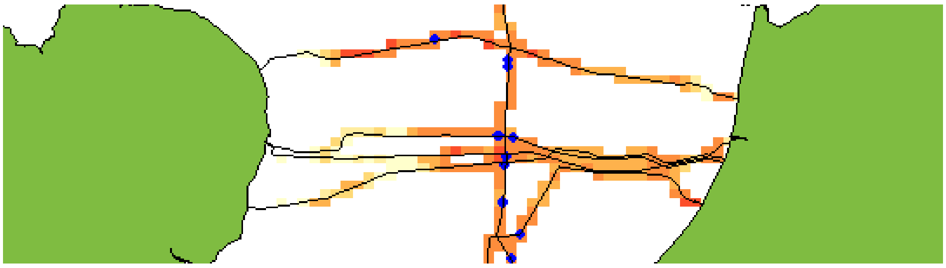
# North Sea submarine cable disruptions and fishing activity

Ir. N.T. Hintzen & dr. mr. ir. M.A.M. Machiels

Report number C117/14-A



IMARES Wageningen UR

(IMARES - Institute for Marine Resources & Ecosystem Studies)

Client: Attn. Steven Bennett
New Saxon House
1 Windsford Way
Boreham Interchange
Chelmsford
Essex, CM2 5PD, England

Publication date: 1 July 2015

**IMARES vision:**:

- To explore the potential of marine nature to improve the quality of life'.

**IMARES mission:**

- To conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas.

**IMARES is:**

- An independent, leading scientific research institute.

P.O. Box 68
1970 AB IJmuiden
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 26
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 77
4400 AB Yerseke
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 59
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 57
1780 AB Den Helder
Phone: +31 (0)317 48 09 00
Fax: +31 (0)223 63 06 87
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 167
1790 AD Den Burg Texel
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 62
E-Mail: imares@wur.nl
www.imares.wur.nl

## Contents

# Summary

At the North Sea seafloor, numerous submarine cables are positioned that connect telecommunication networks between countries. Worldwide, human activities cause most of the cable disruptions with fisheries accounting for nearly half of all reported faults. Due to a recent increase of submarine cable disruptions in the central North Sea area, Global Marine Systems Ltd. requested IMARES to investigate a possible link between these occurrences and the recent gear switch of the Dutch –demersal beam-trawl-fishing fleet. The Dutch fleet introduced the sumwing and later on the pulswing as energy saving modifications in comparison to the traditional beam-trawl equipped with sliders / shoes.

This study shows that there is an increase in communication cable disruptions since the introduction of the wing-type gears in 2009, a crucial element to further investigate the problem. Furthermore, it is unlikely that the south-ward shift in distribution of the traditional beam-trawl fishery since 2009 can be associated with the cable disruptions. Therefore, the wing fishery could be studied in isolation in relation to cable disruptions. Effort of wing-type gears in close vicinity of the disruptions is higher than effort somewhere else at the same communication cables. The difference is however not significant. In more recent years, and especially 2013, there is a clear correlation of wing effort and the cable disruption locations. In 8 of the 15 disruptions in 2013, the last gear passage before a cable disruption was reported, can with reasonable chance be linked to wing gears too.

The results have to be interpreted with care, for a number of cable disruptions no effort by slider-type or wing-type gears could be linked, which indicates that other causes of cable disruptions may need to be analysed too. In addition, no causal relationship between fishing vessel effort and cable disruption can be provided on the basis of GPS data, such as VMS data, alone.

# 1. Introduction

At the North Sea seafloor, numerous submarine cables are positioned that connect telecommunication networks between countries. Worldwide, human activities cause most of the cable disruptions with fishing accounting for nearly half of all reported faults. The cables in the North Sea might be hit and damaged through bottom fishing by the Dutch beam-trawl fleet. Previously, in collaboration with stakeholders, gear modifications have been developed to prevent cable damage by fishing trawl passage. Due to a recent increase of submarine cable disruptions in the central North Sea area, Global Marine Systems Ltd. requested IMARES to investigate a possible link between these occurrences and the recent gear switch of the Dutch –demersal beam-trawl- fishing fleet. Trawling is performed with a net that is kept open and is pulled across the seabed. Traditional beam-trawls have sliders (shoes) attached on each side of a steal beam which cause sea bottom contact. The net and tickler chains are positioned behind this beam. If the cable is buried in the seabed to a depth beneath the trawl slider penetration area, the cable will not be damaged, or due to beam-trawl gear modifications, the sliders may hoover over the cables. Recently some of the traditional beam-trawl fishing vessels got equipped with an innovative gear: the sumwing / pulswing, replacing the steel beam and sliders. Such a wing does not touch the seabed as it is lifted by drag supported by a front extension (the nose, see Figure 1) which guards its position off the seabed. It is unclear to what extent this 'nose' or the wing itself may disrupt communication cables. It is though understood that the 'nose' only infrequently touches the seabed, similar to the wing, and when it does, only hits the seabed with low pressure.

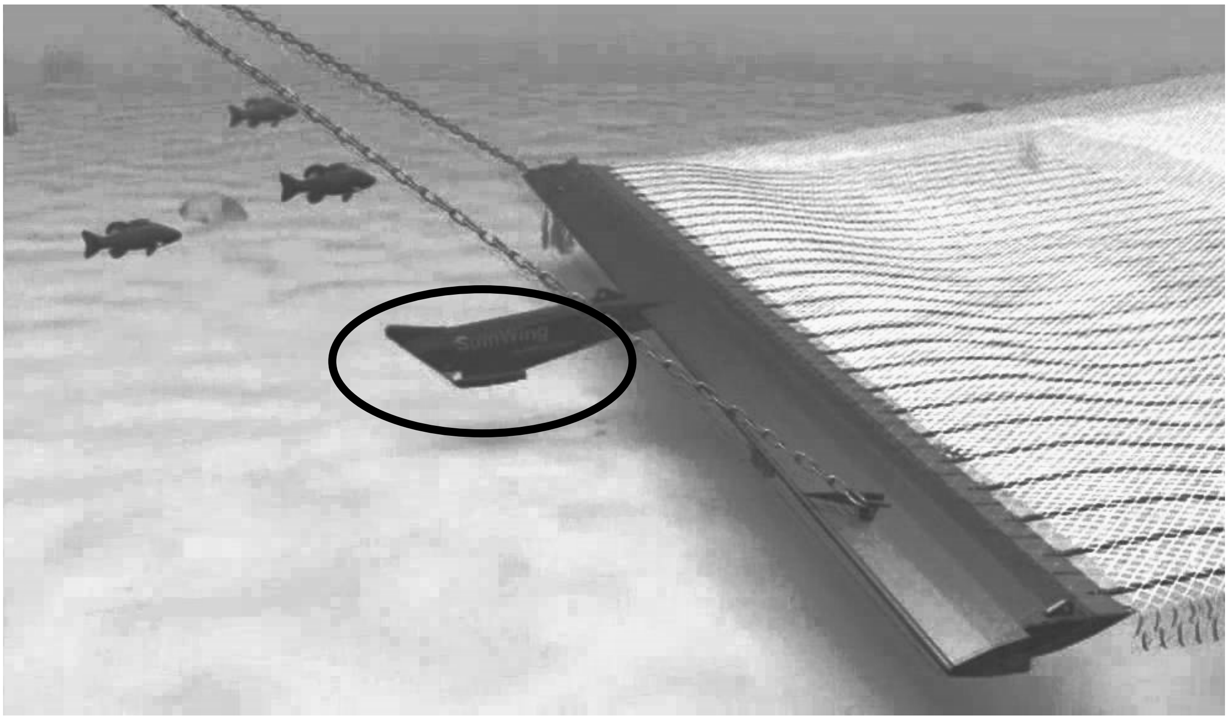


Figure 1: Graphical representation of a wing-type gear. Encircled is the nose of the gear which guards the wing from touching the seabed. (Illustration of sumwing developed by HFK Engineering)

## 2. Assignment

Within this study, the effort allocated by Dutch beam-trawl fishers in the vicinity of submarine cables, for which damage reports are available, will be quantified for traditional gears and new gears equipped with wings. The result of the study should indicate whether the larger number of cable disruptions is related to the introduction of the wing-type gear fishery.

## 3. Materials and Methods

Since the 1st of January 2005 all fishing vessels larger than 15 meters are equipped with a Vessel Monitoring by Satellite system (VMS), while VMS was introduced on-board of vessels larger than 12 meters since the 1st of January 2012. A VMS transponder send 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.

As VMS does not contain any information on the activities of the vessel itself, e.g. regarding fishing gear, catch composition, departure harbour or vessel dimensions, for many fisheries related studies, VMS is coupled by vessel to the fisheries logbooks. These logbooks report per fishing trip (approx. 4 – 5 days) when fishermen leave the harbour, what gear has been used, 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 procedure to pre-process, analyse VMS- and logbook data, combine these datasets and link gear specific effort to the cable disruptions 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.

<u>Data pre-processing:</u>

- 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 exceeding 20 knots
- Logbook records are removed from the analyses when they:
    - Are duplicates
    - Have arrival date-times before departure date-times
    - Overlap in time with other trips

<u>Link VMS and logbook data:</u>

- VMS and logbook datasets are linked using the unique vessel identifier and date-time stamp available in both datasets. In other words, records in the VMS dataset that fall within the departure-arrival timeframe of a fishing trip described as given in the logbooks, are assigned the same trip number. Having the trip number in common allows us to match both datasets

- The TBB gear type was selected and merged with the innovative gear database to distinguish between vessels operating with slider- or wing type gears
- Only VMS and logbook data for the years 2005-2013 were used as no complete picture of fishing effort can be given prior to 2005 (only vessels > 24m were equipped with VMS). Data for 2014 was not yet available for the current study.

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 (slider versus wing) for two kW classes (<= 225kW and > 225kW)
- 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 7.5 knots are characterized as fishing. For small beam trawlers the selected range was approximately 2-7 knots. For large trawlers using sliders the range was approximately 4-8 knots and using wings 4-7 knots.

Increase spatio-temporal resolution:

- VMS recordings are available for fishing vessels approximately every two hours. On a yearly basis this amounts to a vast amount of spatial data. For studies such as the current one, additional detail is required however, to appropriately link cable disruptions in time and space to passing fishing vessels. For this purpose, interpolation routines are used that artificially add intermediate positions between two successive VMS pings. The routine used in this study is described in detail in Hintzen *et al.*, 2010. On average, an additional 8 points are added in between two successive VMS pings which are by default two hours apart, resulting in a dataset with pings every ~12 minutes.

Define area of interest:

- Based on a match between the cable disruption locations and a communication cable database, in total 7 communication cable trajectories were identified that were investigated in this study. They are located in the central North Sea within the ICES rectangles 32F2, 32F3, 33F1, 33F2, 33F3, 33F4, 34F2 and 34F3 (see Figure 2). The study area has further been divided into small squares (a grid) of ~5x5km blocks to allow for more precise spatio-temporal analyses.

Link cable disruptions to fishing effort:

- A dataset was provided by Global Marine Systems Ltd. that included exact position and date & time of the cable disruptions. These disruptions were linked to the interpolated VMS records. To link these breakpoints with VMS records, timing and location of the disruptions in relation to timing and location of VMS must be taken into account. As VMS does not provide exact fishing trawl trajectories, but only gives point estimates every 12 minutes, linking disruptions to VMS is not straight forward. For this reason, the effort associated with all VMS positions that fall within a certain radius from the disruption location was taken as a measure of fishing effort at the disruption location. Screening of the most appropriate radius distance was executed. Similar screening was performed for a 'radius' in time, ranging from 365 to 0 days before the disruption. Results of this screening are given in Appendix A.
- In addition to the screening a 'best' spatio-temporal range was defined. Peer-reviewed literature indicated that VMS records in a range of 15km around the disruption location (based on uncertainty calculations of trawl tracks, Hintzen *et al.*, 2010) and between 30 to 0 days before the disruption, could be considered as the 'best' time-space window. The 30 day limit was chosen based on

indications found in the peer-reviewed literature that state that a fishing ground may remain important up to 3 weeks (Poos & Rijnsdorp 2007).

- With this approach we implicitly assume that a cable disruption may also be caused by a build-up of smaller damage events caused by passages of fishing gear rather than a one-hit occurrence. Information on the last trawl passage before a cable disruption was reported, was not reliably available in the dataset and has therefore been estimated taking uncertainty on fishing trawl tracks into account (see Hintzen *et al.* 2010 for more details). Even so, exact numbers of gear passages at the disruption locations could not accurately be calculated and is therefore not provided here. Though, the original quote indicated that these indicators would be provided. Insights gained during analyses suggested that the approach taken as reported here is more appropriate and accurate to answer the original question posted by Global Marine Systems Ltd.

To test whether the change in the Dutch beam-trawl fleet from slider-type gears to wing-type gears can be seen as a cause for the increase in cable disruptions from 2009-2014, a number of elements were investigated. First, the number of cable disruptions needs to be significantly different in the period before the introduction of the wing-type gears than after.
Secondly, the possibility that the traditional slider-type beam-trawl is not responsible for the increase in disruptions needs to be investigated. Only in the case that this can be confirmed, with a degree of confidence, the effect of the wing-type gears can be studied by itself in direct relationship to the disruptions. Hereto, we compare the effort and distribution of the traditional beam-trawl fleet before and after the introduction of the wing-type gears in 2009.
Finally, it is important to pay attention to effort allocated at other places along the communication cable, away from the disruption location (i.e. a baseline). Only if the effort in close vicinity to the cable disruption is markedly higher than on other sections of the cable, can we conclude that there is a relationship between wing-effort and cable disruptions. For this purpose, each communication cable was split up in 5km sections (similar to the grid cell size used previously) and effort for each 5km section was calculated similar to the procedure used to link effort to each cable disruption (note that in this case, effort was calculated for the entire cable in a window up to 30 days before each cable disruption, this procedure was executed for each individual breakpoint).
To compare the effort at all these 5km sections of the cable to the disruption section, a simple routine was developed in which effort at a disruption was coupled to effort at a random location on the same communication cable, i.e. effort at disruption locations were paired with effort at random locations. This routine was repeated 100 times to get a realistic mean of effort at a random location (as for each randomly drawn cable section effort estimates are different).
On the basis of all effort pairs, combined for all disruption locations, the mean effort at disruption locations could be calculated and compared to the mean effort at the random locations. A statistical test can show here if the mean effort at the disruption location is significantly higher than the mean effort at a random location at the cable.

The estimation of last gear-passage before the cable disruption occurred makes use of a confidence interval surrounding an estimated fishing trawl-track. The trawl track was reconstructed based on interpolation methods. The confidence interval specifies the chance (between 0 and 1) that a trawl track has crossed the cable at the exact disruption location. Only vessels fishing within 3 hours before and after each of the cable disruptions have been taken into account. The result indicates what the chance of impact by either slider-type or wing-type gears is within the three hour window.

## 4. Results

The Area of interest and locations of cables and disruptions since 2004 is shown in Figure 2.

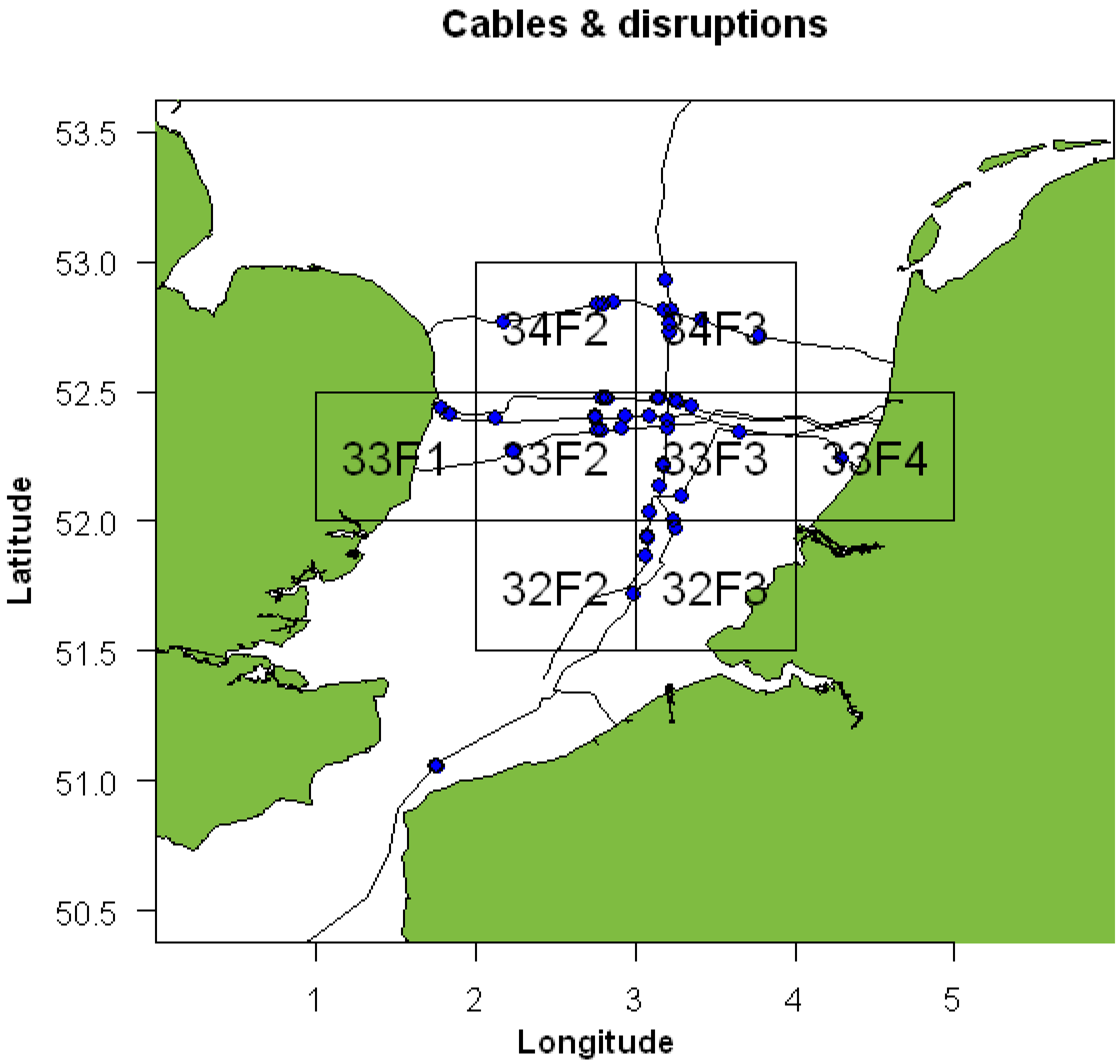



Figure 2. Central North Sea and locations of cables (black lines) and disruptions (coloured dots) from January 2004 to November 2013, overlaid with 8 ICES rectangles (black straight lines).

Cables with cable disruptions stretch across the North Sea, connecting UK with the Netherlands (n=4), Oostende (B) with Norden (D), Oostende (B) with Goonhilly (UK) and Katwijk (NL) with Saint Valery en Caux (F). The total length of the cables depicted is approximately 2280 km. Between 2004 and mid 2014 48 disruptions occurred giving an average of 1.9 disruptions per 1000 km per year.

The Dutch demersal beam-trawl fishing intensity in the area of interest from 2005 to 2013 varies from 12000 days at sea per year (2005) to 7500 days at sea in 2008. Slider gears decrease gradually from 12000 in 2005 to 4400 days at sea in 2013. The overall average is 7800 sea-days per year and the reduction per year amounts on average 920 sea-days. Wing gears, introduced in 2008, increase from 500 in 2009 to 4800 days at sea in 2013. The overall average, since 2008, is 2300 sea-days per year and the increase per year amounts on average 970 sea-days. Both time trends are significant ($p<0.01$). The time series of slider- and wing fishing effort is shown in Figure 3.

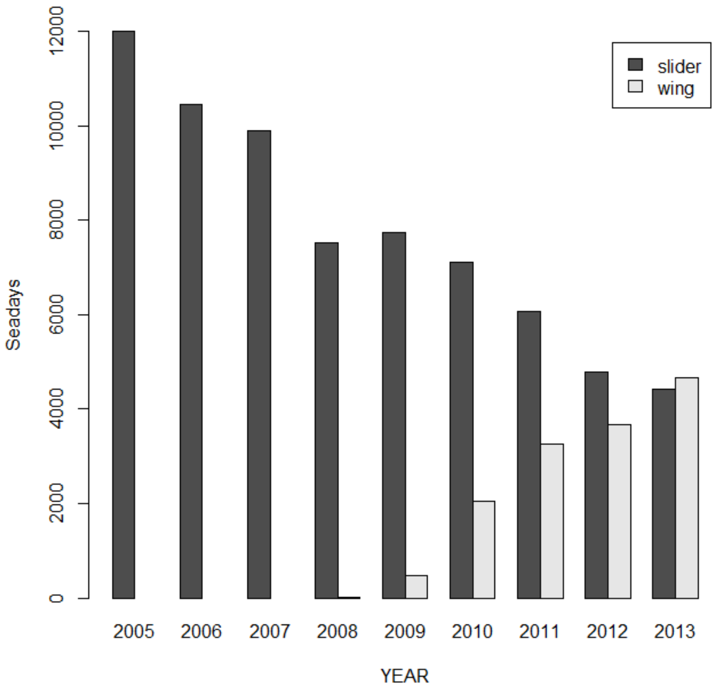



Figure 3. Time series of slider/wing trawl fishing intensity (days at sea) in the area of interest from 2005 to 2013

From 2010-2013 the fishing intensity remains constant at around 9000 fishing days per year. This is due to a gradual decrease of slider trawler effort, which is compensated by an increase of wing trawler effort from 2009 onwards. The minimum slider/wing trawler effort was approximately 7500 sea-days in 2008.

The occurrences of cable-disruptions per year is shown in Figure 4. From 2004 to 2012 the number of incidents ranges from 0 to 7 breaks per year with no clear trend ($p>0.05$). The average faults per year during the period 2004-2008 (one break per year) is significantly lower ($p<0.01$) than the average faults occurrences from 2009-20012 (5.5 breaks per year). We can therefore assume that there is a significant increase in cable disruptions since 2004.

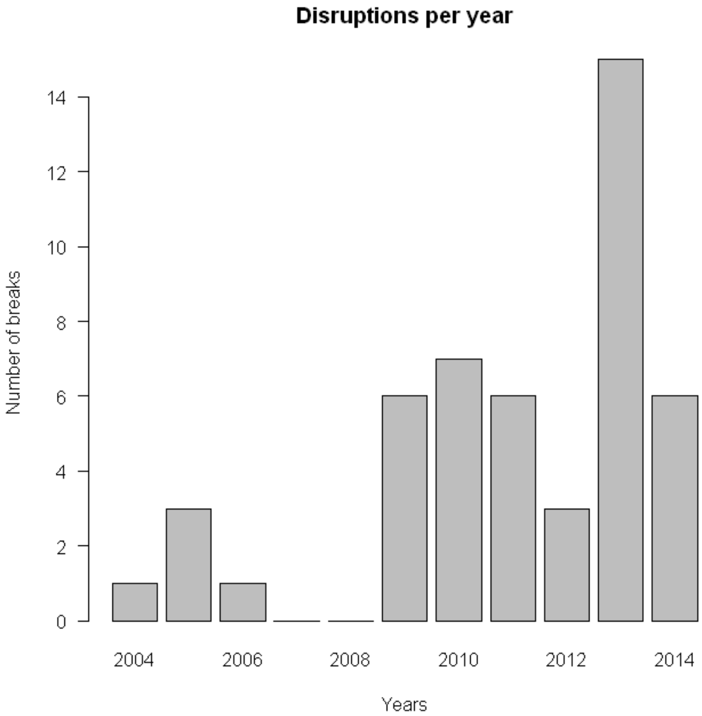



Figure 4. Time series of cable faults on 7 North Sea communication cables from 2004 to mid 2014

The distribution of the traditional beam-trawl fisheries before 2009 is markedly different from the distribution after 2008. This is shown in Figure 5 where effort in days@sea before and after 2008 is presented. It is clearly visible that there is a south-ward shift in effort from the traditional beam-trawlers while the wing-type gears fish further north in the study area. The redistribution of fishing effort (panel bottom-left) by these vessels has not resulted in more densely aggregated effort in the vicinity of the cable disruption locations, which would have shown up as dark purple patches. On average, the ratio between effort before and after 2009 by the traditional beam-trawl fisheries at the cable disruption locations equals to 1.

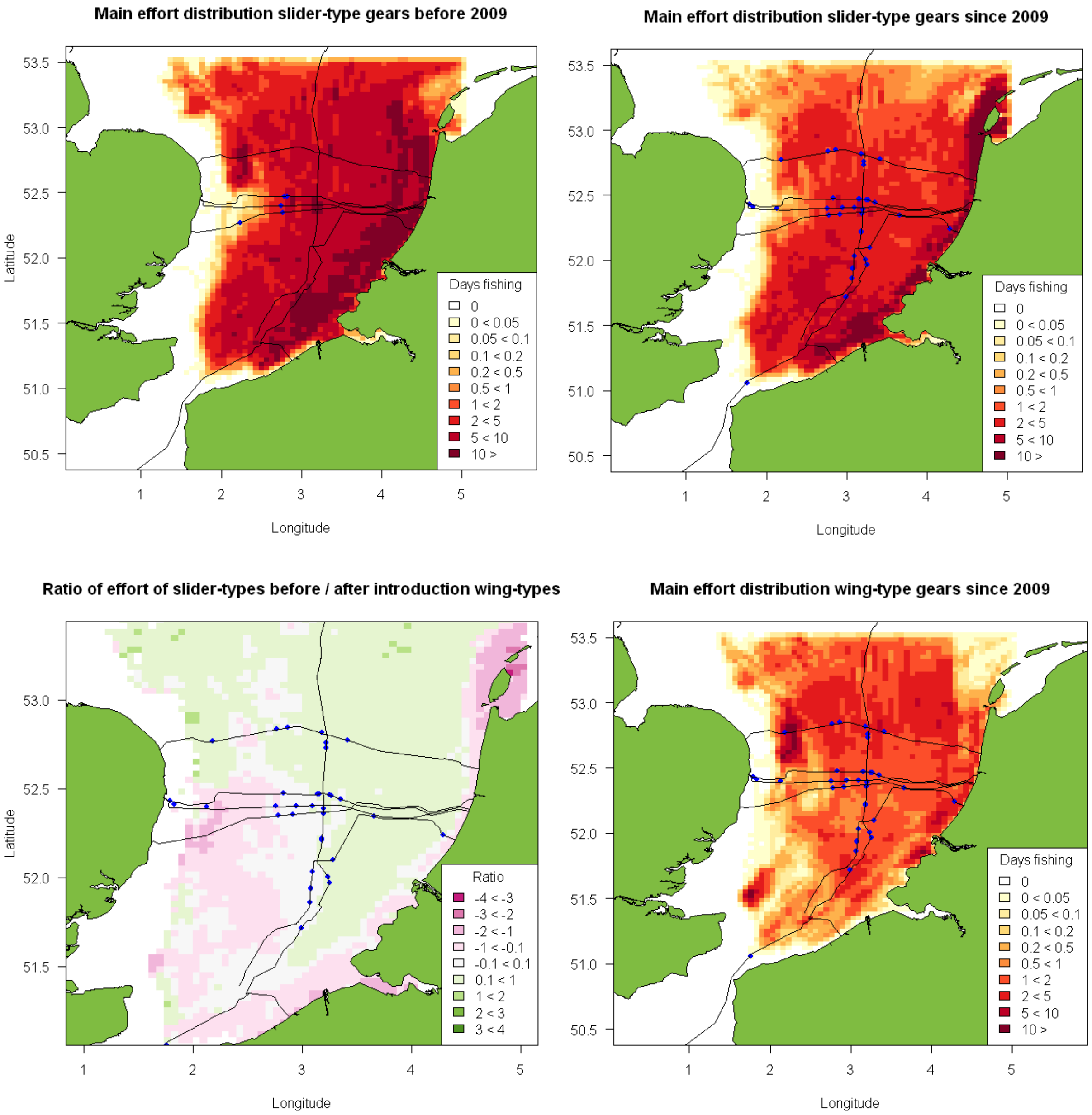



Figure 5: Effort distribution of slider and wing type gears before and after the introduction of wing-type gears in 2008. Top-left figure shows the effort distribution of all beam-trawlers in the study area between 2005-2008 while the effort distribution of the same fleet type since 2009 is given in the top-right figure. The change in distribution is given in the bottom-left figure. In this figure the effort ratio before and after is given, darker green indicates that effort before the introduction of wing gears was higher than after 2009. The bottom-right figure shows the distribution of the wing-type gears since 2009 (effort in 2008 was very small and has therefore been excluded from this figure).

A similar shift can be observed from the logbook data which contains information on all fishing vessels, not only those equipped with VMS (though, the coverage of VMS is ~99%). The area distribution of fishing effort over the ICES rectangles is shown in Table 1. Overall trawler effort is concentrated in ICES rectangles 32(F2&F3) and 33(F3&F4) with on average ¾ of the total sea days spend fishing there. ICES rectangles 34(F2&F3) cover on average ¼ of the effort. Since the introduction wing-type gears in 2008, its effort in ICES rectangles 34(F2&F3) is on average 50% of the total for these wing-type gears.

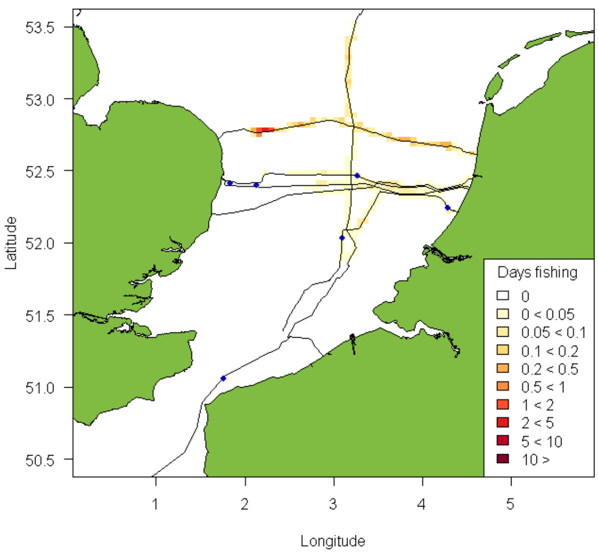
| Gear | Year | ICES rectangle | | | | | | | | Gear total | Total Slider +Wing |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Slider** | | **32F2** | **32F3** | **33F1** | **33F2** | **33F3** | **33F4** | **34F2** | **34F3** | | |
| | **2005** | 1600 | 3140 | 10 | 730 | 2430 | 1200 | 1180 | 1710 | 12000 | 12000 |
| | **2006** | 1340 | 2850 | 0 | 600 | 1970 | 990 | 1220 | 1470 | 10440 | 10440 |
| | **2007** | 1450 | 2450 | 0 | 540 | 1790 | 1310 | 1220 | 1130 | 9890 | 9890 |
| | **2008** | 1090 | 2110 | 10 | 470 | 1460 | 600 | 880 | 910 | 7530 | 7540 |
| | **2009** | 1150 | 1820 | 10 | 750 | 1260 | 870 | 1070 | 810 | 7740 | 8220 |
| | **2010** | 1430 | 1740 | 0 | 620 | 1220 | 940 | 590 | 570 | 7110 | 9170 |
| | **2011** | 1550 | 1380 | 0 | 660 | 1050 | 590 | 460 | 380 | 6070 | 9310 |
| | **2012** | 1590 | 1150 | 0 | 330 | 610 | 580 | 190 | 330 | 4780 | 8440 |
| | **2013** | 1530 | 1510 | 0 | 190 | 210 | 720 | 120 | 130 | 4410 | 9080 |
| **Wing** | | | | | | | | | | | |
| | **2008** | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 10 | |
| | **2009** | 0 | 30 | 0 | 10 | 30 | 10 | 290 | 110 | 480 | |
| | **2010** | 50 | 200 | 0 | 70 | 220 | 140 | 850 | 530 | 2060 | |
| | **2011** | 230 | 380 | 10 | 240 | 430 | 340 | 1020 | 590 | 3240 | |
| | **2012** | 430 | 450 | 10 | 290 | 520 | 420 | 920 | 620 | 3660 | |
| | **2013** | 390 | 700 | 0 | 340 | 870 | 490 | 1020 | 860 | 4670 | |

Table 1: Fishing effort (days at sea) per year in ICES rectangles 32F2, 32F3, 33F1, 33F2, 33F3, 33F4, 34F2 and 34F3 for slider and wing-type trawlers.

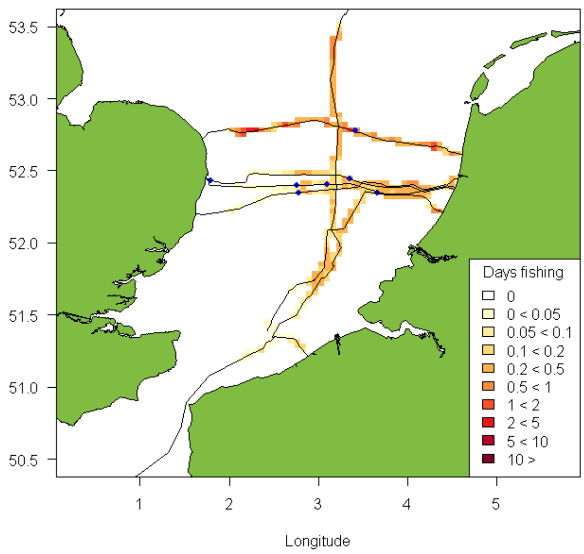
The constant and significant negative trend in slider trawler effort from 2005 to 2013, combined with the significantly higher cable fault occurrence from 2009 to 2013 and lack of additional aggregation behaviour in the vicinity of the observed cable disruption locations, leads to the conclusion that traditional slider-type trawling is not a factor to be considered when explaining the higher fault rate since 2009. Therefore the temporal frame of analyses of the cable faults is limited from 2009 up to 2013, following the development of wing trawling in the area.

To identify if there is a relationship between wing-type gear effort and cable disruptions, one also needs to look at those locations where wing-type gear effort is not associated with cable disruptions. Therefore, wing effort has been estimated for the full length of the communication cables, though bounded by the case study area. Figure 6 shows the annual effort on each of the communication cables in the years 2009 – 2013 for illustration purposes. In 2009, when wing effort was relatively low, most wing effort was located in the northern part of the study area, and covered partially the most northern West-East communication cable studied here. From 2010 onwards, wing effort increases and extends further south. Interpreting the map for 2009 indicates that there is no clear overlap between wing effort and cable disruptions. From 2010 onwards however, substantial wing effort is observed in the vicinity of the disruption locations. Figure 6 shows annual wing effort however, and may not show accurately the effort just prior to the cable disruptions that are observed throughout the year. For this reason, effort for the entire cable prior to each disruption is calculated as well. Results are given in Figure 7.

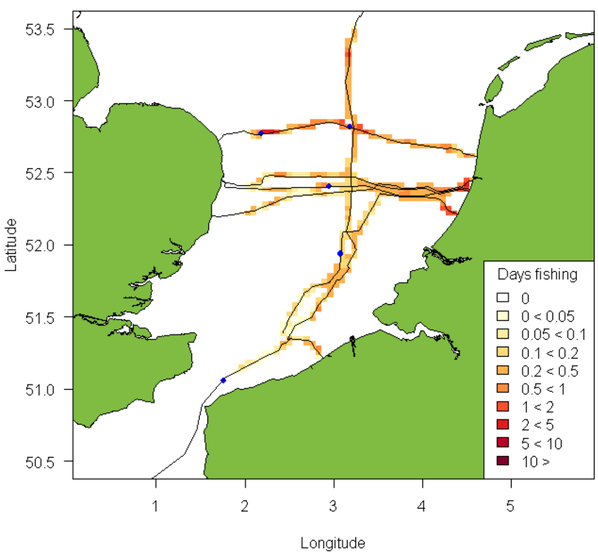
**Main effort distribution wing-type gears in 2009**



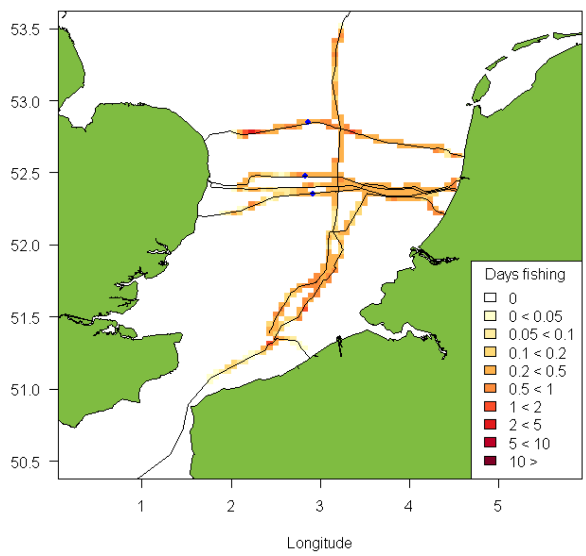

**Main effort distribution wing-type gears in 2010**




**Main effort distribution wing-type gears in 2011**




**Main effort distribution wing-type gears in 2012**



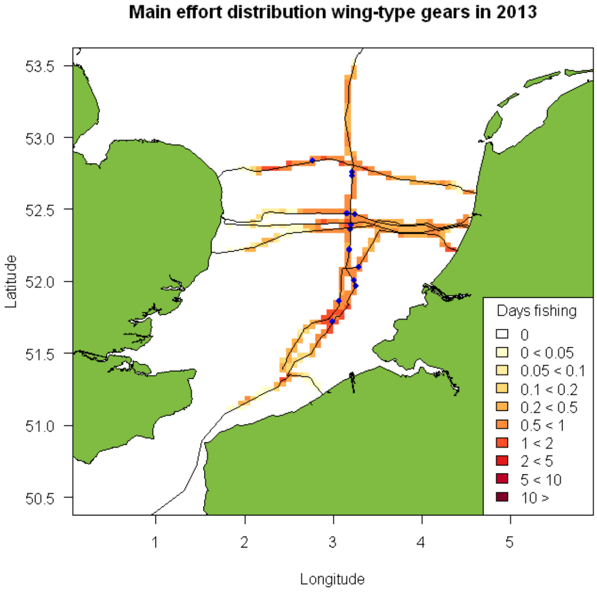



Figure 6. Maps of the wing trawler effort distribution around communication cables for 2009 to 2013. Breakpoints within the year of interest are given as blue dots.

The effort shown in Figure 7 is given for each 5km section. The figure shows that in 2009 wing-type effort was low, though increased towards the end of 2013. There seems to be a reasonable overlap between fishing effort and location of the disruption, indicating that cable disruption is not completely random. There is a lot of variability in effort prior to a cable disruption, even when focussing on the same cable which has encountered a number of disruptions. For example, the effort on cable 2 varies considerably over time and 5km section.

There are a number of breakpoints however (number 2-5, out of 42) which had no wing or slider-type effort associated at all and are therefore not shown in Figure 7. Fishing activity by the Dutch beam-trawl fleet is likely not a cause of these cable disruptions.

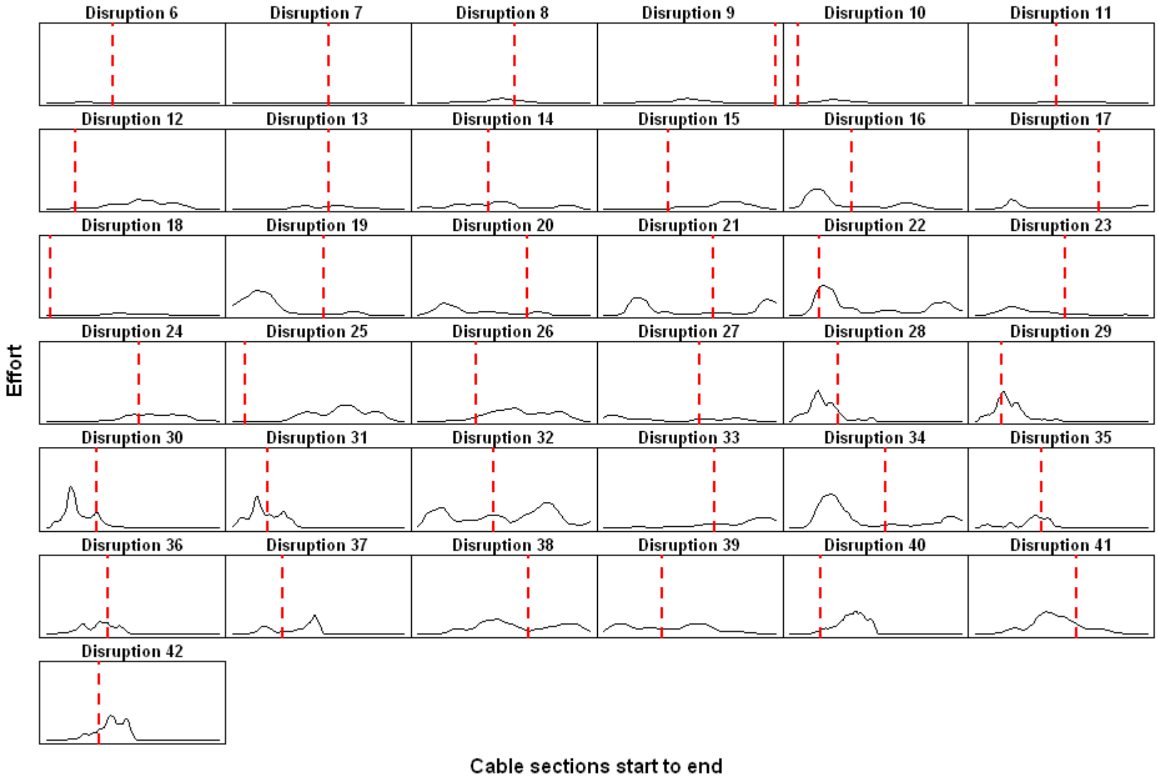



Figure 7. Effort of wing-type gears as estimated for the entire length of the communication cable (where the cable has been subdivided into 5km sections). Either ends of the horizontal axis represent the start and begin point of the communication cable (coast to coast, irrespective of the direction). The location of the disruptions are given by the red dashed line. The black line indicates the amount of effort along this cable from start to end point.

To finally test if the effort at the breakpoint sections is higher than at other locations along the same cable, an analyses was performed in which the effort at the breakpoints (intersection of red dashed line with black line, see Figure 7) was paired to effort at a random location along the same cable (any position of the black line, see Figure 7). The mean effort at all disruption locations combined, and variance among all disruptions, is given in Figure 8 as the shaded boxplot. The paired effort of those cable sections where no cable disruption occurred is given in the white boxplot. The figure shows clearly that mean effort at the breakpoints is higher than mean effort of the random cable sections, especially in 2013.

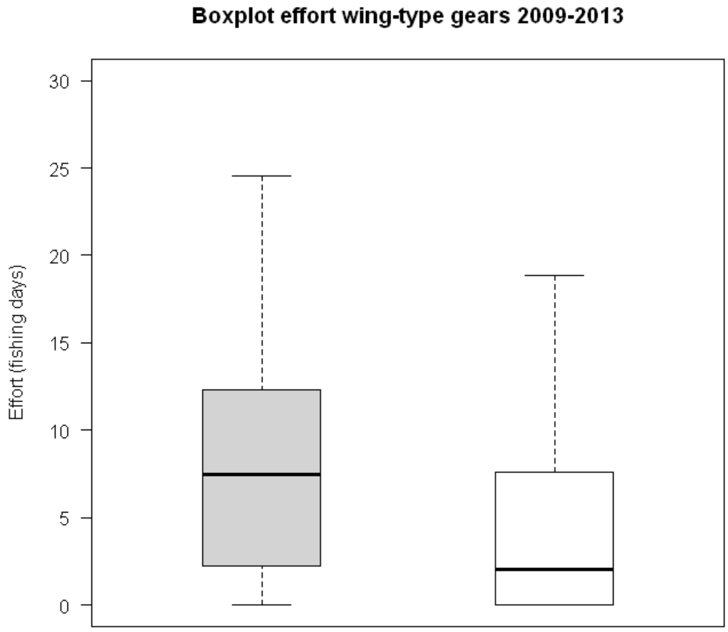



Figure 8. Effort as estimated at the breakpoint locations (shaded grey) and at random locations on the communication cables (white). Mean effort is given in a black solid horizontal line while the boxes indicate the 1st and 3rd quantile. The dashed lines indicate 1.5 times the 1st and 3rd quantile distances.

Estimating if these boxplots are significantly different would require a complex statistical analyses. As this is outside the scope of this study, a simple approximation method has been applied. In this case one random sample (1 out of 100) was taken for which the mean effort equalled the mean out of the 100 random draws. This series, which consists of an effort estimate at 37 random locations was compared with the disruption effort series. The statistical analyses shows that they are not significantly different from each other ($p < 0.2$, assuming p values lower than 0.05 to indicate significance). The comparison is shown in Figure 9 where effort is given for each pair of disruption and random cable effort.

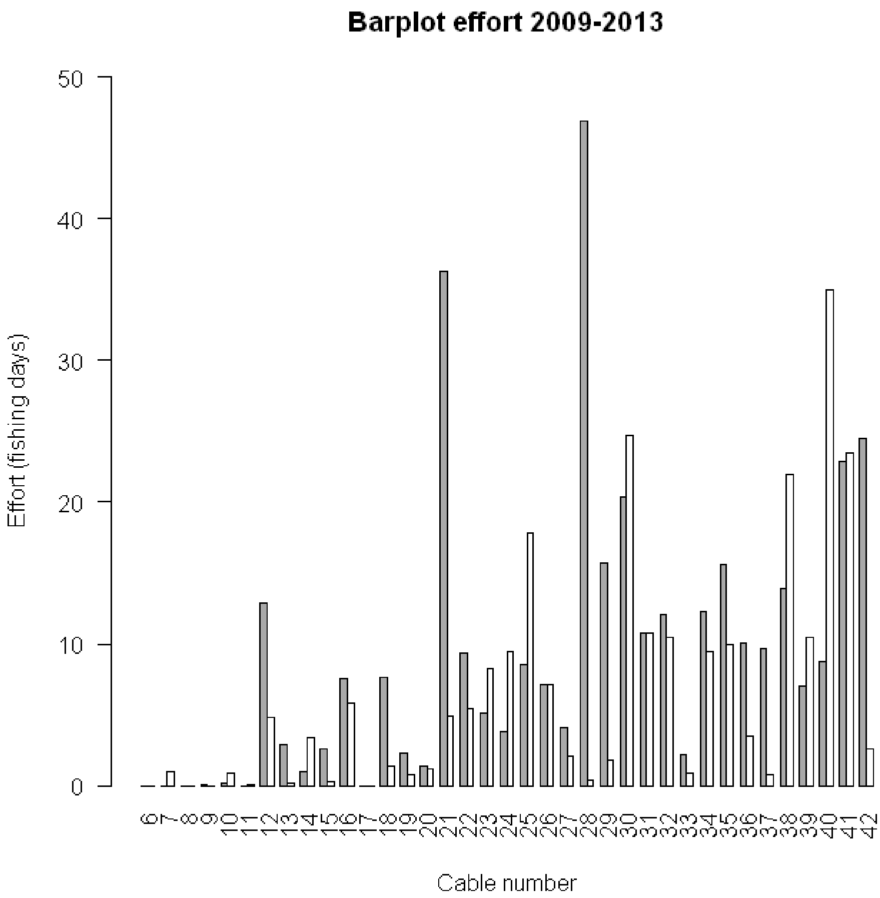



Figure 9. Effort-pairs for each disruption and random cable effort sample. Effort at the disruption locations is given in light-grey while effort at a random location on the same communication cable is given in white.

Whether the last gear passage before the cable broke could be related to either slider-type or wing-type gears, has been investigated. The results are presented in Figure 10 which shows for each of the cable disruptions since 2009 up to 2013 if wing or slider effort was present in the vicinity of the disruption. For only 14 out of the 37 disruptions considered, there is a considerable chance that wing-type fishing has crossed the communication cable at the location of the breakpoint. In 8 out of the 15 breakpoints in 2013 however there is a reasonable chance that wing-type gears are associated with the last fishing gear crossing before the cable broke. Remarkable is the lack of any slider-type gear effort at any of the locations studied.

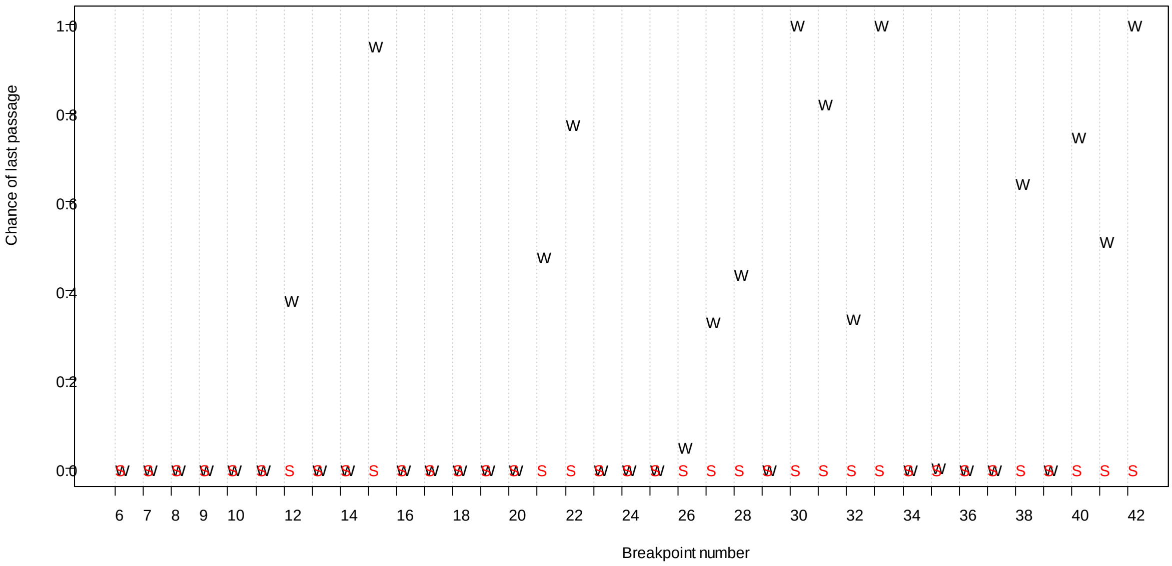



Figure 10. Chance of last passage in vicinity of the cable disruption locations for wing-type and slider-type gears. Chance by slider-type gears are given in red and denoted by ‘S’. Chance by wing-type gears are given in black and denoted by ‘W’.

## 5. Conclusions

The results indicate clearly that the number of cable disruptions, comparing the period before the introduction of the wing-type gears with the period after introduction, has significantly gone up. Whether these disruptions are caused by fishing activity cannot be stated with certainty and was outside the scope of this study. The current study investigated, in case these disruptions were caused by bottom fishing activity, if the recent shift by the Dutch fishing fleet from traditional slider (shoe) type gears to wing-type gears could be correlated to the increase in cable disruptions.

With reasonable degree of certainty we can conclude that the traditional slider-type beam-trawl fishery cannot be seen as a likely explanation of the recent increase in cable disruptions. Fishing effort of this fleet-type has significantly gone down in recent years, also in those areas where the cable disruptions were located. In addition, when investigating fishing trawl passages very close in both time and space from the cable disruptions, no slider activity could be found to have taken place.

There is no direct relationship between the number of cable disruptions caused by year and the amount of effort executed by wing-type gears. Information presented by the client after the analyses of the study were performed indicated however that even more cable disruptions had taken place over 2010-2013. There are indications that wing effort however may be correlated to the increase in cable disruptions. The amount of effort found directly around the cable disruption locations is higher, though not significantly, than the effort found on other cable sections. If more disruption locations become available for analyses, the conclusions may change. 14 out of 37 cable disruptions could directly be linked to substantial wing effort in close vicinity of the cable disruptions.

One of the main reasons no significant relationship between wing effort and cable disruptions could be found is the lack of data. It is likely that over time, when more information on cable disruption locations becomes available or when additional reports on cable disruptions over 2010-2013 become available, significant relationships between wing effort and cable disruptions can be found. It should be noted that the statistical model used to test for significance would require refinement, to e.g. account for inhabitable areas, the statistical distribution of chance of a cable disruption and sensitivity to assumptions made regarding time and space window through which fishing effort was ‘assigned’ to a disruption location.

Furthermore, interpretation of the results should be taken with care. No causal relationship between wing-effort and cable disruptions could be found. Even though it is likely that both relate, VMS or other spatial data such as AIS (Automatic Identification System, a GPS transponder on-board fishing vessels transmitting a signal every 2-3 seconds) cannot be used to link vessel presence to cable disruptions as other (environmental or human) factors may have an effect as well. The low temporal resolution provided by VMS (one ping every two hours) limited the accuracy of our analyses. Using interpolation and confidence interval techniques did improve the understanding of fishing activity in close vicinity of the cable disruptions. Further in-depth analyses would require however high spatio-temporal data such as AIS, to study with more precision the exact fishing trawl tracks. One of the major drawbacks of AIS is the lack in coverage however. Previous analyses by the authors indicated that in over 50% of fishing trips, AIS was turned off. Fishermen are, by law, allowed to turn AIS off if turning it off results in a safer environment for the fishermen. In all other occasions, it is obligatory to have AIS turned on. It is unknown how controlling agencies enforce that AIS is only turned off under dangerous situations. Overall, bias in effort could easily be introduced when measures to account for lack of AIS data are not incorporated.

For a number of disruptions, no wing or slider-type fishing activity could be linked. For example, the first breakpoint reported in 2004, breakpoint 11, the last one in 2009, could both not be linked to either wing or slider effort. The cause of cable disruption for these and other instances may have different explanation than fishing activity by the Dutch fishing fleet. Either UK beam-trawl vessels (flag vessels), Belgian vessels, though more limited in number, otter-board fishery or disruptions caused by anchors could be considered potential causes. For two of these disruptions, the client indicated that those disruptions were indeed caused by anchors. In case of shunt faults, the time of a damage report may differ substantially from the time of the last trawl passage. Under a shunt fault, the cable insulation gets damaged, and seawater directly makes contact to the metallic core of the cable, causing short circuit. To what extend cumulative trawl passages may contribute to an eventual disruption, indicating that the older cables become, the more cable disruptions may be expected, could of importance as well. However, cumulative damages that after several impacts result in cable disruptions are seen as an unlikely explanation according to the client. In case of shunt faults however, accumulation may occur before a damage is recorded.

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

## References

Poos, J.J. and Rijnsdorp, A. D. 2007. The dynamics of small-scale patchiness of plaice and sole as reflected in the catch rates of the Dutch beam trawl fleet and its implications for the fleet dynamics. Journal of Sea Research, 58: 100-112.

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.

## Justification

Report C117/14-A
Project Number: 4301107301

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

Approved: MSc. P. Molenaar
Researcher

Signature:

Date: 1 July 2015

Approved: Dr. ir. N.A. Steins
Head Fisheries Department

Signature:

Date: 1 July 2015

## Appendix A. Screening time & space window to link fishing effort to breakpoint

Wing-type gear effort was linked to each disruption location separately by assuming that all VMS pings in a range of x km and y days could be attributed to the disruption. The figure below shows a screening of 15 km steps and 10 temporal steps and the amount of effort that would be linked within the respective time-km window. Effort is log transformed. Each coloured cell in the figure below shows the amount of effort per km and time block. Whenever a cell is white, no effort was observed. Darker green indicates larger amounts of effort, darker purple indicates lower levels of effort. All effort cumulated between 0-15km and 0-30 days has been used as the most optimal time-space window in the analyses.

## Appendix B. Effort per cable disruption

Number of VMS pings (each representing 12 minutes) linked in a 30 day and 15km window to each of the breakpoints.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Breakpoint** | 1 | 2 | 3 | 4 | 5 | 6 |
| **Effort** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Breakpoint** | 7 | 8 | 9 | 10 | 11 | 12 |
| **Effort** | 0 | 179 | 0 | 0 | 129 | 32 |
| **Breakpoint** | 13 | 14 | 15 | 16 | 17 | 18 |
| **Effort** | 270 | 347 | 47 | 669 | 123 | 0 |
| **Breakpoint** | 19 | 20 | 21 | 22 | 23 | 24 |
| **Effort** | 164 | 138 | 397 | 3939 | 227 | 763 |
| **Breakpoint** | 25 | 26 | 27 | 28 | 29 | 30 |
| **Effort** | 2 | 377 | 417 | 1871 | 4593 | 1989 |
| **Breakpoint** | 31 | 32 | 33 | 34 | 35 | 36 |
| **Effort** | 2254 | 1053 | 571 | 833 | 1324 | 1084 |
| **Breakpoint** | 37 | 38 | 39 | 40 | 41 | 42 |
| **Effort** | 926 | 704 | 792 | 509 | 1396 | 1934 |