Investigation into fishing activity near offshore pipelines

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Summary

On the North Sea bottom lie numerous pipelines to link oil- or gas offshore drilling units, - platforms and processing stations on land. Although pipeline tubes are coated and covered with protective layers, the pipelines risk being damaged through man-made hazards like anchor dropping and fishing activities with bottom trawls.

Fugro Survey B.V. works towards integrated risk assessment of pipelines for amongst others TAQA Energy B.V. Spatial maps of fishing activity would contribute to this risk assessment. Therefore, IMARES was tasked to quantify the amount of fishing activity in the vicinity of TAQA Energy B.V. pipelines. Fishing activity has been quantified at a spatial scale of ~ 68m by 56m blocks using fishing Vessel Monitoring System (VMS) data for 2012.

The results in this study show that small beam-trawling vessels are active within, and just outside the 12 mile zone around the pipelines. In total, between 0 and 8 minutes of trawling is accumulated over the whole of 2012 within each spatial block of 68m by 56m. For the larger beam-trawlers, only present outside the 12 mile zone, in total between 0 and 2.5 minutes per 68m by 56m block of trawling is accumulated. A conversion of these numbers to fishing intensity, a measure for number of times a block is fully trawled, shows that sections of the pipeline are trawled between 0 and 2.5 times a year. This fishing intensity is below the range of 5-10 times a year indicating the most intensively fished areas of the North Sea.

The indicators calculated in this study, reflecting number of potential interactions (fishing effort) of fishing vessels with the pipelines and the potential severity of these interactions (fishing intensity), may contribute to the risk assessment. It should be noted, however, that owing to seasonal changes in fish distribution and yearly changes in fishing gear characteristics, these maps do not provide an accurate base for the prediction of future fishing impact.

1. Introduction

On the North Sea bottom lie numerous pipelines to link oil- or gas offshore drilling units, -platforms and processing stations on land. Although pipeline tubes are coated and covered with protective layers, the pipelines risk being damaged through man-made hazards like anchor dropping and fishing activities with bottom trawls. Although positions of most pipelines are known (position of older pipelines may be less accurate) an avoidance strategy of the fishing fleet is lacking. Over the past decades, around thirty hits by fishing gear were recorded that resulted in pipeline leaks. Each leak caused by a hit by fishing gear may be associated with substantial environmental and economic risks. Identifying these risks may therefore be important in the overall risk assessment of offshore oil- and gas production activities.

Identifying where fishing operations are most dominant around pipeline tracks at the sea bottom can support additional and better targeted surveying operations, executed by Fugro, to check the integrity of pipelines. Survey results may, in combination with risks of fishing impact, result in tailored approaches to further protect pipelines from impacts or improve the design and position of new pipelines.

Fugro requested IMARES to investigate bottom fishing activity near TAQA Energy B.V. pipelines based on VMS (Vessel Monitoring by Satellite) information of the Dutch fishing fleet, giving information on the spatial and temporal distribution of fishing vessel activities.

This study provides, as a proof of concept, a map of fishing intensities in a buffer area around the pipelines that can be used in a GIS application by Fugro to assess risks and advise TAQA Energy B.V. on e.g. additional survey activities. The addition of a fishing intensity layer to the procedure currently applied by Fugro may improve the overall risk assessment for pipeline damages.

2. Assignment

Within this study, we quantify the amount of fishing effort that is allocated at or close to a selection of pipelines by Dutch bottom fishing vessels. In the quantification, measures of uncertainty in the data collected that represents fishing activity, are directly implemented. The final product is a shape file, containing the pipeline trajectories including a buffer area, and the associated fishing effort and intensity within these areas at a precision level of 68m * 56m grid cells.

3. 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 bottom gear types like beam trawlers (referred to with code TBB), otter trawlers (OTB), dredges (DRB and HMD) & Scottish seines (SSC), showing VMS signals around the pipelines track [between latitudes 51.7 and 52.6;longitudes 3.2 and 4.6] are selected (gears such as gillnets or midwater trawls are not taken into account given their limited to non-existing contact with the seabed when in operation).
- Only VMS and logbook data for the entire year 2012 are used.

<u>Define fishing activity:</u>

- 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, depending on the gear used by the vessel. 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.

<u>Increase spatio-temporal resolution:</u>

- 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. Although on a yearly basis this amounts to a vast amount of spatial data, for studies such as the current one, additional detail is required to appropriately link a pipeline route to crossing fishing vessels activities. For this purpose, an interpolation routine is used which estimates intermediate locations between two successive VMS pings. The routine used in this study is described in detail in Hintzen *et al.*, 2010. On average, an additional 700 points are added in between two successive VMS pings which are by default two hours apart, resulting in a dataset with pings every 10 seconds apart.

<u>Define area of interest:</u>

- In total 60km^2 pipeline trajectories were identified that needed investigation in this study. They are located in the North Sea coast within the ICES rectangles 32-33/F3-F4 (see Figure 2). The study area has further been divided into small squares (a grid) of ~68x56 m blocks to allow for more detailed spatial analyses.

<u>Link pipeline location to fishing effort:</u>

- We assume that a pipeline hazard may be caused by a build-up of smaller damage events caused by passages of active fishing vessels using bottom gears. The exact route of fishing vessels is however uncertain given that only every 2 hours exact vessel position data is collected. Therefore, the increased spatio-temporal resolution improvements have to be made. This however, does not account for uncertainty in this interpolation method. Additionally we assume that activity is certain at the locations from which a VMS ping was send to the satellite, but certainty decreases in between these time stamps and decreases further away from the interpolated track. This together creates a 2-dimensional confidence interval for each fishing vessel movement, which can be scaled to represent 2 hours of fishing in total. Figure 1 gives a graphical representation of the interpolation and confidence interval calculation.

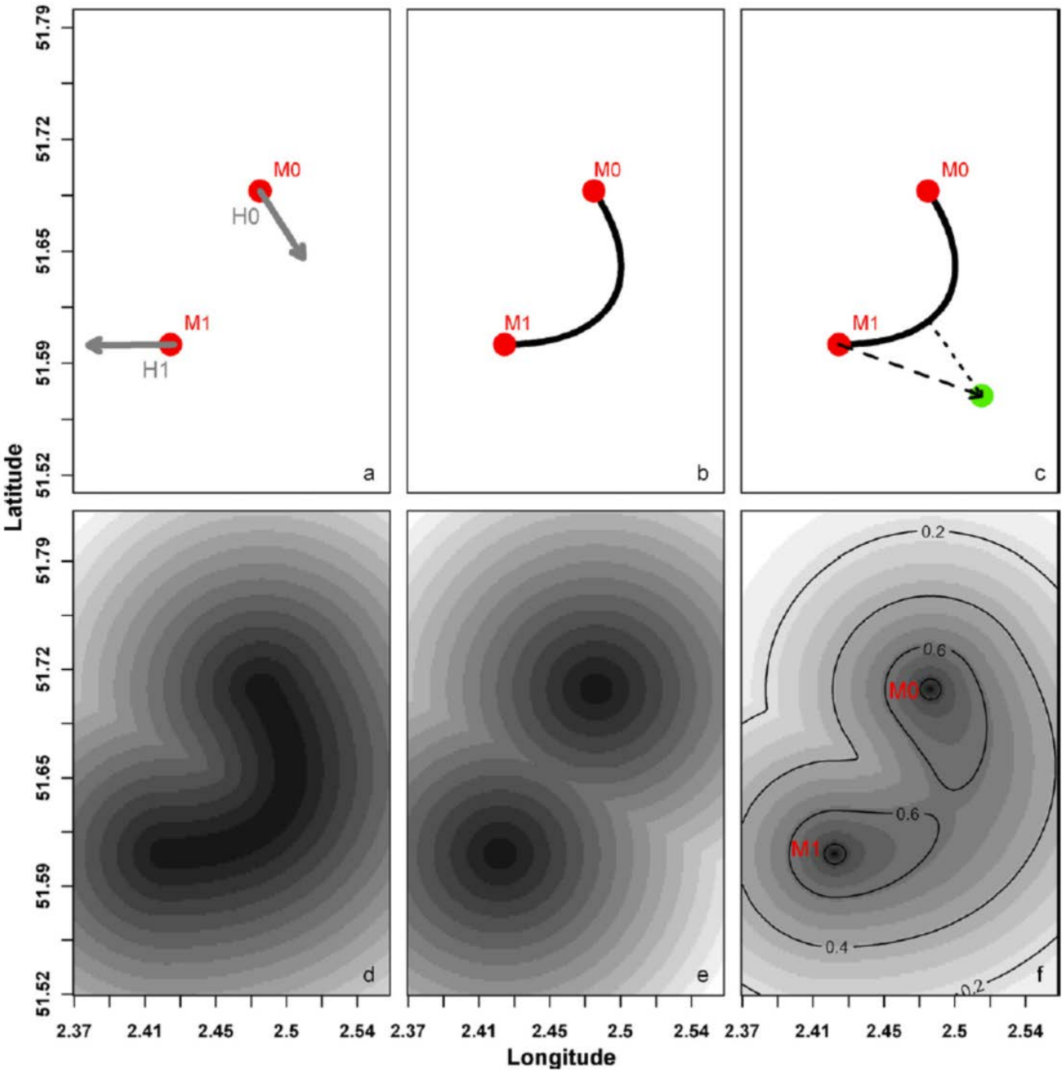


Figure 1. Schematic representation of the interpolation process starting with two succeeding VMS position registrations towards an estimated track surrounded by a confidence interval. (a) The start and end point of the vessel are represented by M0 and M1 respectively, the heading of the vessel at start- and end-point are represented by the small arrows H0 and H1. Based on the value of a scaling parameter these arrows become longer/shorter influencing the curvature of the interpolation (see panel b). For small values of this parameter, the interpolation will approximate a straight line between M0 and M1. (b) Interpolated track based on cubic Hermite spline (black solid line). (c) The parameter DSD for a random point on a grid (green dot) depends on the distance marked by the dashed arrow (black dashed arrow) from M1 to the green dot. (d) Shortest distance from each point on a grid to the interpolated track. Lighter grey represents more distant grid cells. (e) Shortest distance from each point on a grid to either M0 or M1. Lighter grey represents more distant grid cells. (f) Interpolation between two succeeding VMS data points surrounded by a confidence interval. At positions M0 and M1, values equal one.

Note that each grid cell then represents a certain amount (measured in minutes) of fishing activity. This uncertainty is calculated assuming a grid of 68x56m blocks. By cumulating the fishing effort of all vessels of the fleet under consideration, the grid cell values reveal detailed spatial information of fishing activities during a year. By multiplying the fishing activity by gear with, and dividing by surface area of each grid cell, we calculate the fishing intensity. Finally, the pipeline location is overlaid onto the fishing activity grid to link the fishing effort to each pipeline location. A shape file is created containing the fishing activity by grid cell bounded by the pipeline trajectories.

4. Results

The area of interest and pipeline trajectories, as provided by Fugro, is shown in Figure 2. ICES rectangles are squares of 1 degree longitude by 0.5 degrees latitude and follow a naming convention that covers the entire North East Atlantic. Fisheries logbook data is recorded at the ICES rectangle level. It is therefore that the study focusses on three ICES rectangles in the vicinity of the pipelines.

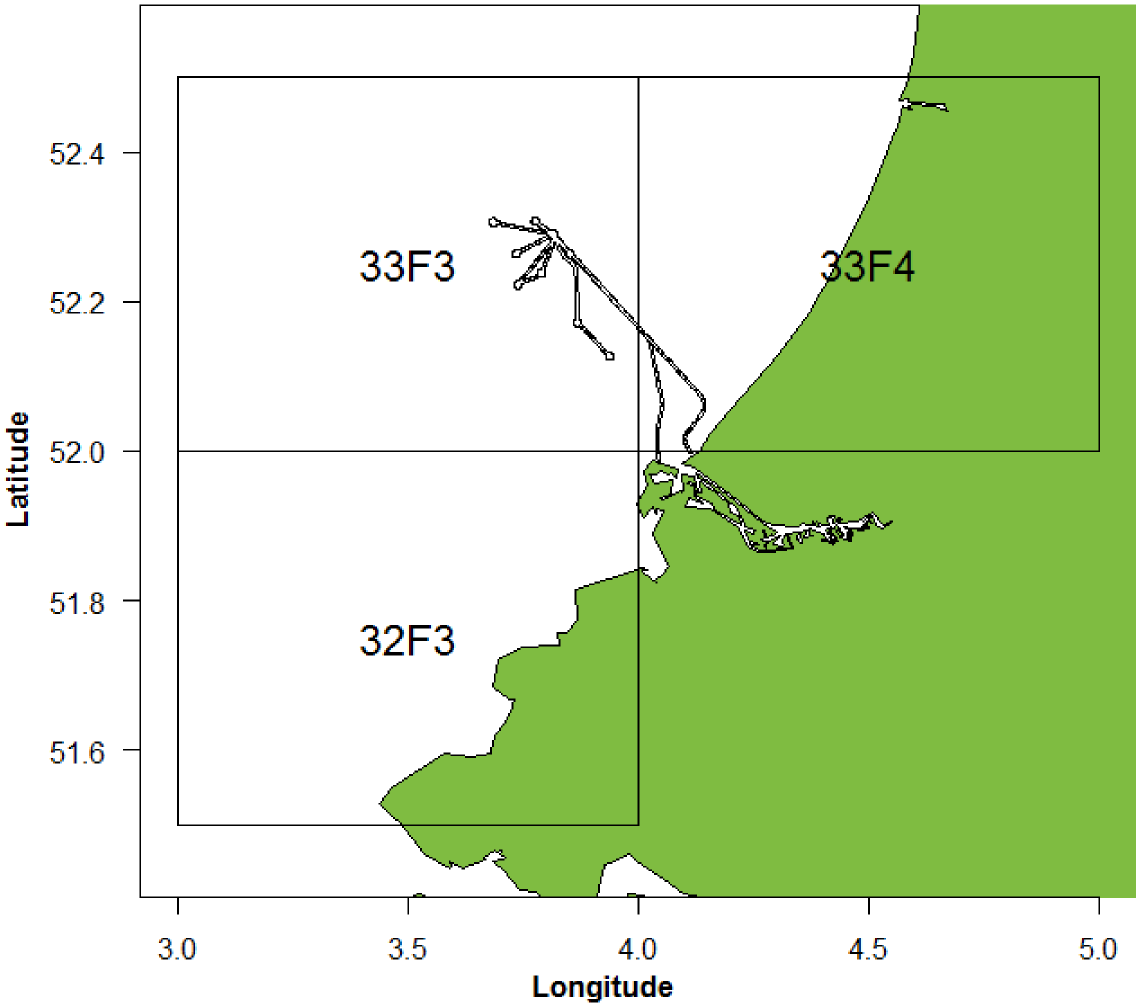
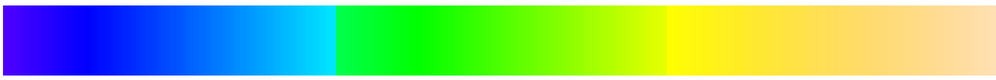


Figure 2. Dutch North Sea coast and locations of pipelines (buffer area around pipelines is given by black lines) overlaid with 3 ICES rectangles (black straight lines).

The Dutch fishing effort in the area of interest in 2012 is mapped in figure 3. The colours used are shown in the palette below:



Dark blue grid cells show the highest fishing intensity and reduced to green, yellow(ochre). The actual values are shown in the palettes right of the figures.

Figures 3-5, 7 show fishing effort of all gears, the beam-trawlers separately and fishing intensity for all gears respectively. Fishing effort is given as total amount of minutes fishing vessels were fishing in each grid cell of 68m X 56m. Fishing intensity is given as the total number of times a grid cell is fully trawled, i.e. total area trawled per grid cell divided by the surface area of a grid cell.

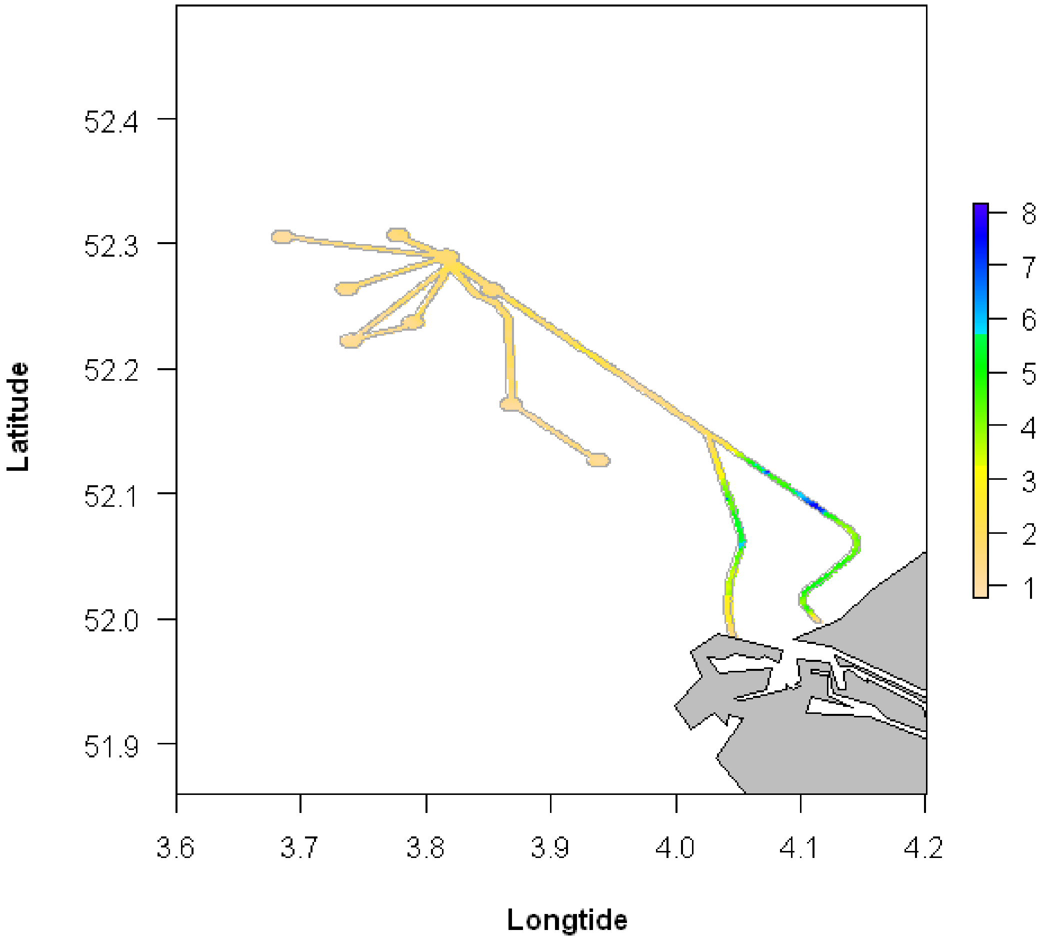


Figure 3. Fishing effort grid-map of all bottom trawlers in 2012. The grid cell dimensions are 68*56 m and the colour indicates the total amount of fishing effort in minutes (see palette). The buffer area around the pipelines are also shown (grey lines).

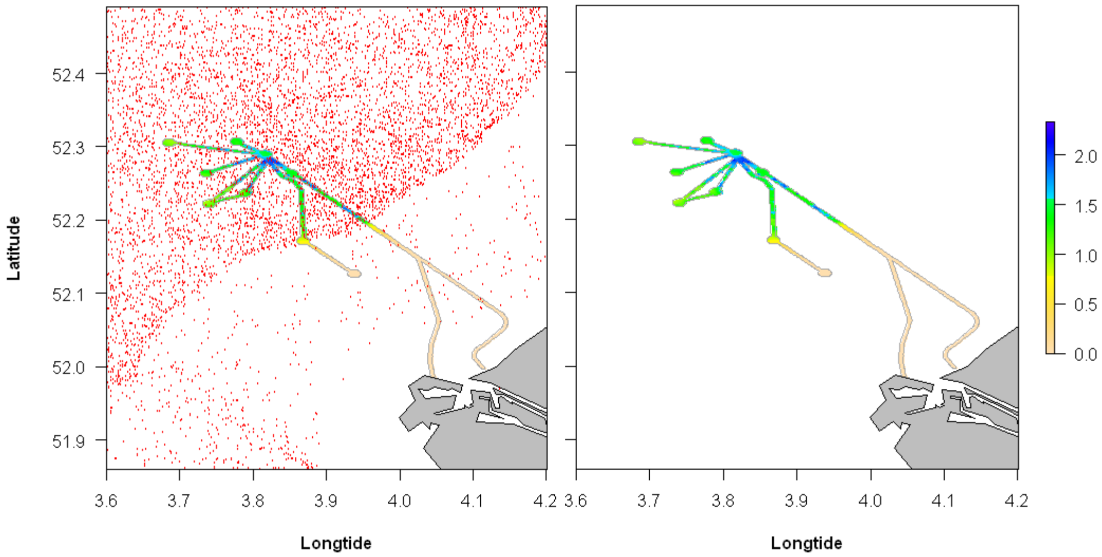


Figure 4. Fishing effort grid-map of large bottom trawlers (TBB, >300hp, restricted to fish outside the 12 mile zone) in 2012. The grid cell dimensions are 68*56 m and the colour indicates the total amount of fishing effort in minutes (see palette). The buffer area around the pipelines are also shown (grey lines). The left-hand figure also shows the VMS pings are recorded in 2012.

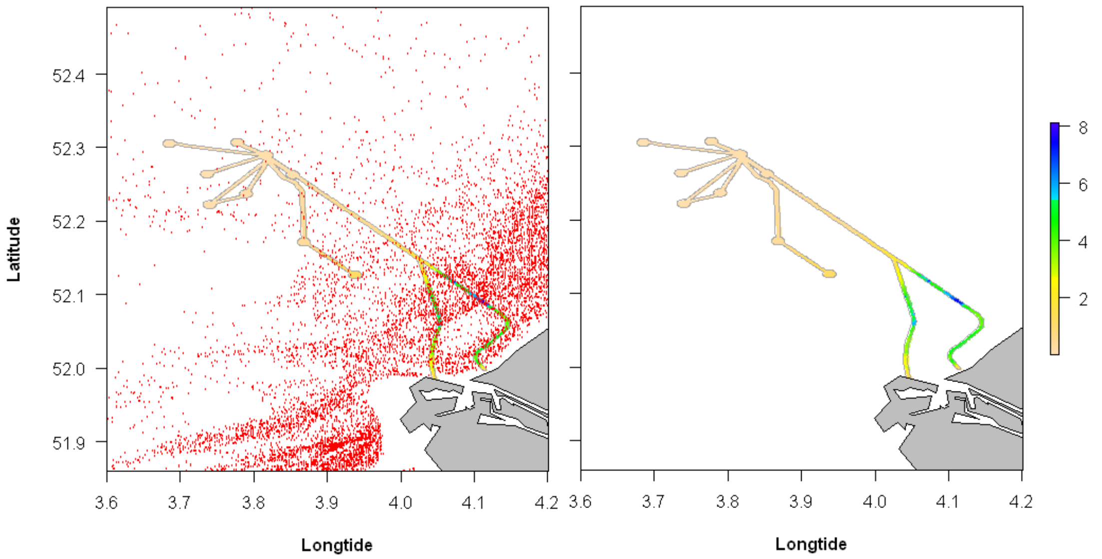


Figure 5. Fishing effort grid-map of small bottom trawlers (TBB, <300hp, are allowed to fish inside the 12 mile zone) in 2012. The grid cell dimensions are 68*56 m and the colour indicates the total amount of fishing effort in minutes (see palette). The buffer area around the pipelines are also shown (grey lines). The left-hand figure also shows the VMS pings are recorded in 2012.

Note that in Figure 4 (left-hand side), VMS pings are also located inside the 12 mile zone, an area not open for larger beam-trawlers to fish. These points indicate misclassification of fishing activity, owing to low speed steaming activity being picked-up as fishing activity. Given the low density of these points, they are considered to be negligible for the interpretation of the final results.

In the area examined the fishing effort found originated mainly from beam-trawlers. The overall mean of total fishing effort per grid cell (n=15000) is 2.29 minutes. The mean of the effort of beamers was 1.37 minutes per grid cells for small beam-trawlers (<300hp, TBB) and 0.89 minutes for large beam-trawlers (>300hp, TBB). The contribution of the remaining bottom gears is less than 2% of the total.

The frequency distribution of the total fishing effort for grid cells around the pipelines and the activity of the two beam-trawler categories is shown in figure 6.

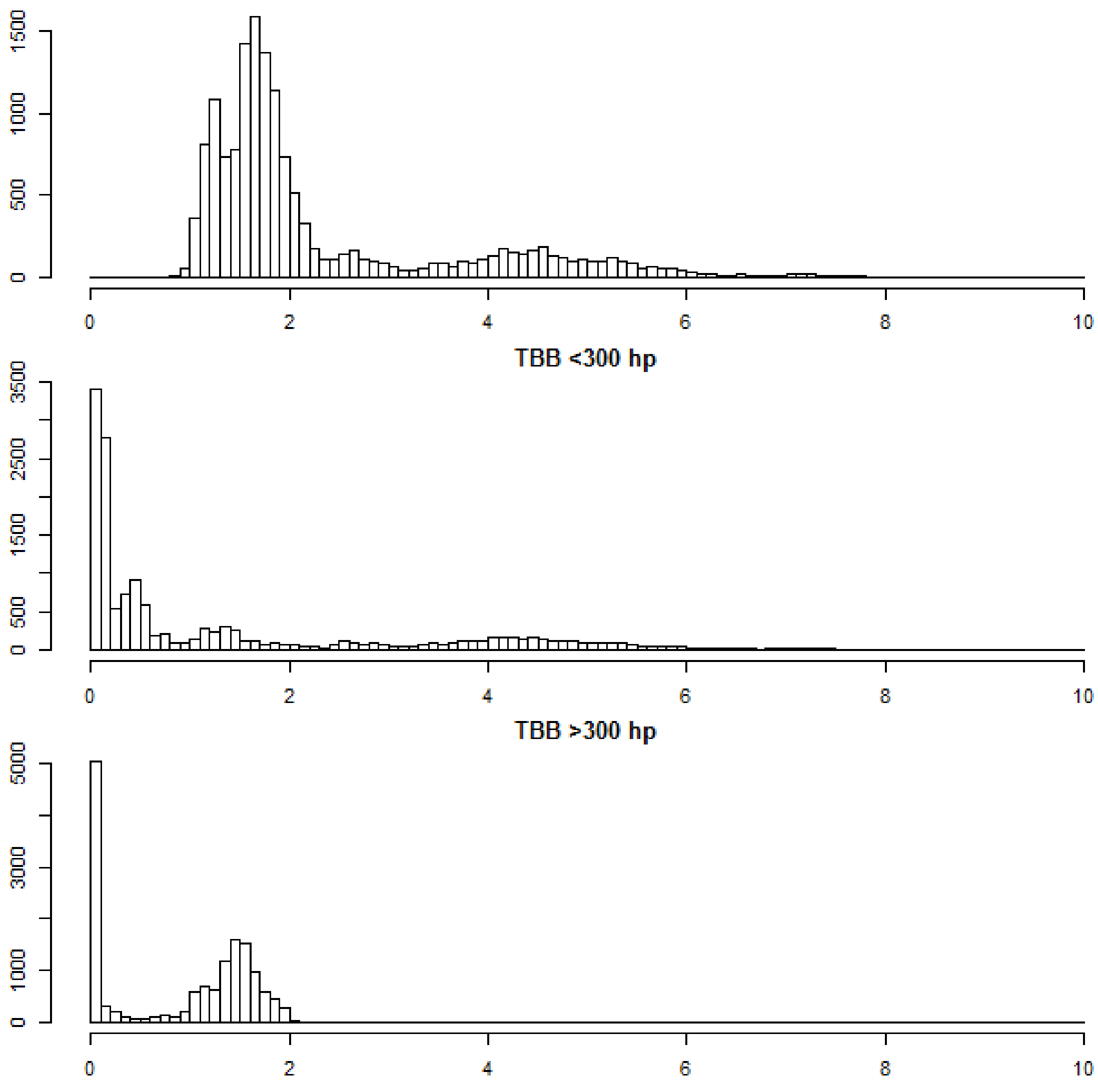


Figure 6. Histograms of (top:) the total fishing effort (measured in minutes per 68m x 56m grid cell) covering the pipelines trajectories, (middle:) small beam-trawlers (<300hp, TBB) and (below:) large beam-trawlers (>300hp, TBB) in the area around the pipelines.

The overall total fishing effort in 2012 along the pipeline trajectory ranges from 0.79 to 8.16 minutes per grid cell per year and is the result of combining the two beam-trawl fleet activities. The spatial distribution by beam-trawl effort depends on the vessel size. The smaller beam-trawl vessels are active within the twelve-mile coast zone while larger beam-trawlers are banned from this area. The fishing effort of small beam-trawlers ranges from 0.023 to 8.14 minutes and shows several modes. The fishing effort of large beam-trawlers ranges from 0.000 to 2.34 minutes and shows 2 clear modes at 0.05 and 1.5 minutes presence in a grid cell.

Fishing intensity for all gears is shown in figure 7. Here, fishing speed and fishing gear width is taken into account. The smaller beam-trawl vessels fish at lower speeds (around 3knots) with gears of approximately 9m wide. The larger beam-trawl vessels fish at higher speeds (around 6knots) with gears of approximately 24m wide. Therefore, fishing intensity does not scale similar to fishing effort, which is shown in figure 7 where the intensity is highest in the area where larger beam-trawlers are active. The fishing effort figure (figure 3) showed that more effort is allocated by the smaller beam-trawlers and thereby showing a markedly different pattern. In 2012, fishing intensity ranged between ~0.2 to just above 2.8 times per year. This means that, at most, each area of 68m X 56m was trawled 2.8 times. North Sea wide, fishing intensities up to 10 times a year are recorded while commonly intensities around 5 times a year are measured.

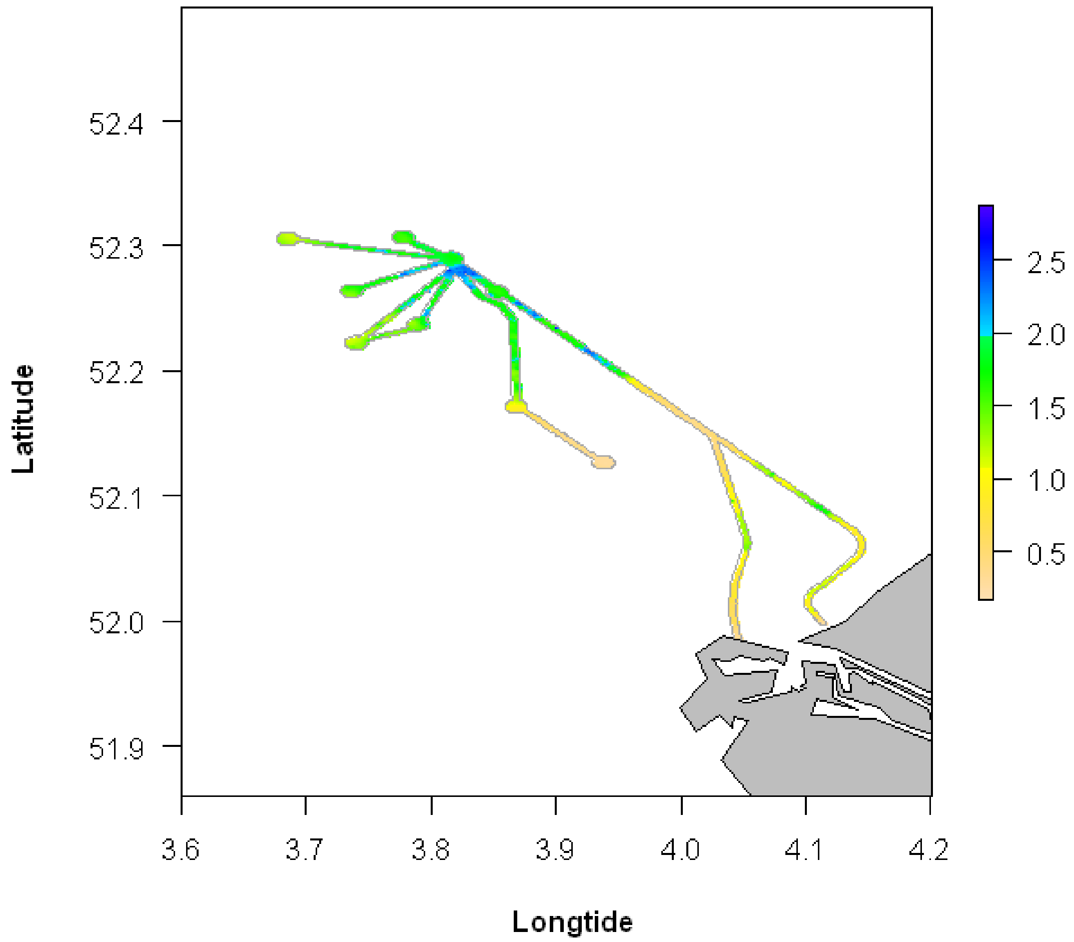


Figure 7. Fishing intensity grid-map of bottom trawlers (TBB). The grid cell dimensions are 68*56 m and the colour indicates the fishing intensity in number of times a full grid cell has been trawled (see palette). The buffer area around the pipelines are also shown (grey lines).

5. Discussion and conclusion

The result from this study provide a clear ‘proof-of-concept’ on how fisheries data can be prepared and made available for integrated risk assessment of oil and gas pipelines.

The results show that the fishing activity of the beam-trawl fleet are most relevant in the study area, and that fishing activity of otter trawlers, seines and dredges is minimal. The beam-trawlers account for 98% of all fishing effort in the study area. From a risk perspective, these gears may be more important than otter trawlers or seines too, as they tow heavy gears over the seafloor while otter trawlers and seines tow much smaller metal plates or clumps over the seabed, limiting the amount of pipeline surface they can damage. Similarly, the beam-trawlers may be further divided into vessels operating traditional beam-trawlers, pulse-trawlers, sumwing or chain-mat trawlers. No information is available however on how much damage a small beam-trawl, a large beam-trawl or otter trawl gear would have on a pipeline. For this reason, all gears are treated similarly when expressing fishing effort indicators.

The figures that include VMS pings, clearly show that no obvious avoidance strategy for pipelines is in place. The distribution of VMS pings in close vicinity of the pipelines is similar to areas further away from the pipelines. No direct ‘attraction’ of fishing activity to pipelines could be observed either, but clear indications of this would require further in-depth analyses.

In this analysis, all types of fishing activity in the vicinity of the pipelines were taken into account, while it could be argued that only fishing tracks over pipelines would be relevant. Also, the direction by which pipelines may be crossed may have an effect on the potential damage / risk to pipelines. Indicators tailored to take direction of crossings into account could be obtained when using AIS data (Automatic Identification System, a GPS transponder on-board fishing vessels transmitting a signal every 2-3 seconds), which provides fishing activity information every 2-3 seconds. The limitations of AIS data, however, are described below. Using all available AIS data though will result in more precise spatio-temporal estimates of fishing activity around pipelines.

The uncertainty related to the long interval rate between successive VMS pings is directly taken into account in this study, here by making use of a confidence interval around potential fishing tracks. This results in a smoothed pattern of fishing impact on all pipeline segments, while it can be argued that the realized fishing intensity around the pipelines will be more scattered. Especially under longer time-periods, the realized fishing intensity and approximation shown in this report will converge however. Assumptions on data filtering and activity detection, and the sensitivity herein, have little effect on the final result as fishing activity can be estimated well.

The interpretation of fishing effort / intensity related to risk should be taken with care. No causal relationship between fishing effort and pipeline damages can be identified based on this type of data analyses. Even though it is likely that both relate, VMS or other spatial data such as AIS cannot be used to link vessel presence to pipeline damages 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 around pipelines. 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, however, the lack in coverage. 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.

Two types of indicators were shown, fishing effort and fishing intensity, and maps of these indicators differed substantially. Fishing effort provides a more suitable indication of fishing gear – pipeline interactions, while fishing intensity provides a more suitable indication of the impact fishing gear may have on pipelines. As it is unclear what type of interaction is associated with the highest risk, both indicators are provided here and should be considered simultaneously in an integrated risk assessment.

It should be noted that the fishing fleet distribution changes by season and by year, owing to seasonal changes in fish availability and changes in what types of gears are being used by fishers. Especially fishers who used to fish with large beam-trawls are known to have switched to new innovative gear types which weigh less and partially hoover over the seabed (pulse trawl, sumwing). These gears have only recently been introduced and new fishing grounds are still explored by these fishers. Therefore, maps of one single year may not accurately represent fishing activity in upcoming years. Repeating this exercise for a larger number of years is recommended to improve predictive accuracy of fishing activity in the vicinity of pipelines.

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.

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Justification

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

Approved: S.T. Glorius, MSc. BSc.
Colleague scientist

Signature:

Date: 19 February 2015

Approved: Dr. ir. N.A. Steins
Head of Fisheries department

Signature:

Date: 19 February 2015