BE AWARE

Bonn Agreement
Accord de Bonn

TREND ANALYSIS
Final report

Bonn Agreement
Accord de Bonn

Salvamento
Marítimo

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The Bonn Agreement area that covers the Greater North Sea and its wider approaches is one of the busiest and most highly used maritime areas in the world. With an ever-increasing competition for space, comes an increased risk of accidents that could result in marine pollution.

The first area-wide risk assessments of marine pollution in the Bonn Agreement area were carried out in the BE-AWARE I project that spanned between 2012 and 2014. These assessments were based on a common methodology that allowed the risks for marine pollution to be mapped and compared under different scenarios.

The outcomes from the BE-AWARE I project and the subsequent BE-AWARE II project have helped to improve disaster prevention by allowing North Sea States to better focus their resources on areas of high risk.

As a follow-up to the BE-AWARE I project, a trend analysis is being undertaken to provide an update and key insights on recent developments in ship traffic, accident statistics, spatial planning and their implications on the risk of marine pollution reported in the BE-AWARE projects for the Bonn Agreement area. Based on the appraisal of recent developments, the trend analysis explores the expected situation in 2030.

The present project is being financed by the Bonn Agreement Contracting Parties with additional financing from Spain (Salvamento Marítimo).

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1. Introduction

In the BE-AWARE I project that spanned between 2012 and 2014, the first area-wide risk assessments of marine pollution in the Bonn Agreement area were carried out. These assessments followed a common methodology and a harmonised approach that allowed the risks for marine accidents and pollution to be mapped and compared under different scenarios.

The BE-AWARE I project assessed the risk of oil spill (mineral oil) in the Bonn Agreement area for 2011 and also made a forecast of the expected risk in 2020. The successive BE-AWARE II project (2014-2015) assessed the fate of the spilt oil (drift, decay etc.) and its impact on the marine environment, i.e. the environmental risk. BE-AWARE II also assessed the effect of different risk management strategies including both preventive and response measures.

A trend analysis has now been undertaken with the purpose of providing an update on recent developments that will influence the marine accident and oil spill risk picture in the Bonn Agreement area as established in the BE-AWARE I project and providing an outlook to the expected situation in 2030.

The Bay of Biscay will become part of the Bonn Agreement after the formal adoption of the decision on the accession of Spain in October 2019 and the ratification process. Additionally, a simplified analysis to evaluate the oil spill risk picture in the Bay of Biscay has been therefore conducted as part of this trend analysis.

The tasks that have been carried out in this trend analysis in the project area are:

- Analysis of transport of oil (i.e. load state of tankers) based on two ports selected for this analysis – Hamburg and Mongstad
- Analysis of accidents and spills for the project area
- Development of AIS-based ship traffic descriptions for two transects selected for this analysis – one in the Channel and the other in the German Bight
- Assessment of recent and expected future developments regarding wind turbines
- Simplified analysis for the Bay of Biscay as additional area of interest
- Analysis of existing outlooks for development of ship traffic till 2030
- Establishment of key trends and insights into evolution of marine accident risk in the Bonn Agreement area today and in 2030 and comparison of results with forecasts made in the BE-AWARE I project

This report documents the results from the above analyses.

2. Scope

The overall geographical scope of the trend analysis is limited to the Bonn Agreement area, including the newly added Bay of Biscay area. Further specific limitation of the scope is done for the specific tasks of the trend analysis, and this is covered in the following chapters of this report. The project area is defined as the sea area as indicated in Figure 2-1.

Figure 2-1 Project area for trend analysis - this includes the Bay of Biscay area shown in light blue (Spanish part) and grey (French part) and the rest of the Bonn Agreement area shown in white and within the boundaries marked in orange.

As during the BE-AWARE I and II projects, inland waterways adjacent to the project area are not part of the scope. Inland waterways are understood as areas, which are only connected to the sea by a minor outlet (e.g. lagoons).

The focus of the present trend analysis is marine accident and oil spill risk in the Bonn Agreement area and therefore on incidents with particular emphasis on spills of oil transported in bulk.

Sabotage, terror and acts of war are not covered by the analysis.

3. Analysis of accidents

3.1 Scope

An analysis of shipping accidents and oil spills in the Bonn Agreement area is presented in this chapter. Accident summary statistics for the current BE-AWARE trend analysis are established for the period 2012-2018 by analysing shipping accident reports provided by the Contracting Parties in the Bonn Agreement area. The analysed results are compared with the corresponding results for the earlier period 2002-2011 that was covered in BE-AWARE I to determine trends in accident development.

Further, the present analysis is extended by the Bay of Biscay area. Records provided by the two countries responsible for this area (i.e. Spain and France) are analysed to establish accident statistics.

3.2 Data overview

The overview of the data received from all the Contracting Parties in the Bonn Agreement area is presented in Table 3-1.

Table 3-1 Overview of shipping accident data provided by countries

Country	Data collection period	Total number of records
Belgium	2015-2018	11
Denmark	2013-2018	49
France	2012-2018[1]	88
Germany	2012-2018	8
Ireland	2012-2018	42
Netherlands	2012-2018	36
Norway	2014-2018	1773[2]
Spain	2002-2018[3]	746
Sweden	2012-2018	70
United Kingdom	2012-2018	499

For consistent comparison, the same accident groups and ship types as used in BE-AWARE I are used in the BE-AWARE trend analysis. Accidents such as collisions, groundings, etc. caused by/during shipping activities as well as fire/explosion are included. Accidents and spills caused by non-shipping activities such as offshore activities, leakage of pipes, deliberate discharges, etc, are not considered in the present analysis. Further, accidents that involved vessels below 300 GT in size are not included in the analysis as for BE-AWARE I.

[1] Accident records for the French part of the Bay of Biscay area for the earlier period (i.e. 2002-2011) were not provided.

[2] Data from Norway includes also precursor events or possible threats (e.g. ship drifting/listing but not leading to or resulting in any accident) in addition to actual accidents. This is further elaborated in section 3.3.1.

[3] The period 2002-2011 (data period of BE-AWARE I) was included in the BE-AWARE trend analysis because the Bay of Biscay was not covered by BE-AWARE I. No accidents were reported in the period 2002-2004.

3.3 Analysis approach and results

This section presents the accident statistics for the Bonn Agreement area for the current period (2012-2018), which are then compared with the results from the BE-AWARE I period (2002-2011) in order to identify trends in the development of shipping accidents.

The analysis presented in this section focuses on changes in the annual number of accidents and spills. To obtain a complete picture, this needs to be considered together with changes in ship traffic (chapter 4). This integrated analysis is provided in chapter 9.

3.3.1 Accidents

Distribution of accidents by country and accident type

The number of shipping accidents within the Bonn Agreement area is estimated for each of the Contracting Parties – this can be seen in Table 3-2. As seen in Table 3-1, the data collection period varies across the Contracting Parties. To facilitate consistent comparison among countries with different data collection periods, the average annual number of accidents is therefore calculated and shown in Table 3-3. In both Table 3-2 and Table 3-3, the results obtained in this trend analysis are also compared with corresponding BE-AWARE I results.

At an overall level, the annual number of accidents in the Bonn Agreement area shows an increase from about 107 during 2002-2011 to 125 during 2012-2018. The reason for this increase is almost entirely due to a significant increase in accidents reported by Norway under the ‘Unknown’ category. Some individual variations in annual accidents are seen in Table 3-3 for the other countries, with an increasing trend seen for some and a declining trend for others. Based on further investigations carried out for the Norway data, it has been established that the Norwegian marine accident reporting system records also precursor events or possible threats (e.g. ship drifting/listing but not leading to or resulting in any accident) in addition to actual accidents – these have been grouped under the ‘Unknown’ accidents category and form a predominant part of this category. While precursor events/threats would be relevant in some contexts, since this analysis is concerned with actual accidents, such events can be excluded here. Unless stated otherwise, the analysis presented in this chapter excludes these ‘Unknown’ accidents.

To have an overall consistent basis, the number of accidents is compared after excluding ‘Unknown’ accidents for all countries – this can be seen in the last rows in Table 3-2 (total accidents) and Table 3-3 (annual accidents). This comparison shows that the annual number of accidents in the Bonn Agreement declined by about 30% from about 92 during 2002-2011 to 65 during 2012-2018, as also seen in Figure 3-1.

Table 3-2 Total number of shipping accidents per country and per accident type – Bonn Agreement area: BE-AWARE I and BE-AWARE trend analysis

	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Sweden	United Kingdom	Total
BE-AWARE I										
Time periods	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	
Collision with vessel	4	24	21	13	0	8	106	0	99	275
Collision with object	0	2	0	0	0	0	19	0	46	67
Grounding	3	21	6	18	0	0	268	1	110	427
Fire	1	11	3	6	0	0	38	1	63	123
Sunk other cause	1	0	5	1	0	1	0	0	1	9
Hull damage other cause	0	0	5	1	0	0	0	0	13	19
Unknown	0	0	3	10	0	0	94	0	42	149
Total reported accidents	9	58	43	49	0	9	525	2	374	1069
Total reported accidents w/o unknown causes	**9**	**58**	**40**	**39**	**0**	**9**	**431**	**2**	**332**	**920**
BE-AWARE Trend analysis										
Time periods	2015-2018	2013-2018	2012-2018	2012-2018	2012-2018	2012-2018	2014-2018	2012-2018	2012-2018	
Collision with vessel	7	3	8	1	0	7	14	2	17	59
Collision with object	1	1	0	0	1	1	17	0	13	34
Grounding	2	2	4	1	13	2	105	4	75	208
Fire	1	0	6	3	2	2	16	2	36	68
Sunk other cause	0	0	7	0	0	1	2	0	4	14
Hull damage other cause	0	0	0	0	0	0	0	0	0	0
Unknown	0	0	2	0	2	0	292	5	4	305
Total reported accidents	11	6	27	5	18	13	446	13	149	688
Total reported accidents w/o unknown causes	**11**	**6**	**25**	**5**	**16**	**13**	**154**	**8**	**145**	**383**

Table 3-3 Annual average number of shipping accidents per country and per accident type: BE-AWARE I and BE-AWARE trend analysis

	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Sweden	United Kingdom	Total
BE-AWARE I										
Time periods	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	2002-2011	
Collision with vessel	0.4	2.4	2.1	1.3	0	0.8	10.6	0	9.9	27.5
Collision with object	0	0.2	0	0	0	0	1.9	0	4.6	6.7
Grounding	0.3	2.1	0.6	1.8	0	0	26.8	0.1	11.0	42.7
Fire	0.1	1.1	0.3	0.6	0	0	3.8	0.1	6.3	12.3
Sunk other cause	0.1	0	0.5	0.1	0	0.1	0	0	0.1	0.9
Hull damage other cause	0	0	0.5	0.1	0	0	0	0	1.3	1.9
Unknown	0	0	0.3	1.0	0	0	9.4	0	4.2	14.9
Total reported accidents	0.9	5.8	4.3	4.9	0	0.9	52.5	0.2	37.4	106.9
Total reported accidents w/o unknown causes	**0.9**	**5.8**	**4**	**3.9**	**0**	**0.9**	**43.1**	**0.2**	**33.2**	**92.0**
BE-AWARE Trend analysis										
Time periods	2015-2018	2013-2018	2012-2018	2012-2018	2012-2018	2012-2018	2014-2018	2012-2018	2012-2018	
Collision with vessel	1.8	0.5	1.1	0.1	0.0	1.0	2.8	0.3	2.4	10.1
Collision with object	0.3	0.2	0.0	0.0	0.1	0.1	3.4	0.0	1.9	6.0
Grounding	0.5	0.3	0.6	0.1	1.9	0.3	21.0	0.6	10.7	36.0
Fire	0.3	0.0	0.9	0.4	0.3	0.3	3.2	0.3	5.1	10.7
Sunk other cause	0.0	0.0	1.0	0.0	0.0	0.1	0.4	0.0	0.6	2.1
Hull damage other cause	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.3	0.0	0.3	0.0	58.4	0.7	0.6	60.3
Total reported accidents	2.8	1.0	3.9	0.7	2.6	1.9	89.2	1.9	21.3	125.1
Total reported accidents w/o unknown causes	**2.8**	**1.0**	**3.6**	**0.7**	**2.3**	**1.9**	**30.8**	**1.1**	**20.7**	**64.8**

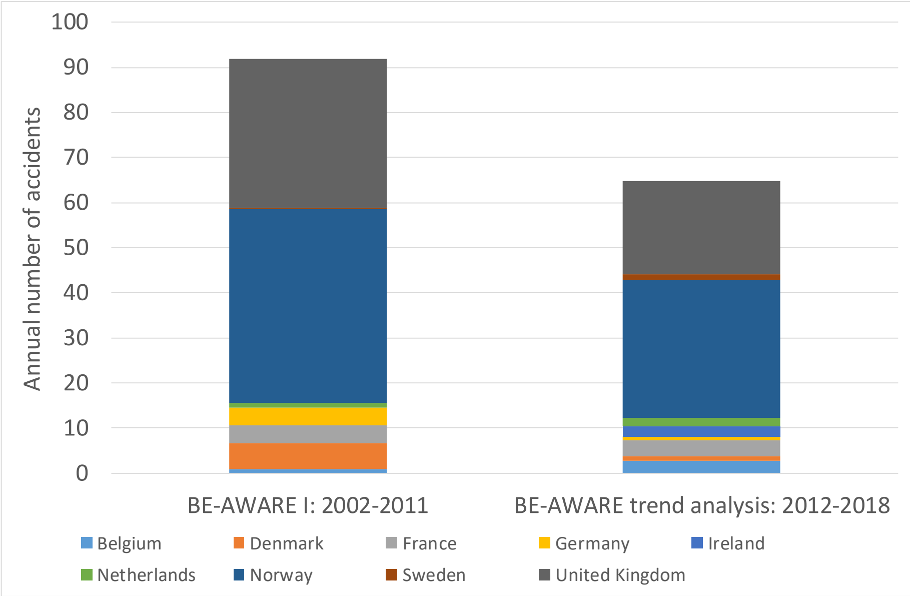


Figure 3-1 Comparison of the annual number of accidents per country where accident reports by unknown causes are excluded: BE-AWARE I and BE-AWARE trend analysis

To provide a geographical overview of the data, a plot of the accident locations for accidents in 2012-2018 is shown in Figure 3-2 where the accidents are distributed per accident type.

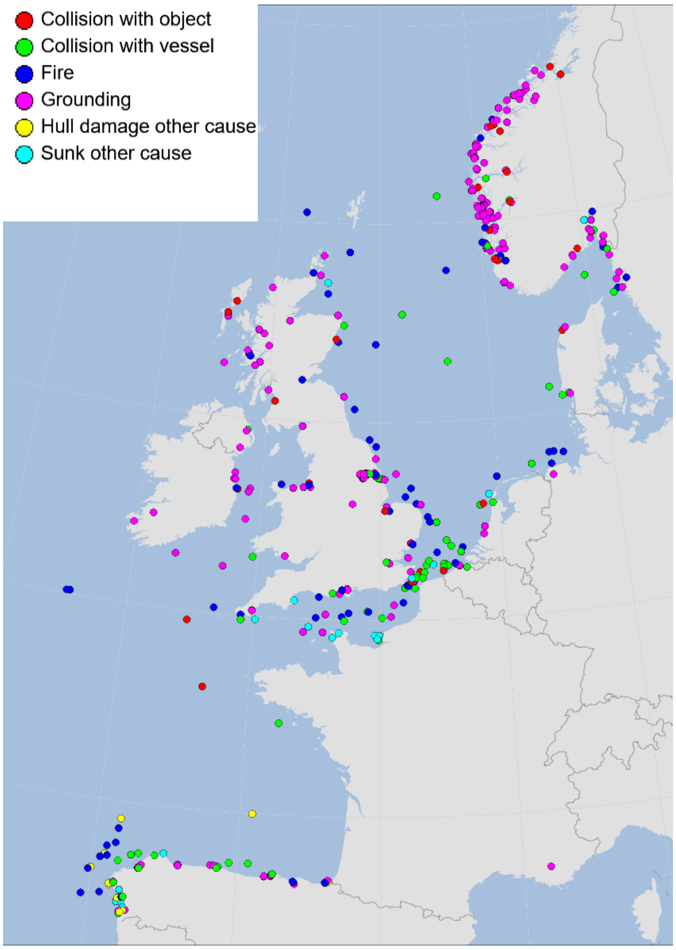


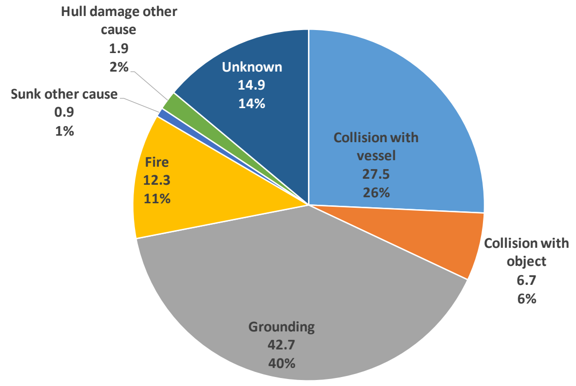
Figure 3-2 Locations of the reported accidents caused by shipping activities in 2012-18, distributed per accident type

In Table 3-4, the average annual number of accidents is presented per accident type (which is basically the same as the last column of Table 3-3) together with their relative contribution. The proportion of each accident type is estimated both with and without including accidents reported as 'Unknown'. These results are also illustrated in Figure 3-3.

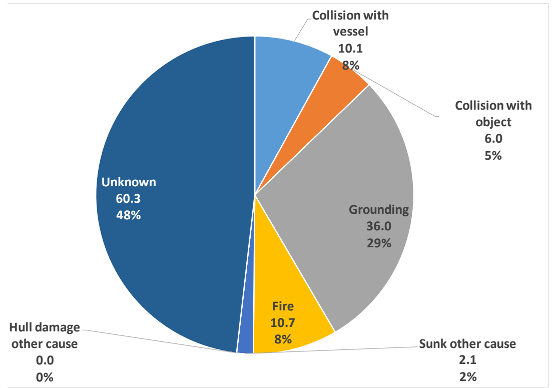
When comparing the relative contributions (with 'unknown' accidents excluded) during 2012-2018 with 2002-2011, there is a significant decrease of about 64% in collisions with vessels and a moderate decrease of 16% in groundings. Other accident types exhibit relatively small changes having a limited impact on the overall number of accidents. Excluding 'unknown' cause accidents, vessel groundings are the largest contributing accident type during 2012-2018, as was the case during 2002-2011. The second-largest contributor in 2002-2011 was collisions with vessels. During 2012-2018, this has changed to fires while collisions with vessels are a close third (with just over 1% less than fires).

Table 3-4 Number of shipping accidents per accident type – Bonn Agreement area: BE-AWARE I and BE-AWARE trend analysis

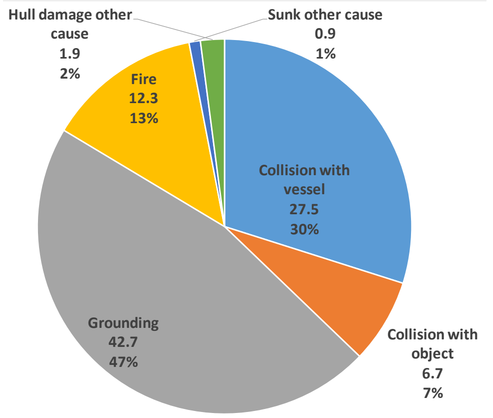
	BE-AWARE I (2002-2011)			BE-AWARE trend analysis (2012-2018)		
Accident type	**Average annual number of accidents**	**% of total**	**% of total, excluding unknown**	**Average annual number of accidents**	**% of total**	**% of total, excluding unknown**
Collision with vessel	27.5	25.7%	29.9%	10.1	8.0%	15.5%
Collision with object	6.7	6.3%	7.3%	6.0	4.8%	9.2%
Grounding	42.7	39.9%	46.4%	36.0	28.8%	55.5%
Fire	12.3	11.5%	13.4%	10.7	8.6%	16.6%
Sunk other cause	0.9	0.8%	1.0%	2.1	1.7%	3.3%
Hull damage other cause	1.9	1.8%	2.1%	0.0	0.0%	0.0%
Unknown cause	14.9	13.9%	-	60.3	48.2%	-
Total	106.9	100%	100%	125.1	100%	100%



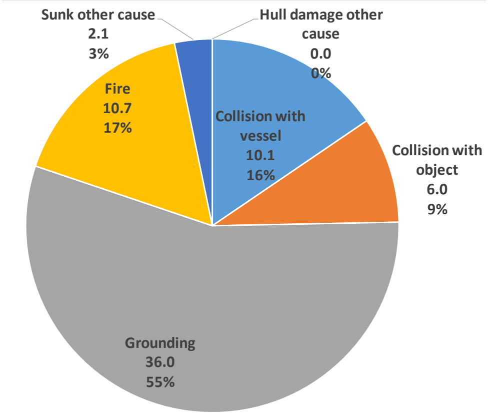
(a) BE-AWARE I (2002-2011) – including unknown causes



(b) BE-AWARE trend analysis (2012-2018) – including unknown causes



(c) BE-AWARE I (2002-2011) – excluding unknown causes



(d) BE-AWARE trend analysis (2012-2018) – excluding unknown causes

Figure 3-3 Shipping accidents per their cause – Bonn Agreement area: BE-AWARE I and BE-AWARE trend analysis

Distribution of accidents by ship type

Next, the contribution from each ship type to the accident statistics is analysed. As can be seen from Table 3-5 and Figure 3-4, the following changes in contributions from each ship type are seen when comparing the BE-AWARE I period 2002-2011 to the BE-AWARE trend analysis period 2012-2018:

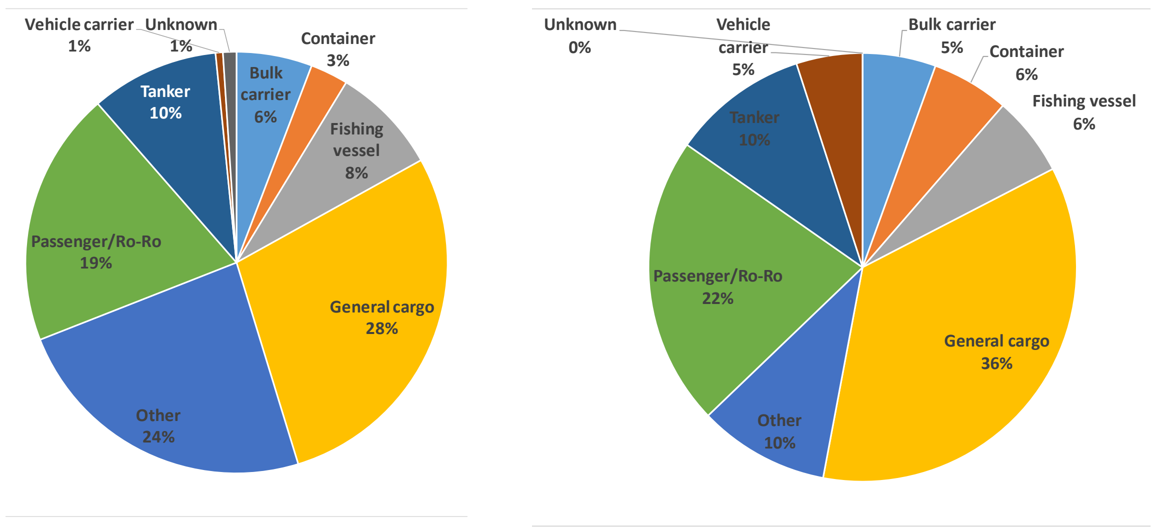
- The number of accidents involving tankers has gone down from 9 per year in 2002-2011 to 7 per year in 2012-2018, i.e. a decline of about 26%. Accidents involving tankers were about 10% of all annual accidents both in 2002-2011 and in 2012-2018.
- About 26 accidents per year in 2002-2011 (corresponding to 28% of yearly accidents in that period) involved general cargo ships, whereas general cargo ships were involved in 23 accidents in 2012-2018 (or 36% of yearly accidents in that period). When considering ship types, general cargo ships were the largest contributors to accidents in both periods.
- There has been a significant decline in the accident contributions reported from 'other' ships. 'Other' ships were involved in 22 accidents per year in 2002-2011 (or 24% of yearly accidents in that period), whereas only 6 accidents per year in 2012-2018 (or 10% of yearly accidents in that period) involved 'other' ships.

For the BE-AWARE trend analysis, ship specific information (including ship type) is extracted from the IHS Fairplay ship database and other databases by using several criteria from the received accident reports such as IMO number, vessel name, call sign or a combination thereof – this allows finding ship-specific information for almost all ships. While the details of how ships involved in accidents were categorised are not available for BE-AWARE I, one possible reason of having lesser percentages for 'other' and 'unknown' ship categories in this BE-AWARE trend analysis when compared to the BE-AWARE I project could be related to the likelihood of being able to find ship specific properties for ships involved in accidents.

To provide a geographical overview of the data, a plot of the accident locations for accidents in 2012-2018 is shown in Figure 3-5 where the accidents are distributed per ship type.

Table 3-5 Number of shipping accidents per ship type – Bonn Agreement area: BE-AWARE I and BE-AWARE trend analysis

	BE-AWARE I: 2002-2011		BE-AWARE trend analysis: 2012-2018	
Ship type	Annual average number of accidents	Relative contribution	Annual average number of accidents	Relative contribution
Bulk carrier	5.3	5.8%	3.6	5.5%
Container	2.7	2.9%	3.8	5.8%
Fishing vessel	7.6	8.2%	3.9	6.0%
General cargo	26.1	28.3%	23.0	35.5%
Other	21.9	23.8%	6.4	9.9%
Passenger/Ro-Ro	18.0	19.6%	14.2	21.9%
Tanker	9.0	9.8%	6.7	10.3%
Vehicle carrier	0.5	0.6%	3.2	5.0%
Unknown	0.9	1.0%	0.0	0.0%
Total	92.0	100.0%	64.8	100.0%



(a) BE-AWARE I (b) BE-AWARE trend analysis

Figure 3-4 Shipping accidents per ship type: BE-AWARE I and BE-AWARE trend analysis

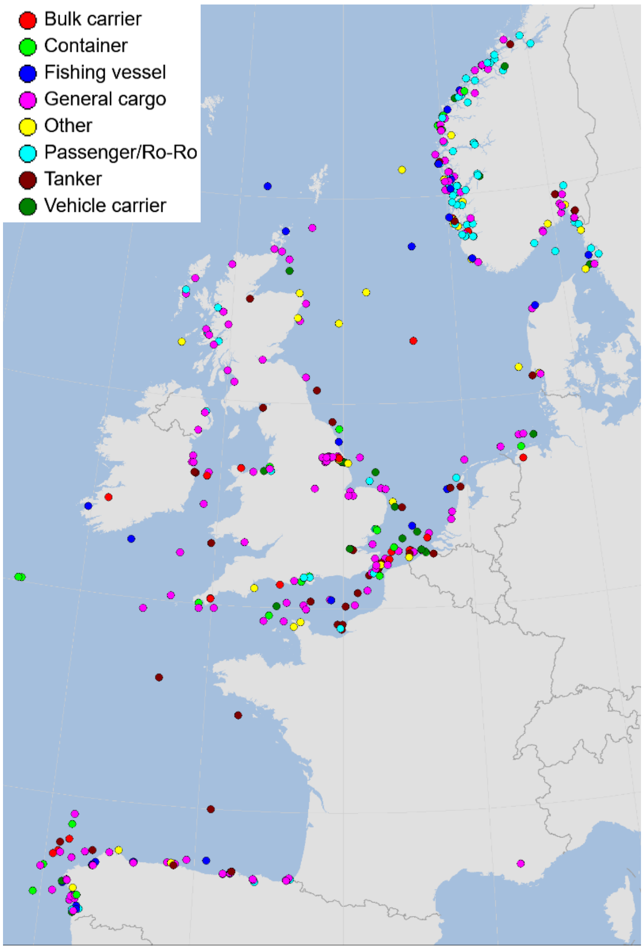


Figure 3-5 Locations of the reported accidents caused by shipping activities in 2012-2018, distributed per ship type

Within tankers, the relative contributions from oil tankers and gas tankers are further investigated. As shown in Table 3-6, almost 83% of the accidents involving tankers for the current period are attributed to oil tankers.

Table 3-6 Classification of tanker vessels for BE-AWARE trend analysis

Tanker type	Total number of accidents	Average annual number of accidents	Relative contribution
Oil tanker	33	5.5	82.6%
Gas tanker	6	1.0	15.3%
Unknown	1	0.1	2.1%
Total	40	6.7	100.0%

3.3.2 Oil spills

For each accident type, the number of accidents that have led to oil spills and the corresponding spill probabilities are estimated and compared with the corresponding results for BE-AWARE I – these results are shown in Table 3-7 and Figure 3-6. For collisions, groundings and fires, an increase in the annual number of oil spills as well as the spill probability is seen when comparing results for the BE-

AWARE trend analysis (2012-2018) to BE-AWARE I (2002-2011). At an overall level, the annual number of oil spills as well as the spill probability given that an accident has occurred (so-called conditional probability) are greater by a factor of about 2.5 during 2012-2018 when compared to 2002-2011. The largest values of spill probabilities given that an accident has occurred are seen for the accident type 'sunk other cause', both in BE-AWARE I as well as in this trend analysis, a significant decline in the 2012-2018 value is seen when compared to 2002-2011. While the reasons for this are not known in detail, this may be attributed to the relatively greater extent of ship damage resulting in general from sinking accidents.

Table 3-7 Number of shipping accidents resulting in oil spills and corresponding spill probabilities per accident type – Bonn Agreement area: BE-AWARE I and BE-AWARE trend analysis

	BE-AWARE I (2002-2011)			BE-AWARE trend analysis (2012-2018)		
Accident type	**Number of accidents resulting in a spill**	**Annual number of accidents resulting in a spill**	**Probability of spill, given that an accident has occurred**	**Number of accidents resulting in a spill**	**Annual number of accidents resulting in a spill**	**Probability of spill, given that an accident has occurred**
Collision with vessel	10	1.0	3.6%	6	1.0	10.2%
Collision with object	0	0	0.0%	3	0.4	8.8%
Grounding	4	0.4	0.9%	8	1.4	3.8%
Fire	2	0.2	1.6%	6	1.0	8.8%
Sunk other cause	8	0.8	88.9%	4	0.6	28.6%
Hull damage other cause	1	0.1	5.3%	0	0.0	-
Unknown	4	0.4	2.7%	6	1.1	2.0%
Total	29	2.9	2.7%	33.0	5.6	4.8%
Total (w/o unknown accidents)	**25**	**2.5**	**2.7%**	**27**	**4.5**	**7.0%**

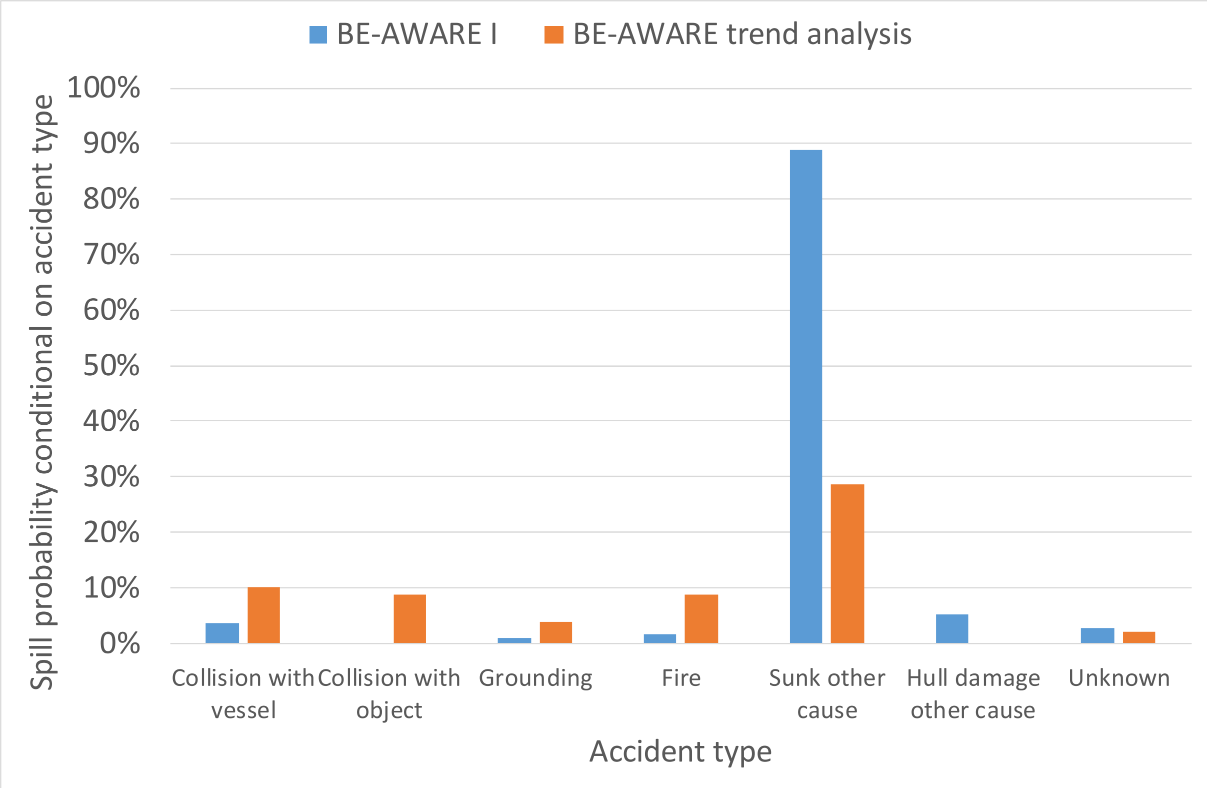
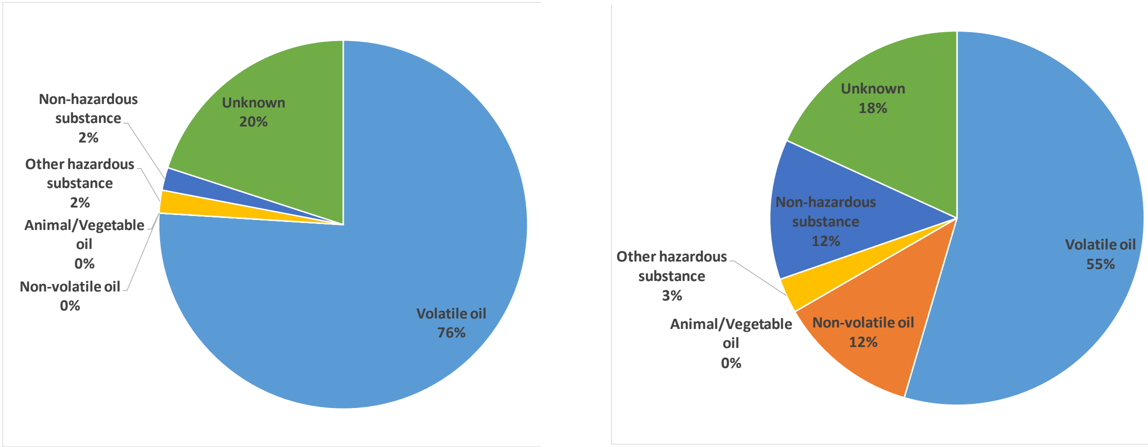


Figure 3-6 Spill probability per accident type – Bonn Agreement area: BE-AWARE I (2002-2011) and BE-AWARE trend analysis (2012-2018)

Details concerning the type of spilled oil are available for most of the accident reports. Using this as basis, the distribution of the oil types involved in oil spills is analysed and presented in Table 3-8 and Figure 3-7 along with the corresponding results for BE-AWARE I. Volatile oil is still seen to have the highest contribution. For BE-AWARE I, there was no contribution reported for non-volatile oil. For the BE-AWARE trend analysis, about 15% contribution is attributed to non-volatile oil. It is more likely that this could be more due to a data classification issue with BE-AWARE I rather than any real trend.

Table 3-8 Distribution of type of spilled oils

Type of oil	BE-AWARE I	BE-AWARE trend analysis
Volatile oil	76%	57.5%
Non-volatile oil	0%	15.0%
Animal/Vegetable oil	0%	0.0%
Other hazardous substance	2%	2.5%
Non-hazardous substance	2%	10.0%
Unknown	20%	15.0%



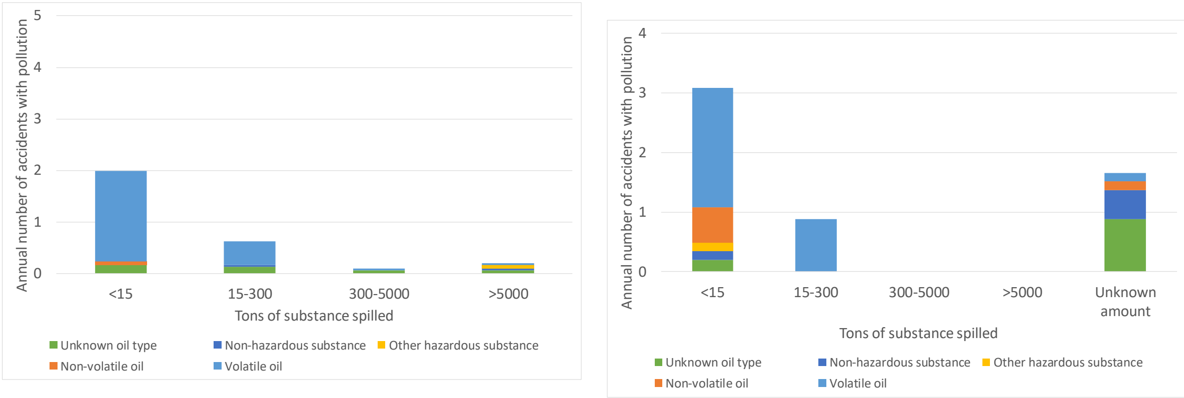
(a) BE-AWARE I (b) BE-AWARE trend analysis

Figure 3-7 Distribution of type of spilled oils

Next, the size distribution of the oil spills is analysed. Whenever possible, the reported pollution size values are expressed as or converted to tonnes. The resulting distribution of spill size per oil type is shown in Figure 3-8 for the trend analysis and also for BE-AWARE I. The spill size distribution available from BE-AWARE I is normalised to the annual number of spills so that the two periods can be consistently compared.

The annual number of accidents with pollution size smaller than 15 tonnes is seen to have increased by 50% in the present (i.e. 2012-2018) period when compared to the past (i.e. 2002-2011) period. One possible reason for the increase in very small (less than 15 tonnes) spills could be differences in reporting standards in the two periods. The annual number of spills with size greater than 15 tonnes is seen to be about the same for the two periods. No spill greater than 300 tonnes is observed for the current period; the maximum pollution size was 200 tonnes. For BE-AWARE I, the maximum size of pollution reported for BE-AWARE I was more than 5000 tonnes.

Figure 3-9 shows the distribution of spill size per accident type. Considering spills of all sizes, about 24% of all oil spills are due to groundings – the sizes from spills resulting from groundings are seen to be relatively small with the largest in this category being 27 tonnes in size. The overall largest observed spill during 2012-2018 of 200 tonnes resulted from a collision with a vessel.



(a) BE-AWARE I[4] (b) BE-AWARE trend analysis

Figure 3-8 Annual number of shipping accidents with pollution per oil type and pollution size

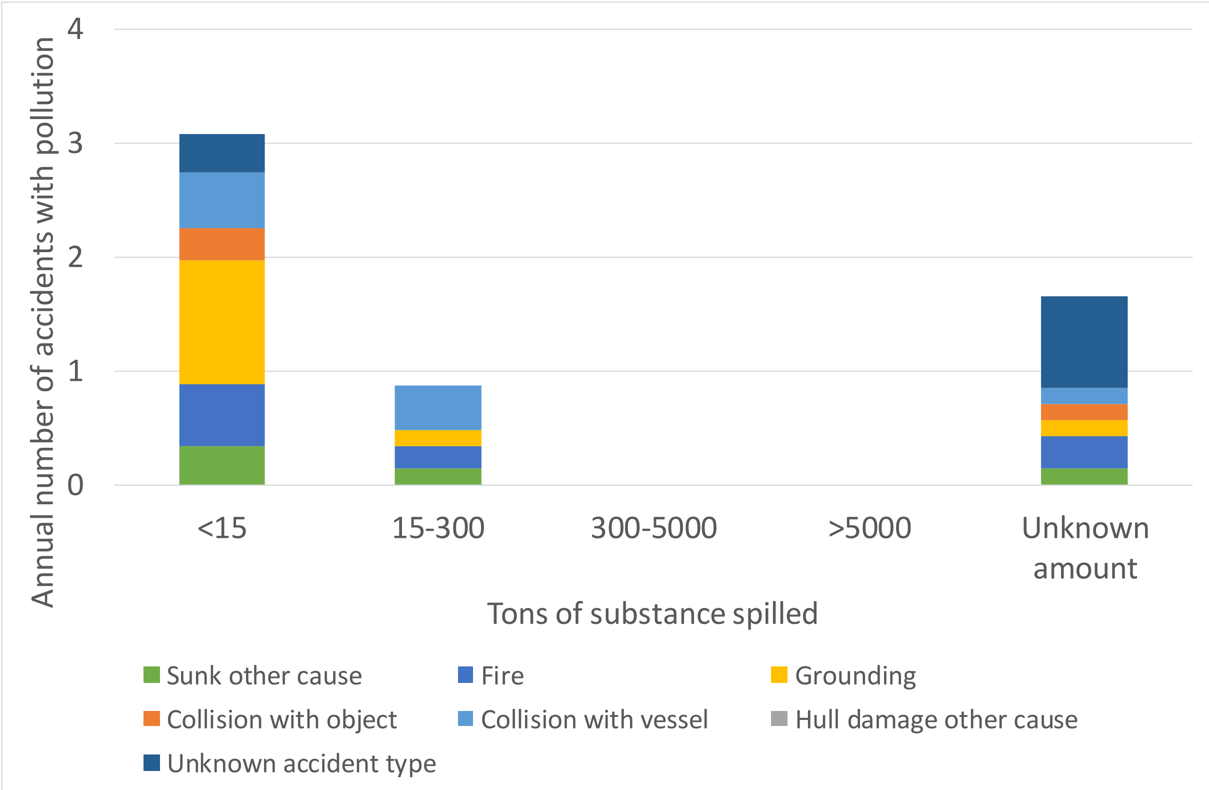


Figure 3-9 Annual number of shipping accidents with pollution per accident type and pollution size

3.4 Overall summary

The main trends with regard to development of shipping accidents and oil spills in the Bonn Agreement area are summarised below, based on comparing the present (2012-2018) period with the past (2002-2011) period:

- The annual number of shipping accidents shows an increase, which is predominantly due to a significant increase in accidents reported as ‘unknown’. As explained at the beginning of

[4] In the report of BE-AWARE I, the spill size statistics are given in terms of the number of accidents, not on a yearly basis. To facilitate comparison, the number of accidents leading to a certain spill size category is normalised to the annual number of oil spills, i.e. 2.9 per year (which can be found in Table 3-7).

section 3.3.1, a majority of such accidents relate to precursor events or possible threats and not actual accidents. When such occurrences are excluded, a 30% decline in annual accident frequency is obtained.

- There is a significant 64% decrease in collisions with vessels.
- There is a moderate 16% decrease in groundings. Vessel groundings are the largest contributing accident type for both periods.
- The annual number of oil spills as well as the conditional spill probability (i.e. given the occurrence of an accident) is greater by a factor of about 2.5. This is mostly due to a 1.5 times increase in reported accidents with pollution size smaller than 15 tonnes.
- The annual accidents with pollution size more than 15 tonnes are about the same for both the periods.
- The maximum pollution size reported for the present period is 200 tonnes whereas it was more than 5000 tonnes for the past period.

Some possible reasons/explanations for the above are discussed in chapter 9 when looking at the overall trends in the development of the oil spill risk picture.

4. Analysis of ship traffic

4.1 Approach

An analysis of ship traffic carried out for two selected transects in the Bonn Agreement area is reported in this chapter. The analysis has been carried out using Automatic Identification System (AIS) data for ship movements/positions for 2018. One of the selected transects is located in the Channel and the other is in the German Bight. The locations of these transects is shown in Figure 4-1.

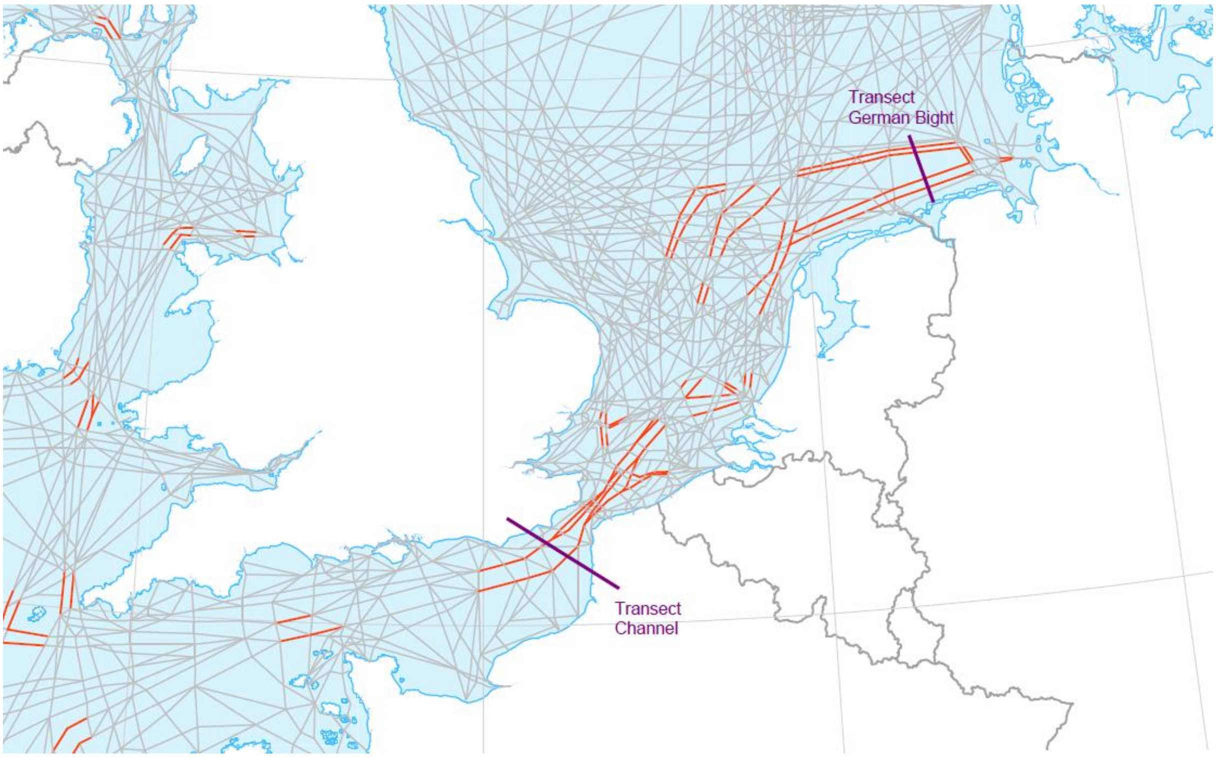


Figure 4-1 Location of transects used in the data analysis. The transect used for the German Bight is option 2.

The analysis of ship traffic involves the following:

- A detailed route net to describe the primary sailing routes in the Bonn Agreement area was developed in BE-AWARE I. For the area covered by the two transects selected for the present analysis, a brief comparative assessment of the route net developed in BE-AWARE I with results from the analysis of the present data is first undertaken to determine if there are any key changes in sailing patterns and routes.
- Frequency distributions per ship type and size of the 2018 ship traffic for the two transects are established. These distributions are compared with the 2011 traffic from BE-AWARE I and the future projections (2020 scenario) made in BE-AWARE I.

4.2 Data summary and visualisation of sailing patterns

4.2.1 German Bight

Data for the German Bight has been provided by *Generaldirektion Wasserstraßen und Schifffahrt (GDWS)*[5] and covers the years 2011 and 2018. The processed and analysed data for the German Bight are shown in the form of illustrative traffic density plots in Figure 4-2 and in Figure 4-3. These plots are obtained by counting the number of ships passing squares of size 100 m by 100 m. The blue cells have relatively the most ship counts and the yellow cells have the least ship counts. The main route from Hamburg to the Channel is clearly seen in blue. The heavily blued dotted areas correspond to wind farms (either existing or under construction) for which a greater traffic density is seen for 2018 when compared to 2011. No other changes in ship sailing patterns and routes are seen when comparing Figure 4-2 and Figure 4-3.

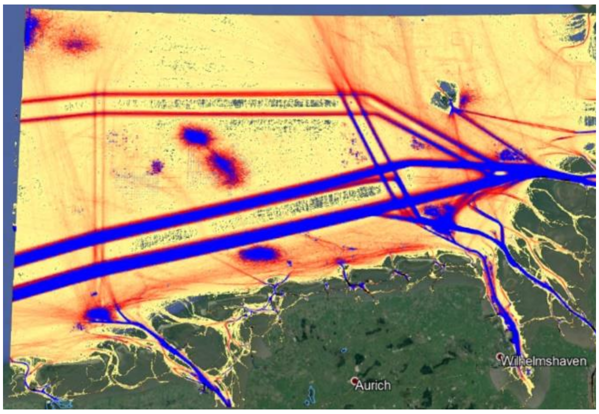


Figure 4-2 Visualisation of German Bight AIS data for 2011

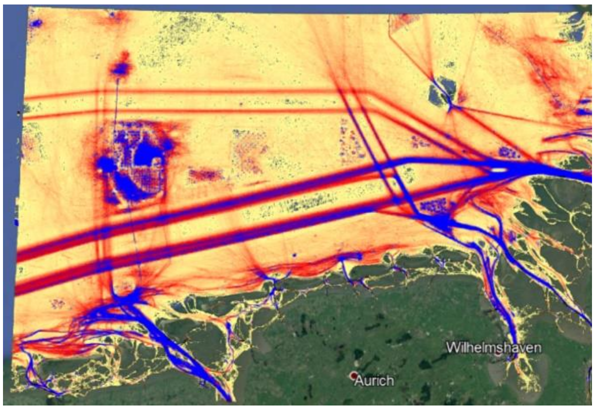


Figure 4-3 Visualisation of German Bight AIS data for 2018

Figure 4-4 and Figure 4-5 show the number of AIS records in the Bight data for 2011 and 2018. It is noted that about 8% data is missing for 2011 and about 40% for 2018. To account for this missing data, suitable factors to scale up the ship traffic analysed using the available data are therefore applied. From Figure 4-4 and Figure 4-5, it is seen that the number of records is generally constant during the periods for which data is available. This means that scaling factors are reasonable to use for this analysis.

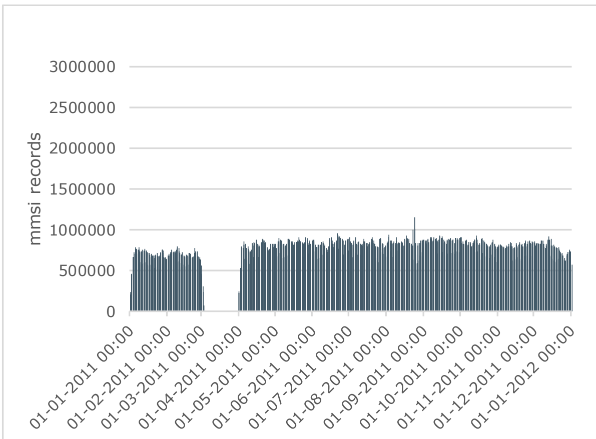


Figure 4-4 AIS records for 2011 for German Bight

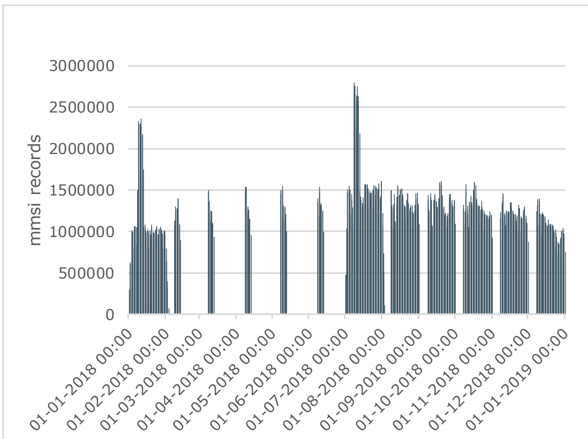


Figure 4-5 AIS records for 2018 for German Bight

[5] Directorate-General for Waterways and Shipping

4.2.2 Channel

Data for the Channel has been provided by the French Navy and covers the year 2018. In Figure 4-6, the processed and analysed data is shown in a 100 m by 100 m traffic density plot. The blue cells have relatively the most ship counts and the yellow cells have the least ship counts. The traffic density plot for the corresponding area from BE-AWARE I is shown in Figure 4-7. No significant changes in sailing patterns and routes are seen when comparing Figure 4-6 and Figure 4-7.

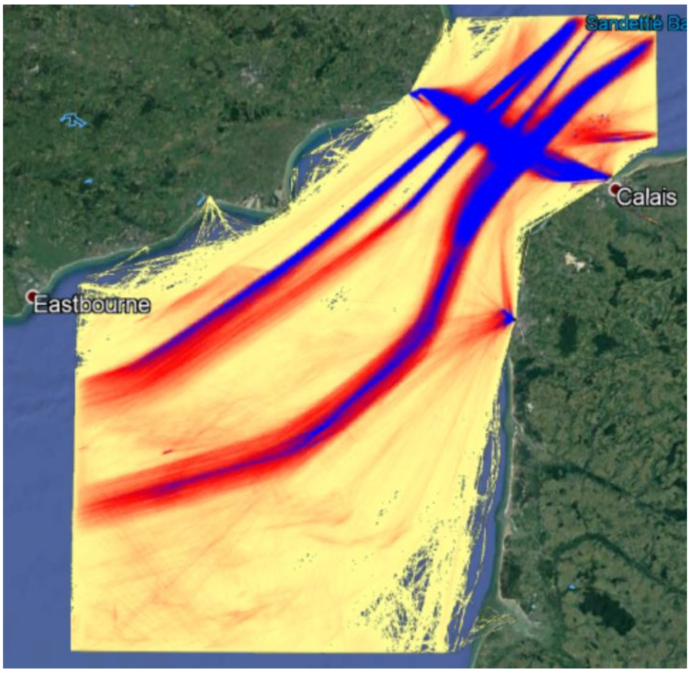


Figure 4-6 Visualised AIS data for the Channel for 2018

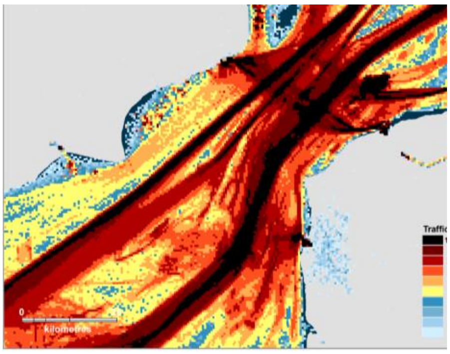


Figure 4-7 Traffic density plot for the Channel for 2011 – extract from BE-AWARE I

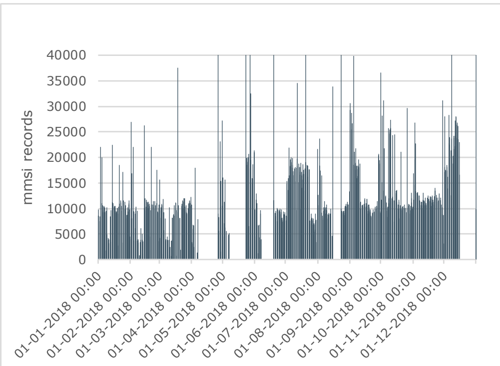


Figure 4-8 AIS records for 2018 for the Channel

In Figure 4-8, the number of AIS records for the Channel data are shown. About 24% data is seen to be missing. To account for this missing data, suitable factors to scale up the ship traffic analysed using the available data are therefore applied.

4.3 Results and discussion

4.3.1 German Bight

Comparison of 2011 traffic

For BE-AWARE I, German AIS data for the Bight was not available in 2011 and therefore Danish and Dutch AIS data was used together with applying suitable scaling factors to account for the fact that the Danish data does not cover the entire Bight. For the present analysis, 2011 AIS data for the Bight has been made available and is used to establish traffic frequency distributions. Figure 4-9 shows how the Bight traffic distributions established in BE-AWARE I based on scaling the Danish data compares with the now established distributions based on 2011 AIS data. In total, the values obtained from the present analysis of 2011 AIS data are greater than the 2011 BE-AWARE I values by about 7%, i.e. the values for 2011 traffic in BE-AWARE I were underestimated. The number of tankers from the present 2011 AIS data analysis is greater by about 50% when compared to the corresponding BE-AWARE I value. On the other hand, the number of general cargo and packed cargo ships obtained from the present 2011 AIS data analysis are greater by about 3% when compared to the respective BE-AWARE I values.

Apart from the tanker numbers, it appears that there is good agreement between the scaled BE-AWARE I data and the recently delivered dataset. The different deviation with respect to ship type may be due to the method that was used for scaling up the Danish and Dutch AIS data.

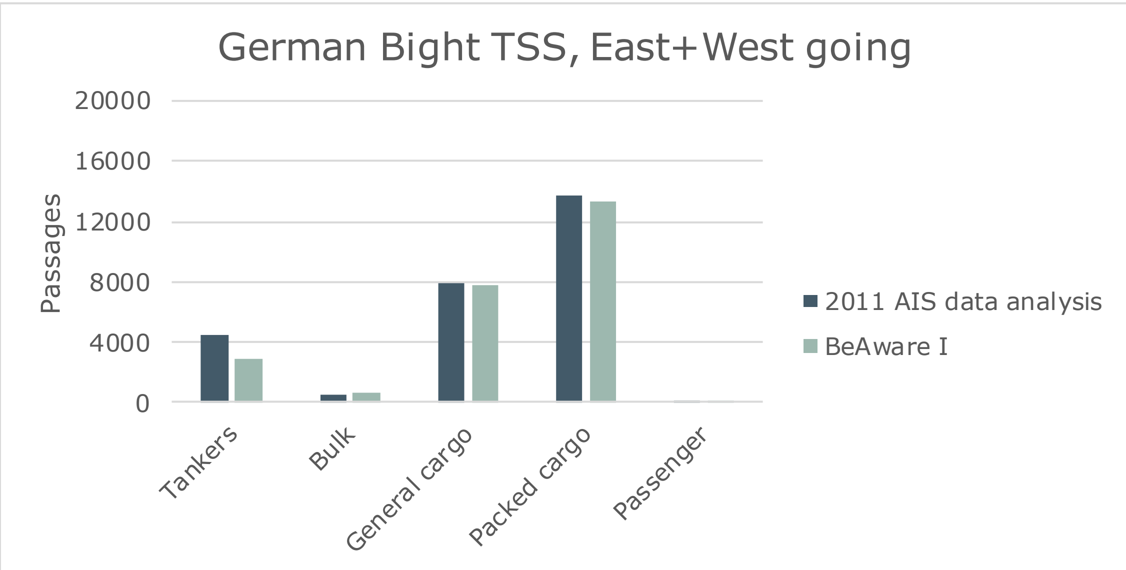


Figure 4-9 Comparison of the number of ships as per BE-AWARE I and present analysis using actual AIS data for 2011. (Packed cargo is container ships + Ro-Ro cargo ships.)

Comparison of 2018 and 2011 traffic situations

The 2018 traffic density map for the Bight is shown in Figure 4-10 together with the 2011 route net established in BE-AWARE I. The overall evaluation is that the location of the major routes remains unchanged. The only major change is the North-South route to the west of the offshore wind farm area in the Bight. The vertical black line is the passage line where the number of ships is measured to make an estimate of the change in traffic.

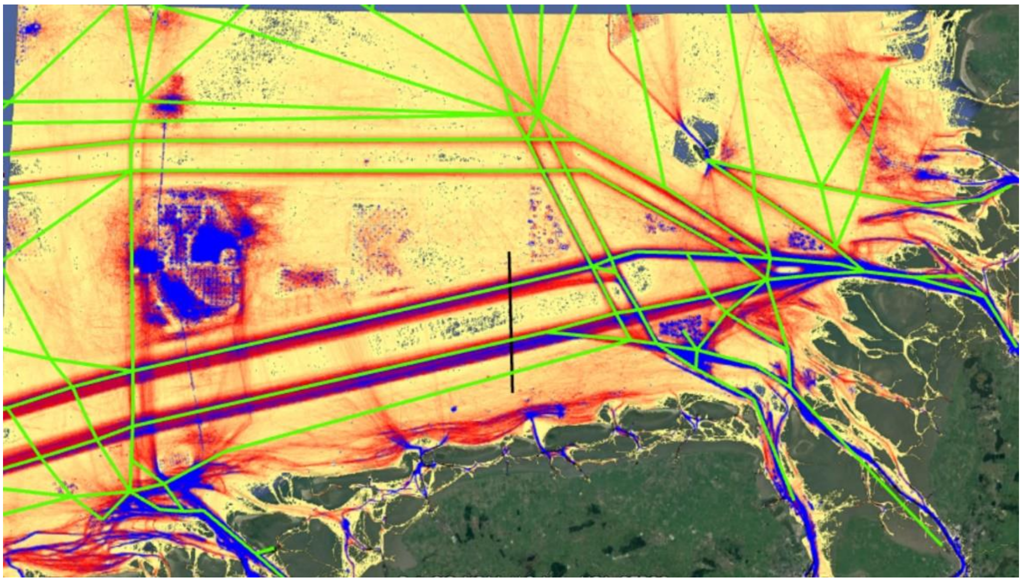
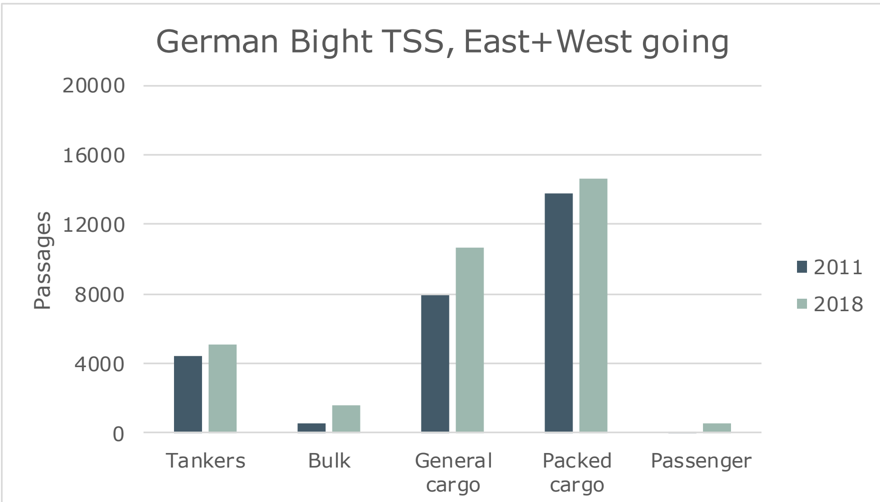


Figure 4-10 German Bight traffic density plot for 2018 with BE-AWARE I routes 2011 in green. The vertical black line is the passage line used for traffic estimation.

In Figure 4-11, the number of ships passing the black passage line in both directions is shown for 2011 and 2018. In general, all ship types show an increase in traffic; the overall increase from 2011 to 2018 is about 21%. While the extent of this increase is relatively modest at 6% for packed cargo ships and 14% for tankers, a significant increase of 34% is seen for general cargo ships and massive increases of 209 % for bulk carriers and 475% for passenger ships are seen. These % increases need to be considered together with the absolute number of passages for each ship type which can also be seen in Figure 4-11.

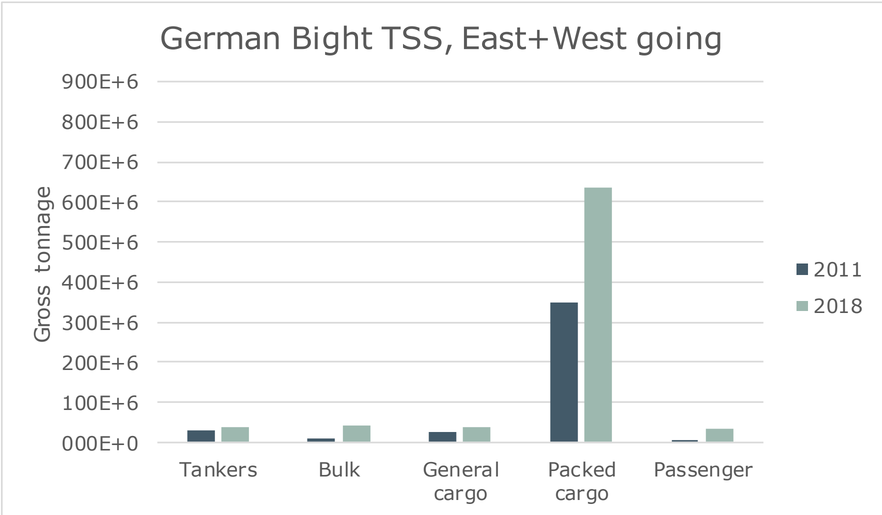


Ship type	Change
Tankers	+14 %
Bulk carrier	+209%
General cargo	+34 %
Packed cargo	+6 %
Passenger	+475%

Change in the number of ships from 2011 to 2018.

Figure 4-11 Number of ships in 2011 and 2018 crossing the selected passage line in the German Bight, distributed per ship type

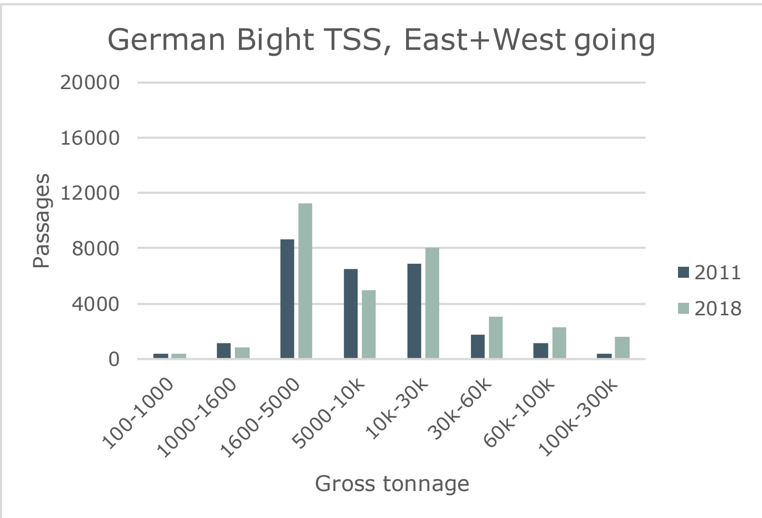
The above change in number of ships does not necessarily show the change in cargo carried, as there could be a change in the sizes of ships from 2011 to 2018. Figure 4-12 shows a plot comparing the total Gross Tonnage (GT) of ships obtained by multiplying the number of ships with their GT. Tanker sizes have increased by 26% in GT terms and container ships by 83%. Very significant multi-fold increases in GT are seen for bulk carriers (379%) and passenger ships (1149%); the absolute total gross tonnage values for these ship types are much lower when compared to packed cargo. The huge rise in passenger ships is due to an increase in cruise ships from 48 in 2011 to 240 in 2018 and a substantial increase in size of cruise ships. On overall, a 90% increase in total GT is seen from 2011 to 2018.



Ship type	*Change*
Tankers	+26%
Bulk carrier	+379%
General cargo	+55%
Packed cargo	+83%
Passenger	+1149%

Change in the total gross tonnage of ships from 2011 to 2018.

Figure 4-12 Total gross tonnage in 2011 and 2018 for ship traffic crossing the selected passage line in the German Bight

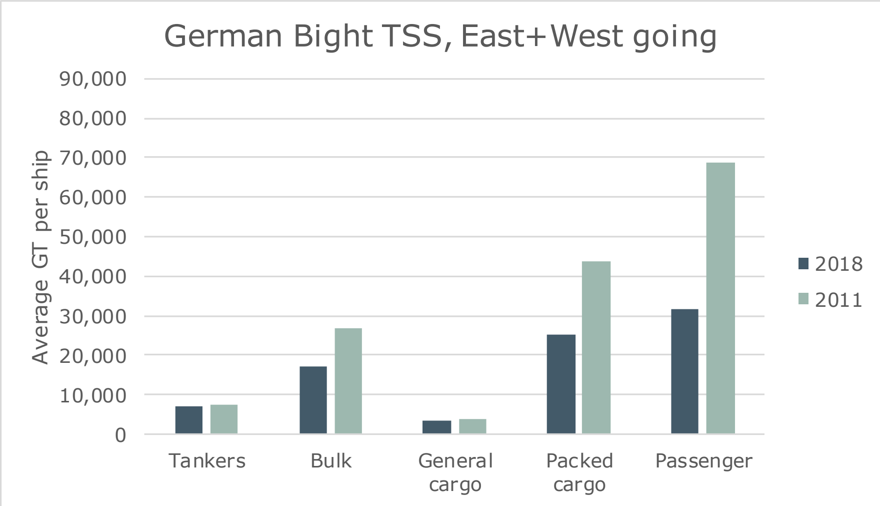


GT class	*Change*
100-1000	+14%
1000-1600	-27%
1600-5000	+30%
5000-10000	-24%
10000-30000	+16%
30000-60000	+78%
60000-100k	+107%
100k-300k	+320%

Relative change in number of ships for the eight GT classes from 2011 to 2018.

Figure 4-13 Number of ships in 2011 and 2018 crossing the selected passage line in the German Bight, distributed per GT class

In Figure 4-13, a comparison of the 2011 and 2018 traffic in the form of a distribution per ship size (GT class) is shown. Further, the change from 2011 to 2018 in the average GT per ship for each ship type is shown in Figure 4-14. These figures confirm the general trend seen in global ship size development, namely that the average vessel size in the shipping fleet for merchant and passenger ships is increasing. In general, the number of ships in smaller size classes is either declining or associated with a smaller percentage increase whereas ships in larger size classes are associated with larger percentage increases. This trend is seen generally in Figure 4-13, albeit with a few exceptions. Considering all ship types, a 57% increase in average GT per ship is seen from 2011 to 2018.



Ship type	*Change*
Tankers	+11%
Bulk carrier	+55%
General cargo	+15%
Packed cargo	+72%
Passenger	+117%

Change in the average gross tonnage per ship from 2011 to 2018.

Figure 4-14 Change in average gross tonnage per ship from 2011 to 2018 for ship traffic crossing the selected passage line in the German Bight

4.3.2 Channel

The 2018 traffic density map for the Channel is shown in Figure 4-15 together with the 2011 route net established in BE-AWARE I. The locations of the major BE-AWARE I routes remain unchanged for the 2018 traffic.

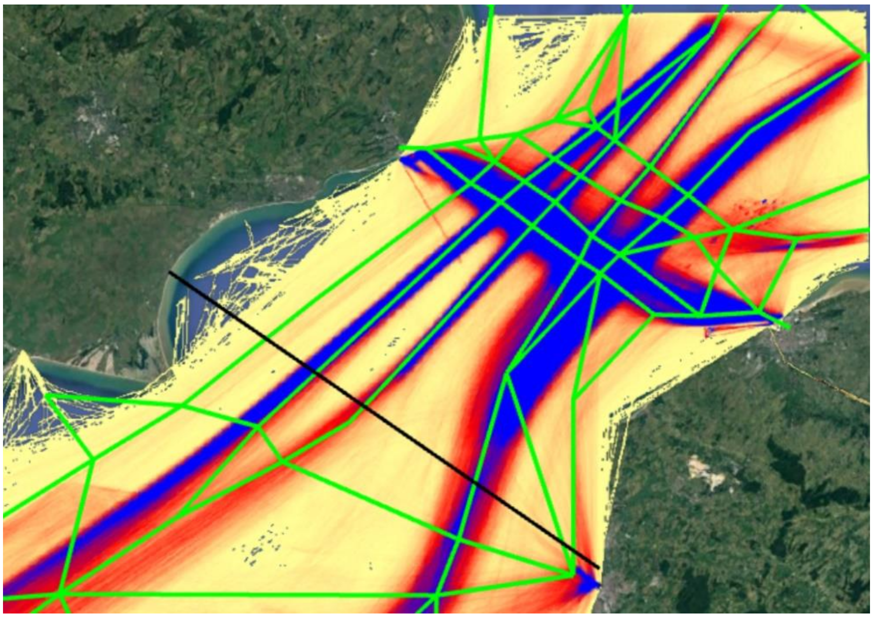
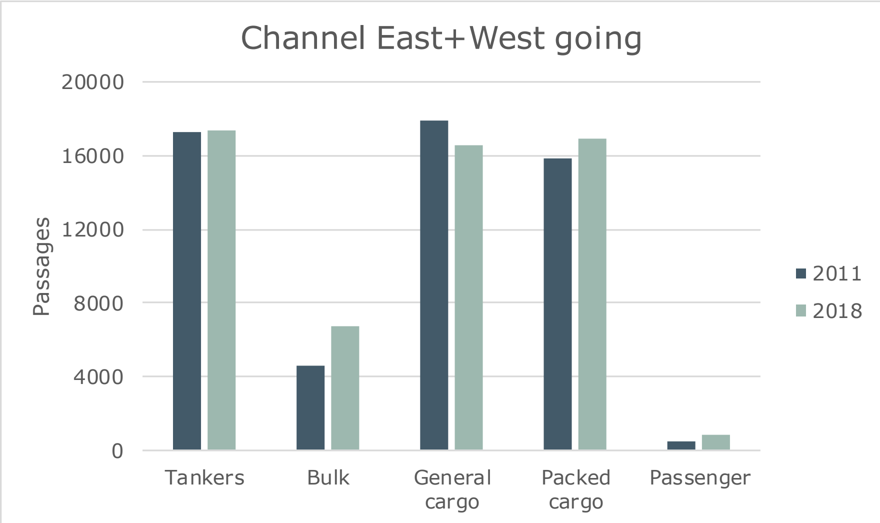


Figure 4-15 Channel traffic density plot for 2018 with BE-AWARE I routes in green. The black line is the passage line used for comparing the 2011 values.

To see the change in the number of ship passages from 2011 to 2018, a passage line (the black line in Figure 4-15) has been established. Figure 4-16 shows a comparison of the number of ships in 2011 and 2018 that crossed this passage line in the Channel. An overall increase of 4% is seen for the ship traffic from 2011 to 2018. While the tanker traffic is seen to be almost unchanged (1% increase), package cargo ships show a modest 7% increase. More appreciable increases in passages are seen for bulk carriers (46%) and passenger ships (68%). General cargo ships are the only ship type to show a decline in passages – the extent of this decline is 8 %.



Ship type	*Change*
Tankers	+1 %
Bulk carrier	+46 %
General cargo	-8 %
Packed cargo	+7 %
Passenger	+68 %

Change in the number of ships from 2011 to 2018.

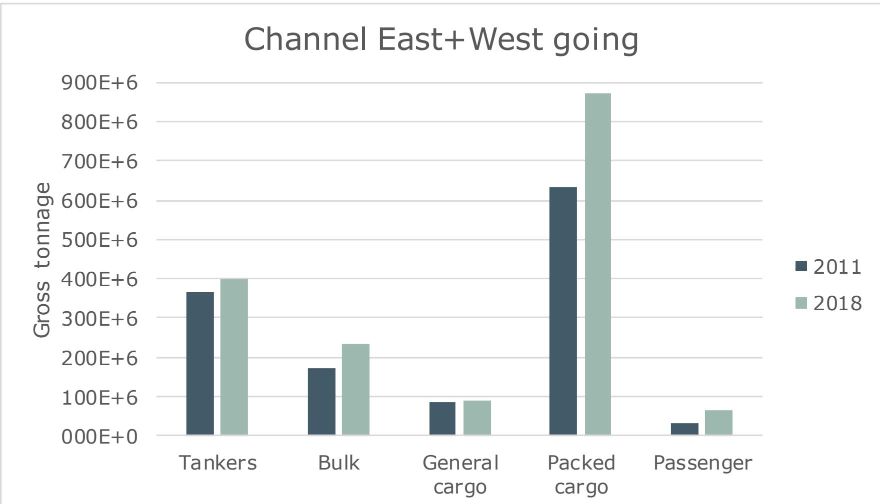
Figure 4-16 Number of ships in 2011 and 2018 crossing the selected passage line in the Channel, distributed per ship type

The total GT of ships that sailed through the Channel in 2011 and 2018 is shown in Figure 4-17. When seen together with the change in number of ship passages, the change in GT shows if ship sizes have changed. The distribution of the Channel traffic per ship size (GT class) for 2011 and 2018 is shown in Figure 4-18. The 2011 to 2018 change in average GT per ship for each ship type can be seen in Figure 4-19.

Considering tankers as an example, the total GT increase as seen in Figure 4-17 is 8%. The increase in passages for tankers is 1% as per Figure 4-16. So the resulting extent of ship size increase (to result in an 8% total tonnage increase) is about 8% - this can also be seen in Figure 4-19, reflecting that the growth in tonnage is carried almost entirely due to increase in tanker sizes. Modest changes in ship sizes are seen for bulk carriers and general cargo ships.

The growth in ship sizes is much more pronounced for packed cargo ships. While the total GT for these ships has increased by 38 % (Figure 4-17), the increase in passages is only 7% (Figure 4-16). So the resulting increase in ship size for packed cargo ships is about 29% (Figure 4-19).

Finally, it is seen from that the size of the passenger ships also increased by about 25% (Figure 4-19). On overall, there is a 29% increase in GT for all ships from 2011 to 2018.

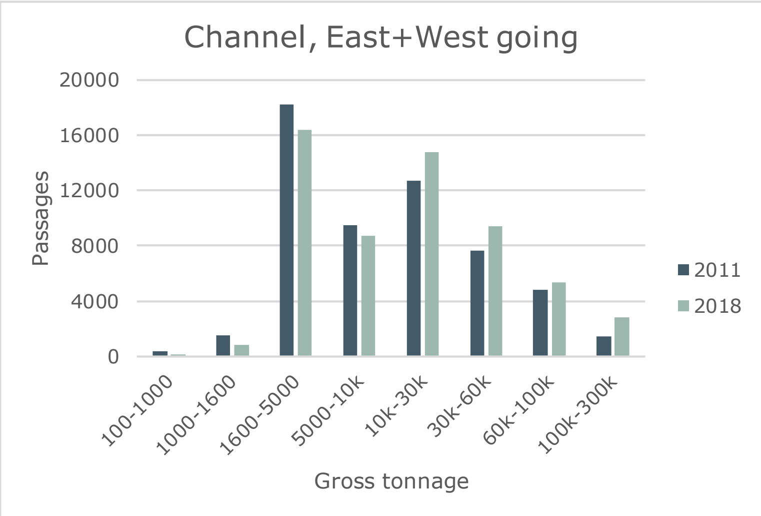


Ship type	*Change*
Tankers	+8 %
Bulk carrier	+37 %
General cargo	+4%
Packed cargo	+38 %
Passenger	+110%

Change in the total gross tonnage of ships from 2011 to 2018.

Figure 4-17 Total gross tonnage in 2011 and 2018 for ship traffic crossing the selected passage line in the Channel

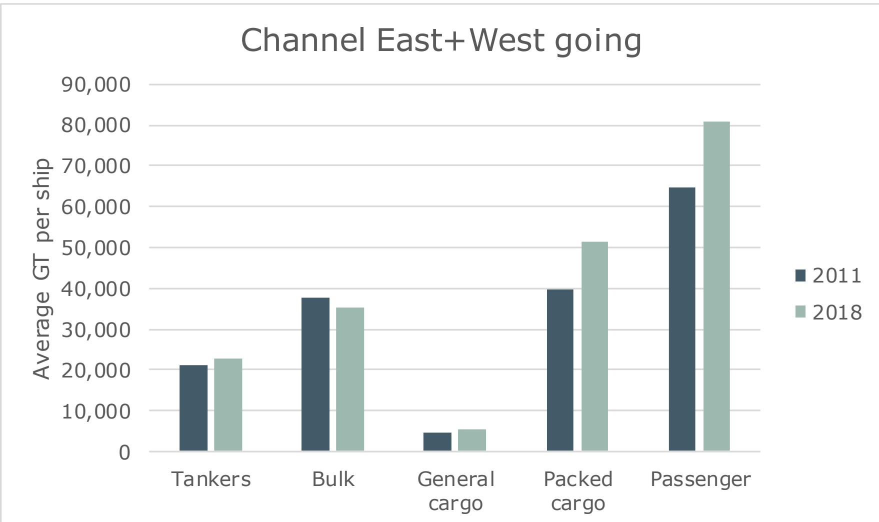
Considering all ship types as shown on Figure 4-19, a 24% increase in average GT per ship is seen from 2011 to 2018. As seen also for the Bight traffic, the general trend seen in global ship size development is also seen here, namely that the average vessel size in the shipping fleet for merchant and passenger ships is increasing. This trend is clearly seen in Figure 4-18, where ships in smaller size classes show a decline whereas ships in larger size classes are on the increase.



GT class	*Change*
100-1000	-58%
1000-1600	-45%
1600-5000	-10%
5000-10000	-8%
10000-30000	+16%
30000-60000	+23%
60000-100k	+11%
100k-300k	+92%

Relative change in number of ships for the eight GT classes from 2011 to 2018.

Figure 4-18 Number of ships in 2011 and 2018 crossing the selected passage line in the Channel, distributed per GT class



Ship type	*Change*
Tankers	+8%
Bulk carrier	-7%
General cargo	+12%
Packed cargo	+29%
Passenger	+25%

Change in the average gross tonnage per ship from 2011 to 2018.

Figure 4-19 Change in average gross tonnage per ship from 2011 to 2018 for ship traffic crossing the selected passage line in the Channel

4.4 Comparison with BE-AWARE I traffic projections

The annual future growth rates for ship passages/voyages and GT were predicted in BE-AWARE I. These predictions were made for the period 2011-2020 and are shown in Table 4-1. A comparison of the future projections as per BE-AWARE I is made with the actual 2018 ship traffic obtained from the present analysis.

Table 4-1 Yearly traffic and tonnage growth rates predicted for 2011-2020 as per BE-AWARE I

Ship type	Annual growth rate for number of ships	Annual growth rate for GT
Tankers	0.4%	1.2%
Bulk	0.9%	1.7%
General cargo	0.4%	-0.3%
Packed cargo	1.2%	5.2%

For the Channel, the 2011 traffic taken from BE-AWARE I is combined with the growth rates in Table 4-1 to obtain the predicted values for 2018. These predicted values are then compared with the actual values for 2018 as established in this analysis (section 4.3.2). This comparison is shown in Figure 4-20 for ship passages and in Figure 4-21 for total GT. These figures show that the predicted values match very well with the actual values for all tankers and containers – the predicted-actual difference in these cases is within ±3%. For bulk carriers, the actual values are greater than the predicted values by about 37% for the number of passages and by about 21% for the total GT. Considering all merchant ships (i.e. tankers, bulk, general cargo and packed cargo), the actual number of passages is about 1% lesser than the predicted value and the actual total tonnage is about 1% greater than the predicted value. This shows a very good degree of accuracy for the predictions in BE-AWARE I when applied to traffic passing through the Channel.

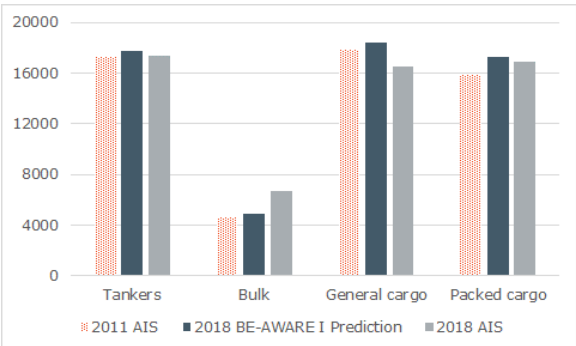


Figure 4-20 Comparison of Channel traffic in 2018 as per BE-AWARE I predictions and actual AIS data

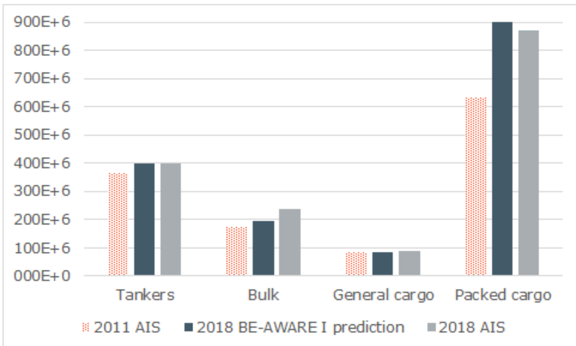


Figure 4-21 Comparison of the predicted GT in 2018 and the actual AIS data for 2018 (Channel data)

A similar comparison is made for the Bight traffic. For this comparison, the 2011 traffic from BE-AWARE I (Figure 4-9) is combined with the growth rates in Table 4-1 to obtain the BE-AWARE I predicted values for 2018. These predicted values are then compared with the actual values for 2018 as established in this analysis (Figure 4-11 and Figure 4-12). This comparison is shown in Figure 4-22 for ship passages and in Figure 4-23 for total GT. It is seen that the actual 2018 ship passages are greater than the BE-AWARE I predictions for 2018. Considering all merchant ships (i.e. tankers, bulk, general cargo and packed cargo), the actual number of passages in 2018 is about 21% greater than the predicted value, with the predicted-to-actual increase for tankers being 67%. A different picture is seen when comparing the predicted and the actual total GT. Considering all merchant ships, the actual overall total GT for 2018 is about 23% lower than the predicted value. This is driven by the actual value of the total GT for packed cargo ships being less than the predicted value and the fact that packed cargo ships account for a predominant part of the overall total GT. The actual total GT for tankers, bulk carriers and general cargo ships is, on the other hand, higher than their respective predicted values.

The above shows that while the growth in ship passages for the Bight traffic has been underestimated in BE-AWARE I, the growth in ship sizes has been overestimated. Given the good degree of correspondence seen earlier in this section between the predicted and actual traffic crossing the Channel, the differences seen for the Bight traffic could possibly stem from a more than foreseen growth for the part of traffic in the Bight Traffic Separation Scheme (TSS) that does not use/reach till the Channel. This could be attributed to issues concerning the available AIS data for the Bight in BE-AWARE I (as also referred to at the beginning of section 4.3.1) and possibly also local uncertainties associated with the overall traffic prognosis made during BE-AWARE I, particularly given that it came at the time of the economic crisis in 2011 and needed to predict the extent to which economic activity would rebound in the future.

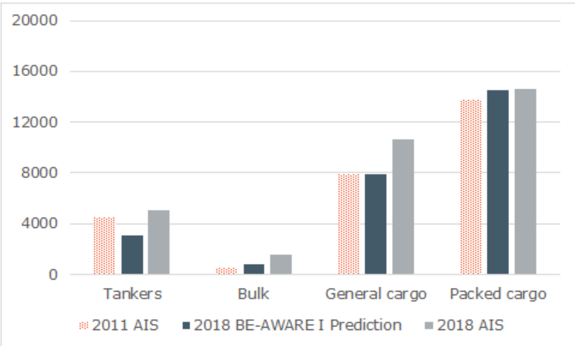


Figure 4-22 Comparison of the Bight traffic in 2018 as per BE-AWARE I predictions and actual AIS data

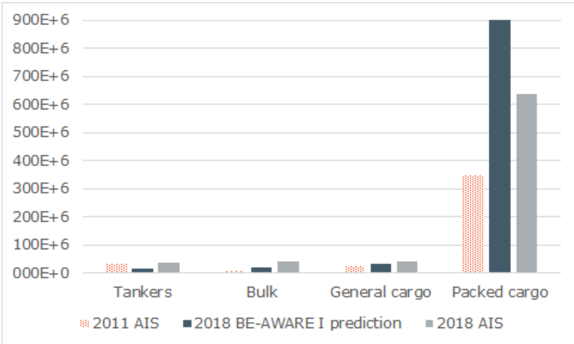


Figure 4-23 Comparison of the predicted gross tonnage in 2018 and the actual AIS data for 2018 (Bight data)

4.5 Overall summary

The main trends from the ship traffic analysis are summarised below:

- No significant changes in sailing routes in the Channel and Bight are seen, except for increased ship movements around offshore wind farm areas in the Bight – this is addressed further in chapter 6.
- The 2011-to-2018 increase in ship passages is about 21% for the Bight traffic and about 4% for the traffic crossing the Channel.
- The average Gross Tonnage (GT) per ship has increased by about 57% for the Bight traffic and by about 24% for the traffic crossing the Channel.
- In 2011, the average GT per ship for the Channel traffic was about 47% higher than that for the Bight traffic. In 2018, the average GT per ship for the Channel traffic is still higher but by only 16%. The lower average GT per ship for the Bight traffic can be seen as one of the contributory factors for the bigger growth margin in size for the Bight traffic.

- Combining the above increases in ship passages and ship sizes, the growth in total Gross Tonnage (GT) from 2011 to 2018 is about 90% for the Bight traffic and about 29% for the traffic crossing the Channel.
- Compared to the increases in ship passages, much greater % increases are seen for the growth in GT. This confirms the global trend in ship size development that the ships are getting bigger and bigger.
- From a comparison of the predictions made in BE-AWARE I with the actual 2018 traffic distributions determined from the present analysis,
    - a very good degree of correspondence is seen for both ship passages and ship sizes for the traffic crossing the Channel, and
    - the actual traffic in the Bight is about 21% more than the predictions in BE-AWARE I.

5. Analysis of oil cargo load state and oil type

5.1 Scope

An analysis of the oil transport to and from selected ports in the Bonn Agreement area is presented in this chapter. The main objective of the analysis is to establish loading state distributions per tanker types and size classes and to estimate the division of oil types in the loaded tankers. The analysis is carried out for the two ports Mongstad and Hamburg, in Norway and Germany respectively.

The results obtained from the analysis of the present (i.e. for 2018) situation are compared with the corresponding past results from the BE-AWARE I project (i.e. for 2011). Based on this, general trends in oil transport in the overall Bonn Agreement area are discussed.

5.2 Data analysis

5.2.1 Data overview

The port of Mongstad

Mongstad is a refinery/oil terminal in Norway. The data from the port of Mongstad has 1226 shipment records for 2018. Each shipment record reports the vessel name, call sign, arrival and departure dates, ship size – i.e. Net Register Tonnage (NRT), Gross Tonnage (GT), Dead Weight Tonnage (DWT) – last and next ports, cargo type and quantity, and activities at the port (either import/unloading or export/loading). Unreported departures and arrivals of empty vessels are estimated by tracking the shipment records of individual vessels. These numbers are added to the total number of journeys.

The port of Hamburg

The data received from the port of Hamburg comprises 1863 shipments for 2018. For each shipment record, the IMO number of a vessel is available which facilitates a precise classification of ship type. The given dataset additionally reports the quantity and type of cargo onboard a ship even if such cargo was not transferred at the port of Hamburg. This information allows a more rigorous estimation of the loading percentage of ships to and from Hamburg. As for the Mongstad port data, the number of possible empty arrivals and departures is estimated by tracking the activities of each unique vessel.

5.2.2 Data analysis

To have analysis results comparable to the results obtained for BE-AWARE I, the same rules as in BE-AWARE I are adopted to classify ship types and oil types. Ships are classified into one of 8 size classes by their GT as shown in Table 5-1. It is seen that no ship reported by both ports falls into the size class 8.

Table 5-1 Ship size classes

Ship size class	Ship size [GT]
1	$100 \leq GT < 1000$
2	$1000 \leq GT < 1600$
3	$1600 \leq GT < 5000$
4	$5000 \leq GT < 10000$
5	$10000 \leq GT < 30000$
6	$30000 \leq GT < 60000$
7	$60000 \leq GT < 100000$
8	$100000 \leq GT < 300000$

In this analysis, only the journeys/port calls for oil tankers are statistically analysed. Two out of the four tanker types addressed in BE-AWARE I are merged to facilitate a direct comparison (Table 5-2). Tankers in the port data are also classified into one of the three categories based on ship name and either call sign or IMO number of individual vessels.

Table 5-2 Ship type category

BE-AWARE I	BE-AWARE trend analysis
Tanker, crude oil	Crude oil tanker
Tanker, product	Oil product tanker
Tanker, chemical/prod Tanker, chemical incl. Tanker, others	Chemical/product/other tanker

Four representative oil types are considered in this task as for BE-AWARE I, which are crude oil (representative type no. 19), fuel oil (20), gasoil and diesel (21), and gasoline (22). All mineral oils are represented by these four types. Goods other than these types are not of focus in this analysis and thus are not treated as oil substances.

5.3 Results

5.3.1 Mongstad

The overall results of loading percentages of the tankers sailing to and from Mongstad are summarised in Table 5-4. Corresponding results from BE-AWARE I can be seen in Table 5-3. A comparison of Table 5-3 and Table 5-4 shows that at an overall level, the loading percentages of tankers arriving in Mongstad is much less than that for tankers departing from Mongstad. Looking in further detail, the loading percentage of crude oil tankers for 2018 (BE-AWARE trend analysis) is seen to have almost doubled since 2011 (BE-AWARE I). The loading percentages for the two different periods are visually compared in Figure 5-1.

From Table 5-3 and Table 5-4, the number of all tanker journeys in and out of Mongstad is seen to have registered a significant 43% decrease from 2011 to 2018; the extent of this decrease is about 30% for crude oil tankers. To determine the impact of this trend on the amount of oil transported, the reduction in journeys needs to be considered together with possible growth in tanker sizes – this is addressed in chapter 4.

Table 5-3 Overview of loading percentages for Mongstad in BE-AWARE I (2011)

	Total number of journeys departing from Mongstad			Total number of journeys arriving in Mongstad			Total number of journeys to and from Mongstad		
	Size class [GT]			Size class [GT]			Size class [GT]		
	<10000	≥10000	Total	<10000	≥10000	Total	<10000	≥10000	Total
Total number of ships identified from Traffic database / AIS									
Crude oil tanker	0	208	208	0	208	208	0	416	416
Product/Chem/Other tanker	930	552	1482	944	553	1497	1874	1105	2979
Tanker total	930	760	1690	944	761	1705	1874	1521	3395
Total number of ships transporting oil analysed from Aggregated Port Cargo Data									
Crude oil tanker	0	57	57	0	59	59	0	116	116
Product/Chem/Other tanker	875	674	1549	24	69	93	899	743	1642
Tanker total	875	731	1606	24	128	152	899	859	1758
Cargo model: % loaded with oil									
Crude oil tanker	-	27%	27%	-	28%	28%	-	28%	28%
Product/Chem/Other tanker	94%	122%	105%	3%	12%	6%	48%	67%	55%
Tanker total	94%	96%	95%	3%	17%	9%	48%	56%	52%

Table 5-4 Overview of loading percentages for Mongstad in BE-AWARE Trend analysis (2018)

	Total number of journeys departing from Mongstad			Total number of journeys arriving in Mongstad			Total number of journeys to and from Mongstad		
	Size class [GT]			Size class [GT]			Size class [GT]		
	<10000	≥10000	Total	<10000	≥10000	Total	<10000	≥10000	Total
Total number of ships identified from Port Data									
Crude oil tanker	0	145	145	0	146	146	0	291	291
Product/Chem/Other tanker	468	347	815	468	347	815	936	694	1630
Tanker total	468	492	960	468	493	961	936	985	1921
Total number of ships transporting oil analysed from Aggregated Port Cargo Data									
Crude oil tanker	0	80	80	0	74	74	0	154	154
Product/Chem/Other tanker	452	299	751	17	49	66	469	348	817
Tanker total	452	379	831	17	123	140	469	502	971
Cargo model: % loaded with oil									
Crude oil tanker	-	55%	55%	-	51%	51%	-	53%	53%
Product/Chem/Other tanker	97%	86%	92%	4%	14%	8%	50%	50%	50%
Tanker total	97%	77%	87%	4%	25%	15%	50%	51%	51%

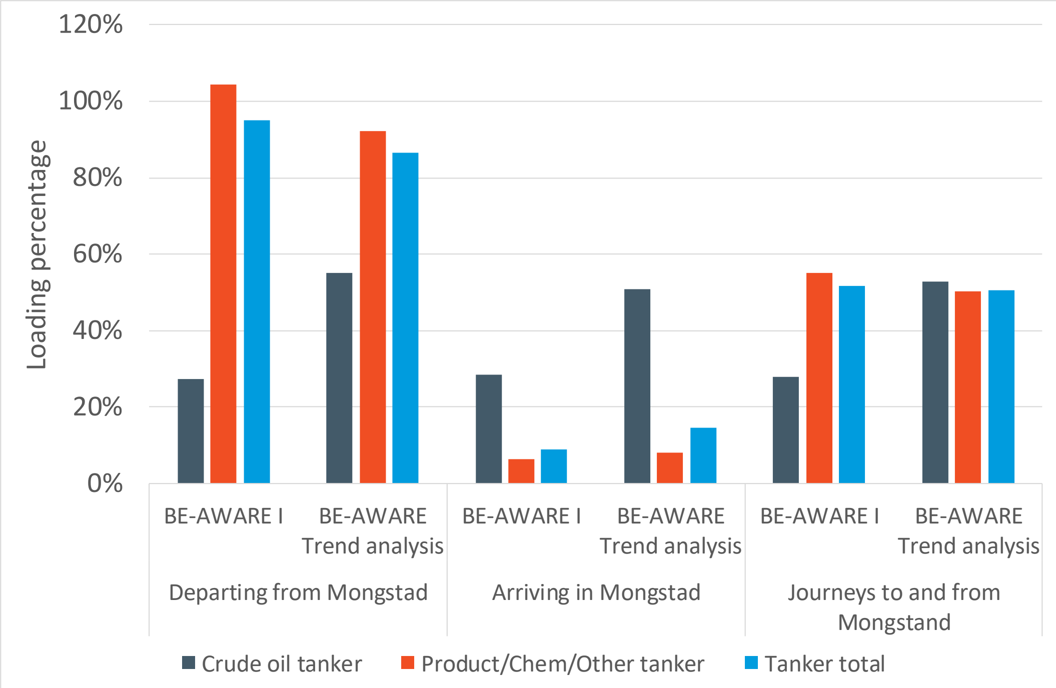


Figure 5-1 Loading percentages of tankers to and from Mongstad in 2011 (BE-AWARE I) and 2018 (BE-AWARE trend analysis

The loading percentage per ship type is further analysed per GT class - this can be seen in Table 5-5. For the BE-AWARE trend analysis, the loading percentages are seen to be mostly close to 50% regardless of type and size of ships when averaging over inbound and outbound journeys. Together with the loading percentages, the number of journeys per GT class and ship type is also provided to view the loading percentages in the right perspective with respect to frequency. (For BE-AWARE I, the number of journeys could not be split completely for the earlier period since raw results are not available from the previous report.)

Table 5-5 Average loading percentage for Mongstad in 2011 and 2018

Tanker type	GT class	2011 Loading percentage	2011 Total number of journeys[6]	2018 Loading percentage	2018 Total number of journeys
Crude oil tanker	1	-	0	-	0
	2	-		-	0
	3	-		-	0
	4	-		-	0
	5	0%	416	50.0%	4
	6	5.7%		50.0%	18
	7	68.2%		53.2%	269
	8	0%		-	0
Oil product tanker	1	62.7%	All product tankers in classes 1 to 4 = 1874	-	0
	2	0%		50.0%	2
	3	47.1%		50.3%	304
	4	45.2%		50.0%	14
	5	67.4%	All product tankers in classes 5 to 8 = 1105	50.0%	36
	6	69.7%		50.0%	22
	7	100%		50.0%	10
	8	-		-	0
Chemical/prod/other tanker	1	62.7%	Included in all product tankers – see above	-	0
	2	-		-	0
	3	47.1%		48.9%	376
	4	45.2%		50.0%	240
	5	67.4%	Included in all product tankers – see above	50.2%	594
	6	69.7%		50.0%	32
	7	-		-	0
	8	-		-	0

The distribution of oil types in tankers to and from Mongstad obtained for the BE-AWARE trend analysis (2018) is compared to the results from BE-AWARE I (2011) in Table 5-6 and Figure 5-2. Some significant changes in loading patterns are observed. For tankers unloading oil at the port (i.e. journeys to Mongstad), the proportion of fuel oil unloaded shows a decline from 2011 to 2018 and a corresponding increase is seen in the proportions of crude oil and gasoline unloaded. The tankers loading oil at the port (i.e. departing from Mongstad) show a reduction in the proportion of gasoline loaded from 2011 to 2018 and are loaded with a higher proportion of gasoil and diesel instead. When making a 2011-to-2018 comparison at an overall level, the relative proportions of crude oil, fuel oil and gasoil show an increase while the proportion of remaining gasoline is seen to have dropped.

[6] Note that the results in BE-AWARE I do not provide a break-up for the number of journeys per size class into oil product tankers and chemical/prod/other tankers.

Table 5-6 Percentage of the amount of different oil types loaded to/unloaded from an average tanker at Mongstad in 2011 (BE-AWARE I) and 2018 (BE-AWARE trend analysis)

Type of oil	2011			2018		
	Load	Unload	Overall	Load	Unload	Overall
19: Crude oil	5.2%	29.4%	6.4%	9.2%	52.6%	15.2%
20: Fuel oil	5.3%	68.2%	8.6%	5.2%	33.3%	9.1%
21: Gasoil, diesel light fuel oil	58.9%	2.4%	55.9%	68.9%	1.9%	59.5%
22: Gasoline	30.6%	0.0%	29.0%	16.8%	12.1%	16.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

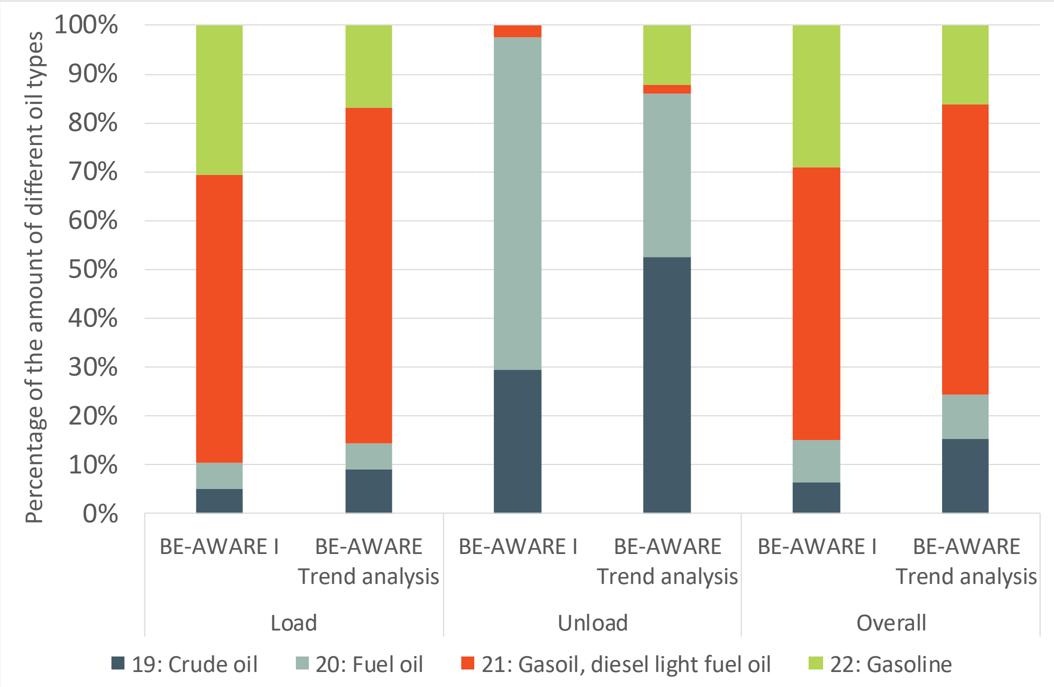


Figure 5-2 Percentage of the amount of different oil types loaded to/unloaded from an average tanker at Mongstad

The distribution of oil types in 2018 is further split per ship type and shown in Figure 5-3. Crude oil tankers mostly carry crude oil, regardless of loading or unloading activities. Oil product tankers mostly carry gasoline on their journey to Mongstad and are most frequently loaded with gasoil/diesel when they depart from Mongstad. The most loaded oil type to be transported chemical/product/other tankers is gasoil when departing from Mongstad and fuel oil when arriving in Mongstad.

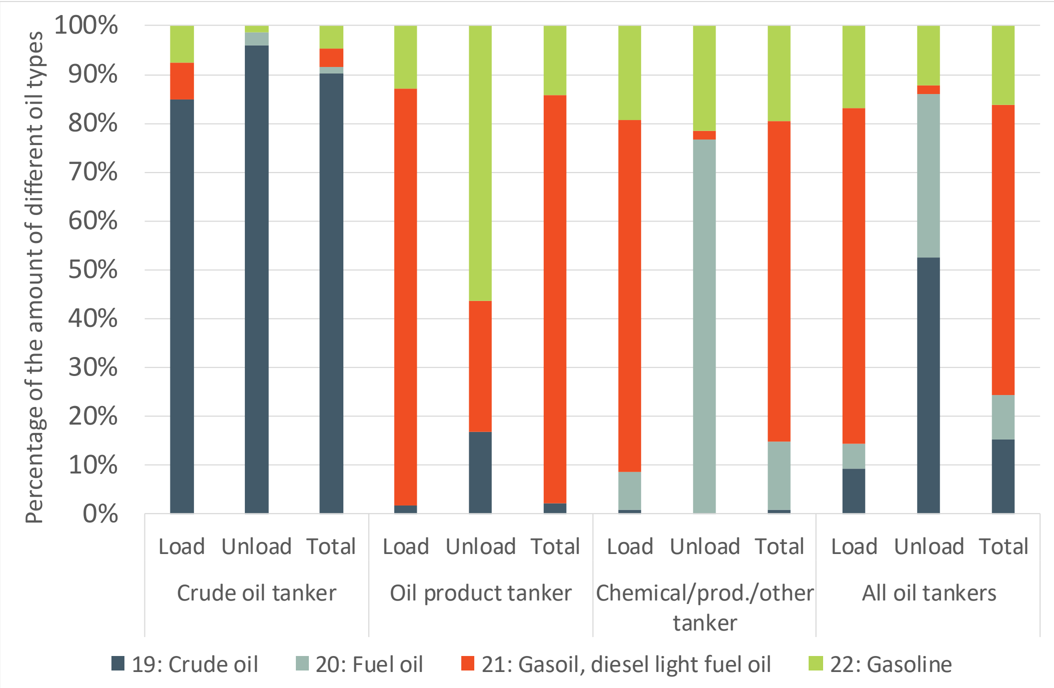


Figure 5-3 Percentage of the amount of different oil types loaded to/unloaded from an average tanker per tanker type and activity at Mongstad in 2018 (BE-AWARE trend analysis)

5.3.2 Hamburg

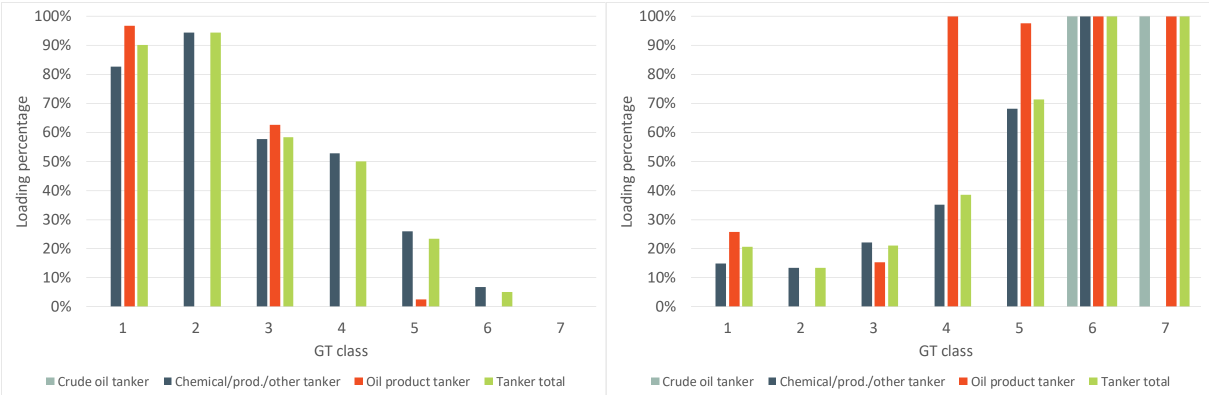
In this chapter, the analysis results for the port of Hamburg are presented. Due to unavailability of raw data from this port during BE-AWARE I, a comparative analysis is not possible.

The loading percentages per ship type and size class are summarised in Table 5-7. A clear loading pattern is observed in relation to ship size. Relatively smaller-sized tankers tend to arrive empty on their journey to Hamburg but are loaded with oil when they depart from the port. This is opposite to the loading picture for larger tankers; they predominantly arrive in a loaded state and leave empty. The same pattern can be clearly seen in Figure 5-4. It is also noted that crude oil tankers have only been recorded unloading at the port.

Table 5-7 Overview of loading percentages for Hamburg in 2018 (BE-AWARE Trend analysis)

	Total number of journeys departing from Hamburg								**Total number of journeys arriving in Hamburg**							
	Size class [GT]								**Size class [GT]**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Total number of ships identified from Port Data																
Crude oil tanker	0	0	0	0	0	4	17	0	0	0	0	0	0	4	17	0
Chem/prod./other tanker	162	230	353	125	336	15	0	0	162	230	353	125	336	15	0	0
Oil product tanker	186	0	59	7	41	1	1	0	186	0	59	7	41	1	1	0
Tanker total	348	230	412	132	377	20	18	0	348	230	412	132	377	20	18	0
Total number of ships transporting oil analysed from Aggregated Port Cargo Data																
Crude oil tanker	0	0	0	0	0	0	0	0	0	0	0	0	0	4	17	0
Chem/prod./other tanker	134	217	204	66	87	1	0	0	24	31	78	44	229	15	0	0

Oil product tanker	180	0	37	0	1	0	0	0	48	0	9	7	40	1	1	0
Tanker total	314	217	241	66	88	1	0	0	72	31	87	51	269	20	18	0
Cargo model: % loaded with oil																
Crude oil tanker	-	-	-	-	-	0%	0%	-	-	-	-	-	-	100%	100%	-
Chem/prod./other tanker	83%	94%	58%	53%	26%	7%	-	-	15%	13%	22%	35%	68%	100%	-	-
Oil product tanker	97%	-	63%	0%	2%	0%	0%	-	26%	-	15%	100%	98%	100%	100%	-
Tanker total	90%	94%	58%	50%	23%	5%	0%	-	21%	13%	21%	39%	71%	100%	100%	-



(a) Ships departing from Hamburg (b) Ships arriving in Hamburg

Figure 5-4 Loading percentage of tankers to and from Hamburg

The overall loading percentage per tanker type and size is estimated by combining the records from import and export activities. The loading percentages are mostly around 50% while some deviations up to 10% are observed for the different combinations of tanker type and size. The number of journeys is also provided to give an indication of how many records have been used to arrive at the loading percentage in each case.

Table 5-8 Overall loading percentage per ship type and size for Hamburg

Tanker type	GT class	Loading percentage	Total number of journeys
Crude oil tanker	1	-	0
	2	-	0
	3	-	0
	4	-	0
	5	-	0
	6	50.0%	8
	7	50.0%	34
	8	-	0
Oil product tanker	1	61.3%	372
	2	-	0
	3	39%	118
	4	50.0%	14

	5	50.0%	82
	6	50.0%	2
	7	50.0%	2
	8	-	0
Chemical/product/other tanker	1	48.8%	324
	2	53.9%	460
	3	39.9%	706
	4	44.0%	250
	5	47.0%	672
	6	53.3%	30
	7	-	0
	8	-	0

The distribution of oil types is further estimated per ship type and loading/unloading activities. As shown in Table 5-9 and Figure 5-5, fuel oil and gasoil/diesel are most frequently carried by the tankers to and from Hamburg. Crude oil tankers are seen to be loaded with crude oil with a high frequency.

Table 5-9 Percentage of the amount of different oil types loaded to/unloaded from an average tanker at Hamburg

Type of oil	Crude oil tanker			Oil product tanker			Chemical/prod./other tanker			All oil tankers		
	Load	**Unload**	**Total**	**Load**	**Unload**	**Total**	**Load**	**Unload**	**Total**	**Load**	**Unload**	**Total**
19: Crude oil	-	90%	90%	0%	2%	1%	0%	0%	0%	0%	4%	2%
20: Fuel oil	-	0%	0%	82%	29%	64%	49%	35%	46%	57%	32%	50%
21: Gasoil, diesel light fuel oil	-	10%	10%	18%	64%	33%	46%	60%	48%	39%	59%	44%
22: Gasoline	-	0%	0%	0%	6%	2%	5%	5%	6%	4%	5%	5%

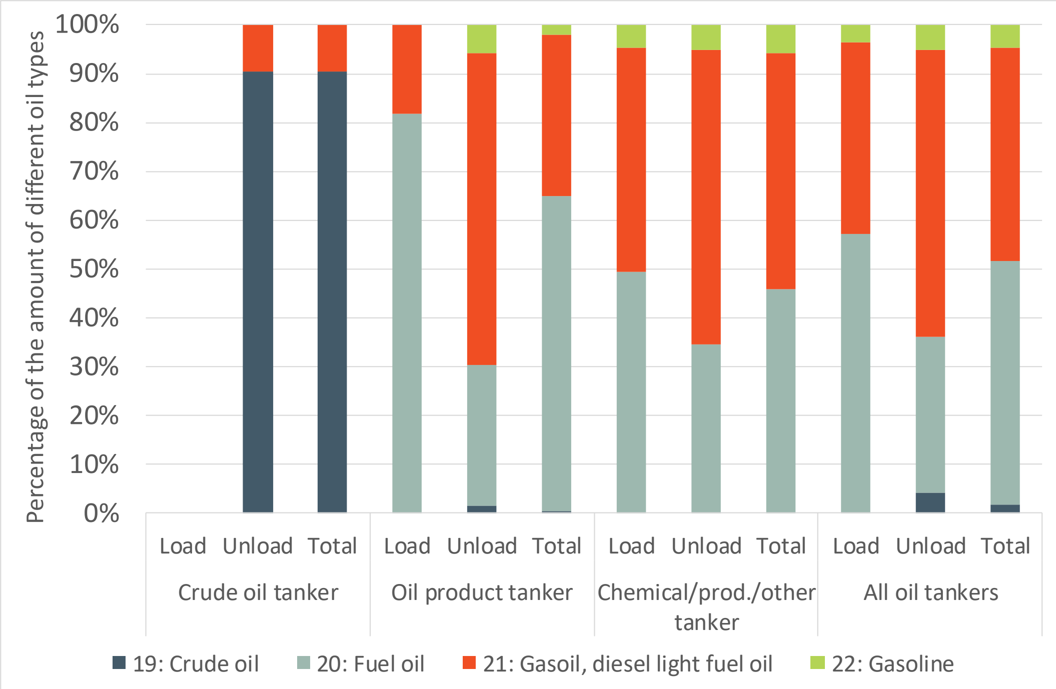


Figure 5-5 Percentage of the amount of different oil types loaded to/unloaded from an average tanker at Hamburg

5.3.3 Assessment for the Bonn Agreement area

Average loading percentage

The port data from Mongstad and Hamburg is integrated to estimate the average loading percentage of tankers in the Bonn Agreement area for the current period – these results are shown in Table 5-10 and Figure 5-6. Since the two ports are considered as representative samples of the overall situation in the North Sea with a large number of individual ports, it is decided to take an unweighted average, i.e. Mongstad and Hamburg are both considered with the same weight regardless of the absolute number of oil tanker journeys to and from each of these two ports. A comparison with the corresponding loading percentage for 2011 as per BE-AWARE I is also made.

When comparing the 2018 (i.e. BE-AWARE trend analysis) situation with 2011 (i.e. BE-AWARE I), the loading percentages for tankers are higher with a couple of exceptions (oil product tankers in GT class 5 and 7). However, it can be doubted that the actual numbers have increased; it is more likely that some of the data from 2011 were showing a somewhat unrealistic picture, indicating a loading percentage of close to zero for a number of ships in both directions, i.e. travelling in and out of Rotterdam and Antwerp, cf. Annex 3 of the BE-AWARE I Oil Cargo Model report (Bonn Agreement, 2014b).

In the end, simple economic considerations show that it is unlikely that ships would have an average overall (i.e. considering travelling in and out of ports) loading percentage of significantly less than 50 %, corresponding to 100 % loading in one direction and 0 % loading on the way back (or vice versa). Thus, there is good reason to believe that the updated results from 2018 are closer to reality. In addition, they show a good correspondence with the 2011 data from Mongstad, the only port being part of the goods transport analysis both in BE-AWARE I and the BE-AWARE trend analysis.

Table 5-10 Average loading percentage of tankers in the Bonn Agreement area: BE-AWARE I (2011) and BE-AWARE trend analysis (2018)

Tanker type	GT class	BE-AWARE I (2011)		BE-AWARE trend analysis (2018)	
		Loading percentage[7]	Sample size	Loading percentage[8]	Sample size
Crude oil tanker	1	-	Not available	-	0
	2	-		-	0
	3	0%		-	0
	4	0%		-	0
	5	30.2%		50.0%	4
	6	21.3%		50.0%	26
	7	40.6%		51.6%	303
	8	29.0%		-	0
Oil product tanker	1	36.3%		61.3%	372
	2	21.9%		50.0%	2
	3	41.0%		44.7%	422
	4	33.9%		50.0%	28
	5	67.6%		50.0%	118
	6	45.3%		50.0%	24
	7	56.6%		50.0%	12
	8	-		-	0
Tanker chemical/prod and others	1	30.2%		48.8%	324
	2	3.7%		53.9%	460
	3	21.6%		44.4%	1082
	4	17.4%		47.0%	490
	5	31.2%		48.6%	1266
	6	25.3%		51.7%	62
	7	-		-	0
	8	-		-	0

[7] This is the unweighted average of the loading percentages for Rotterdam, Antwerp and Mongstad

[8] This is the unweighted average of the loading percentages for Hamburg and Mongstad

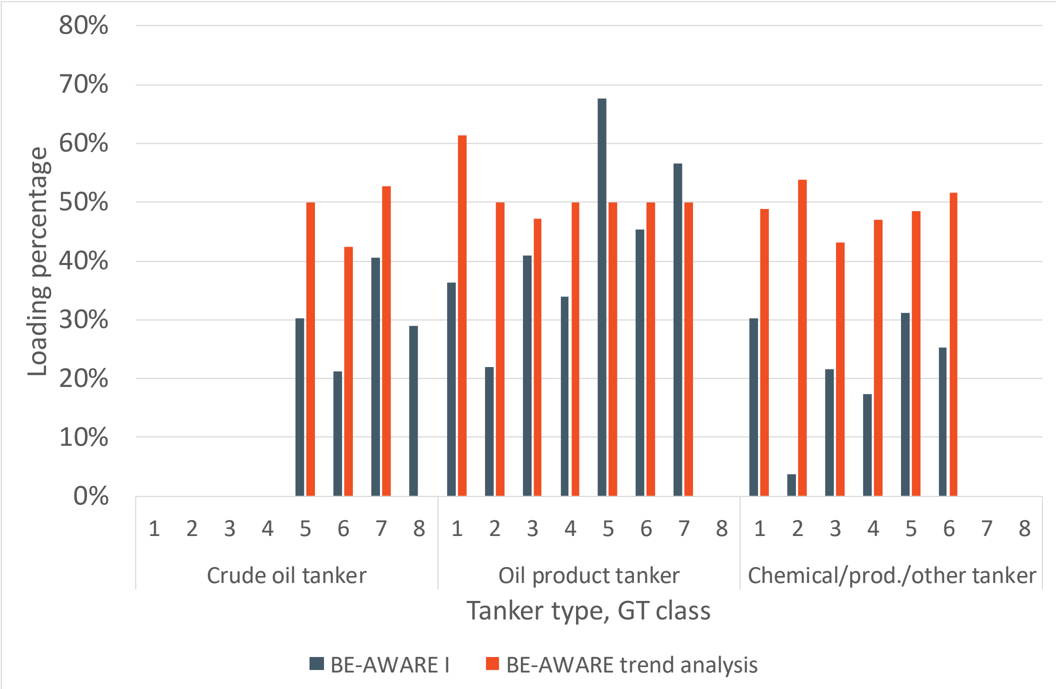


Figure 5-6 Average loading percentage of tankers in the Bonn Agreement area: BE-AWARE I (2011) and BE-AWARE trend analysis (2018)

Division of oil types

The overall distribution of oil types in the tankers loaded with oil is estimated and shown in Table 5-11. When compared with BE-AWARE I results, crude oil tankers, as per the BE-AWARE trend analysis, are seen to be loaded with relatively more crude oil while the proportion of fuel oil shows a significant decrease. For oil product tankers and chemical/product and other tankers, an increase in the relative proportion of gasoil/diesel is seen from 2011 to 2018 while the relative proportions of the remaining three oil types are decreased or remain similar accordingly. Again, some of the above trends are likely to be due to the different selection of representative ports (Rotterdam/Antwerp/Mongstad in 2011 vs. Hamburg/Mongstad in 2018).

Table 5-11 Percentage of the amount of different oil types in an average tanker in the Bonn Agreement area in 2011 (BE-AWARE I) and in 2018 (BE-AWARE trend analysis)

	2011			**2018**		
Oil type	**Crude oil tanker**	**Oil product tanker**	**Chemical/ prod./other tanker**	**Crude oil tanker**	**Oil product tanker**	**Chemical/ prod./other tanker**
19: Crude oil	65%	10%	2%	90%	1%	0%
20: Fuel oil	25%	38%	55%	1%	39%	33%
21: Gasoil, diesel light fuel oil	9%	37%	25%	5%	53%	56%
22: Gasoline	1%	15%	18%	4%	7%	12%

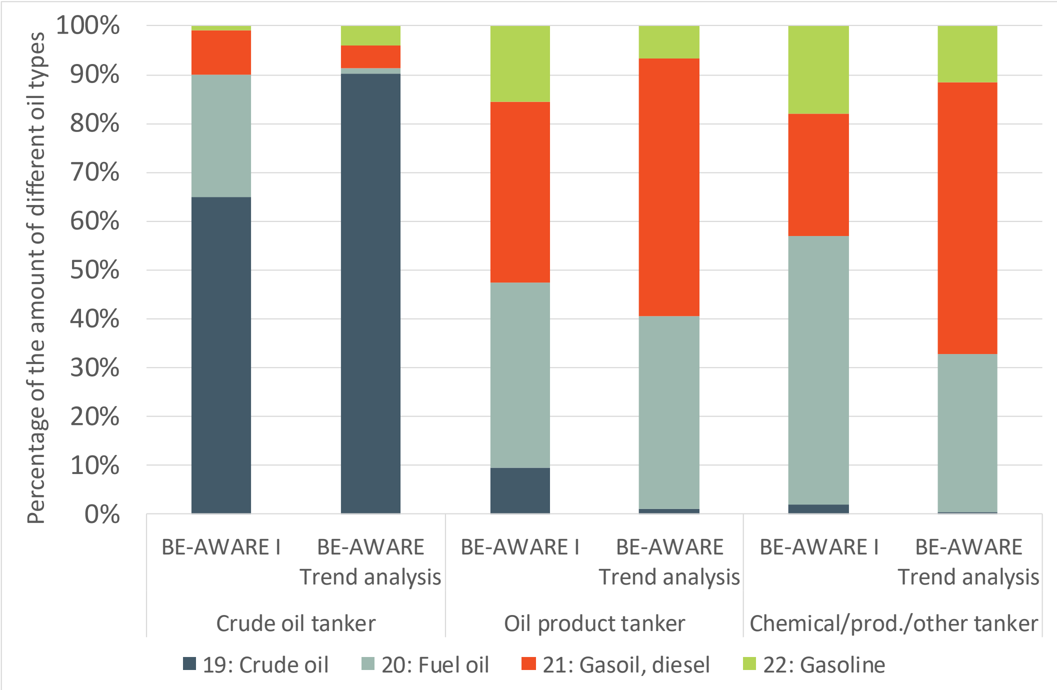


Figure 5-7 Percentage of the amount of different oil types in an average tanker in the Bonn Agreement area: BE-AWARE I and BE-AWARE trend analysis

5.4 Overall summary

In summary, the loading percentages of oil tankers show a general increase from 2011 (BE-AWARE I) to 2018 (BE-AWARE trend analysis); for 2018, these percentages are seen to be generally distributed around 50% with a low variability. It is most likely that these numbers have been at a similarly high number already back in 2011 but have been misrepresented in the original analysis. With regard to relative proportion of oil types, a clear decline in the percentage of fuel oil is noticed. Gasoline is also seen to be less carried than before, with a smaller extent of reduction compared to fuel oil. The reduced proportions for these two oil types are matched with corresponding increases in crude oil proportions for crude oil tankers and gasoil/diesel proportions for the remaining tanker types.

When looking at the heavy oil types together (i.e. crude oil and fuel oil), their proportion is unchanged on crude oil tankers. However, there is a significant drop in heavy oil types on all other tanker types (product tankers, chemical/product tankers and other tankers). As part of the Sulphur Emission Control Area (SECA) regime, it is noted that regulations restricting the maximum sulphur content in fuel oil on board ships from 1% to 0.1% came into force in the North Sea from the 1st of January 2015. While this regulation applies to fuel used by ships, it needs to be investigated whether the SECA effect has resulted in a reduced use of heavy oil types and their transport.

6. Analysis of development of windfarm areas

6.1 Approach

The first objective of this task is to map the existing areas dedicated for wind turbines within the project area (Wider North Sea). This indicates the "as per now" situation and illustrates the areas that actively are utilised for wind turbines.

The next objective is to map the plans for future development of wind turbine areas in the project area. This is conducted for the selected year for the outlook, i.e. for 2030.

For the entire project area, this task provides

- a comparison between windfarm areas forecasted for 2020 in the BEAWARE I project and windfarm areas in the existing situation described in the present Trend analysis.
- an evaluation of the trend in the development from the present situation until 2030

The analysis is based on area considerations, and the conditions for selected main marine traffic lanes are commented on where appropriate. Results of the analysis are carried out on sub-regional level, similar with the approx. six sub-areas applied in BE-AWARE.

6.2 Data requirements, data received

The maps were prepared based on the information provided by the Contracting Parties.

Maps for existing and planned wind turbine areas in the respective sea areas were requested from each partner. The maps show the location and extent of the existing and planned wind turbine areas.

The requested format was GIS shape file and pdf map for each country included in the study. The pdf maps were intended for visual check of the GIS data regarding the location and status of the windfarms in each country. However, it was not possible for all countries to contribute with the requested data and/or data formats. In (Table 6-1*),* we show the data and data formats provided with from the participant countries.

Preliminary maps created with the given information, were circulated to Bonn Agreement Secretariat and among the Contracting Parties for mutual acceptance of the quantity as well as the quality of the provided information.

The data received from United Kingdom was separated in two blocks, one for Scotland and one for the rest of UK. The data structure, grouping and sources were different for these two data packages. Hence, we have decided to respect this data separation and show the data from Scotland and the data for the rest of UK separately all along this chapter (Trend analysis: Wind turbines).

Table 6-1: Data deliverance by the partnering countries

Country	Data	Data format	Comments
Norway	Windfarms	Shape file, confirmed by e-mail	
Sweden	N/a	Confirmed by e-mail	no windfarms in the studied area
Denmark	Windfarms	Shape file, confirmation e-mail	
Germany	Windfarms	2 Shape files, confirmation text file	
Netherlands	Windfarms	1 Mpk file and confirmation map jpg	
Belgium	Windfarms	10 Shape files, 1 excel and confirmation e-mail	
UK (England, Wales & N. Ireland)	Wind, wave and tidal farms	1 Website, 2 pdf reports and confirmation emails	
UK (Scotland)	Wind, wave and tidal farms	1 Website, 2 pdf reports and confirmation emails	
Ireland	Windfarms	9 shape files, word file, confirmation e-mails	
France	Wind, wave and tidal farms	3 excel files, 3word files, 2 pdfs, 1 jpg, confirmation e-mails	1 windfarm reported with no GIS data available
Spain	Windfarms	2 pdfs, 2 websites	no GIS data available

6.3 Results and discussion

6.3.1 Windfarms

The individual countries have assigned windfarm areas with different time frames. Most of the countries have assigned the windfarm areas according to the industry applications and are therefore assigned to be operational in a certain year. However, Denmark, Norway and Scotland as well have reserved large areas for windfarm development with no specified due date.

In general terms, all windfarm areas which are in operation or under construction were categorised as operational in 2021. All areas which are consented and at different levels in the approval process were considered as operational by 2030. All other areas, which are reserved/granted for wind farm uses in the Marine plans but have no specific data, have been presented as "beyond 2030".

Below the windfarm maps for the Bonn Agreement area, which was extended by including the Bay of Biscay, are presented.

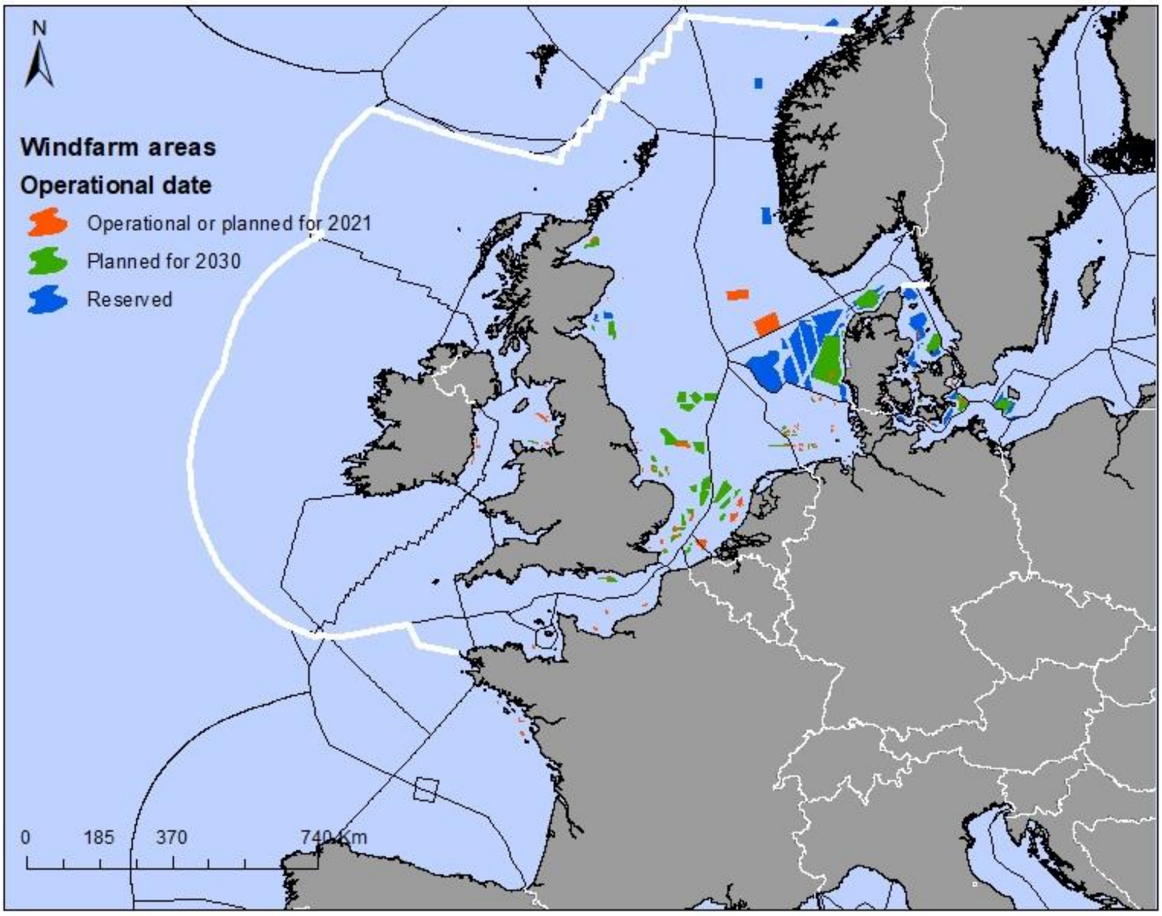


Figure 6-1 Windfarm areas in the project area comprising the Bonn Agreement area (white boundary) as well as of the Bay of Biscay.
"Reserved" refers to the category "Beyond 2030".
White thick line: Bonn Agreement area
White thin line: Country borders
Black lines: EEZ and limits of oceans and seas
(http://www.marineregions.org/gazetteer.php?p=details&id=2350)

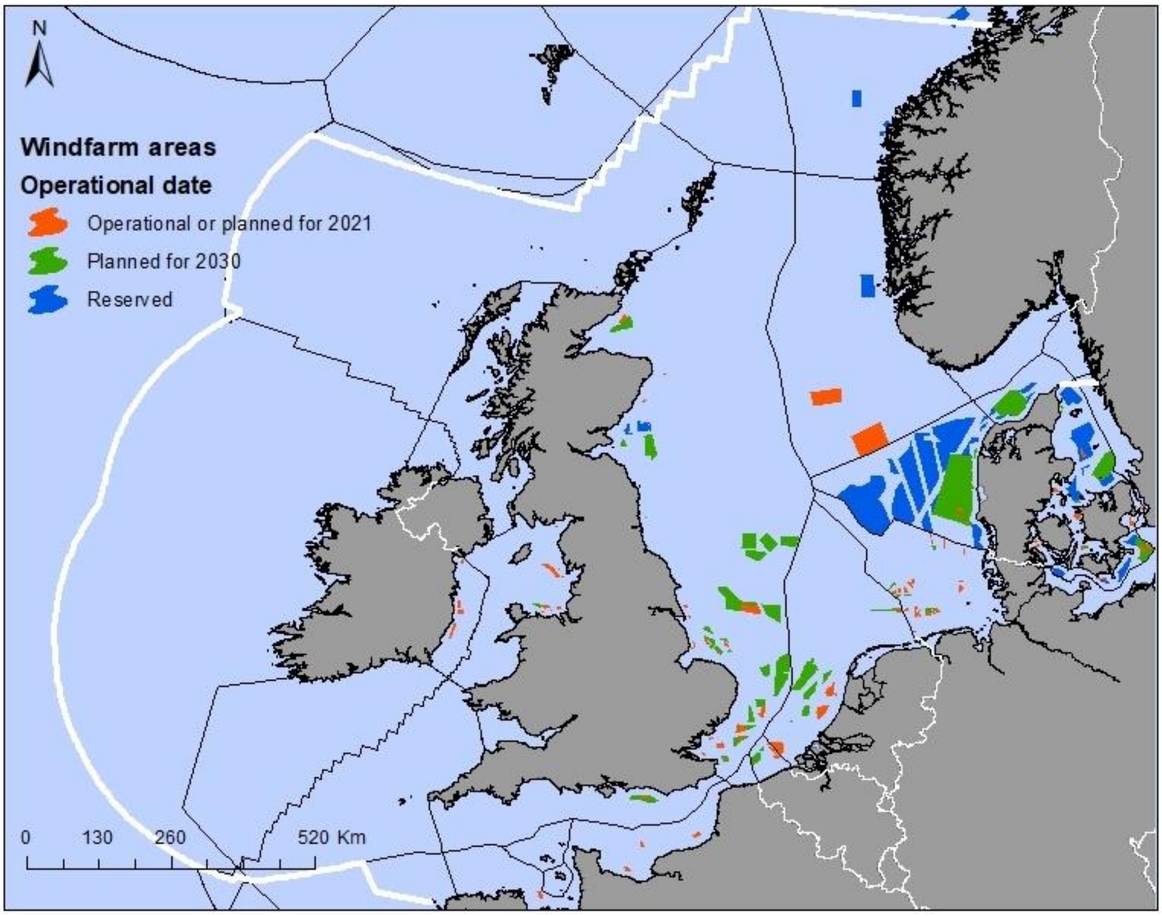


Figure 6-2: Windfarm areas in the original Bonn Agreement area. "Reserved" refers to the category "Beyond 2030".
***France is missing a Windfarm, located at the in the area marked with a red circle (GIS data was not available)** (See explanation of lines in **Figure 6-1**).

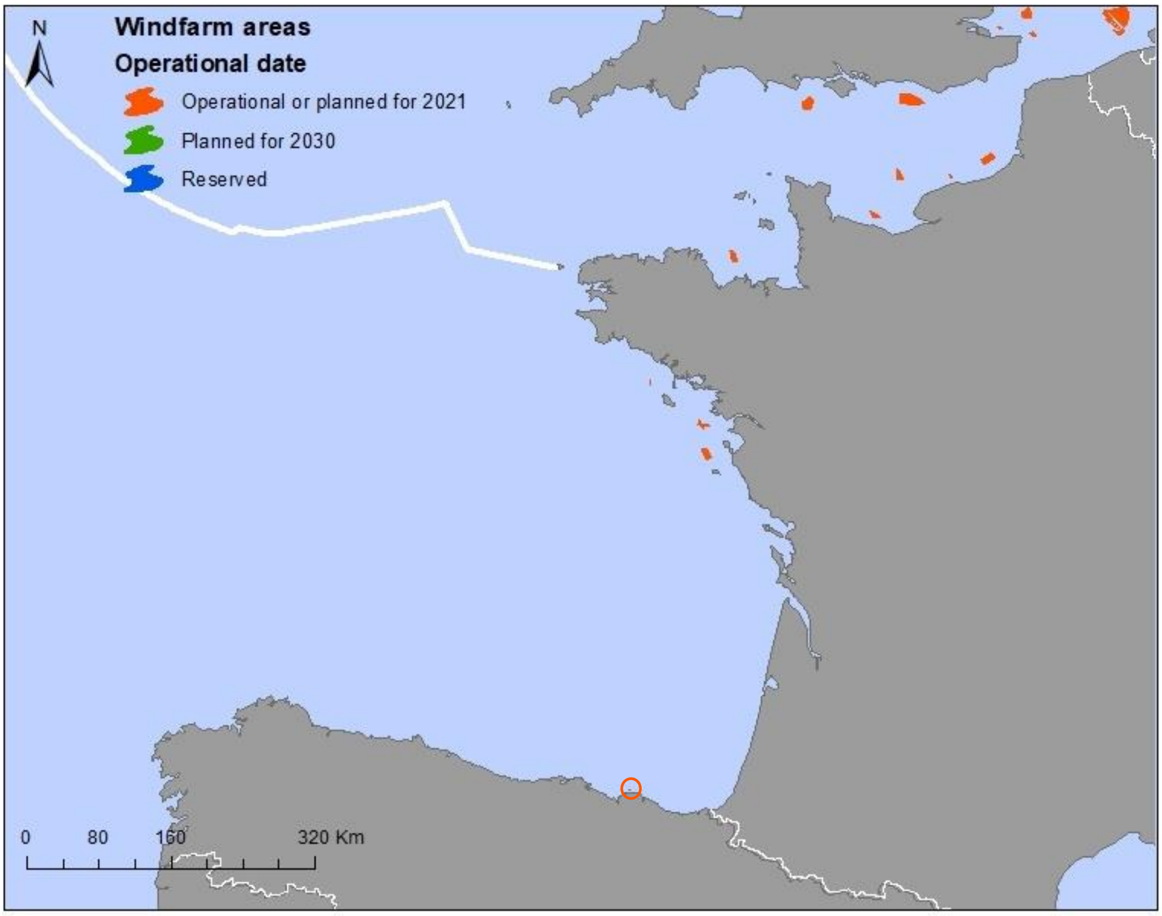


Figure 6-3: Windfarm areas in the Bay of Biscay.
*Spain did not provide a GIS file of the wind farm area the GIS area is hence taken from Emodnet (http://www.emodnet-humanactivities.eu/view-data.php). (See explanation of lines in **Figure 6-1**).

The areas occupied by wind farms for 2021, 2030 and beyond 2030 are given in Table 6-2.

Table 6-2: Number and area extension of windfarm areas in the Bonn Agreement area.
***Spain did not provide a GIS file of the wind farm area the GIS area is hence taken from Emodnet (http://www.emodnet-humanactivities.eu/view-data.php).**

	Planned 2021		Extra Planned 2030		Reserved areas	
	Areas (no.)	Extent (Km^2)	Areas (no.)	Extent (Km^2)	Areas (no.)	Extent (Km^2)
Norway	2	3966	0	0	5	1779
Sweden	-	-	-	-	-	-
Denmark	26	867	10	11790	51	50508
Germany	28	881	1	353		
Netherlands	8	1081	6	2107		
Belgium	11	178	3	282		
UK (Engl., Wales, N.I.)	46	4890	9	4808		
UK (Scotland)	12	220	6	2086	3	546
Ireland	4	260	0	0		
France	5	429				
All Bonn Agreement	142	12771	35	21426	59	52834
France	3	185				
Spain	1*	5	-	-	-	-
All Bay of Biscay	4	191				

Maps for the different EEZ's are given for each country below:

Norway

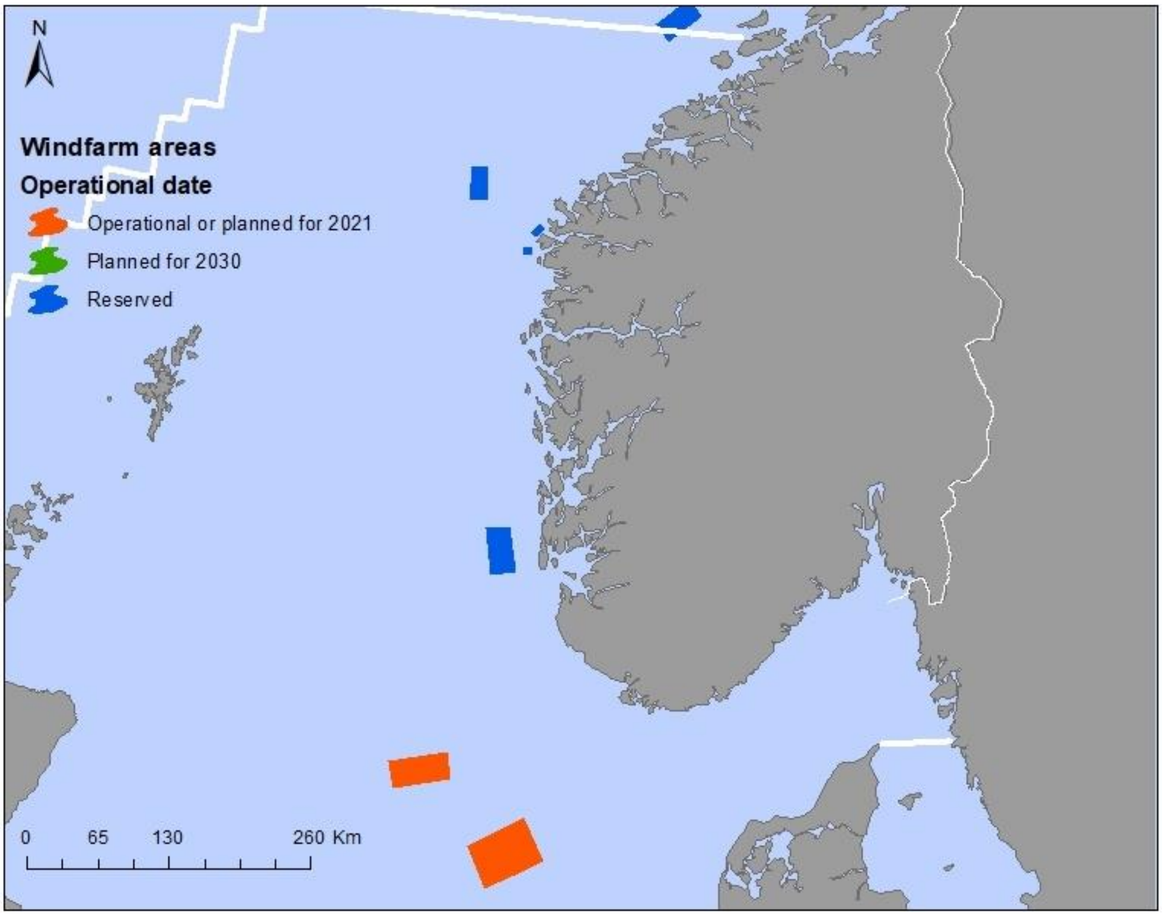


Figure 6-4: Windfarm areas in Norway

Sweden

No windfarms are planned for the Swedish part of the Bonn Agreement area.

Denmark

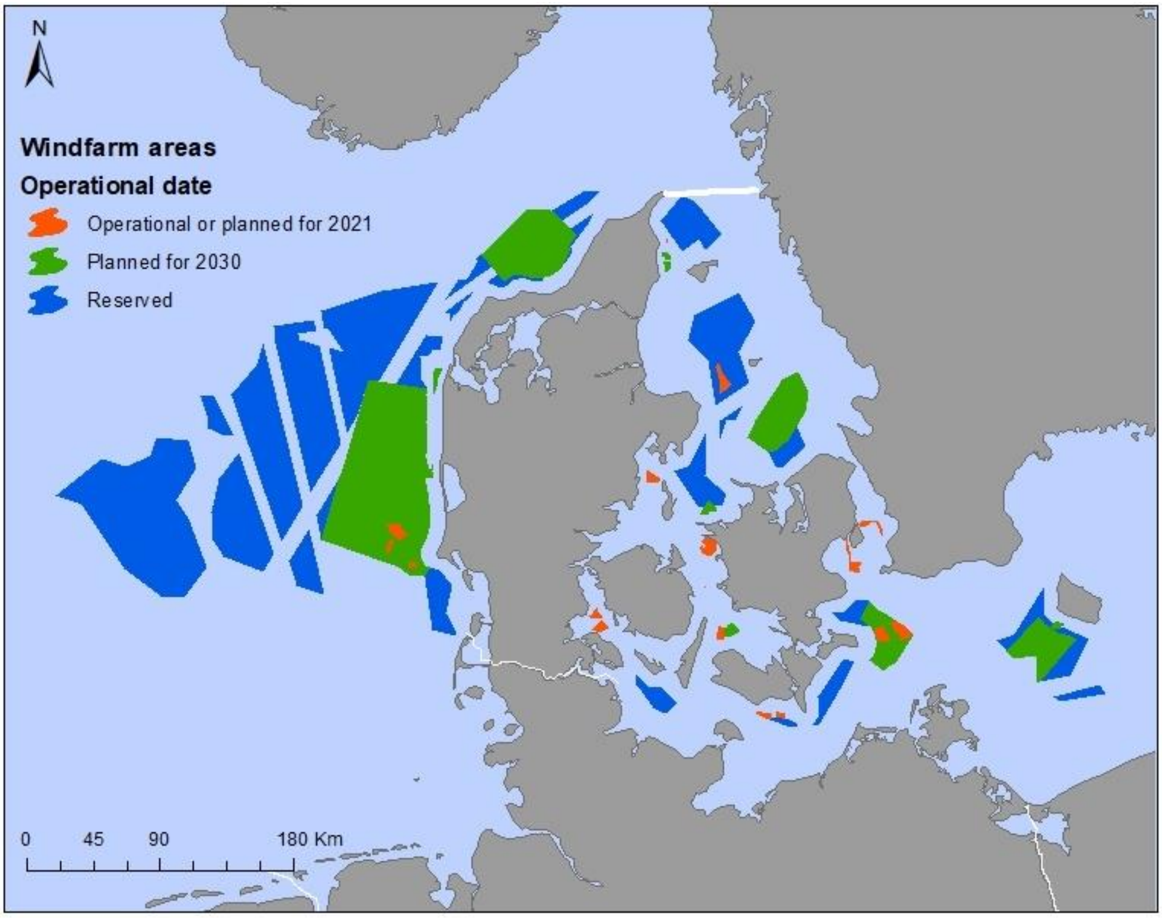


Figure 6-5: Windfarm areas in Denmark

Figure 6-5 indicates wind farm areas overlapping the navigation corridors from Skaw to the Channel (green areas overlapping traffic corridors). The map represents the preliminary areas of interest for wind farms, based on parameters such as physical parameters like wind energy, water depth, wave climate, soil condition etc. The map will be subject to more elaboration, so that either no wind mills will be in traffic lanes or the traffic lanes will be moved.

Germany

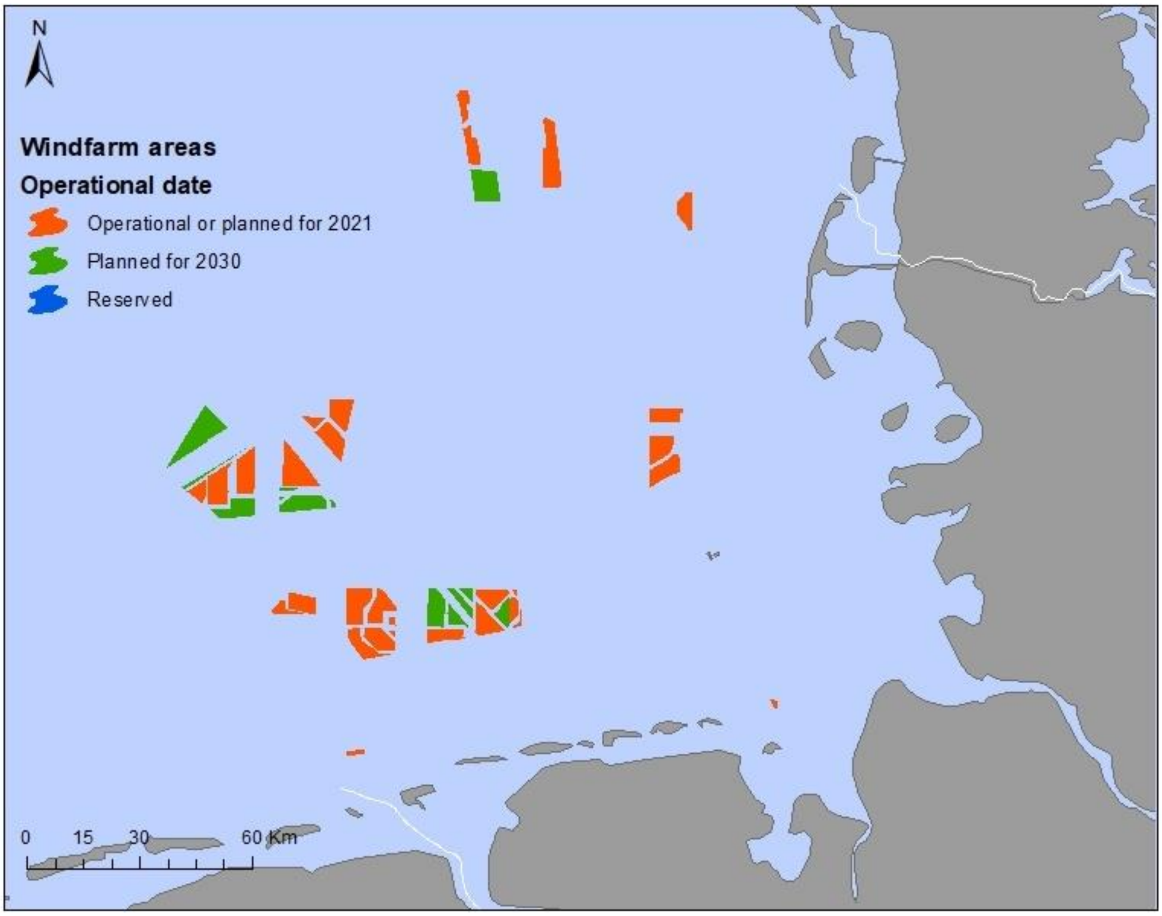


Figure 6-6: Windfarm areas in Germany

The Netherlands

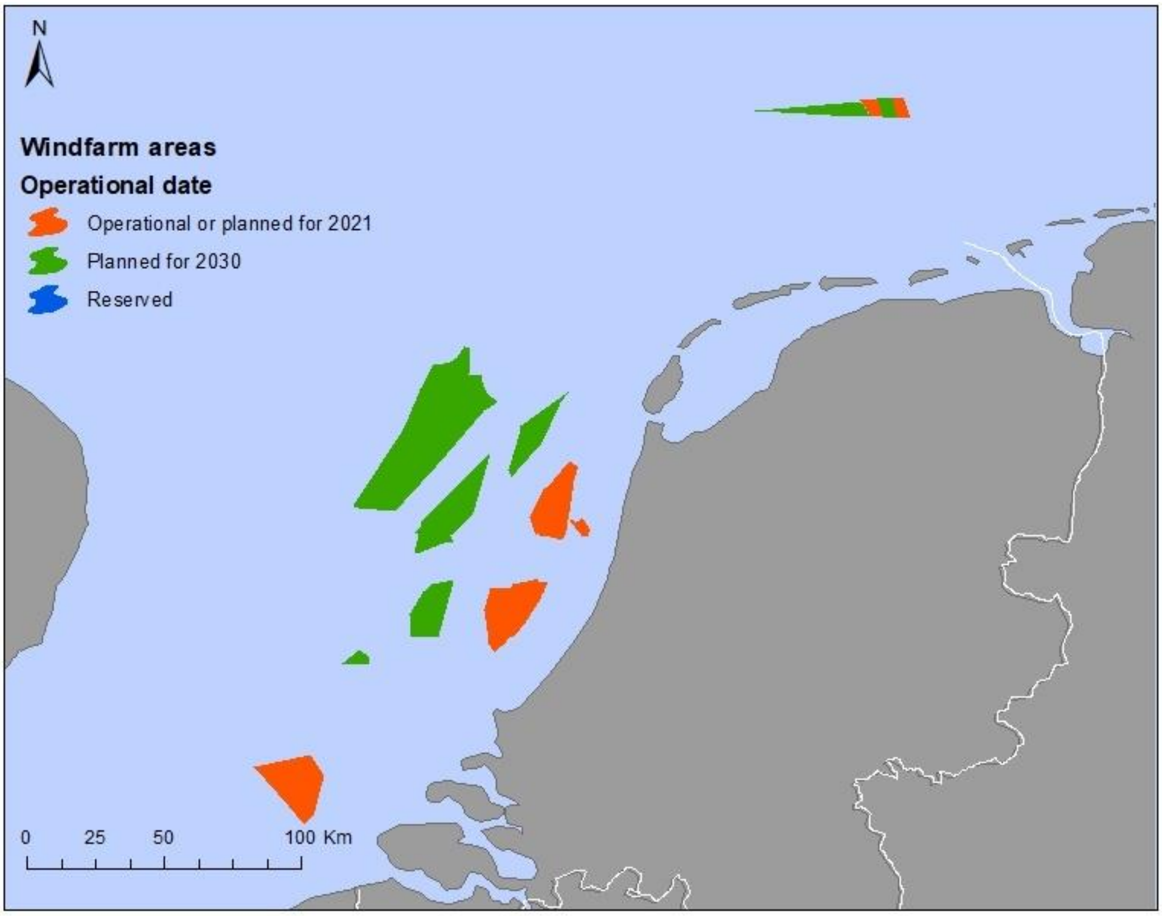


Figure 6-7: Windfarm areas in The Netherlands

Belgium

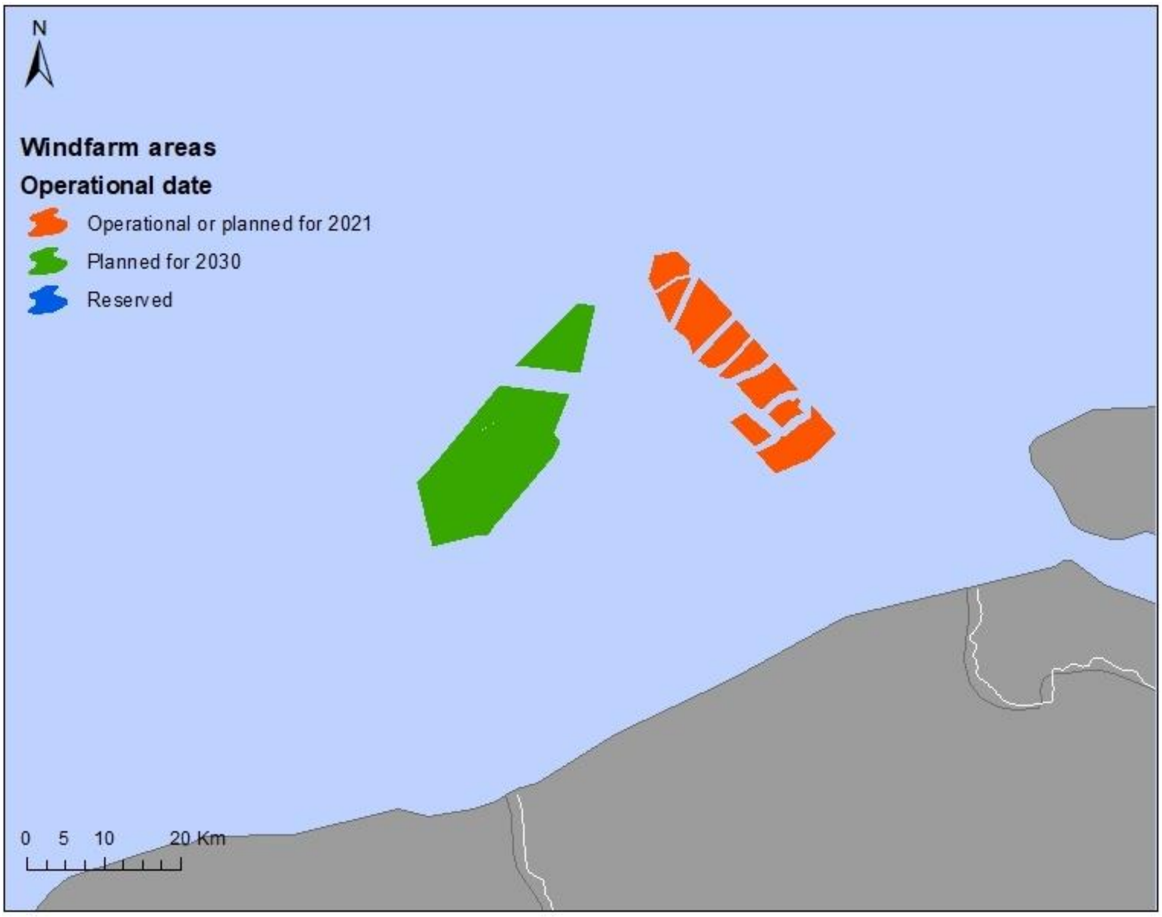


Figure 6-8: Windfarm areas in Belgium

United Kingdom

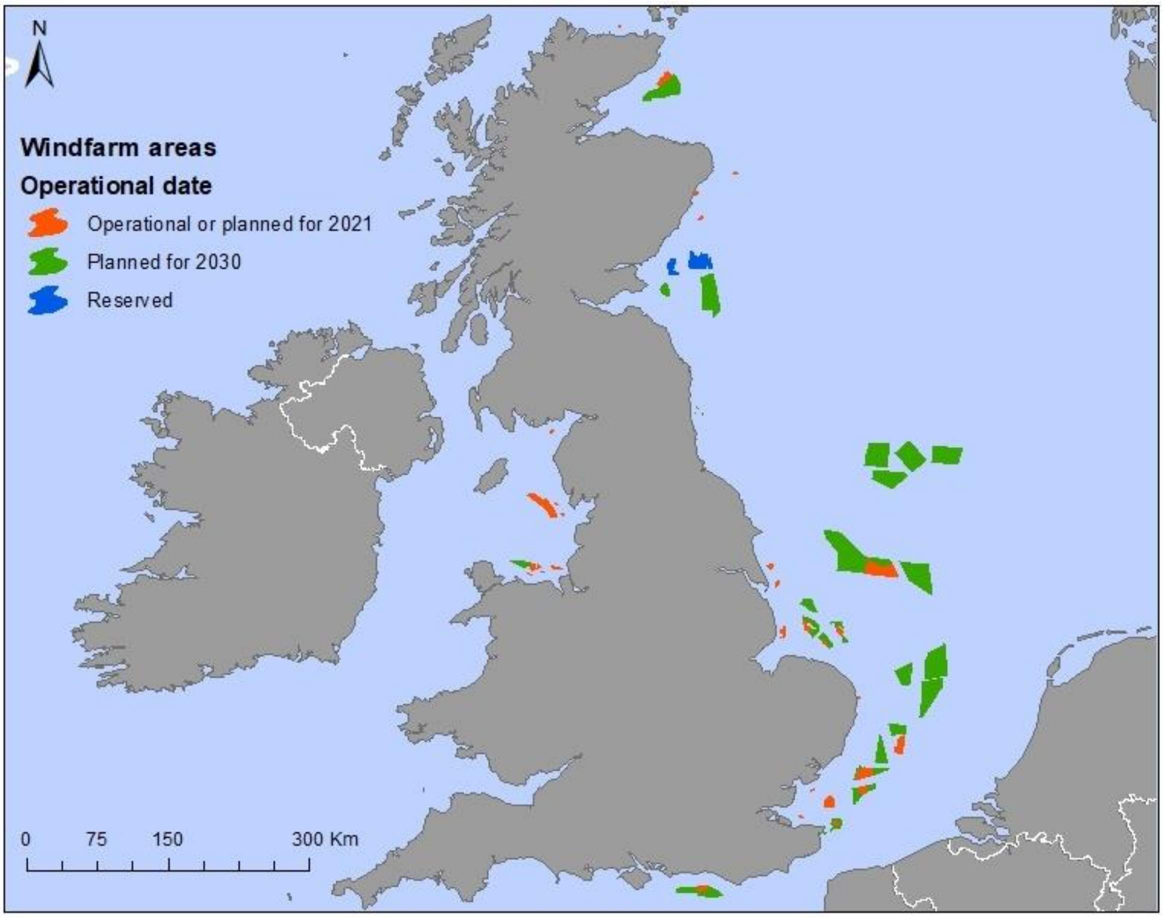


Figure 6-9: Windfarm areas in United Kingdom

Ireland

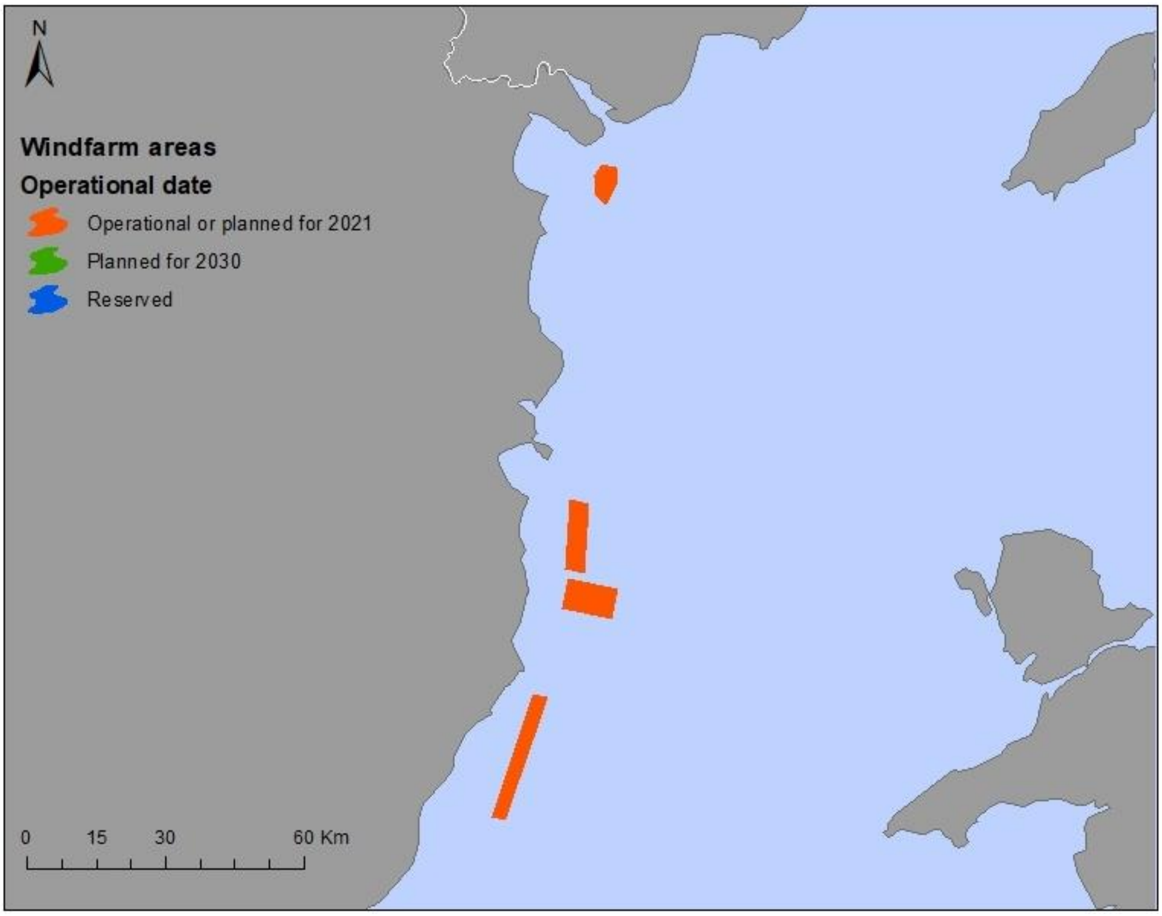


Figure 6-10: Windfarm areas in Ireland

France

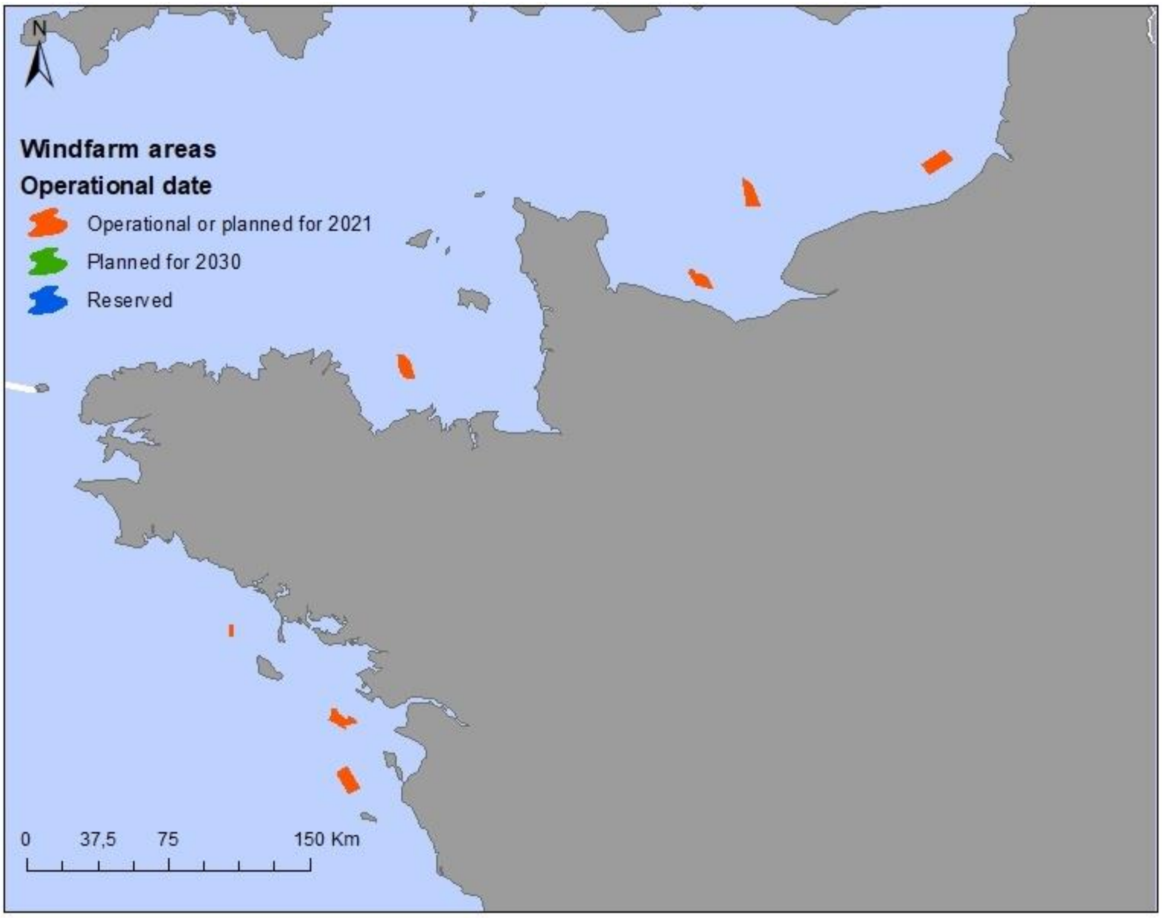


Figure 6-11: Windfarm areas in France

Spain

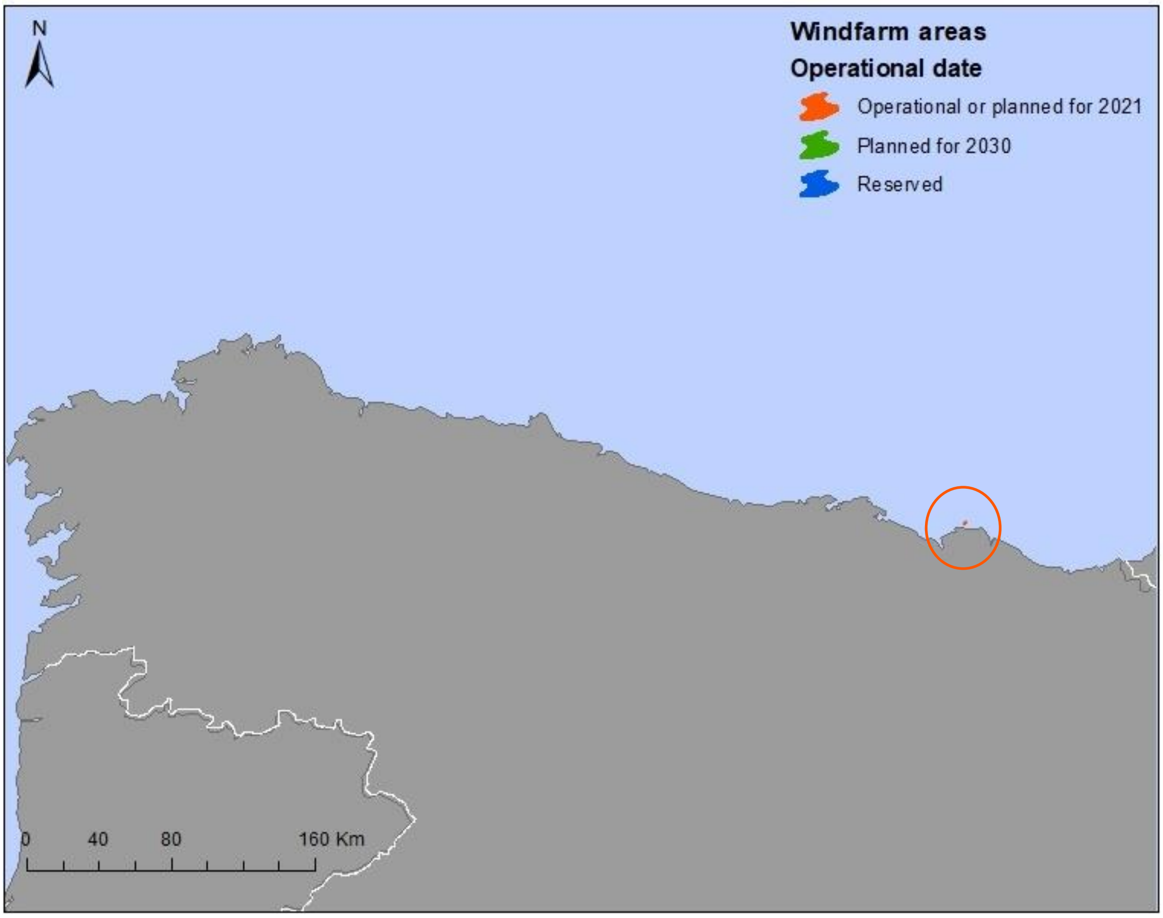


Figure 6-12: Windfarm areas in the Cantabric region of Spain

Comparison with BE-AWARE I

The above maps provide the opportunity to compare the areas of operational windfarms at present (2021) with the windfarm areas, that were expected to be present at 2020 as per the forecast made in the BE-Aware I project.

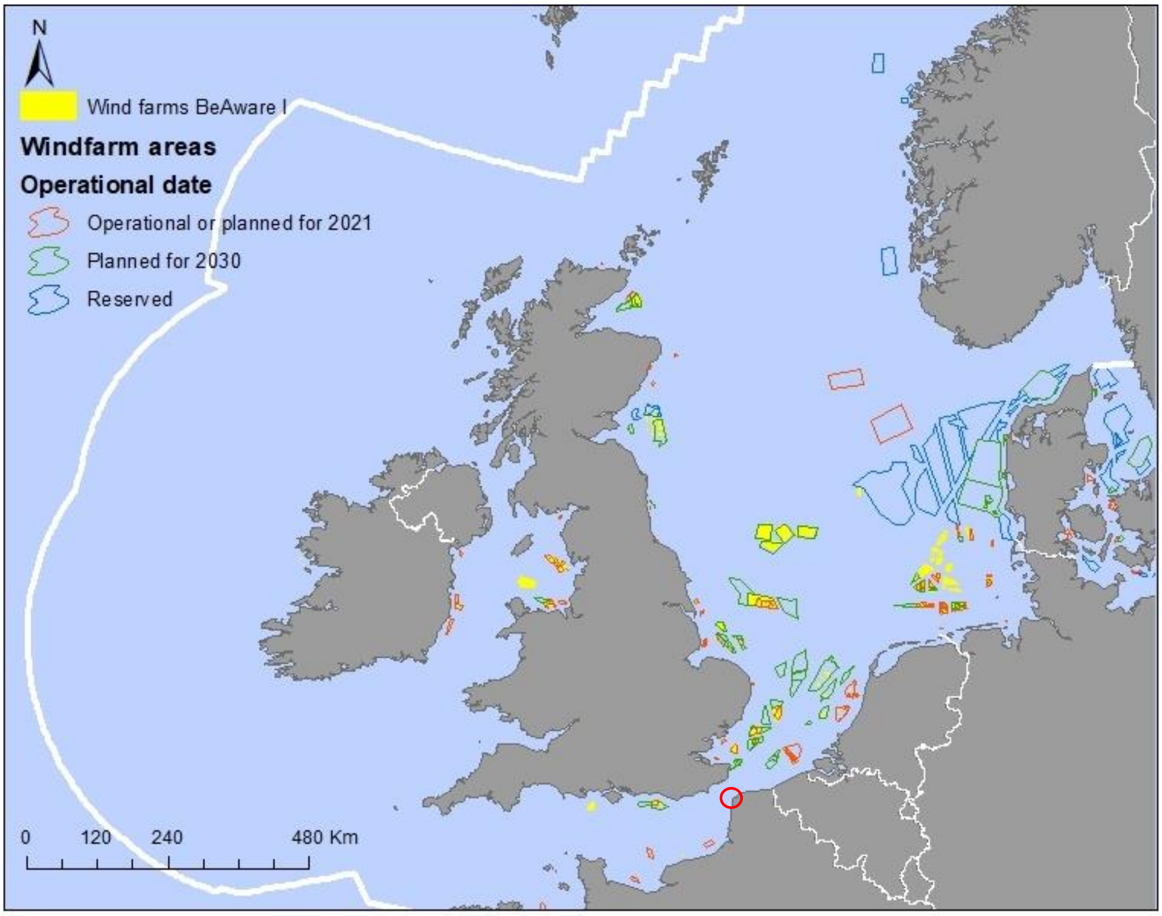


Figure 6-13: Comparison between the predicted windfarm distribution in the Bonn Agreement area for 2021, from the project BE-AWARE I
Yellow areas: What existed in 2011 and what was forecast for 2020
Orange areas: Operational or in operation by 2021)
(Green areas: Operational or in operation by 2030).
*France is missing a Windfarm, located at in the area marked with a red circle (GIS data was not available).

The map in Figure 6-12, shows a comparison between the windfarms predicted for 2020 in the project BE-AWARE I and the current predictions for each country. In this map, we find four different area types:

- The Areas in yellow, are those that were predicted for development in BE-AWARE I but were not constructed nor are they considered in the current national plans.
- The areas in yellow, surrounded by an orange line are those that were predicted in BE-AWARE I and are currently operational or set to be operational by 2021.
- The areas surrounded by an orange line are areas that were not predicted in BE-AWARE I but that are currently set to be operational by 2021.
- Finally, the areas in Yellow surrounded by a green line are those that were predicted in Be-AWARE I to be operational by 2020, but that are currently predicted to be operational by 2030.

The variation from the accuracy of the initial prediction (BE-AWARE I) and the current prediction differs from country to country. In general terms, the current tendency is towards more and bigger windfarms (Figure 6-12 and table 6-3). It is also visible that some of the original predicted windfarms have been delayed from 2020 to 2030.

Hence, the current trend, indicates a more rapid increase in windfarm development than expected during BE-AWARE I. This may be a result of the increased focus in Europe on sustainable energy production.

The large areas reserved for future development indicates that the development of windfarms in the North Sea is likely to continue beyond 2030.

Table 6-3: Comparative analyses between the numbers of windfarm areas and their total extent predicted in the project BE-AWARE I to the present.

	Estimated BE-AWARE I2020	Trend analysis 2021	Trend (increase)
Number of Areas	102	142	39 %
Extent (Km^2)	10,132	12,771	26 %

Trend to 2030

Table 6-4 indicates that the number of locations and especially the total extent for windfarms will increase by 2030. Denmark (~1360 %), followed by the Scottish part of the UK EEZ Scotland (~950 %) are the countries or regions where the total windfarm area is expected to increase mostly with respect to the 2021 situation. Furthermore, Denmark and the Scottish part of the UK have already assigned (in addition to the 2030 areas) remarkably big areas for windfarm development (open to the market but with no specific plans). The Netherlands, Belgium and the remaining parts of the United Kingdom will as well increase, by around or more than 100%, their windfarm areas towards 2030. Germany has planned to increase 40 % of the total windfarm area by 2030. No specific plans were found for further windfarms development for Norway, Sweden, Ireland or France. However, Norway has already reserved 5 areas within the Bonn Agreement area which are bound to windfarm development, although no specific dates or plans are provided.

Table 6-4: Comparative analyses between the number of windfarm areas (irrespective of size) and the area sizes of windfarms predicted to be operational by 2021 and 2030.

	Trend from 2021 to 2030 (% increase)	
	Relative increase in number of wind farms (%)	Relative increase in area of wind farms (%)
Norway	-	-
Sweden	-	-
Denmark	38	1360
Germany	4	40
Netherlands	75	195
Belgium	27	159
UK (England, Wales & N. Ireland)	20	98
UK (Scotland)	50	948
Ireland	-	-
France	-	-
All Bonn Agreement	25	168

The project does not have information on any planned windfarm areas towards 2030 in the Bay of Biscay

6.3.2 Tidal and wave farms

Apart from windfarms, other renewable energy facilities at sea are expected to require space at sea. The following facilities for tidal and wave energy are planned for in the Bonn Agreement area.

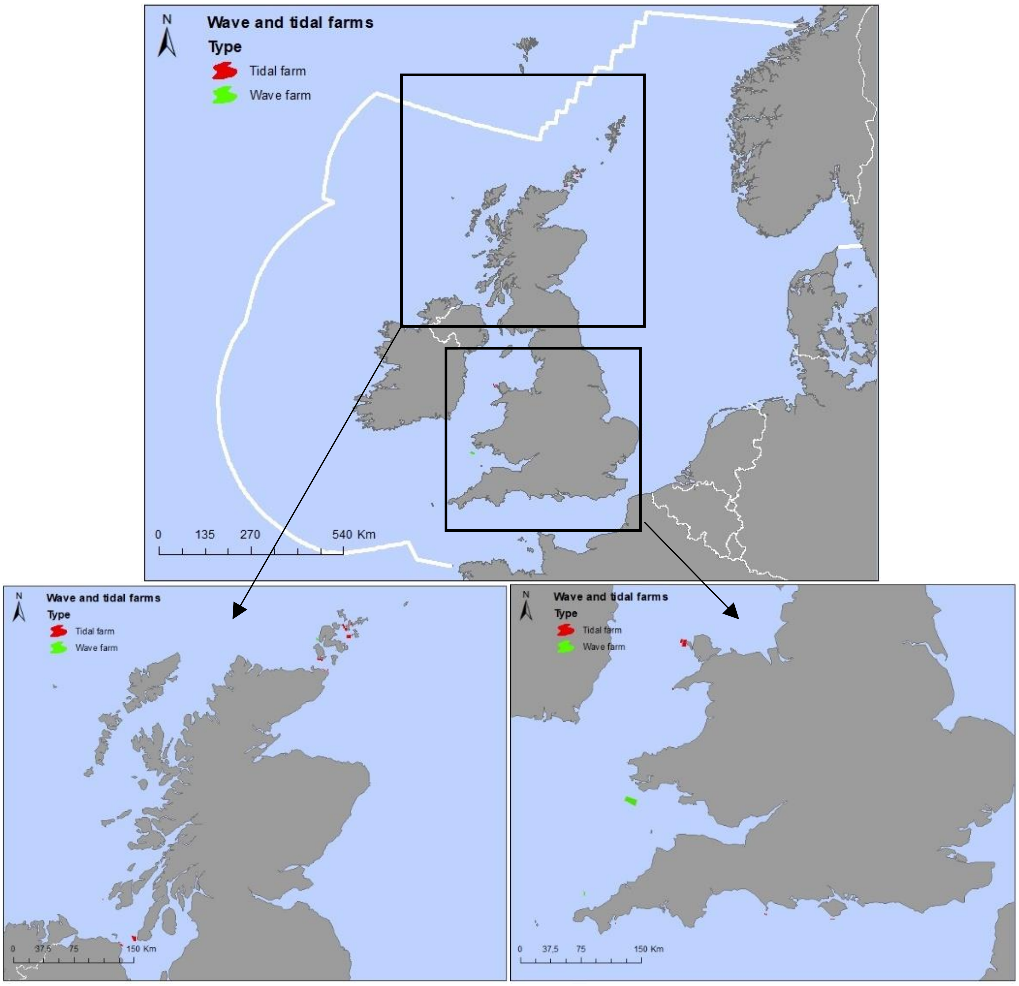


Figure 6-14: Wave and tidal farms in the Bonn Agreement area. Close-up for United Kingdom.

Table 6-5: Number of areas and their extent of wave and tidal farms in the Bonn Agreement area.

	Areas (no.)		Extent (Km^2)	
	Tidal	Wave	Tidal	Wave
UK (England, Wales & N. Ireland)	13	3	72	100
UK (Scotland)	16	3	101	8

The windfarm area for Spain will be a shared facility for wave and wind, however it is the same extension, hence it is not considered separately in this section.

Based on the above, the tidal and wave energy facilities are limited in numbers and spatial extent and therefore of minor importance compared with the effects of windfarms for the navigational safety and consequent environmental protection. Even though it is not specified in this report, we have indications (Emodnet and National energy plans from Spain) that wave and tidal farms will be included in the future plans of France and Spain as well. The extent of these areas is however presently unknown.

6.4 Overall summary

The windfarm locations predicted in the Bonn Agreement area are developing faster than predicted for 2020 in BE-AWARE I in 2011 (both in number and spatial extent). For the year 2021, the spatial extent is about 25% larger than that predicted for 2020 in BE-AWARE I.

The development of windfarms until 2021 is particularly high in the Southern North Sea area (Dutch, Belgian and UK EEZ). For the years until 2030 and beyond, this trend is expected to continue. In addition, the development of windfarms in the Danish EEZ within the Bonn Agreement area is expected to expand considerably.

Windfarms can be expected to occupy more area in those parts of the North Sea that are closest to the potential consumers (Southern part). This area also is the part of the North Sea with dense ship traffic. Therefore, it is likely to foresee increased risk for accidents from 2021 to 2030, particularly for the traffic route through the English Channel, German Bight and along the Danish West coast towards Skaw. For the Netherlands and for Denmark the relative increase in number of windfarm areas predicted from 2021 to 2030 is 75% and 38% respectively, indicating that the space, that is remaining for navigation, might decrease mostly in areas with highest traffic density. This imposes an increased risk for navigational accidents (collisions and groundings), as discussed in Chapter 9.

7. Simplified analysis for Bay of Biscay

7.1 Introduction

The Bay of Biscay will became part of the Bonn Agreement after the formal adoption of the decision on the accession of Spain in October 2019 and the ratification process. Therefore, it was not part of the risk analyses carried out in BE-AWARE I and II. A simplified analysis of the oil spill risk for the Bay of Biscay has been carried out as part of this trend analysis. This means that the entire analysis methodology/models applied for BE-AWARE I have not been applied for this simplified analysis.

First, an analysis of AIS data of ship movements in 2018 in the Bay of Biscay region was carried out to identify the primary sailing patterns and to develop vessel traffic intensity maps for this region. Further, some distributions of ship types and size classes for selected routes in the region have been established. This work followed the same approach used in BE-AWARE I for development of the ship traffic model.

An analysis of historical records of sea accidents and oil spills in the region was then carried out to establish key statistics for shipping accidents and oil spills.

Based on the above analyses and using relevant results and models from BE-AWARE I, an estimate of ship-ship collisions and powered groundings in the region is made. Given that this is a simplified analysis only the accident frequencies and not their consequences are modelled.

The above suite of analyses provides a solid basis for future detailed assessments of marine pollution and oil spill risk in the Bay of Biscay region.

7.2 Ship traffic

7.2.1 Data summary and visualisation of sailing patterns

Data from France

AIS data for 2018 for the French part of the Bay of Biscay has been provided by the French Navy. In Figure 7-1*,* the processed and analysed data is shown in a traffic density chart with cell size 400 m by 400 m. As before, the blue cells have relatively the most ship counts and the yellow cells have the least ship counts. For the main route in this area, it is clearly seen that as the distance into the Atlantic increases, lesser and lesser data is available in the dataset provided for this analysis. If the entire data were available, then the main route along Brittany (France) and Cape Finisterre (Spain) would be all blue.

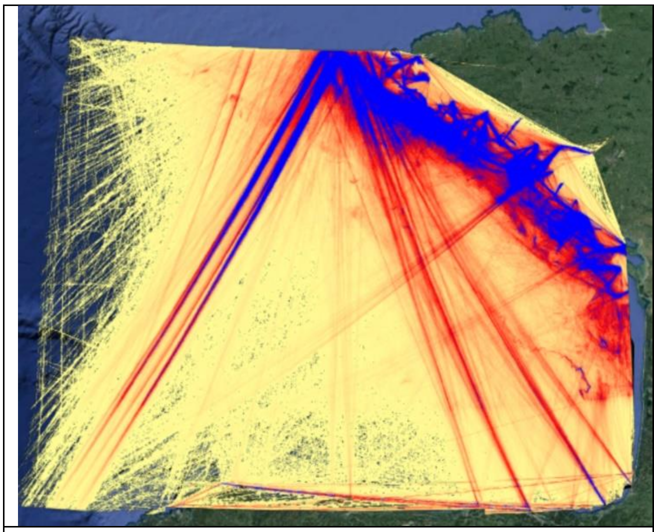


Figure 7-1 French AIS data for the Bay of Biscay for 2018

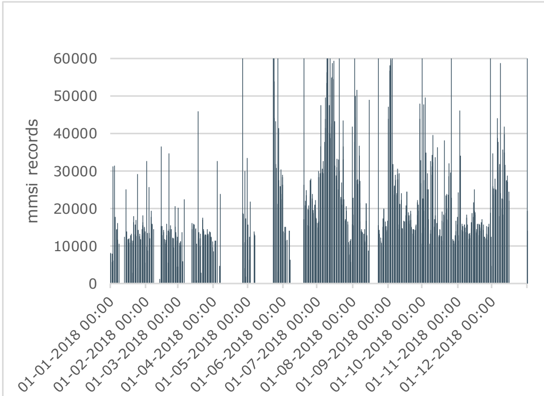


Figure 7-2 AIS records provided by France for 2018 for Bay of Biscay

The number of AIS records received for the French part of Biscay is shown in Figure 7-2. About 30 % of the data is missing for 2018 and suitable scaling factors are applied to account for this missing data. The size of the Bay of Biscay means that it is not completely covered by the land-based stations, which generally only receive full data below 100 km.

Data from Spain

AIS data for the Bay of Biscay area with latitude less than 44.6 degrees for 2018 has been provided by the Spanish maritime administration. The processed and analysed data is shown in Figure 7-3 in a density chart with cell size 400 m by 400 m. As before, the blue cells have relatively the most ship counts and the yellow cells have the least ship counts. The number of available AIS records can be seen in Figure 7-4; about 11% of the data are missing and this is accounted for in the analysis by use of corresponding scaling factors.

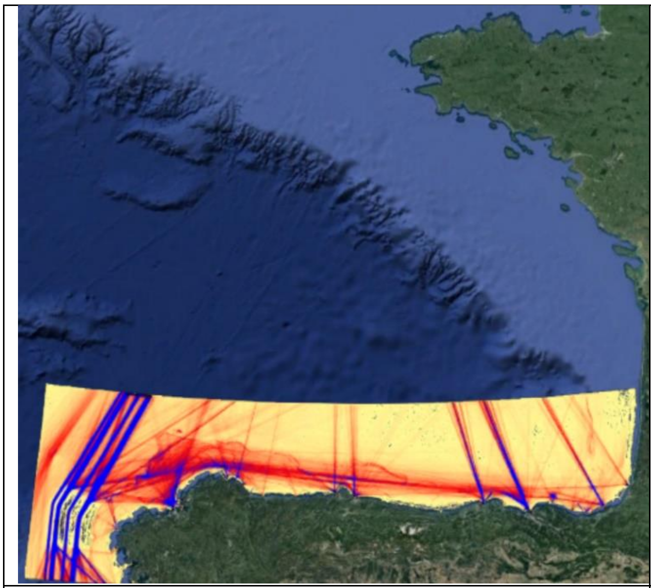


Figure 7-3 Spanish AIS data for the Bay of Biscay 2018

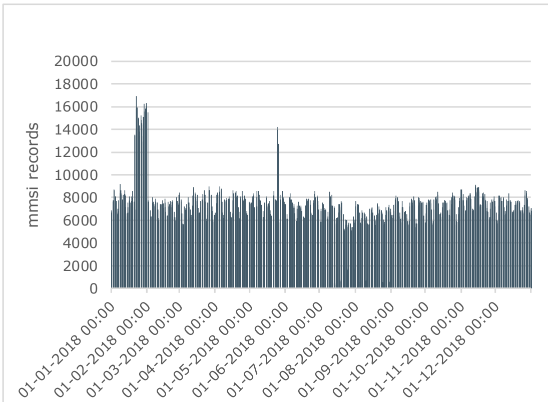


Figure 7-4 AIS records provided by Spain for 2018 for Bay of Biscay
(The missing data are difficult to see)

7.2.2 Analysis of routes and ship traffic distibutions

Using the density plot for the Bay of Biscay we can establish the major routes in the area. This is done in Figure 7-5 and Figure 7-6. The eastern routes along the French coast are very rough and will only give an idea of the number of ships here. It is clearly seen that the data are very thin in the middle of the Bay. These are then found by extrapolating the data near to the coast. For example, leg 3 is given the same traffic as leg 4. In Table 7-1 a distribution per ship type of the number of ships on each leg is shown. In Table 7-2, the number and the size of ships for each ship type on selected legs are shown.

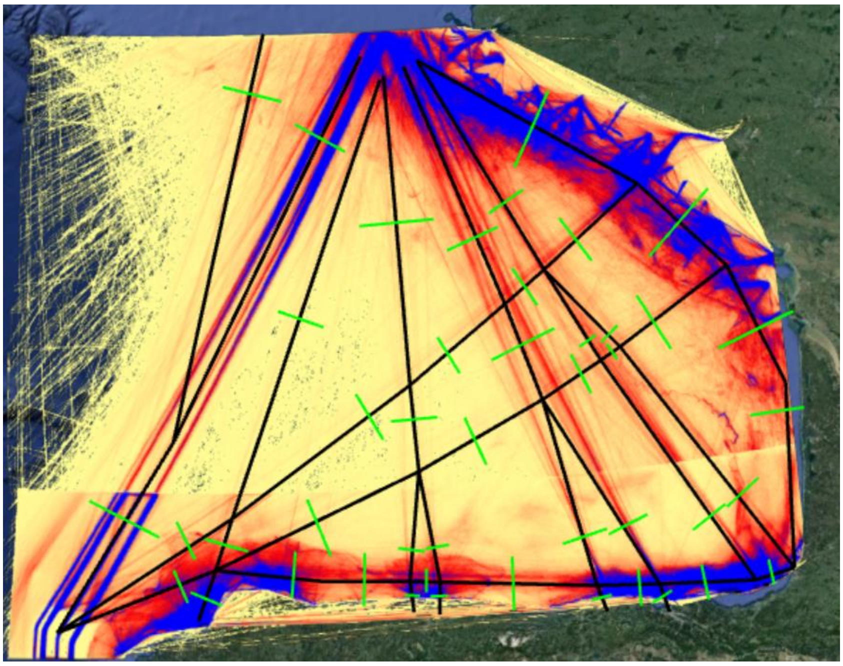


Figure 7-5 Major routes created from the density plot together with passage lines.

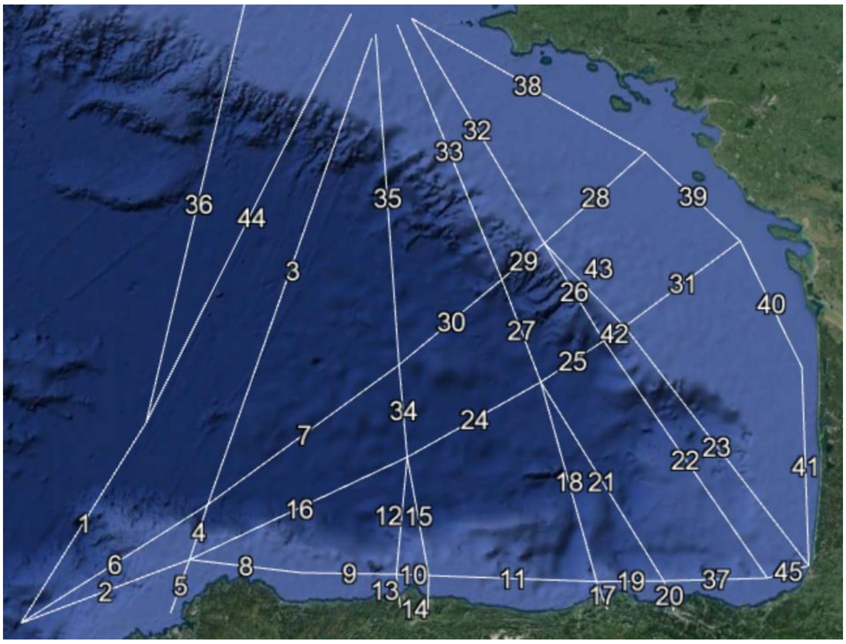


Figure 7-6 Identification numbers for the legs/routes

Table 7-1 *Number of merchant ships in both directions on the 45 legs*

Leg ID	Tankers	Bulk	General cargo	Packed cargo	Passenger	Other	Total
1	6744	3796	7044	9021	402	704	*27711*
2	816	727	2399	1097	46	169	*5254*
3	368	44	627	94	81	101	*1315*
4	368	44	627	94	81	101	*1315*
5	492	56	752	95	99	776	*2270*
6	593	327	467	692	12	85	*2176*
7	593	327	467	692	12	85	*2176*
8	1064	779	2512	945	99	337	*5736*
9	1035	763	2536	951	102	464	*5851*
10	424	393	1765	715	64	237	*3598*
11	859	338	1943	954	117	435	*4646*
12	61	79	412	4	4	34	*594*
13	74	112	504	0	6	85	*781*
14	114	450	612	119	21	270	*1586*
15	285	475	75	7	27	925	*1794*
16	209	150	532	102	19	57	*1069*
17	146	113	738	912	381	54	*2344*
18	112	67	621	855	412	69	*2136*
19	263	85	985	181	89	326	*1929*
20	1510	326	1253	1220	347	43	*4699*
21	694	163	984	1111	324	39	*3315*
22	12	21	810	390	9	122	*1364*
23	79	12	370	3	27	167	*658*
24	209	150	532	102	19	57	*1069*
25	209	150	532	102	19	57	*1069*
26	12	21	810	390	9	122	*1364*
27	808	230	1606	1964	736	108	*5452*
28	154	49	72	173	0	43	*491*
29	198	62	90	218	0	55	*623*
30	198	62	90	218	0	55	*623*
31	31	44	146	1	2	23	*247*
32	92	33	1181	393	36	289	*2024*
33	808	230	1606	1964	736	108	*5452*
34	114	367	889	79	11	61	*1521*
35	114	367	889	79	11	61	*1521*
36	961	541	1006	1290	56	99	*3953*
37	108	14	644	148	32	261	*1207*
38	1285	293	1362	655	62	1203	*4860*
39	400	212	906	144	50	2586	*4298*
40	174	6	198	74	14	857	*1323*
41	4	11	120	2	4	1016	*1157*
42	12	21	810	390	9	122	*1364*
43	79	12	370	3	27	167	*658*
44	5780	3254	6037	7731	344	604	*23750*
45	70	15	421	7	2	146	*661*

Table 7-2 ***Number of ships and their sizes in both directions on selected legs. The top line is gross tonnage. The left number is the leg ID. Example: For leg 7 there are 93 tankers between 1600 and 5000 gross ton.***

1	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	0	991	1312	2354	696	1082	309	0	6744
Bulk	0	0	1	126	100	1905	1491	162	11	0	3796
General ca	0	6	66	4130	2065	671	106	0	0	0	7044
Packed ca	0	0	1	58	719	1450	2710	2029	2054	0	9021
Passenger	0	1	0	7	6	72	51	125	140	0	402
Other	21	144	51	209	98	130	44	1	3	3	704
Total	21	151	119	5521	4300	6582	5098	3399	2517	3	27711

7	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	0	93	61	198	38	146	57	0	593
Bulk	0	0	0	2	18	185	116	5	1	0	327
General ca	0	0	5	244	148	56	14	0	0	0	467
Packed ca	0	0	0	2	10	493	138	34	15	0	692
Passenger	0	1	0	5	0	0	4	2	0	0	12
Other	3	67	0	6	0	7	1	0	1	0	85
Total	3	68	5	352	237	939	311	187	74	0	2176

11	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	0	230	184	257	50	138	0	0	859
Bulk	0	0	0	20	29	147	139	2	1	0	338
General ca	0	0	46	1108	622	127	40	0	0	0	1943
Packed ca	0	0	0	10	213	517	131	78	5	0	954
Passenger	0	3	0	46	3	19	14	16	16	0	117
Other	111	300	7	13	2	2	0	0	0	0	435
Total	111	303	53	1427	1053	1069	374	234	22	0	4646

16	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	0	56	37	78	10	19	9	0	209
Bulk	0	0	0	1	12	91	45	1	0	0	150
General ca	0	0	7	336	122	47	20	0	0	0	532
Packed ca	0	0	0	0	5	43	20	23	11	0	102
Passenger	0	0	0	6	2	2	6	3	0	0	19
Other	4	44	2	4	0	3	0	0	0	0	57
Total	4	44	9	403	178	264	101	46	20	0	1069

32	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	1	51	22	15	2	1	0	0	92
Bulk	0	0	0	0	2	30	1	0	0	0	33
General ca	0	1	43	1014	114	9	0	0	0	0	1181
Packed ca	0	0	0	0	0	391	1	1	0	0	393
Passenger	0	0	0	32	0	0	0	4	0	0	36
Other	67	219	1	2	0	0	0	0	0	0	289
Total	67	220	45	1099	138	445	4	6	0	0	2024

33	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	24	389	158	151	24	40	22	0	808
Bulk	0	0	0	21	24	92	93	0	0	0	230
General ca	0	1	28	1185	284	86	22	0	0	0	1606
Packed ca	0	0	0	6	714	1039	127	76	2	0	1964
Passenger	0	2	0	3	1	224	490	5	11	0	736
Other	64	27	5	10	1	1	0	0	0	0	108
Total	64	30	57	1614	1182	1593	756	121	35	0	5452

38	0	100	1000	1600	5000	10000	30000	60000	100000	300000	Total
Tankers	0	0	0	622	146	368	27	61	61	0	1285
Bulk	0	0	0	142	7	75	67	2	0	0	293
General ca	0	2	25	1003	229	75	28	0	0	0	1362
Packed ca	0	0	0	2	200	369	82	1	1	0	655
Passenger	0	2	0	10	2	22	17	8	1	0	62
Other	804	185	61	126	6	21	0	0	0	0	1203
Total	804	189	86	1905	590	930	221	72	63	0	4860

In Figure 7-7 the histograms showing the lateral distribution of ship traffic for each leg is shown. It is clearly seen that the routes in the middle and west needs data. As the Spanish AIS data comes from ships nearer the coast, these will be used to estimate the number of ships on the legs that are missing data.

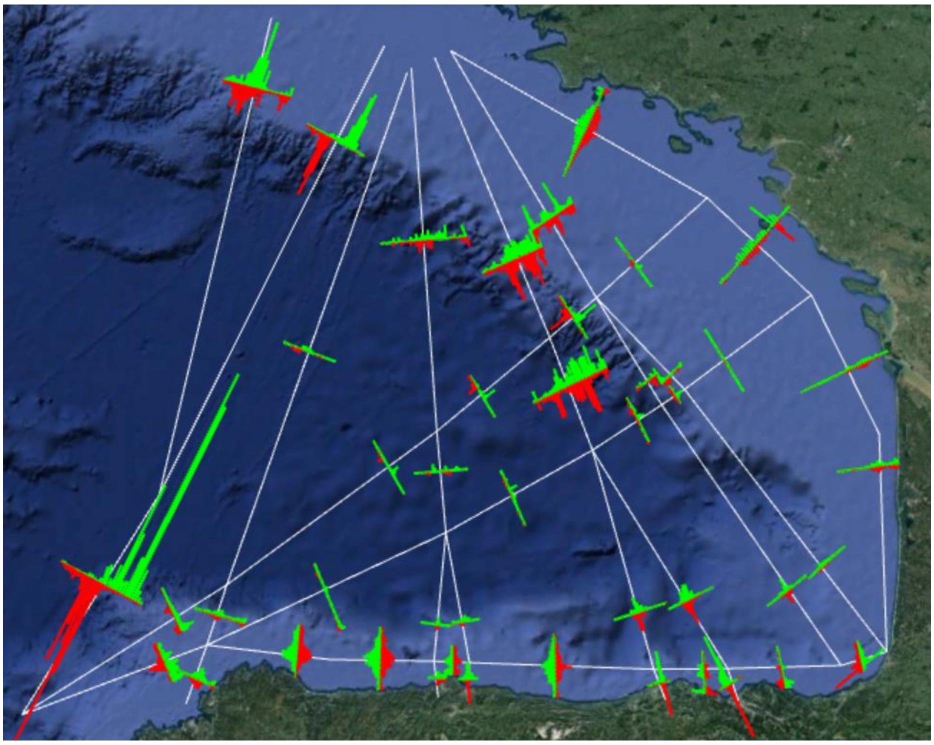


Figure 7-7 Major routes together with passage lines and histograms for each passage line.

All the distributions are fitted to a normal distribution. A part of some of the distributions might be more precisely represented by uniform distributions but for simplicity they are treated as normal distributions. For a simplified analysis this does not change the overall result much.

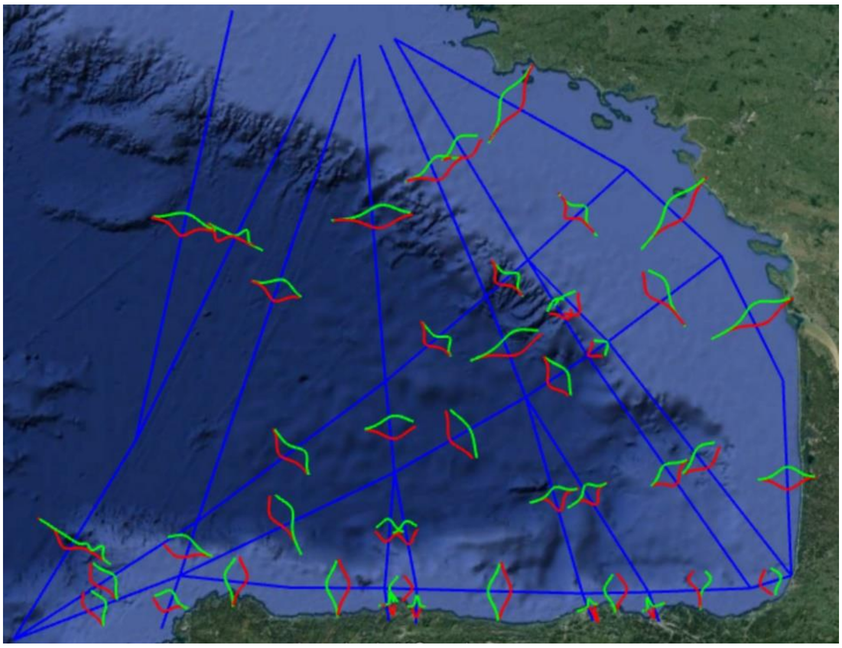


Figure 7-8 The histograms fitted to probability distributions

7.3 Accidents analysis

7.3.1 Accidents

For the Bay of Biscay area, data provided by Spain and a subset of the data provided by France are relevant (cf. Chapter 3). As shown in Table 7-3 and Table 7-4, most of the accidents are reported from Spain. Only one accident was registered in the French part of Bay of Biscay. The annual number of accidents is about 5 for 2012-2018 which is about the same for the 2007-2011. . It is noted that there was no French data provided for the Bay of Biscay for the period prior to 2012.

Table 7-3 Total number of shipping accidents – Bay of Biscay

	Spain	Spain	France	Total (Spain + France)
Time periods [years]	2007-2011	2012-2018	2012-2018	2012-2018
Collision with vessel	7	6	1	7
Collision with object	0	0	0	0
Grounding	6	13	0	13
Fire	9	2	0	2
Sunk other cause	0	8	0	8
Hull damage other cause	3	6	0	6
Unknown	0	0	0	0
Total reported accidents	**25**	**35**	**1**	**36**

Table 7-4 Annual average number of shipping accidents – Bay of Biscay

	Spain	Spain	France	Total (Spain + France)	% of total
Time periods [years]	2007-2011	2012-2018	2012-2018	2012-2018	2012-2018
Collision with vessel	1.4	0.9	0.1	1.0	19.4%
Collision with object	0.0	0.0	0.0	0.0	0.0%
Grounding	1.2	1.9	0.0	1.9	36.1%
Fire	1.8	0.3	0.0	0.3	5.6%
Sunk other cause	0.0	1.1	0.0	1.1	22.2%
Hull damage other cause	0.6	0.9	0.0	0.9	16.7%
Unknown	0.0	0.0	0.0	0.0	0.0%
Total reported accidents	**5.0**	**5.0**	**0.1**	**5.1**	**100%**

The relative contributions from the different accident types is seen to be different to that for the Bonn Agreement area. Figure 7-9 shows the distribution of accidents per accident type for the current (i.e. 2012-2018) period. While grounding is the largest accident type contributor for the Bay of Biscay as seen in Figure 7-9 and this is also the case for the original Bonn Agreement area, its relative proportion is lower for the Bay of Biscay. When compared to the original Bonn Agreement area, noticeably larger proportions are seen for accident reported as '*sunk other cause*' and '*hull damage other cause*'. Violent storms are known to occur in the Bay of Biscay, so this is likely to give more cases of hull damage by wave action or capsizing due to combined wind and wave action.

The relative proportion of fires is about 6% for the Bay of Biscay which is much lower than the 15% contribution from fires to accidents in the rest of the Bonn Agreement area. Also, it is seen that there have been no reported instances of collisions with objects during 2012-2018.

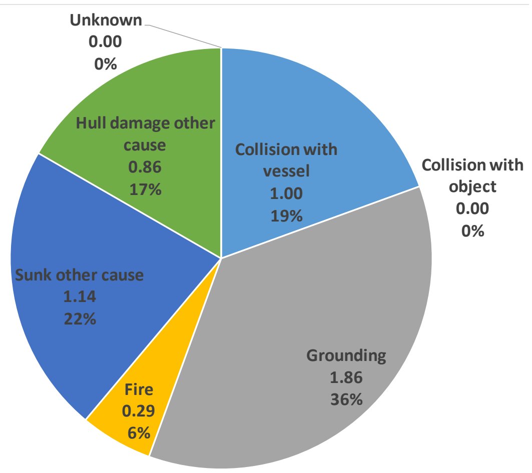


Figure 7-9 Shipping accidents per accident type – for Bay of Biscay during 2012-2018

The annual average number of accidents per ship type is presented in Table 7-5 and Figure 7-10. A clear difference compared to the original Bonn Agreement area is that the largest contribution comes from fishing vessels. It is noted that the received accident records include a large number of accidents involving fishing vessels; a majority of those were discarded in this analysis due to the ship size being smaller than 300GT.

Table 7-5 Number of shipping accidents per ship type – for Bay of Biscay during 2012-2018

Ship type	Total number of reported accidents	Average number of reported shipping accidents per year	Contribution per ship type
Bulk carrier	2	0.3	5.6%
Container	2	0.3	5.6%
Fishing vessel	9	1.3	25.0%
General cargo	7	1.0	19.4%
Other	6	0.9	16.7%
Passenger/Ro-Ro	6	0.9	16.7%
Tanker[9]	2	0.3	5.6%
Vehicle carrier	2	0.3	5.6%
Unknown	0	0.0	0.0%
Total	36	5.1	100%

[9] One accident by oil tanker, one by unknown tanker type.

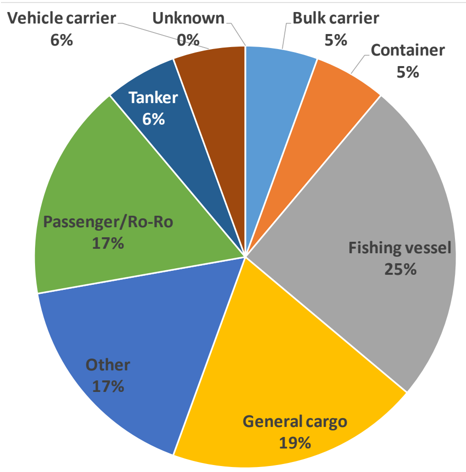


Figure 7-10 Shipping accidents per ship type – for Bay of Biscay during 2012-2018

7.3.2 Oil spills

Only two oil spills are reported for the Bay of Biscay during 2012-2018 – both these are as a result of collision between vessels. The resulting probability of oil spill is calculated and shown in Table 7-6. While the overall spill probability is higher for the Bay of Biscay than that for the Bonn Agreement area, its implication should not be generalised because the number of observed accidents and oil spills is too small. However, it is in line with the general observation that ship-ship collisions are one of the main sources of major oil spill events.

In earlier years, the Bay of Biscay was the site of two catastrophic cases of hull damage due to bad weather, Erika in 1999 (30,000 tonnes of oil released) and Prestige in 2002 (50,000 tonnes of oil released). Both cases involved single-hull tankers, a construction type that was phased out during the years 2005-2010 (for tankers of 5,000 DWT and above).

Table 7-6 Number of shipping accidents resulting in oil spills and corresponding spill probabilities per accident type – for Bay of Biscay during 2012-2018

Accident type	Total number of accidents	Total number of accidents resulting in a spill	Conditional prob.
Collision with vessel	7	2	28.6%
Collision with object	0	0	-
Grounding	13	0	0.0%
Fire	2	0	0.0%
Sunk other cause	8	0	0.0%
Hull damage other cause	6	0	0.0%
Unknown	0	0	-
Total	36	2	5.6%

The two reported oil spills involved the release of non-volatile oil. The pollution size is known for only one of these spills and this is described in terms of the pollution area as 0.04 km².

7.4 Modelling of vessel collisions and groundings

As with BE-AWARE I, the primary focus of the model is to estimate the expected number of collisions with vessels, as this accident type is generally seen as the main contributor to oil spill risk and particularly considering large consequence events. Moreover, it is the accident type that is most difficult to localise, as opposed to groundings (concentrating and grounds and coasts) or fire, hull damage and sinking due to other causes (evenly distributed risk along the sailing routes). As seen in Table 7-4, groundings are largest contributors in terms of frequency of accidents.

Considering the above, a model for estimating the number of collisions and groundings in the Bay of the Biscay is made. The modelling principles applied to estimate the frequency of crossing collisions and en route collisions (head-on and overtaking scenarios) are the same as for BE-AWARE I. However, the present analysis applies a simplified traffic model highlighting some of the main routes and intersections.

7.4.1 Collisions

The collision frequencies are determined based on the models used in BE-AWARE I (Bonn Agreement, 2014a). An accident causation[10] probability of $3 \cdot 10^{-4}$ per year per ship passage on a route is used – this is a value for Danish waters and has been used in e.g. in an oil spill study (carried out in 2007) for Danish waters and in a ship collision risk analysis (carried out in 2009) for the Great Belt Fixed Link. This value is used here as a reference value in the absence of any specific values for the Bay of Biscay. The results from the analysis are shown in Table 7-7. For the estimation of these frequencies, it is assumed that no ships have pilot onboard and no effect of the presence of a Vessel Traffic Service (VTS) for traffic monitoring is included. Both pilotage and VTS are risk reducing measures and disregarding them for all ship types and routes provides a conservative estimate of the accident frequencies.

The total return period is one collision every 4 years. Route collisions account for 59 % of the collisions and the contribution of node collisions is 41 %.

Table 7-7 **Yearly number of calculated collisions involving different merchant ship types**

	Head-on	Overtaking	Node	Total	Return period
Bulk	0.0034	0.0115	0.0138	0.0287	35
Container	0.0038	0.0362	0.0166	0.0567	18
General cargo	0.0101	0.0296	0.0324	0.0721	14
Passenger	0.0012	0.0008	0.0032	0.0052	191
Ro-Ro	0.0046	0.0116	0.0133	0.0295	34
Tanker gas	0.0014	0.0044	0.0045	0.0104	97
Tanker oil	0.0065	0.0194	0.0183	0.0443	23
Total	**0.0310**	**0.1136**	**0.1023**	**0.2469**	**4.1**

In Figure 7-11 we see the number of route collisions for the most contributing legs. The dominating routes are the three westernmost legs where ships are sailings from the Far East and Mediterranean to Northern Europe. These three legs (1, 36, 44) contribute 76 % of the

[10] The probability that a ship on collision course does not undertake (successful) evasive action. This probability includes both human and technical failure.

route collisions. The reason leg 44 contributes more than leg 1 is that the traffic on leg 1 is more separated than on leg 44.

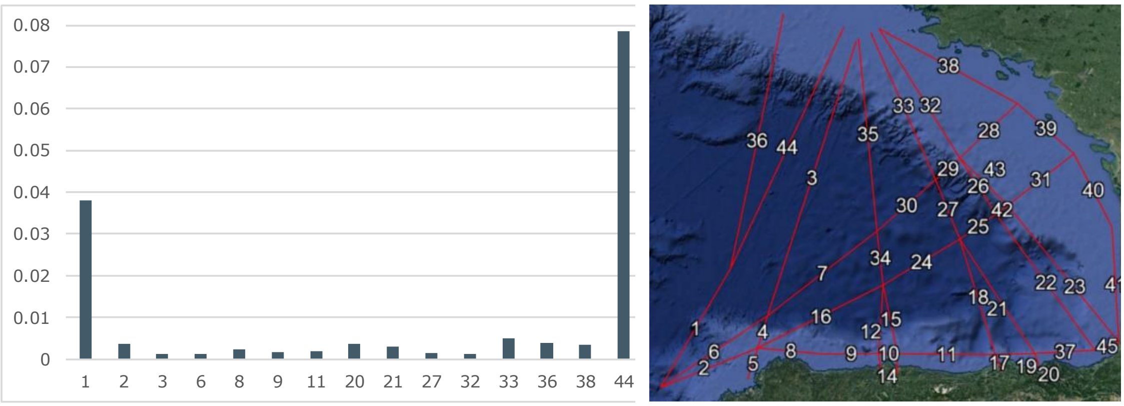


Figure 7-11 Yearly number of calculated head-on and overtaking collisions. The leg IDs are shown to the right

In Figure 7-12 we see the number of node collisions for the most contributing nodes. Again, it is the western leg nodes that dominates. The nodes where ships meet outside the harbours along the Spanish and French coast contribute 45 % of the node collisions.

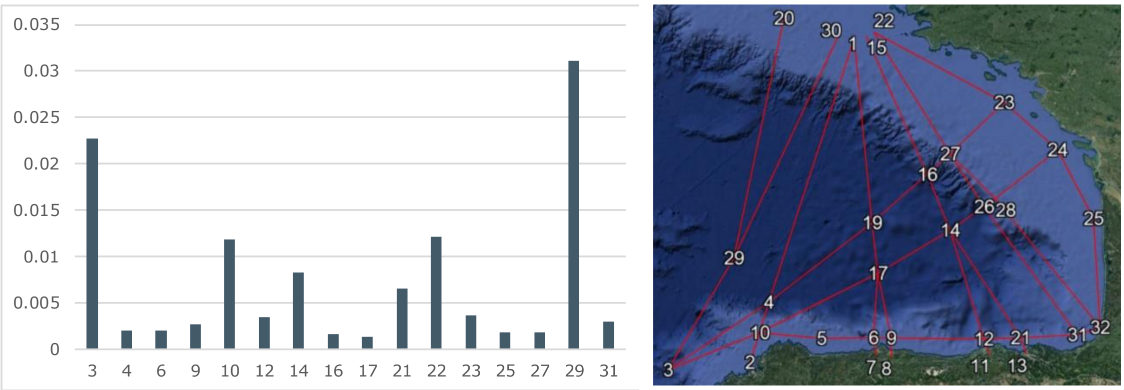


Figure 7-12 Yearly number of calculated node collisions. To the right the node IDs are shown

7.4.2 Groundings

As the draught and loading conditions were not available in the AIS data, the frequencies of only powered groundings in the coast line are calculated.

Two accident scenarios in accordance with (Larsen, 1993) are considered for estimating the number of powered groundings in the area. The first is called Category I and is used for ships sailing on a route but failing to avoid an obstacle on this route due to human error or technical failure. This is shown in Figure 7-13 for the ships sailing on the leg P2-P3. The second accident category considered is category II which refers to ships that forget to turn when sailing from one to leg to the next. This is also shown in Figure 7-13 by the ships sailing on the leg P1- P2 where ships are supposed to turn at P2.

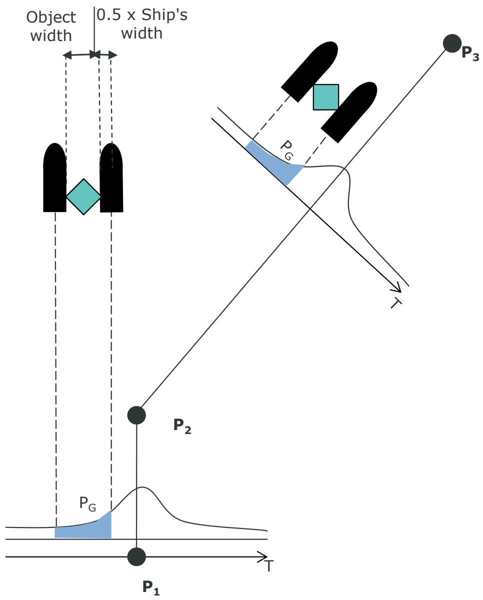


Figure 7-13 Grounding method. Cat I: Ships on route P2-P3. Cat II: Forget to turn P1-P2-P3

Some of the key parameters used in this analysis are:

- Accident causation probability: $1.6 \cdot 10^{-4}$ per year per ship passage on a route, as per the causation probabilities for grounding in IWRAP[11] MK2 tool for maritime risk assessment (Friis-Hansen, 2008)
- For the Cat II or 'forget-to-turn' scenario, it is assumed that navigators will check the position of their vessel every 10 minutes (after omitting to turn, through such checks they will have the opportunity to correct their course at a later point). The event of checking the position of the ship is described as a Poisson process. This means that there is a certain likelihood of the check not happening (and the ship continuing on a wrong course and thereby on a potential grounding course) every 10 minutes which is a function of the distance of the ship from a potential grounding location and the speed of the ship.
- As for collisions, no risk-reducing effect due to pilotage or the presence of VTS are included.

The number of calculated groundings for different ship types is given in Table 7-8. The total number of merchant ship groundings is 1 per year. In Figure 7-14 it is shown which legs contribute the most to the groundings. The most contributing legs are not surprisingly the legs close to the coast. In Figure 7-15 and Figure 7-16, it is shown which coast line segments have the most groundings.

Table 7-8 Yearly number of calculated groundings involving different merchant ship types

	Cat I	**Cat II**	**Total**	**Return period**
Bulk	0.0470	0.0111	0.0580	17.2
Container	0.0453	0.0272	0.0725	13.8
General cargo	0.3312	0.0380	0.3692	2.7
Passenger	0.0060	0.0111	0.0171	58.6
Ro-Ro	0.0285	0.0243	0.0528	18.9
Tanker gas	0.0203	0.0048	0.0250	40.0
Tanker oil	0.1183	0.0171	0.1354	7.4
Total	**0.5965**	**0.1335**	**0.7301**	**1.4**

[11] IALA Waterway Risk Assessment Programme, where IALA stands for International Association of Marine Aids to Navigation and Lighthouse Authorities

Table 7-9 Return period for ship types and ship sizes (LOA in m)

	25-50	50-75	75-100	100-125	125-150	150-200	200-250	250-300	300-350	350-400	Total
Bulk			624	94	270	32	145	281			**17.2**
Container			7869	448	30	32	256	1101	1871	3857	**13.8**
General ca		636	5	11	21	77	847				**2.7**
Passenger	2354	8318	337	4724	1337	164	200	1171	1556		**58.6**
Ro-Ro			2506	1599	55	33	265				**18.9**
Tanker ga			88	208	602	277		282			**40.0**
Tanker oil		3383	46	23	38	31	202	148	8390		**7.4**
Total	**2353.8**	**502.7**	**4.0**	**6.5**	**7.6**	**6.7**	**38.9**	**63.9**	**771.3**	**3856.7**	**1.4**

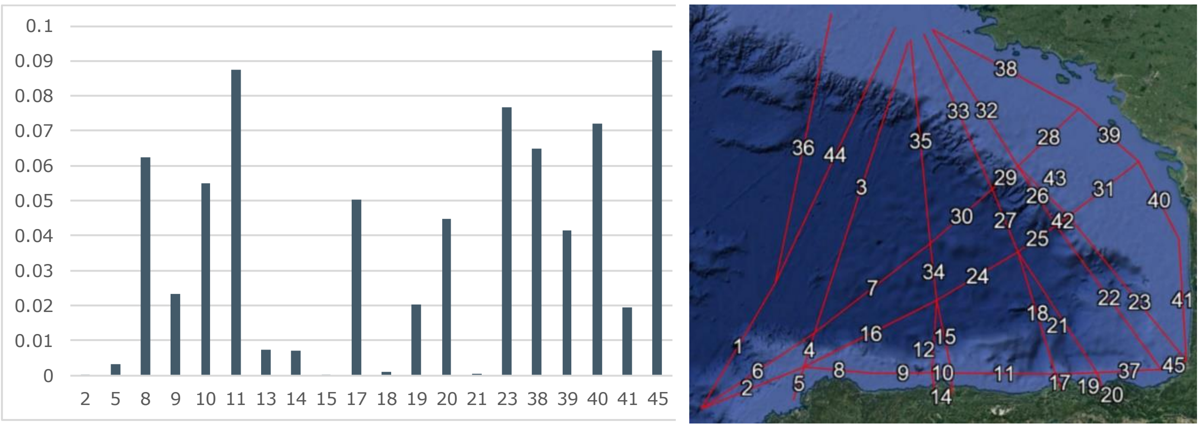


Figure 7-14 **Yearly number of groundings from the 20 most contributing legs**

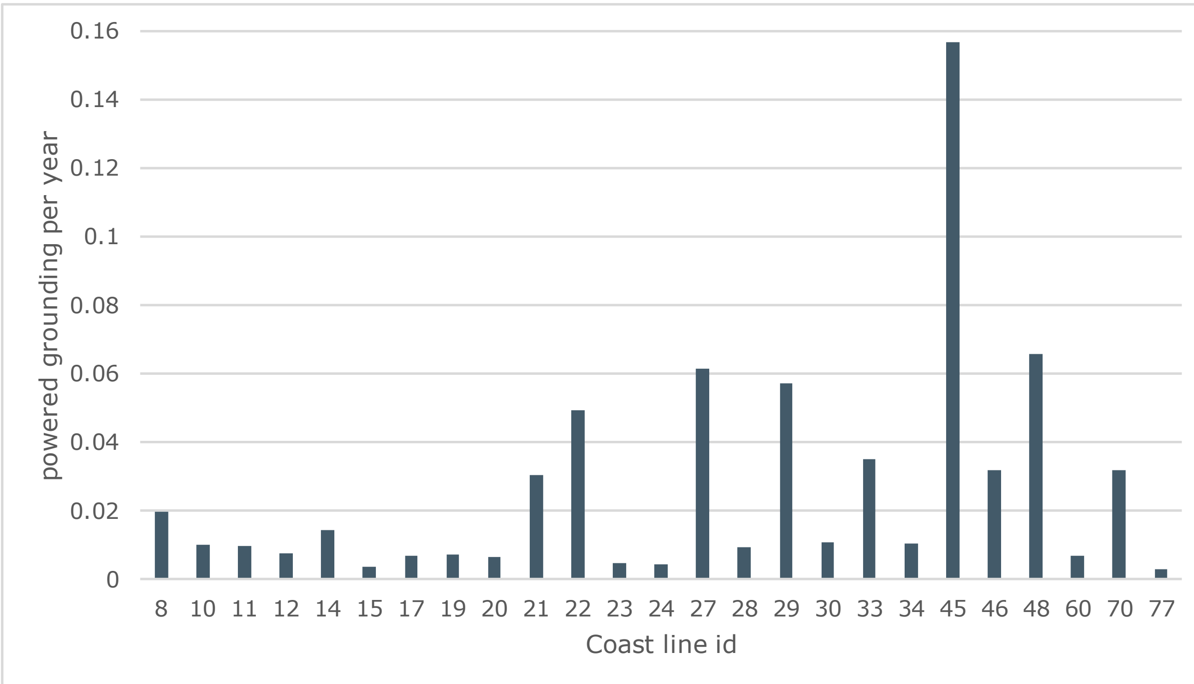


Figure 7-15 **Yearly number of groundings from the 25 most contributing coast line id's.**

Figure 7-16 Coast line id and colour scale. Yellow<0.02. Orange: 0.02-0.04. Red>0.04 groundings per year

7.4.3 Comparision with observed accidents

Accident data for the Bay of Biscay has been analysed (section 7.3) and the yearly observed accidents are reported in Table 7-4. The data indicate 1.0 collision every year and 1.9 groundings every year. The number of calculated collisions is 0.25 per year (Table 7-7) and the number of groundings is calculated to 0.5 per year(Table 7-8). For both collisions and groundings, the calculated frequencies are about 1/4th of the observed values despite of choosing a number of conservative modelling assumptions.

The likely cause for this underestimation is the relatively simple traffic model that only represents the main routes (cf. Figure 7-11). This type of coarse route net will typically give good results for unrestricted sea areas at some distance from the coast. In fact, a substantial share of the observed collisions occurred very close to the coast, i.e. outside the route net used in the traffic model (Figure 3-2). More precise results for the coastal areas would require a more granular traffic model than what can be achieved within a simplified analysis. It is likely that the grounding frequencies difference is within the margin of error of the model given the relative simplified modelling done here. Besides, the simplified model only addresses powered groundings, but disregards drifting groundings. It should also be noted that some of the observed collisions might not be relevant for the model (e.g. events inside ports) and thereby narrow the difference.

7.4.4 Next steps in estimating the oil spill risk

A simplified assessment of accident risk as the driver of oil spill risk has been reported in this chapter. Both observations (Figure 3-2) and model predictions (Figure 7-11 and Figure 7-12) indicate a concentration of ship-ship collisions in the Atlantic Ocean off Costa de la Muerte. Given that this accident type is one of the main contributors to oil spill risk with a high probability of spillage given collisions (cf. Table 3-7 and Table 7-6), this area is undoubtedly a hot spot for oil spill risk.

The findings for the accident risk in the Bay of Biscay provide a good foundation to comprehensively understand the oil spill risk picture for the Bay of Biscay and has identified the key focus areas for in terms of accident types that need to be considered in greater detail when building a detailed oil spill risk model for the region.

The BE-AWARE I project estimated the expected risk of oil spill per year in the Bonn Agreement area, considering the likelihoods and consequences (size) of oil spills. As mentioned in section 7.1, the simplified nature of this analysis for the Bay of Biscay has meant that consequences are not considered. Hence as part of development of a detailed oil spill risk model, the modelling of consequences from oil spills also needs to be considered.

7.5 Overall summary and possible next steps

Statistical analysis

The main conclusions from the statistical analysis of shipping accidents and oil spills in the Bay of Biscay are summarised below:

- The annual number of shipping accidents is about 5 for the current period 2012-2018, and this is about the same for the past period 2007-2011.
- Vessel grounding is the largest contributing accident type at 36% and followed by sinking (22%), collision with vessel (19%) and hull damage (16%).
- Considering vessels of more than 300 GT in size, about 25% of the reported accidents involve fishing vessels and 20% involved general cargo vessels.
- The relative contribution picture from accident types and ship types is seen to be different for the Bay of Biscay when compared to the Bonn Agreement area, presumably at least in part due to the higher prevalence of severe weather conditions and the greater proportion of fishing vessels.
- 2 spills are reported for Bay of Biscay during 2012-2018. This corresponds to a conditional spill probability (i.e. probability of oil spill given that an accident has occurred) of 5.6% which is higher compared to that for the Bonn Agreement area. The very limited number of spill occurrences for the Bay of Biscay should be kept in mind while generalising this result on the conditional spill probability.

Modelling of accidents

Ship-ship collisions primarily take place around the large routes in the western Biscay. A total of 1 collision every 4 year should be expected. The collisions involve all ship types except that passenger ships and gas tankers have a low involvement due to their low numbers. The simplified traffic model presumably leads to an underrepresentation of the collisions risk in the coastal areas, especially in the vicinity of ports.

Powered groundings happen more often that ship-ship collisions. A total of 1 grounding every 1.4 year is calculated. General cargo ships and oil tankers are more involved than the other ship types.

Grounding primarily takes place on the Spanish north coast and the French south west coast. The French coast is sandy here and therefore given a ship grounding accident, the damage to the ship is expected to be less. The Spanish coast however is rocky, and a grounding can easily result in at least rupture of the hull.

It should be noted that the actual values are probably higher if compared to the historical observed values, which is presumably mainly due to the simplified modelling of the coastal areas. At the open sea, the ship-ship collision hot spot off the Costa de la Muerte indicated by the model fits well with the observed historical accident pattern.

In addition to collisions and groundings, the distinctive marine accident risk picture for the Bay of Biscay area established in this analysis shows that the modelling of hull damage and sinking (without collision or grounding) and their consequences needs to be particularly considered for the Bay of Biscay area, given that these accidents types contribute to about 38% of marine accidents in the area. Ideally, a more detailed analysis would add more precision by establishing a finer route mesh especially for the coastal areas and by putting more focus on some of the event types that are of specific relevance for the Bay of Biscay, namely hard-weather damages of all type (hull damage and sinking without collision or grounding) as well as drifting groundings.

A detailed oil spill risk model for the Bay of Biscay can be built upon the present analysis through a focused modelling of the relevant accident types and by considering the consequences from the oil spills. This will provide a complete risk picture and help to review, evaluate and implement effective risk mitigation and response measures with regard to marine accidents, oil spills and environmental protection.

8. Future trends on ship traffic

8.1 Approach

This chapter addresses the development of the future vessel traffic from 2018 till 2030 in the Bonn Agreement area. The development of future traffic will be influenced by changes in traffic volumes (i.e. amounts of cargo transported) and changes with regard to vessel sizes. These changes are discussed for each ship type and the main drivers and trends that will shape the future traffic situation till 2030 are identified.

8.2 Outlook to 2030 – growth in traffic volumes

Trends for all cargo

1. As part of traffic forecast studies commissioned in 2015 by the Federal Ministry of Transport and Digital Infrastructure in Germany, a maritime forecast for 2030 was prepared (German Federal Ministry of Transport and Digital Infrastructure, 2015). That study considered 36 seaports with traffic relevant to Germany – this includes 19 German seaports and 17 seaports in other European countries. This broad coverage of seaports makes it a good reference for use in establishing maritime traffic growth trends in the North Sea area.

   The key findings from that study are:

   - The volume of cargo relevant to Germany that is handled by these 36 seaports will rise from 438 million tonnes to 712 million tonnes between 2010 and 2030 – this corresponds to an average annual growth rate of 2.5%.
   - At the North Sea ports relevant to Germany (i.e. including German and foreign North Sea ports taken together), the volume of cargo handled will rise from 367 million tonnes in 2010 to 599 million tonnes, corresponding to an average annual growth rate of 2.5%.
   - For the German ports on the North Sea, the average annual growth rate from 2010 to 2030 is about 3%.

   Considering the above, the expected growth from 2018 to 2030 in sea cargo for North Sea ports relevant to Germany is obtained as about 35%.

2. As per information provided by Denmark for this trend analysis, the EU Maritime Spatial Planning (MSP) project 'Coherent Linear Infrastructures in Baltic Maritime Spatial Plans' or Baltic LINes has prepared future traffic forecasts for Baltic Sea ports for 2030 and 2050. These forecasts are relevant for this trend analysis, given that traffic from these ports out of the Baltic connects to the North Sea either through the Kiel Canal, the Great Belt or the Sound. The forecasts establish three scenarios – limited growth, sustainable growth and fast growth. For these scenarios, the annual growth rates over 2015 to 2030 in total turnover (in tonnes) of Baltic seaports are projected to be 2.6%, 3.3% and 3.9% respectively.

   Considering the above, the 2018 to 2030 growth in sea cargo for Baltic Sea ports is about 36% and 59%.

   In addition to the above, the Baltic LINes project has also made forecasts of the future change in number of vessel calls in the Baltic Sea region for the different ship types. Considering the limited growth, sustainable growth and fast growth scenarios, the expected annual growth rates till 2030 are as summarised in Table 8-1 below.

Table 8-1 Growth rates in vessel calls for Baltic seaports

	Annual growth rates in vessel calls from 2015 to 2030		
Ship type	**Limited growth**	**Sustainable growth**	**Fast growth**
Container	1.8%	2.1%	2.4%
Liquid bulk tanker	1.5%	2.2%	2.7%
General cargo	-4.8%	-3.8%	-3.0%
Dry bulk	2.3%	3.1%	3.9%

Based on the above, the growth in vessel calls from 2018 to 2030 expected in the Baltic sea region is expected to be between:

- *23% and 33% for containers,*
- *20% and 38% for liquid bulk,*
- *-44% and -31% for general cargo, and*
- *31% to 58% for dry bulk.*

3. *As per information provided by France for this trend analysis, a 40% growth in cross-channel traffic from 2018 to 2030 is expected based on forecasts for the ports of Boulogne-sur-Mer and Calais.*
4. In 2017, about 1.2 billion tonnes of goods were transported through the Hamburg-Le Havre (HLH) range, which is one of the busiest shipping routes in the world. Of this, the port of Rotterdam had the largest share at about 39%.

   As per information provided for the port of Rotterdam by the Netherlands for this trend analysis, the development of the actual cargo throughput over the past 3 years has followed the lowest growth scenario trendline from past forecasts. On this basis, the 2018 forecast determines that growth till 2040 would be less than that forecast in previous years and that the cargo throughput would stabilise and even decline for some scenarios. The main reason for this trend is a predicted drop in energy demands from fossil fuels and transition to other (e.g. green) sources.

   Considering all the growth scenarios in the Rotterdam forecasts, the 2018 to 2030 growth in cargo throughput for the port of Rotterdam is expected to be between about -27% and 56%.
5. As per information provided by Norway for this trend analysis, projections for sea freight transport in Norway have been made by the Institute of Transport Economics (Transportøkonomisk institutt TØI, 2017). The projections broadly consider two categories – domestic transport and import/export at Norwegian seaports, and provide the following:

   - Domestic – For all freight other than oil and gas, annual growth rates of 0.5% for 2016-2022 and 1.4% for 2022-2030 are predicted.
   - Import/export – Freight other than oil and gas is forecast to grow by about 1.4% during 2016-2030.

   Based on the above, the 2018 to 2030 growth in cargo for Norwegian seaports is obtained as about 17% for all other freight excluding oil and gas.

Trends for containers

1. Of the 1.2 billion tonnes of goods transported through the Hamburg-Le Havre (HLH) range, the share of the port of Antwerp was about 19% in 2017.

As per information provided by Belgium for this trend analysis, projections of the future container handling capacity made for the port of Antwerp have considered different growth possibilities and arrived at the following:

a) In the case where Antwerp can solve port capacity restrictions (= standard prognosis following the current evolution in the Hamburg-Le Havre range), forecasts predict that maritime container traffic will continue to grow until 2030. The annual growth in TEU is estimated for three growth scenarios in this case, all of which are associated with positive growth and thereby increased capacity:
    - High growth scenario: 4.4% for 2017-2025, 2.2% for 2025-2035 and 1.5% thereafter.
    - Medium growth scenario: 3.8% for 2017-2025, 1.9% for 2025-2035 and 1.25% thereafter.
    - Low growth scenario: 3.0% for 2017-2025, 1.5% for 2025-2035 and 1.0% thereafter.

b) In the case where there is relatively less growth in container traffic than case a), some capping of capacity is expected and the addition of new capacity is partial. The TEU volumes are therefore expected to decline from now till 2022 and then enter a consolidation period with growth reaching about 1% until 2030. No information on the declining rate till 2022 is available, hence the following growth scenario is taken in this case:
    - Growth scenario for case b): 0% growth till 2022 and 1% growth for 2022-2030.

c) In the case with relatively the least growth prospects, there is no extra/new capacity added. The TEU volumes are expected to decline from now till 2025 and then enter a consolidation period with growth reaching about 1% until 2030. No information on the declining rate till 2025 is available, hence the following growth scenario is taken in this case:
    - Growth scenario for case c): 0% growth till 2025 and 1% growth for 2025-2030.

Considering the above cases and scenarios, the 2018 to 2030 growth in container TEU volumes for Antwerp is estimated to be between about 5% and 51%.

2. As per the 2030 German maritime traffic forecast (German Federal Ministry of Transport and Digital Infrastructure, 2015), the volume of containers handled by the German seaports will grow from a total of 13.0 million TEUs to 30.1 million TEUs between 2010 and 2030 – this amounts to an average annual growth rate of 4.3%.

   The 2018 to 2030 growth in container TEU volumes for German seaports is estimated to be about 66%.

3. Information provided by Sweden for this trend analysis contains projections for growth in container (TEU) volumes loaded and unloaded at Swedish TEN-T[12] ports. A 78% increase in TEU volumes is expected over a period from 2014 to 2040.

   Assuming uniform growth at an annual rate obtained from the above projection, the 2018 to 2030 growth in container TEU volumes for Swedish ports is obtained as about 30%.

Trends for general cargo / conventional freight

1. As per the 2030 German maritime traffic forecast (German Federal Ministry of Transport and Digital Infrastructure, 2015), the average annual rate of growth in the volume of conventional freight handled by German seaports is expected to about 2.8 % between 2010 and 2030.

[12] Trans-European Transport Network

The expected growth from 2018 to 2030 in conventional freight handled by German seaports is obtained as about 39%.

Trends for oil and gas tankers

1. Information provided by Sweden for this trend analysis contains projections for growth in export and import volumes handled at Swedish TEN-T ports. For exports of crude oil and oil products, a 14% decline is projected between 2012 and 2040. A growth of 30% between 2012 and 2040 is projected for import of crude oil and oil products.

   Assuming uniform growth at an annual rate obtained from the above projection, the 2018 to 2030 growth in crude oil and oil products handled at Swedish ports is obtained as about 16%.

2. As per information provided by Norway for this trend analysis, the following projections for oil and gas transport through Norwegian seaports are made by the Institute of Transport Economics (Transportøkonomisk institutt TØI, 2017):

   - Domestic – The annual growth rates for oil and gas transport are 1.6% for 2016-2022 and 1.9% for 2022-2030.
   - Import/export – Oil and gas transport volumes are expected to grow by 2% in 2016-2022 and by 1.4% in 2022-2030.

   It is noted that the above projections do not make any specific allowance with regard to energy transition plans/measures in connection with e.g. meeting climate-change related targets/ requirements.

   Based on the above, the 2018 to 2030 growth in cargo for Norwegian seaports is obtained as about 22% for oil and gas.

Trends for cruise/passenger vessels

The data provided by the Contracting Parties do not give any indications on future growth rates for passenger and cruise vessels.

As per the *Shippax Market* (Shippax, 2016) publication which documents volume statistics and market reports for ferries, cruises and ro-ro vessels, the global average trend for future growth in cruise passengers is about 5% per year based on data for the past 5 years.

A study of the cruise market in the Baltic Sea Region and the North Sea (Uniconsult, 2014) makes some projections for 2025 for North-West Europe which is the segment of relevance for the North Sea and includes the ports of Hamburg and Amsterdam. That study projects an average growth rate of about 4.8% per year for cruise passenger visits till 2025 – this rate is seen to be about the same as the global average growth rate of 5% per year. Cruise ship calls are expected to grow by 3.5% per year. Since the growth rate in ship calls is less than that for passenger visits, this difference is met by a corresponding increase in ship sizes.

The above-cited cruise market study also makes projections for the port of Hamburg – a growth rate larger than the average for North-West Europe is predicted. The projected growth rates till 2025 are of 6.3% per year for passenger visits and 4.2% per year for ship calls.

Assuming uniform growth at the annual rate as per the above projections for North-West Europe, the 2018 to 2030 growth is obtained as about 76% for cruise passenger visits and 51% for cruise vessel calls.

8.3 Outlook to 2030 – growth in vessel sizes

To meet the demand posed by the growth in traffic volumes, the general trend seen in ship fleet development is that the vessel fleet is moving to larger and larger sizes for most ship types, i.e. the average deadweight tonnage or dwt per ship type in a given population is increasing. This is primarily due to possible advantages gained by realising economies of scale while using larger vessels for transport. This trend can be seen e.g. in global vessel fleet data shown in Figure 8-1. For most ship types, Figure 8-1 shows that the % change in average deadweight tonnage (dwt) or vessel size is greater than the % change in number of ships. This means that growth in cargo tonnage will be achieved by a combination of growth in number of voyages and a growth in vessel sizes.

Ship type	No of ships 2016	mill dwt 2016	dwt-% share of total 2012	dwt-% share of total 2016	Av. growth '12-'16 (%) No of ships	Av. growth '12-'16 (%) dwt
Tankers	14039	600.1	37.2	35.0	2.2	2.9
- Crude and products	7065	443.9	28.3	25.9	1.8	2.1
- Oil/Chem. & chem. tankers	5204	101.7	5.8	5.9	2.3	5.0
- Gas tankers	1770	54.5	3.1	3.2	3.1	5.5
Bulk/OBO carriers	10919	752.9	41.6	43.9	3.8	5.8
- Bulk carriers	9541	674.4	37.5	39.3	4.2	5.7
- other bulk carriers	1378	78.5	4.1	4.6	1.6	7.4
Container ships	5239	244.2	13.6	14.2	0.8	5.6
General cargo ships	16892	112.3	7.2	6.5	-0.3	2.1
- Conventional cargo ships	12285	51.6	3.7	3.0	-0.9	-0.7
- Special cargo ships	1522	36.4	1.8	2.1	4.8	8.6
- Car carriers	785	12.4	0.8	0.7	2.3	2.8
- Reefer ships	781	4.4	0.4	0.3	-3.7	-4.1
- Cargo RoRo ships	1519	7.5	0.5	0.4	1.0	-1.1
Passenger ships	4316	6.5	0.6	0.4	2.2	1.8
- Pure passenger ships	1675	2.2	0.1	0.1	2.1	3.1
- Cargo/RoRo passenger ships	2641	4.3	0.3	0.3	2.3	1.2
Total	**51405**	**1716.1**	**100.0**	**100.0**	**1.5**	**4.4**

Figure 8-1 World merchant fleet in 2016 and comparison with 2012. *(Taken from Shipping Statistics And Market Review 2016, Institute of Shipping Economics and Logistics, Germany)*

The data provided by the Contracting Parties do not give any detailed indications on future growth rates for vessel sizes. As part of a vessel collision risk analysis carried out in 2015/2016 for the Great Belt Fixed Link in Denmark, the size development for ships using the Great Belt and sailing in the North Sea and the Baltic Sea was studied for a period from 2015 to 2025. Given the general nature of that study, the trends from that study are quite relevant for this analysis. Table 8-2 shows the growth rates from that study. For each ship type, the growth rate in vessel size is expressed as an annual % change in the average vessel dwt. The overall growth in vessel size obtained by applying this annual growth rate over 2018-2030 is also shown in Table 8-2. While making forecasts of future ship traffic for different ship traffic populations/routes, this overall growth rates in Table 8-2 need to be considered together with the historical size development and other relevant factors particularly applicable for each population/route.

Table 8-2 Growth in ship sizes

Ship type	**Annual change in average vessel dwt (%)**	**Overall change in average vessel dwt 2018-2030 (%)**
Bulk	2.4%	33%
Container	2.0%	27%
General cargo	1.2%	15%

Tanker gas	2.0%	27%
Tanker oil	2.1%	28%
Passenger/cruise	2.0%	27%

8.4 Discussion of trends and overall summary

A summary of the growth rate projections discussed in section 8.2 is provided in Table 8-3.

Table 8-3 Summary of trends for growth in cargo

Ship type	Trend for	Region/country/port	Overall growth 2018-2030
All cargo	Growth in cargo volumes/tonnage	North Sea ports relevant for Germany	35%
All cargo	Growth in cargo volumes/tonnage	Baltic Sea ports	Between 36% and 59%
All cargo except oil and gas	Growth in cargo volumes/tonnage	Norwegian seaports	17%
All cargo	Growth in vessel calls	Cross-Channel traffic	40%
All cargo	Growth in cargo volumes/tonnage	Rotterdam port	Between -27% and +56%
Conventional freight	Growth in cargo volumes/tonnage	German seaports	39%
Containers	Growth in container TEU	German seaports	66%
Containers	Growth in container TEU	Swedish seaports	30%
Containers	Growth in container TEU	Antwerp port	Between 5% and 51%
Containers	Growth in vessel calls	Baltic Sea ports	Between 23% and 33%
General cargo	Growth in vessel calls	Baltic Sea ports	Between -44% and -31%
Dry bulk	Growth in vessel calls	Baltic Sea ports	Between 31% and 58%
Oil and gas tankers	Growth in cargo volumes/tonnage	Swedish seaports	16%
Oil and gas tankers	Growth in cargo volumes/tonnage	Norwegian seaports	22%

The following key trends are identified for vessel traffic growth till 2030 – the % values below refer to overall growth from 2018 to 2030:

- The projections for all cargo indicate a growth range with a base estimate of about 35%, an optimistic estimate close to 60% and a pessimistic estimate under 20%.
- A much broader range of growth rate projections is seen for data from individual ports when compared to data for seaports in a country or region. The ports of Rotterdam and Antwerp have either negative or very low growth rates for their pessimistic growth scenarios. Estimates at country/regional level are characterised by a relatively narrow range for growth rates, reflecting the greater resilience of the system to absorb e.g. some individual shocks.

- Considering the data for Baltic seaports, a cargo growth rate of 36% to 59% is expected – this applies to all freight including containers. The growth rate for vessel calls for containers is seen to be lower at about 23%-33%. This difference can be attributed to the size effect trend in ship fleet development namely that vessels are getting bigger and bigger. Hence a certain increase in cargo will be generally met not by an equal/corresponding increase in vessel calls but rather by a combined increase in vessel calls and an increase in vessel sizes
- A 30%-66% growth in container TEU volumes is seen based on data for Swedish and German seaports, corresponding to an average growth rate of 48%.
- As per data for Baltic seaports, vessel calls for general cargo are expected to drop by 31% to 44%, indicating the general trend of increasing containerisation at the expense of other cargo.
- A 16%-22% growth in tonnage is seen for oil and gas tankers as per data for Norwegian and Swedish seaports – this corresponds to an average growth rate of 19%. These projections do not make any specific allowance for energy transition plans/measures in connection with e.g. meeting climate-change related targets/ requirements.
- Dry bulk is expected to register growth between 31% and 58% as per data for Baltic seaports, giving an average of 45%.
- Growth rates in vessel sizes are seen to be around 27% for containers and oil and gas tankers. The highest size growth rates at about 33% are expected for bulk carriers whereas the relatively lowest growth rates are associated with general cargo vessel sizes which will grow at about 15%.

Based on the trends discussed in this chapter and the traffic development seen from 2011 to 2018 for the traffic crossing the Channel (section 4.3.2) , an overview of the expected growth from 2018 to 2030 in tonnage, ship size and ship movements for the Channel traffic is provided in Table 8-4. The range of values represent different growth scenarios and possibilities. In general, forecasting of future traffic is beset with numerous uncertainties, the values provided are therefore to be seen as rough estimates aiming to provide a general overview of the expected traffic situation in 2030.

Table 8-4 Estimates for the 2018-to-2030 growth in sea cargo tonnage, ship size and ship movements for traffic crossing the Channel

Ship type	Growth in tonnage	Growth in ship size	Growth in ship movements
Tankers	16% to 22%	21% to 28%	-10% to 1%
Containers	30% to 66%	27% to 45%	-11% to 31%
Bulk	17% to 59%	11% to 33%	-12% to 43%
General cargo	9% to 30%	15% to 19%	-9% to 11%

Table 8-4 shows that the presently seen trend of relatively less % increase (or in some cases a decline) in ship movements and a greater % increase in vessel size is likely to continue also for the development of traffic from 2018 till 2030.

The expected growth in vessel traffic volume/tonnage in general depends on the development of global and regional trading patterns and associated scenarios, including the relevant nature and cycles of expected economic growth. The expected growth in vessel size typically considers global and regional future trends in the development of shipping fleet for each vessel type or cargo group, taking into account relevant considerations from transport economics.

In principle, the source studies from which the growth rates reported in this chapter are taken aim to consider the effects of numerous micro-level and macro-level economic, social, technological and other factors influencing growth. Such forecasts are still subject to significant uncertainties that can arise e.g. from the disruptive effects of possible future major economic crises and/or significant geo-political developments such as Brexit.

9. Overall risk: Status 2020 and outlook to 2030

9.1 Approach

This chapter summarises the key insights into the development of oil spill risk in the Bonn Agreement area. A comparison of the 2011 situation and the 2020 forecast (both of which were covered in BE-AWARE I) is made with the present trend analysis and an outlook for the future situation till 2030 is discussed.

The insights and outlook to obtain an overall qualitative risk picture with focus on spills of oil and are based on integrating the results from the analyses reported in previous chapters:

- accidents and oil spills (chapter 3),
- ship traffic (chapter 4),
- oil cargo loading and oil type distribution (chapter 5),
- windfarm areas (chapter 6)
- outlooks on future ship traffic development (chapter 8).

9.2 Summary of key trends influencing oil spill risk

Ship traffic growth from 2011 to 2018

- No significant changes in sailing routes in the Channel and Bight are seen, except for increased ship movements around offshore wind farm areas.
- The 2011-to-2018 increase in ship passages is about 21% for the Bight traffic and about 4% for the traffic crossing the Channel.
- For the average GT per ship, a 57% increase from 2011 to 2018 is seen for the Bight traffic and about 29% for the traffic crossing the Channel.
- Compared to the increases in passages, much greater increases are seen for the growth in GT or ship size. This confirms the global trend in ship fleet development that ships are getting bigger and bigger to accommodate increasing demand by realising economies of scale while using larger vessels for transport.

Oil cargo loading and oil type distribution

- The percentages of loaded tankers for 2018 are generally distributed around 50% with a low variability. While these loading percentages are higher than for 2011 in BE-AWARE I, this is more likely due to possible interpretation and classification issues in BE-AWARE I rather than due to any real trend.
- With regard to relative proportions of oil types, the percentages of fuel oil and gasoline are lower for 2018 when compared to 2011.
- These reduced proportions for fuel oil and gasoline mean corresponding increases in crude oil proportions for crude oil tankers and gasoil/diesel proportions for the remaining tanker types.

- When looking at the heavy oil types together (i.e. crude oil and fuel oil), their proportion is unchanged for crude oil tankers. However, there is a significant drop in heavy oil types for all other tanker types (product tankers, chemical/product tankers and other tankers).

Accidents and spills

- The annual number of shipping accidents shows a 30% decrease for 2012-2018 (analysis period for this trend analysis) when compared to 2002-2011 (analysis period for BE-AWARE I).
- The number of collisions with vessels shows a significant 64% decrease from 28 per year in 2002-2011 to 11 in 2012-2018. This is an important finding, since collisions with vessels are the main driver with respect to oil spill risk from vessels, cf. BE-AWARE I (Bonn Agreement, 2014a).
- The number of groundings has gone down by approximately 16% from 43 per year in 2002-2011 to 36 per year in 2012-2018. Vessel groundings are the largest contributing accident type for both periods. In those cases where groundings led to spills, these were predominantly limited to spill sizes below 15 tonnes.
- The number of yearly accidents with pollution size smaller than 15 tonnes in 2012-2018 is about 50% higher than that for 2002-2011. This could possibly be due to increased accident reporting or due to the effectiveness of risk reducing measures in limiting the extent of pollution from spills.
- The number of annual accidents with pollution size greater than 15 tonnes are about the same for both the periods. However, the distribution of pollution sizes for these spills are quite different. In 2012-2018, all spills greater than 15 tonnes ranged from 15 tonnes up to 200 tonnes in size. For 2002-2011, all spills greater than 15 tonnes were from 15 tonnes up to 5000 tonnes.
- No spills of size greater than 200 tonnes were reported in 2012-2018. This may be attributed, among others, to the significant drop in the number of collisions. However, it also needs to be considered that large spills are relatively rare events, thus making it difficult to derive meaningful statistics even for a 10-year period.
- The maximum pollution size reported in 2012-2018 was 200 tonnes whereas it was more than 5000 tonnes for 2002-2011.

Development of wind turbine areas

- The spatial extent of windfarms in the Bonn Agreement area in 2021 is expected to be about 25% larger than that predicted for 2020 in BE-AWARE I.
- The development of windfarms until 2021 is particularly high in the southern North Sea area (Dutch, Belgian and UK EEZ). This also includes areas where there is dense ship traffic.
- The increasing occupation of marine space by windfarms is expected to continue also in the next decade (2020-2030) for the entire North Sea area.

Accident and oil spill risk in the Bay of Biscay

- There were on average 5 shipping accidents per year in the Bay of Biscay area during 2012-2018, and this is about the same as seen during 2007-2011.
- 36% of these accidents were vessel groundings followed by sinking due to other causes (22%), collision with vessel (19%) and hull damage due to other causes (16%).
- The relative contribution picture from accident types and ship types is seen to be different for the Bay of Biscay when compared to the Bonn Agreement area, presumably at least in part due to the higher prevalence of severe weather conditions and the greater proportion of fishing vessels.

Ship traffic development from 2018 till 2030

- Growth in cargo tonnage or volumes is expected to vary depending on cargo type. While container tonnage is expected to grow by 48% on average from 2018 to 2030, the average growth rates are likely to be about 19% for tankers and 45% for bulk carriers.
- The overall average increase in vessel sizes are expected to be about 27% for containers and tankers and about 33% for bulk carriers.
- As seen for 2011-2018, the same trend of a smaller (or possibly a decrease in some cases) relative increase in ship movements coupled with a larger relative increase in ship size is expected to continue till 2030.

9.3 Comparison of observed oil spill with BE-AWARE I 2020 forecast

In BE-AWARE I, a forecast of the risk of oil spill (in tonnes of oil spilled per year) for the Bonn Agreement area in 2020 was established. The BE-AWARE I analysis considered accidents related to ships alone (collisions with vessels or groundings) and related to offshore installations (oil and gas platforms, wind farms and other fixed objects) either due to being hit by vessels or from the installations themselves.

In this trend analysis, while all shipping accidents are analysed, accidents involving installations are not considered. From the 2020 forecast, accident types that can be compared with the current analysis are therefore identified and their associated risk contributions extracted – this is shown in Figure 9-1.

Based on the analysis of the reported data for oil spills in section 3.3.2 (Figure 3-9), the distribution of the observed annual oil spill during 2012-2018 per spill size and accident type is shown in Figure 9-2. The observed annual situation over 2012-2018 is taken to be representative of the present situation and hence comparable to the 2020 forecast. A comparison of the 2020 forecast with the observed annual situation in 2012-2018 shows the following:

- The predicted and observed spill amounts from spills up to about 300 tonnes are about the same, but with a tendency towards a higher number of small spills and a lower number of medium-sized spills than predicted.
- No spills larger than 200 tonnes have been reported during 2012-2018 whereas the risk from such spills is the largest contributor to the predicted 2020 oil spill risk.

Very large spills of size greater than 5000 tonnes are very rare events with return periods much larger than the seven-year (2012-2018) data period for this analysis. Similarly, the large spills (300-5000 tonnes) are relatively rare events. It is therefore likely that while the risk of large and very large spills still remains (with a very low likelihood of occurrence), this risk has just not been realised during 2012-2018.

In the present case, the largest observed spill event had a size of 200 tonnes, corresponding to a yearly average of 50 tonnes (the spill occurred in the EEZ of Belgium where four years of accident data are available, cf. Chapter 3). This spill happened to be just below the lower range of the 300-5000 tonnes interval. Had it had a different spill size, e.g. halfway between 300 and 5000 tonnes, the statistics would obviously have matched the prediction to a higher degree. Thus, the deviation between prediction and statistics does not indicate a mismatch between model and reality. The randomness of this type of rare event will naturally decrease over a longer observation period, thus providing a better basis for comparison.

When comparing the predicted and observed values, collisions with vessels are seen to the largest contributors in both cases, accounting for about 70% of the amount of oil spilled as per the predicted values and about 50% as per the observed values.

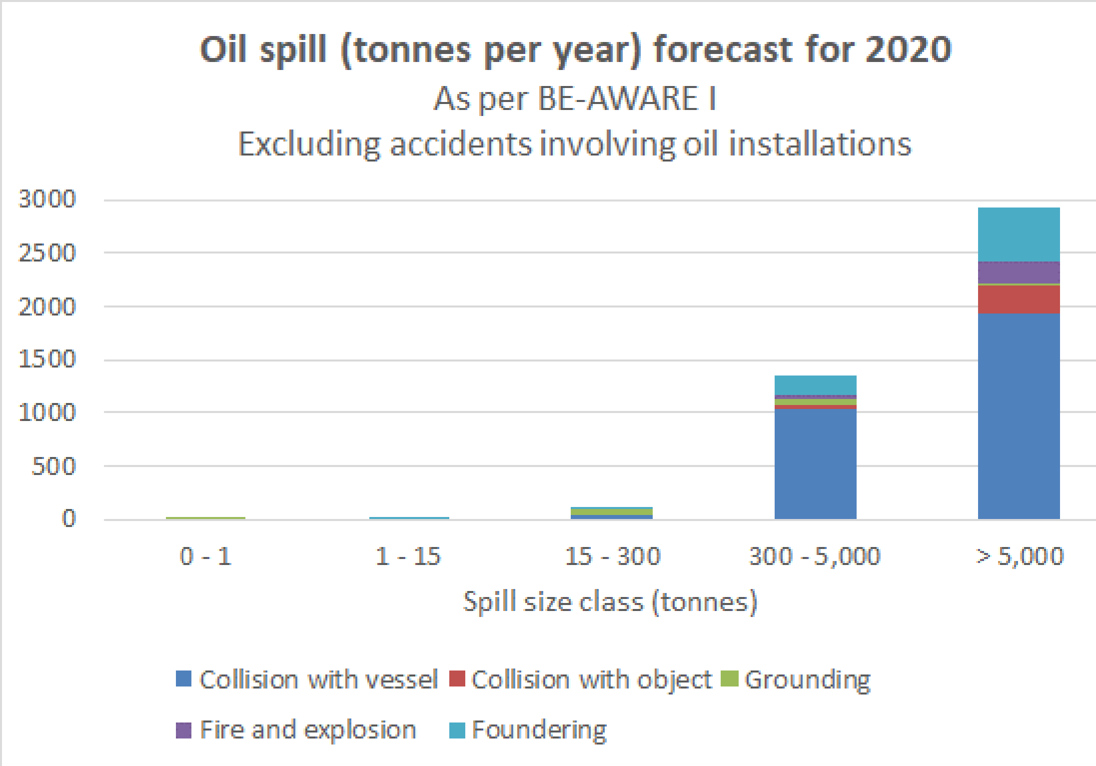


Figure 9-1 Oil spill forecast for 2020 as per BE-AWARE I, excluding accidents involving oil installations

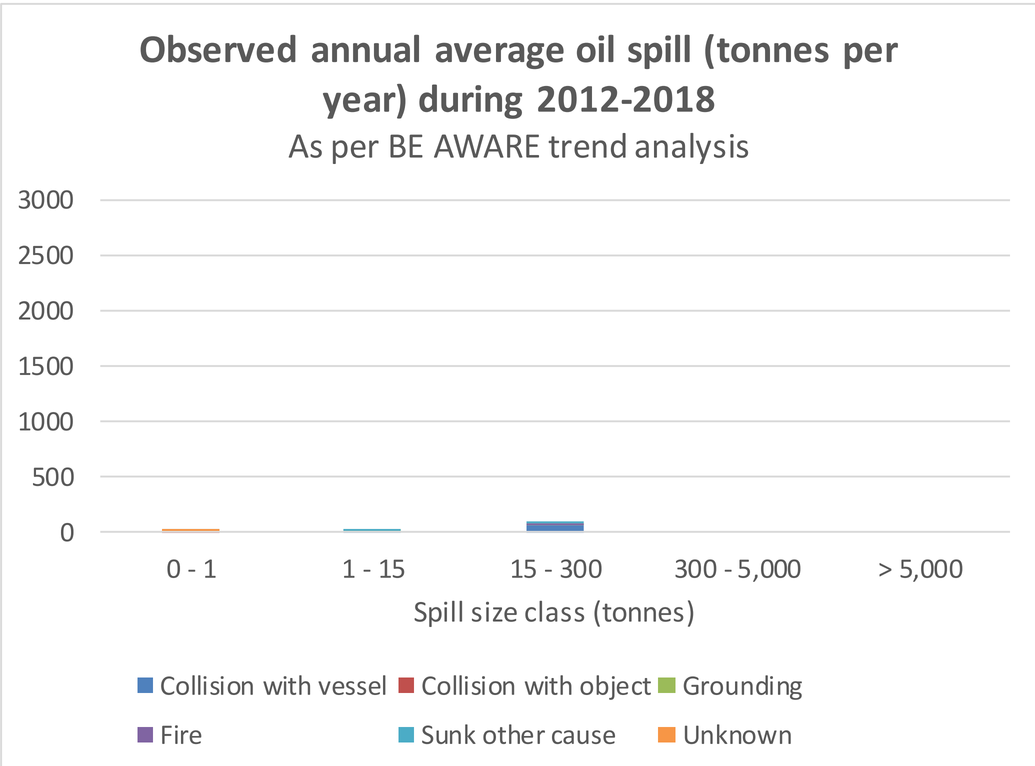


Figure 9-2 Observed annual average oil spill during 2012-2018 as per BE-AWARE trend analysis

9.4 Conclusions and outlook

The following key findings are identified from this trend analysis when comparing the 2018 situation with 2011:

- A modest increase of about 13% is seen for ship passages whereas ship sizes show a much larger 43% increase.
- There is a 25% overall increase in the spatial extent of windfarm areas, thereby meaning a possibly reduced navigational space particularly in some dense traffic areas.
- The number of accidents per year show a decrease of 30%. There is a 64% decrease in collisions with vessels.
- While the number of small spills (of size less than 15 tonnes) has increased by 50%, the number of spills larger than 15 tonnes stays at about the same level.
- No spills larger than 200 tonnes were reported in 2012-2018. This means that the total amount of oil spilled per year has decreased. However, it should be noted that very large oil spills are infrequent events even during a 10-year period, so this finding should not be attributed too much significance. The size of the largest oil spill reported was 200 tonnes for 2012-2018 whereas this was more than 5000 tonnes for 2002-2011.

The above shows that the increased traffic and increased ship size together with possibly reduced navigational space do not translate into a corresponding increase in accidents. The risk of spills from accidents is unchanged for medium-sized (15-300 tonnes) spills. The risk from small spills (below 15 tonnes) has risen significantly. The possible reasons for this development could be an increased reporting of all spills or the effectiveness of intervention and response capacities in limiting spills to small sizes. There have been no spills of sizes larger than 200 tonnes of released oil during 2012-2018.

In summary, it appears that the risk-reducing measures introduced over the last decade and the recent levels of emergency intervention capacities have had a positive effect either with respect to navigational safety or in mitigating the extent of oil spills, more or less stabilising the risk situation despite growing ship sizes and ship passage numbers.

The work carried out in the BE-AWARE I and II projects has been instrumental in establishing an implementation plan (Bonn Agreement, 2019) for risk management which broadly identified mitigation measures into two categories: traffic regulation (including AIS alarms, TSS, VTS) and intervention & response capacities. The trends of growing ship sizes and ship passages combined with reduced navigation space due to windfarm development points to an increasing congestion of ship traffic in the Bonn Agreement area – this calls for a sustained continuation of traffic regulation related measures identified in the BE-AWARE implementation plan. Further, no spills larger than 200 tonnes were observed in the Bonn Agreement area during 2012-2018 – this points to the effectiveness of measures related to intervention and response capacities in limiting the extent of spill sizes and preventing large spills.

The efforts to increase safety at sea and to ensure environmental protection by implementing risk reducing measures for traffic regulation and safeguarding sufficient intervention and response capacities should therefore be continued.

The development of ship traffic from 2018 till 2030 is expected to show a similar trend as seen for 2011-2018, i.e. a smaller relative increase (or possibly a decrease in some cases) in ship passages coupled with a larger relative increase in ship size.

The challenges posed by further increases in ship sizes and passages together with decrease in navigational space due to increasing windfarm area developments are undoubtedly adding risk compared to the present situation. At the same time, it needs to be acknowledged that shipping has become safer and safer over the past decades and there is no evident reason to believe that this process has come to a stop.

Thus, additional ship passages and increasing vessel sizes as well as narrowed shipping corridors do not necessarily translate into increased overall accidents and spills. Nevertheless, these developments represent new requirements that need to be considered while evaluating and reinforcing response capacities to oil spills and marine pollutions.

10. Abbreviations

AIS	Automatic Identification System
DWT	Dead Weight Tonnage
EEZ	Exclusive economic zone
GT	Gross Tonnage
HNS	Hazardous and noxious substances
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IMO	International Maritime Organisation
IWRAP	IALA Waterway Risk Assessment Programme
RRM	Risk-reducing measure
SECA	Sulphur Emissions Control Area

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Summary of information provided by the Contracting Parties used in this Trend Analysis

Type of data (chapters in which the data is primarily used)	**Belgium**	**Denmark**	**France**	**Germany**	**Ireland**	**Netherlands**	**Norway**	**Spain**	**Sweden**	**United Kingdom**
Accidents and spills for 2012-2018 (Chapters 3 and 7)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
AIS ship movements data for 2018 (Chapters 4 and 7)			✔ Channel Bay of Biscay	✔ Bight				✔ Bay of Biscay		
Oil shipments to and from ports for 2018 (Chapter 5)				✔ Hamburg			✔ Mongstad			
Existing and planned wind turbine areas (Chapter 6)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Future development and prognoses for goods transport (Chapter 8)	✔	✔	✔	✔	✔	✔	✔	✔	✔	