Distribution of fishing intensity of pulse- and beam trawling in the North Sea

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IMARES rapport C146A/15

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Contents

Introduction

This research is commissioned by Cooperatieve Visserij Organisatie, Emmeloord. IMARES was asked to prepare an overview of the impact of the Dutch -North Sea- pulse trawling in 2014 in comparison with traditional beam trawling in 2010.

1. Assignment

Within this study, we quantify the fishing intensity that is allocated at the various sediment- and energy habitats type areas found in the North Sea by selected Dutch bottom fishing vessels. For 2010 traditional beam trawlers and for 2014 pulse trawlers are selected. Trawling frequency, as a measure of impact, equals the surface area covered by the fishing gear per unit time as a fraction of the surface area of a specific habitat.

2. Materials and Methods

Since the 1st of January 2005 all fishing vessels larger than 15 meters are equipped with VMS, while VMS was introduced on-board of vessels larger than 12 meters since the 1st of January 2012. A VMS transponder sends approximately every 2 hours a signal to a satellite providing information on the vessel's ID, position, time & date, direction and speed. Hence, VMS is a useful data source to study the distribution of the fishing fleet both in time and space. The Dutch ministry of Economic Affairs is tasked with the collection of VMS data of all Dutch fishing vessels. VMS data of foreign vessels, even inside the EEZ, are made irregularly available for scientific purposes. All VMS positions are collected in the WGS84 coordinate reference system.

As VMS does not contain any information on the activities of the fisheries itself, e.g. regarding fishing gear, catch composition, departure harbour or vessel dimensions, for many fisheries related studies, VMS is coupled to fisheries logbooks. These logbooks report per fishing trip (approx. 4 – 5 days) when fishermen leave harbour, what gear has been used to fish, their catch composition and a rough estimate of the location of the catches for each 24 hour period. Both VMS and logbook data report on the fishing vessel ID, which allows for the coupling of the two datasets and study fisheries distribution at higher spatial and temporal scales.

A summary of the process to pre-process, analyse VMS- and logbook data, combine these datasets and link gear specific effort to the pipelines is given below. A more detailed description on the processing and assumptions made during this process can be found in Hintzen et al. (2013) http://edepot.wur.nl/248628.

Data pre-processing:

- VMS and logbook data are received from the Ministry of Economic Affairs and stored in a local database at IMARES.
- VMS records are considered invalid and therefore removed from the analyses when they:
    - are duplicates or pseudo-duplicates (indication of malfunctioning of VMS device)
    - identify an invalid geographical position
    - are located in a harbour
    - are located on land
    - are associated with vessel speeds > 20 knots
- Logbook records are removed from the analyses when they:
    - are duplicates
    - have arrival date-times before departure date-times
    - overlap with other trips

Link VMS and logbook data:

- VMS and logbook datasets are linked using the unique vessel identifier and date-time stamp in both datasets available. 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 unique trip number from the logbook record which allows matching both datasets

- Fishing trips, using the bottom gear beam trawl (referred to with code TBB) and mesh sizes of 70 mm or more are selected. VMS and logbook data for the entire years 2010 and 2014 are used.

Define fishing activity:

- Speed recordings obtained from VMS data are used to create frequency plots of these speeds, where along the horizontal axis the speed in knots is given and the vertical axis denotes the number of times that speed was recorded. In general, 3 peaks can be distinguished in such a frequency plot. A peak near 0 knots, associated with being in harbour/floating, a peak around the average fishing speed and a peak around the average steaming speed. These analyses are performed separately per gear type for two kW classes (<= 225kW and > 225kW) as these vessel types show different fishing behaviour and are allowed to fish in different regions.
- According to the method described above, a number of VMS records can be associated with fishing activity. In general, vessel speeds between 1.5 and 8 knots are characterized as fishing. For small beam trawlers the selected range was approximately 2-7 knots. For large trawlers the range was approximately 4-8 knots.

Spatial resolution:

- VMS recordings are available for fishing vessels approximately every two hours. Suppose the vessel speed is 4 knots, the distance between two successive VMS locations is approximately 15 km. The area covered by the trawling operation (km^2) was estimated per VMS record by multiplying time period between records (hr), The vessel speed (km/hr) and the width (km) of the gear. The fishing activity derived from VMS data can be assigned to different habitats by using the habitat map from the EUSeaMap project (Cameron, 2011). Since the grid-cell size is 2 km^2 a vessel may pass several grid-cells between two VMS recordings. Therefor the VMS locations are interpolated, taking 20 linear steps of the time interval between VMS records.

Define area of interest:

- As study area Central- and Southern North Sea (= ICES Divisions IVb & IVc) is taken. This area covers approximate 350 000 km^2.

Link location to fishing effort and fishing frequency:

- Given the location and trawling area of each VMS record, locations are linked to cells of a grid of the study area with a resolution of 1 by 1 minute latitude/longitude. The total surface area of all grid cells in which trawling took place gives an estimate of the Trawled Area in the different habitat areas. Adding up the areas covered by trawling operations gives an estimate of the Area Trawled. The ratio of Area Trawled and habitat area is an estimate of the average fishing frequency of the habitats. The ratio of Trawled Area and habitat area is an estimate of the part the habitat area that is fished.
- Given the surface area of each grid-cell, ranging from 1.9 to 2.2 km^2, the fraction of the cell-area covered by the trawling operation, which ranged from 0 to 1.42 km^2, is estimated for each VMS record. These area coverage estimates are aggregated per grid-cell and gear-type (year) giving an estimate of the total fishing frequency in each grid-cell for both gear-types per year.
- According to fishing frequency breaks of <0.1, 0.2, 0.5, 1, 2, 5, 10 and >10, the areas of grid cells with similar fishing frequency are estimated, resulting in an area distribution of fishing frequency within the various habitats. The distribution patterns are used to compare the fishing intensities of beam trawling and pulse trawling.

Compare fishing effort beam trawlers and pulse trawlers:

- The fishing effort of beam trawlers and pulse trawlers is estimated by multiplying the estimated days at sea associated with a VMS record with the engine power (kW) of the vessel tabulated. The resulting kWdays are aggregated per habitat type area.
- On a grid-scale of 1/16 ICES square the aggregated fishing effort of beam trawlers and pulse trawlers is divided by the total efforts of the gears to get the relative effort distribution in the North Sea area. The ratio of these two relative efforts are mapped to show the relative importance of the two fisheries in the area

3. Results

The area of interest is shown in Figure 1. The area covered by the habitat types is given in Table I.

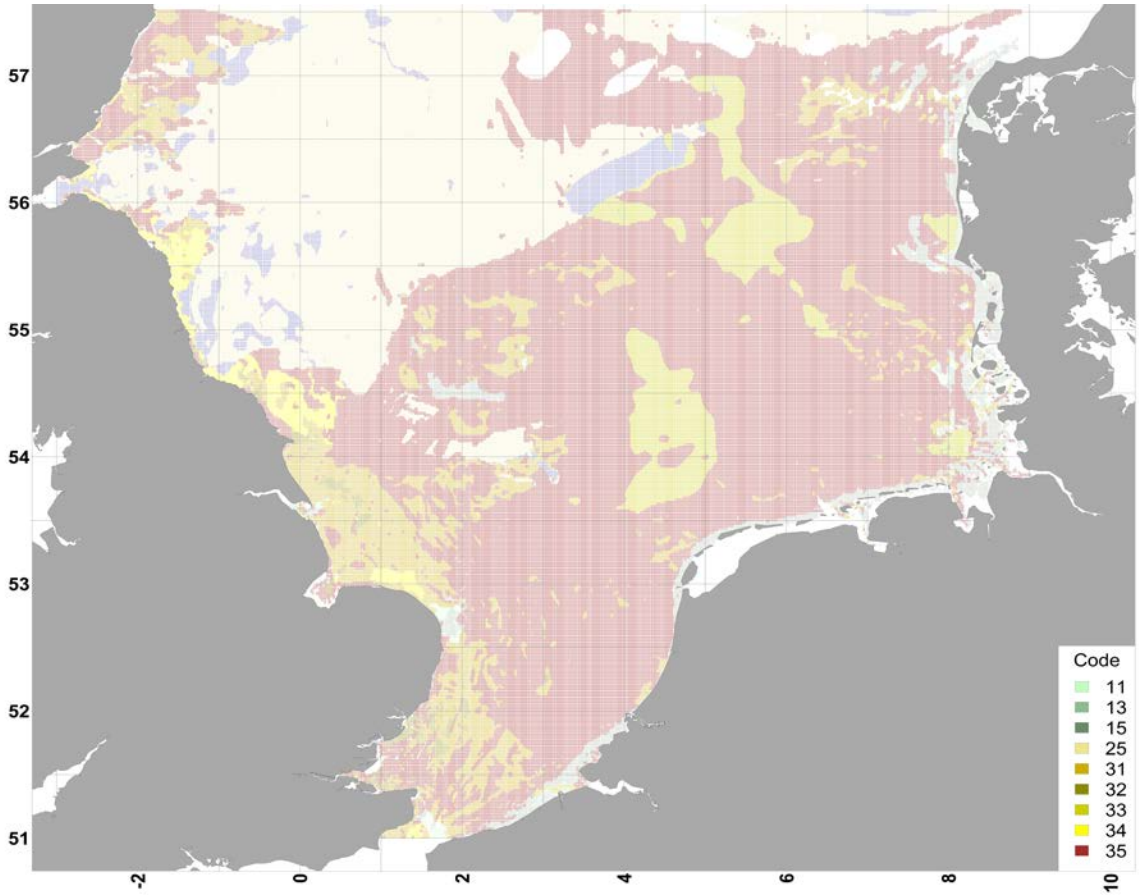

Figure 1. Grid-map of Central and South North Grid colours show the major habitat types. The coding of the habitats is given in Table I.

Table I. Area coverage by different habitats (sediment type & energy level) within the North Sea area shown in figure 1. The first digit of the habitat code indicates the energy level (1:high, 2: low & 3: moderate). The second digit indicates the sediment type (1 to 7, see first column of table I)

	Habitat: Energy level			
	1	2	3	
Habitat: Sediment Type	High	Low	Moderate	Sum
1 Coarse sediment	2206	3825	37307	43338
2 Mixed sediment	71	140	1846	2057
3 Mud to sandy mud	1071	4699	17815	23585
4 Rock or other hard substrata	86	1961	4640	6687
5 Sand to muddy sand	10630	86036	188481	285147
6 Seabed	2771	2	305	3078
7 Till	249	1323	3723	5295
Sum	17084	97986	254117	369187

Table I shows that ¾ of the study area is covered by habitats with a moderate dynamics or sand to muddy sand sediment

Table II. Trawled Area, and Area Trawled of beam trawling (BT) and pulse trawling (PULSE) in different habitats.

Habitat type				Trawled Area		Area Trawled	
Code	Substrate	Dynamic	NS Area Km^2	BT Km^2	PULSE Km^2	BT Km^2	PULSE Km^2
00	0 rest	0 rest	19155	2939	669	366	44
11	1 Coarse sediment	1 High	2206	149	84	62	52
13	3 Mud to sandy mud	1 High	1071	270	210	158	51
15	5 Sand to muddy sand	1 High	10630	2734	1392	664	268
25	5 Sand to muddy sand	2 Low	86036	2567	2252	1451	301
31	1 Coarse sediment	3 Moderate	37307	11846	9189	9551	5606
32	2 Mixed sediment	3 Moderate	1846	210	69	71	26
33	3 Mud to sandy mud	3 Moderate	17815	9411	5119	5719	516
34	4 Rock or other hard substrata	3 Moderate	4640	84	80	36	5
35	5 Sand to muddy sand	3 Moderate	188481	89908	66613	72502	23675
ALL			369187	120118	85677	90580	30544

In Table II, the Trawled Area and the Area Trawled for both gears per habitat type area is presented. On average 32% of the area of all NS habitats is fished by beam trawlers and 23% by pulse trawlers. The coverage of the habitats moderate energy & sand to muddy sand substrate (code 35) and moderate energy & mud to sandy mud substrate (code 33) is higher than the average for beam trawling. Pulse trawling shows a coverage higher than 23% in the same habitat type areas.
Area Trawled is overall about 75% of the Trawled Area for beam trawlers indicating an average trawling frequency of 0.76 in the trawled area or 0.24 in the whole NS Area. The trawling frequency of the pulse fishery is lower. The overall ratio Area Trawled and Trawled Area of pulse trawling is 0.36, which means a trawling frequency of 0.081 in the whole NS Area. Trawling frequencies above this average are found in habitats with code 33 and 35 for beam trawling and 31 and 35 for pulse trawling

Table III. Trawled area (km^2) of trawling frequency classes in different habitat types for beam trawling and pulse trawling

	Beam Trawlers								Pulse trawlers						
	Trawling Frequency Classes														
Habitat Code	0-0.1	0.1-0.2	0.2-0.5	0.5-1	1-2	2-5	5-10	>10	0-0.1	0.1-0.2	0.2-0.5	0.5-1	1-2	2-5	5-10
0	2183	269	293	126	66	2	0	0	557	53	51	8	0	0	0
11	73	8	22	23	21	0	0	0	41	2	4	13	17	6	0
13	72	39	47	62	34	15	0	0	131	11	30	28	9	2	0
15	1384	357	522	374	92	4	0	0	916	155	139	118	62	2	0
25	1014	316	351	348	355	182	0	0	1435	330	361	119	6	0	0
31	4787	819	1336	1252	1936	1662	53	0	3051	976	1649	1313	1656	542	2
32	124	23	27	13	13	11	0	0	48	0	2	6	11	2	0
33	2739	727	1556	2219	1933	211	19	6	4409	354	229	23	60	40	4
34	52	2	6	14	4	6	0	0	74	2	2	0	2	0	0
35	26142	7097	12977	14470	19664	9160	381	16	26695	9160	15058	9793	4795	1083	29

The area distribution of trawling frequency classes for the different habitats is shown in Table III and figures 2a-j. Table III contains the area's covered by fishing within combinations of trawling frequency classes and habitat type areas. Note the trawling frequency class 0 (area with no fishing) is omitted from the table and figures. Figure 2 shows the distribution of the trawling frequencies as a percentage of the habitat type area. Figure legends give the habitat type area, the Trawled Area of beam and pulse and the percentage of the habitat area without any beam- or pulse trawling.

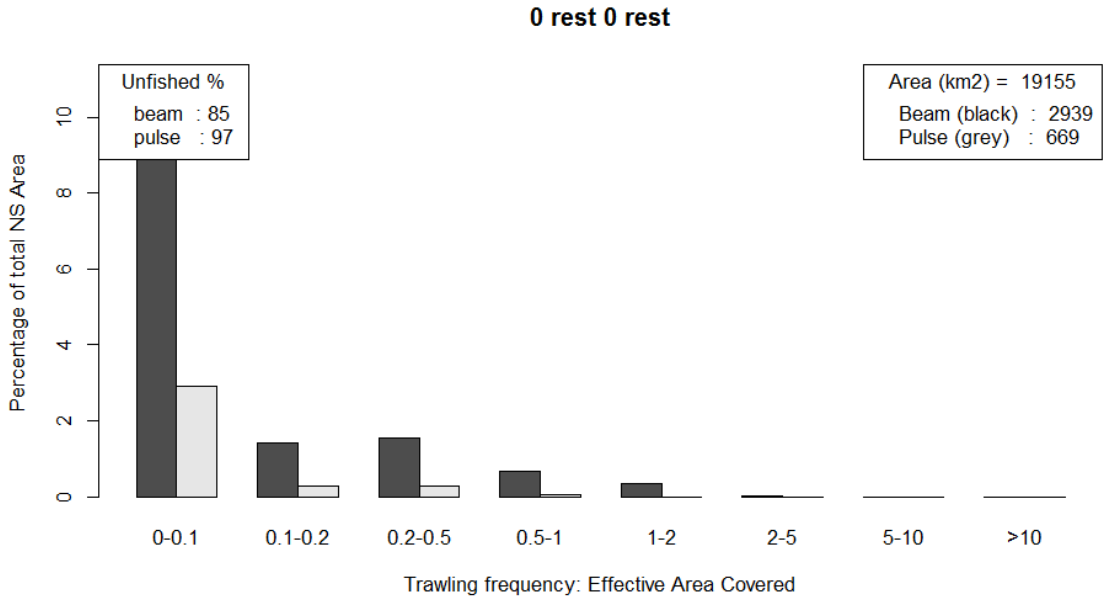

Figure 2a

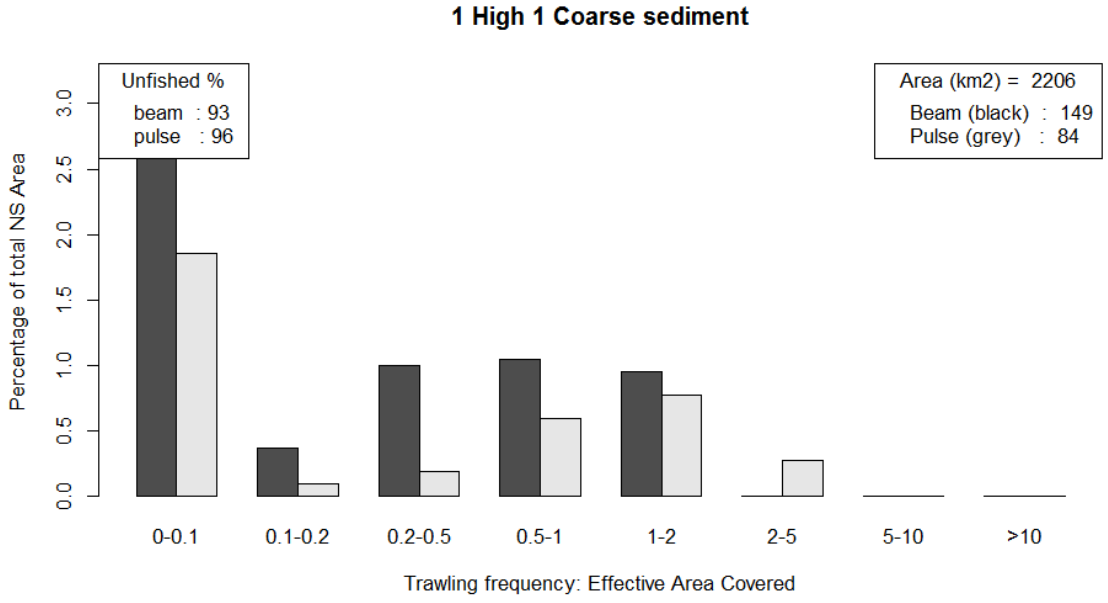

Figure 2b

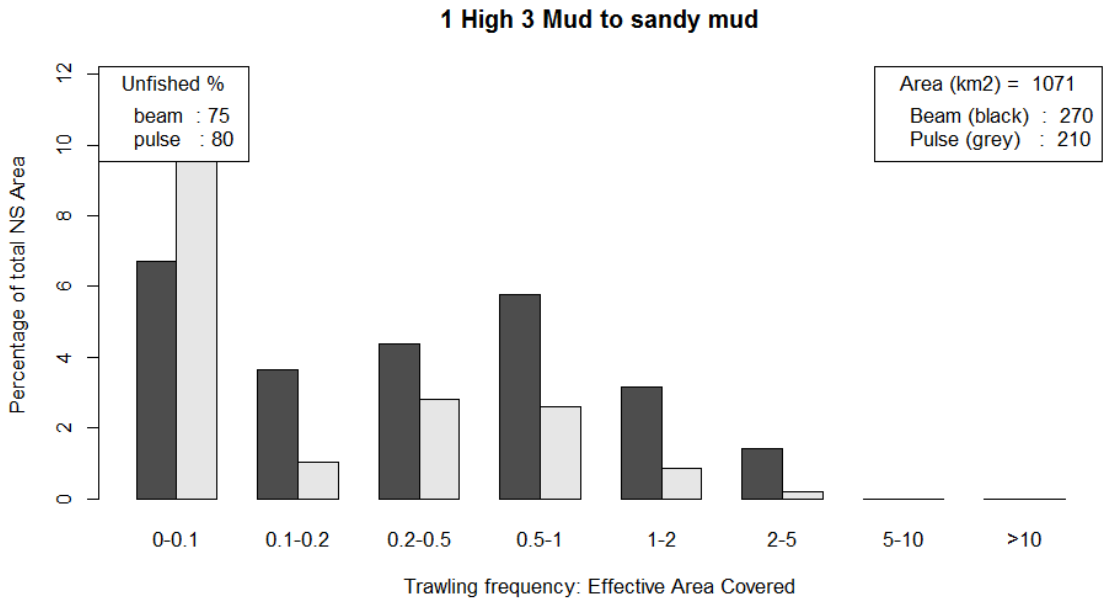

Figure 2c

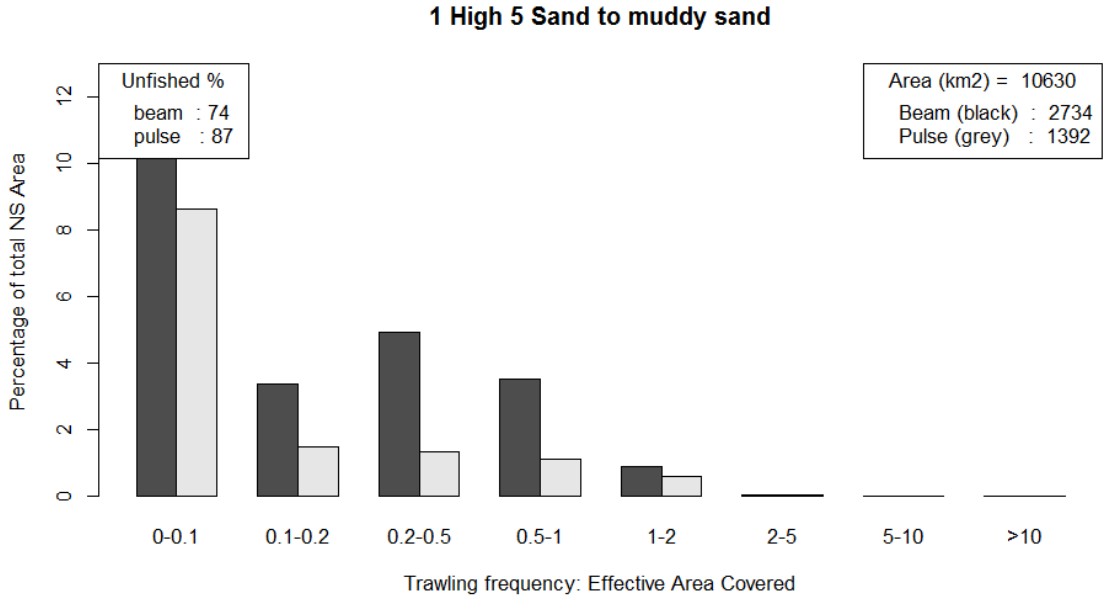

Figure 2d

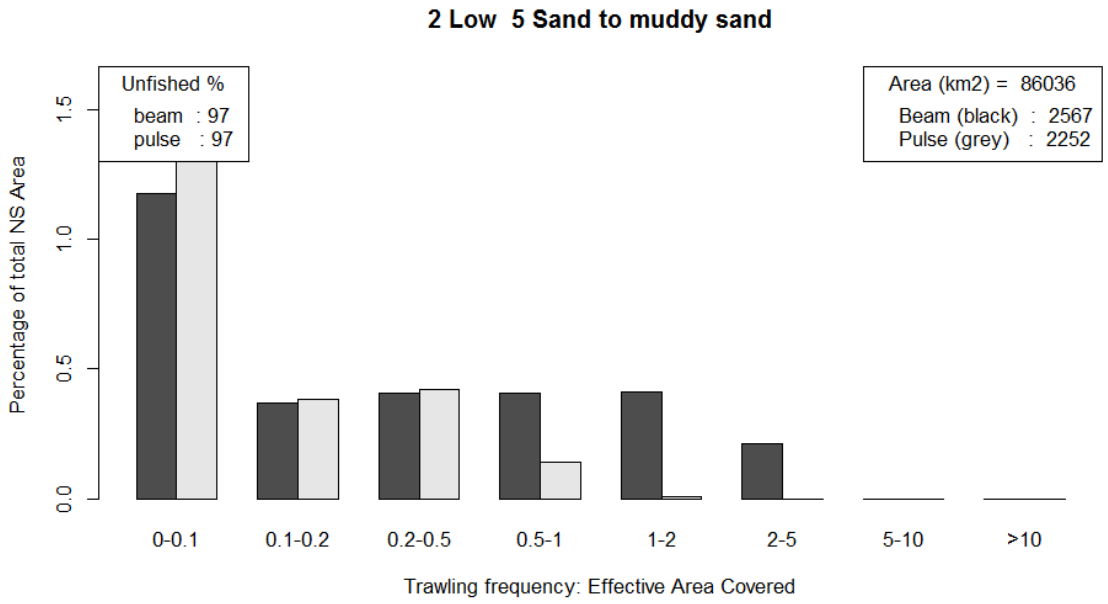

Figure 2e

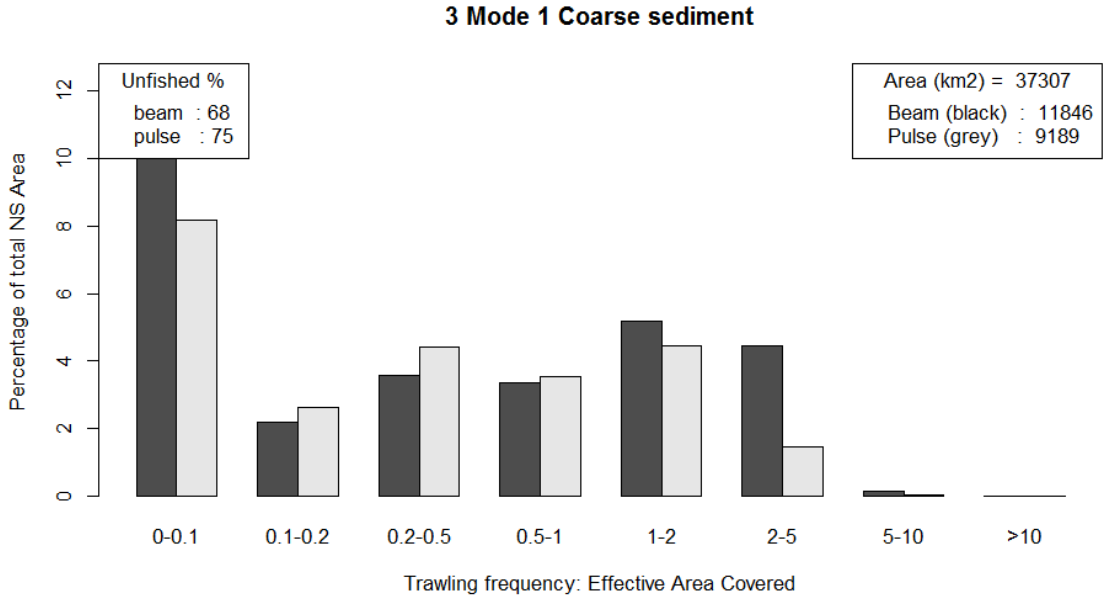

Figure 2f

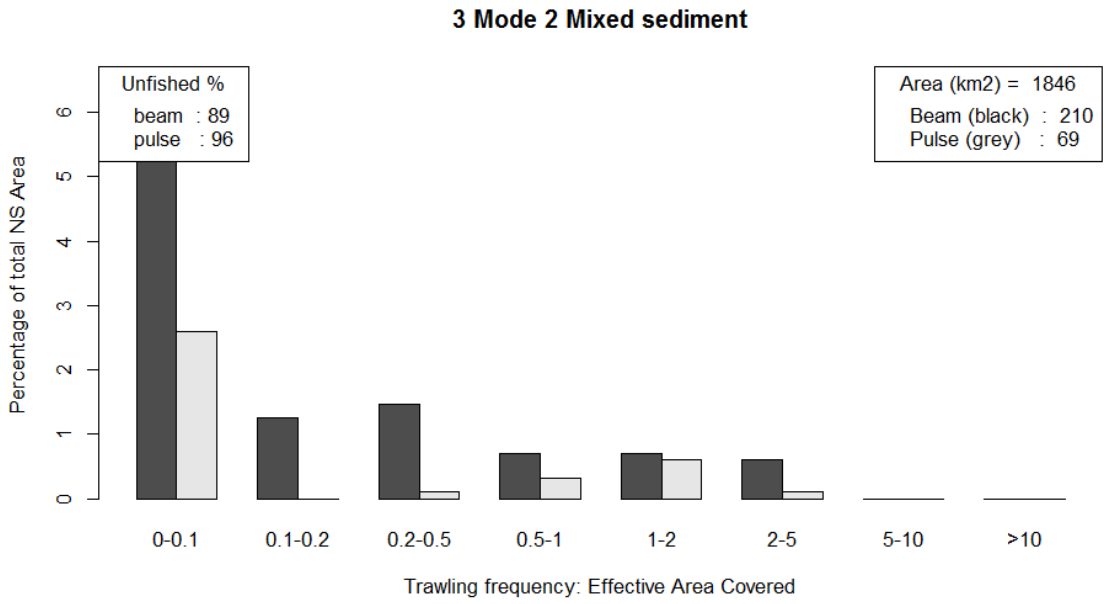

Figure 2g

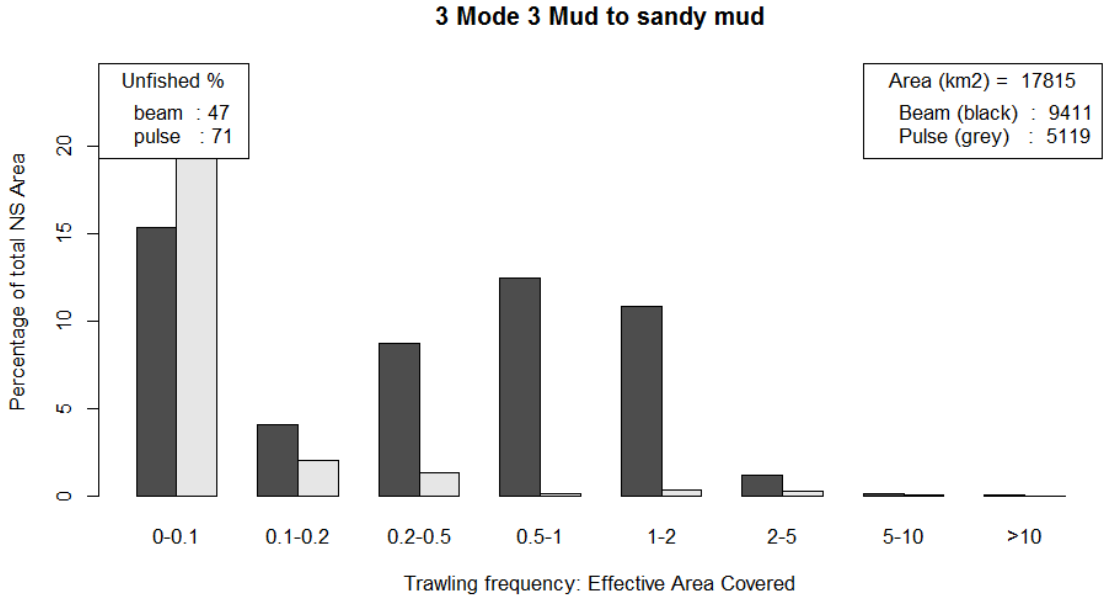

Figure 2h

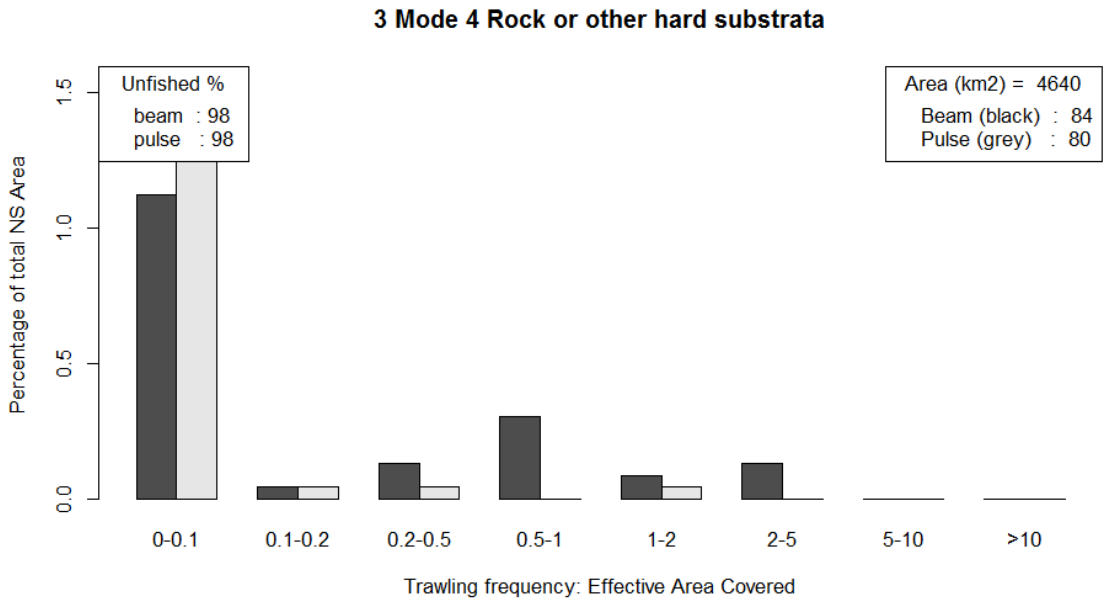

Figure 2i

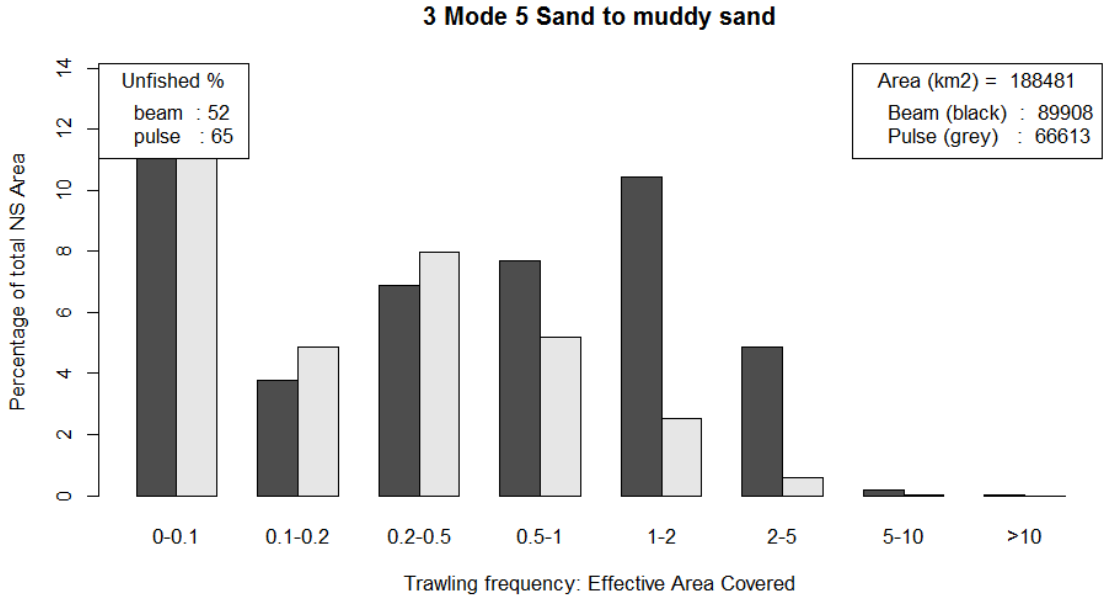

Figure 2j

Figure 2a-j. Trawling frequencies of habitat areas with 8 categories ranging from 0-0.1 to more than 10.

Apart from some modes for the lowest trawling frequency, the modes of the frequency distribution of the beam trawling frequency is 0.2-1 trawl operations per year for most of the habitat type areas. For habitat codes 31 and 35 the mode is 1-2.
The modes found in the frequency distribution of the pulse trawling frequency is 02-0.5 for habitat codes 13, 15, 25, 34 and 35 and 1-2 for habitat codes 31 and 32.

Table IV. Fishing effort (kWdays@sea) of beam trawlers in 2010 and pulse trawlers in 2014 distributed among the different habitat areas in the North Sea

			Gear type	
Code	Substrate	Dynamic	Beam trawl	Pulse trawl
00	0 rest	0 rest	127000	16000
11	1 Coarse sediment	1 High	15000	15000
13	3 Mud to sandy mud	1 High	23000	9000
15	5 Sand to muddy sand	1 High	121000	49000
25	5 Sand to muddy sand	2 Low	437000	116000
31	1 Coarse sediment	3 Moderate	3130000	2186000
32	2 Mixed sediment	3 Moderate	19000	6000
33	3 Mud to sandy mud	3 Moderate	1463000	171000
34	4 Rock or other hard substrata	3 Moderate	17000	3000
35	5 Sand to muddy sand	3 Moderate	19790000	8116000
ALL			25142000	10687000

In Table IV the distribution of fishing effort among the habitat types of the North Sea is given. Approximately ¾ of the total effort is applied in the habitat area with moderate dynamics and sand to muddy sand sediment (code 35). This habitat area covers 55% of the whole North Sea surface.
The comparison of effort distribution between beam trawlers and pulse trawlers on a scale of 1/16's of an ICES square is shown in figure 3.
The distribution area of beam trawlers is larger than pulse trawlers resulting in area's (north/north-east) were only beam trawlers are found. Pulse trawlers apply relatively more effort in areas of ICES rectangles (31-36)F2, (35-38)F3 and 40(F5-F7)

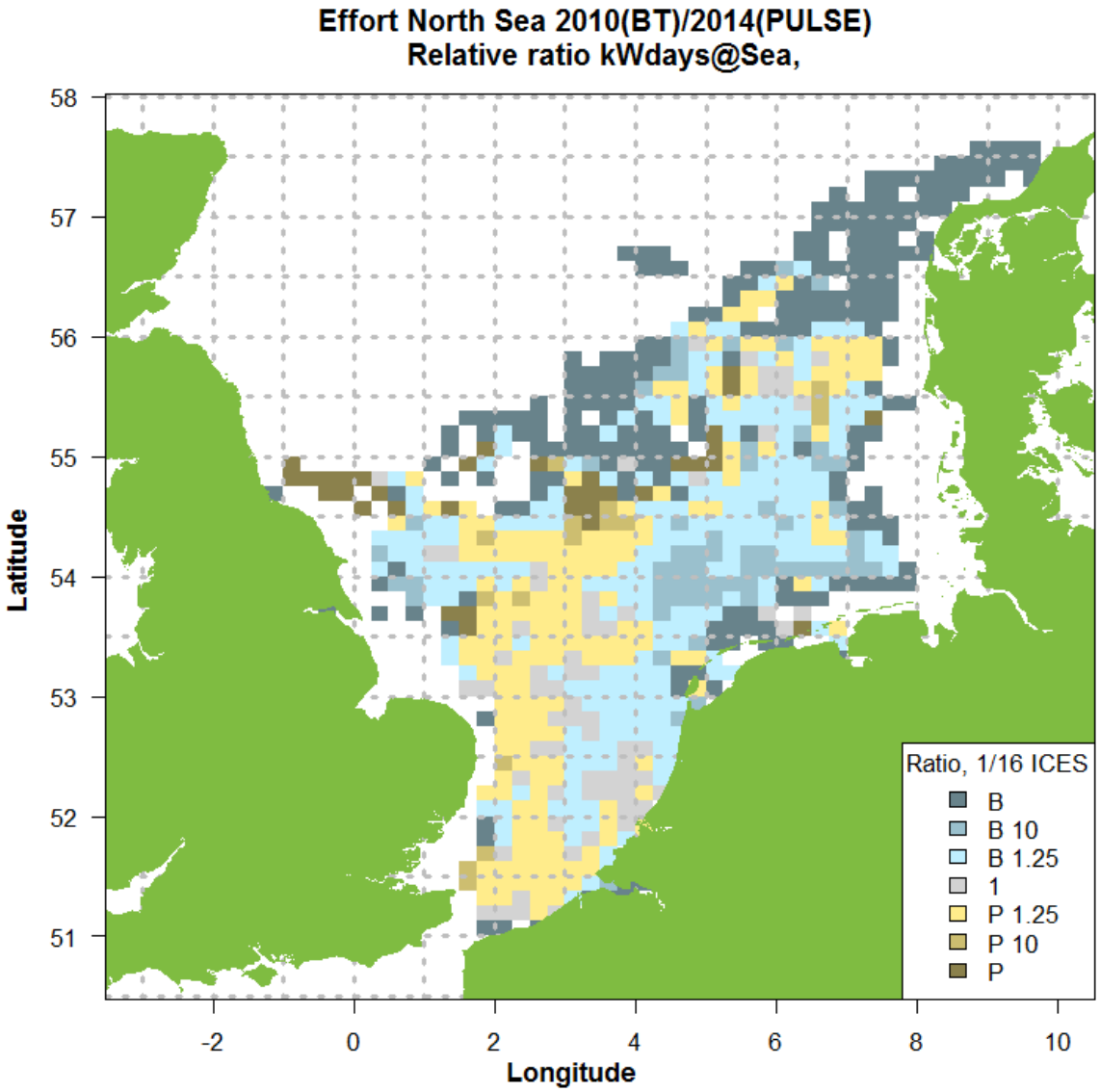

Figure 3 Map of the ratio of relative efforts of beam trawlers and pulse trawlers in the North Sea. P and B in the legend refer to coloured areas in the map where only Pulse- or Beam trawlers are fishing. 1 in the legend refers to coloured areas in the map where the relative ratio of P/B effort is between $1.25^{\pm 1}$.

4. Conclusion

About 90 % of the fishing area of Dutch trawlers are found within the high energy habitat type areas. The beam trawlers in 2010 are concentrated in sand , mud - and coarse sediment habitats. The pulse trawlers in 2014 fish in sand to muddy sand and coarse sediment habitat and slightly less in mud to sandy mud sediments.

The total estimated effort in 2010 of the beam trawlers adds up to 25 million KWdays at sea while in 2014 the effort of the pulse trawlers adds up to 11 million KWdays at sea. Owing to this marked difference, partly due to the decommissioning of vessels and switching to pulse gear mid 2014, the fishing impact of the pulse gear is lower than the beam trawlers in 2010. If 2015 pulse gears were to be compared to 2010 there could be differences in the intensity at habitats. 2015 data will be available early 2016.

5. 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 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

6. References

Hintzen, N. T., Piet, G. J., and Brunel, T. 2010. Improved estimation of trawling tracks using cubic Hermite spline interpolation of position registration data. Fisheries Research, 101: 108-115.

Cameron, A. and Askew, N. (eds.), 2011. EUSeaMap - Preparatory Action for development and assessment of a European broad-scale seabed habitat map final report.

7. Justification

Rapport C146/15
Project Number:4301000007-21

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

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Researcher

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Date:29 October 2015

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Signature:

Date: 30 October 2015