Published 4 July 2016
Version 2, 8 July 2016
Version 3, 31 October 2016

1.6.6.4 OSPAR request for further development of fishing intensity and pressure mapping

Advice summary

VMS and logbook data were requested from ICES Member Countries. Data for the OSPAR maritime areas were received from 13 of these sources, but only data from 11 countries were complete and could be used to develop this advice.

A comparison was made between the VMS data and the logbook data submitted to ICES. The proportions of the total fisheries and landings (fishing days and landings by vessels with VMS, divided by fishing days and landings by all vessels > 10 meters) represented by the VMS data were on average 81% and 82% of the fishing days in 2014 and 2015, respectively, and 84% and 88% of the landings, compared to the total logbook data. However, the estimates are overestimates of the proportions of total fisheries represented by the data. This is due to data not being delivered by all countries fishing in OSPAR areas and that some of the submitted data were unsuitable for processing. In addition, activities of vessels < 10 meters were not included.

There are currently no suitable comprehensive sources of position data for regional spatial analyses of fishing vessels < 12 m overall length. ICES advises that such data should be developed.

ICES has mapped the surface and subsurface fishing intensity by bottom-contacting mobile gears for the OSPAR maritime area for 2014 and 2015.

ICES advises that if finer-scale information is needed, data could be improved if the polling frequency of VMS is increased. An alternative would be to collate AIS and co-analyse it with raw VMS data and logbooks. Additional improvements in fishing data quality could be achieved by more detailed logbook information. Increase in precision of assessments of fishing intensity in both time and space can well be done using sophisticated algorithms and modelling of raw VMS data. However, any increase in precision of mapping fishing effort needs to take into account the increasing risk of infringing data confidentiality, regulations, and agreements.

ICES advises that AIS information comes at high cost, but few benefits for regional-scale assessment of fishing abrasion (Extent of physical damage indicator, BH3).

AIS information could be used to describe fishing pressure by vessels exceeding 15 m in length (i.e. VMS data covers a greater proportion of the fleet). However, AIS would need to be combined with logbook data to accurately resolve fishing activities; this will bring issues in relation to confidentiality. AIS has limitations in that it is mandatory only for vessels of 15 m length or longer, and since it is not an enforcement tool, AIS systems can be switched off. There are costs associated with establishing a datacentre to collate AIS data and purchasing the information from commercial vendors.

Request

ICES is requested by OSPAR "using the latest versions of the indicator description/summaries of the 'Extent of Physical damage indicator' (BH3), to:

- *a) 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 WGSFD meeting in June 2015;*
- *b) Estimate the proportions of total fisheries represented by the data;*
- *c) 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);*
- *d) Prepare maps for the OSPAR maritime area (including ABNJ) on the spatial and temporal intensity of fishing using mobile bottom contacting gears;*
- *e) Provide advice on the development and application of alternative smaller grids (smaller resolution than 0.05°) to improve the analysis of fishing abrasion data:*

i. *What data and methods can be used for regional assessments, including pros and cons on data accessibility, and costings, if possible;*
ii. *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.*

f) *Provide advice on the applicability and use of AIS data, in particular to:*
i. *Ascertain if it can be used as supporting information for the spatial analysis of fisheries data;*
ii. *Indicate if it can be used as an alternative source of data to VMS;*
iii. *Indicate potential costing for the collation and management of AIS data;*
iv. *Advice can be based on a case study or pilot area.*

Elaboration on the advice

a) Collect relevant national VMS and logbook data for 2014

VMS and logbook data for 2014 and 2015 were requested from ICES Member Countries. Data were received from 13 of these, but as shown in Table 1.6.6.4.1 only data from 11 Contracting Parties were complete and could be used in developing this advice.

The quality of the submitted data increased over previous years, following the implementation of an improved system to standardize data submission and to check and improve data quality.

Table 1.6.6.4.1 Countries to whom the 2016 ICES data call on VMS and logbook data was sent and their submissions.

Belgium	✓	The Netherlands	✓
Denmark	✓	Lithuania	✓
Faroe Islands	× -unsuitable data submission	Norway	✓
France	✓	Portugal	✓
Germany	✓	Russia	×
Greenland	×	Spain	×
Iceland	× -unsuitable data submission	Sweden	✓
Ireland	✓	United Kingdom	✓

✓: Suitable data submission ×: Unsuitable data submission ×: No data submitted

b) Estimate the proportions of total fisheries represented by the data

The proportions of the total fisheries and landings (fishing days and landings by vessels with VMS, divided by fishing days and landings by all vessels > 10 meters), represented by the VMS data compared to the logbook data delivered to ICES, were estimated by OSPAR region (Table 1.6.6.4.2). On average VMS data represented 81% and 82% of the fishing days in 2014 and 2015, respectively, and 84% and 88% of the landings. However, the estimates presented in Table 1.6.6.4.2 are overestimates of the proportions of total fisheries represented by the data delivered to ICES.

Firstly, data from five countries fishing in the OSPAR area were either not submitted or were unsuitable for processing. Landings and fishing effort data from these countries were not included in the analyses. For example, of the nine countries that reported catch data in response to a questionnaire sent out by WGCATCH (ICES, 2016b) and that were fishing in the OSPAR area, 28% of the vessels carring VMS (12 m or longer) were Spanish vessels for which no VMS data was submitted. These vessels fish predominantly in OSPAR regions III, IV, and V.

Secondly, VMS is not used on-board vessels less than 12 m in length. It is estimated that such vessels represent 86% of the active EU vessels in the OSPAR area; however, many of these vessels do not use mobile bottom-contacting gear. Vessels smaller than 10 m do not maintain a logbook. The smaller (< 10 m) vessels are not as active as larger (> 12 m) vessels (average 68 days at sea per year per active vessel, compared to 152 days) and have a relatively low proportion of total landings. Not including the smaller vessels in the analysis will predominantly underestimate the effects on the benthos near land.

The data used in the analysis was in general representative for the different gear groups with the exception of dredges, where VMS data only represents 61% and 62%, respectively, of the total days at sea in 2014 and 2015. This is due to a relative large proportion of the effort in the scallops, mussels, clams and cockles fisheries being conducted by vessels between 10 and 12 metres in length.

Vessels less than 10 m in length accounted for the majority of the active vessels (Figure 1.6.6.4.1) and days-at-sea (Figure 1.6.6.4.2), but by far the greatest volume of landings is taken by vessels 15 m and longer (Figure 1.6.6.4.3). The relative amounts of fishing effort of the > 10 m fleet, represented by vessels using VMS, was calculated by gear group, OSPAR area, and year (2014 and 2015) represented by fishing days and landed weight (Table 1.6.6.4.1).

Table 1.6.6.4.2 Fishing days and landed weight represented by the VMS data provided to ICES by gear group and OSPAR region for the years 2014 and 2015 when compared with logbook data. ICES did not receive data from a number of nations fishing in the OSPAR area and was not able to take into account fishing effort and landings by vessels < 10 meters as these do not maintain a logbook. This means that the estimated proportions of fisheries represented by VMS and logbook data given in the table only reflects the proportion of fisheries by the nations for which data was delivered, and only for vessels over 10 metres. The figures are therefore overestimates of the total fisheries represented by the data, particularly in OSPAR regions I, IV, and V. Percentages in brackets indicate fishing days less than 100 or total weight less than 100 tonnes.

Year	OSPAR region	Gear group	Fishing days with VMS	Total landed weight with VMS
2014	I: Arctic waters	Beam	(87%)	(98%)
		Dredge	0%	0%
		Otter	97%	96%
		Demersal seine	82%	83%
	II: Greater North Sea	Beam	93%	96%
		Dredge	68%	51%
		Otter	83%	97%
		Demersal seine	92%	98%
	III: Celtic Seas	Beam	96%	100%
		Dredge	75%	72%
		Otter	86%	99%
		Demersal seine	100%	100%
	IV: Bay of Biscay and Iberian Coast	Beam	97%	100%
		Dredge	1%	1%
		Otter	60%	68%
		Demersal seine	99%	100%
	V: Wider Atlantic	Beam	(100%)	(100%)
		Otter	100%	97%
		Demersal seine	(100%)	(100%)
	All regions	All gears	81%	84%
2015	I: Arctic waters	Beam	(70%)	(71%)
		Dredge	0%	0%
		Otter	97%	97%
		Demersal seine	84%	84%
	II: Greater North Sea	Beam	93%	92%
		Dredge	68%	61%
		Otter	85%	99%
		Demersal seine	96%	98%
	III: Celtic Seas	Beam	98%	99%
		Dredge	78%	73%
		Otter	88%	99%
		Demersal seine	98%	100%
	IV: Bay of Biscay and Iberian Coast	Beam	100%	100%
		Dredge	2%	2%
		Otter	62%	72%
		Demersal seine	100%	100%
	V: Wider Atlantic	Beam	(93%)	(94%)
		Otter	100%	76%
		Demersal seine	(100%)	(100%)
	All regions	All gears	82%	88%

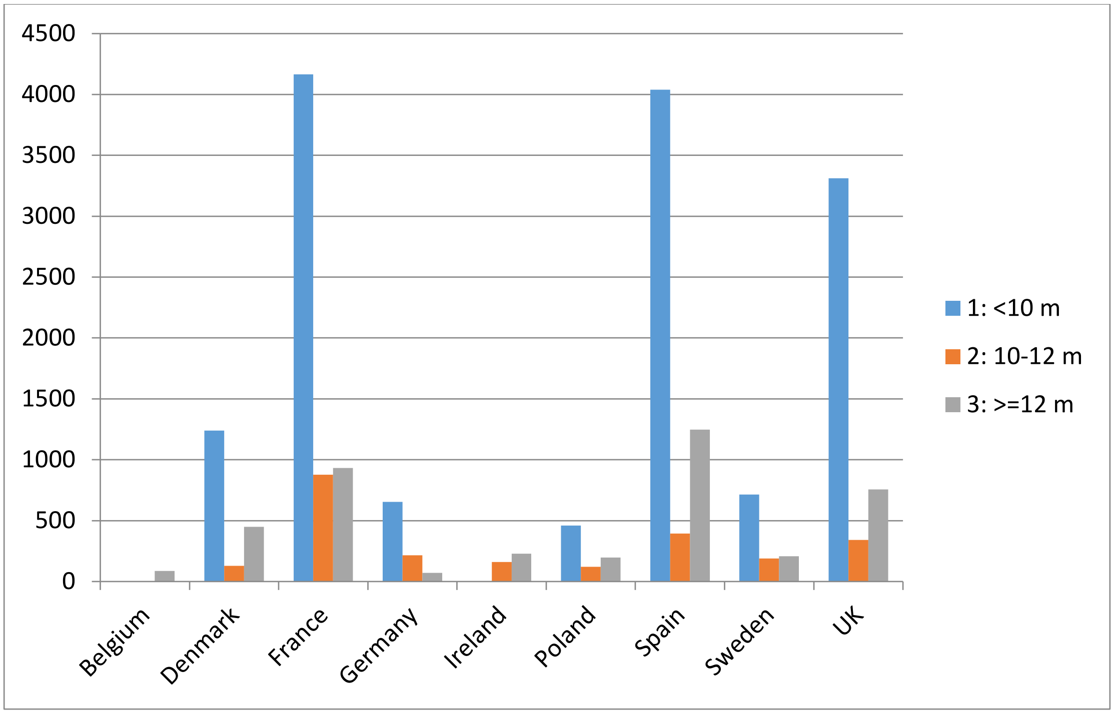

Figure 1.6.6.4.1 Number of active vessels per country and vessel length group in 2012 (ICES, 2016b).

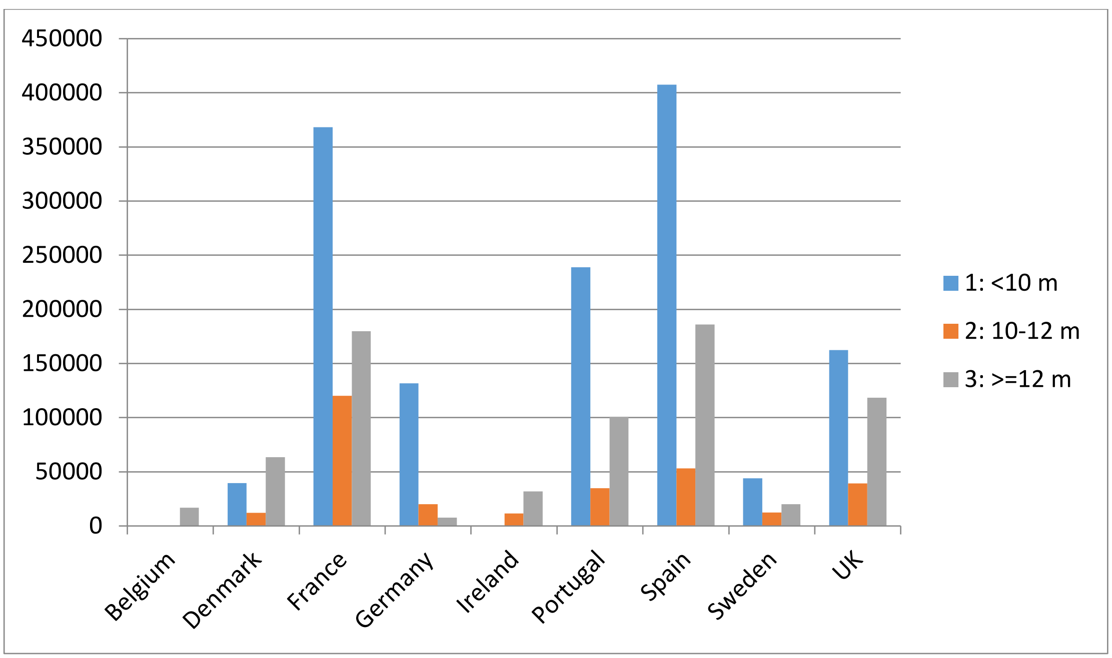

Figure 1.6.6.4.2 Number of days-at-sea per country and vessel length group in 2012 (ICES, 2016b).

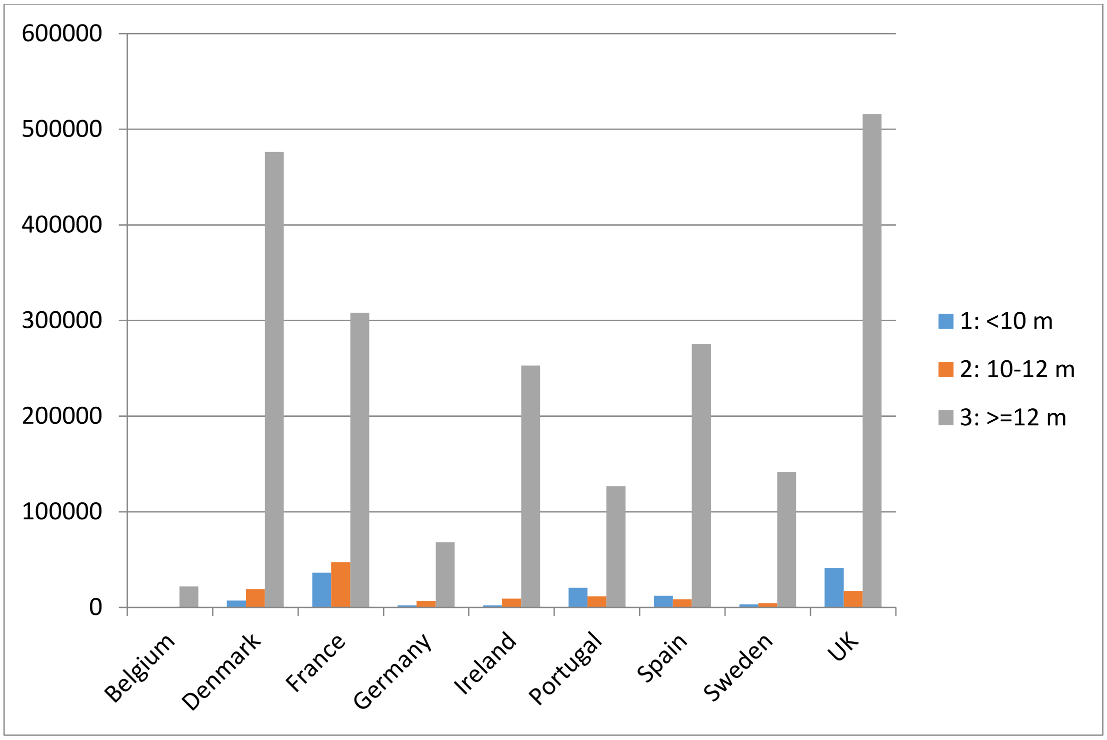

Figure 1.6.6.4.3 Total fish and shellfish landings per country and vessel length group in tonnes in 2012 (ICES, 2016b). Fish landings only for Belgium and Germany.

c) Non-VMS data

The only non-VMS position and fishing effort data available to ICES was from logbooks. In the EU these are mandatory for vessels 10 m or longer in overall length. Logbooks are thus the only position data available for vessels 10–12 m in length, and for most countries the positions are given by ICES statistical rectangle. These data showed that vessels in the 10–12 m category tended to fish close to the coast.

There are currently no suitable comprehensive sources of position data for fishing vessels under 12 m overall length.

d) Maps of spatial and temporal intensity of fishing using mobile bottom contacting gears in the OSPAR maritime area

ICES generated maps of surface and subsurface abrasion pressure for beam trawl, dredge, otter trawl, demersal seine, and a total of these gears, for the years 2014 and 2015. These were plotted for the whole OSPAR area, and separately for OSPAR regions II, III, and IV (Annex 1, Figures 1.6.6.4.5–1.6.6.4.20; ICES, 2016c). Beam trawls and dredges were not used outside OSPAR regions II, III, and IV, and thus the wider maps for these gears are not presented.

e) Advice on the development and application of alternative smaller grids

ICES addressed the issue of finer-scale information by examining both improved data collection and improved data analysis.

Ideas and concepts for improving the precision of estimation of distribution of fishing activities were reviewed for advantages and disadvantages and, where possible, costs (data collection Table 1.6.6.4.3 and data analysis Table 1.6.6.4.4 in Annex 2).

The data could be improved if the polling frequency of VMS was increased (more positions given per fishing operation). An alternative would be to collate AIS data (as it is transmitted at a much higher polling frequency than VMS) and co-analyse it with raw VMS data. Both of these data improvements would enable finer-scale grids to be used to describe distribution of the fishing activities.

Additional improvements in fishing data quality could be achieved by 1) including start and end position / time of a fishing haul in logbooks, 2) extending the coverage of VMS / AIS to smaller fishing vessels, and 3) including detailed gear characteristics, such as gear width, in the logbook.

ICES is aware of few other methods to include effort data for those fisheries that do not supply logbook data (< 10 m vessels). Systems to monitor the location of small, coastal fishing vessels have been developed in Ireland, France, Spain, Denmark, and the UK. For example, inshore VMS (iVMS) transmits positional and speed data via the GPRS network at 5-minute intervals and, if outside of GPRS range, this data can be stored for later transmission. Such systems may be able to contribute to improved regional assessments in future, but only if standardized systems are widely adopted.

Statistical spatial modelling can be used to increase the precision of assessments of fishing intensity in both time and space. Any increase in precision of fishing effort mapping needs to take data confidentiality regulations and agreements into account.

In general it would be difficult to make most concepts operational at the scale of the OSPAR area without considerable effort (and cost). ICES noted that most data and methods would be more suitable for assessments at the small (e.g. protected area) scale. The nested grid approach could be used, but it would be difficult to transfer information in a standardized way between countries fishing in the same area and therefore unsuitable for regional-scale assessments.

f) Applicability and use of AIS data

AIS data is a high-frequency positioning system designed for vessel security. It is only mandatory for fishing vessels larger than 15 m and optional for smaller fishing vessels. It uses the VHF (radio) system, and position data are only stored if they are picked up by a base station (located on land or on oil/gas platforms or, at a higher cost, by satellites). The surface-based station AIS coverage is therefore better inshore than offshore (Figure 1.6.6.4.4). AIS can be switched off.

If available, the AIS data can supplement raw VMS and logbook data by giving more detailed information on fishing tracks between VMS positions. At present ICES has access only to aggregated VMS data; it is therefore only possible to compare the results derived from the two data sources, rather than combine them.

Using AIS as an alternative or additional source of data to VMS has advantages and disadvantages. There is no obligation on countries to submit AIS data (in contrast to the obligation for EU Member States to provide VMS data). AIS data can, however, be obtained from commercial vendors (at a cost) or can be accessed through national databases. AIS data would need to be combined with raw logbook data or the EU fleet register to get information on the gear used. The fleet register is not always accurate on gear types and for polyvalent vessels it is not possible to tell what gear was in use at a particular time.

The results from the mapping of aggregated VMS and AIS data were compared for six gear types that are widely used. It was concluded that effort distribution based on AIS is correlated to effort distribution based on aggregated VMS, but overall effort is severely underestimated by AIS.

The precise cost of AIS data for the OSPAR area depends on the quantity purchased (higher precision would require larger amounts of data). Historical AIS data can be bought from Marinetraffic.com and the cost of, for example one million AIS positions is listed as €1,969. If vessel positions were, for example, required every ten minutes, and approximately 2,500 vessels > 15m are at sea on any one day, then one million data points would be needed approximately every three days. Additionally, there would be a processing and management cost for AIS data, including linking the data to logbooks or fleet registers.

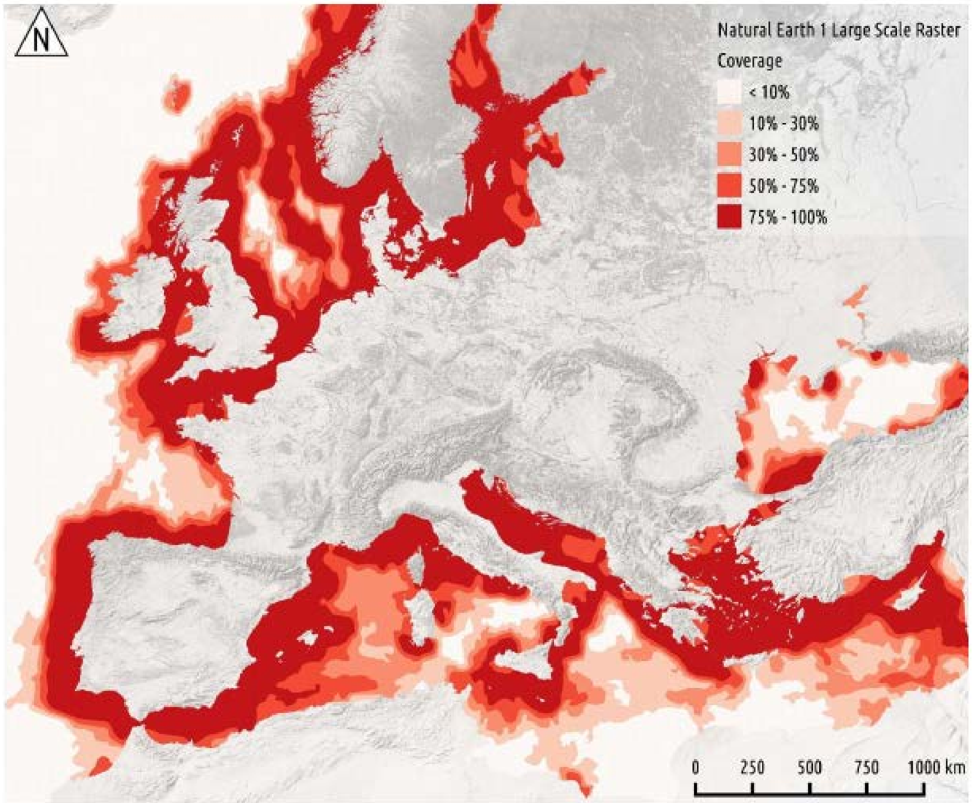

Figure 1.6.6.4.4 Spatial coverage and reliability of AIS data from surface-based stations (Vespe *et al.*, 2016).

Methods

b) Estimate the proportions of total fisheries represented by the data

The proportion of total fisheries represented by the fishing abrasion pressure outputs was calculated by proxy, using active fleet, fishing days, and landings weight (Table 1.6.6.4.2).

c) Non-VMS data

The effort (kW fishing days) from logbooks that could be linked to VMS activity data was compared to that which could not be linked to VMS data (Table 1.6.6.4.1), and the ratio of landings not covered by VMS were plotted by ICES rectangle for each gear type.

d) Maps of spatial and temporal intensity of fishing using mobile bottom contacting gears in the OSPAR maritime area

The swept area is calculated as hours fished × average fishing speed × gear width. The hours fished is given with the VMS data. The data call also asked for the average fishing speed as optional information, which means that in some of the data the average fishing speeds were missing and needed to be estimated from similar métiers, where this information was given. The gear width, expressed as surface and subsurface bottom contact, was estimated based on relationships between average gear widths and average vessel length or engine power (kW) found in the EU-FP7 BENTHIS project (Eigaard *et al.*, 2015) and expert input.

Caveats

A number of caveats apply to this advice.

The following need to be considered when interpreting the results from VMS analysis of fishing intensity.

- The outputs can only reflect the data submitted. Spain, Greenland, and Russia did not submit data, while Iceland and Faroe Islands submitted data that was unsuitable. The maps are therefore incomplete for any areas where vessels from these countries operate.
- Many countries have substantial fleets of smaller vessels that are not equipped with VMS (< 12 m) or logbooks (< 10 m for the EU fleet in the OSPAR area) and which are therefore not captured by these maps. These vessels occur mainly in coastal, nearshore waters.
- The methods for identifying fishing activity from the VMS data varied between countries; therefore there may be some country-specific biases. Additionally, activities other than active towing of gear may have been incorrectly identified as fishing activity. This would have the effect of increasing the apparent fishing intensity around ports and in areas used for passage.
- The fishing abrasion pressure methodology is based on broad assumptions in terms of the area affected by abrasion, which can lead to both underestimates and overestimates in actual surface and subsurface abrasion.
- The calculation of fishing intensity, as well as of surface and subsurface abrasion needs knowledge of fishing hours and speed, and of gear widths. Both fishing hours and speed were part of the data request. However, fishing speed was not always supplied, and in such cases, estimates of fishing speed were based on average supplied fishing speed values. Gear widths were estimated from relationships between average gear widths and average vessel lengths or engine power (kW).
- Some Contracting Parties submitted data with non-standard gear codes; fishing effort from these gears could thus not be included. The fishing effort covered by these codes will have a minor effect on the overall results.
- Inconsistencies may occur in the gear coding. Examples include dredges coded as HMD (mechanized dredges, including suction dredges) instead of DRB (boat dredge), and OTT (otter twin trawl) coded as OTB (bottom otter trawl). Gear codes were corrected when possible.

Sources and references

Eigaard, O. R., Bastardie, F., Breen, M., Dinesen, G. E., Hintzen, N. T., Laffargue, P., *et al.* 2015. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science, doi:10.1093/icesjms/fsv099. 17 pp.

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

ICES. 2016b. Report of the Working Group on Commercial Catches (WGCATCH), 9–13 November 2015, Lisbon, Portugal. ICES CM 2015/SSGIEOM:34. 111 pp.

ICES. 2016c. Maps of surface and subsurface abrasion pressure for beam trawl, dredge, otter trawl, demersal seine, and a total of these gears, for the years 2014 and 2015. Available as ESRI Raster data at: http://ices.dk/sites/pub/Publication%20Reports/Data%20outputs/OSPAR_mapping_bottom_fishing_intensity_data_outputs_2016.zip

Vespe, M., Gibin, M., Alessandrini, A., Natale, F., Mazzarella, F., and Osio, G. C. 2016. Mapping EU fishing activities using ship tracking data. arXiv:1603.03826 [cs.OH]. 11 March 2016, version 1. doi: 10.1080/17445647.2016.1195299.

Annex(es)

Annex 1 – Maps

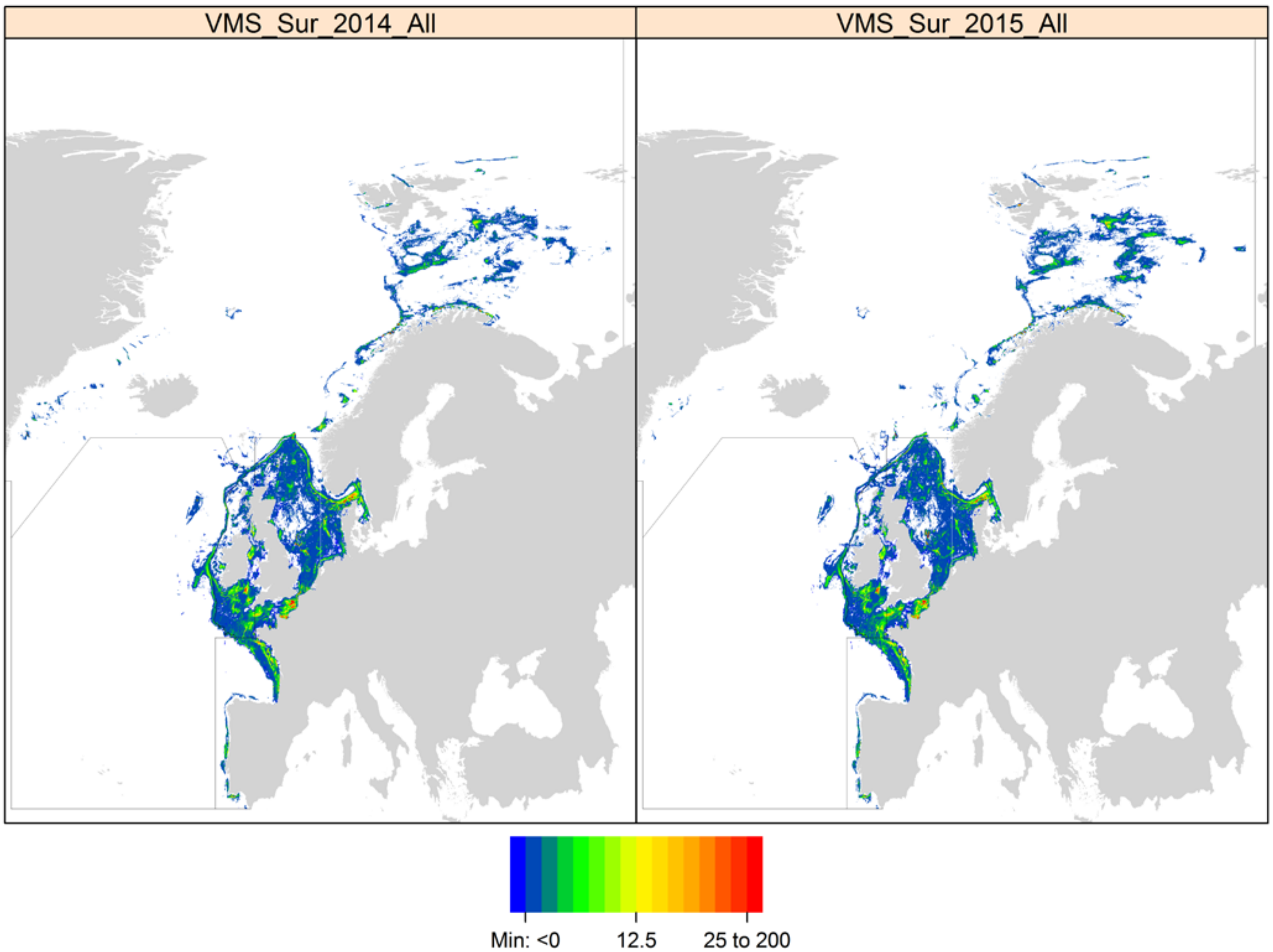

Figure 1.6.6.4.5 All fishing gears (i.e. total) surface swept area ratio for the years 2014 and 2015 in the OSPAR area. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

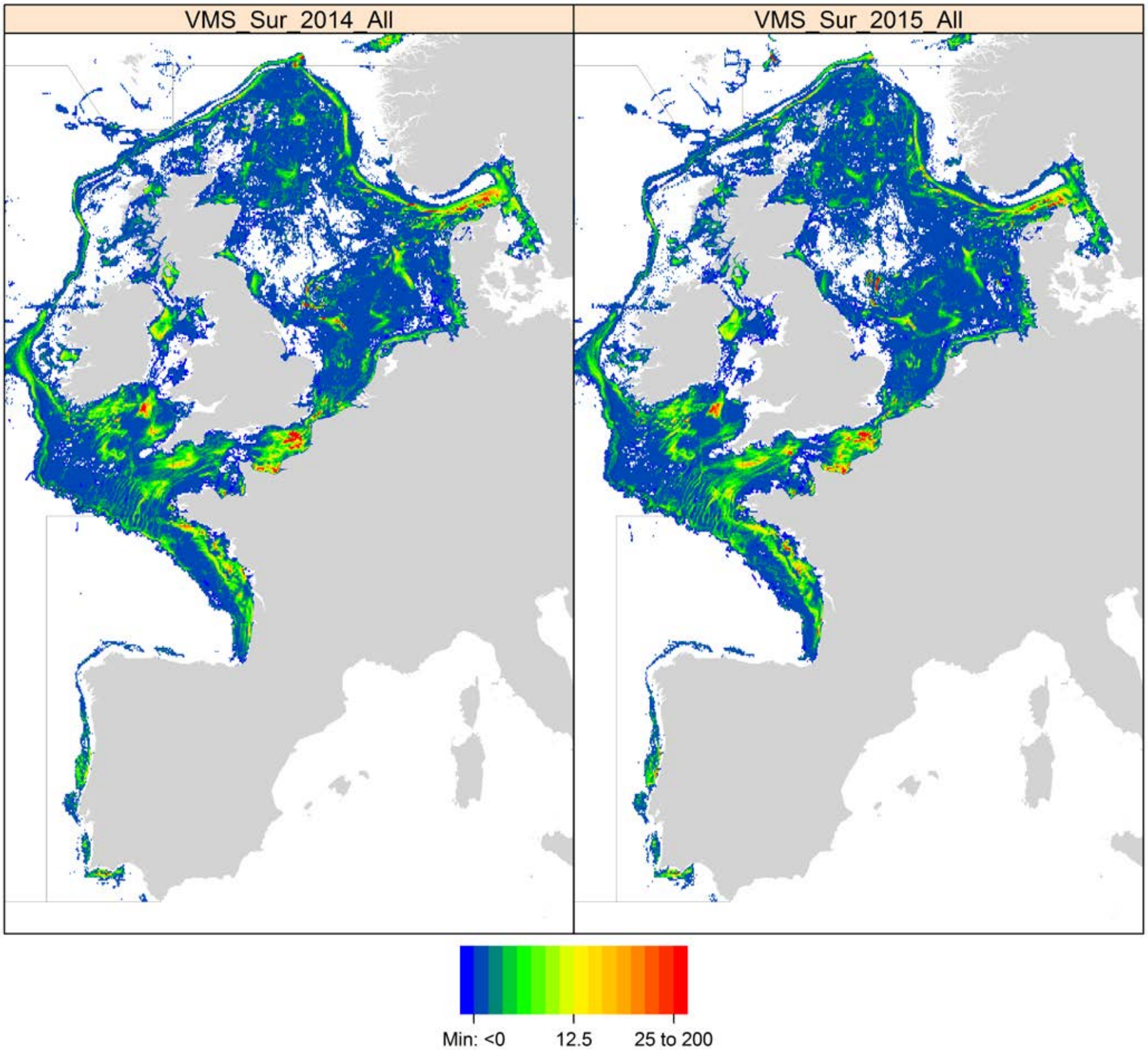

Figure 1.6.6.4.6 All fishing gears surface swept area ratio for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

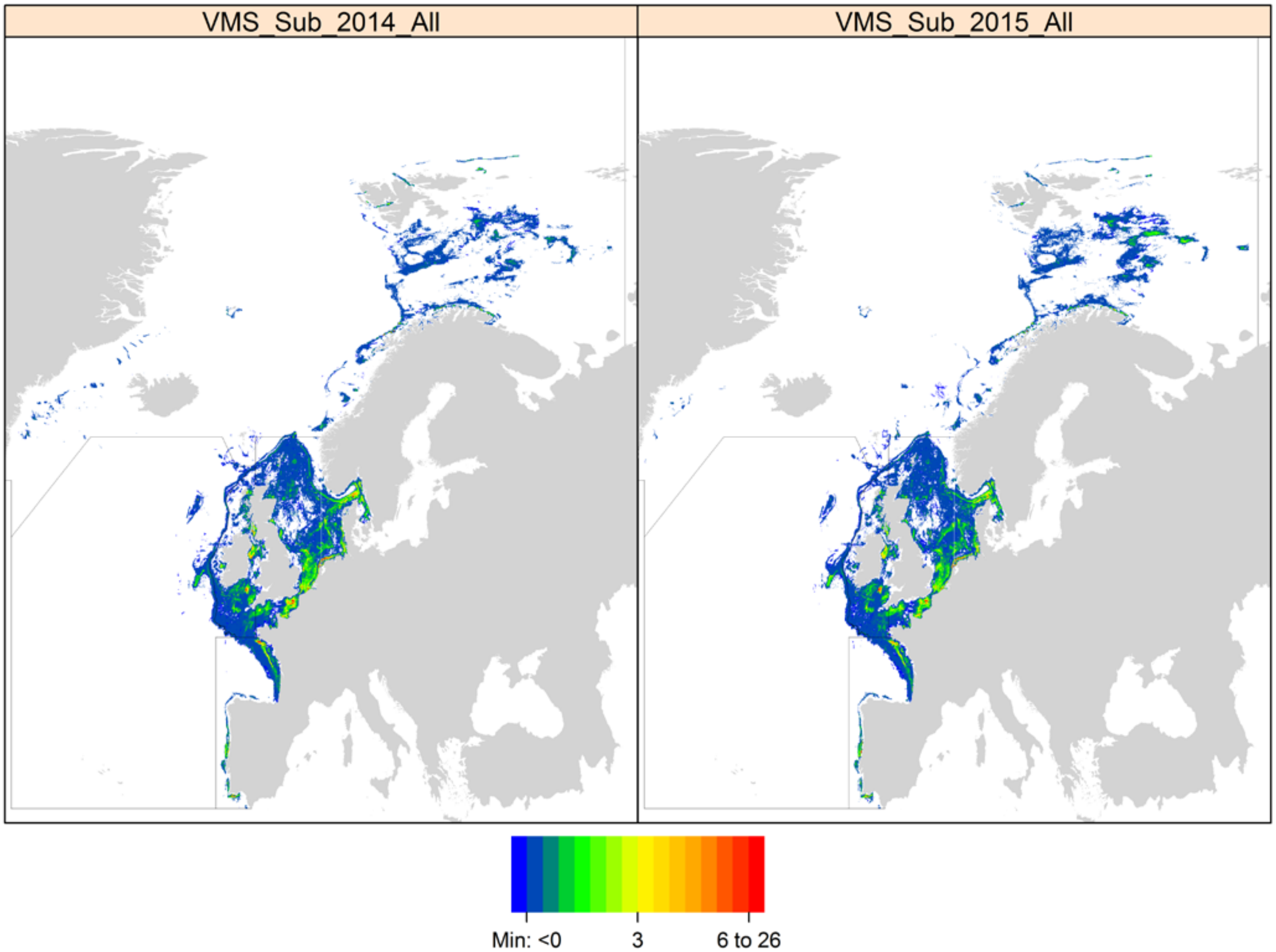

Figure 1.6.6.4.7 All fishing gears (i.e. total) subsurface swept area ratio for the years 2014 and 2015 in the OSPAR area. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

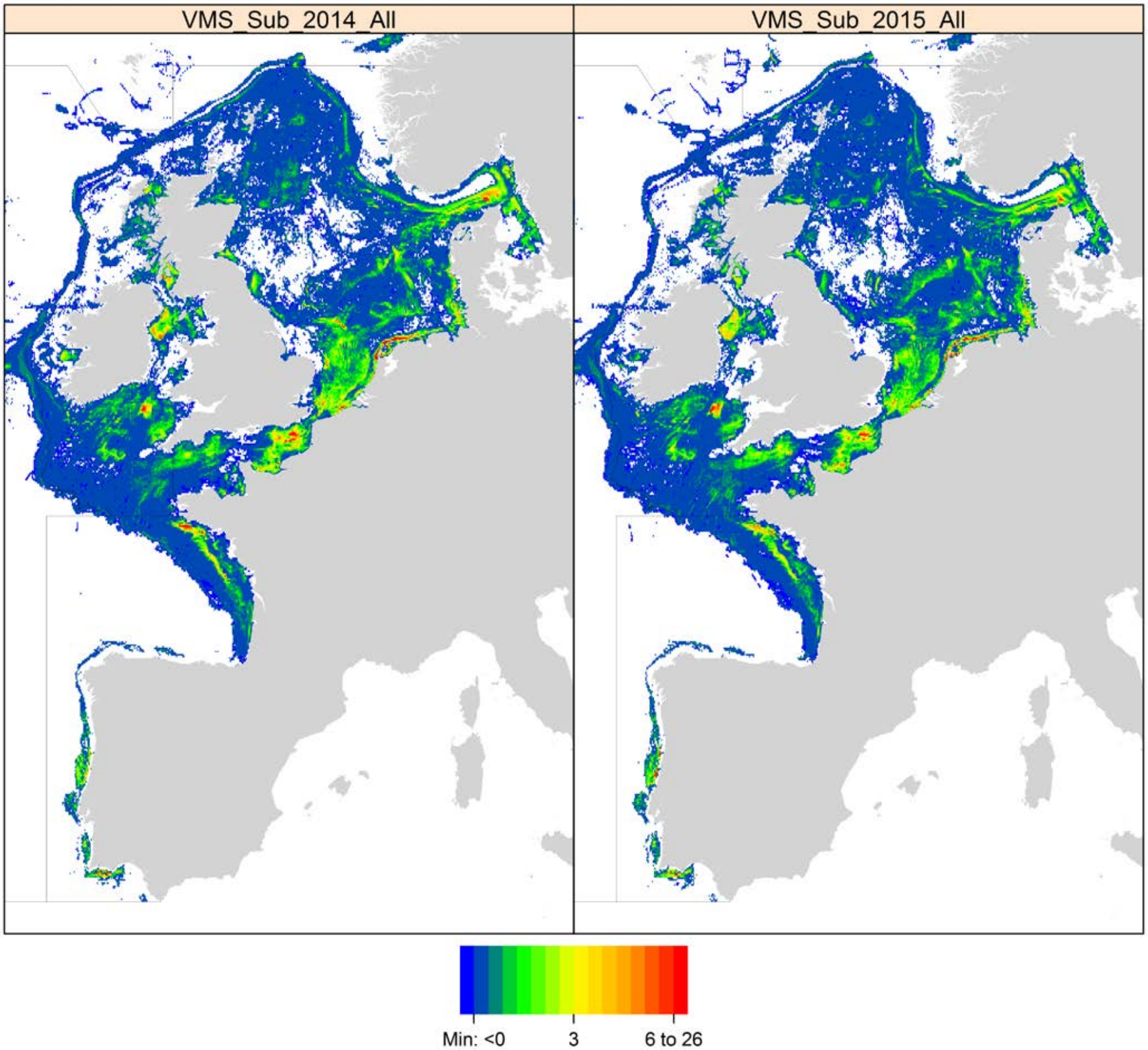

Figure 1.6.6.4.8 All fishing gears (i.e. total) subsurface swept area ratio for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

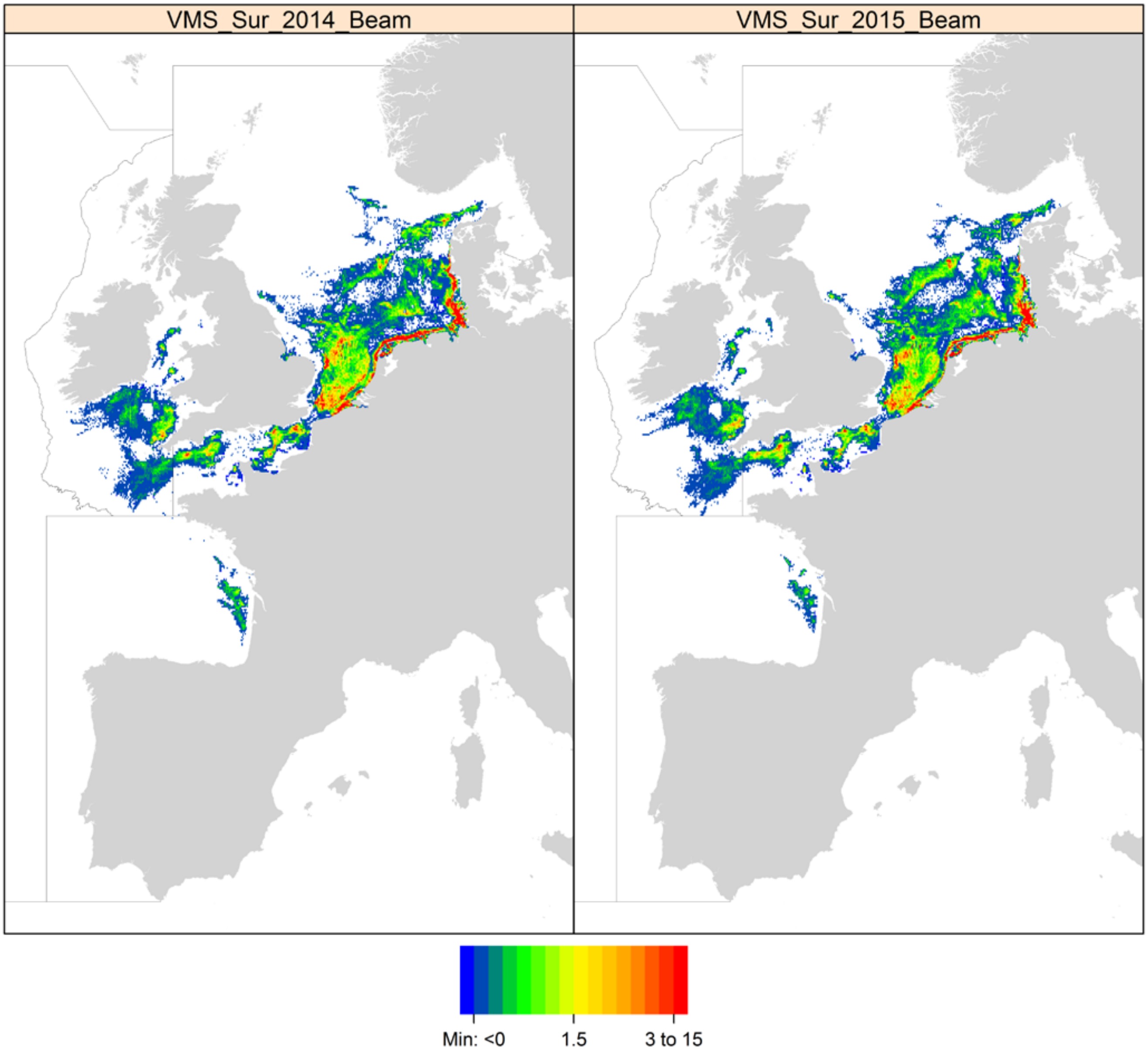

Figure 1.6.6.4.9 Surface swept area ratio of beam trawls for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

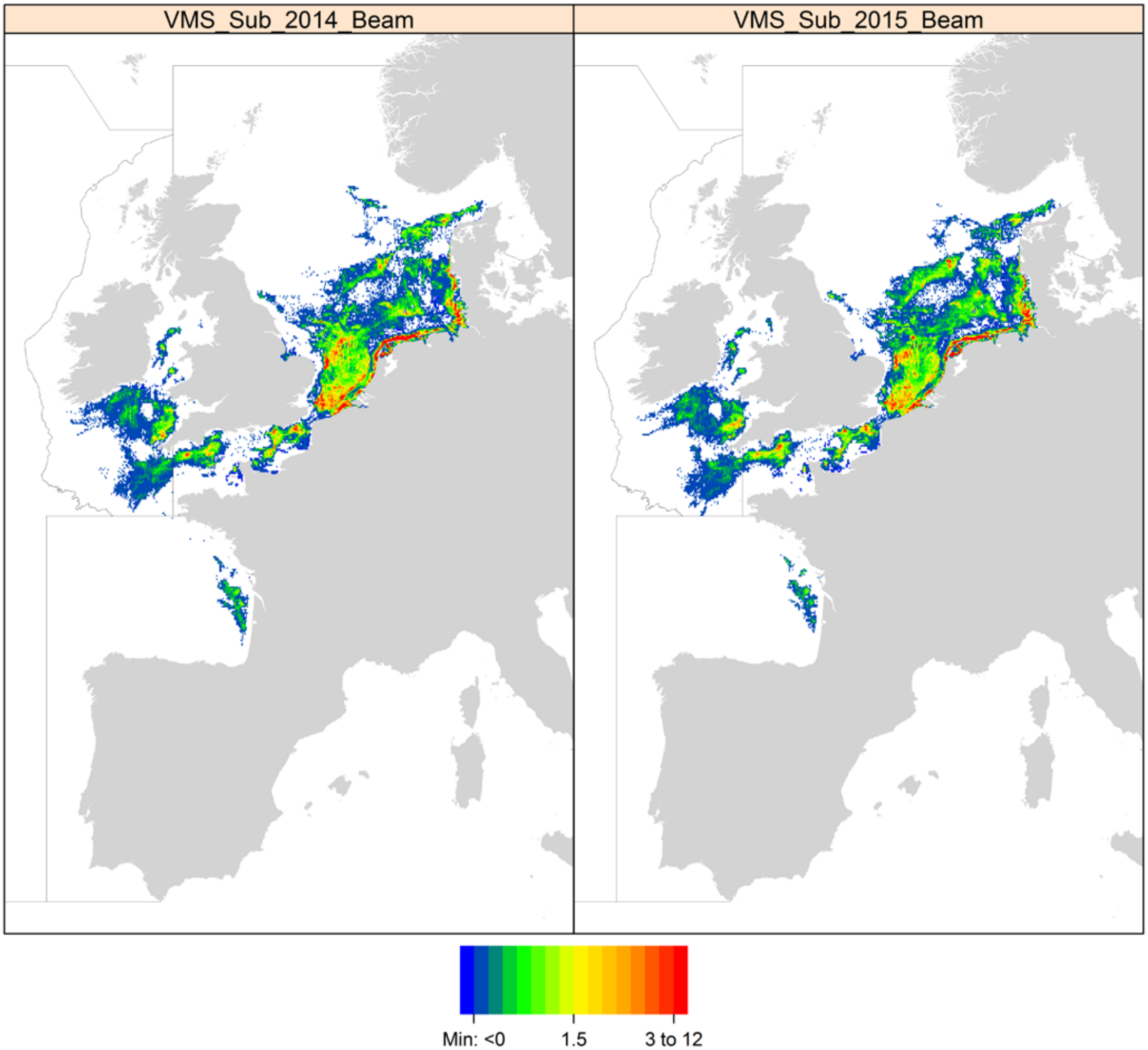

Figure 1.6.6.4.10 Subsurface swept area ratio of beam trawls for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

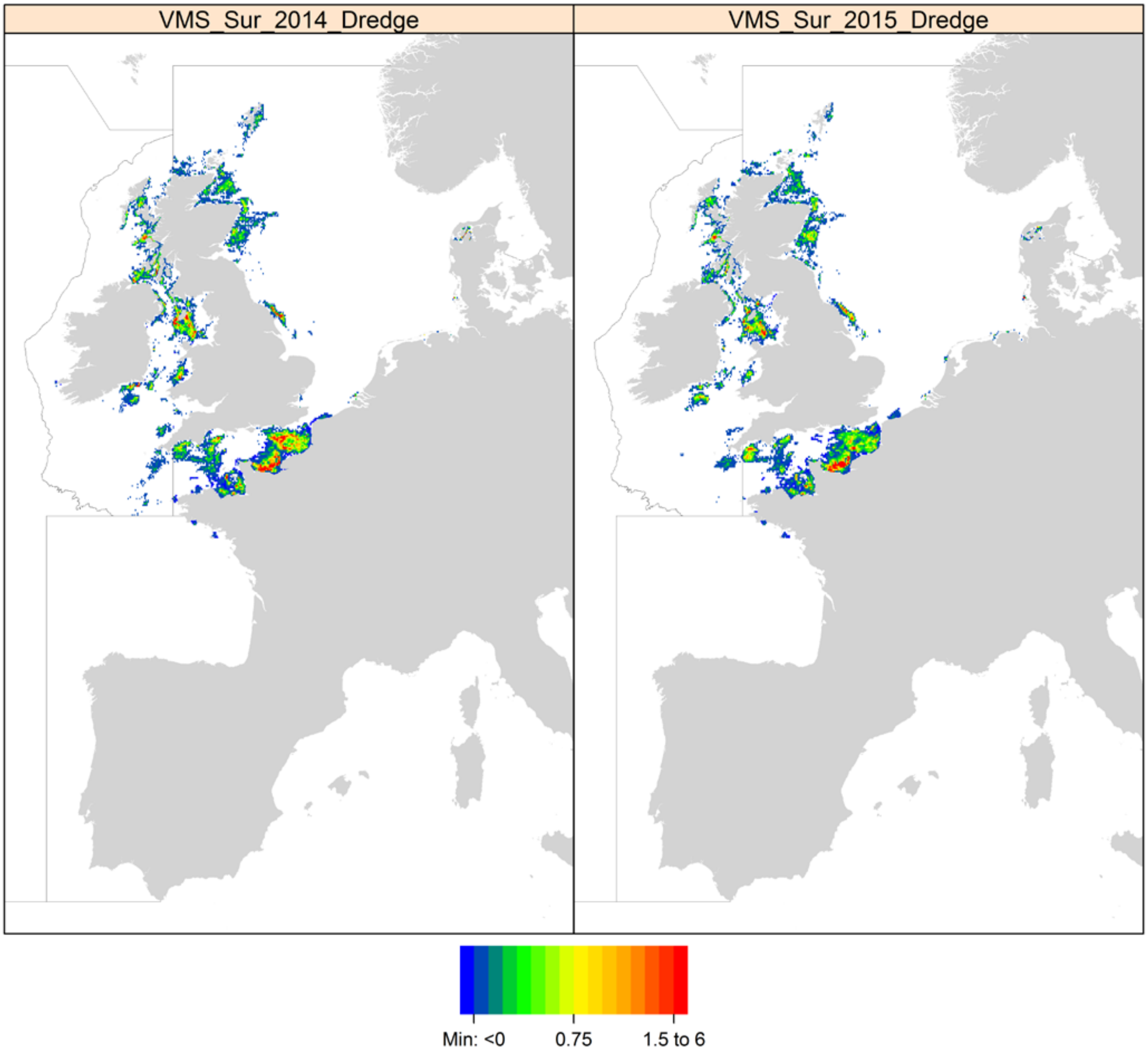

Figure 1.6.6.4.11 Surface swept area ratio of dredges for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

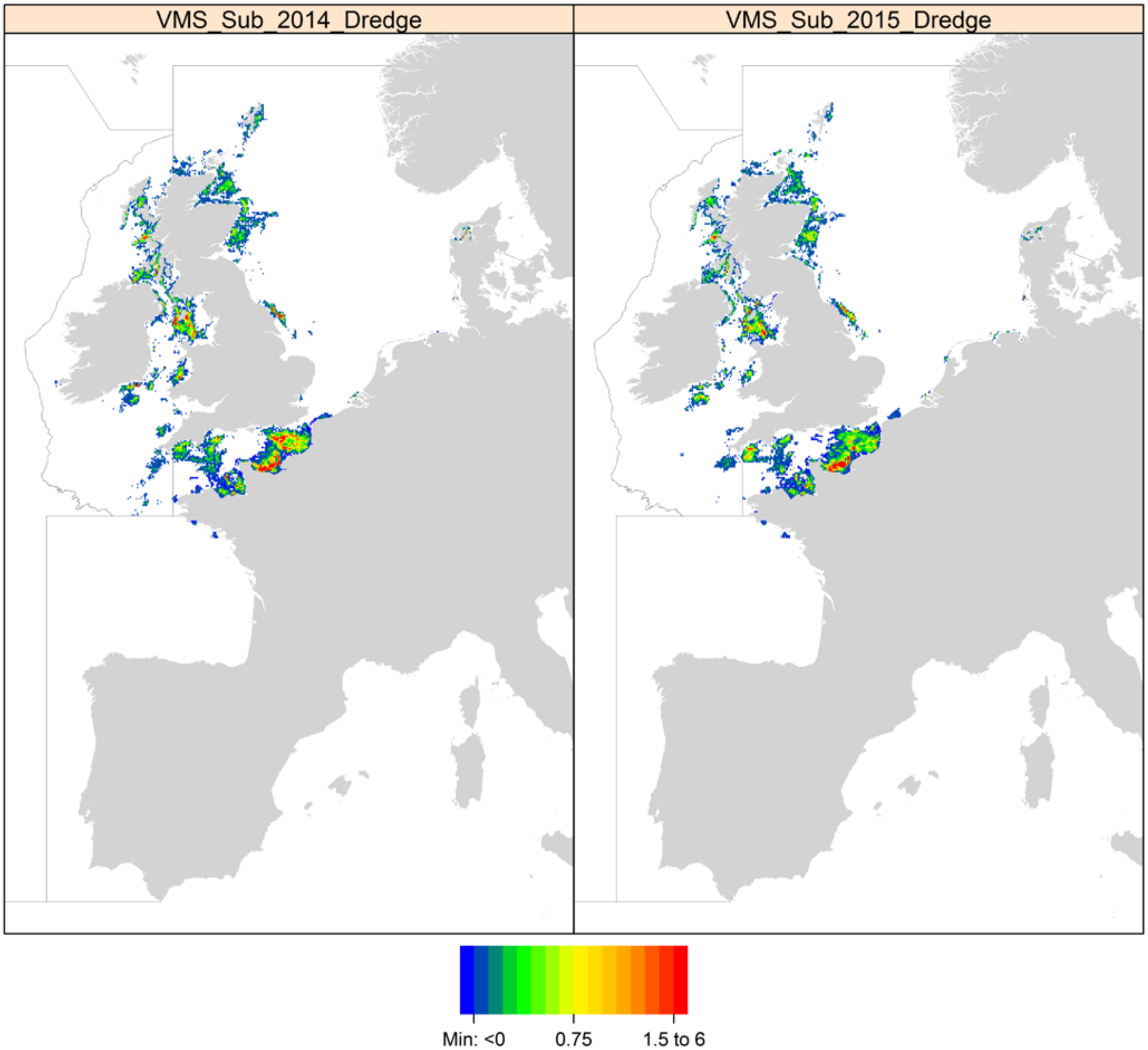

Figure 1.6.6.4.12 Subsurface swept area ratio of dredges for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

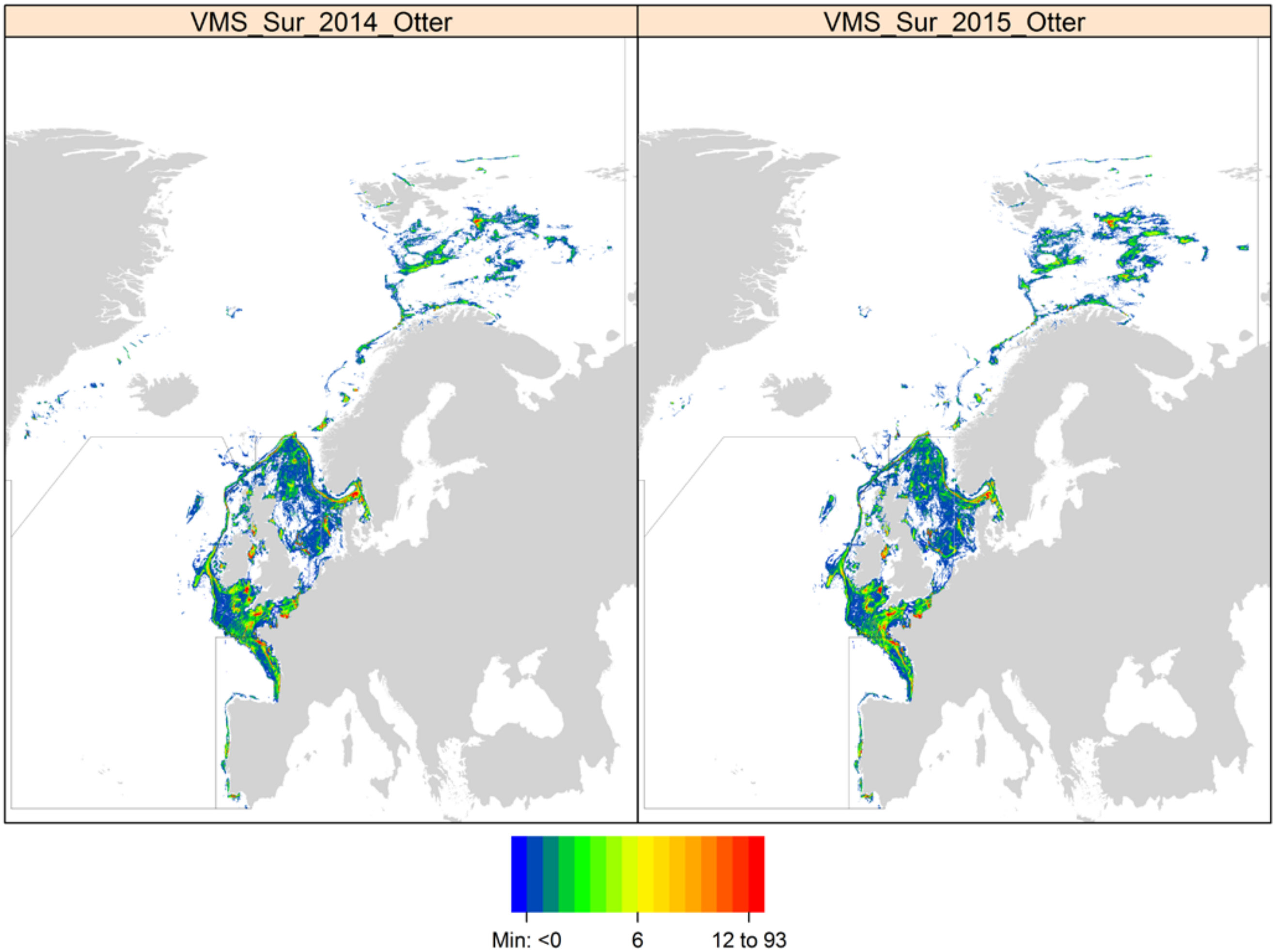

Figure 1.6.6.4.13 Surface swept area ratio of otter trawls for the years 2014 and 2015 in the OSPAR area. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

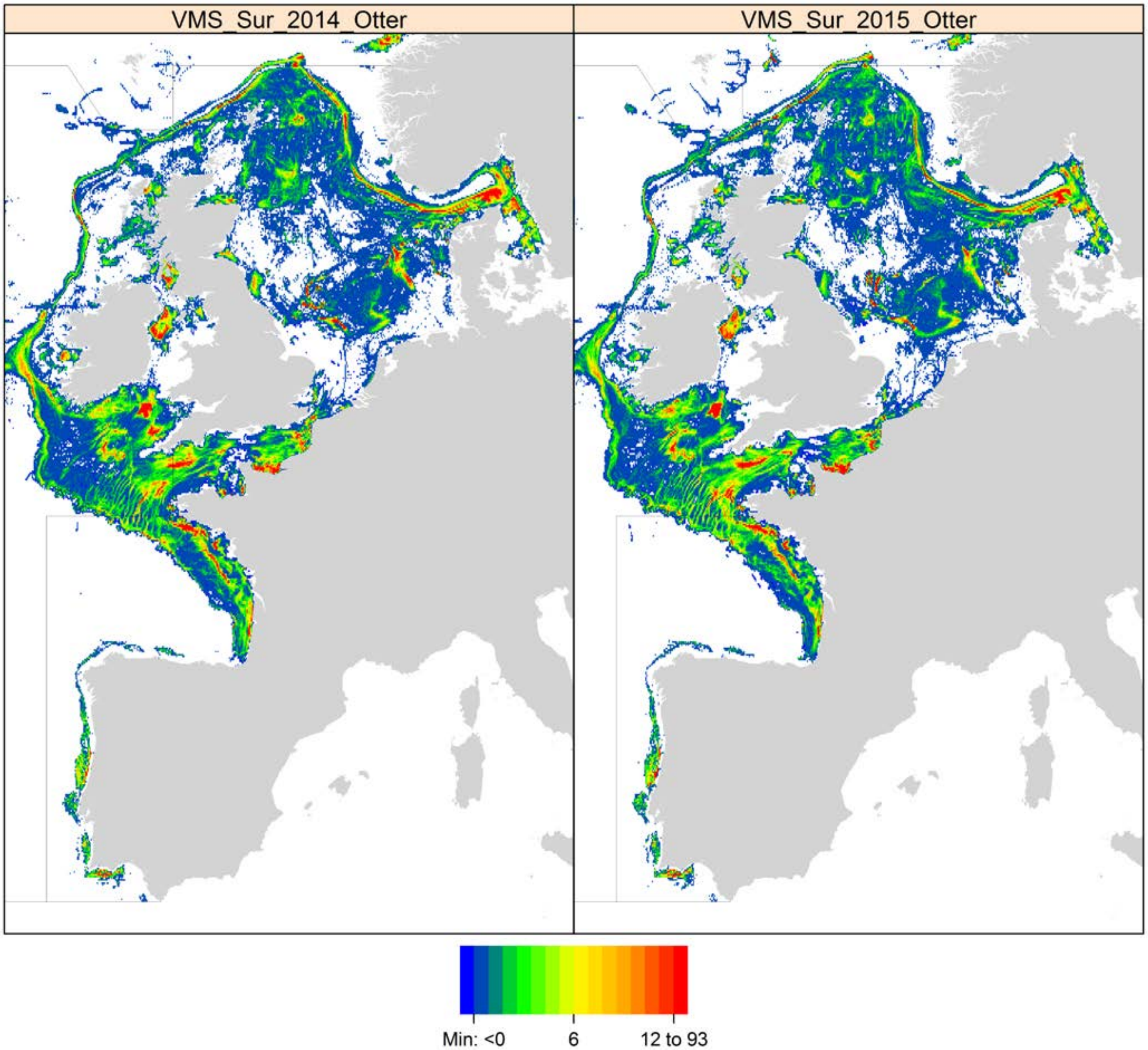

Figure 1.6.6.4.14 Surface swept area ratio of otter trawls for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

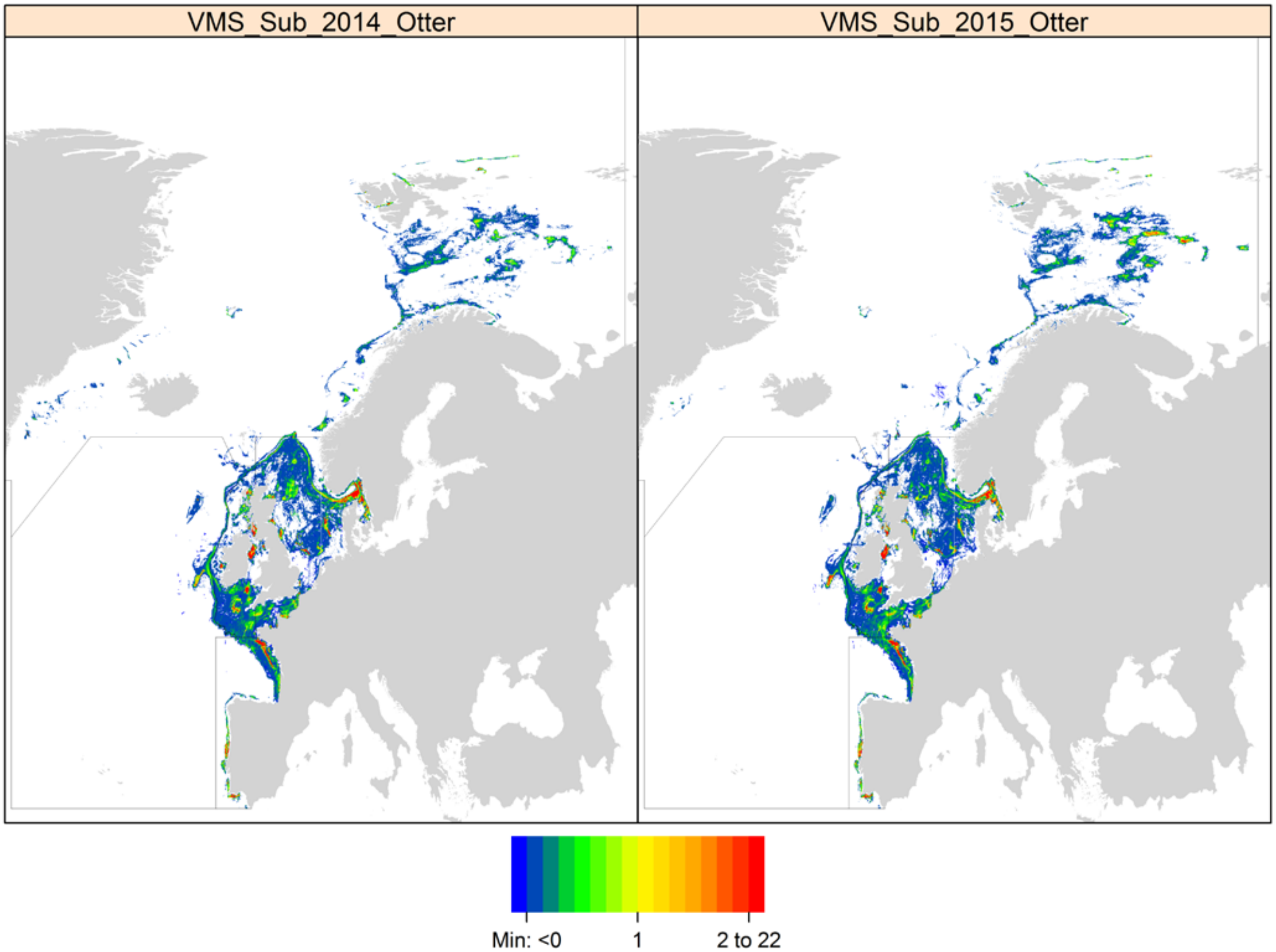

Figure 1.6.6.4.15 Subsurface swept area ratio of otter trawls for the years 2014 and 2015 in the OSPAR area. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

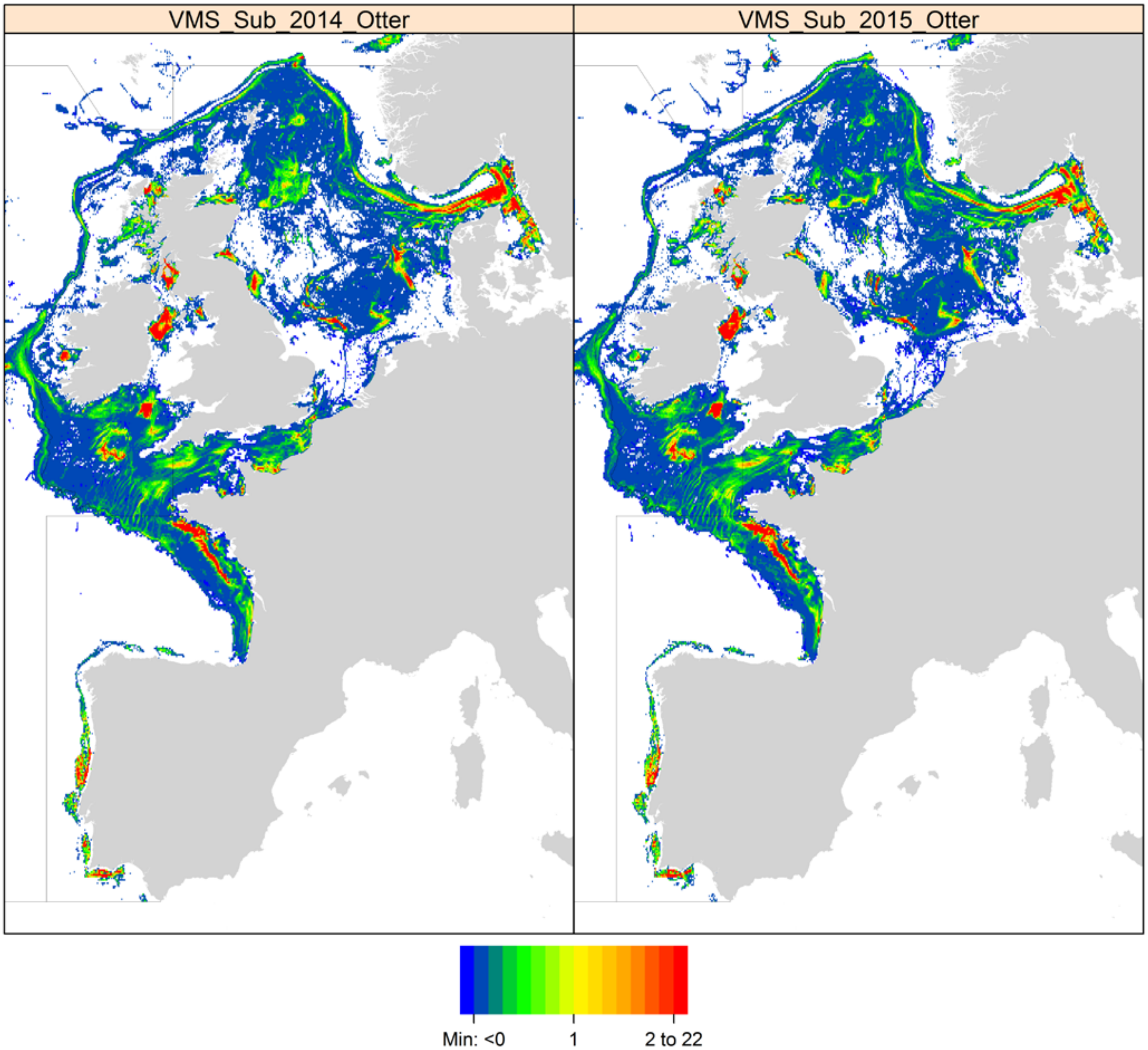

Figure 1.6.6.4.16 Subsurface swept area ratio of otter trawls for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

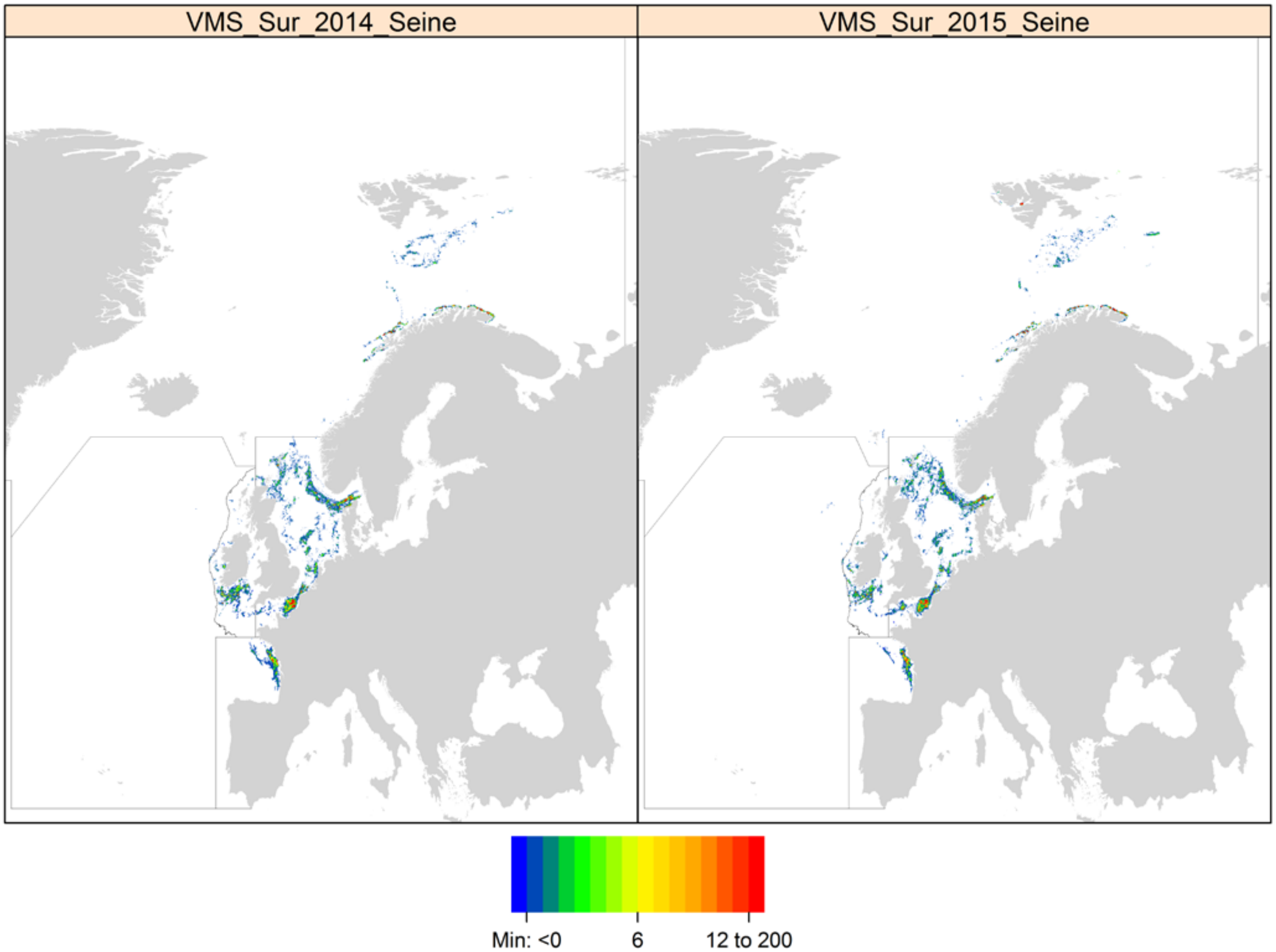

Figure 1.6.6.4.17 Surface swept area ratio of demersal seines for the years 2014 and 2015 in the OSPAR area. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

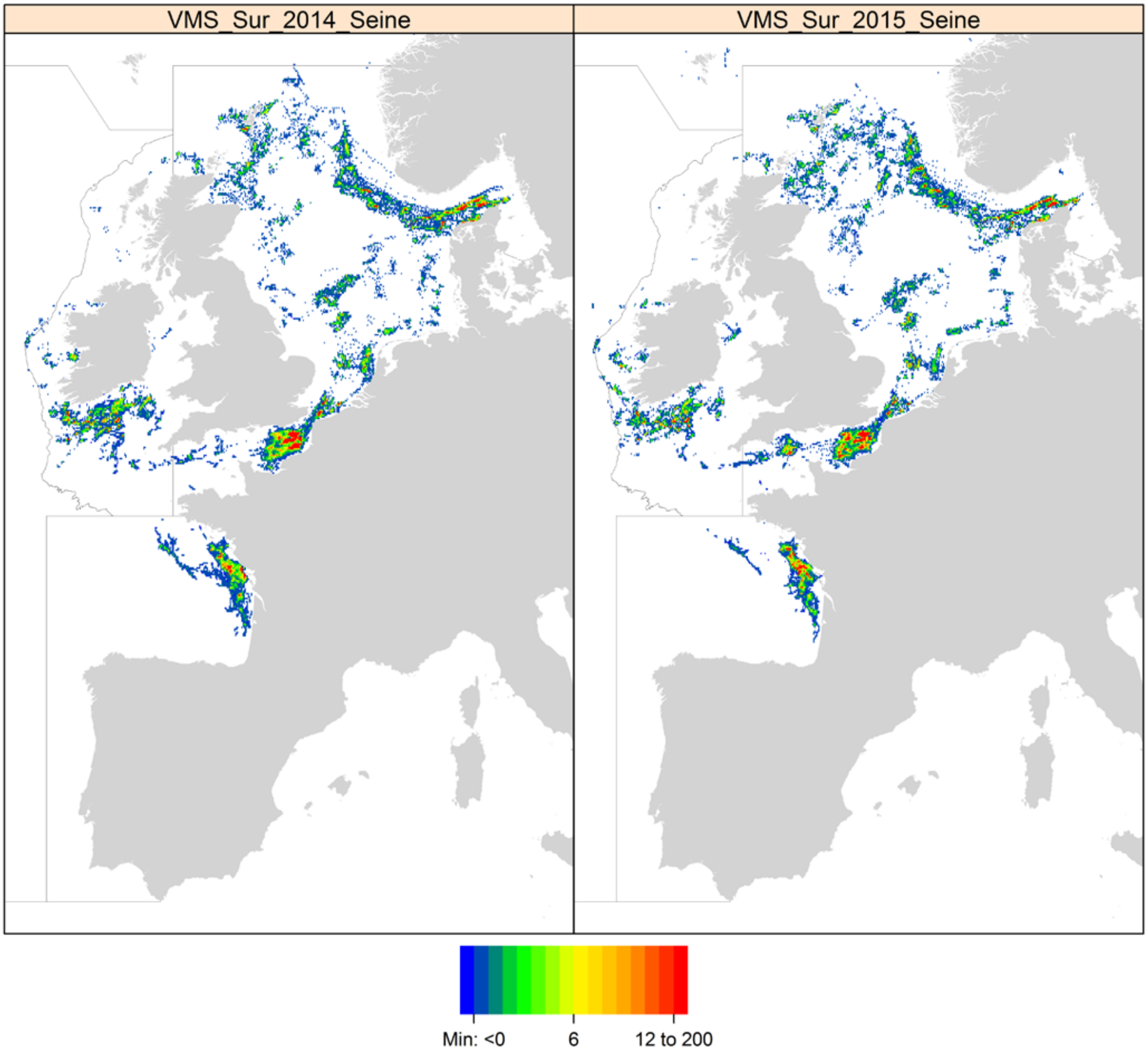

Figure 1.6.6.4.18 Surface swept area ratio of demersal seines for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

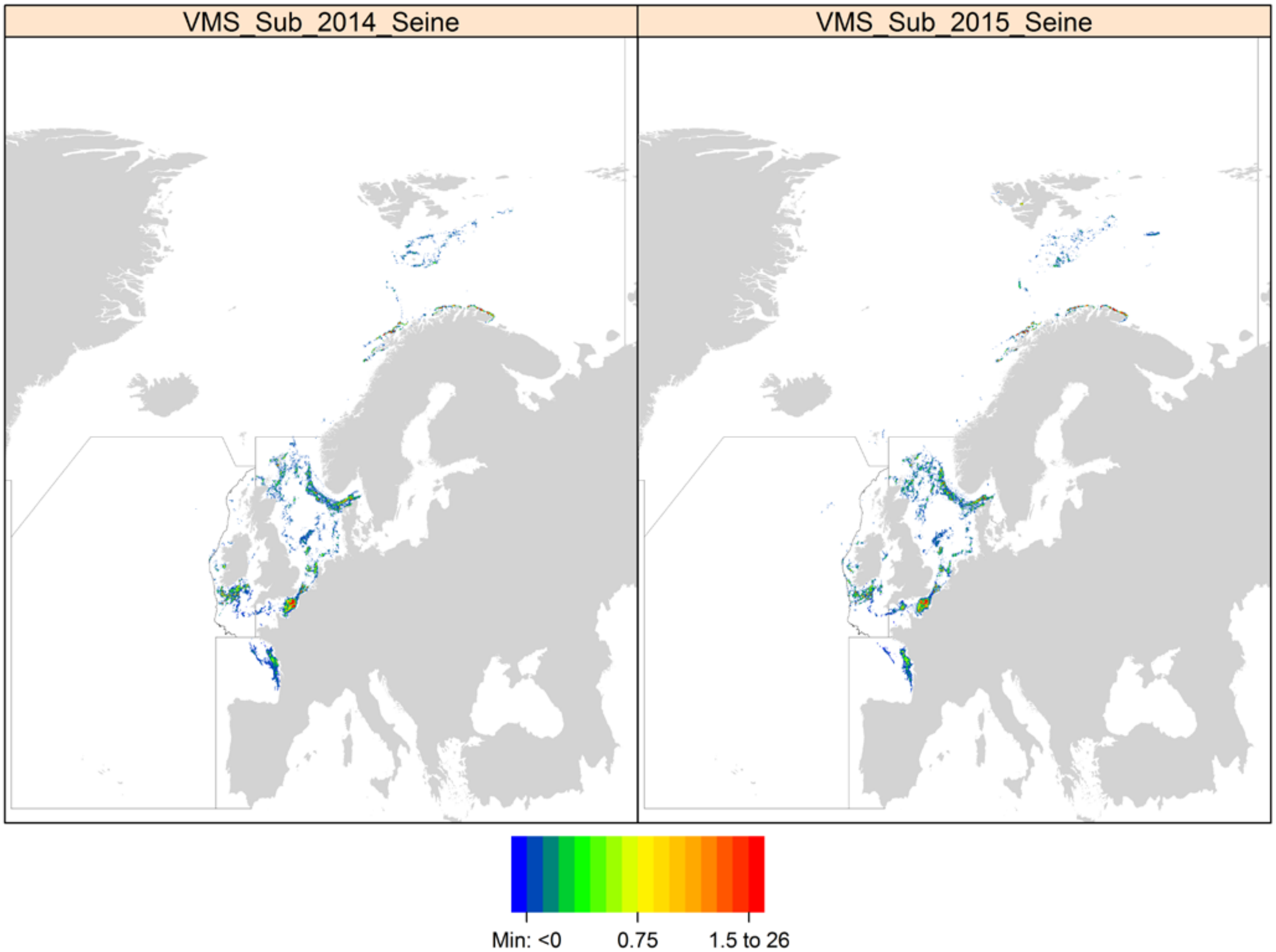

Figure 1.6.6.4.19 Subsurface swept area ratio of demersal seines for the years 2014 and 2015 in the OSPAR area. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated
†Version 3: Figures updated

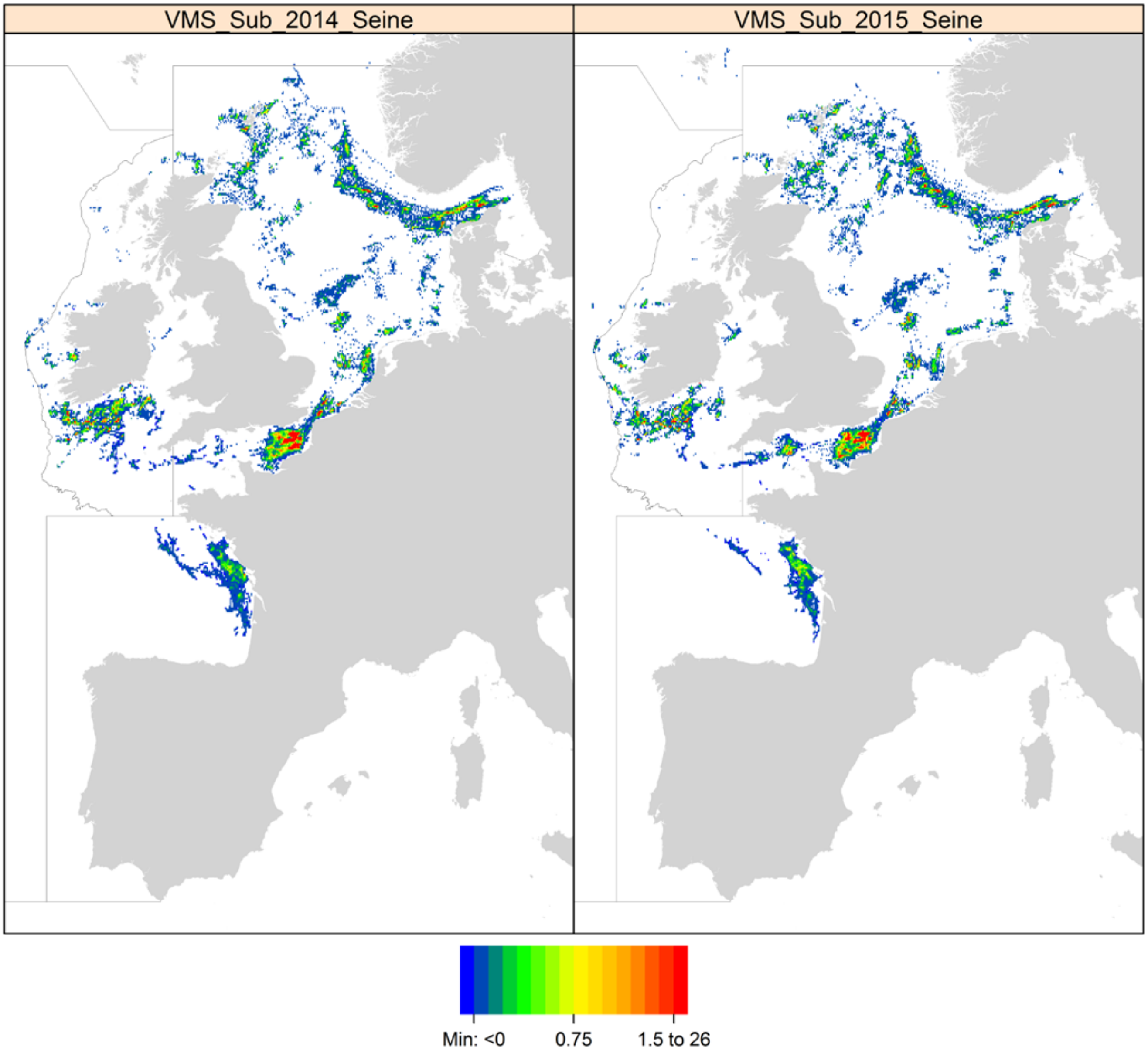

Figure 1.6.6.4.20 Subsurface swept area ratio of demersal seines for the years 2014 and 2015 in OSPAR regions II, III, and IV. Note that caveats described in this advice apply when interpreting maps.*†

*Version 2: Figures updated

†Version 3: Figures updated

Annex 2 – Evaluation of options for improving precision of estimation of distribution of fishing activities

Table 1.6.6.4.3 Data

Data	Advantages	Disadvantages apart from cost	Costs
Automatic Identification System (AIS)	High resolution (detection of behaviour easier plus finer spatial location), no need to interpolate	Large amount of data; accessibility unclear, can be switched off (depends on national legislation); needs shore-/platform-based receiver stations or more costly satellites; no direct link to logbook data; small boats are generally not required to have AIS; the system is designed for safety and not for control/research, therefore its use may cause resentment by fishers.	May require purchasing of data. Data storage capacities, processing capacities; may need reduction/filtering of data
Plotter data from industry	High resolution (detection of behaviour easier plus better spatial location), no need to interpolate	Industry may not be willing to provide this information, verification of completeness and correctness difficult.	High effort to collect and format this data
E-logbook (if start and end of hauls are recorded)	No need to estimate activity from speed, small amount of extra data needs to be stored; reduced need for VMS-data analyses	Still being implemented in many Contracting Party fleets. Small boats are generally not required to use e-logbook; data availability controlled by flag state of vessel. Relies on fishers entering data correctly.	A relatively small amount of extra data processing
Higher VMS frequency /variable frequency (higher when active/fishing)	Cannot easily be switched off (controlled by national fisheries agencies)		Increased transmission, storage, and processing of data
Include vessel activity in VMS signal	No need to estimate activity	Development of active sensor for all gears	Extra infrastructure (sensor), extra data
Coverage of small vessels by VMS	Large increase in information about many very small vessels	Costs might be greater than revenues; acceptation by fishers low	Extra infrastructure
Satellite-photos (day and night)	Regular interval; might detect illegal fisheries; visual confirmation of activity; might be especially suitable for passive gears from small (non-VMS) vessels	Low frequency (once per day); identification of gears/vessels difficult; processing time consuming	Acquiring photos; processing
Aerial surveys/ observations/ drones	Might detect illegal fisheries; visual confirmation of activity; flexible; suitable in coastal areas and shallow waters, remote locations	Infrastructure would need to be developed. Depends on weather conditions.	Development and installation of infrastructure, operation, processing; Maybe cheaper than inspection vessels
Questionnaires	Expert knowledge from the industry; better understanding of fisheries (especially small vessels)	Representative sample in OSPAR area may be difficult; industry may not be willing to give information, verification difficult; statistical analysis and interpretation may be difficult	Development of questionnaire; processing of data

Table 1.6.6.4.4 Analysis

Methods	Advantages	Disadvantages	Costs
Statistical spatial methods			
Improved interpolation of tracks by more detailed modelling using existing information (heading, speed)	Already developed, covariates usually available	Needs parameterization for each fishery	Processing time much greater
Improved interpolation of tracks by including further physical covariates, e.g. topography, sediments, habitats	Potentially greater accuracy of fishing tracks	Much development would be needed. Physical information is patchy in the OSPAR area and often not detailed enough	Greater development costs. Cost may exceed benefit.
Interpolation of fishing effort, e.g. using kriging using covariates, such as topography and other features	Easy to expand to include covariates (variables); estimate of uncertainty included; continuous scale; covariates easily available, no more fisheries data needed; reduced confidentially issues since single tracks and positions	Slow, no explicit behavioural element	Development and processing costs relatively high
Mechanistic spatial methods			
IBMs (individual-based models)	Includes behavioural elements; mechanistic approach improves understanding of processes and fisheries behaviour; assumptions and behaviour may be tested (e.g. against high resolution data)	Requires assumptions and parameterization of fisher behaviour; uncertainties might not be clear	Development and processing costs relatively high.
Fisheries simulations such as ISIS FISH	Includes fisher behaviour and interactions between fisheries and population dynamics of fish; can include multiple species, stocks and métiers; scenario testing (evaluation of management options)	Parameterization difficult; processing is slow, especially with high spatial resolution	Development and processing costs relatively high.
Dynamic state variable models	Strong dependences of choices within a year (e.g. quota use); includes behaviour and interactions between fisheries and population dynamics; can include multiple species, stocks and métiers	Parameterization difficult; processing is slow, especially with high spatial resolution	Development and processing costs relatively high.
Grids and polygons			
Finer grid (finer than 0.05°) depends on input data, or data processing (see interpolation above)	Easily available (concepts are known)	Depends on data availability; risk of infringing confidentiality increases with increasingly fine grids	As above for interpolation options, higher VMS signal frequency
Nested grid	Easily available already, no development needs	Different shape/character of grid for each country, year, month, gear, métier may be different; depends on effort/ observations/ input data. Difficult to standardize between countries; opportunities for comparison are limited	See above for higher VMS signal frequency

Methods	Advantages	Disadvantages	Costs
Hexagons	Better tessellation on a sphere (e.g. football, planet earth); better for IBMs	Does not fit in established global straight line systems (lat, lon; ICES rectangles); mismatch with other existing data in rectangular systems	Development of labelling system; transferring existing data to hexagonal data
Pre-stratified design	Stable grid cells / polygons over years/countries, etc.; can fit with established global straight line systems	May mismatch with existing data in rectangular systems; changes and trends might not be represented in preselected design	Development of stratification