ICES WGSFD REPORT 2018

HUMAN ACTIVITIES, PRESSURES AND IMPACTS STEERING GROUP

ICES CM 2018/HAPISG:16

REF. ACOM, SCICOM

Report of the Working Group on Spatial Fisheries Data (WGSFD)

11–15 June 2018

Aberdeen, Scotland, UK

ICES
International Council for the Exploration of the Sea
CIEM
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2018. Report of the Working Group on Spatial Fisheries Data (WGSFD), 11–15 June 2018, Aberdeen, Scotland, UK. ICES CM 2018/HAPISG:16. 79 pp.

Contents

Executive summary

The Working Group on Spatial Fisheries Data (WGSFD) met at JNCC, Aberdeen, Scotland, UK, 11–15 June 2018. ICES had issued a data call for aggregated VMS and logbook data for the years 2009–2017 (updates for 2009–2016, new data for 2017).

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 WGSFD experts for quality. In case concern was raised, data submitters were consulted and asked to revise and resubmit data if necessary (see Annex 6). This substantially improved understanding potentially outlying data and the data quality as a whole. The ICES data centre facilitated this entire process. At the meeting, the products for OSPAR were reviewed by the WGSFD group where no mistakes were highlighted. The ICES data centre will hence publish OSPAR results.

Furthermore, the group was updated on a number of VMS/AIS/Logbook related projects, which are ongoing at national labs, including presentations on the use of AIS and VMS, the analyses of static gears, the use of VMS and logbook data in spatial stock assessments and the quantification of repetitive trawling intensities.

On request by NEAFC, members of WGSFD had analysed produced maps of fishing activity in NEAFC areas using the VMS and logbook information collected by NEAFC. A product was delivered to ICES WGDEC, which was used to advice on the impact of fisheries on Vulnerable Marine Ecosystems.

Furthermore, WGSFD addressed Terms of Reference on methodology to assess static fishing gears, quantifying and explaining the spatio-temporal variability of fishing fleets, best practice on analysing VMS data, and contributing to the preparation of an EU request to advise on appropriate methods to assess the spatial extent and distribution of physical disturbance pressures on the seabed. In addition, WGSFD explored if it would be possible to publish fishing effort or seafloor abrasion maps to the greater ICES public. Given potential sensitivity the group could not conclude on this as yet.

WGSFD has the ambition to publish peer-reviewed papers on two of the ToRs dealing with quantifying and explaining the spatio-termporal variability of fishing fleets across the ICES areas and to present best-practices on how to analyse and use VMS data from a world-wide perspective. Analyses were carried out at WGSFD to contribute to these manuscripts.

1 Administrative details

Working Group name

Working Group on Spatial Fisheries Data (WGSFD)

Year of Appointment within current cycle

2016

Reporting year within current cycle (1, 2 or 3)

3

Chair(s)

Niels Hintzen, the Netherlands

Christian von Dorrien, Germany

Meeting dates and venues

17–20 May 2016, Brest, France

29 May – 2 June 2017, Hamburg, Germany

11–15 June 2018, Aberdeen, Scotland, UK

2 Terms of Reference

A	**COMPLETED - DEVELOP ROBOUST METHODS TO CALCULATE DCF ENVIRONMENTAL INDICATORS 5, 6 AND 7.**
b	Work on standardized methods to analyse, and produce products that describe, the fishery in space and time
c	Review ongoing work for analyzing spatial fisheries data.
d	Initiate innovative methods to analyze spatial fisheries data.
e	Completed - 2016/1: Further development of fishing intensity/ pressure mapping. Following on from the format of the previous OSPAR requests; OSPAR requests ICES, using the latest versions of the indicator description/summaries of the 'Extent of Physical damage indicator' (BH3), to: • Collect relevant national VMS and logbook data for 2014. The data request should follow same format as last's year and include any amendments following the WG SFD meeting in June 2015; • Estimate the proportions of total fisheries represented by the data; • Using methods developed in previous advice, where possible, collect other non-VMS data for 2014 to cover other types of fisheries (e.g. fishing boats < 12m length); • Prepare maps for the OSPAR maritime area (including ABNJ) on the spatial and temporal intensity of fishing using mobile bottom contacting gears; • Provide advice on the development and application of alternative smaller grids

	(smaller resolution than 0.05°) to improve the analysis of fishing abrasion data: o What data and methods can be used for regional assessments, including pros and cons on data accessibility, and costings, if possible; o Explore any alternative approaches such as the "Nested grid approach", to ascertain if it can be used to provide supporting data to refine and calibrate the abrasion fishing layers. This can be done using a case study or pilot area. • Provide advice on the applicability and use of AIS data, in particular to: o Ascertain if it can be used as supporting information for the spatial analysis of fisheries data; o Indicate if it can be used as an alternative source of data to VMS; o Indicate potential costing for the collation and management of AIS data; o Advice can be based on a case study or pilot area.
f	Completed -Produce spatial fishery distribution product on a specific fishery - (Advisory request)
g	Completed -Produce impact maps by combining and evaluating benthic information on sensitivity (from WGDEC, BEWG, WGMHM) together with fishing pressure maps (fishing abrasion, weight and value of landed catch), taking into account differences in benthic impact of the various fishing gears / metiers.
h	Completed -Using NEAFC VMS and catch data, describe "fisheries activities in and in the vicinity of such (VME) habitats" (areas defined by WGDEC) within the NEAFC Convention Area in 2015. If possible, descriptions should be made of each area near such habitats, and separate each bottom contact gear type (e.g. static or mobile gears). Provide a technical document that can be used to discuus a revision of the NEAFC VMS agreement with ICES, and ANNEX VII (4) of the NEAFC Scheme of Control and Enforcement (Jan–Jun 2015).
i	Develop methods to estimate fishing activity and/or effort of static gears using from positional data, logbook data, observer data and questionnaires
j	Quantify and explain the spatio-termporal variability of fishing fleets across the ICES areas.
k	Present best-practices on how to analyse and use VMS data from a world-wide perspective.
l	WGSFD 2018 is requested to do prepatory work for the EU request to ICES on advising on *"appropriate methods to assess the spatial extent and distribution of physical disturbance pressures on the seabed (D6C2 of the Commission Decision 2017/848/EU)"*.

3 Summary of Work plan

Year 1	Continuing WGSFD work from 2013–2015 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. Improving methods to calculate fishing intensity and inititiate development of innovative methods to analyse spatial fisheries data, including the sandeel fishery in the North Sea as a case study. A request from OSPAR is expected again in 2016. Invite an expert on DCF indicators.

Year 2	Continuing WGSFD work from 2013–2015 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. Improving methods to calculate fishing intensity and inititiate development of innovative methods to analyse spatial fisheries data.
Year 3	Continuing WGSFD work from 2013–2015 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. Improving methods to calculate fishing intensity and inititiate development of innovative methods to analyse spatial fisheries data. Advisory request under ToR l)

4 Summary of Achievements of the WG during 3-year term

- Develop robust methods to calculate DCF environmental indicators 5,6 and 7: WGSFD calculated and performed sensitivity tests on different methods to calculate the DCF indicators. These activities were concluded in 2017.
- Work on standardized methods to analyse and produce products that describe the fishery in space and time: WGSFD refined the workflow over the years that can be used as a template by member states to address the annual ICES data-call on VMS and logbook data. Furthermore, WGSFD designed the methods to further process the VMS and logbook data to calculate sea-floor abbrasion. Products have been used by OSPAR, HELCOM, Sandeel benchmark, WGDEC, BEWG, WGMHM and different ADGs such as ADGFBI, ADGVME.
- Review ongoing work for analyzing spatial fisheries data: Each year at WGSFD presentations were given by members on intersessional activities and developments in their labs. Short descriptions of these activities are desribed in the annual reports.
- Develop methods to estimate fishing activity and/or effort of static gears: Several intersessional activities were undertaken to investigate how best to analyse static gears. WGSFD has not concluded on a standardized approach yet on how these data could be incorporated in the regular workflow.
- Quantify and explain the spatio-temporal variability of fishing fleets across the ICES areas: WGSFD has collated data and designed methodology to analyse the spatio-temporal variability of fishing fleets in ICES areas. A statistical model has been designed and appropriate co-variate data been collected. Intersessionally results will be prepared.
- Present best-practices on how to analyse and use VMS data from a world-wide perspective: A literature study and extensive discussions were undertaken at WGSFD to condense best practices on VMS data analyses. Intersessionally results will be gathered and turned into a manuscript.
- WGSFD has demonstrated how AIS data could be used in analyses relating to the spatial and temporal distribution of fishing, through a number of presentations and discussions. Recommendations on how to progress in this field are given.

5 Final report on ToRs, workplan and Science Implementation Plan

5.1 ToR A: Develop robust methods to calculate DCF environmental indicators 5, 6 and 7

WGSFD calculated and performed sensitivity tests on different methods to calculate the DCF indicators. These activities were executed and discussed in 2016 and 2017 and are hence reported extensively in the interim reports. WGSFD showed how different indicators could be calculated taking different assumptions on e.g. aggregation of fishing inside a gridcell. Tables on these indicators were produced and showed the time- and ecoregion changes in the spatial extent of fishing, areas not impacted by mobile bottom gear and the aggregation of fishing activities. These methods were made publicly available as equations within the WGSFD reports and as R/SQL scripts at the working group SFD github (https://github.com/ices-eg/wg_WGSFD/tree/master/DCF%20indicators).

Interim deliverables on Tor A are described in the WGSFD interim report of 2016: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2016/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf

And final deliverables on ToR A in the WGSFD interim 2017 report: http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2017/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf

5.2 ToR B: Work on standardized methods to analyse, and produce products that describe, the fishery in space and time

The quality of the outputs produced by the ICES secretariat and WGSFD is highly dependent on the quality of the data provided by the member states as well as the routines to process and analyze these data. Due to the complexity of the data and the different setups individual countries have for holding and extracting VMS /Logbook data, trying to standardize workflows and/or final products can be a challenging task. To address these issues, WGSFD in 2015 proposed developing a best practices guide and workflows in R to help states stream line data extraction, cleaning, aggregating and submission processes. The R-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 continuously improved over the last years. The status of data submissions is given in table 5.2.1.

Table 5.2.1. Status of data submission.

	Data submitted	Comments
Belgium	Yes	
Denmark	Yes	
Estonia	Yes	
Faroe Islands	No	
Finland	Yes	
France	Yes	
Germany	Yes	
Greenland	No	
Iceland	Yes	Only VMS data for metiér OTB were submitted.
Ireland	Yes	
Latvia	Yes	
Lithuania	Yes	
Netherlands	Yes	
Norway	Yes	
Poland	Yes	
Portugal	Yes	
Russia	No	
Spain	No	
Sweden	Yes	
UK	Yes	

An additional way to achieve a high quality of the data products is to identify any potential issues and doubtful results in the submitted and aggregated data as early as possible. Once these issues are highlighted, a deeper analysis on the data could reveal whether these deviances are reflecting true changes or are based on errors in the data that can to be corrected. A thorough quality check process increases both, the reliability on the data used in the analysis as well as the confidence by the final recipient in the advice given.

ICES secretariat, ICES Data Center and WGSFD used a multi-step approach, following a four-eye principle wherever possible, to ensure that data submissions and aggregated data do have the best quality possible. Each national data submission was analyzed 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 Center 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 2016, comparing the data submitted in 2017 versus the data submitted in 2018 and between years 2016 and 2017. These maps were checked for any deviations by WGSFD experts in plenary during the meeting, no major issues where 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.

5.3 ToR C: Review ongoing work for analyzing spatial fisheries data

Annually, WGSFD received many contributions from members presenting intersessional work on analysing spatial fisheries data. In the 2016 and 2017 report short paragraphs are provided on the content of these presentations. Below the contributions from 2018 are captured.

Roi Martinez – combining AIS and VMS

Roi Martinez has presented an update of his MPA management tool built in R Shiny. It gives to the tool user a friendly interface to the fishing effort model R scripts running in the background of the tool. This tool was developed in a web application format to give access to several concurrent users regardless their location and without need of installation of any software.

The MPA management tool is using VMS locations as effort indicator data source, therefore AIS data was presented as future implementation into the tool in combination with the VMS data to improve spatial-temporal resolution of benthic habitat impact assessment. In relation to the spatial analysis of extent of the fishing gear impact, the AIS data could support a better fishing vessels trip track-line estimation. Applying a buffer to these vessel track lines with the averaged width of fishing gear using in each trip we could obtain the swept area ratio by trip in a polygon shape. Then the cumulative swept area would be aggregated by c-square and obtain a more accurate impact indicator than the current analysis with VMS locations.

Per Finne – AIS and static gears

Presented recent work on AIS data from the Lofoten Sea covering an important cod fishing area. Norway has collected three years of AIS from the fishing fleet < 15m, which primarily do not have electronic logbook and VMS. Over half of the fleet under 15m have AIS installed, even though it is not mandatory. The proportion is increasing each year and the same vessels are responsible for over 75% of the total catch in that group. Secondly we took a closer look at static gears using different available sources, together with

AIS. Finally a short presentation on Skagerrak Sea showing implemented ideas from the working group in actual regulations, in order to keep allowing the fishing vessels to trawl across boarders in the same haul.

Josefine Egekvist – AIS and small scale fisheries

It was investigated if AIS can supplement the VMS data for the vessels below 12 meters that doesn't have VMS for Danish vessels. It is optional to have AIS installed for fishing vessels less than 15 m. AIS data from the Danish Maritime Agency, which picks up AIS positions in Danish waters, have been made publicly available from 2006 onwards, and the number of fishing vessels with AIS has increased during the period. Data were filtered to keep positions from Danish fishing vessels with approximately 5 minutes interval. To merge the AIS data with logbook data (to know the gear used), a vessel-id is necessary, and is found through merging with the fleet register by call sign. In some cases, this is not possible, and it is checked if it is possible to find the vessel-id directly from the AIS vessel name. The AIS data are merged with logbook data by vessel-id and date, and a speed filter is applied depending on the gear used, giving around 4 million AIS positions the last years. For analysis of how AIS can supplement the VMS data, an extraction was made of AIS data from vessels with logbooks, without VMS (around 200 000 AIS positions the last years). Some of the fishing vessels in the AIS dataset could be defined as recreational tour boats (250–300 000 AIS positions the last years).

An issue with the AIS data is that it can be turned off, e.g. at good fishing spots, while that is not possible with the VMS data. An analysis was made of trips from Danish vessels fishing in Kattegat. AIS data were merged with logbooks, and "holes" of more than 30 minutes in AIS time series within fishing trips were identified. The reason for a "hole" in AIS data could be due to the fishermen turning it off, but it could also be caused by that the vessel was at a place where the signal was not received by the Danish Maritime Agency. The analysis showed that in average 5% of the fishing trips in Kattegat with vessels less than 12 m had "holes" during the period 2006–2017. An analysis of coverage of AIS and VMS data shows that the use of AIS data can supplement the VMS data, especially in the case of gillnets.

As the AIS positions are of higher frequency than the VMS data, the grid resolution in exchange formats can be on a higher resolution. The VMS data are reported on a 0.05 degree grid, while the AIS data can be reported on a 0.01 degree grid.

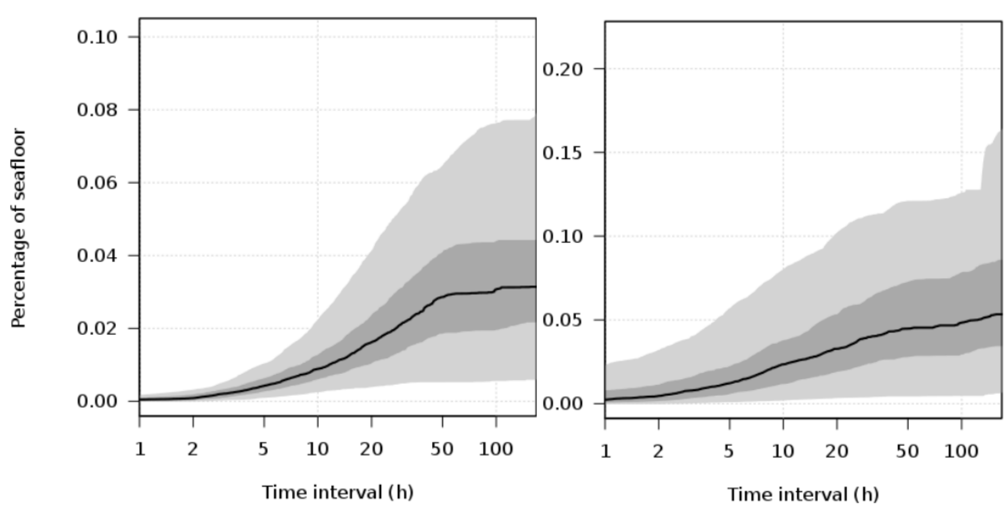
Pedro Lopes – AIS data

Presented recent work on the identification of the different fleets operating in Madeira-Tore (North Atlantic), on an area previously defined as a critical area under the Marine Strategy Framework Directive (MSFD). The combined analysis of VMS and e-logbook allowed the identification of fishing events and the estimation of the fishing intensity by gear type, as well as the identification of several general patterns for fishing operations. The Portuguese fishing fleet operating in this area comprises mainly longliners, alternating between bottom longline activities in spring and summer and pelagic longline in autumn and winter.

A study was presented on the activity of a continental longliner fishing in seamounts of the Madeira-Tore, that could be followed during a single fishing trip, based on the analysis of high-frequency AIS data combined with on-board registers of fishing positions and associated catches. When available, AIS data represent an invaluable tool for identifying and detailing fishing operations, allowing the recognition of spatial fishing patterns for longliners operating in North Atlantic.

Niels Hintzen – Repetitive trawling

The occurrence of repetitive trawling events within a week in the most frequently fished ICES rectangles by the Dutch beam-trawl fleet were investigated. Repetitive trawling exposure occur when a trawl passes over the exact same spot twice. Given that these activities occur at the spatial scale of the gear, we analysed trawling tracks at a grid cell size of 25 by 25meter. After applying interpolating techniques to estimate trawl passages we calculated the time difference between trawl passages in the exact same grid cell. Since the analyses was executed for 52 weeks in a year, a bandwidth of results was obtained, presented in the figure below. The repetitive exposures were expressed as percentage of the seafloor in a specific ICES rectangle (32F2 in the figure below for Pulse (left) and traditional beamtrawl (right)). All areas considered (4 ICES rectangles in total), the part of the seabed that is disturbed repetitively is very small. Only up to 0.3 (pulse) - 0.8% (beam trawl) of the pixels of the most intensively trawled ICES rectangles may encounter a repetitive exposure with intervals of less than one week. These estimates are based on the most intense traditional beam or pulse-trawl fished areas in the North Sea. At time intervals taken within a day, these percentages drop further down to <0.16% and <0.5% for pulse trawl and traditional beam trawl, respectively.



5.4 ToR D: Initiate innovative methods to analyze spatial fisheries data

Results on this ToR will be reported on under ToR J.

5.5 ToR E: Further development of fishing intensity/ pressure mapping

WGSFD contributed to generate fishing intensity and pressure maps for the HELCOM and OSPAR regions together with the ICES secretariat. Quality control on data used for these maps was performed by WGSFD and in 2016, the generation of the maps were taken care by WGSFD. From 2017 onwards the ICES secretariat generated the maps. Results were used in advice and published as such on the ICES webpage.

Interim deliverables on ToR E are described in the WGSFD interim report of 2016: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2016/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf

And final deliverables on ToR E in the WGSFD interim 2017 report: http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2017/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf

Final deliverables in terms of maps for OSPAR and HELCOM can be found here:

2016:
http://ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special_Requests/OSPAR_further_development_of_fishing_intensity_and_pressure_mapping.pdf

2017:
http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special_requests/OSPAR.2017.17.pdf

http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special_requests/HELCOM.2017.18.pdf

2018:
http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/Special_requests/ospar.2018.14.pdf

5.6 ToR F: Produce spatial fishery distribution product on a specific fishery

WGSFD generated the required maps as requested by the Sandeel benchmark workshop to show the fine-scale spatio-temporal distribution of the sandeel fishery in the North Sea. Results were send directly to the benchmark group that took place in 2017.

Final deliverables on ToR F are described in the WGSFD interim report of 2016: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2016/01%20WGSFD%20-

%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf (see Annex 6 on page 165)

5.7 ToR G: Produce impact maps by combining and evaluating benthic information on sensitivity (from WGDEC, BEWG, WGMHM) together with fishing pressure maps

WGSFD generated the required maps as requested by the different working groups. Results were send directly to the group that took place in 2016.

Final deliverables on ToR G are described in the WGSFD interim report of 2016: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2016/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf (see page 68).

5.8 ToR H: Using NEAFC VMS and catch data, describe "fisheries activities in and in the vicinity of such (VME) habitats" (areas defined by WGDEC) within the NEAFC Convention Area in 2015

WGSFD generated the required maps as requested by WGDEC after extensive analyses of the NEAFC data. Results were send directly to the group that took place in 2017 and 2018 and were used for advice in among others VME related topics.

Interim deliverables on ToR H are described in the WGSFD interim report of 2016: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2016/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf

And final deliverables on ToR H in the WGSFD interim 2017 report: http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPI/2017/01%20WGSFD%20-%20Report%20of%20the%20Working%20Group%20on%20Spatial%20Fisheries%20Data.pdf

Advice related to ToR H can be found here:

2017:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/vme.neafc.pdf

2018:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/vme.neafc.pdf

5.9 ToR I: Develop methods to estimate fishing activity and/or effort of static gears using from positional data, logbook data, observer data and questionnaires

Little is known about spatial-temporal dynamics of static gears, i.e. where do shoot their gear, how long are gears in the water, what are the gear dimensions used. Using a variety of data sources we aim to develop standardized methodology to improve on estimating the high spatial-temporal impact of static gears.

To address this ToR an overview of current EU legislation on reporting of gear dimensions of static gears is given. The majority of vessels fishing with passive gears are small vessels and many of them don't have VMS onboard. Therefore, to get information on the spatial extent of the fishery, some data are available from logbooks and some of the vessels have AIS or another high-frequency position data source. In the case of passive gears, it is important to distinguish between the vessel fishing effort, which is related to when the vessel is handling the gear (setting or hauling), and the gear fishing effort, which is related to when the passive gear is soaked in the water. Examples are given where fishing activity is estimated for passive gears.

- Differences between vessel effort and gear effort in relation to passive gears

One of the main difficulties with passive gears lies in the definition of meaningful effort descriptors. Effort descriptors currently available are either vessel hours spend operating the gears, estimated by decomposition of the speed profile in VMS data, or days at sea from the logbook/sales notes. However, because of their passive operative mode, vessel fishing effort is at least partially decoupled from gear effort and some gears may be actually fishing in the interval between vessel days at sea.

A range of different situations was identified for passive gears which raise various issues regarding effort quantification from VMS and logbook data. In all cases, soaking time is a key information lacking:

- For long liners, the speed filter does not capture the setting step, only the slower step of picking up the lines. A close visual inspection of the tracks easily reveals the line setting step, which closely overlap in space with the line picking-up one. Soaking time would thereafter be a straightforward time difference between closest pings in the setting and picking up phases (with a possible drift). Further work is needed to develop routines to automatically and routinely detect such ping associations.
- For pots and nets, the gear operation may correspond to either setting the gear or picking up/emptying it. The two phases can coincide with, for example, emptying, rebaiting and soaking of pots in the same operation when a pot stays at the same place. The gear effort should therefore be the soaking time. Automatic detection of associated gear setting and catch collection events to estimate the soaking time appears to be problematic, at least solely on the basis of a speed filter. The setting phase, in particular, can be missed if it is not coincidental with catch collection, as it can be operated at higher speed in some cases (e.g. self-shooting pot lines).

Passive gears do not fish at constant rate over time. The attractiveness or catchability of the gear may decrease over time (e.g. asymptotic catch for pots, due to bait consumption, escapement, and saturation). Although there is an extensive enough literature about efficiency of passive gears and its relationship to immersion time (e.g. Zhou and Shirley, 1997a, 1997b; Groeneveld *et al.*, 2003; Rotherham *et al.*, 2006; Bacheler *et al.*, 2013; Anders, 2015), this is highly dependent on gear and attractant (if relevant) characteristics as well as on target species. An even coarse quantification of passive gears efforts would therefore require the collection of more information in the context of the logbook-VMS data call, if this information is collected in national logbooks.

Basic missing information about passive gears includes, but is not limited to:

- number of hooks for longlines.
- dimensions of nets.
- number of pots deployed.

Legislation on collection of information on passive gears

The subgroup analysed which data on passive gears are collated from logbooks, and it was discussed how such data can be used. Furthermore, the WG considers paramount ensuring consistency of results across MS and across vessel size categories.

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) and hooks and lines including handlines and longlines (LHP, LHM, LLS, LLD, LL, LTL, LX). In accordance with Commission Implementing Regulation (EU) No 404/2011 of 8 April 2011 Annex X, following general and minimum information requested to record on the vessels fishing activities with static gear, there is obligation on the gear dimension as follows: total length of nets, total number of pots/traps and total number of hooks. However, inconsistency between Annex X and Annex XI has been noticed. The subgroup assumed that dimension is compulsory to report. That information should have been gathered by Member States since amendments were adopted in Commission Implementing Regulation (EU) 2015/1962 of 28 October 2015. The subgroup stressed that these additional variables do not belong to the core set of dimension variables for vessels without logbooks. Based on the information already collected from control regulation and considering the minimum requirement that is common to all MS, the information on dimension could be requested in further data calls. The subgroup highlighted the need on soaking time for static gear fishing effort.

As well was noted the recent relive of proposal for a Regulation of the European Parliament and of the Council amending Council Regulation (EC) No 1224/2009, and amending Council Regulations (EC) No 768/2005, (EC) No 1967/2006, (EC) No 1005/2008, and Regulation (EU) No 2016/1139 of the European Parliament and of the Council as regards fisheries control. The proposal aims at revising the flexibility on the specifications of a vessels tracking system (not necessary satellite-based). All vessels including those below 12 metres length must have a tracking system. Only two categories of fishing vessels are defined: > 12 m and <= 12 m. For fishing vessels of 12 metres length overall or more the estimated quantities of each species in kilograms live weight shall be provided per haul or per fishing operation must report their catches electronically.

Review of data sources available for passive gears

Many outputs from different working groups and workshops connected with small scale fisheries (SSF) data collection are available already, which is relevant as many of the smaller vessels are fishing with passive gears.

- Report on the DCF Workshop on "Common understanding and statistical methodologies to estimate/re-evaluate transversal data in small-scale fisheries". 21–23 May 2013, Nantes, France.
- Report of the Working Group on Commercial Catches (WGCATCH). 9–23 November 2015 Lisbon, Portugal.
- Report of the Working Group on Commercial Catches (WGCATCH). 7–21 November 2016, Oostende, Belgium.
- Report on the 2nd Workshop on Transversal Variables. 22–26 February 2016, Nicosia, Cyprus.
- Meeting on Statistical Issues and Methodologies (SIM subgroup of DCF/PGECON). 12–24 December 2016, Rome, Italy.
- Report on the PGECON subgroup DCF workshop on small scale fisheries. 25 - 29 September 2017, The Hague, the Netherlands.
- Report of the Working Group on Commercial Catches (WGCATCH). 6–20 November 2017, Kavala, Greece.

During the DCF workshop on small scale fisheries (PGECON subgroup) which was held in The Hague, 25–29 September 2017 an overview of European SSF was made. Information was presented and summarized on SSF data collection methodologies from 18 countries for four different regions (North Sea, Mediterranean Sea, Atlantic and Baltic). It was discussed how to calculate fishing activity for SSF. Countries provided information about SSF spatial distribution resolution. In most cases, spatial resolution is available on the scale of ICES rectangle or GSA (Geographical Sub-Areas in the Mediterranean) area level, in some cases even with lower resolution as on ICES fishing areas. In some countries information is available about coordinates of haul positions. In most of countries information about number of fishing gear and their dimension is collected or estimated, this could be used to estimate the impact of static gears with higher spatial-temporal resolution in the future.

Logbooks and VMS

Electronic logbooks are mandatory for vessels above 15 m in Norwegian waters and above 12 m in EU waters. It is mandatory to use electronic logbooks for vessels larger than 10 m (8 m in the Baltic), but vessels below 12 m can still fill in paper logbooks, that are then entered into databases.

The ICES data call for combined VMS and logbook data also includes passive gears, where a speed filter is typically applied.

Table 1 below shows an output on VMS coverage for static gears in average from 2009–2017 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 doesn’t 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.

Table 1. Fishing days and landing weight represented by VMS data by static gear group for the years 2009 to 2017. No data were submitted from Spain, Greenland, Faroe Islands and Russia.

Year	Area	Gear group	Fishing days without VMS	Fishing days with VMS	Percentage of fishing days with VMS	Total weight without VMS	Total weight with VMS	Percentage of total weight with VMS
Mean of 2009 - 2017	27.1	static	3158	5241	62	6128794	14613711	70
	27.12	static	14	44	75	2111	55448	96
	27.14	static	106	256	71	319240	1238504	80
	27.2	static	7632	23305	75	17288704	46249281	73
	27.4	static	61775	12771	17	19602183	17750841	48
	27.5	static	160	40999	100	287706	140307088	100
	27.6	static	21926	4192	16	10828522	9917509	48
	27.7	static	130487	19508	13	49739883	27799112	36
	27.8	static	77599	13921	15	11747607	14425011	55
	27.9	static	10780	9434	47	1954443	4512423	70
	27.10	static	213	156	42	69831	100928	59
	27.3.a	static	7430	1151	13	1928492	969193	33
	27.3.b	static	3865	76	2	1438069	41653	3
	27.3.c	static	11640	348	3	2184945	205959	9
	27.3.d	static	86856	3212	4	40715677	2643979	6
	TOTAL		476202	150784	24	183999634	314107753	63

In both EU and Norway information on passive gears like total number of hooks (long line) or total length of gillnets deployed is or can be reported in logbooks. The numbers reported seem to be reported in different units in some cases, affecting the quality of the information.

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.

Other data sources

A substantial part of the vessels fishing with passive gears is below the length where it is required to have logbooks and VMS, and therefore other data sources are needed to describe the fishery. The data sources for the passive 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 have developed apps for smartphones for reporting on trip, fishing time and position and gear use, e.g. the MOFI app used in Germany. In Norway, the coast guard is collecting data on the locations of passive gears. In addition, observer data can be useful for validation.

Sale notes and AIS

The sales notes have information about landing composition and main catch area. In Norway gear information is also available in the sales notes, while in other coutries, the gear information need to be derived from other data sources like monthly reports, fleet register or licences. Those data source doesn't have information on gear dimensions, only on gear and main catch area, and need to be coupled with AIS data for acceptable spatial resolution. Standard method of speed filtering of AIS in intervals between landing dates gives an approximate fishing area. To clean AIS data one could use depth, terrain type and spatial regulation data if available. As a more advanced option pattern recognition could be used. It is often easy to spot visually which gear is used and this detection should be possible to automate through coding. Please also see other section on working with AIS data for a more comprehensive discussion.

Summary

To summarize for static gears, we need to use a multi-data source approach to get close to the same information detail as on active gears. Even then there will be difficulties with measures on fishing gear effort because of less details in the logbooks. The majority of the static gear fleet is below length limit for electronic logbook and VMS tracking, and they are not required to use AIS, but part of the fleet nevertheless have AIS installed, depending on the fishing area. The different national authorities seem to be expanding at an increasing rate the use and requirements for AIS.

5.10 ToR J: Quantify and explain the spatiotermporal variability of fishing fleets across the ICES areas

Introduction

A decadal view on fisheries distribution and variability over time is lacking from the literature. This information has however now become available through the ICES data-calls on VMS and logbook data and therefore makes a valuable data source to investigate, describe and explain the spatio-temporal use of the European seas by the different fisheries. The aim of ToR j) is to quantify and explain the spatio-termporal variability of fishing fleets across the ICES areas. First, an EOF analysis (Preisendorfer, 1988) will be performed to decompose the space-time variability in the time-series of gridded maps of fishing effort or intensity into principal spatial modes and their amplitudes. This will allow describing the patterns of variability. Then, a spatio-temporal modelling approach will be performed to explain the described fishing effort patterns using covariates. This modelling approach offers a flexible framework for selecting and modelling the effect of relevant covariates as well as time and space dependence. This will be applied to some selected fisheries from ICES areas, for instance the otter trawls targeting demersal fish in the North Sea. For this fishery, the expected results should allow to quantify the importance of various environmental or anthropogenic covariates that may drive the fishing effort or intensity distribution over space and time.

Material & Methods

Data sources

We compiled data from different sources to investigate the spatio-temporal variability of demersal fishing effort (Otter board trawlers, OT_DMF) in the North Sea (Table 2). Fishing effort as dependent variable was calculated from Vessel Monitoring System data (VMS) provided by the ICES data center in collaboration with WGSFD. Data were available as monthly means for grid cells with a size of 0.05°*0.05° from 2009–2017. Currently, eleven covariates are considered in the model. Hydrographic variables, primary productivity as well as natural disturbance rate were spatially and temporally resolved parameters and were aggregated or disaggregated respectively to match the VMS data set. Sediment characteristics and location parameters (distance to coast, bottom positioning index) were time-invariant and oil price as proxy for economic costs of fishing space-invariant parameters.

Table 2. Preliminary list of variables to be included in the hierarchical bayesian spatial model (HBSM). Note that fishing effort is the dependent variable, while all the others constitute the covariates to be used in the HBSM.

Variable	Unit	Resolution		Time period	Source/ Link
		Spatial	Temporal		
Fishing effort (OT_DMF)	h	0.05° x 0.05°	monthly	2009-2017	ICES data centre/ WGSFD
Distance to coast	m	0.05	NA	NA	WGSFD (Roi Martinez, pers. Comm.)
Bottom positioning index	m	0.166° x 0.166°	NA	NA	GIS extraction
Natural disturbance rate	%	0.125° x 0.125°	monthly	NA	Wilson et al. (2018) https://doi.org/10.5194/essd-10-109-2018 https://pure.strath.ac.uk/portal/en/datasets/data-for-a-synthetic-map-of-the-northwest-european-shelf-sedimentary-environment-for-applications-in-marine-science(1e27b806-1eae-494d-83b5-a5f4792c46fc).html
Mud Gravel Sand	% of surface sediment	0.125° x 0.125°	NA		
Rock	% covered				
Bottom Temperature	°C	0.2° x 0.2°	monthly	2009-2014	AHOI model (Riboni & Akimova, 2015) (https://www.thuenen.de/en/sf/projects/ahoi-a-physical-statistical-model-of-hydrography-for-fishery-and-ecology-studies/
Bottom Salinity	psu				
Primary productivity	mg C * m^{-2}* day^{-1}	0.166° x 0.166°	monthly	2009-2014	MODIS R2018 (Marc Taylor, pers. comm.) (http://orca.science.oregonstate.edu/1080.by.2160.monthly.xyz.vgpm.m.chl.m.sst.php).
Oil price	€	NA	monthly	2009-2017	https://www.indexmundi.com/commodities/?commodity=crude-oil-brent&months=120&currency=eur.

Describing the space-time variability using EOF analysis

The EOF analysis is a method developed in Meteorology and Oceanography by Preisendorfer (1988) to decompose the space-time (residual) variability in the time series of maps into principal spatial scales and their time amplitudes. The method is actually a particular Principal Component Analysis (PCA) applied to a series of gridded maps. This method was widely used. For instance, such decomposition was applied in fishery sciences to understand the spawning distributions of the anchovy in the Bay of Biscay (Petitgas *et al.*, 2014). The decomposition is a linear factorisation of spatial components (eigenvectors), that are constant in time, and amplitudes (principal components), that are variable in time. The variability around the mean map is, thus, modelled as the sum of spatial components that are weighted by their annual amplitudes. Detailed equations can be found in Petitgas *et al.* (2014).

To achieve the decomposition, a matrix of anomalies is computed by removing the time averaged map from the original time series of maps. Then the EOF decomposition is performed on this matrix of anomalies. Practically, a principal components analysis of the covariance matrix in space over time (or alternatively of time over space) derived from the matrix of anomalies (see Petitgas *et al.*, 2014 for details) allows to compute the eigenvalues (overall variance accounted for by the components), eigenvectors (spatial components) and principal components (time amplitudes).

To retain the most meaningful EOFs and interpret their spatial patterns, we used the eigenvalues and the 'local' explained variance (Schrum *et al.*, 2006; Woillez *et al.*, 2010). The 'local' explained variance at a given location associated with a given EOF is the proportion of variance across time that the spatial components and time amplitudes explain at that location. When the map of local variance shows an interpretable pattern, the EOF is meaningful as it explains variability in particular areas. When the combination of the spatial component and its amplitude are of the same sign, then the composed signal is positive and when they are of opposite signs, the composed signal is negative.

Modelling the spatio-temporal distribution of fishing effort

In order to estimate and predict the intra and inter-annual dynamics of fishing effort in the North Sea, Hierarchical Bayesian spatial model (HBSM) will be used. The model essentially assumes that fishing effort (herby calculated as the number of hours that a particular vessel spent at sea fishing) at nearby locations and time intervals are more similar than those more far apart. Moreover, it allows including a set of covariates that can be used to assess the proportion of spatial variation in fishing effort that is explained by those covariates. Here, in particular, we will test the effect of the covariates highlighted in section X.

The overall structure of the model is similar to a Generalized Linear Model (GLM), where the relationship between the response variable Y_i and a set of covariates x_i is described through a linear predictor η. The linear predictor is, in turn, linked to the mean of the response $E(Y_i)=\mu_i$ by means of a link function g, such that $g(\mu_i)=\eta_i$. In this way, the general model can be summarized as follows:

$$\eta_{s,t} = \beta_0 + \sum_{m=1}^{M_k} \beta_k x_k(s,t) + \xi(s,t)$$

where β_0 is an intercept vector, β_k a design matrix that quantifies the fixed effect of some covariates X_k, and ξ(s,t) represents the spatio-temporal structured random effect.

The ξ(s,t) term was considered as a Gaussian Random Field (GRF), which reduces to a multivariate Gaussian distribution (MG) with mean zero and covariance matrix Σ when evaluated at a finite set of locations:

$$\xi(s,t) \sim MG(0,\Sigma)$$

Here Σ was treated as a separable random field process, such that its variance can be decomposed into a spatial covariance matrix, Σ_S=s(ij)∈ R^(n x n), and temporal covariance matrix, Σ_T=T(ij)∈ R^(m x m).

The spatial covariance will be specified through a Matérn distribution, such that:

$$\Sigma(s_i, s_j) = \frac{\sigma^2}{2^{v-1}\Gamma(v)} (\kappa|s_i - s_j|)^v K_v(\kappa|s_i - s_j|$$

where |s_i-s_j | is the Euclidean distance between two sampling locations i and j; σ^2 the marginal spatial variance; K_v the modified Bessel function of the second kind and order v > 0, which measures the degree of smoothness of the spatial process; κ is the scale parameter that is related to the to the distance at which the spatial correlation becomes nearly zero.

Finally, for the temporal covariance we will use a first-order autoregressive (AR1) process, which depends on an exponential decay function that is expressed in terms of the absolute difference among consecutive time intervals |t_i-t_j | and the temporal correlation ϱ_T :

$$\Sigma(t_i, t_j) = \exp(|t_i - t_j| \cdot \rho_t)$$

Model inference

Provided that the model is performed under a Bayesian prism, all parameters will be treated as random variables where their estimations will be obtained through marginal posterior distributions. Inferences will be achieved by means of the Integrated Nested Laplace Approximation (INLA) methodology and its respective R-package (www.r-inla.org) (for more details, please refer to the latest review of Rue *et al.*, 2017). Due to lack of prior knowledge, default non-informative priors for all fixed-effect parameters as recommended by Held *et al.* (2010) will be assigned. These priors are essentially designed to have little influence on the posterior distribution and hence can be regarded as an attempt to unify the frequentist and Bayesian statistics.

Model selection

Model selection will be conducted on a backward stepwise method, starting always from the full model, i.e., model with all covariates included. The goodness-of-fit of the models will be accessed through the Watanabe Information Criterion (WAIC; Watanabe, 2010). Moreover, predictive quality of the models will be achieved through the Conditional Predictive Ordinate (LCPO) as indicated in Roos & Held (2011). Both WAIC and LCPO are inversely related to the compromise between parsimony, fit, and predictive quality; therefore, the lower their values, the better the model.

Prediction of fishing effort

To predict fishing effort across the North Sea, it will be first necessary to divide the study area into a triangular mesh (Figure 2). Provided that it will be used for the final prediction, this constitutes a crucial step during the modelling procedure. It is, therefore, paramount that the triangles should have regular shapes and sizes (Lindgren *et al.*, 2011). Moreover, because the variance usually becomes twice as larger at the border when compared to the main domain, the triangulation needs to be spatially extended to avoid the boundary effect (for more details refer to Lindgren & Rue, 2015 and Krainski *et al.*, 2017).

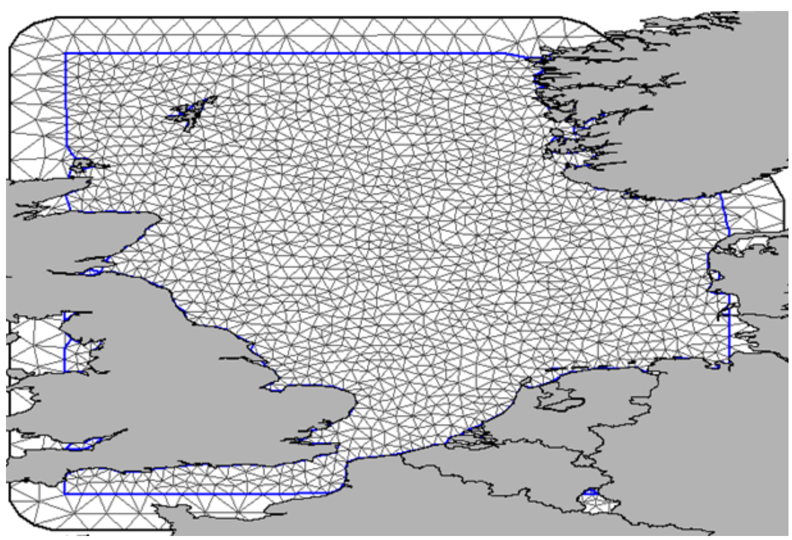


Figure 2. Provisory triangular mesh that will be used to predict fishing effort in the North Sea.

5.11 ToR K: Present best-practices on how to analyse and use VMS data from a world-wide perspective

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

A subgroup of the working group considered this term of reference, and developed a work plan for the production of a peer-reviewed paper examining best practices. The paper will focus on four main areas. Firstly, how rules surrounding access to data function within Europe and other nations, and the specific issues faced within regional fisheries management organisations where multiple national regimes may apply. Secondly, the acquisition and management of data, and how alternative and ancillary sources of spatial data can contribute to our understanding of spatial patterns of fishing activity revealed through VMS data. Thirdly, approaches to analysis of data will be considered. This will include methods for determining fishing activity through speed profiles and turning angles, relation between fishing activity from VMS and bathymetry, gridding of effort data, and interpolation between VMS polls into tracks. Finally, we will review applications of VMS analysis in studying fisheries catch, benthic impacts, spatial planning, effort measurement and displacement, and interactions between fishing vessels, marine mammals, seabirds and other wildlife. The review will serve to highlight commonalities of approach, best practices and areas where improvements could be made through the adoption of new techniques.

5.12 ToR L: WGSFD 2018 is requested to do prepatory work for the EU request to ICES on advising on appropriate methods to assess the spatial extent and distribution of physical disturbance pressures on the seabed

The ICES Working Group on Spatial Fisheries Data's (WGSFD) mandate is to collate and analyze high resolution spatial fisheries data collected through a bespoke data call issued by ICES Secretariat to all EU ICES states. Such data call is used to answer specific advice requests by OSPAR and HELCOM. And for the creation of data products for the assessment of DCF indicators 5, 6 and 7 and for the OSPAR's indicator BH3 'Extent of Physical damage'.

The benthic fishing pressure layers created by the WGSFD can be used in the assessment of D6C2 as they contain:

- an estimation of fishing effort measured in kWhFishingHours and Fishing hours
- an estimation of fishing intensity/pressure/abrasion measured as surface and subsurface swept area and swept area ratios.

Following a request from OSPAR in 2016, the WGSFD has compared fishing effort calculated from VMS data and from AIS data only (ICES, 2016). Recent Similar exercise was carried out by Shepperson *et al.* (2018) and IMARES (2014). In the paper from Ferra' *et al.* (2018) AIS data are used to analyse the change of impacts in trawling activity for the Mediterranean Sea.

In WGSFD 2016, the comparison was carried at an aggregate level especially due to the fact that it is not possible to access raw VMS and logbook data. The results of the comparison were in line with the published literature:

AIS is a useful additional source of information in fisheries and has a better coverage in coastal areas due to the terrestrial network of receivers. AIS can improve the resolution of VMS and logbook data and allows to identify a fishing vessel track better, time resolution of AIS is a considerable advantage to the one/two hours time resolution of VMS data. In total, AIS estimated fishing effort tends to underestimate total fishing effort calculated from VMS data. The estimation of fishing effort by gear, requires AIS data to be coupled with gear information. Logbooks contain information on the gear used for every trip, while for AIS data there is no gear information and it has to be obtained from other sources or estimated (put ML papers on gear estimation). When such information is derived from the fleet register, fishing effort estimation is directly affected because it is assumed that the gear indicated on the fleet register is used in every trip.

Primary gear information in the fleet register is at manually inserted by the owner of the boat and most of the fishing vessels in in the fleet register are bottom trawlers (OTB). This inflation of bottom trawlers in the fleet register results in an overestimation of the share of fishing effort attributable to bottom trawlers (OTB) and an underestimation of the other bottom contacting gears (see ICES 2016).

The group supports the findings in the 2016 report and in Shepperton (Shepperton, 2018) and Ijmuiden (Ijmuiden, 2014) and advice that a better comparison for European waters would start from coupling AIS, VMS and logbook data at individual vessel level, which is possible only at member state level due to confidentiality of raw VMS and logbook data.

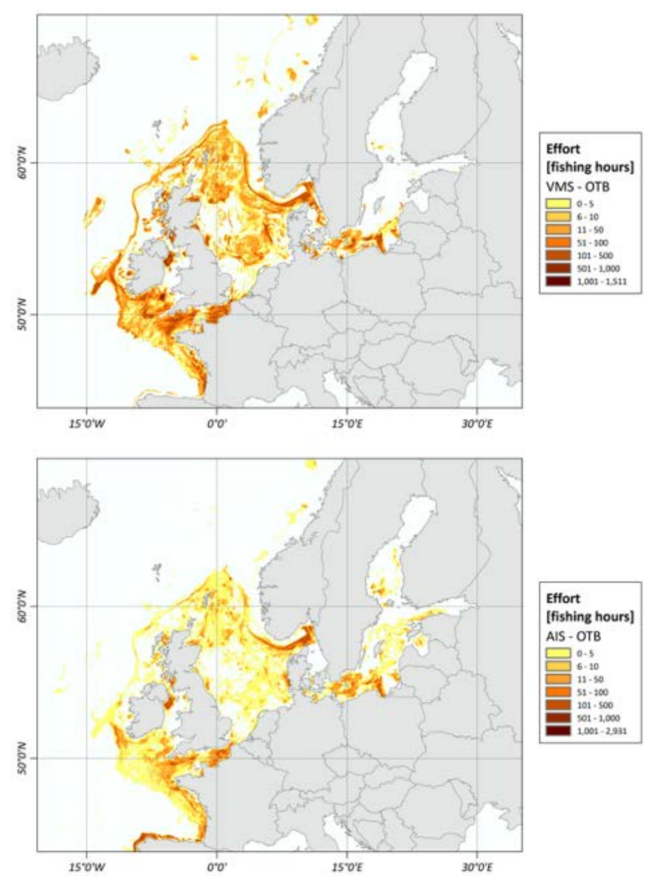


Figure 3. Total fishing effort calculated from VMS data and from AIS data (ICES, 2016, page 179).

A recent collaboration between Global Fishing Watch and the WGSFD group attempted a direct comparison at individual fishing vessel level for the Dutch fleet (see table below), with the same results as previous published research (Figure 4). The following table presents a statistical summary of AIS and VMS data for the Dutch fleet.

	AIS	VMS	AIS/VMS	Logbook
Total vessels (number)	474	319	1.49	549
Total active effort (fishing hours)	904499	1041371	0.87	1256044
Total fishing effort (fishing hours)	477246	590573	0.81	1110446
Match vessels (number)	233	233	1.00	549
Match active effort (fishing hours)	553385	734121	0.75	1087667
Match fishing effort (fishing hours)	310813	551618	0.56	980387

The figures show that it is difficult to find a common dataset with matching vessels between the two positioning systems and that AIS tends to underestimated the total fishing effort. The EU wide comparison exercise carried out by the group in 2016, highlighted the same problem in linking the different sources of data.

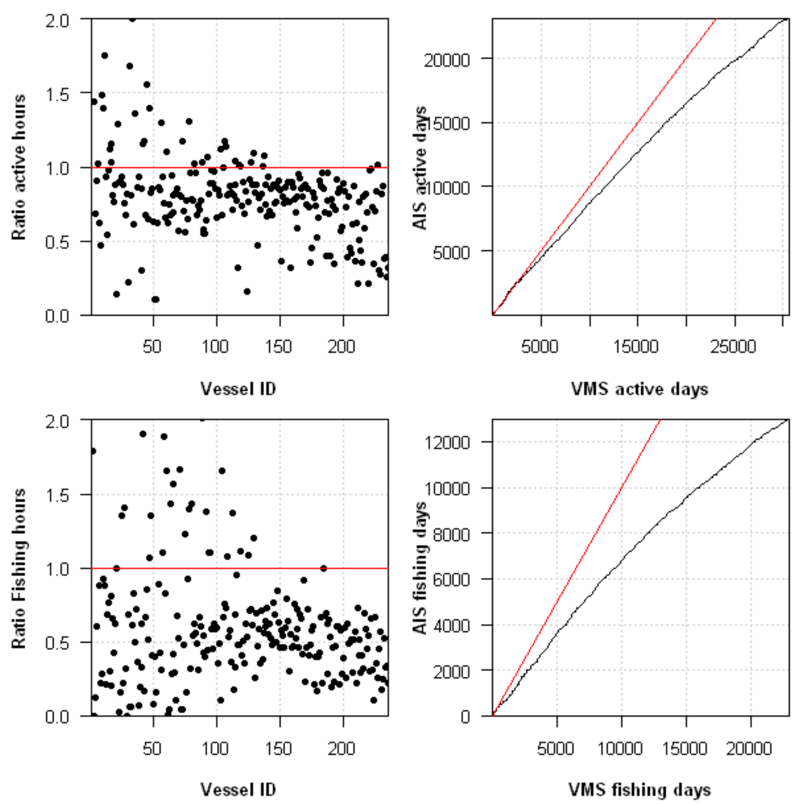


Figure 4. Total fishing effort calculated from VMS data and from AIS data for the Dutch fleet matched at individual level (IJmuiden, 2014).

Accuracy in the estimation of fishing effort

The official sources of fishing effort for EU member states is 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 by the cumulative effect of linking different datasets with difference level of accuracy together. However, if we leave the individual accuracy issues on a side, we can assess the different combinations of AIS, VMS, logbook and ancillary data and the information gain obtained from them. The following table present 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:

Sources of Data	**Gear information**	**Is the gear used in the fishing trip**
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)	Y
AIS	gear is inferred	Y[1]

AIS coverage issues: spatial, temporal and vessel

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. The following table presents the main coverage issues fro AIS data and for MMSI which is the main field used to link AIS data with other datasets.

[1] Subjected to accuracy of the prediction algorithm.

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 multiple MMSI.
Spatial Coverage	MMSI is linked to the device and not the fishing vessel.
Temporal Coverage	Coupling with ancillary information.
	Matching AIS data with the fleet register is also a difficult for the lack of a complete common field. The match is performed on the CALL SIGN or IRCS when available or using fuzzy methods based on phonetic distance.
	Not present in the EU Fleet Register
	Could be affected by the recent GDPR

Temporal coverage within the year is affected by spatial coverage and by vessel coverage issues. Vessel coverage can be a direct consequence of spatial and temporal coverage, but it also depend on intentional AIS on/off switching, on the level of uptake of AIS 9relevant especially for the small vessels where AIS is not mandatory) and on the level of completeness of the data providers.

Availability of AIS in European waters

The number of years covered by AIS data for EU Member States, has been established by EU Council Regulation (EC) No 1224/2009, that sets the uptake of the system through a roll out campaign started in 2012 and vessels of 24 meters long. The 2013 AIS is mandatory for vessels of 18 or more meters long and, since May 2014, AIS class A devices are mandatory for vessels of 15 and more meters long.

Supranational sources of data

AIS data streams are collected by a network of terrestrial receivers and satellite receivers.

For most of ICES member states, terrestrial AIS data are collected by the National Coast Guard and shared with the National Maritime Agencies and satellite AIS is either collated from the countries satellites or acquired from commercial vendors with license fees increasing when historical data are needed . HELCOM has pioneered the use of AIS in fisheries since 2001 and has worked to ease the process of accessing AIS data to other fisheries research institutions. Since 2005, the Baltic Sea countries can benefit of the HELCOM AIS network that collates regionally real time AIS data streams and makes it available to all the countries.

The European Maritime Safety Agency has been increasing the use of Earth Observation data for Maritime Awareness. SafeSeaNet for example is a traffic and monitoring system targeted to enhance maritime safety that leverages on the integration of several positioning system data, including AIS.

Data access to SafeSeaNet data and to Satellite AIS data for research is administrated through an application procedure: requests are examined case by case and the research domain applications where data can be used are also limited.

Accessibility (cost, restrictions on access, sensitivity)

VMS and logbook data are subjected to confidentiality issues but AIS data is not. AIS data are collected by the national coast guards, or other organizations involved in Search And Rescue (SAR) operations. However, such organizations, work on tight schedules and might allow access to raw data: some Member State's National Maritime Agencies provide AIS data for fishing vessels in a format that is more manageable and can be linked to VMS and logbook data.

Access to raw AIS data is subjected to the organization collecting the data: national maritime agencies can allow access to national fisheries scientists for research purposes. In addition several commercial vendors are offering added AIS data making free access to raw data, depending on the service level agreement with the customer.

Added value for the use of AIS

AIS data can be used to complement VMS for vessels larger than 12 meters can provide information for vessel for which we have logbook but not VMS (10–22 meters vessels) it could provide information for vessels smaller than 10 meters. The following table summarizes the advantage of using AIS in fisheries research:

Vessel length	**VMS**	**Logbook**	**AIS**	**Gain from adding AIS**		**Sales Notes**
				Time	Space	
8–20 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 minutes)	Location/track vessel information Better definition of fishing operations for the in shore fleet	Voluntary (exceptions mandatory in Norway)
10–22 meters	Voluntary	Mandatory	Voluntary	Time resolution from day to minutes. Better fishing	From ICES rectangle to vessel track.	Mandatory

				effort estimation for D6C2 assessment purposes (gear from trip and not from fleet register		
12–25 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

Technical requirements for processing AIS fisheries data

AIS data for fishing vessels are considerable smaller in size when compared to the entire AIS dataset that contains all type of ships. Linking AIS and VMS/Logbook data requires additional modelling skills and infrastructure that are outside the knowledge of fisheries scientists:

- working with big data
- spatial data analysis and modelling skills
- technical knowledge of the NMEA standards for AIS

Accuracy in the link between AIS data and other sources of data would be greatly improved if both datasets had a common field. When linking with the fleet register for example, the MMSI field is not available. ICES member states in the Baltic have pioneered the use of AIS in fisheries and have established good practices for the analysis of AIS data.

Ancillary data sources

Sales notes can provide additional information when all the others are missing. The European Market Observatory for fisheries and aquaculture (EUMOFA) collates data about first sale notes and makes it available to the public. However, the dataset is patchy in coverage making unreliable small scale analysis. Bathymetry can be used in fishing effort estimation as a covariate in fishing effort estimation: most of the fishing activity for occurs in coastal and along the continental shelf (Natale, 2015).

When assessing physical disturbance, in order to investigate impacts, the European nature information system web site, EUNIS, provides data on benthic habitats and species for EU and non EU waters.

The location of Marine Protected areas can help in detecting areas here fishing is forbidden or regulated through the year: allowing a better estimation of the fishing activity. Marine protected areas are stored in the World Database on Protected Areas (WDPA) hosted by the International Union for Conservation of Nature (IUCN).

6 Cooperation

- **Cooperation with other WG**
  - Request from WKSand on the sandeel fishery (2016)
  - Request for input for the WKFBI workshop (2016)
  - Request from WGDEC on fishing activities at VME habitats (2016, 2017, 2018)
- **Cooperation with Advisory structures**
  - Support to ICES Secretariat and ICES Data Centre by quality checks of member's data submissions and data products as basis for advice to clients, like EU and IGOs (2016, 2017, 2018)
- **Cooperation with other IGOs**
  - Request from OSPAR (2016)

7 Summary of Working Group self-evaluation and conclusions

WGSFD work in 2016–2018 has continued to prove that there is a demand for fine scaled spatial fisheries information. Outputs on fishing intensity from WGSFD have been requested by the EU as well as OSPAR and HELCOM for work on MSFD descriptor 6 and other questions. Examples are: maps of fishing pressure by combining and evaluating benthic information on sensitivity together with fishing intensity, taking into account differences in benthic impact of the various fishing gears /métiers, describing 'fisheries activities in and in the vicinity of (VME) habitats' within the NEAFC Convention Area, separated for each bottom contact gear type by using NEAFC VMS and catch data, support to ICES Secretariat in formulating advice by developing standardized processes for Quality Checks of submitted data sets and by reviewing the data products and recommendations on the applicability and use of AIS data, in particular to ascertain if it can be used as supporting information for the spatial analysis of fisheries data and if it can be used as an alternative source of information if VMS data are missing.

The group suggests continuing to deliver quality and quality controlled spatial fisheries data products to advice on impact of fisheries on marine habitats, and on spatial distribution of fishing effort (for e.g. WGDEC, WGFBIT, WGBYC). The group further aims to analyse spatial and temporal patterns in fishing and investigate ways to include higher detailed spatial information such as AIS.

Annex 1: List of participants

Name	Address	Email
Neil Campbell	Marine Scotland Science Marine Laboratory 375 Victoria Road AB11 9DB Aberdeen United Kingdom	Neil.Campbell@gov.scot
Rabea Diekmann	Thünen Institute of Fisheries Ecology Herwigstraße 31 27572 Bremerhaven Germany	Rabea.diekmann@thuenen.de
Christian von Dorrien (Co-Chair)	Thünen Institute of Baltic Sea Fisheries Alter Hafen Süd 2 18069 Rostock Germany	christian.dorrien@thuenen.de
Dan Edwards	Joint Nature Conservation Committee, Inverdee House, Torry, Aberdeen, AB11 9QA, UK	Dan.edwards@jncc.gov.uk
Josefine Egekvist	Danmarks Tekniske Universitet Institut for Akvatiske Ressourcer Kemitorvet Building 201, room 147 2800 Kgs. Lyngby Denmark	jsv@aqua.dtu.dk
Maurizio Gibin	European Commission Joint Research Centre Institute for the Protection and Security of the Citizen (IPSC) Maritime Affairs Unit TP05A Via Enrico Fermi 2749 I-21027 Ispra (VA)	maurizio.gibin@jrc.ec.europa.eu
Niels Hintzen (Co-Chair)	Haringkade 1, 1976CP, Ijmuiden, The Netherlands	Niels.hintzen@wur.nl
Irina Jakovleva	Fisheries Service under the Ministry of Agriculture Naujoji uosto str. 8 A Klaipeda Lithuania	Irina.Jakovleva@zuv.lt
Patrik Jonsson	Swedish University of Agricultural Sciences Institute of Marine Research Turistgatan 5 P.O. Box 4 453 21 Lysekil Sweden	Patrik.jonsson@slu.se

Maksims Kovsars	Institute of Food Safety, Animal Health and Environment (BIOR) Fish Resources Research Department 8 Daugavgrivas Str. 1048 Riga Latvia	Maksims.Kovsars@bior.lv
Roi Martinez	Pakefield Road Lowestoft Suffolk NR33 0HT United Kingdom	roi.martinez@cefas.co.uk
Jeppe Olsen	Danmarks Tekniske Universitet Institut for Akvatiske Ressourcer Kemitorvet Building 201, room 147 2800 Kgs. Lyngby Denmark	jepol@aqua.dtu.dk
Collin Millar	H. C. Andersens Boulevard 44–26 DK 1553 Copenhagen V Denmark	colin.millar@ices.dk
Yves Reecht	Marine Institute Rinville ORANMORE – Co. Galway H91 R673 Ireland	Yves.Reecht@marine.ie
Torsten Schulze	Thünen Institute of Sea Fisheries Herwigstraße 31 27572 Bremerhaven Germany	Torsten.Schulze@thuenen.de
Mathieu Woillez	Ifremer, STH Centre de Brest Technopole de Brest -Iroise P.O. Box 70 29280 Plouzané France	Mathieu.Woillez@ifremer.fr
Lara Salvany	H. C. Andersens Boulevard 44–26 DK 1553 Copenhagen Denmark	lara.salvany@ices.dk
Einar Hjörleifsson	Skúlagata 4, 101 Reykjavík, Iceland	einarhj@hafro.is
Marie-Christine Rufener	Danmarks Tekniske Universitet Institut for Akvatiske Ressourcer Kemitorvet Building 201 2800 Kgs. Lyngby Denmark	mruf@aqua.dtu.dk
Jérôme Weiss	Ifremer, STH Centre de Brest	Jerome.Weiss@ifremer.fr

	Technopole de Brest -Iroise P.O. Box 70 29280 Plouzané France	
Marta Suska	Morski Instytut Rybacki - PIB / National Marine Fisheries Research Institute ul. Kołłątaja 1, 81–232 Gdynia	msuska@mir.gdynia.pl
Per Finne	FMC Norway Statistics Department Directorate of Fisheries Strandgaten 229, Bergen NORWAY	Per.Finne@fiskeridir.no
Genoveva Gonzales Mirelis		Genoveva.gonzales-mireles@imr.no
Pedro Lopes	IPMA, I.P. (Portuguese Institute for Sea and Atmosphere), Rua Alfredo Magalhães Ramalho, 6 1495–206 Lisboa, Portugal	pedro.lopes@ipma.pt

Annex 2: Recommendations

None.

Annex 3: WGSFD resolution 2019–2021

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 1–2	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	In order to estimate the effort of the passive fishing gear, other	3.5; 5.4; 6.1	Year 1–2	Sections in working group reports to ICES containing:

	gears	parameters (soaking time, gear length, number of hooks etc.) are needed. During the next term, WGSFD will further evaluate whether these parameters can be estimated from VMS, fleet characteristics and observer data to produce speed filters and describe typology of various fishing events for different gear categories.			i) spatial maps of fishing activity, and ii) fishing effort maps through parameterization of soak 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.

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 4: WGSFD self-evaluation 2016–2018

1) Name: Working Group on Spatial Fisheries Data (WGSFD).

2) Year of appointment: 2016

3) Chairs:
Josefine Egekvist, Denmark (2016);

Niels Hintzen, the Netherlands and Christian von Dorrien, Germany (2017–2018)

4) Venues, dates and number of participants per meeting.

Brest, France, 17–20 May 2016, 22 participants

Hamburg, Germany, 29 May – 2 June 2017, 21 participants

Aberdeen, United Kingdom, 11–15 June 2018, 24 participants

WG Evaluation

5) If applicable, please indicate the research priorities (and sub priorities) of the Strategic Plan to which the WG make a significant contribution.

- GOAL 2 (SCICOM): Understand the relationship between human activities and marine ecosystems, estimate pressures and impacts, and develop science-based, sustainable pathways
- GOAL 3 (ACOM): Evaluate and advise on options for the sustainable use and protection of marine ecosystems
- WGSFD work in 2016–2018 has continued to prove that there is a demand for fine scaled spatial fisheries information. Outputs on fishing intensity from WGSFD have been requested by the EU as well as OSPAR and HELCOM for work on MSFD descriptor 6 and other questions. Outputs can also be used for ecoregion advice as well as in descriptions of fisheries activity.

6) In bullet form, list the main outcomes and achievements of the WG since their last evaluation. Outcomes including publications, advisory products, modelling outputs, methodological developments, etc.

- Robust methods developed to calculate DCF environmental indicators 5, 6 and 7. This output could be implemented by the ICES data centre as a standard output for the ICES ecoregion advice.
- Maps of fishing pressure by combining and evaluating benthic information on sensitivity together with fishing intensity, taking into account differences in benthic impact of the various fishing gears / métiers.
- Described “fisheries activities in and in the vicinity of (VME) habitats” within the NEAFC Convention Area, separated for each bottom contact gear type by using NEAFC VMS and catch data.
- Support to ICES Secretariate in formulating advice by developing standardized processes for Quality Checks of submitted data sets and by reviewing the data products.

- Recommendation on the applicability and use of AIS data, in particular to ascertain if it can be used as supporting information for the spatial analysis of fisheries data and if it can be used as an alternative source of information if VMS data are missing.

7) Has the WG contributed to Advisory needs? If so, please list when, to whom, and what was the essence of the advice.

- EU 2016, 2017, 2018
- OSPAR 2016, 2017
- HELCOM 2017
- NEAFC 2018

8) Please list any specific outreach activities of the WG outside the ICES network (unless listed in question 6). For example, EC projects directly emanating from the WG discussions, representation of the WG in meetings of outside organizations, contributions to other agencies' activities.

9) Please indicate what difficulties, if any, have been encountered in achieving the workplan.

- Delay in the provision of data from several states.
- Non-response to the data call from some states.
- Difficult to fully assess the data quality as aggregated (rather than raw) data have been requested. Different interpretations of the data call and different methods are applied to process the raw data.

Future plans

10) Does the group think that a continuation of the WG beyond its current term is required? (If yes, please list the reasons)

Yes, because

- More requests for advice on impact of fisheries on marine habitats are either forwareded already (eg, EU request to ICES June 2018) or highly probably;
- Requests from other ICES expert groups (e.g. WGDEC, WGFBIT, WGBYC) on spatial distribution of fishing effort;
- There is still a need to improve methods to investigate, analyize and map the distribution of fisheries effort and pressure on fine spatial and temporal scales;
- Use of alternative sources of position of fishing effort, e.g. AIS data or data from other sources (REM, data loggers).

11) If you are not requesting an extension, does the group consider that a new WG is required to further develop the science previously addressed by the existing WG.

(*If you answered YES to question 10 or 11, it is expected that a new Category 2 draft resolution will be submitted through the relevant SSG Chair or Secretariat.*)

12) What additional expertise would improve the ability of the new (or in case of renewal, existing) WG to fulfil its ToR?

13) Which conclusions/or knowledge acquired of the WG do you think should be used in the Advisory process, if not already used? (please be specific)

Annex 5: Examples (ToR I)

Example: Comparison of vessel speeds and soaking times for static gears – illustration with the French Recopesca database

Jérôme Weiss, IFREMER

Since 2005, Ifremer has implemented the Recopesca project for French vessels. It consists in fitting out a sample of voluntary fishing vessels with sensors recording data on fishing effort and physical parameters such as temperature or salinity (Leblond *et al.*, 2008). In particular, a sensor records depth and duration of immersion, for passive and active gears, while a GPS monitors the position of the vessels at configurable and regular intervals (1, 5 or 15 minutes). The fishing time of the static gear can be measured through the duration of immersion of the device (soaking time). An algorithm was developed to reconstruct fishing operations from these depth profiles. Flagging of errors and quality checks are directly implemented in this algorithm to qualify these operations.

Vessels speed profiles have been computed both during fishing operations (when the gear is soaked) and between fishing operations (when the gear is outside the water). For example, 490 fishing trips for potters between 12m and 15 m have been sampled in the North coast of Brittany (see Figure x1, left) between 2007 and 2017. Positions near harbours (less than 2 nautical miles) were filtered from the dataset. The speed densities respectively corresponding to fishing operations (during soaking time, black curve) and to non-fishing operations (during non-soaking time, red curve) are represented in Figure x1 (right).

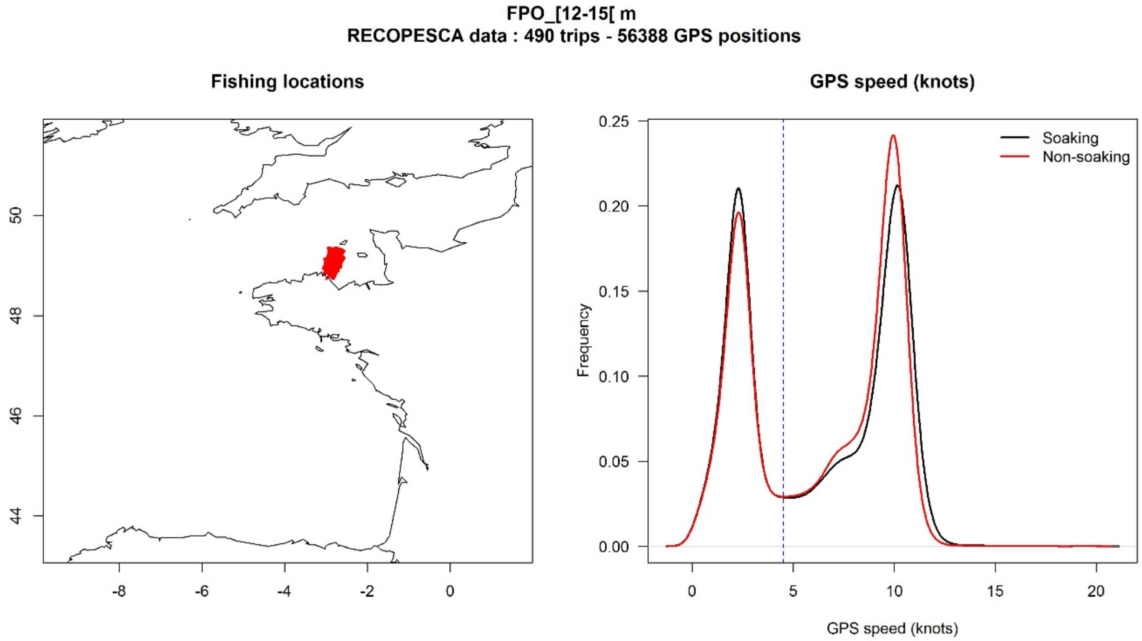


Figure x1. Left: location of the 490 Recopesca fishing trips for potters between 12 and 15 meters (left). Right: speed densities corresponding to fishing operations (during soaking time, black curve) and to non-fishing operations (during non-soaking time, red curve).

Interestingly, the obtained densities are very similar, with modes at same speeds (around 3 and 10 knots):

- High speeds observed during soaking times correspond to when the vessel comes back to the harbour after having soaked the pots in the water, or when it leaves the harbour in order to recover the pots. In this case, filtering the vessel speed to estimate fishing effort underestimate the soaking time.
- Low speeds observed during soaking times correspond to the preparation/immersion of other lines of pots, given that some pots are already into the water. In this case, the traditional approach to estimate fishing effort (generally by filtering the vessel speed) corresponds to the gear effort expressed in soaking time.
- Low speeds observed during non-soaking times correspond to when the vessel installs, recovers or empties the pots, just before/after the immersion of the gear. In that case, filtering the vessel speed to estimate fishing effort overestimate the soaking time.
- High speeds observed during non-soaking times correspond to when the vessel comes back to the harbour after having recovered all its the pots, or when he leaves the harbour in order to install its the pots. In that case, filtering the vessel speed to estimate fishing effort is in accordance with the gear effort expressed in soaking time.

This example helps to draw first conclusions:

- **For static gears, the traditional approach to estimate fishing effort by filtering the vessel speed do not correspond, generally, with the gear effort expressed in soaking time**.
- **However, filtering the vessel speed allows to see where static gears are located**. Figure x2 shows an example of a track of a potter, where speeds under 4.5 knots are underlined in red. This simple filter helps to see where the lines of pots are located.

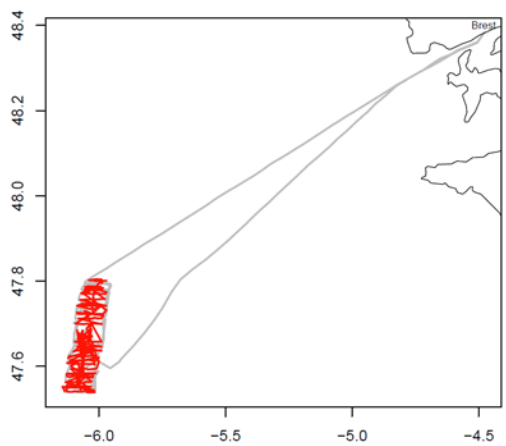


Figure x2. Track of a potter taken from the Recopesca database. Speeds under 4.5 knots are underlined in red.

The soaking time is a valuable indicator of fishing effort for static gears. Table x2 gives the mean soaking time (expressed in hours) by gear and length class based on Recopesca fishing trips database.

Table x2. Mean soaking time (hours) by gear and length class based on Recopesca fishing trips database.

GEAR_LENGTH	NB_VESSELS_RECOPESCA	NB_TRIPS_RECOPESCA	MEAN_SOAKING_TIME_H
FPO_[10-12[m	3	792	49.4
FPO_[12-15[m	1	490	55.6
FPO_[18-24[m	5	371	20.5
FPO_[6-10[m	12	1399	65.8
GEN_[10-12[m	1	277	13.9
GEN_[12-15[m	1	333	5.5
GN_[10-12[m	1	16	21.6
GN_[18-24[m	1	11	18.1
GNS_[10-12[m	4	887	16.3
GNS_[15-18[m	3	220	53.7
GNS_[18-24[m	4	217	28.5
GNS_[6-10[m	1	7	47.8
GTR_[12-15[m	1	3	81.9
GTR_[15-18[m	2	45	21.6
GTR_[18-24[m	1	130	24.9
LLS_[10-12[m	3	232	5.5
LLS_[6-10[m	2	22	39.6

References

Leblond *et al*. 2008. The Recopesca project: a new example of participative approach to collect in-situ environmental and fisheries data using fisheries vessels of opportunity, ICES Annual Science Conference 2008, 22–26 September, Halifax (Canada)

Example: Icelandic longline fishery

All Icelandic fishing vessel are required to send AIS/VMS signals while out of harbour. The reporting frequency is every 5 minutes, except in few distant areas along the continental slope where only VMS signals with a 1 hour frequency is available. One of the objectives of the system is safety at sea, the coastguard being responsible for real time monitoring of all activities. If a signal from a vessel goes missing, an immediate response is issued, including contacting near-by vessels followed by search-and-rescue operation being instigated.

All Icelandic fishing vessels are required to report activity of each fishing event, including start time, start and end position, gear type used and duration of the operation (towing time, soaking time, etc.) and catch composition by species. Recording of some variables are voluntary, e.g. for longline the time of setting, start and end time of hauling. In 2017 approximately 85% of the logbook longline recordings provide such details, while soaktime reporting is 100%, this latter field being compulsory.

The frequency of the position and the details in the logbook records provide an opportunity to match these two sources by matching the time event in the AIS/VMS signal with reported time interval of fishing activity. The accuracy of the reported fishing activity interval could potentially be tested using speed as a secondary criterion.

Given that “little is known about spatial-temporal dynamics of static gears, i.e. where do they shoot their gear, how long are gears in the water, what are the gear dimensions used” some preliminary analysis of the Icelandic longline fishery is describing some of the patterns observed in this static gear fishery.

The most reported soaking time is 5 hours while that based on the derived soak time (time from start of setting to time of start of hauling) is somewhat lower (Figure x3). The derived hauling time is however bimodal (Figure x4), the lower mode being around 7 hours while the larger mode at around 19 hours. This bimodality is largely driven by size of the vessels, the larger boats generally setting out longer lines than the smaller vessels. Similar patterns are observed when it comes to number of hooks (Figure x5)

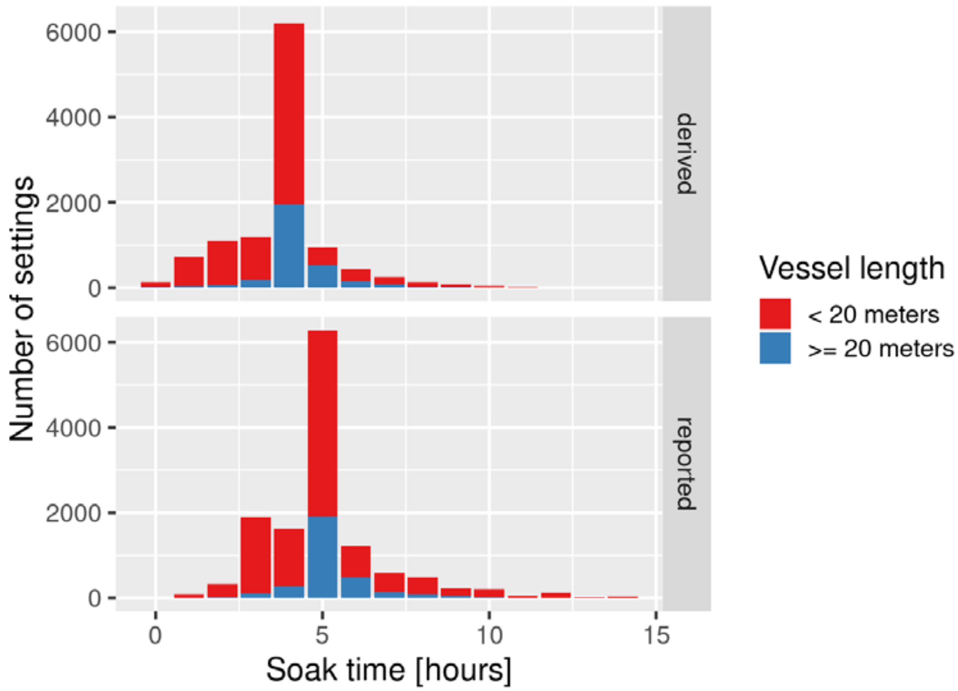


Figure x3. Reported soaking time (upper panel) compared with derived soaking time (time from start of setting to time of start of hauling, lower panel) for Icelandic longline fishery.

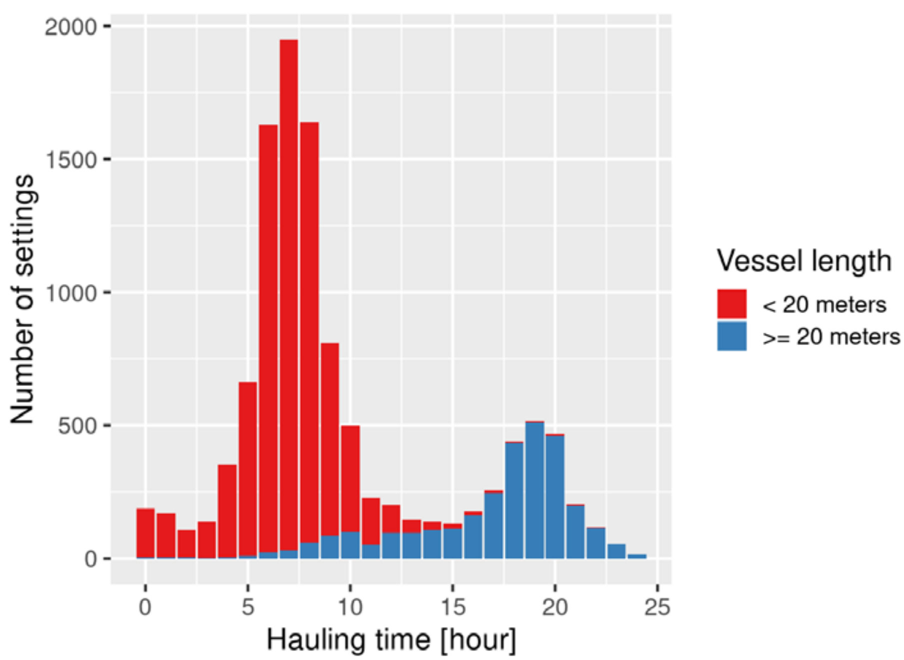


Figure x4. Derived hauling time for Icelandic longline fishery.

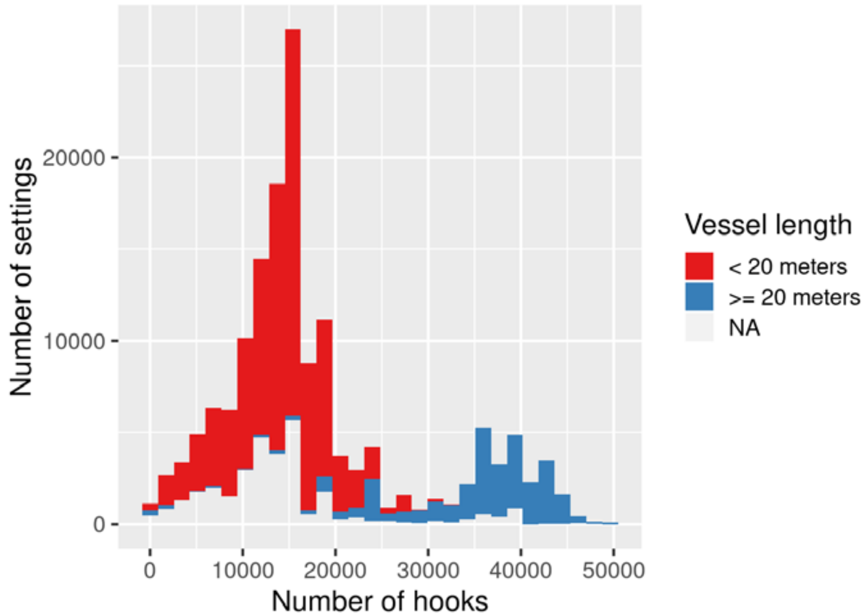


Figure x5. Number of hooks from Icelandic longline fishery.

A typical spatial pattern of a single vessel using longline gear is pictured in figure x6. On the coarse scale there is indication that speed may be the primary variable for identifying fishing activity.

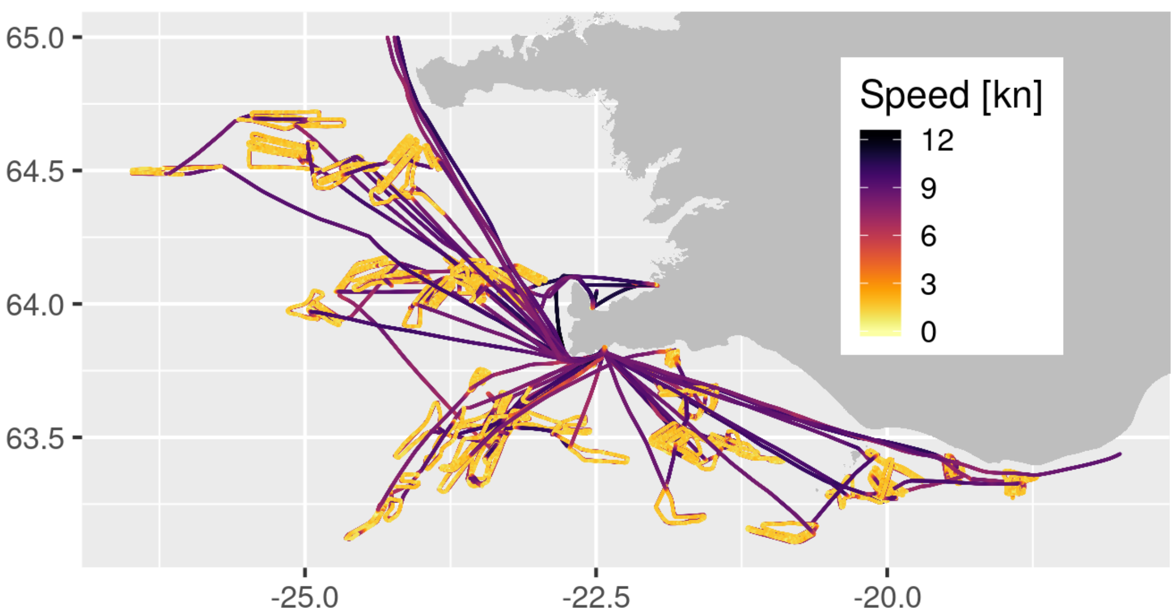


Figure x6. Typical fishing pattern from an Icelandic longline vessel.

A sample of the pattern at a finer scale for time and speed is shown in figure x7. Over the duration of four days, four different settings were reported in the logbooks, in all cases the time of start of setting, time of start and end of hauling were reported. The setting speed was generally in the range of 5–7 knots while the hauling speed was in the range of 0 to 2.5 knots. After the setting is finished there is generally higher speed reported, this activity being cruising from the end position of the setting to the point where the setting originally started. In this example there is a general agreement between the time reporting in the logbooks and the speed as recorded in the AIS/VMS data. In addition speed alone seems to be a reasonable proxy for hauling activity. However, in the first setting there is a period of higher speed within what was defined as hauling activity. Inspection of the spatial data (figure x8) indicate that this is because in the middle of the hauling the line the activity was suspended but then resumed from the end position of the original setting. The most likely reason is that the link between the legs of the line may have broken.

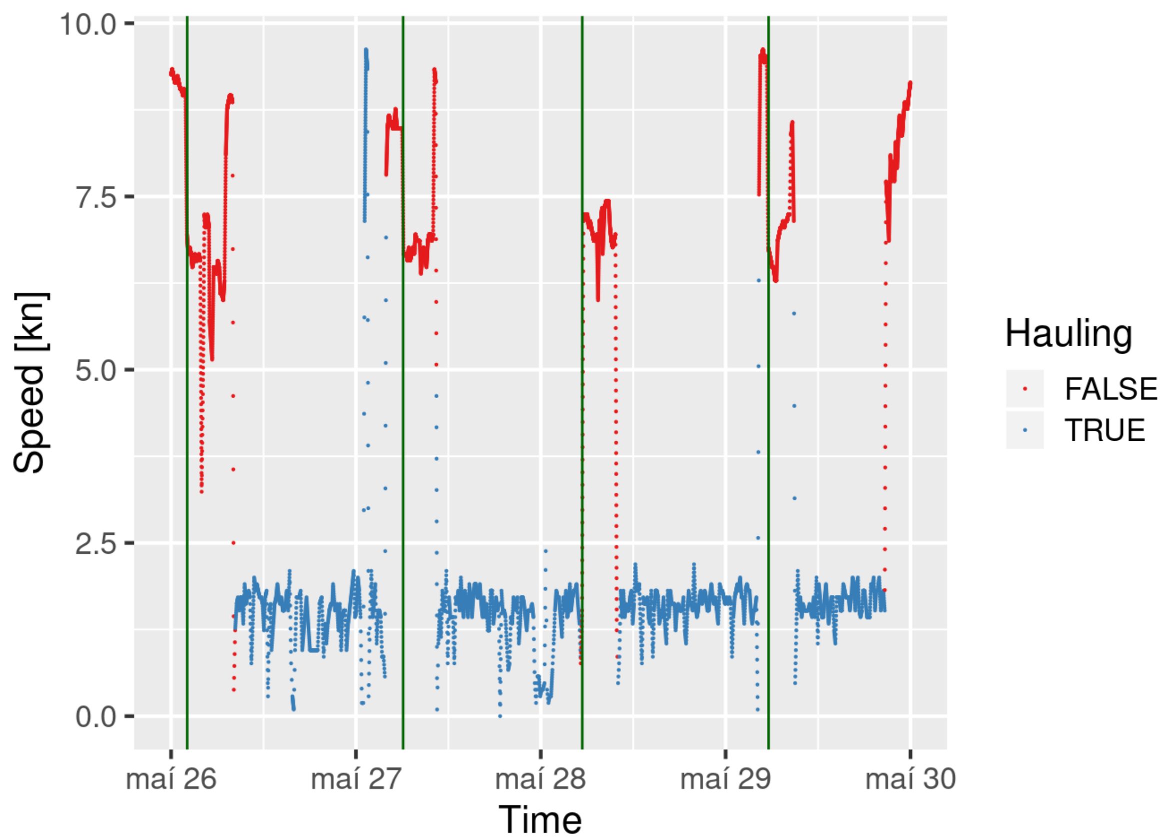


Figure x7. Illustration of speed.

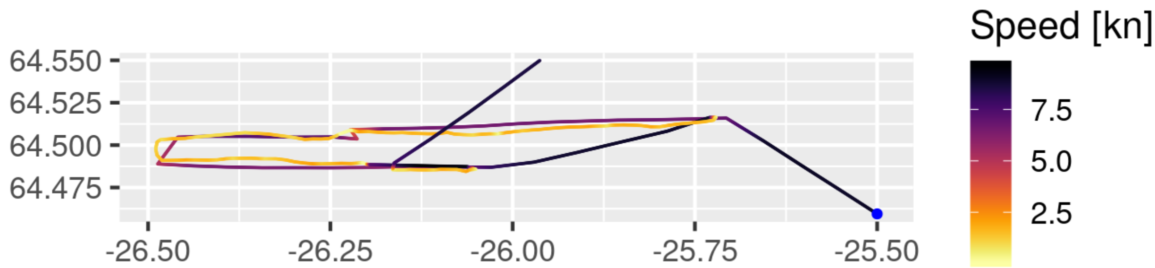


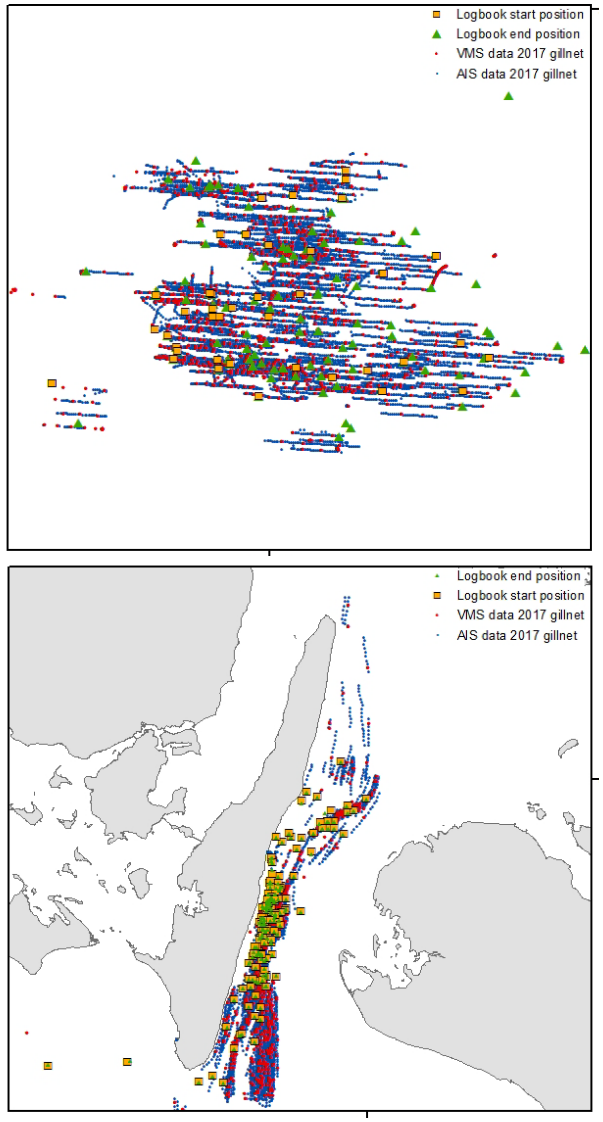
Figure x8. Example of a setting and hauling of a longline.

In other cases investigated the time reported in the logbooks were not in such a good conformity with the AIS/VMS data as shown above.

Example: Danish gillnets where AIS, VMS and logbook start and end positions were available in 2017 data

Data from trips where gillnet were used and where VMS, AIS and start and end positions were available. A speed filter of 0–4 knots was applied to both AIS and VMS data. In most cases all three data sources displays the fishing grounds, but at different detail level, the AIS data displaying the fishing activity in more detail than the VMS. Start and end positions from the logbooks are often overlapping, and does not seem to show where the fishing activity is taking place as precisely as the VMS and AIS data.

As shown in figure x9 below, in many cases, the AIS and VMS data are overlapping, and seem to be representing the location of the fishing activity; however in some cases there is some noise in the data when only applying the speed filter. Methods to remove that noise should be investigated, e.g. using other relevant data sources like bathymetry or habitat type.


Logbook start position
Logbook end position
VMS data 2017 gillnet
AIS data 2017 gillnet
Logbook end position
Logbook start position
VMS data 2017 gillnet
AIS data 2017 gillnet

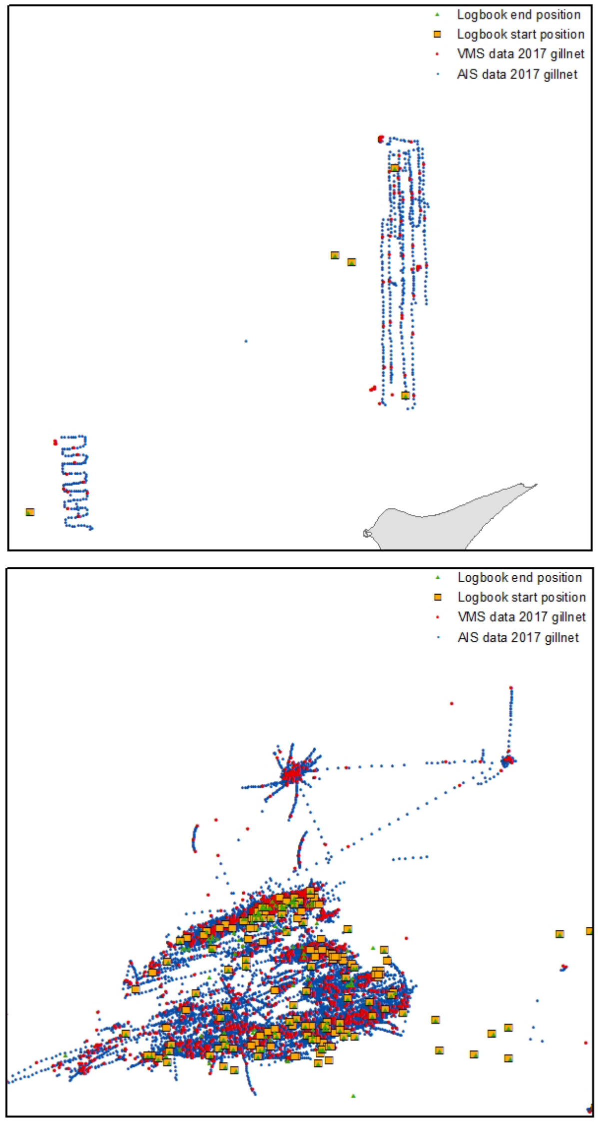


Figure x9. Four examples of fishing activity for gillnets where VMS, AIS and logbook positions were available.

Examples of inshore VMS tracks with available logbook/sales note data for the Irish fishing fleet

Inshore VMS are high frequency VMS over the GPRS network. In the most recent setting for the Irish fleet, the device is sending a ping every 5 minutes (15 minutes when still for a long period of time). It is mandatory for dredgers targeting razor clams in Irish waters; however, a few vessels operating passive gears are also equipped on a voluntary basis. Some fishing trips operating pots and gillnets can in particular be identified (examples of tracks in figures x10-x12) by linking iVMS data with logbook or sales notes data. They illustrate how the speed filter matches some events but most probably miss some other – possibly shooting events at higher speed – as some sequences of sharp turns and short straight lines are still detected as steaming. They also highlight differences in the complexity of the fishing tracks, which could be exploited for pattern recognition in cases where the used gear cannot be detected from landing /sales data.

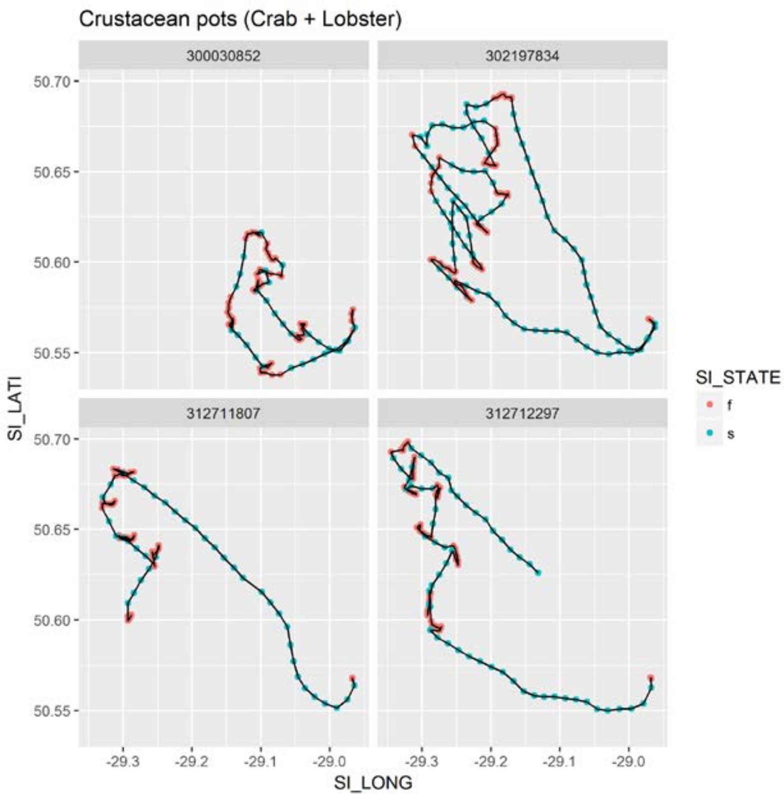


Figure x10. Example tracks of fishing trips operating crustacean pots, targeting crab and lobsters. Fishing events were detected using a global speed filter for pots (FPO) in the dataset: fishing between 0–2 knots. Positions randomly shifted for anonymity purpose.

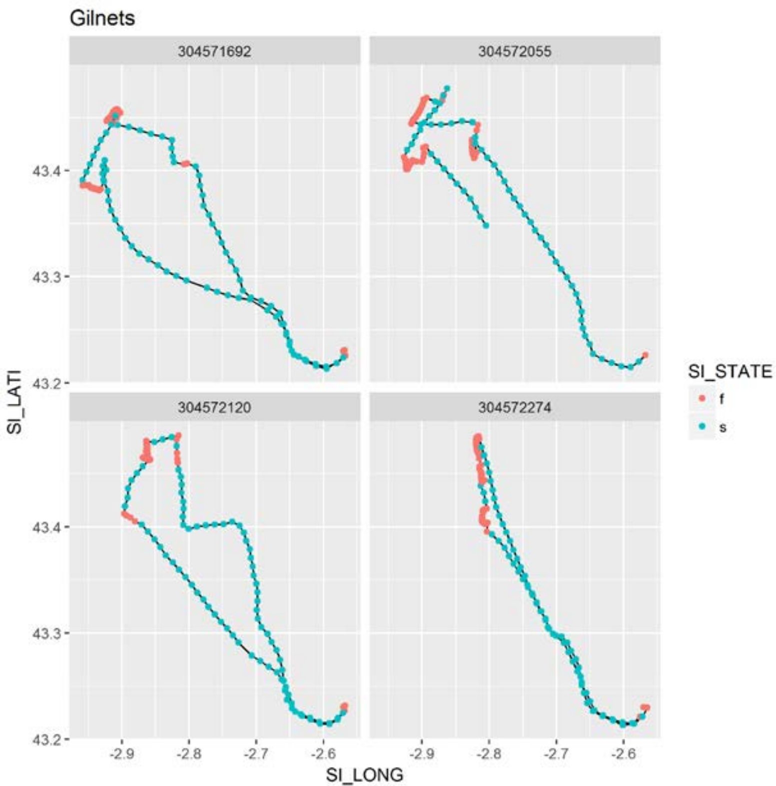


Figure x11. Example tracks of fishing trips operating gillnets. Fishing events were detected using a specific speed filter for gillnets (GNS) in the dataset: fishing between 0–2.5 knots. Positions randomly shifted for anonymity purpose.

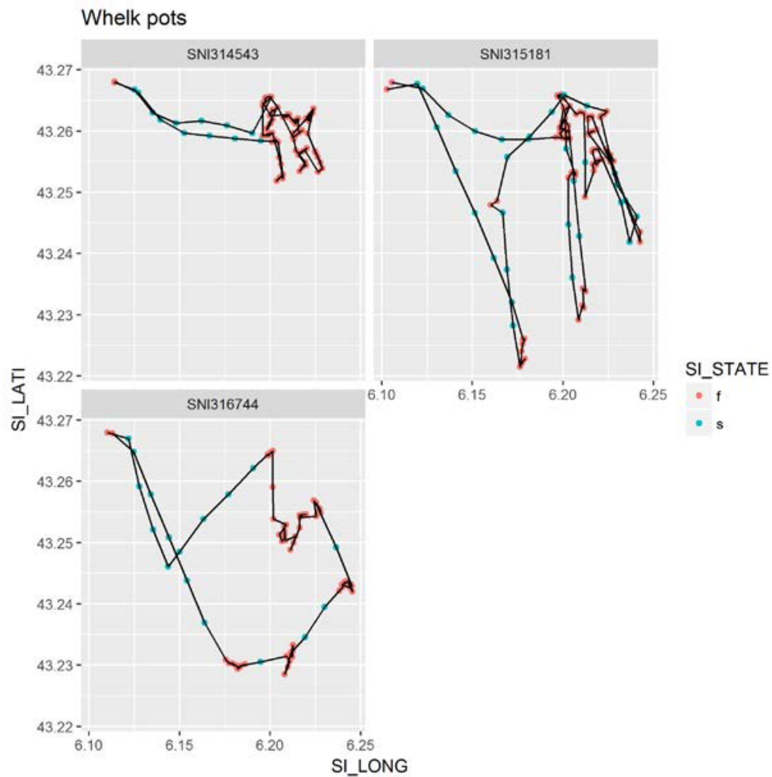


Figure x12. Example tracks of fishing trips operating whelk pots. Fishing events were detected using a global speed filter for pots in the dataset (gear code FPO): fishing between 0–2 knots. Positions randomly shifted for anonymity purpose.

Example: Data sources for passive gears in Norway

Available data sources for catch activity from Norwegian vessels:

- Electronic logbooks (vessels above 15m NEZ and 12m EU Waters)

In the Detailed Catch Activity (DCA) report under block B there is a mandatory field for quantity of deployed gear, reported as total number of hooks (long line) or total length of gillnets deployed. The field for total length of gillnets is of variable quality since many instead use this as number of nets, even though the regulation is clear on this point. A better format check in data import or at input stage in the software would be recommended. There is also a mandatory field for mesh size, required since 11th August 2012. In the national regulation for the Norwegian EEZ there is a mandatory addition (compared to the EU regulation) for total number of pots when fishing for snow crab.

The main challenge with logbooks from static gears is that they are allowed to send a summary report for each 24-hour period. It is still possible to send a detailed report with several fishing operations per DCA corresponding to each line setting or gillnet being deployed, but most only send the summary version.

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 gears. It seems that the start time and position is reported as the first fishing operation, which would be the first gillnet or line being either set or hauled that specific 24 hour period which the DCA report is a summary of. Similarly, the stop time (derived from the duration field) and position is the end of the last fishing operation. A few seem to report duration as the actual soaking time, but here is no unique ID for each setting which could have made it possible to calculate soaking time from earlier DCA reports. There is also no field indicating if a report is a summary or a detailed version, meaning a report with a single operation can be both.

Besides these points the DCA report and level of detail is identical to reporting from other gear groups. So regarding effort for static gear we could have access to total number of hooks or total length of gillnets (including mesh size) per 24 hour period, together with at least two positions representing approximate fishing area.

Reporting of static gear to the Coast Guard.

In the main national regulation for fishing there is a paragraph demanding vessels to report setting of static gear to the Coast Guard. This is mandatory for vessels fishing with gillnet, line (including drifting line) and traps i) north of N62° outside the baseline, ii) gillnet targeting blue halibut north of N62° and iii) gillnet targeting monkfish.

This includes both setting and hauling time and positions, together with vessel information. Last year it was also possible to report this with an app, which have made it easier. In fishing intense areas the dataset is almost complete. Generally, over half of the fleet under 15m report their gear, even though it is not mandatory for the majority of vessels. The proportion is increasing each year and the same vessels are responsible for over 85% of the total catch in that fleet group.

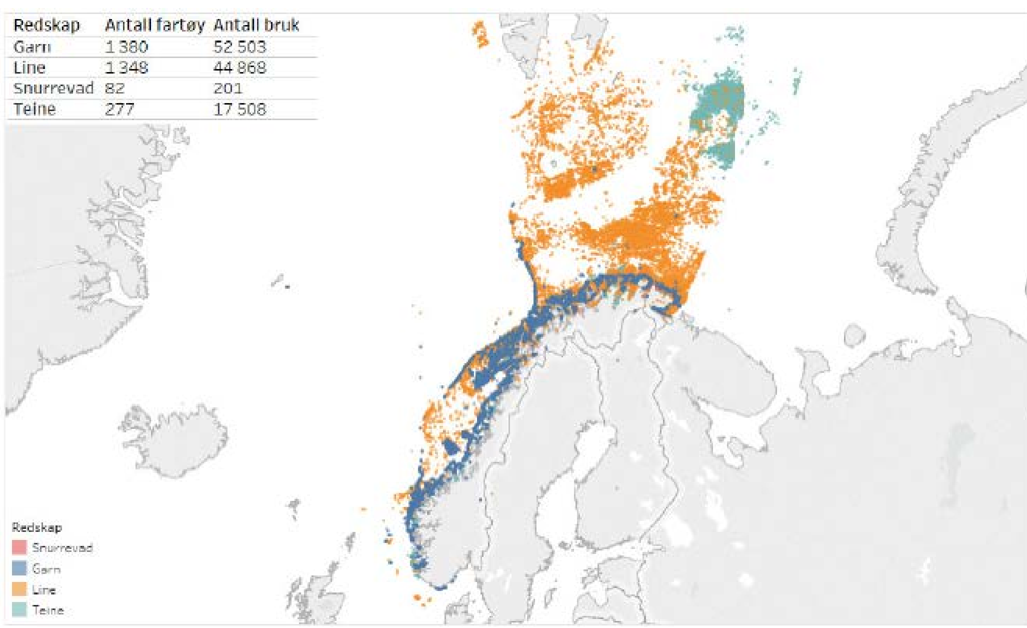


Figure x13. Illustration of reporting of passive gears positions through the coastguard in Norway.

The quality of coordinates is varied, and the reports can include i) single point ii) polylines or iii) polygons. Some are exported from the chart plotter and therefore more detailed than the summary report in the electronic logbooks, but they are at the same time missing catch data and information on effort. There is also a problem with vessels not reporting end of fishing, or removal of gear in shorter periods, in order to hold on to their patch throughout the whole of season.

Below is a detailed map illustrating passive gears during 2018's main cod season in Lofoten (Figure x14).

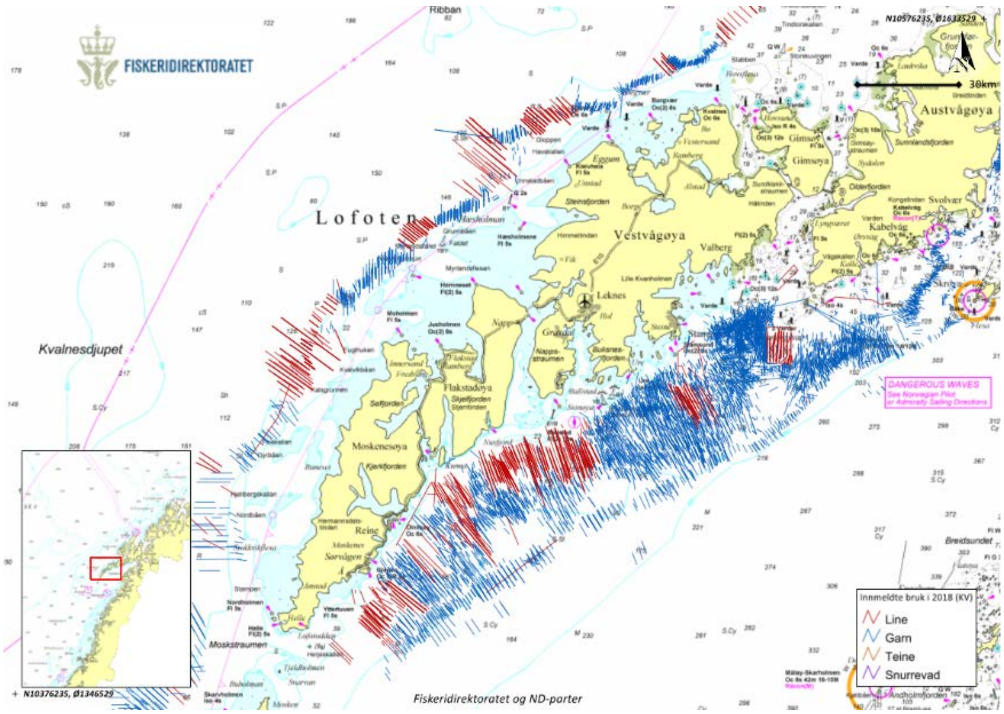


Figure x14. Illustration of passive fishing gears reported to the Norwegian coast guard during the main cod season in Lofoten in 2018.

It is possible to increase spatial resolution with AIS-data using speed filtering and possibly pattern recognition to increase precision. In figure x15 is a simple comparison of i) only line settings and ii) line settings with added AIS if available

i) only line settings ii) line settings with added AIS if available

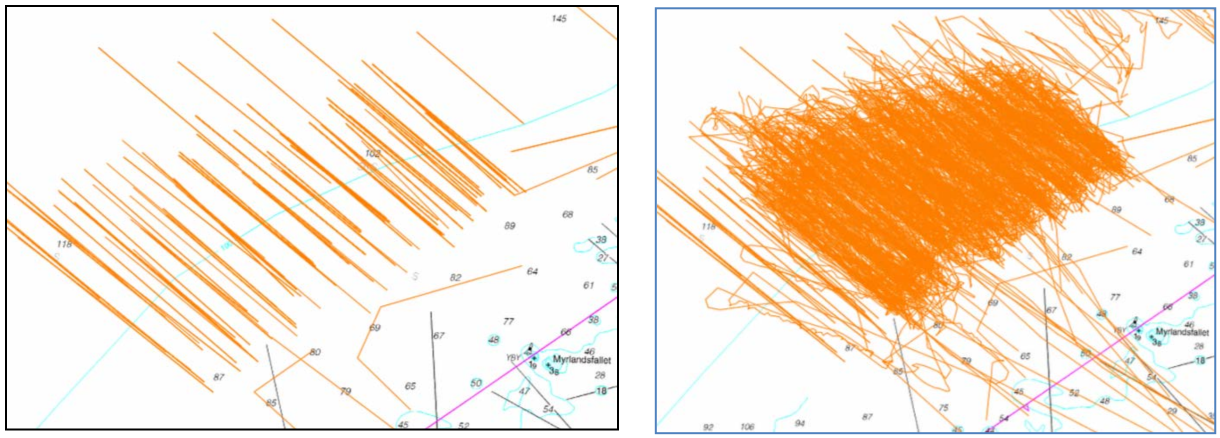


Figure x15. Comparison of data including i) only line settings and ii) line settings with added AIS if available.

Sale slips (landing document)

A sale slip is mandatory in Norway when landing the catch. These have information on gear and main catch area, but need to be coupled with AIS data for acceptable spatial resolution.

Conclusions and work to be done

The data sources and data quality for each data source seem to vary across countries, and therefore the best method for analysing the fishing patterns for the passive gears would vary between countries. The method using a speed filter for VMS and AIS data seem to be working relatively well to point out fishing grounds for passive gears and to calculate the fishing vessel effort. The method could be refined using other data sources relevant to specific gears like water depth or seafloor habitat data or using pattern recognition.

Data sources on fishing gear effort is also varying across countries, but where available, work could be done to combine e.g. number of hooks with the longline spatial information or soaking time and length of gillnets depending on the data source. If high-frequency position data are available, the length of gillnets can be derived directly from that data source. But in case that logbook data are available with start and end positions the length of the gillnet can be derived from this data source, in other cases the logbook only provide one position for the passive gears, and the length of the gears are entered directly, but direction of the gears are not known in that case.

Further work should be done on effort indicators for passive gears, and in future data calls, additional information on number of hooks for longlines, number of pots, total length of gillnets and soaking time might be included to give better estimates of fishing effort from passive gears. Methods could be developed to distinguish setting and hauling of passive gears and to allocate the landings.

Annex 6: Audit trail of VMS data processing and quality

Table 1. Description of QC process (31 March-11June 2018).

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
In 2017 a shift in effort with gear DRB was detected for the first time.		Acknowleged at national level, confirmed shift and that submitted data are correct.
A sharp decline in smaller vessel was detected		Acknowledged at national level and confirmed that there has been a reduction in number of trips for vessels smaller than 15 meters.
Value in submission do not correlate with gear OTM.		Acknowledged at national level and confirmed that data provided for OTM is based on logbook data.
Steaming positions in first submission were not filtered out at national level.	Acknowleged at national level, data was re-submitted with steaming positions filtered out.	
Drop in gear OTB data in between 2016 and 2017		Acknowleged at national level. It was confirmed that OTB metier, which is only for cod fishery, is currently inactive.
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.
Distribution of VMS entries for 2011 was abnormal.		Acknowledged at the quality check of the overall dataset. VMS entries detected in mainland. pending resubmission.
There was no information on fishing hours		Acknowleged at the national level and error with uploading detected. Correct data was resubmitted.

No data for vessels >= 12m length		Acknowleged at the national level that confirmed value.
Sharp drop in number of recordssubmitted in 2017 compared to previous years.	Acknowleged at the national level and correct data was resubmitted	
Data reported for vessel length classes 8 - 12m is scarce	Acknowleged at the national level and correct data was resubmitted	
Data reported for metier GNS is scarce		Acknowleged, and it was confirmed that only 2 vessels fished with this gear code
Missing gears (FPN, FPO, FYK, SDN) for 2016 and 2017.	Acknowleged at the national level and correct data was resubmitted.	
Sharp price drop observed in 2016–2017 submission.	Acknowleged at the national level. Prices per species are available with a delay of one year. New data were submitted with price update.	
Missing metiers in 2016 and 2017 in submission.		Acknowleged at national level. Further investigation detected inconsistent métier coding. Corrected data was resubmitted.
No value in logbooks in submission.		Acknowleged at national level. Confirmed that logbook data set with value was provided in the original submission (Annex2_2009_2017).
Bottom trawl of shrimp fisheries had been wrongly coded.	Acknowledged at the quality check of the overall dataset. Coding was corrected and data re-submitted	
Reduction of 30% in VMS records in 2017 compared to 2016. A difference between submission years was noticed for: 1) days-at-sea for beam trawl (TBB) in the North Sea, 2) average fishing speed patterns, 3) median and mean fishing hours, and 4) average kw hours patterns	A collation problem at national level was detected via QC report. Discrepancy in methods used to compile national data was corrected between different submission years (2009–2016 vs 2017). Data was resubmitted.	
Average vessel length was not available for all years.		Acknowleged at national level. Data not available.
Slight changes in VMS distribution between data calls were detected in VMS data. Average vessel length was not available for all years		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

Annex 7: Updated Maps of Fishing Activity in the NEAFC Regulatory Area, 2017

By Neil Campbell, Marine Scotland Science

Analysis

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 tables were linked using a unique identifier (the “RID” field) which changes on a six-monthly basis to protect anonymity of vessels. As there is no date information in the catch records, catches can only be linked to vessels at this level of resolution, complicating the interpretation of results.

The VMS data were filtered in R to exclude all duplicate reports, polls outside the year 2017, 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 while 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 1).

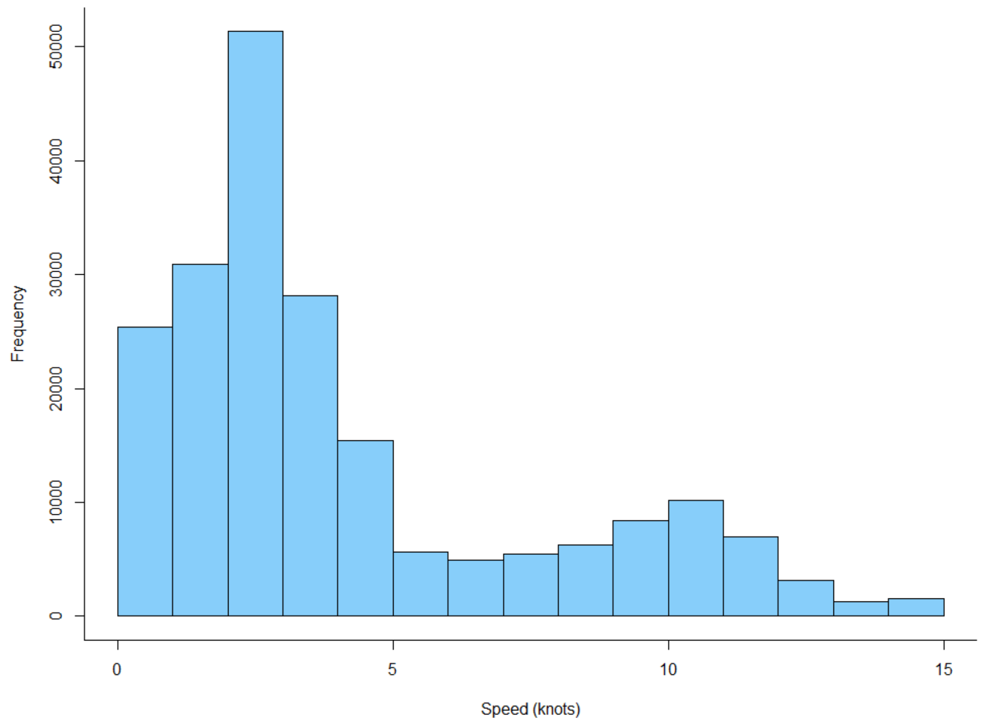


Figure 1. Histogram of derived speeds for all gears, based on position and time, conforms to expected distribution.

Rasters of effort (time associated with pings at speeds of 0–5 knots) were prepared for the area from 39.5°N to 64°N and 42°W to 7°W (i.e. covering the area of the NEAFC regulatory area in which there are spatial measures for the protection of VMEs) for vessels registered as using mobile bottom contact gears (otter trawl - OTB, twin-rigged otter trawl - OTT, pair trawl - PTB and shrimp trawl - TBS). Rasters of effort have also been prepared for static gear (gear codes "LL", "LLS", "LLD", "GND", "GNS" and "LNB"), and for vessels for which no gear code was available, again based on time associated with pings at speeds of 0–5 knots.

For vessels recorded as using mobile bottom contacting gears, consecutive pings at fishing speed (0–5 knots) were grouped into putative tows, to assist with interpretation of data and to serve as a quality check. Those vessels operating in waters greater than 1500m or fishing in directions other than parallel with the prevailing isobaths direction can be considered as being miscoded and representing midwater trawling.

A set of up to four maps (bottom-trawl tow-lines, gridded effort for vessels registered as using bottom contact gear, gridded effort for vessels with no gear type registered and gridded effort for static gear) have been produced for each area considered. Where there is not significant effort by a gear type in an area maps are not presented.

Results

Hatton Bank

The closures to the northern side of Hatton Bank are generally well observed (Figure 2). A small number of bottom trawl tows appear to extend into the closed area at the easternmost part of the existing bottom fishing area, however these incursions are limited (Figure 3). There was little evidence of vessels using static bottom contact gears (Figure 4), or activity of vessels without a registered gear type (Figure 5), in this area. Closures on the western side of the bank are also well observed (Figure 6; Figure 7)

Rockall Bank

The VME closures on the eastern side of Rockall Bank are also generally well observed, although there is some suggestion of trawling and vessels with no gear type registered operating within the Haddock Box (Figure 8; Figure 9; Figure 11). Vessels registered as using static gears work outside this area (Figure 10). To the south of Rockall Bank, trawling is now better confined to the "existing bottom fishing area" (Figure 12; Figure 13) while static gears continue to be used across the bank (Figure 14).

South of Iceland

As in previous years, the pattern of activity around the Reykjanes Ridge is somewhat confused (Figure 15; Figure 16; Figure 17). 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 1300–1500 m.

Mid Atlantic Ridge Seamounts

As seen last year, bottom trawling activity appears to be taking place on an unnamed seamount to the south of the MAR closure, outside the existing bottom fishing area (Figure 18). 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. Fishing also appears to be occurring on the Chaucer seamounts to the south, including within the Southern MAR (C) closure area (Figure 19).

Other areas

Examination of VMS data revealed two small patches of activity west of Biscay, in the regions of approximately 45.8N 19W and 46.3N 16.5W (Figure 21). Given the low levels of effort it is not apparent exactly what is taking place here, however as both regions are visited by vessels registered as using both static and mobile gears it suggests that some feature of interest exists here.

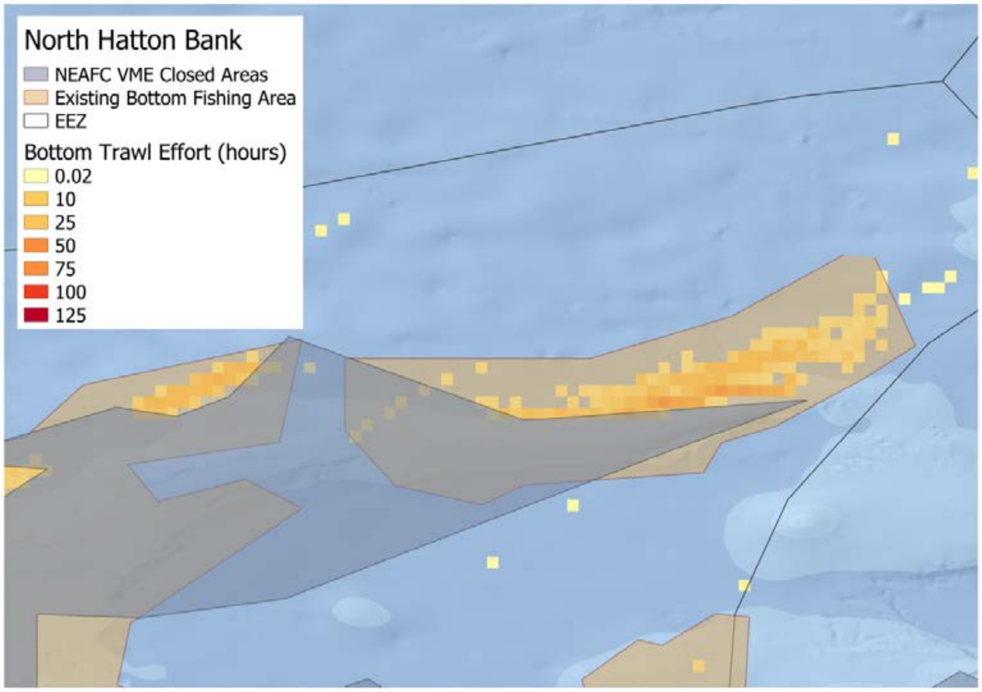


Figure 1. Gridded effort for vessels registered as using mobile bottom contact gears, to the north of Hatton Bank

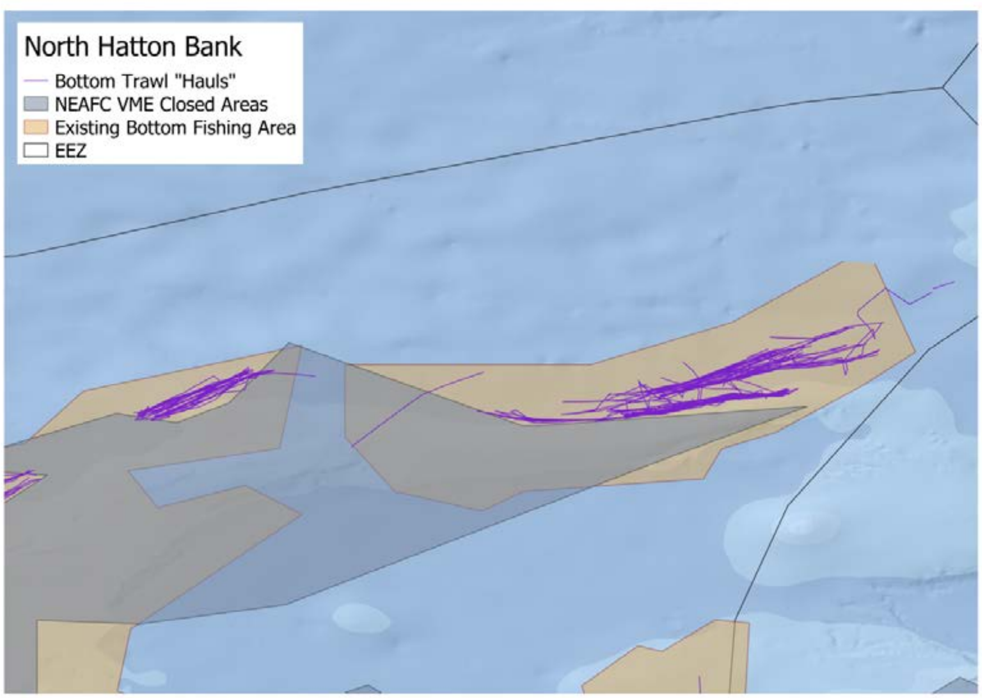


Figure 2. Putative mobile bottom gear "tows" to the north of Hatton Bank.

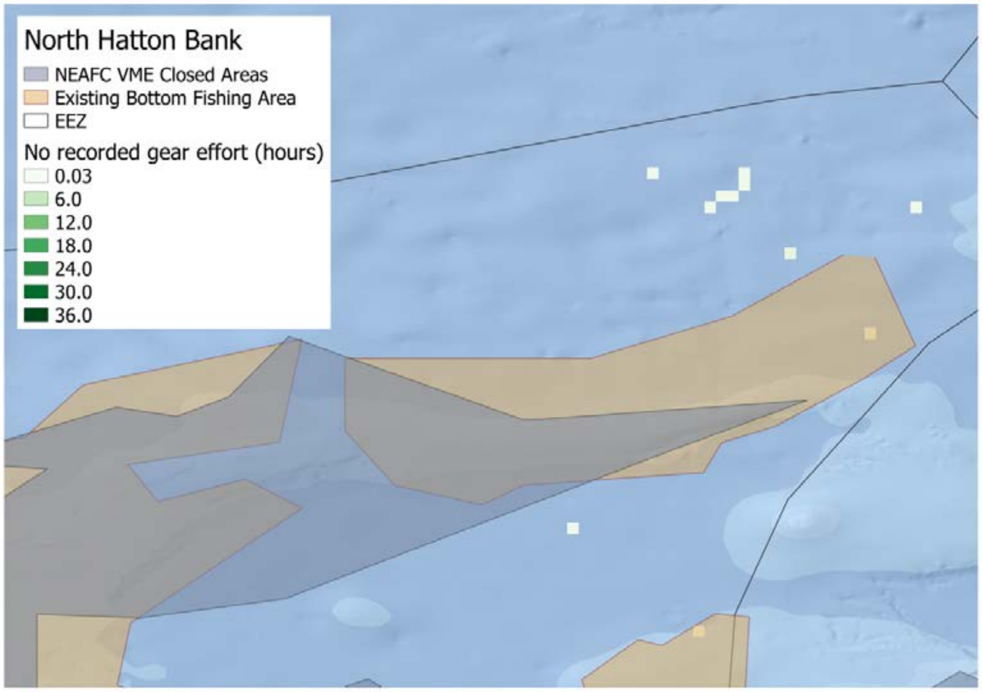


Figure 3. Gridded effort for vessels with no recorded gear type, to the north of Hatton Bank.

Figure 4. Gridded effort for vessels registered as using static gears, to the north of Hatton Bank.

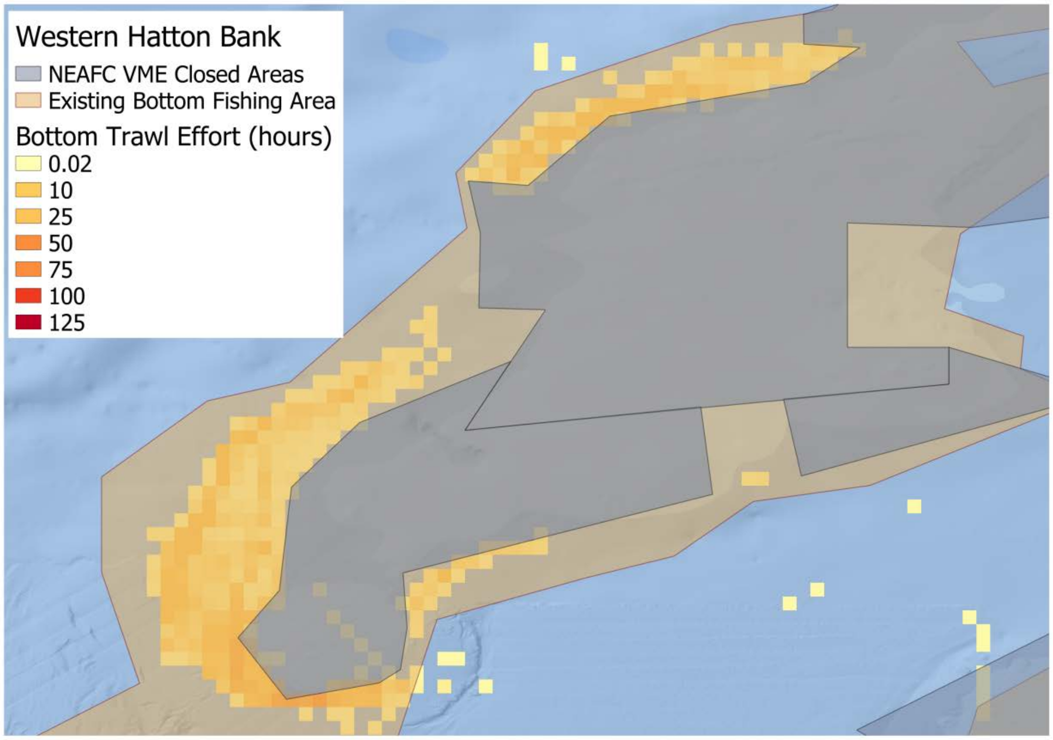


Figure 5. Gridded effort for vessels registered as using mobile bottom contact gears, to the west of Hatton Bank.

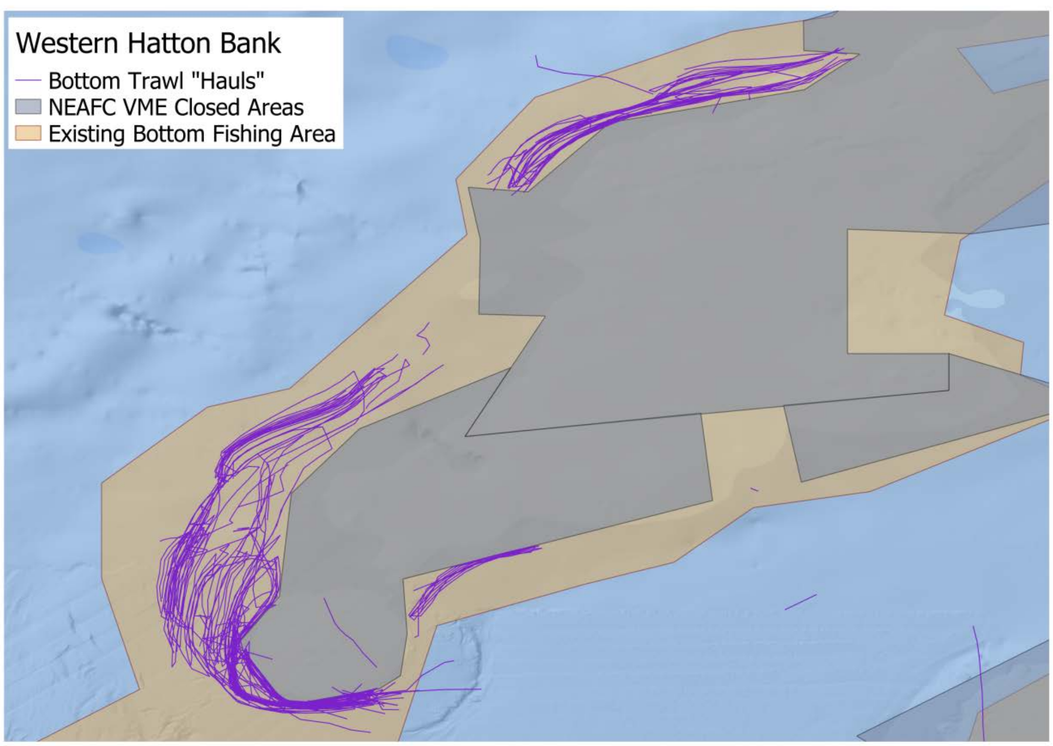


Figure 6. Putative mobile bottom contact gear "tows" to the west of Hatton Bank.

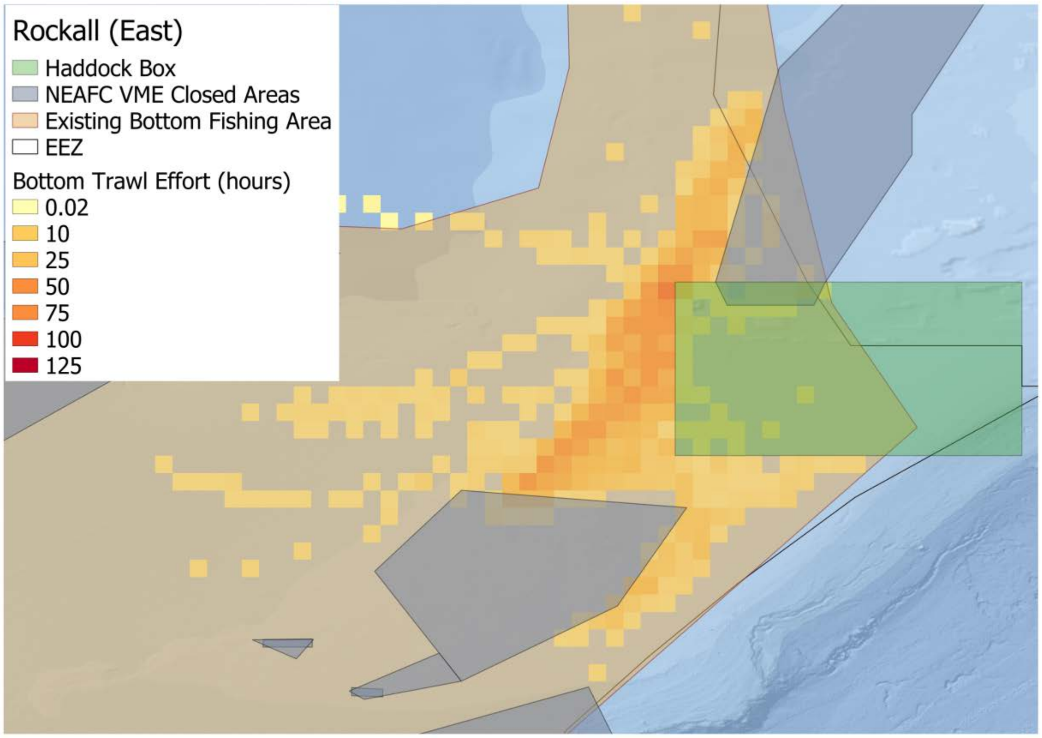


Figure 7. Gridded effort for vessels registered as using mobile bottom contact gears, to the east of Rockall Bank.

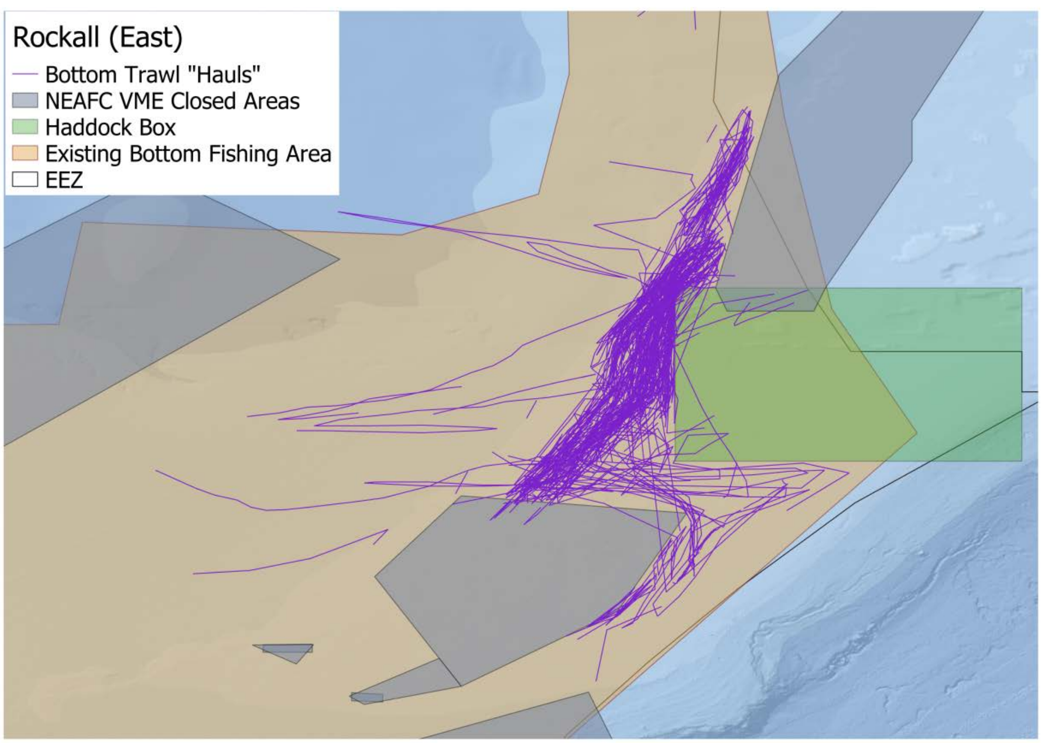


Figure 8. Putative mobile bottom contact gear "tows", to the east of Rockall Bank.

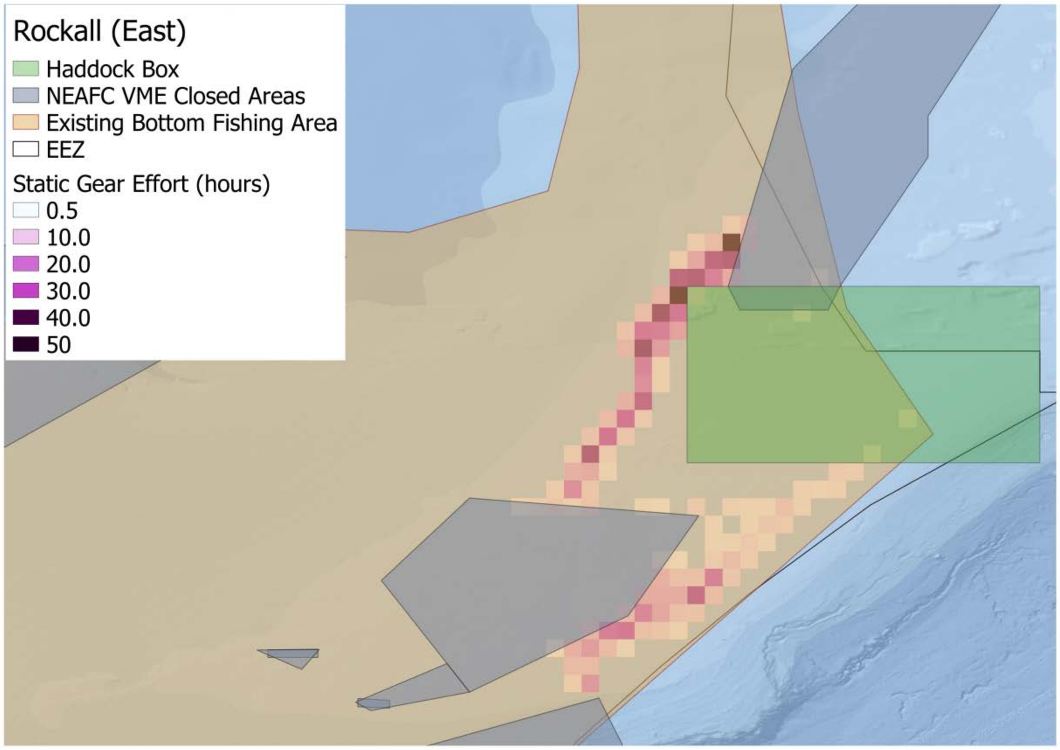


Figure 9. Gridded effort for vessels registered as using static gears, to the east of Rockall Bank.

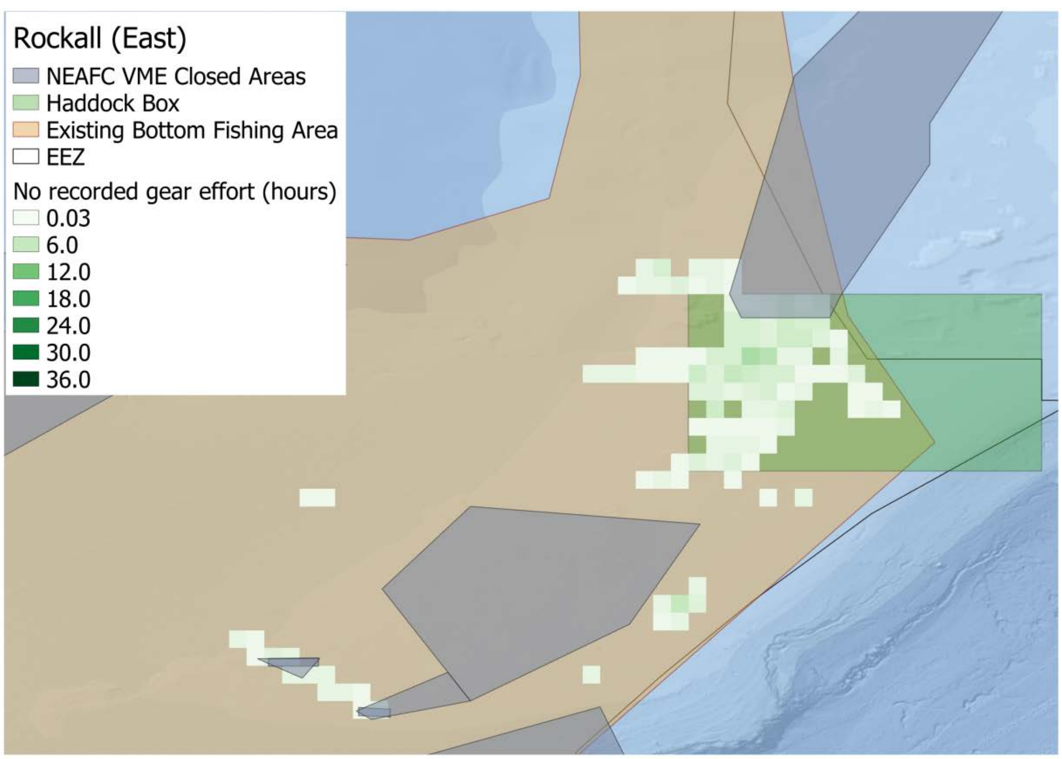


Figure 10. Gridded effort for vessels with no registered gear type, to the east of Rockall Bank.

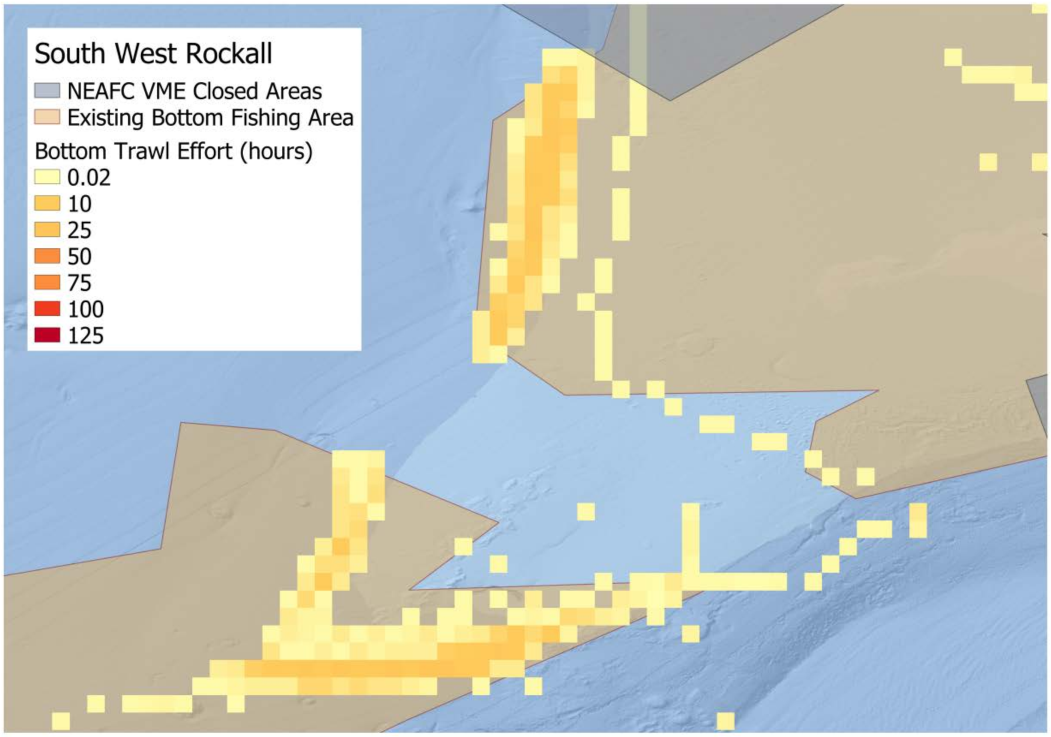


Figure 11. Gridded effort for vessels registered as using mobile bottom contact gears, to the southwest of Rockall Bank.

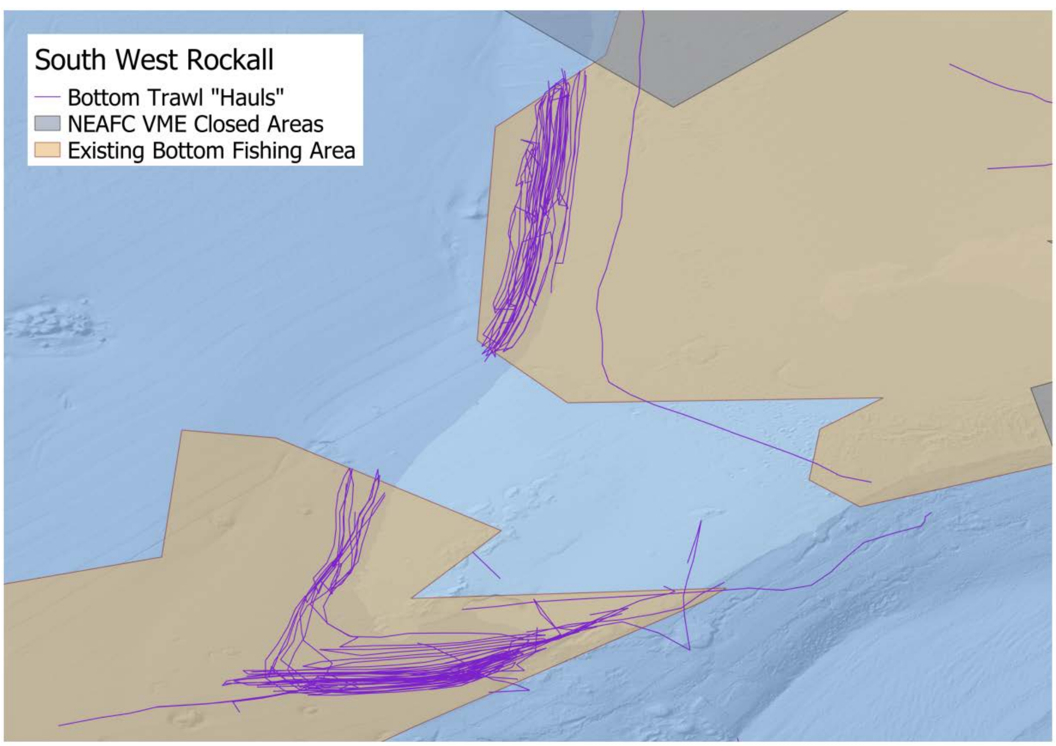


Figure 12. Putative mobile bottom contact gear "tows", to the southwest of Rockall Bank.

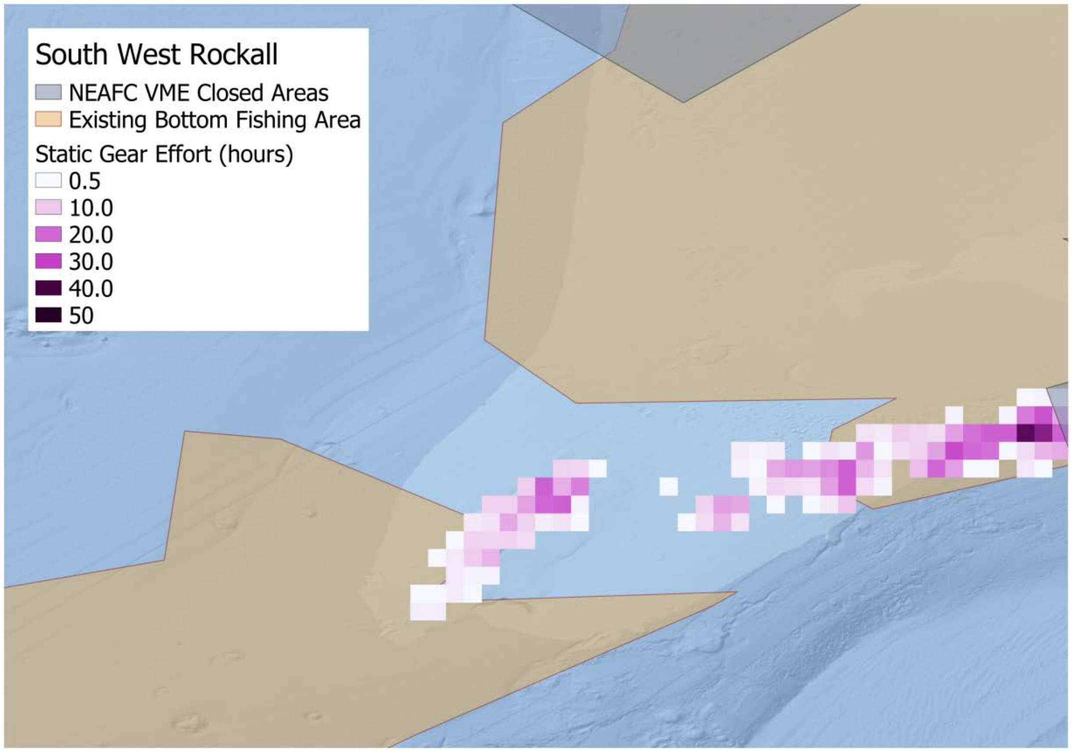


Figure 13. Gridded effort for vessels registered as using static gears to the southwest of Rockall.

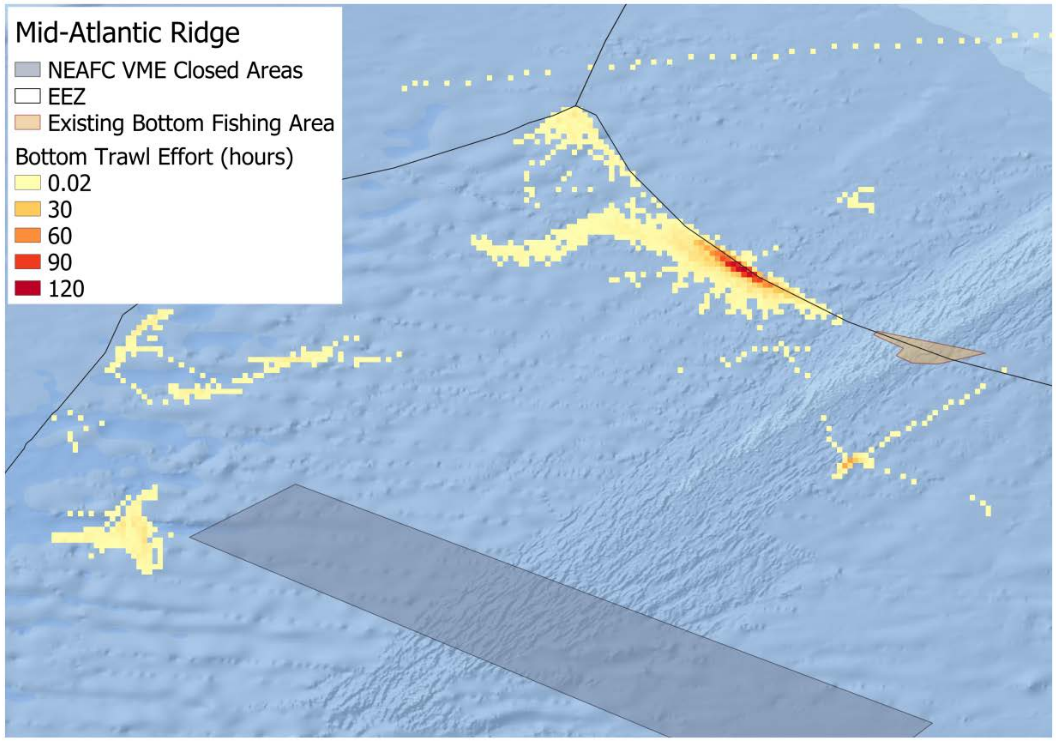


Figure 14. Gridded effort for vessels registered as using mobile bottom contact gears to southwest of Iceland.

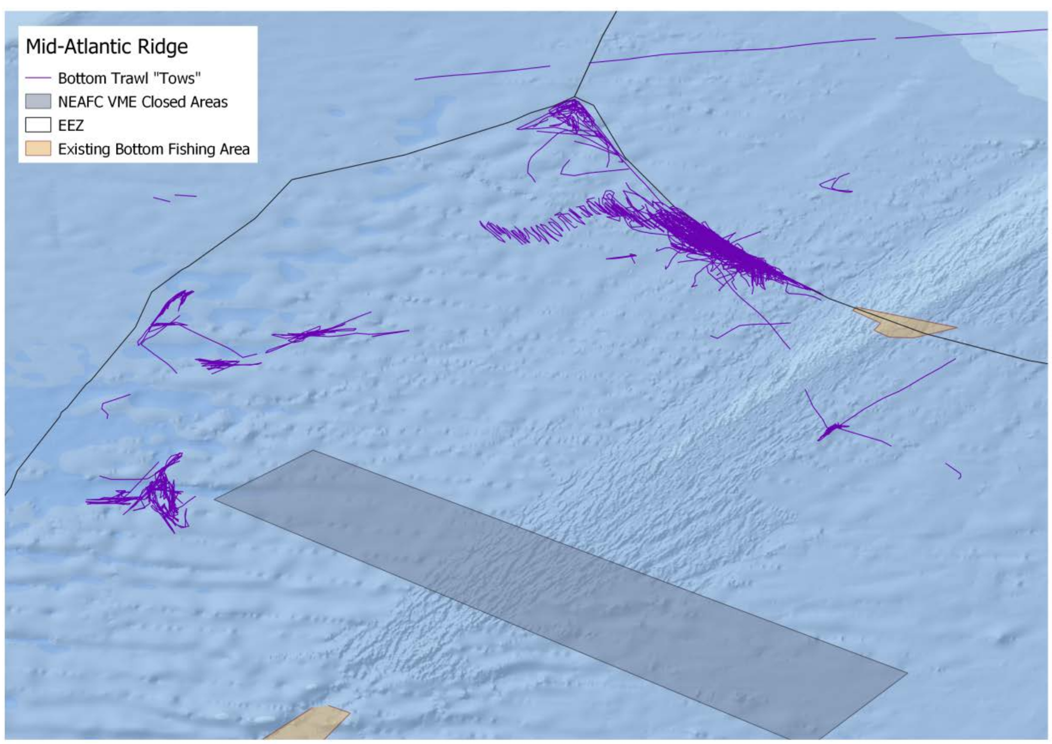


Figure 15. Putative mobile bottom contact gear "tows" to southwest of Iceland.

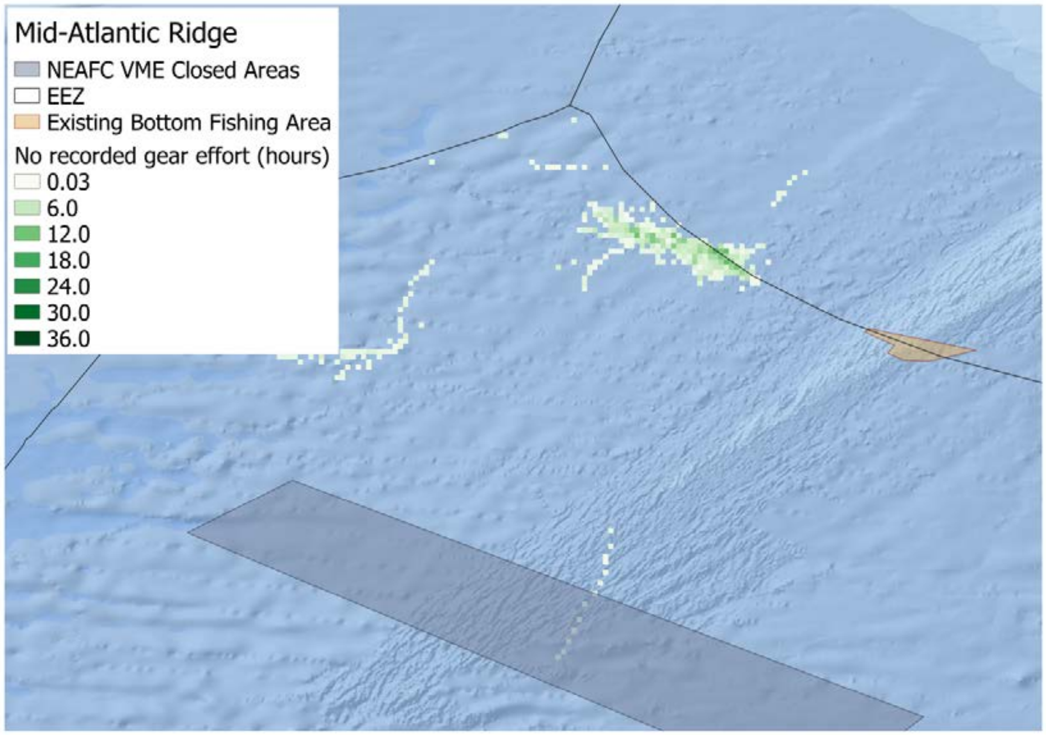


Figure 16. Gridded effort for vessels with no registered gear type, to southwest of Iceland.

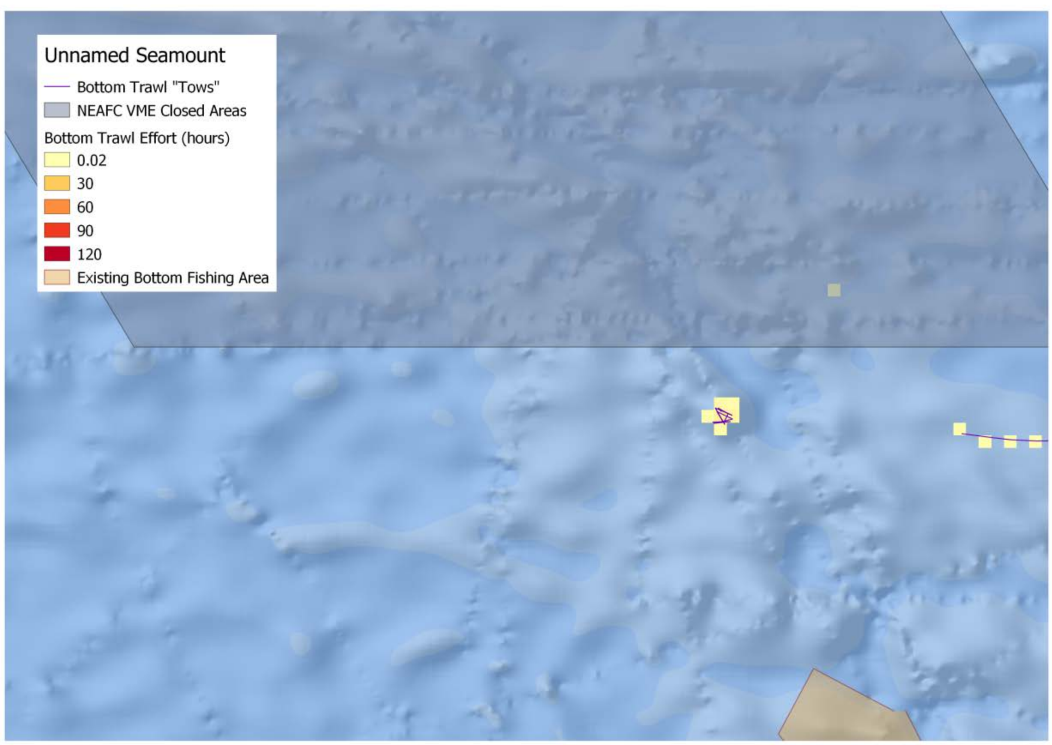


Figure 17. Gridded effort and putative tows for vessels registered as using mobile bottom contact gears, on seamount to south of MAR Closure.

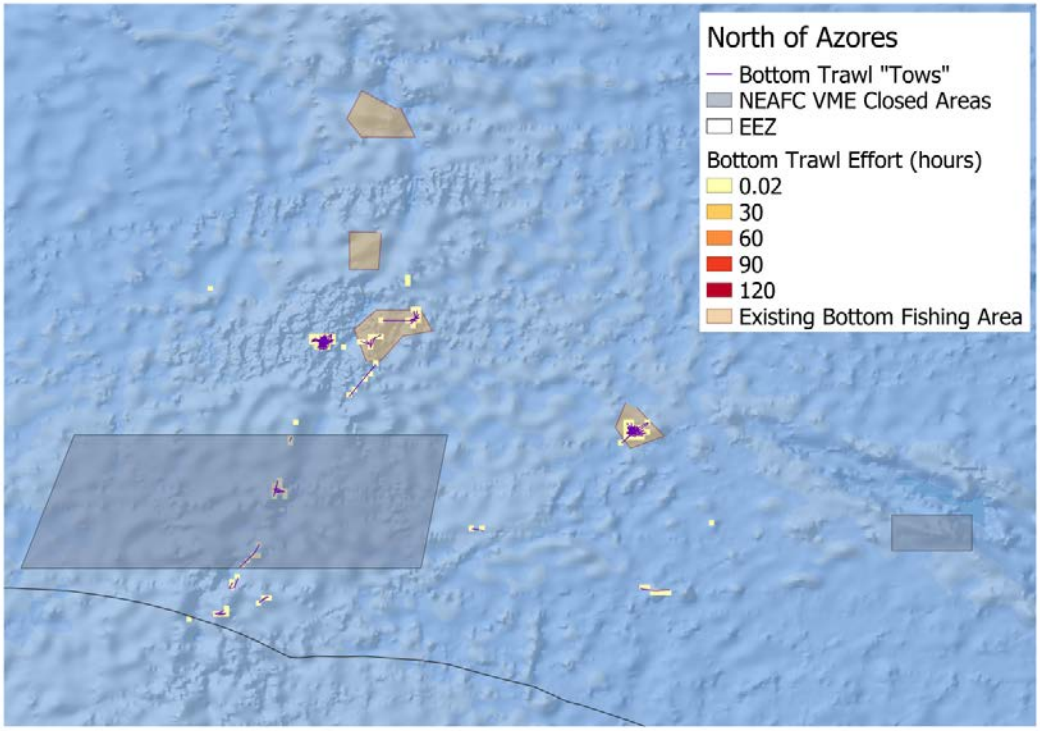


Figure 18. Gridded effort and putative tows for vessels registered as using mobile bottom contact gears, to north of Azores.

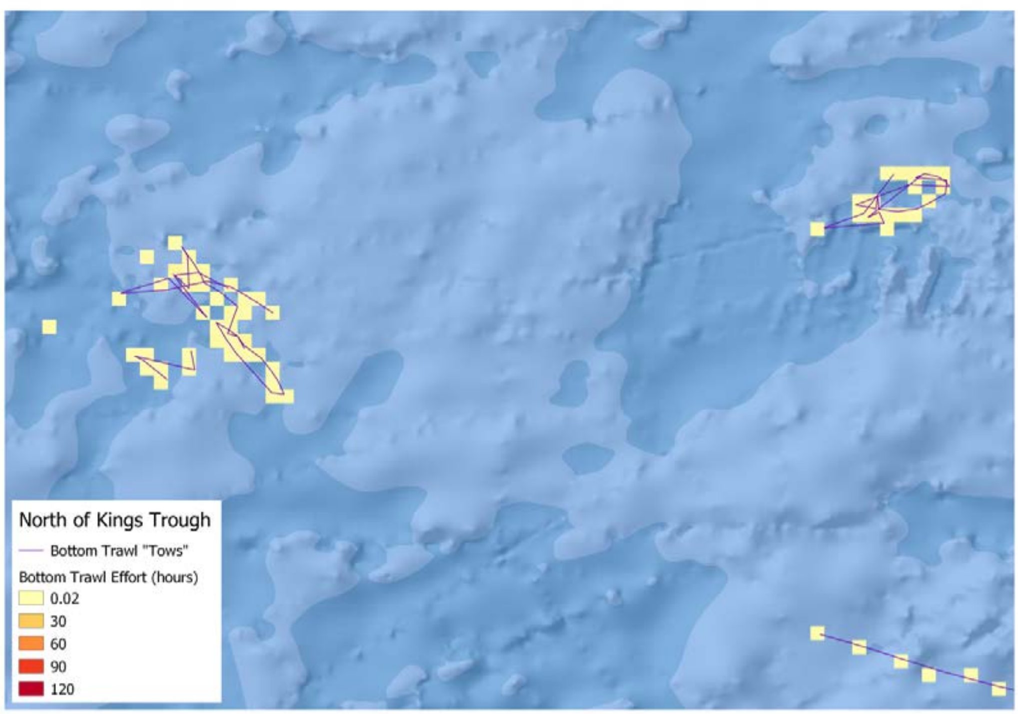


Figure 19. Gridded effort and putative "tows" for vessels registered as using mobile bottom contact gears, north of Kings Trough.

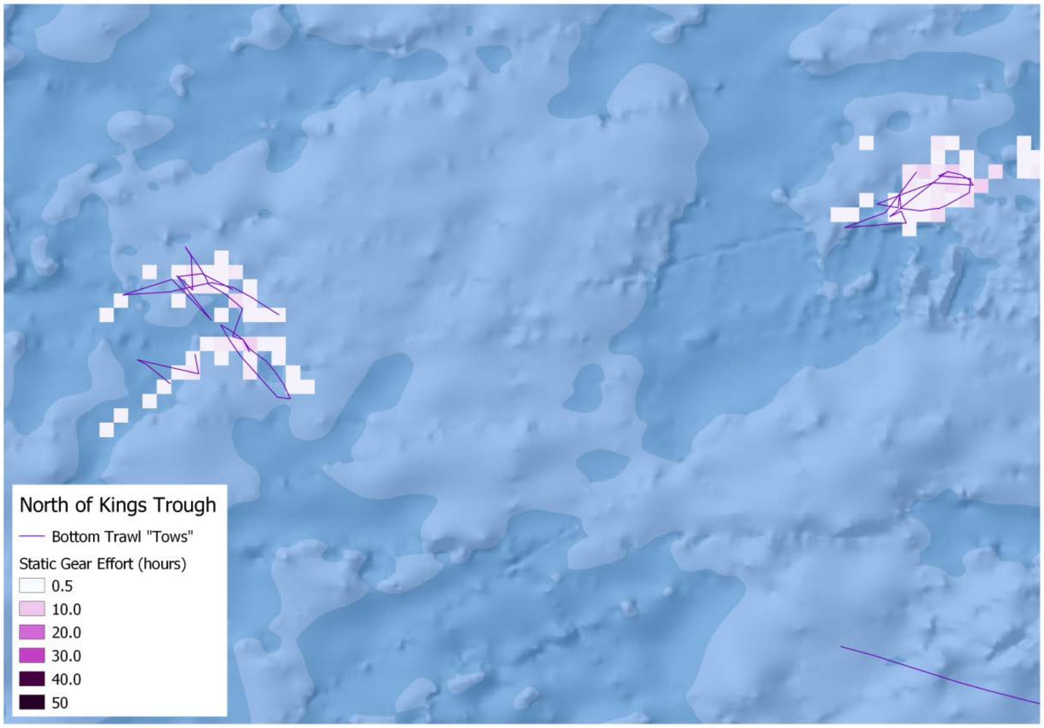


Figure 20. Gridded effort for vessels registered as using static gears, along with putative mobile bottom contact gear "tows", to north of Kings Trough.

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

Reviewers: James Asa Strong (National Oceanography Centre, UK - Chair), Rabea Diekmann (Thuenen Institute for Fisheries Ecology, Germany), and Emanuela Fanelli (Polytechnic University of Marche, Italy)

Secretariat: Sebastian Valanko

Review provided to: ADGVME (Advice Draft Group Vulnerable Marine Ecosystems)

Review period: 27 May – 7 June 2018

Overview

In response to the three advice requests (DGMARE, EU, NEAFC), this report (i) reviews the spatial data, provided by the Working Group on Deep-water Ecology (WGDEC), on the distribution, vulnerability and abundance (VME index) of VMEs in the North East Atlantic; (ii) examines the methods used to derive the VME distribution (method behind the VME Index); (iii) reviews the processing and presentation of VMS (Vessel Monitoring System) data within the NEAFC (North-East Atlantic Fisheries Commission) regulatory area; and (iv) comments on the potential issues surrounding the overlap analysis of VME and NEAFC VMS data. The Working Group on Deep-water Ecology (WGDEC) and Neil Campbell (Working Group on Spatial Fisheries Data - WGSFD), analysing fishing activities in the NEAFC regulatory area, provided the reports for review. The review document is structured according to the three requests.

The review group worked by correspondence during the period indicated. Two teleconference meetings were held during the review – one on the 1st June 2018 to agree on (i) the approach to the review; (ii) request any additional documentation or clarification from the ICES Secretariat; and (iii) identify the main advice points for the report. A second meeting was held on the 6th June, 2018, to ratify the final advice provided in this report.

1. DGMARE request – "advice on a prioritised list of bottom fisheries closures areas where VMEs are likely to occur, taking into account the current fishing footprint"

1.1 Representation of the distribution of VMEs

VME information was sourced from the WGDEC 2018 report and the RGVME commend the group for collating this enormous amount of information consolidating data from visual and catch survey as well as from the literature. It is noted that the WGDEC have included a significant volume of new observations through the ICES VME Data Call in 2017/18. However, the vast majority of these observations are not relevant to the EU area.

Based on the general scarcity of observations, the RGVME support the use of the VME Index (for combining VME indicators) for estimating the distribution of VMEs. The Review Group did share the concerns of the WGDEC (WGDEC, 2018) on how abundance data are included and weighted in the calculation of the VME Index – without consistent and considered thresholds supported by field observations, it was felt that this information currently offered little additional information.

Within the calculations for the VME Index, it was not clear to the RGVME whether OSPAR habitat observations had been included in the Index as bona fide habitat records. Also, it wasn't clear as to how multiple indicator observations within a c-square, if any, were merged or averaged to produce a final Index value. One assumes that multiple indicators within a c-square should increase the VME Index.

The Review Group noted that the distribution of VME observations is extremely patchy and sparse. The reporting of absence data will aid in the interpretation of the VME presence records (e.g. if there are lots of absences, one can assume a patch distribution or, when few absences are reported, that the scatter observed is the product of undersampling). It is noted that WGDEC makes the recommendation (addressed to the ICES Data Centre) that absence information should be recorded. Having absence information will further allow using a broad array of geo-statistical modelling techniques, which is a recommendation for a future WGDEC ToR (see below).

The RGVME caution against the exclusion of VME Index c-squares, based on the filtration method detailed in section 4 of WGDEC (2018), before the overlap analysis. The exclusion of low, medium and high (low confidence only) vulnerability index c-squares in Section 4 is a significant modification of the underlying VME indicator data. It is evident that the exclusion step results in a significant change in the density and distribution of VME vulnerability index c-squares, as demonstrated between sections three and four of the WGDEC report. The RGVME do not question that in order to indicate where "VMEs are likely to occur", many of the c-squares with lower vulnerability indices should be excluded. However, the review group believe that the removal of lower index c-squares should be done after the overlap analysis. The inclusion of all of the VME c-squares may provide interesting insights into the relationship between VME vulnerability, VMS-derived effort and depth bands. For example, although not providing any information on cause or effect, it might be informative for the advisory phase to understand the correspondence between the VME vulnerability index and fishing intensity, e.g. only low vulnerability index c-squares are found in areas with the highest fishing effort.

At some point in the overlap analysis, it will be necessary to filter VME Index c-squares to represent better where VMEs are likely to occur. The review group note that little justification was provided for the filtration method detailed in section 4 of the WGDEC (2018) i.e. the exclusion of low, medium and high (low confidence only) vulnerability index c-squares. Based on the importance of these exclusions for the density and distribution of VMEs, it would seem prudent and transparent to provide a thorough justification for the choice of exclusion rules applied.

The RGVME suggest that overview maps and tables are provided for the VME observations and c-squares (with a clear link to the ICES VME data portal). Once again, the inclusion of absence observations or some estimate of sampling effort within a regional would assist greatly in the interpretation of large expanses of no data. It is also noted that VME observations of both habitats and indicators come from point sampling with cameras and grabs as well as from prolonged trawling tows - WGDEC needs to carefully consider how to standardise and represent these very different sources of information in a comparable manner. It is also likely that the ability to sample, and therefore detect, certain VME indicators might be different between sampling methods – this may also require consideration within the WGDEC report.

By using the full VME index and habitats observations, the RGVME are content that the surfaces provided do represent the best available evidence for estimating the distribution of VMEs. It is clear that the VMEs are often associated with bathymetric and geomorphological features. As such, they are amenable to geo-statistical modelling techniques (as we are sure WGDEC have also realised). Based on the sparsity of observations, the RGVME suggest that predictive modelling techniques will be a useful method for providing a fuller representation of 'suitable habitat' or potential VME distribution. By using confidence intervals, priority areas for fisheries closures should be identifiable even in areas that are currently underrepresented in the ICES VME database.

1.2 Advice on the overlap analysis based on the review of the input data sets

Vessel Monitoring System data, collated by ICES, will be used to establish the fisheries footprint in the North East Atlantic. The RGVME notes that the WGSFD are reviewing ICES-based VMS data for the overlap analysis.

The RGVME highlight that the VME Index and habitat observations are very scattered and sparse, which might complicate the overlap analysis. To overcome the issues of poor coverage, it is recommended that geo-statistical modelling techniques that produce predicted probability surfaces for VMEs are investigated in the future by WGDEC.

In the absence of modelled VME surfaces and considering the scattered nature of the VME vulnerability index c-squares, steps to spatially buffer the VME observations can be considered. Given that sampling effort is likely to be generating much of the scatter within the VME observation, it might seem appropriated to apply neighbourhood buffers. However, buffering without considering any environmental information could be problematic. Many VMEs are found along strong environmental (depth) gradients and simply extrapolating VMEs to neighbouring grid cells may be an over-simplification of the actual configuration. As an interim solution, it might be more prudent to apply expert judgement when buffering points and by this delineating VMEs.

Fisheries intensity information will be provided by ICES as surface and subsurface swept area ratio (SAR) per grid cell (0.05°*0.05° C-square). Due to the high sensitivity of VMEs to trawling activities, RGVME suggest to overlap VME information with surface SAR estimates rather than with subsurface SAR.

RGVME suggests plotting the frequency of occurrence of VMEs and average fishing intensities versus water depth/depth bands in order to inform decision-making. This will provide context on the value for VMEs of closed areas versus de facto closed areas that are too deep (or steep/with natural constraints) for current fishing practices.

It is worthwhile considering that areas with a high fishing effort potentially provide high revenues. If high-effort areas are closed, fisheries might be displaced to other areas with, so far, modest or no fishing activity. Therefore, the decision needs to be made if either all VMEs with a certain characteristic/threshold should be closed for fisheries, or if not which percentage. In the latter case, it is possible to close the areas which currently experience only a modest/no fishing activity and preserve the respective habitats that have not been historically fished and therefore damaged.

Based on this review, RGVME are content that the 'VME vulnerability index and habitat observations' represents the best available evidence for representing the likely distribution of VMEs, and is a suitable evidence base for ICES to provide the requested advice to DGMARE.

2. EU - 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

2.1 Occurrence of VMEs

VME information was sourced from the WGDEC 2018 report. It is noted that the WGDEC have included a significant volume of new habitat observations (n = 3118) through the ICES VME Data Call in 2017/18. The vast majority of these observations are outside European waters and 99 new habitat observations were reported within European waters (mostly within UK waters). It was not clear to the RGVME whether OSPAR habitat observations had been included as VME occurrences within the WGDEC report.

Use of the VME vulnerability index, which is the basis of VME reporting under the DGMARE and NEAFC requests, greatly increases the density and distribution of relevant VME observations.

The Review Group noted that the distribution of VME observations is extremely patchy and sparse. The reporting of absence data will aid in the interpretation of the VME presence records (e.g. if there are lots of absences, one can assume a patch distribution or, when few absences are reported, that the scatter observed is the product of under-sampling). It is noted that WGDEC makes the recommendation (addressed to the ICES Data Centre) that absence information should also recorded. Also, should WGDEC investigate the use of geo-statistical modelling to delineate VMEs, having absence information will allow a broad array of geo-spatial modelling techniques to be used. The latter issue should also be an important recommendation for WGDEC.

It is also noted that VME observations of habitats come from point sampling with cameras and grabs as well as from prolonged trawling tows - WGDEC needs to carefully consider how to standardise and represent these very different sources of information in a comparable manner. It is also likely that the ability to sample, and therefore detect, certain VME habitats might be different between the differing sampling methods – this may also require consideration within the WGDEC report.

The RGVME are content that the information provided by WGDEC is the best available evidence for representing the occurrence of VMEs. It is likely that the occurrence of VMEs is substantially under-sampled and it is, therefore, wise to consider the information provided as a mere indication of the likely distribution of VMEs. As stated earlier, it is possible that the use of the VME vulnerability index (i.e. use of indicator species) may provide useful supporting data for interpreting the distribution of VMEs. Furthermore, it is clear that the VMEs are often associated with bathymetric and geomorphological features. As such, may be amenable to geo-statistical modelling techniques (as we are sure WGDEC have also realised). Based on the sparsity of observations, the RGVME highlight the value of predictive modelling techniques for providing a fuller representation of 'suitable habitat' or potential VME distribution. By using confidence intervals, it should be possible to identify habitats that are sensitive to fishing activities and that are currently missing or underrepresented in the ICES VME database.

Based on this review, RGVME are content that the VME habitat occurrence observations represents a suitable evidence base for representing the known distribution of VMEs, and is a suitable evidence base for ICES to provide the requested advice to the EU.

3. NEAFC - 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

A review of the information representing vulnerable habitat (VME habitats and VME indicator species as presented by the VME vulnerability index) is provided in Section 1.1 (1 DGMARE request – 1.1 Representation of the distribution of VMEs).

The RGVME was asked to review information about the fisheries footprint in relation to VMEs. The VMS data provided by NEAFC and were processed by Neil Campbell. The supporting report describes the data, the limitations and potential errors, and provides raster layers of fishing effort covering the NEAFC regulatory area with specific maps for five areas with spatial measures for the protection of VMEs.

The analysis generally follows the workflow described by WGSFD (ICES 2016). However, the data from the NEAFC area partly differ from the data that are submitted according to the ICES data call in relation to VMS/Logbook data for fishing activities in the North East Atlantic and the Baltic Sea. These differences include: (i) catch records don't have date information and can be linked to VMS data only on a 6-monthly basis; (ii) minimum interval between two consecutive VMS polls is four hours instead of two; (iii) the analysis of speed profiles is based on all vessels registered as using trawl gears rather than by each specific gear type or vessel and resulted in an overall definition that vessels are fishing at a speed of 0–5 knots; (iv) fishing effort is given in hours rather than as swept area, which is due to the fact that gear width cannot be estimated appropriately. Further, the report mentions problems with the quality of speed data. The RGVME evaluates that the data issues and problems were addressed adequately and the output of the analyses was representative. Some misinterpretations, e.g. of gear type or vessel's activity cannot be completely avoided with the currently available information, but, when relevant, were mentioned in the text accordingly.

The presentation of four different maps for each area is appreciated as it gives additional information according to the quality of the assessment. The spatial layer that is important for an overlay with VME records is the gridded effort of vessels using mobile bottom contacting gears. The spatial resolution of the grid cells (0.05°*0.05° C-square) may be slightly too high (due to 4h ping intervals) creating artefacts especially at low fishing intensities but is in accordance to the WGSFD workflow (ICES, 2016) and corresponds to the resolution used in the WGDEC report. The maps with putative tows illustrate that trawling seems to concentrate at the border of closed areas, and vessels usually comply with measures. The maps further provided credence to the underlying data and the processing method. However, RGVME caution against the use of interpolated tow lines for producing raster layers as long as the minimum transmission interval is 4h.

Generally, the analysis of fishing effort could be improved by (i) a higher polling frequency, (ii) the provision of detailed logbook information (including catch data and the gear type used), and (iii) the improvement of speed reports. Nevertheless, the currently available information on the intensity of fishing with bottom contacting and static gears were produced adequately allowing an overlay with VME layers.

For the future, RGVME note that in addition to an annual analysis of fishing effort:

1. information about the area specific inter-annual variation in fishing intensity should be provided to assess if fishing happens only sporadically or chronically,
2. a spatial layer representing the multiannual fishing effort (e.g. 2012–2017) should be produced, and
3. an analysis of the amount of overlap between fishing activities and area closures for each (potential) spatial measure would be informative.

These data products could then assist in defining a prioritised list of fisheries closure areas. Fishing intensity maps, such as figure 21 of the report, could further help identifying particular areas of interest to bottom trawling and providing guidance to potential features associated to VMEs.

Based on this review, RGVME are content that the VME vulnerability index and habitat observations represents the best available evidence for representing the likely distribution of VMEs, and is a suitable evidence base for ICES to provide the requested advice to NEAFC. Equally, RGVME are content that the NEAFC VMS data are also sufficient to indicate the intensity and distribution of fishing effort with the NEAFC area.

4. References

ICES 2016. Interim Report of the Working Group on Spatial Fisheries Data (WGSFD), 17–20 May 2016, Brest, France. ICES CM 2016/SSGEPI: 18. 244 pp.

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.