.39 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Northeast of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.



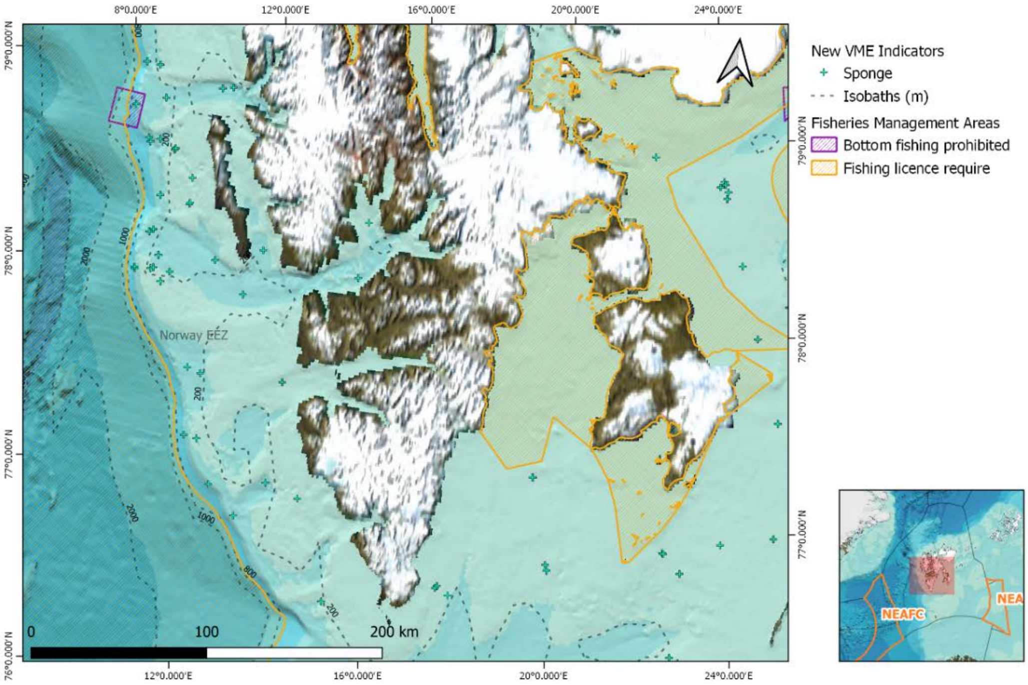
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.40 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Northwest of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.41 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Southeast of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.



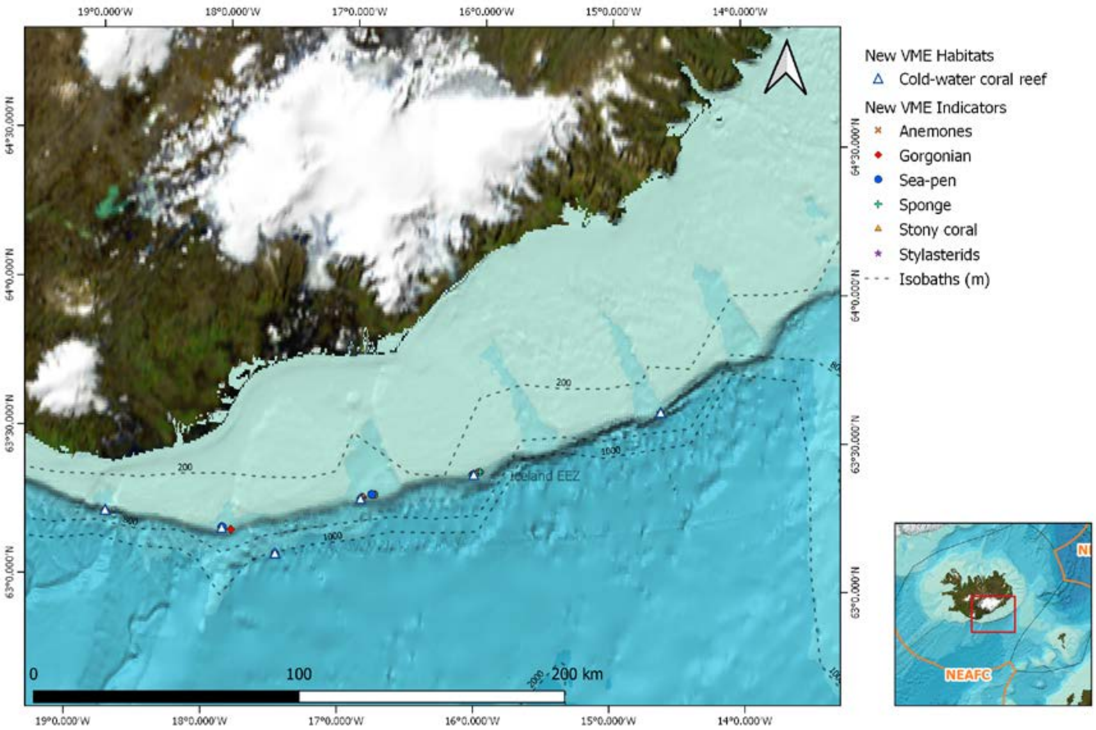
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Fisheries management areas: Fisheries Directorate Norway. Custom map projection:Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.42 New VME indicator records (green crosses) submitted to the VME database in 2019 for the North West Barents Sea (Svalbard) showing the area to the Southwest of Svalbard within (yellow and purple areas) and outside the fishery protection zone around Svalbard.

4.3.10 Iceland

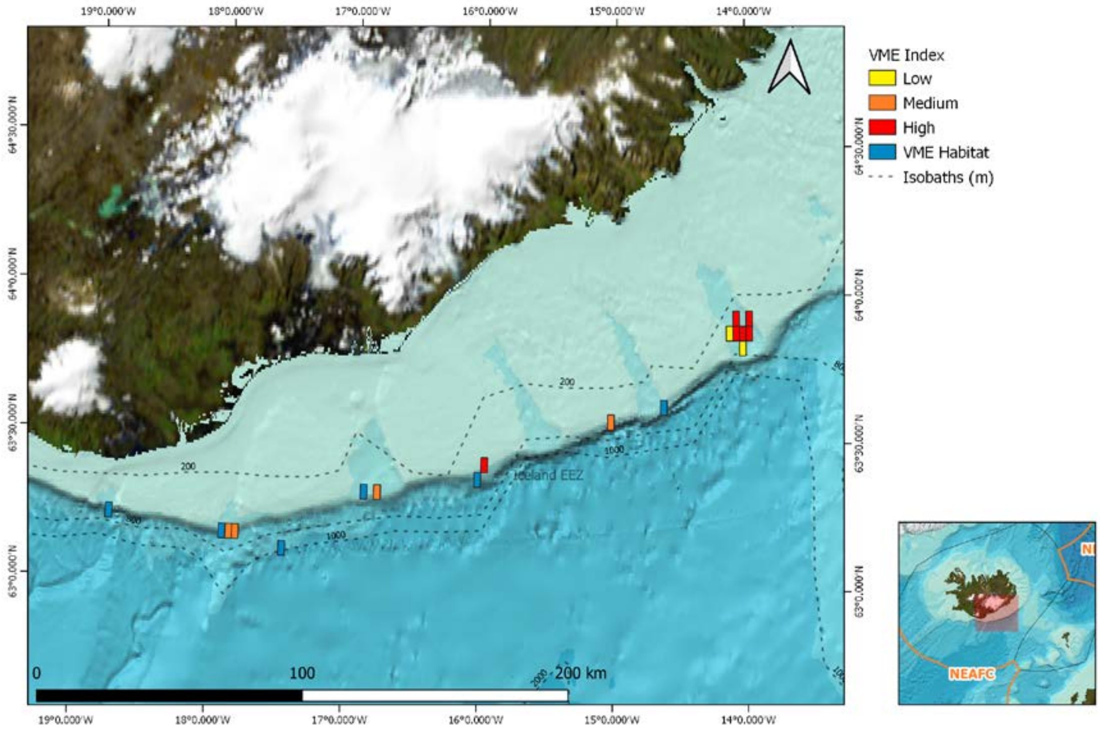
New VME data from Iceland were submitted from along Iceland's southern shelf (Figure 4.43 and Figure 4.46). The data were from a 2004 survey by the Marine and Freshwater Research Institute, as detailed in section 3.3.6.

Updated outputs of the weighting algorithm with these new VME data are shown in Figure 4.44 and Figure 4.47, and the confidence layer for the VME index is shown in Figure 4.45 and Figure 4.48**Error! Reference source not found.**.



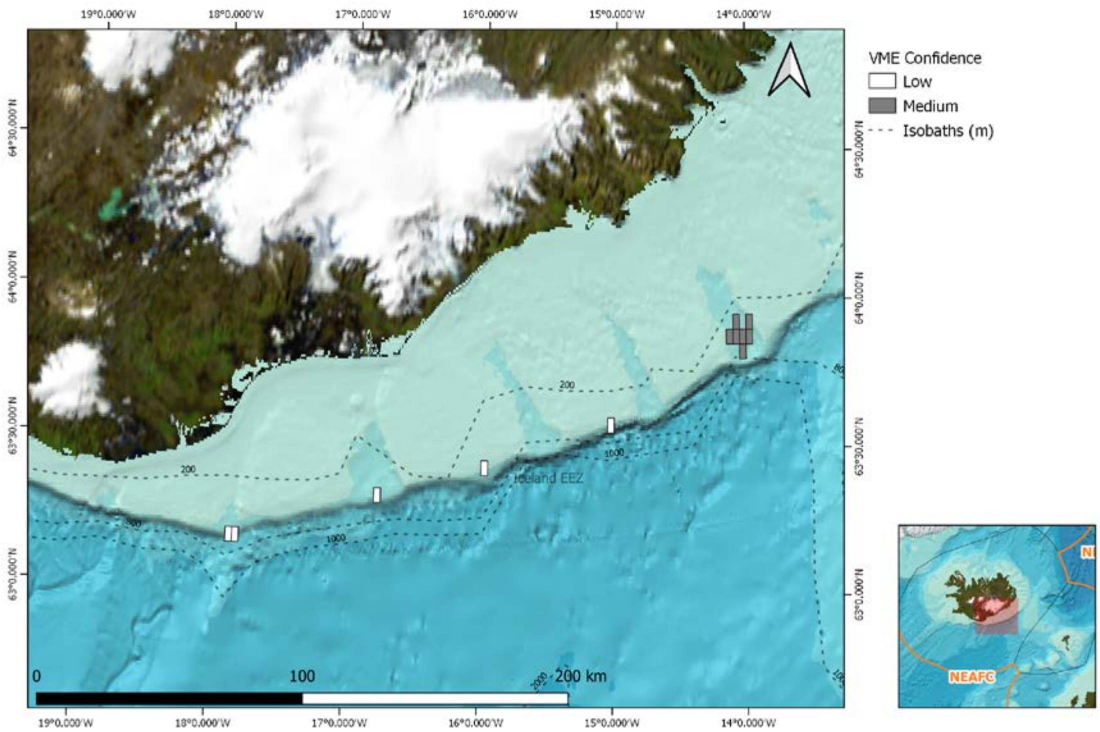
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.43 New VME records submitted to the VME database in 2019 for the Southeast of Iceland within the Iceland EEZ. Note, other VME records from the VME database for this area are not displayed. See also Figure 4.46.



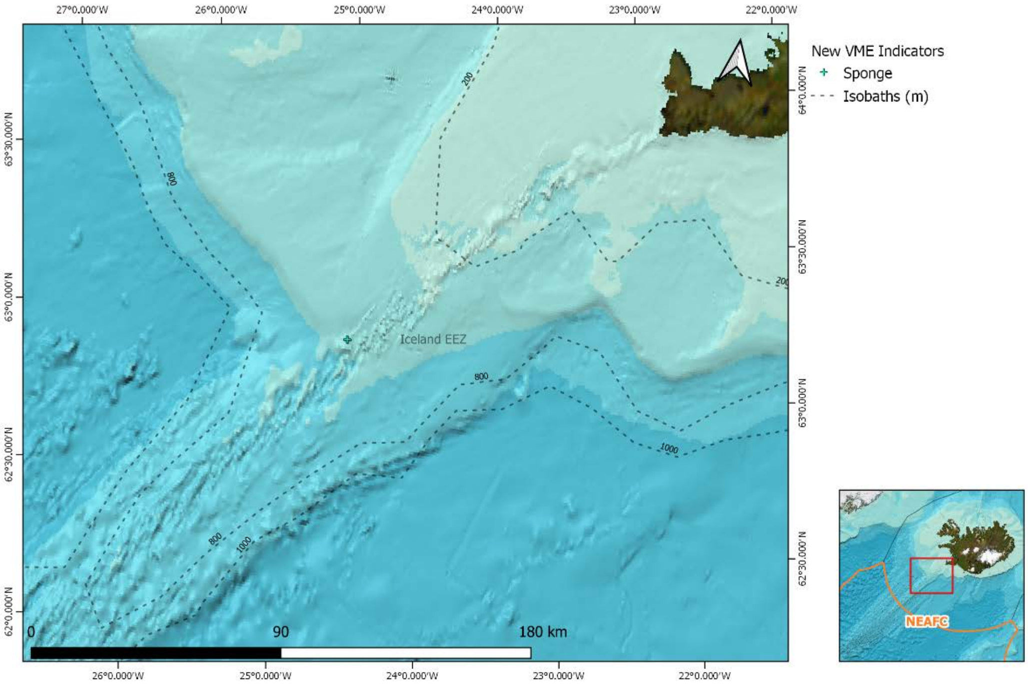
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.44 Output of the VME weighting algorithm for the area shown in Figure 4.43 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 2019) records from the ICES VME database.



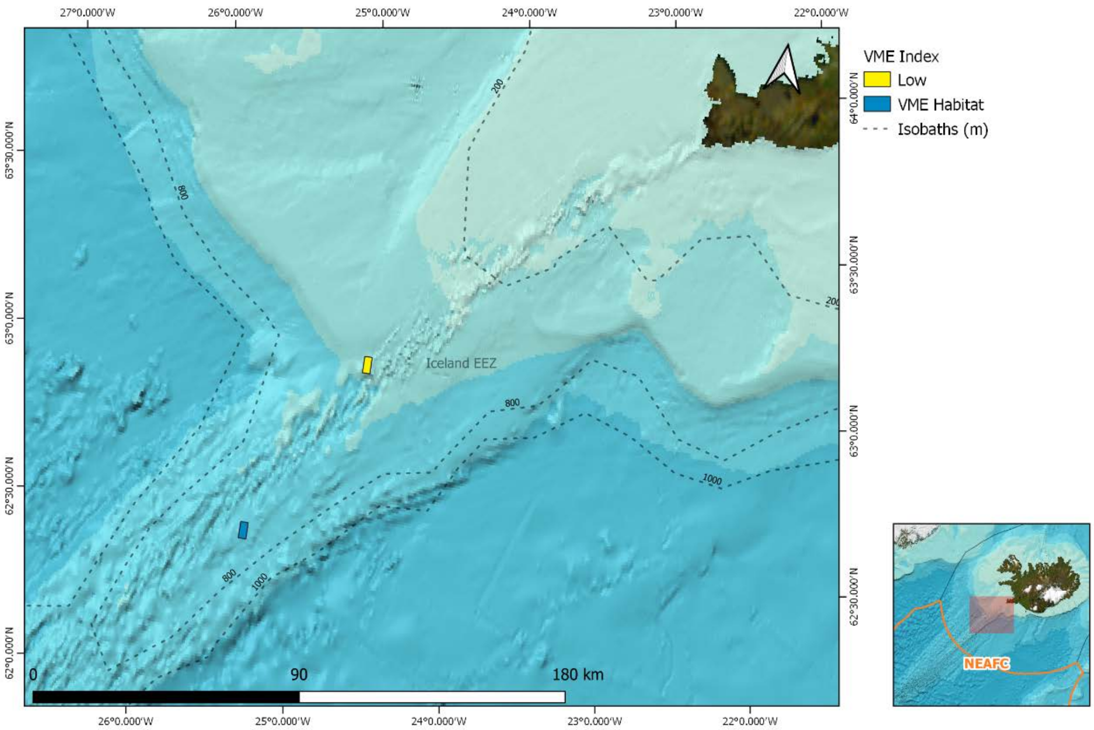
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.45 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.44). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.46. New VME records submitted to the VME database in 2019 for the Southwest of Iceland within the Iceland EEZ. Note, other VME records from the VME database for this area are not displayed. See also Figure 4.43.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.47 Output of the VME weighting algorithm for the area shown in Figure 4.46 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 2019) records from the ICES VME database

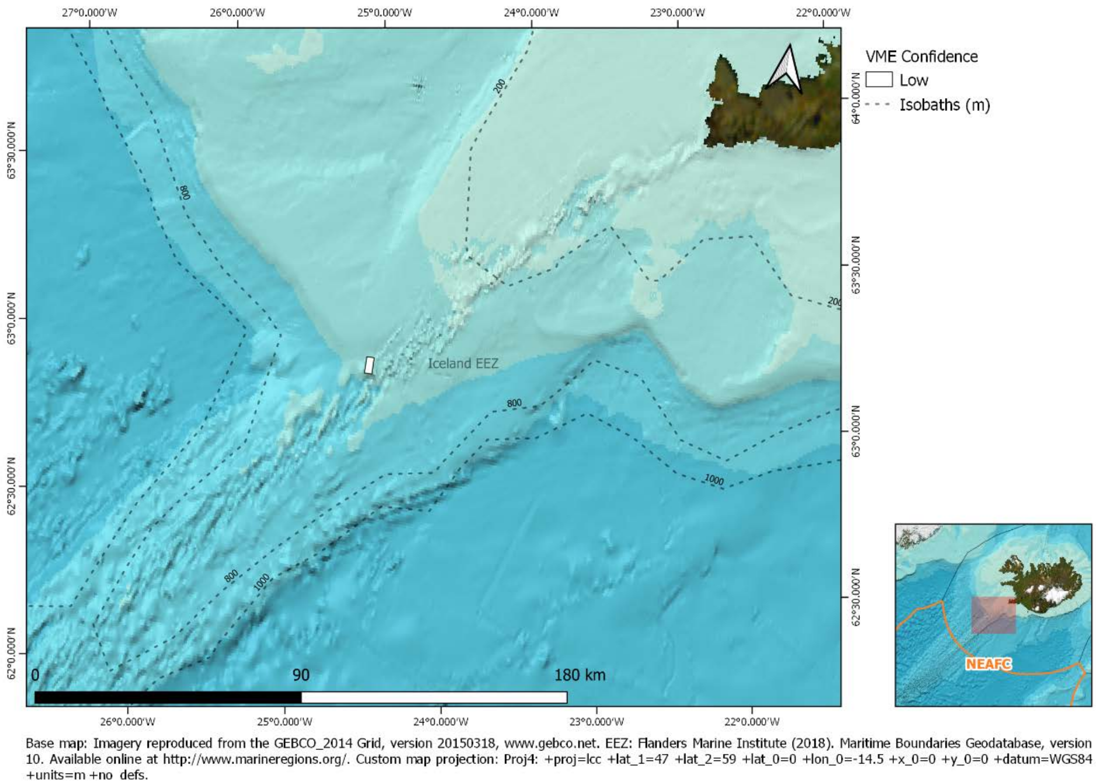


Figure 4.48 The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.47 Error! Reference source not found.**). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.**

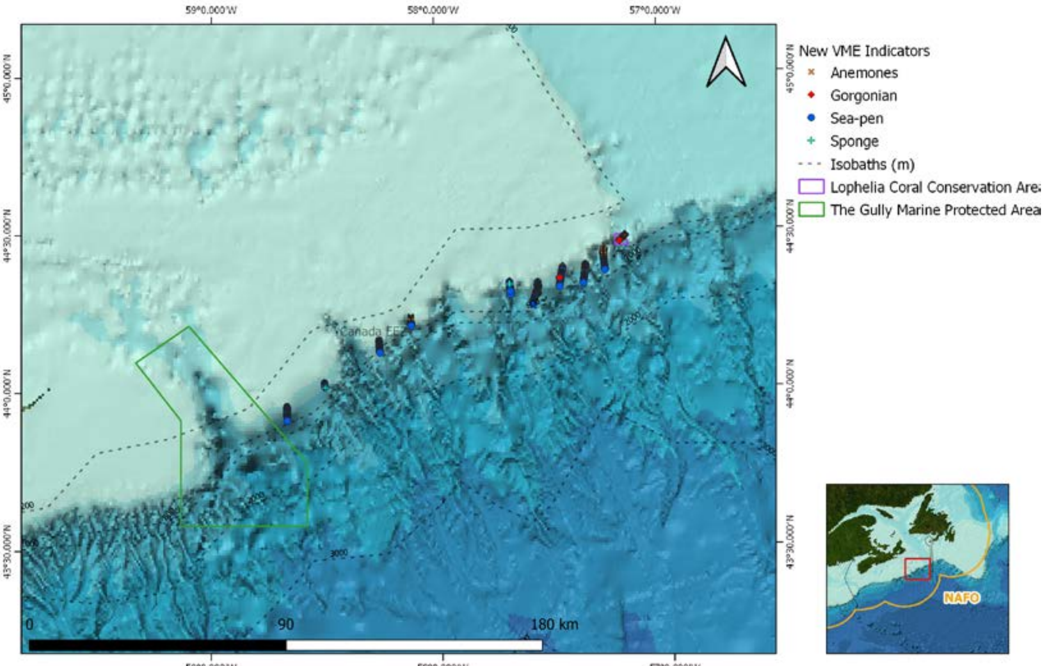
4.3.11 Eastern Scotian Slope, Canada

A total of 21 353 records of VME indicators and habitats were submitted by Canada from a research survey on the Canadian Coast Guard Ship *Hudson*. These data were from the Eastern Scotian Slope, within the Canadian EEZ, see 3.3.2 for more details. These provide a significant number of new VMEs to the VME database, in addition to the 13 745 submitted in 2018. New VME indicator records included gorgonians, sea pens, and sponges.

The area where new data have been collected (Figure 4.49) has been announced as a proposed "Other Effective Area-Based Conservation Measure" called the "Eastern Canyons Proposed Conservation Area"[9].

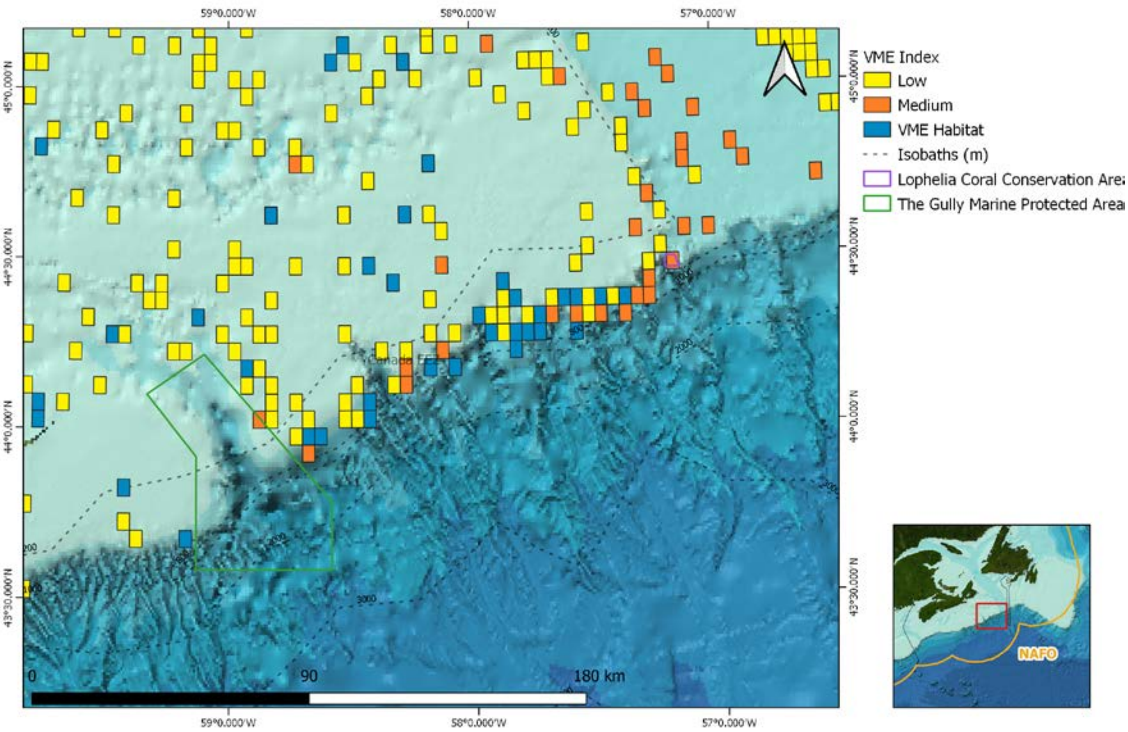
Updated outputs of the weighting algorithm with these new VME data are shown in **Figure 4.50** and the confidence layer for the VME index is shown in Figure 4.51.

[9] https://www.canada.ca/en/fisheries-oceans/news/2018/03/three-new-potential-marine-conservation-measures-announced-off-the-coast-of-nova-scotia.html



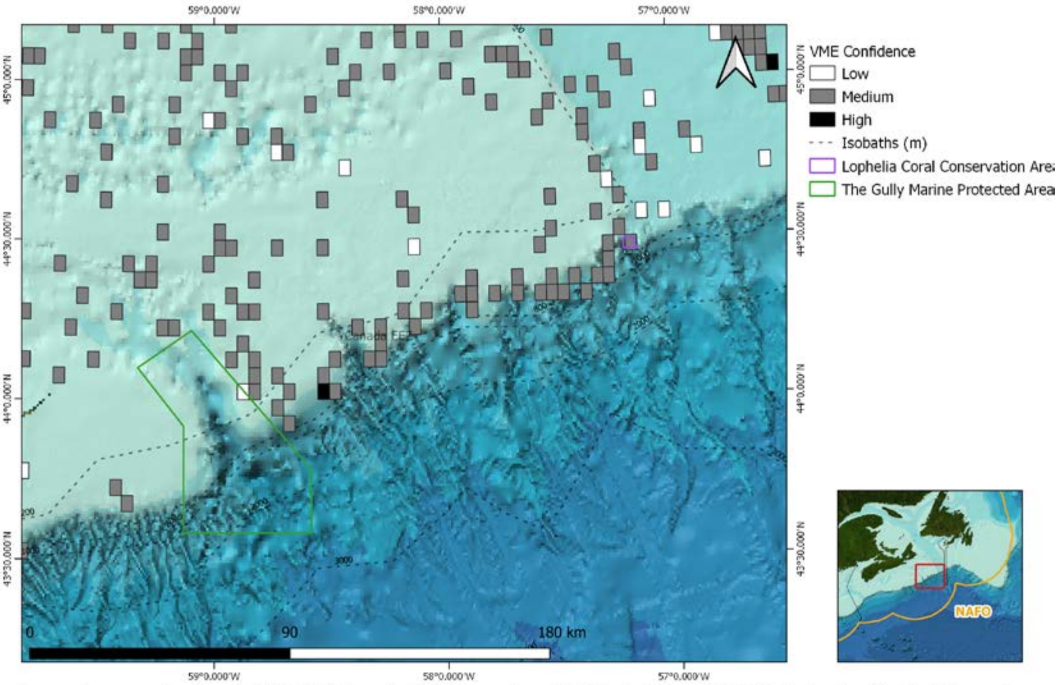
Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection:Proj4: +proj=lcc +lat_1=49 +lat_2=77 +lat_0=0 +lon_0=-59 +x_0=0 +y_0=-8000000 +datum=WGS84 +units=m +no defs.

Figure 4.49. New VME records submitted to the VME database in 2019 within the Canadian EEZ. Note, other VME records from the VME database for this area are not displayed.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection:Proj4: +proj=lcc +lat_1=49 +lat_2=77 +lat_0=0 +lon_0=-59 +x_0=0 +y_0=-8000000 +datum=WGS84 +units=m +no defs.

Figure 4.50. Output of the VME weighting algorithm for the area shown in Figure 4.49 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 2019) records from the ICES VME database.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection:Proj4: +proj=lcc +lat_1=49 +lat_2=77 +lat_0=0 +lon_0=-59 +x_0=0 +y_0=-8000000 +datum=WGS84 +units=m +no defs.

Figure 4.51. The confidence layer associated with the VME weighting algorithm's VME Index layer (Figure 4.50). Note that actual records of VME (e.g. VME habitats) are not assigned a confidence rating. Note, this includes all (not only 2019) records from the ICES VME database.

4.4 Analysis of the 2018 VMS submission from NEAFC, in order to provide information and maps on fisheries activities in the vicinity of vulnerable habitats (VMEs)

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. These 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 by WGSFD to exclude all duplicate reports, polls outside the year 2018, 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 there were issues again with quality of speed data. The "estimated speed" and "vessel speed" columns contained no values, and whilst the "SP" field did contain numeric values, they ranged from zero to 500, suggesting a problem with decimal places, however not in a consistent manner across the dataset. As a means of avoiding this problem, a derived speed was 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 all gears. Visual examination of speed profile histograms for vessels registered as using trawl gears suggests that this demarcation is appropriate (Figure 4.52).

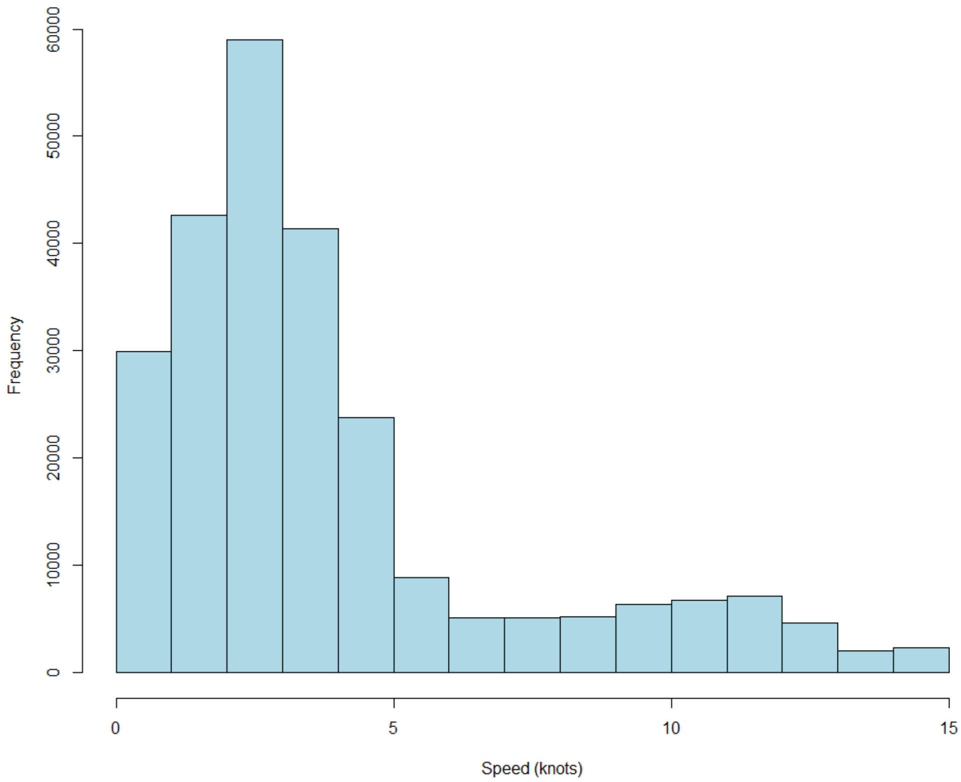


Figure 4.52 Histogram of derived speeds for all gears, based on position and time, conforms to expected distribution.

The speed filtered pings (0–5 knots) are represented as points on the map, as this was considered the best option for display purposes. These are given for vessels registered as using mobile bottom contact gears (otter trawl – OTB and shrimp trawl - TBS), static gear (gear codes "LL" and "LLS"), and for vessels for which no gear code was available ("NIL"). 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 4.1).

Table 4.1 Number of pings (N) registered against each fishing gear type (Gear) in the speed filtered (0-5 knots) NEAFC VMS data. Gear codes: Pots (FPO), longlines (not specified) (LL), set longlines (LLS), no gear code (NIL), bottom otter trawls (OTB), midwater otter trawls (OTM), purse seines (PS), bottom shrimp trawls (TBS).

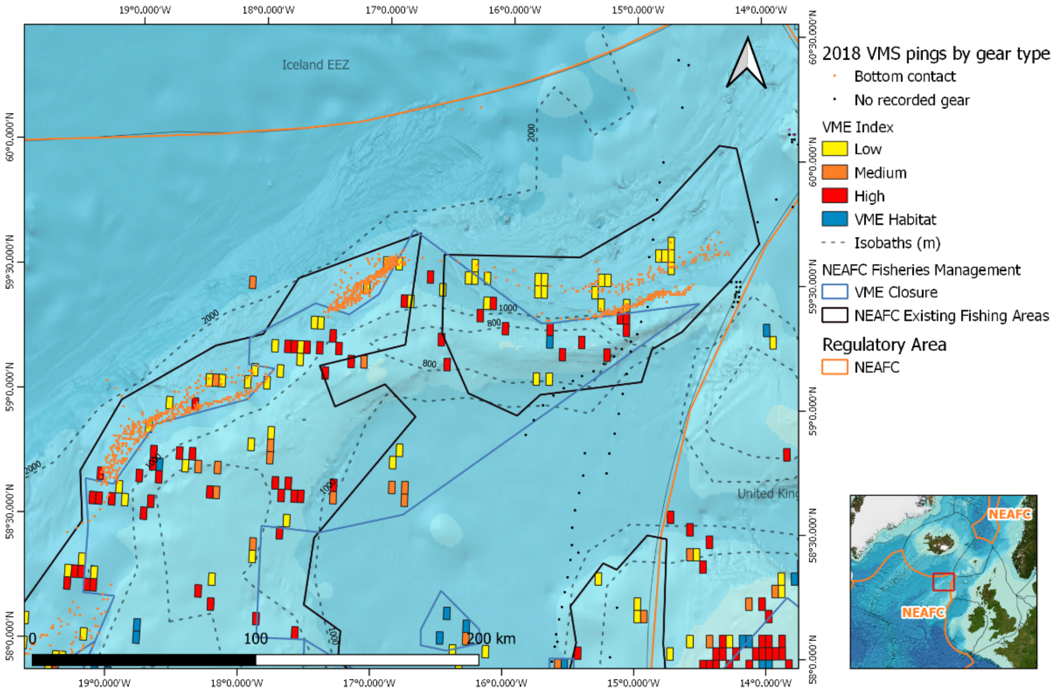
Gear	N
FPO	1282
LL	31
LLS	831
NIL	25364
OTB	38649
OTM	128252
PS	264
TBS	2056

4.4.1 Results

The VMS ping data was mapped together with the VME Index outputs, showing likelihood of VME presence based on the VME weighting algorithm, by WGDEC 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, the Barents Sea and to the west of the Bay of Biscay (Josephine Seamount).

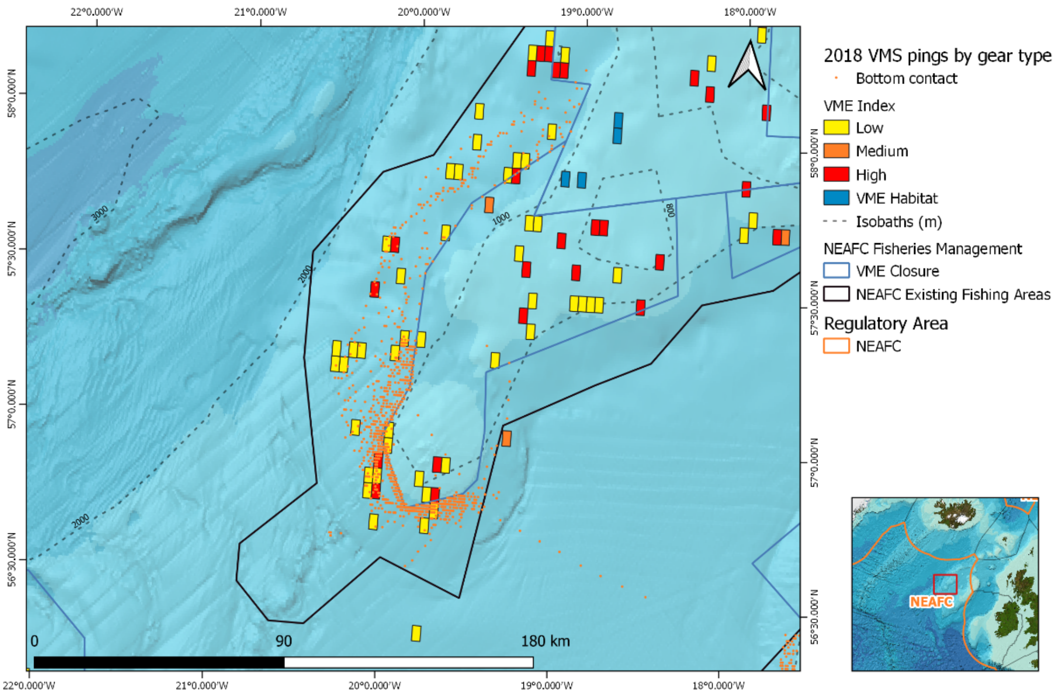
4.4.1.1 Hatton Bank

The closures to the northern side of Hatton Bank are generally well observed (Figure 4.53). A small number of bottom trawl tows appear to extend into the closed area at the easternmost part and along the northernmost part of the existing bottom fishing area, however, these incursions are limited. The highest levels of fishing are closely associated with the boundary of the closed areas. There was little 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 Figure 4.54).



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.53. VMS pings for bottom contact gears (orange) and no recorded gear (black) to the north of Hatton Bank, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

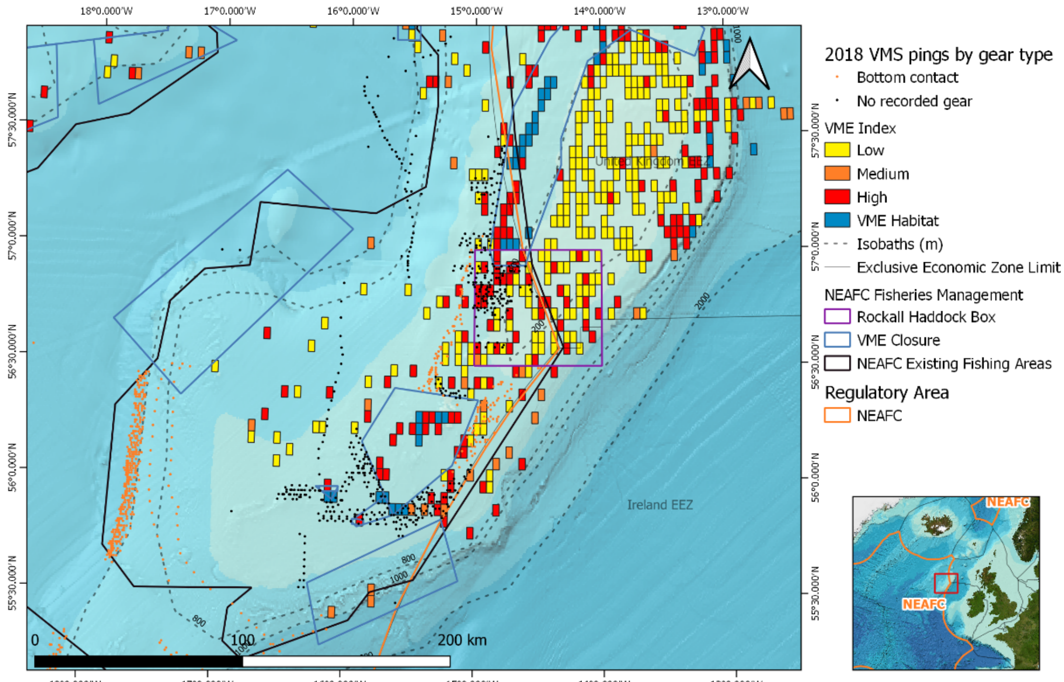


Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.54 VMS pings for bottom contact gears (orange) to the west of Hatton Bank, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

4.4.1.2 Rockall Bank

The VME closures on the eastern side of Rockall Bank are also generally well observed, although there is some suggestion of vessels with no registered gear type operating within the Haddock Box, particularly in the northwest quadrant (Figure 4.55). Vessels registered as using static gears work outside this area. To the south of Rockall Bank, trawling continues to be better confined to the "existing bottom fishing area" (Figure 4.55). Static gears appear to be absent from the small areas at the southerly end of the bank in which they were observed last year.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.55. VMS pings for bottom contact gears (orange) and no recorded gear (black) for the Rockall Bank, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME.

4.4.1.3 South of Iceland

As in previous years, the pattern of activity around the Reykjanes Ridge is somewhat confused (Figure 4.56). A high proportion of this activity takes place in waters over 3000m in depth – too deep to represent bottom fishing activity – and is believed to be vessels targeting mid-water redfish being miscoded in the database. One potential area of actual bottom fishing is still seen to the southeast of the mid-Atlantic ridge. The seabed in this area is at around 1300 – 1500m.

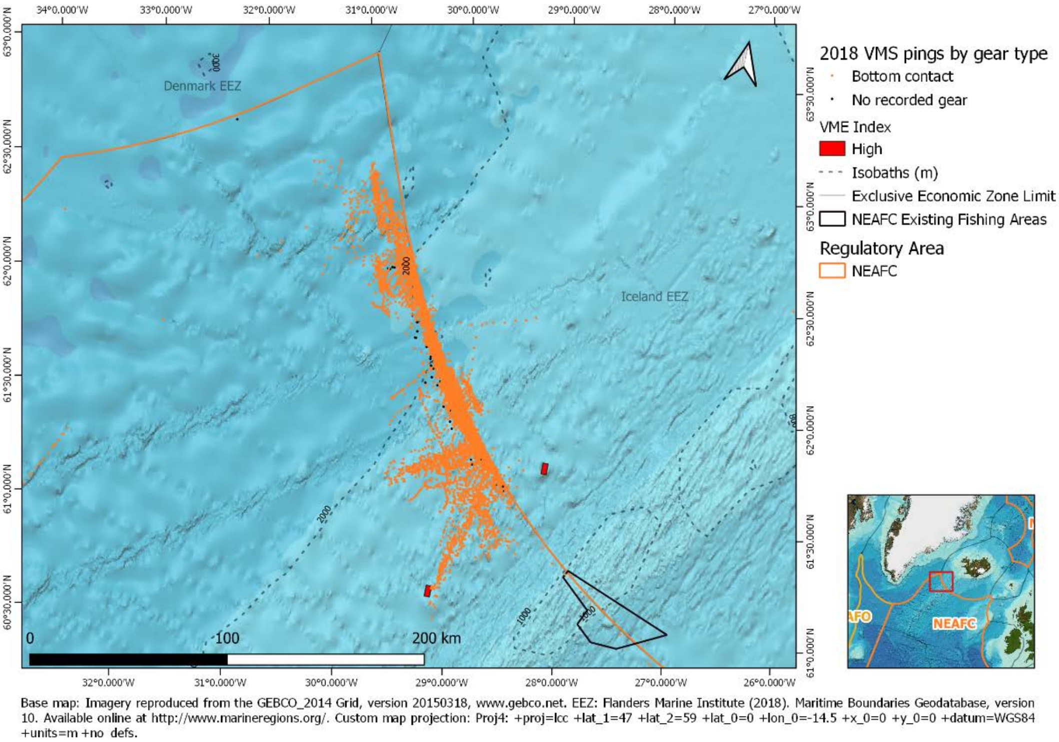
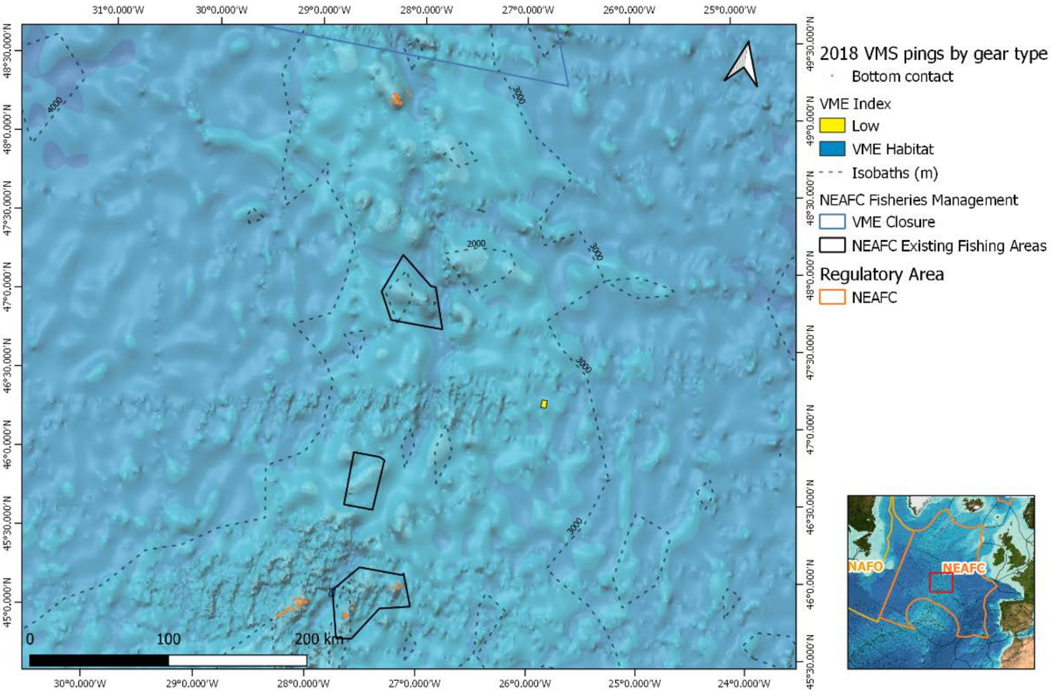


Figure 4.56. VMS pings for bottom contact gears (orange) and no recorded gear (black) to the South of Iceland.

4.4.1.4 Mid Atlantic Ridge Seamounts

As seen in the previous two years, bottom trawling activity appears to be taking place on an unnamed seamount to the south of the Mid Atlantic Ridge (MAR) closure, outside the existing bottom fishing area (Figure 4.57). Slightly further south, bottom trawling takes place inside the existing bottom fishing area, as well as on a seamount to the west of the Olympus knoll. The fishing observed last year on the Chaucer seamounts to the south, including within the Southern MAR (C) closure area, is not evident this year.

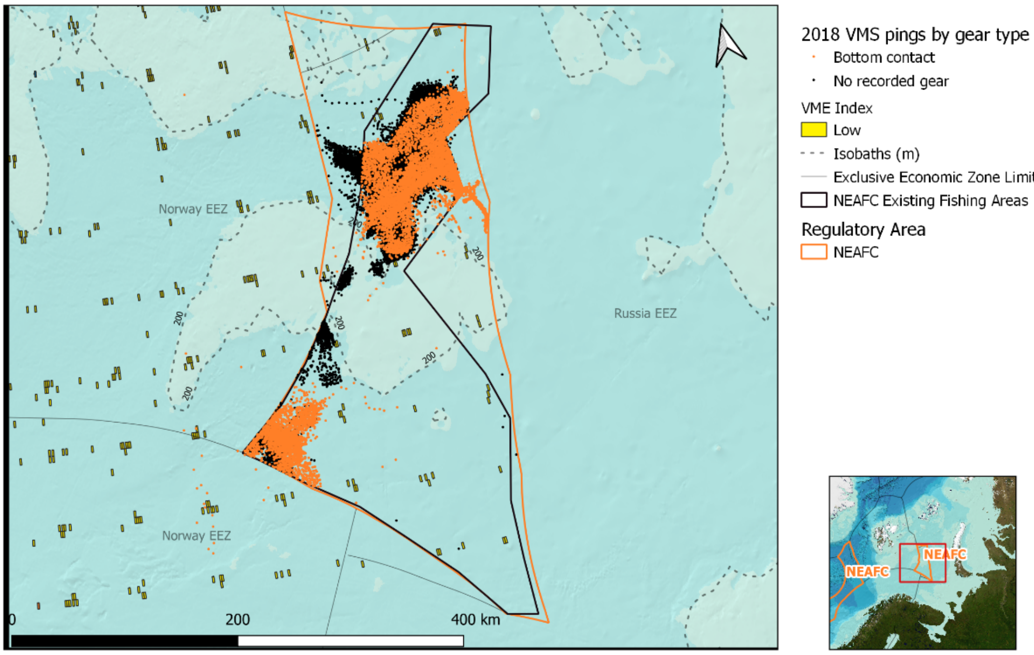


Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.57. VMS pings for bottom contact gears (orange) on the Mid Atlantic Ridge

4.4.1.5 Barents Sea

Activity within the Barents Sea is being reported this year due to the submission of new VME records. Fishing activity is most intense in the north and east of this area for both bottom trawling and where no gears were reported (Figure 4.58). To the north of the NEAFC area there is some suggestion that activity is expanding beyond the existing fishing area, particularly to the west for vessels with no reported gear type. Static gears appear not to be used in this area.

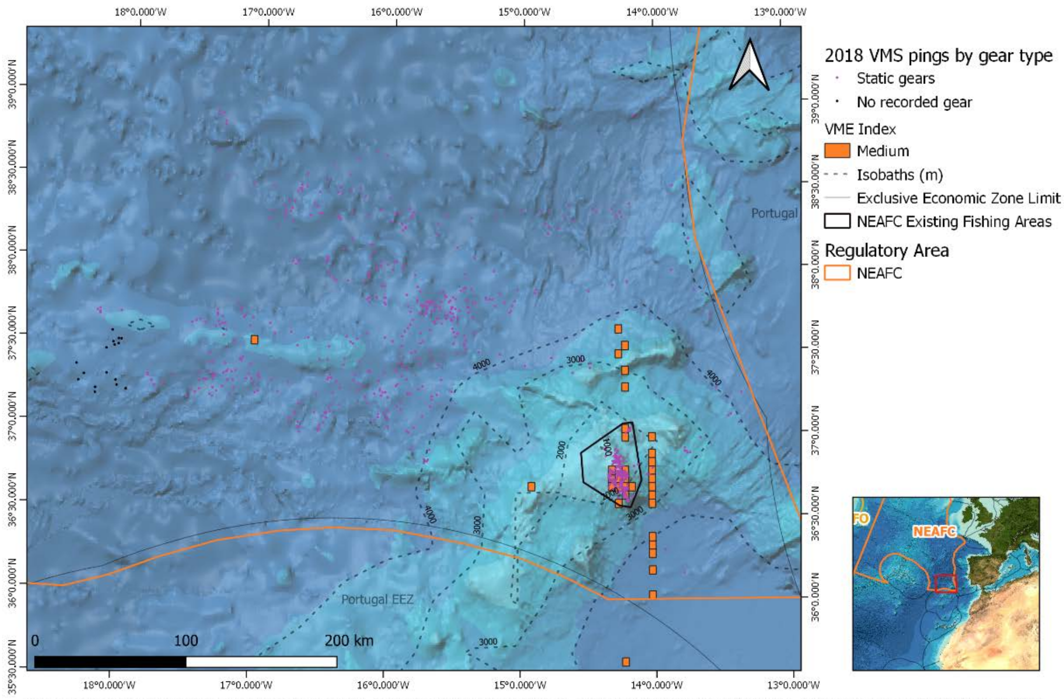


Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=66 +lat_2=76 +lat_0=0 +lon_0=23 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.58 VMS pings for bottom contact gears (orange) and no recorded gear (black) for the Barents Sea NEAFC regulatory area, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high).

4.4.1.6 West of the Bay of Biscay

Examination of VMS data revealed areas of activity to the west of the Bay of Biscay. Within the Josephine seamount (JOS1 area) and to the west of this area there is extensive activity of static gears (Figure 4.59). A small area, further west still, also shows some fishing activity from unreported gear types.



Base map: Imagery reproduced from the GEBCO_2014 Grid, version 20150318, www.gebco.net. EEZ: Flanders Marine Institute (2018). Maritime Boundaries Geodatabase, version 10. Available online at http://www.marineregions.org/. Custom map projection: Proj4: +proj=lcc +lat_1=47 +lat_2=59 +lat_0=0 +lon_0=-14.5 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs.

Figure 4.59. VMS pings for static gears (purple) and unreported gears (black) to the west of the Bay of Biscay and within Josephine Seamount, overlain with the outputs of the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high).

4.5 References

Frederiksen, R., Jensen, A., and Westerberg, H. 1992. The distribution of the scleractinian coral *Lophelia pertusa* around the Faroe islands and the relation to internal tidal mixing, Sarsia, 77:2, 157-171, DOI: 10.1080/00364827.1992.10413502

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

Annex 8: Technical minutes from the Vulnerable Marine Ecosystems Review Group

- RGVME
- By correspondence August 2019
- Participants: Emanuela Fanelli (Chair), Rabea Diekmann, Miriam Tuaty Guerra and Sebastian Valanko (ICES Secretariat)
- Working Group: WGDEC and WGSFD

1. Overview

In response to the two advice requests (EU, NEAFC), this report reviews (i) the spatial data, historical and new information, provided by the Working Group on Deep-water Ecology (WGDEC) and the Working Group on Spatial Fisheries Data (WGSFD), on the distribution, vulnerability and abundance (VME index) of VMEs in the Northeast Atlantic, and (ii) the occurrence of fisheries activities in the vicinity of VMEs in the NEAFC convention area.

The review group worked by correspondence during the period indicated (from 1st to 16th August 2019). A first email exchange among the participants took place at the beginning of July in order to agree on the review approach. Participants decided to work simultaneously, providing separate reviews and then the chair organized a teleconference on 9th August 2019, to identify the main advice points for the report.

Then the RG worked by correspondence and all members considered there was no need for a further teleconference. They agreed by correspondence on 16th August 2019 on the final advice provided in this report.

The review document is structured according to some general remarks and the two requests.

2. General remarks:

Three areas were considered in the NEAFC Regulatory Area (Hatton Bank, Rockall Bank, and the North East Barents Sea) and ten areas within the EEZs of EU countries and wider.

For each area, the report provides maps with 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. The method used for the calculation of the VME index had been described in Section 7 of the WGDEC 2018 report (ICES, 2018).

a) The RG is highly pleased about the extensive dataset (indicator and habitat records) that was collected as response to the ICES data call in 2019 and that was analysed by WGDEC. In total, 26 379 new presence records were received, some of them had been considered in previous WGDEC reports, but were not yet included in the ICES database (JNCC resubmission). Of all new records, 93 were located within the NEAFC Regulatory Area, and the remaining 26 286 were found within the Exclusive Economic Zones of North Atlantic ICES/NAFO member states. Of these records, 21 353 were provided by the Department of Fisheries and Oceans (DFO) of Canada. No new VME submissions were received for areas within the NAFO Regulatory Area.

This large amount of data likely increases the confidence in the 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) According to the request of the Review Group in 2018, also absence data were reported, with a total of 433 records collected between 2006 and 2018 and 314 records as part of

2019 data call, spread across the NEAFC Regulatory Area (Rockall Bank and the Barents Sea), the UK's EEZ, Ireland's EEZ, Norway's EEZ, and Russia's EEZ, which may aid in the interpretation of the VME presence records. WGDEC mentioned doubts about the usefulness of absence data, as data from ROV and trawling provide absence records at different spatial scales. Additionally, data from trawling are not fully reliable because trawling has a low VME catchability. As a consequence, WGDEC did not consider absence records as part of their ToRs but proposed a specific ToR for 2020. The Review Group recognises the caveats but supports WGDEC in analysing absence data in future meetings and further recommends to continue collecting absence data in future data calls. Additionally, as already highlighted by the RG 2018, having absence information will allow a broad array of geospatial modelling techniques to be used in the future.

c) Regarding point 3.3 "Data Providers for ToR [a]" the RG noted that in some sections the type of VME habitats or indicators is described, whereas in others only summary tables are provided. The RG recommends harmonization of descriptions.

d) The RG suggests that in data-rich areas, i.e. where regular surveys were carried out, it would be useful to present data additionally on a spatial-temporal scale in order to evaluate changes in VMEs distribution over time.

e) The RG considers for the next years that the WGDEC should focus on the definition of thresholds for the different VMEs (not only corals and sponges). The RG is aware that this could be a hard task but at the same time considers it could be an improvement in the VME weighting system.

f) As reviewed last year, the use of the VME vulnerability index (i.e. use of indicator species) with the associated confidence index provides useful supporting information for interpreting the distribution of VMEs. Still, considering the patchy distribution of the observations, the RGVME supports the use of predictive modelling techniques for providing a fuller representation of 'suitable habitat' or potential VME distribution.

g) The RG fully supports the development of an automation process for the inclusion of OSPAR records into the ICES VME database using a data script in R, as mentioned in the Report.

h) RGVME 2018 had mentioned that some details about how the VME likelihood index was calculated remained unclear. Unfortunately, this was not clarified in this year's report (e.g. concerning multiple indicator observations in one grid cell). RGVME thus asks WGDEC to outline the method again in the following year report and address the concerns mentioned by RGVME in 2018.

3. EU request –"As part of the MoU with the European Commission, ICES is requested to: 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".

Altogether, ten areas were considered within the EEZs of EU countries and wider (Faroe-Shetland Channel, Rockall Bank, Rosemary Bank Seamount, Wyville-Thomson Ridge, Irish continental shelf, Spanish continental shelf (Gulf of Cadiz), Formigas Seamount (Azores, Portugal), Mid-Norwegian continental shelf, Central Barents Sea and South West Barents Sea (Tromsø Flaket), and North West Barents Sea (Svalbard)).

The report stated that e.g. Norway provided 995 records of VME habitats from 2006-2016 and data from 2006 to 2018 for sponges (2291 new presence records). The RG considers that in case of data-rich areas, where regular surveys have been carried out, it would be useful to present data additionally on a spatial-temporal scale, in order to assess if VMEs have been impacted by fisheries throughout the reported period (e.g., if a decrease in the number of records was observed).

Concerning Iceland, the 1279 new records reported, were obtained from a survey carried out in 2004, which means 15 years ago. The RGVME considers that, although this information is rather old, in case of new surveys, it could provide a georeferenced base against which to compare new data and assess the VMEs status.

Spain submitted new VME records for Spanish and Portuguese waters as well. However, the origin of the latter is not appropriately specified, neither in the text, nor in the Table. The RGVME considers that both the origin and the new VME types must be clearly specified, as from the Gazul Mud Volcano (Gulf of Cadiz, Spain) or from the Formigas Seamount (Azores, Portugal). Such practice should apply both to the current and future reports.

4. 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.

Three areas were considered in the NEAFC Regulatory Area: Hatton Bank, Rockall Bank, and the North East Barents Sea.

Considering the new records observed on Rockall Bank (Figure 4.2), just in the central area of the bank, the RGVME wondered about the low likelihood of encountering VMEs. The same consideration can be applied for data from North East Barents Sea (Figure 4.8). The RG is aware that the weighting algorithm takes into account abundance data, but also considers that thresholds are established only for some groups of species, i.e. corals and sponges, and this could affect the output of the analysis when such index is applied to other species.

The RGVME was additionally asked to review information about the fisheries footprint in relation to VMEs. VMS data from 2018 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.

Similar to ICES (2018) the report mentions problems with the quality of the VMS speed data in 2018. The polling frequency was still low (4h), which is however beyond the influence of WGSFD. Further, speed information was largely missing and therefore vessel speeds had to be calculated as the great-circle (orthodromic) distance between consecutive points reported by a vessel, divided by the time difference between them. The group used a speed of 5 knots to demarcate fishing from non-fishing pings for all gears. The presented speed profile indicates that this is a reasonable threshold, at least for mobile bottom contacting gears. It would be however useful to exclude static gears from the speed histogram in the future, as fishing activity of the latter is likely related to lower vessel speeds.

Generally, RGVME evaluates that the currently available information on the intensity of fishing with bottom contacting and static gears was analyzed adequately and thus allowed an overlay with VME layers. Further, RGVME considers the representation of speed filtered pings as points on maps with VME records as best display option.

The maps in the report (Figs. 4.53 to 4.59) illustrate that trawling often concentrates along the border of closed areas; vessels usually comply with measures. However, as point data VMS pings on the maps are small, RGVME recommends that in the future the number of pings (identified as fishing) within closed areas should be given as well. Although misinterpretations due to the speed-filtering algorithm are possible, it would give further information about fishermen's compliance with measures.

Based on this review, RGVME is content that the VME vulnerability index and habitat observations represent the best available evidence of representing the likely distribution of VMEs, and are a suitable evidence base for ICES to provide the requested advice to the EU and NEAFC. RGVME further evaluates that VMS data, despite all data problems, were analysed adequately and the output of the analyses was sufficient to indicate the intensity and distribution of fishing activities within NEAFC regulatory areas.

References

ICES. 2018. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5–9 March 2018, Dartmouth, Nova Scotia, Canada. ICES CM 2018/ACOM:26. 123 pp.