A collaborative approach to mapping value of fisheries resources in the North Sea (Part 1: Methodology)

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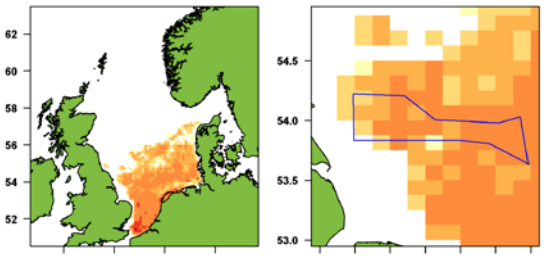
Report number C001/13



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Summary

IMARES and LEI are both contracted on occasion to perform VMS-analyses to produce maps of fishing activity or economic value of fisheries in particular area(s) in the North Sea. Until present, IMARES and LEI use their own methodology which is inspired mostly on their own unique data availabilities which may lead to different results. This in turn may lead to questioning of these methodologies and results, especially in relation to estimations of economic value. The aim of the current study is to compare both methodologies by IMARES and LEI en decide upon a common (unique) methodology for producing fishing activity and value maps and estimating economic value of specific areas. The current report describes the jointly agreed methodology between scientists from IMARES and LEI, using input from the fishing industry. This methodology can be readily applied in future projects aimed at describing the value of particular areas in the North Sea in terms of fishing activity. A secondary aim - included on request of the Dutch Fish Product Board (PVIS) - is to address the question of how IMARES and/or LEI can make use of knowledge of the fishing industry in VMS mapping projects.

The comparison of IMARES and LEI data extraction, processing and analyses proved useful because it shed light on specific advantages and disadvantages of different available data sources and (minor) differences in customary procedures used in the two institutes. Agreement on one unique method to be used by both institutes in the future, making use of the best available datasets that the two institutes share among them, was reached. This method was discussed with industry representatives present at a workshop on 7 December 2012 and applied in the current case study for producing figures and maps on economic value in relation to the Hornsea area.

1. Introduction

IMARES and LEI are both contracted on occasion to produce maps of fishing activity or economic value of fisheries in area(s) of the North Sea. Such maps are based on analyses of VMS data. At present, many requests are in the context of Marine Protected Area designations (e.g. Natura 2000 areas) or for the development of off-shore wind farms. Until present, IMARES and LEI have used their own methodology which is inspired mostly on their own unique data availabilities. Dutch industry representatives noted that due to differences in the methodologies, results may differ. In addition, a recently produced report by IMARES (Coers and Hintzen 2012) in response to a request from Poseidon Aquatic Resource Management Ltd[1], (hereafter called Poseidon) lead to discussions where Dutch fishermen (representatives) were triggered to question the used methodology, especially in relation to estimations of economic value. This methodology should be readily applicable in future projects aimed at describing the value of particular areas in the North Sea in terms of fishing activity. Although the current study reports on data from one single year (2011), the methodology is adaptable to provide an overview over a period encompassing more than one year.

2. Assignment

The current study was a collaboration between scientists form IMARES and LEI involving demersal fishing industry representatives. The project was financed collaboratively by Rijkswaterstaat (Ministry of Infrastructure and Environment) and the Dutch Fish Product Board (PVIS).

The aim of the current study is to compare both methodologies by IMARES and LEI en decide upon a common (unique) methodology for producing fishing activity and value maps. The current report describes the jointly agreed methodology between scientists from IMARES and LEI, using input from the fishing industry (see '3. Material and Methods' section and Appendix B).

For the purpose of comparing methods, a case study is conducted focussing on active gears used by the demersal fishing fleet in the North Sea; i.e. beam trawls, otter-trawls, twin-trawls and flyshoot. It uses the Hornsea area (UK) as the area of interest for presenting the results as well as two additional reference areas for comparison of the results in relative terms. Vessels with passive gear and vessels fishing under a non-Dutch flag are not included in the analyses.

A secondary aim is to address the question of how IMARES and/or LEI can make use of knowledge of the fishing industry in VMS mapping projects. A half day workshop was held with industry representatives to discuss the method in detail, addressing all assumptions made. A complementary document provides a report of this workshop describing the process which lead to the agreement of the method and addressing the question of how best to involve stakeholders in VMS mapping projects (Coers et al. 2013).

[1] Poseidon Aquatic Resource Management Ltd, 10 Davidson Rd, Edinburgh, EH4 2PE. www.consult-poseidon.com

3. Materials and Methods

The methods used to process and analyse the VMS and Logbook data are described in detail in Appendix B. Below, a summary of the process is given listing the general steps in the process.

Data processing:

- VMS and logbook data are received from the ministry of EZ and stored in a local database at IMARES and transformed into the 'VMS' and 'logbook' format for VMS and logbook data respectively (for a description of these commonly used data formats, see Hintzen et al. 2012).
- Price data are obtained from a number of sources (see appendix B)
- VMS records are removed when they are:
    - Duplicates or pseudo-duplicates
    - Not positioned on the globe
    - Located in a harbour
    - Located on land
    - Associated with vessel speeds > 20 knots
- Logbook records are removed when they:
    - Are duplicates
    - Have arrival times before departure times
    - Start before the 1st of January of the year considered (despite the fact that the end of the trip falls within the considered year)
    - Overlap with other trips

Link VMS and logbook data

- VMS and logbook datasets are linked using the vessel identifier and date-time stamp. In other words, records in the VMS dataset that fall within the departure-arrival timeframe of a trip described in the logbook are assigned the trip number from the logbook record

Define activity:

- Based on gear characteristics, speed profiles are made where observable peaks indicate different fishing behaviour (in harbour / floating, fishing, steaming)
- Data is added to VMS records to indicate those records that are associated with fishing activity

Spatial distribution of activity:

- All landings and their value are summed per logbook record
- The value record obtained from the logbooks is equally assigned to VMS records that have vessel id, fishing date and fishing position (in ICES squares) in common

Define area of interest and reference areas:

- Here, the Hornsea area is the chosen area of interest and in addition two reference areas (Poseidon and North Sea) have been defined (see also figure 1)

Creating the figures:

- A grid is defined based on 1/16th of an ICES square
- The value of landings of VMS pings are summed 1/16th ICES square
- Based on the range of values, a colour classification is defined
- Maps are made based on the value and associated colour on the 1/16th ICES square resolution
- Two sets of maps are delivered: one without and one with the individual VMS pings overlaid on the grid as small black dots

Creating the tables:

- The value records of VMS pings are aggregated by gear and area (Hornsea area, Poseidon area or North Sea (area IV))
- Surface of each of the reference areas is calculated
- Value per km^2 of the reference areas is calculated as the value for the area divided by the surface of the area

4. Results

Analysing the 2011 VMS and Logbook data, for the whole Dutch fleet and a subset of four gear types, has resulted in a dataset describing the economic value of fishing on a high spatial resolution. With this dataset maps can be created at 1/16th of an ICES square indicating the value of fishing. In addition, the economic value of specific areas can be estimated, e.g. the area of interest or reference areas.

In table 1 (below), a summary of total value (euros) per area is given, also as a measure of value per km^2, directly related to the surface of each of the areas.

Table 1: Overview of estimated economic value of landings in 2011 for the area of interest (Hornsea) and two reference areas (North Sea and Poseidon area) for comparison. Values are provided for the whole of the Dutch fleet as well as the four selected gear types.

	Value in k€			**Value in € per km^2**		
Gear	Hornsea	North Sea	Poseidon	Hornsea	North Sea	Poseidon
ALL*	3660	222239	32117	767	363	719
OTB	58	11017	1881	12	18	42
OTT	87	4491	1646	18	7	37
SSC	57	6385	604	12	10	14
TBB	3415	173031	27179	715	283	609

* 'All' literally means all gears included in the logbook data set. These include the four selected gears as well as all types listed in Appendix A.

In a number of maps (next pages) we show:

- The area of interest (the Hornsea area)
- One reference area (the North Sea (ICES area IV))
- The value of fishing for all gears (including gear types TBB, OTB, OTT and SSC) in 1000 euro per year on a grid of 1/16th of an ICES square, as well as per gear type TBB (Beam Trawls), OTB (Otter trawls) , OTT (Otter twin trawls) and SSC (Scottish Seines).
- The value of fishing for all gears as well as per gear type overlaid with the actual VMS positions associated with fishing behaviour.

"All gears" does not mean the sum of the four selected gears. Rather, the entire Dutch fishing fleet is meant, including all demersal and pelagic fisheries. This is illustrated in a comparison of figures 2 and 3, where figure 2 shows substantial fishing activity around the Scottish Islands, while this is not visible in any of the four maps in figure 3, which only show results for the four selected demersal gears.

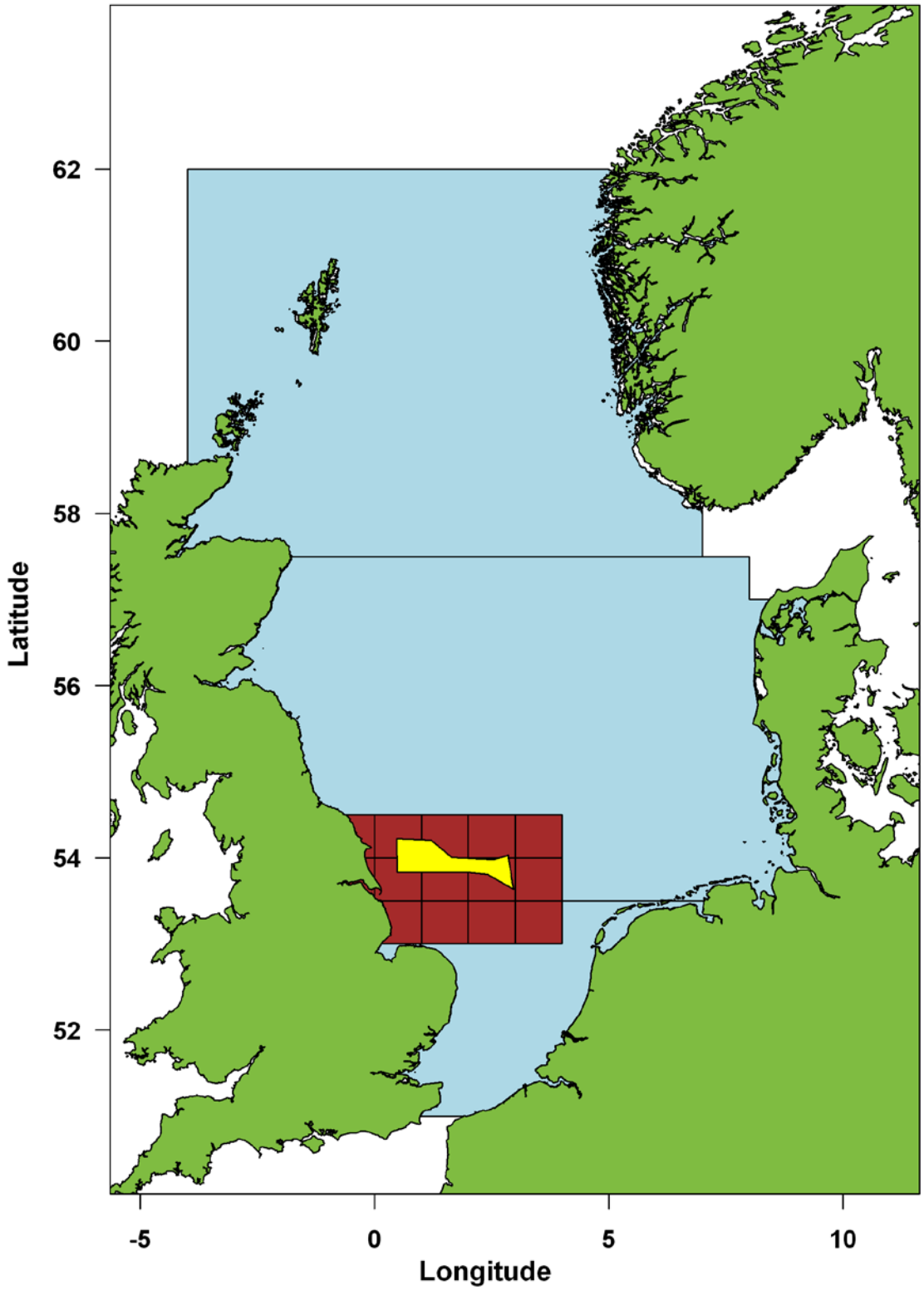

Figure 1: Area of interest. The North Sea area (area IV) is given in light blue. The Poseidon area (ICES rectangles associated with the Poseidon study) are given in brown. The Hornsea area is given in yellow.

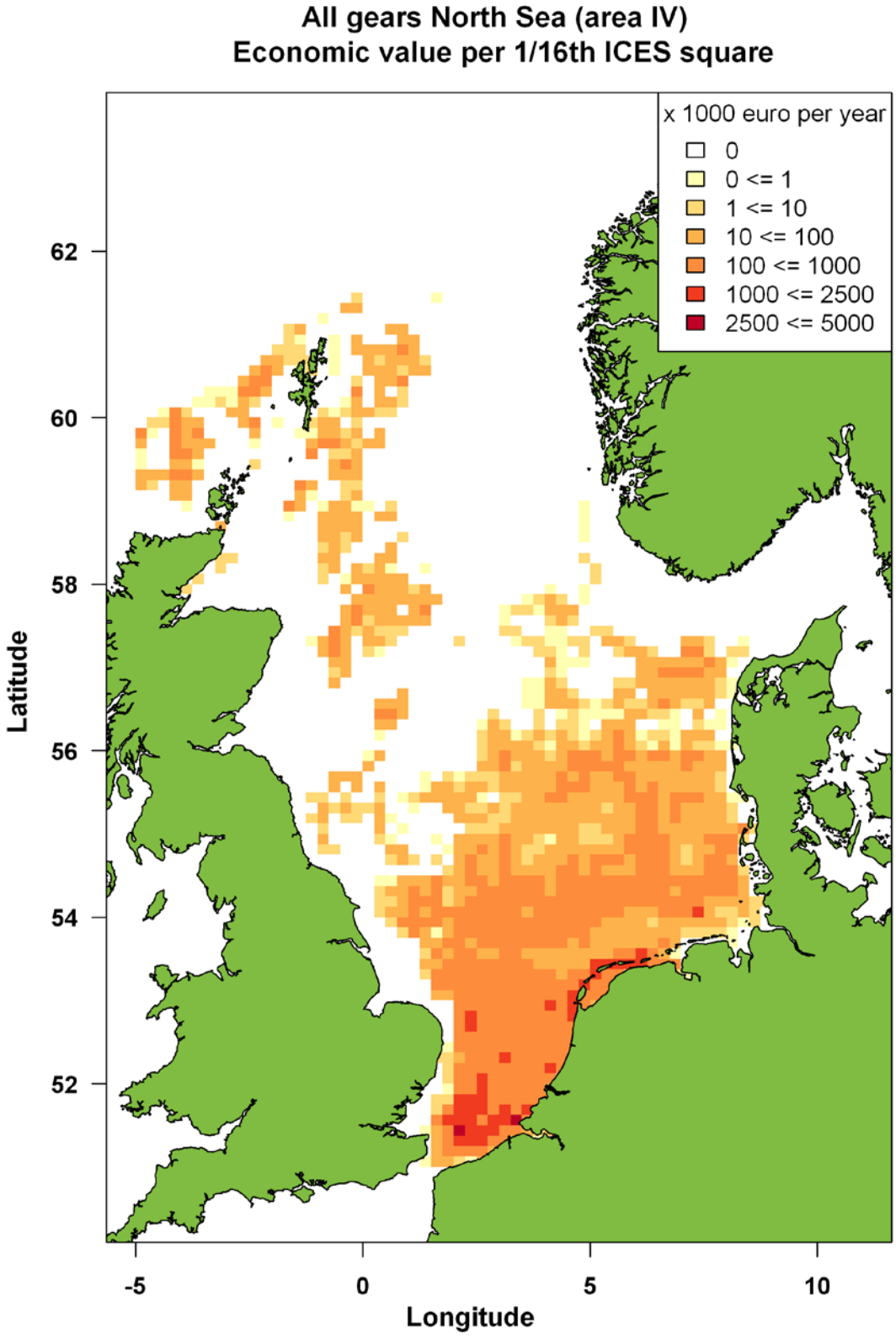

Figure 2: Map of the economic value of fishing in the study area (North Sea, ICES area IV). The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

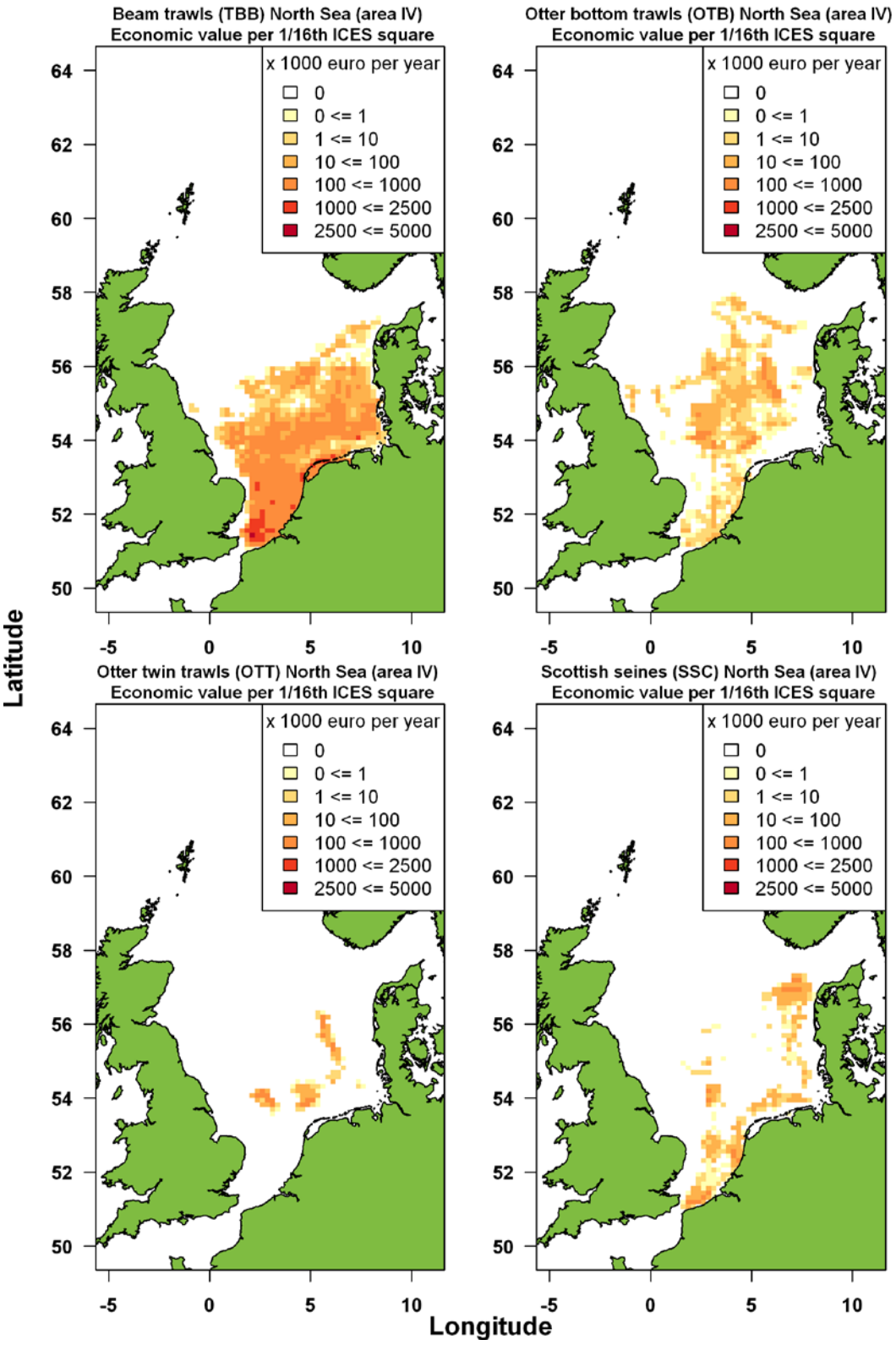

Figure 3: Maps of the economic value of fishing in the study area (North Sea, ICES area IV) for four different gear types. The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

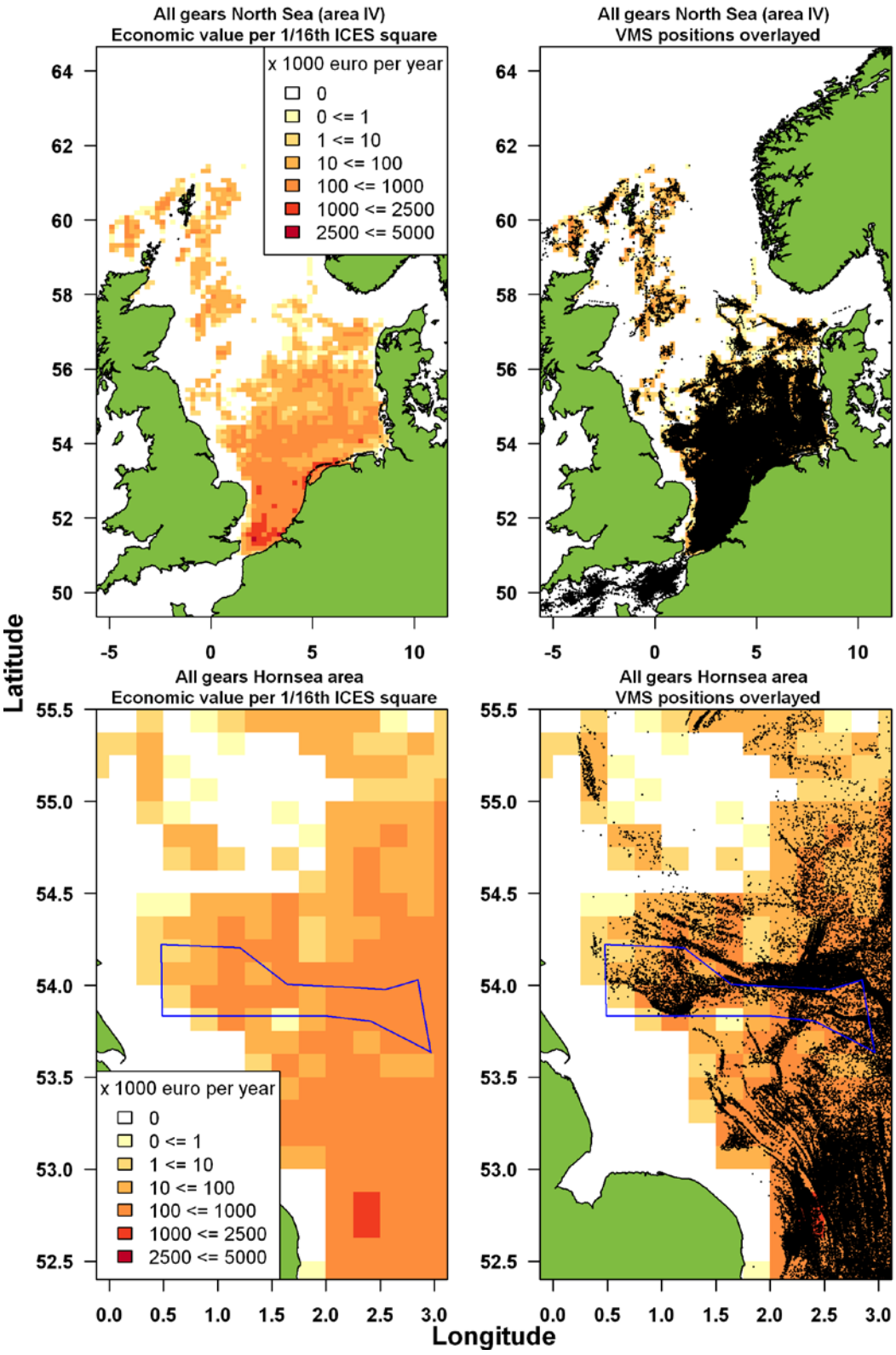

Figure 4: Maps of the economic value of fishing in the Hornsea (bottom) and North Sea (ICES area IV; top) for all gear types, including actual VMS positions in black dots (right). The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

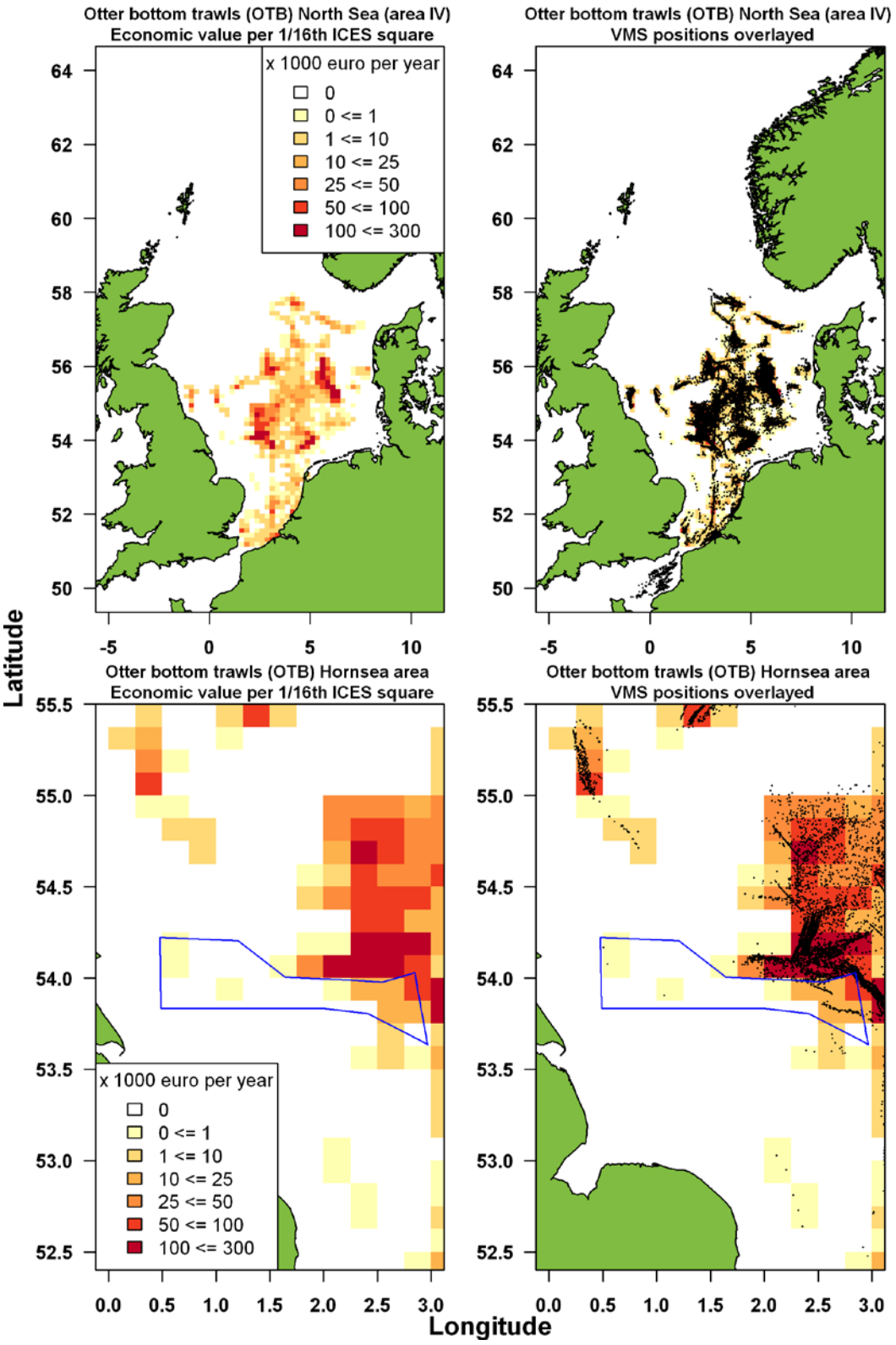

Figure 5: Maps of the economic value of fishing in the Hornsea (bottom) and North Sea (ICES area IV; top) for Otter Trawling, including actual VMS positions in black dots (right). The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

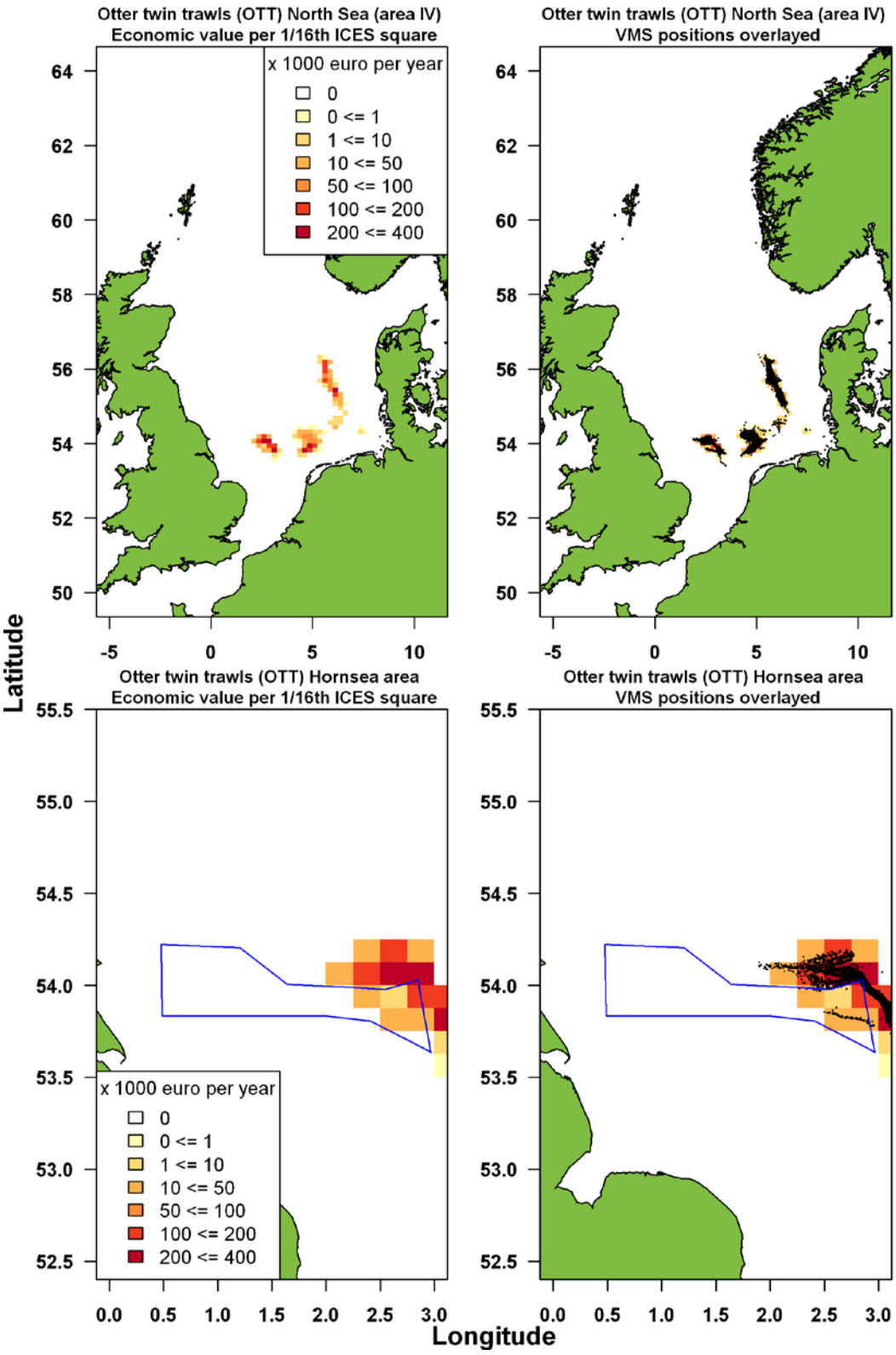

Figure 6: Maps of the economic value of fishing in the Hornsea (bottom) and North Sea (ICES area IV; top) for Otter Twin Trawling, including actual VMS positions in black dots (right). The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

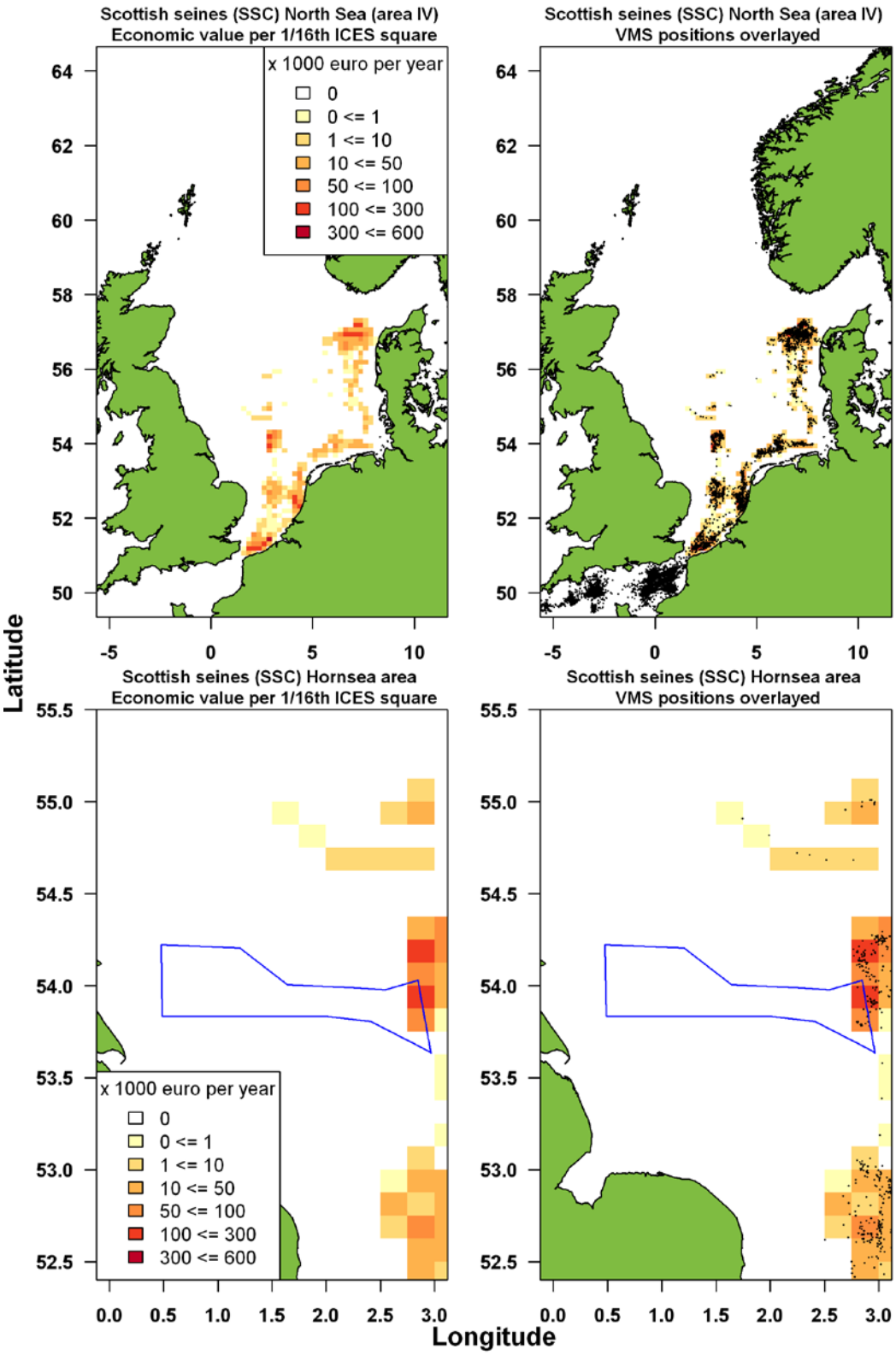

Figure 7: Maps of the economic value of fishing in the Hornsea (bottom) and North Sea (ICES area IV; top) for Scottish Seines, including actual VMS positions in black dots (right). The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

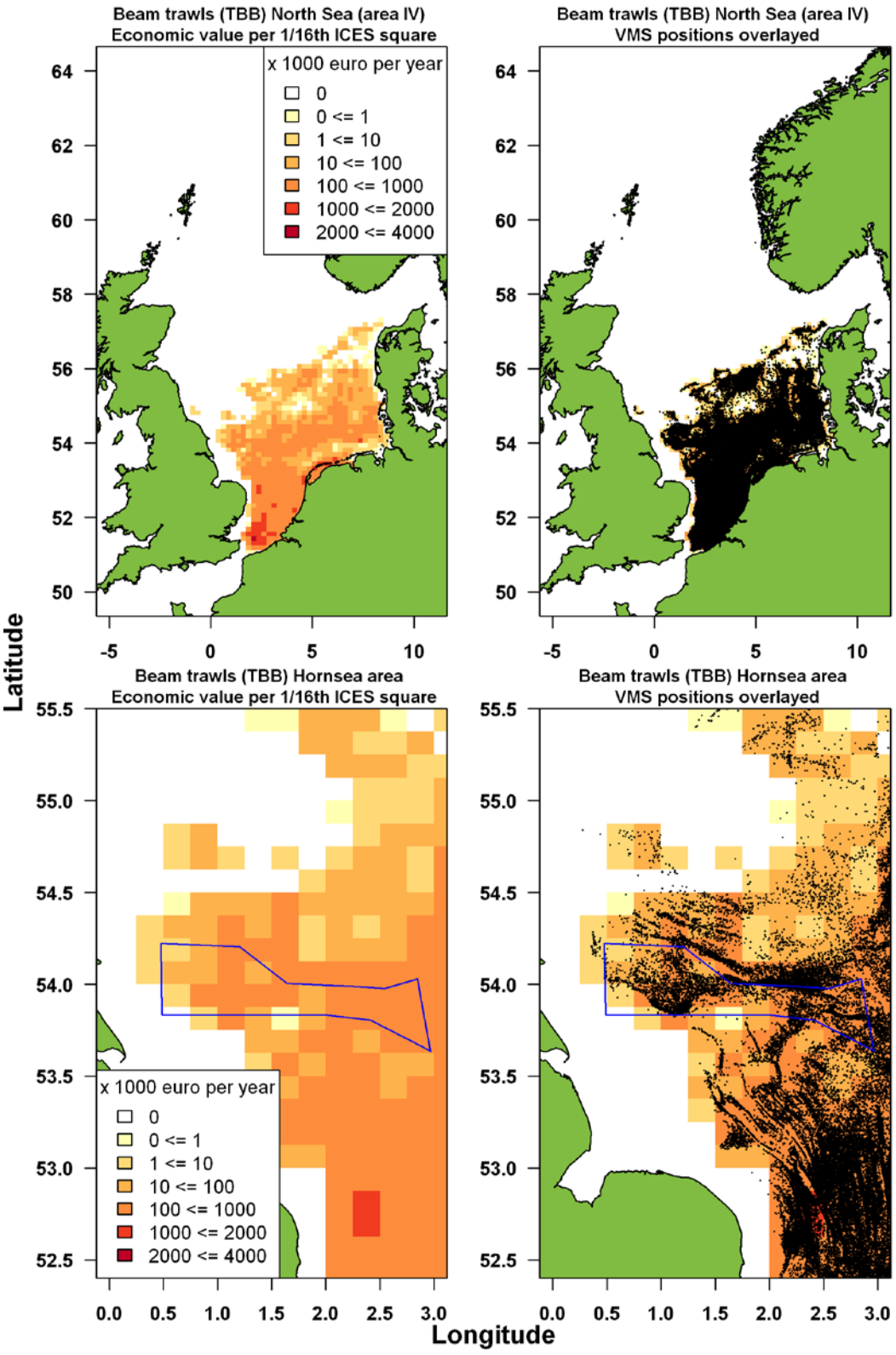

Figure 8: Maps of the economic value of fishing in the Hornsea (bottom) and North Sea (ICES area IV; top) for Beam Trawling, including actual VMS positions in black dots (right). The value of fishing is aggregated at a 1/16th of an ICES square grid and the colour of the grid cells indicate the associated value. Darker red indicates more valuable areas.

5. Conclusions and Discussion

Data availability and data processing

Agreement on a single method to be used by both institutes in the future, using the best available shared datasets, was reached. This method was discussed with industry representatives at a workshop on 7 December 2012 and thereafter applied to the current case study to produce maps of economic value in relation to different areas and. The developed methodology can be readily applied in future projects aimed at describing the value of particular areas in the North Sea in terms of fishing activity. Although the current study reports on data from one single year (2011), the methodology can be also relatively easily adapted to provide an overview over a period encompassing more than one year.

Price data was used from LEI and only complemented with data from IMARES for a number of lacking species. Despite some limitations (e.g. not being able to distinguish between gears) the data from LEI was regarded as the most accurate source of information currently available (for more details see workshop report (Coers et al 2013).

Data analysis

The most difficult step in estimating the economic value of landings from a particular area is the determination of whether VMS pings represent a vessels fishing activity or steaming activity. This is typically based on the speed associated with the VMS ping. For each individual gear type, assumptions have to be made on which speeds relate to which activity. Most often, a fixed speed range associated with fishing is subjectively defined per gear. However, with the development of the VMStools software package (Hintzen et al. 2012) the range can be derived from the data itself. It was concluded that this objective method was preferable over the fixed range method and should be used in the future.

Results for the Hornsea area

Table 1 shows for the TBB fleet that the Hornsea area – located within the Poseidon area - represents a higher economic value in terms of landings in 2011 (715€ per km2) than the Poseidon area (609€ per km2). This 17% difference indicates that for any project aiming at determining values for specific areas, it is important to choose the appropriate area of interest. Furthermore, it can be concluded that the Hornsea area in 2011 was approximately 2.5 times as valuable per km^2 as the North Sea on average. These figures show that for estimation and interpretation of the value of a specifically shaped area (such as is the case with the Hornsea area), it is imperative to have a shapefile available for conducting the analysis and it is useful to make similar calculations for a number of other reference areas for comparison.

6. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

References

Coers, A. and N.T. Hintzen. 2012. 2011 Landings statistics and fishing activity maps based on VMS and logbook data of the Dutch fishing fleet. IMARES report C096/12.

Hintzen, N. T., G. J. Piet and T. Brunel. 2010. Improved estimation of trawling tracks using cubic Hermite spline interpolation of position registration data. Fish. Res. 101(1-2):108-115.

Hintzen, N.T.; Bastardie, F.; Beare, D.J.; Piet, G.J.; Ulrich, C.; Deporte, N.; Egekvist, J.; Degel, H. 2012. VMStools: Open-source software for the processing, analysis and visualisation of fisheries logbook and VMS data. Fisheries Research 115-116. p. 31 - 43.

Oostenbrugge, J.A.E. van, H. Bartelings and F.C. Buisman. 2010. Distribution maps for the North Sea fisheries; Methods and application in Natura 2000 areas. LEI report 2010-067 ISBN/EAN: 978-90-8615-459-3.

Coers, A., N.T. Hintzen and K.G. Hamon. 2013. A collaborative approach to mapping value of fisheries resources in the North Sea (Part 2: Methodology)IMARES report C002/13. (In press)

Justification

Rapport C001/13
Project Number: 4301105201

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Jan Jaap Poos
Researcher

Signature:

Date: 7 January 2013

Approved: Dr. ir. T.P. Bult
Head of department Fisheries

Signature:

Date: 30th January 2013

Appendix A. Gear types

Gear type international code notification and description. Gear types in shaded grey are considered in detail within this study.

Gear code	Gear description	Gear type	Dutch name (colloquial)
BNT	Fyke net	Fixed	
BTF	Fishing gear with living bait	Unknown	
DRB	Boat dredges	Towed	
FPO	Pots	Fixed	
FYK	Fyke net	Fixed	
GN	Gillnets	Fixed	
GND	Gillnets (drifting)	Drifting	
GNS	Gillnets (standing)	Fixed	
GTN	Combined gill-trammel net	Fixed	
GTR	Trammel nets	Fixed	
HMD	Mechanical (suction) dredge	Towed	
LH	Hand- and pole-line	Fixed	
LHM	Handlines and pole-lines (mechanised)	Fixed	
LHP	Handlines and pole-lines (hand operated)	Fixed	
LL	Long lines	Towed	
LLD	Long lines (drifting)	Drifting	
LLS	Long lines (set)	Fixed	
MIS	Other fishing gear	Unknown	
OFG	Other passive and other gear	Unknown	
OTB	Otter bottom trawls	Towed	Demersale bordentrawl
OTG	Other towed gear	Towed	
OTM	Otter midwater trawls	Towed	
OTT	Otter twin trawls	Towed	Gepaarde demersale bordentrawl
PS	Purse seiner	Towed	
PTB	Pair bottom trawls	Towed	
PTM	Pair midwater trawls	Towed	
SDN	Danish seines	Towed	
SPR	Pair seine	Towed	
SSC	Scottish seines	Towed	Zegen
TBB	Beam trawls (including beam trawls shrimps (TBS))	Towed	Boomkor

Appendix B. Detailed description of data processing and analyses

Data processing

VMS and logbook data are retrieved directly from the ministry of EZ. These data are checked for common errors (i.e. missing fields and typos) and imported in a local database at IMARES. Upon extraction, the data is directly transformed to fit the 'tacsat' and 'eflalo' data formats for the VMS and logbook records respectively. These two data formats are required to analyse and visualize the VMS and logbook data using the VMStools software package (Hintzen et al. 2012).

Price information is used from different sources for different fish species, depending on their availability and/or accuracy. When available, monthly average prices per species, which LEI receives from the Dutch Fish Product Board (PVIS) are used. However, PVIS does not collect price data for all species landed. For those species where prices are not available the average price calculated from sales slips information in the IMARES database is used. Finally, a number of pelagic species are rarely traded on the fish auctions and price data is used that is collected (as annual average prices) directly from fishing companies by LEI. The landings values were determined from the landings data using the statutory conversion factors from live to market weight (see Van Oostenbrugge et al. 2010 for the conversion factors per species) and the average market prices per species and month.

Before starting analyses, checking the data to ensure that the information in tacsat and eflalo is correct is necessary. Duplicate records in tacsat are removed, where duplicates are exact copies of the vessel ID, latitude and longitude position and date-time stamp. In those cases where succeeding date-time stamps are less than 5 minutes apart, only the first record is retained, because these records are considered are pseudo-duplicates. Also, positions that are not on the globe, e.g. outside 90° latitude or 180° longitude, outside the 0 - 360° compass range, or speeds larger than 20knots are removed. Points on land and points in harbour are removed from the tacsat dataset. To check whether a tacsat position is located inside a harbour, all positions are checked against a harbour list containing +/- 4000 harbours using the *pointInHarbour* function of vmstools. A record is considered to be inside the harbour if it is within a 3 mile range from the harbour midpoint GPS location. To check whether a tacsat position is located on land, it is overlaid with a coastline map with the *pointOnLand* function of vmstools (see figure B1 for a graphical result of points on land and points in harbour analyses).

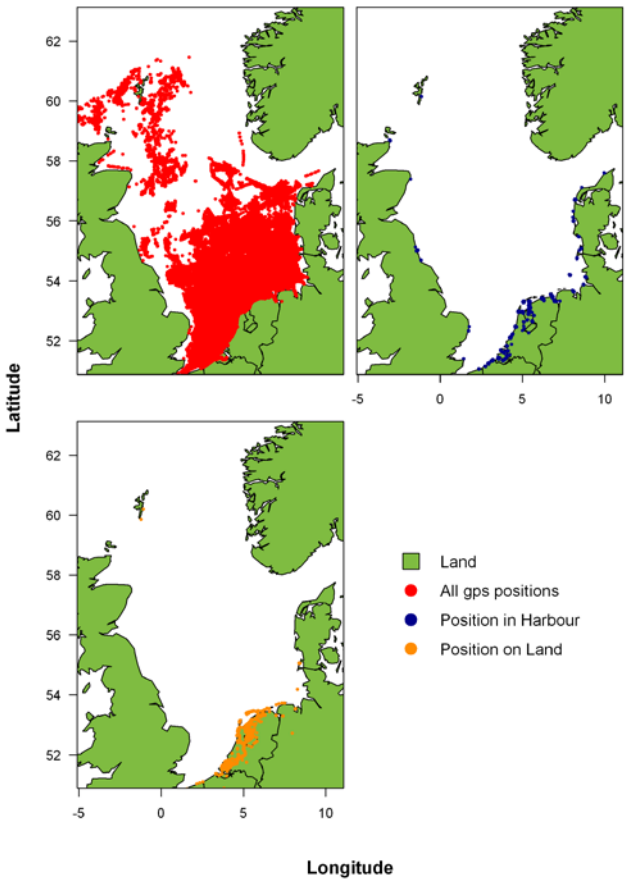

Figure B1. Identification of points on land and points in harbour. Topleft panel shows the distribution of all tacsat GPS positions within the 50-62 latitude and -4-10 longitude range in 2011. The topright panel shows all positions that are indicated to be in harbour while the bottom left panel indicates those records to be considered on land.

The eflalo dataset is also quality checked. Duplicate records in eflalo are removed, where duplicates are exact copies of the trip number, gear, ICES square fished and fishing date. No further id checking is necessary because vessel id and trip number are unique by default, since this is one of the checks carried out when data is imported into the IMARES local database. . Records with missing departure or arrival time, or records with arrival times before departure time are deleted, as well as records before the 1st of January of the year considered. Whenever a trip overlaps with another trip (e.g. a trip within a trip, or a trip with departure date before the preceding trips arrival date), the dates are corrected, if a trip is within another trip, landings are aggregated and the shorter trip is removed.

Linking VMS and logbook datasets

As the tacsat data provides only information on location, direction and speed and the eflalo dataset information of the vessel (e.g. gear type) and on landings and prices per species, these two datasets need to be linked before any spatial analysis on fishing activity, landings or value can be conducted. Both datasets do include a vessel id common and date-time stamps in each record. Eflalo includes a departure and arrival date-time while tacsat includes a date-time stamp per ping. Those tacsat records that fall within the departure-arrival timeframe of eflalo can thus be assigned the trip number from the eflalo record with the *mergeEflalo2Tacsat* function. The trip number can thereafter be used attribute additional information from the logbook data to the VMS dataset; such as landings, value or gear type (to allow for an analysis of speed profiles by gear type).

Defining activity:

Economic value maps created based on the linked tacsat and eflalo datasets should only include those VMS positions associated with fishing; not those with steaming or floating. Hence, activity of a vessel needs to be defined. This is typically done based on speeds associated with fishing activity. In order to do this, gear-specific fishing speed profiles are defined using the *activityTacsat* function of VMStools.

Per gear type, a frequency distribution is created based on the observed (instantaneous) speeds. In general, 3 peaks can be distinguished. A peak near 0, associated with in harbour / floating, a peak around fishing speeds and a peak around steaming speeds. To determine which behaviour is associated with what speeds, normal density curves are fitted to each of these peaks. To fit a normal density curve through the first peak, a slight modification to the data needs to be made, simulating a perfectly mirrored speed profile around 0 (see figure B2 for an example).

In total five peaks are fitted to the observed speed distribution, also including the duplicated speeds with minus sign. The first and fifth and second and fourth curve are identical in position and shape. Where the dark blue line is above the light blue line, the speeds are associated with in harbour / floating. Where the light blue line is above the dark blue or pink line, the speeds are associated with fishing. Where the pink line is above the light blue line, the speeds are associated with steaming.

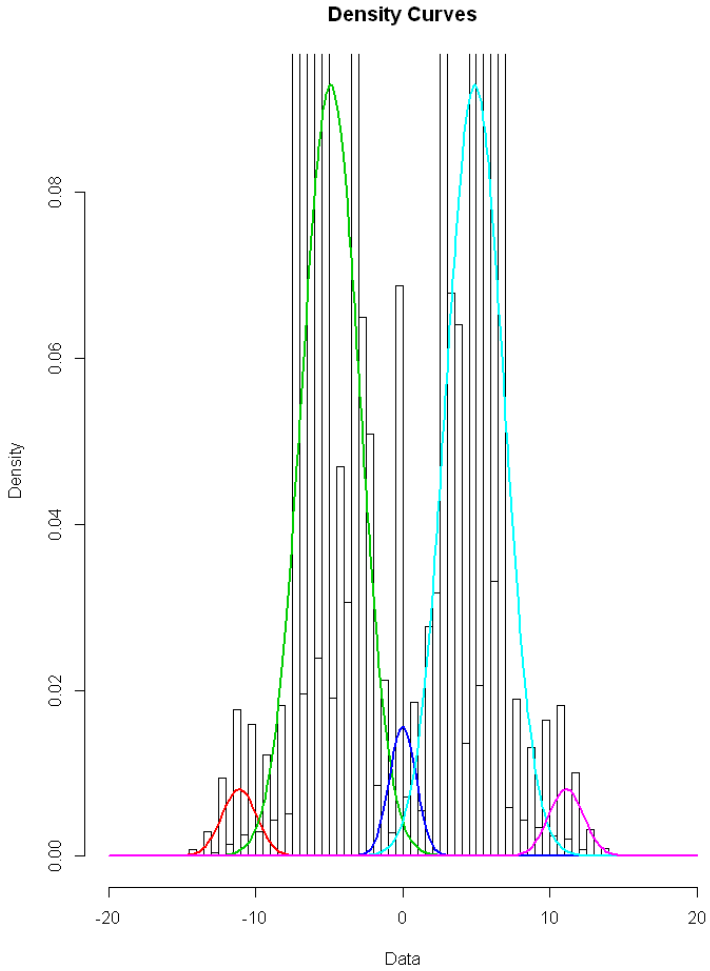

Figure B2. Frequency distribution of Beam Trawl records. The horizontal axis indicates speeds (knots) while the vertical axis indicates frequency.

The results of this analyses for the 2011 VMS and logbook data are given in figure B3, where each of the 4 gear types are analysed to define activity thresholds. Subsequently, an identifier whether a vessel is fishing or not (no fishing = 0, fishing = 1) is added to each tacsat record.

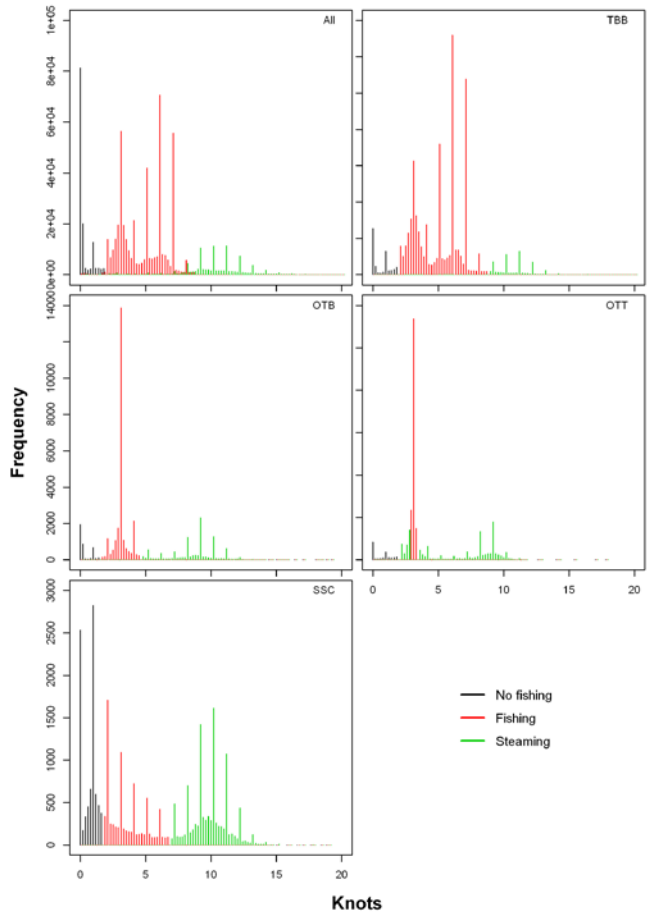

Figure B3. Identification of activity based on speed profiles per gear type. Black bars represent no fishing speeds, red bars identify speeds associated with fishing and the green bars represent steaming behaviour. Per gear type, the speed thresholds vary as the speed profiles per gear type are different.

Define area of interest and reference areas:

Since some level of uncertainty is related to estimated economic value figures regarding the area of interest in relation to a number of reference areas for comparison is useful. The area of interest is to be compared to two reference areas. Here, the Hornsea area is chosen as the area of interest. It is defined using a shapefile which was downloaded from http://www.thecrownestate.co.uk/media/236214/offshore-wind-uk.zip on 27 November 2012). The North Sea is chosen as a first reference area and is defined as ICES area IV). The Poseidon area is chosen as a second reference area and defined by a selection of ICES rectangles (37E9, 37F0, 37F1, 37F2, 37F3, 36E9, 36F0, 36F1, 36F2, 36F3, 35F0, 35F1, 35F2, 35F3) as used in the report for Poseidon Consultancy Ltd (Coers and Hintzen 2012) for comparison. (see also figure 1).

Spatial distribution of activity:

To create economic value maps at a high spatial resolution, the combination of tacsat and eflalo data is used where eflalo reports on economic value and tacsat reports on spatial position of fishing activity. For

each eflalo record, all landings values for all species are lumped into one euro value. These values are equally distributed among the tacsat records that are associated with fishing. To do this accurately, values are only assigned to those tacsat records which have fishing date, vessel id and trip number in common with the respective eflalo record with the function *splitAmongPings*. In case no exact match can be found, fishing date is replaced by ICES square and a perfect match is found once more. Remaining non-match records are linked to tacsat with a match only on trip basis. In the rare occasion that no eflalo record can be linked to a tacsat record, the remaining values are distributed equally over all tacsat records associated with fishing. This procedure ensures that the value present in the original eflalo dataset is same in the tacsat dataset. This process results in a tacsat dataset complemented with a value (in euros) per ping column.

Creating the figures:

The North Sea is divided in cells 1/16th of an ICES square (0.25 degrees longitude x 0.125 degrees latitude). For each of those cells, the value of landings is calculated as the sum of the value allocated to the pings of the selected gears ("all", "TBB", "OTT", "OTB" and "SSC") positioned in the cell. A colour scale (from fair yellow to brown) is created to indicate the intensity of the value of landings in each cell (the values at which colours change are defined manually). The maps are created by filling each cell with the colour defined by the value of landings in the cell. For some of the maps, the individual VMS pings are also drawn as black dots.

Creating the tables:

In a similar way as for the maps, VMS pings and their associated values are allocated to areas (Hornsea area, the Poseidon area and the North Sea (ICES area IV)). For the selected gears ("all", "TBB", "OTT", "OTB" and "SSC"), the value of landings of the VMS pings is summed for all the pings situated in the areas of interest to obtain the value of landings for the area. To allow comparison of the different areas despite their different sizes, the value per area is divided by the surface of each area (in km^2). The resulting value of landings per km^2 is an indicator of the economic importance of the areas.