REPORT.

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SHIPPING ANALYSIS OF THE NORTH SEA

UNDERTAKEN ON BEHALF OF

DEUTSCHES BUNDESMINISTERIUM DES INNERN, FÜR BAU UND HEIMAT

TABLE OF REVISIONS

Rev	Date	Description of Amendment	Author	Checked	Approved
A	03/12/20	Work in Progress: Draft Report up to work package 02. Issued for early comments.	George Savvopoulos; Diego Cerquenich	Christoph Ruck	Johan Gahnstrom
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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

London Offshore Consultants (LOC), a part of the AqualisBraemar LOC Group (ABL), performed a nautical risk study in the area of the North Sea, with particular interest in the current and future offshore windfarm development between 2020 and 2040. This work is commissioned by the German Federal Ministry of the Interior, Building and Community. The main objective of the study is to identify the significant shipping routes in the North Sea based on current traffic patterns, and in parallel consideration with the existing and future offshore windfarm developments and other aquaculture installations, develop proposals for a coherent system of shipping routes in the North Sea.

The work included a traffic study, for the identification of the main shipping routes, and the identification of the qualitative characteristics of the traffic that uses them. The study identified the different patterns between merchant and work/support vessels, and the extent to which they utilise the same space. The main shipping route in the North Sea, is the N-S route from the Dover Strait along the West coast of the European Continent, through the German Bight and into Skagerrak. This is the main merchant traffic route that conveys trans-continental traffic to the European hub ports and the Baltic Sea, with a tear diverging to the Arctic Sea. Secondarily, there are the UK coastal shipping route that carries traffic from the main N-S route along the East coast of the UK and the Norwegian Coastal corridor that connects the Baltic Sea to the Northern corridor. Additional routes crossing the central parts of the North Sea and English Channel are used by Ro-Ro and General cargo vessels that connect the Continent to the UK. Work vessels use these corridors to mobilise, however for most of the time operate between a project home-port and specific project locations, with long periods of time spent offshore at the latter.

The observations of the traffic study were subsequently combined with the insight provided by the North Sea States' authorities in terms of the future renewables developments foreseen by their current maritime spatial plans (or forming parts of the relevant discussions where the latter are still under development/review) and were developed into a projection of the North Sea (excluding Kattegat) developments layout for the year 2040. As accurate information in most cases is not available as to the exact footprint of future developments, but rather study/tender areas, the study conservatively assumed the full footprint of these areas in the modelling and navigational analysis exercises.

A risk study was undertaken to identify the areas in the North Sea with the highest concentration of collision, allision, and grounding risk. This included the modelling of the traffic corridors in the North Sea, and the traffic quantities observed in 2019, to identify the areas in the top 5th and top 10th percentile of risk. This formed the benchmark case for the rest of the exercise, that considered the impact in this risk profile of initially the traffic increase anticipated between 2020 and 2040, and subsequently that of the change in the traffic routes induced by the development of future offshore renewable installations. The aim was to note the areas with the most notable increases in the risk profile. The study noted that the risk intensity in the North Sea is predominantly concentrated on and around the main N-S traffic corridor from the Dover Strait to Skagerrak and the Baltic Sea, and the approaches to the main hub ports of Rotterdam and Antwerp. The risk increases with the introduction of additional traffic, and in most cases with the introduction of offshore renewables developments that understandably reduce the space available to navigation and induce route changes.

Examined individually, the traffic increase is noted to have a more significant impact to the risk increase compared to the traffic routes alteration. This signifies that in line with the actual fluctuation of traffic in the coming years, the risk increase may develop sooner or later than the time assumed in the present study. Whilst the study considers two snapshots in time, 2019 and 2040, changes in reality will happen gradually, and thus there are opportunities for cross-country coordination and subsequent intervention and adjustment to mitigate risks in the areas where these are found to concentrate.

In addition, the time and sequence in which the future offshore renewables developments will materialise will have a significant effect in the way navigation will adjust around them and the development of risk with time. As such developments will be preceded by targeted, area-specific, probabilistic navigational risk assessments (on up-to-date vessel traffic and intended footprint) the authorities will have the opportunity identify and implement the interventions required safe navigation.

On the larger scale, with marine traffic not expected to stop its growth in 2040, the North Sea states would benefit from the promoting a denser collaboration regime for managing this change. Especially so, as the risk introduced to the system by a change does not necessarily occur at the location of the change, and it may thus well be transferred into a different jurisdiction. This can be as simple as regular periodic communication between authorities on upcoming developments and observations in the change of marine traffic and renewable industry trends, or as advanced as a joint plan preparation, with outlined interventions to be triggered by predetermined conditions in space and traffic.

The study concludes with risk mitigation measures in the order of route alternatives where the planned offshore installations disrupt the current traffic pattern. Most of the routeing adjustments regarded alteration made to circumnavigate obstructions, with little impact on the overall routeing system of the North Sea and risk associated. The English Channel and southern section of the North Sea are characterized by several IMO traffic separation schemes and therefore the maritime spatial plan expected in those areas does not represent an obstruction requiring course deviation. Moving northward to the German Bight, the complexity of the designated areas for future developments in the German and Danish Economic Exclusive Zones requires actions to mitigate the risk of erratic traffic within their area of interest. This mitigation might be reached with the introduction of recommended routes joining existing paths or with the establishing of a traffic separation scheme. However, these mitigations involve the decision of several coastal States to proceed towards a common objective, and it can be said that one of the present study outcomes is that better co-ordination and consensus in the decision-making process would facilitate possible mitigation measures and guidelines homologation amongst the various maritime authorities of the North Sea, to facilitate consensus in the decision-making process.

The present study aspires to be a contributor in strengthening close collaboration between the coastal States of the North Sea and a starting point in a collective approach aimed at identifying and resolving future challenges in a productive and timely manner.

2 INTRODUCTION

2.1 GENERAL

The European Union "2030 Climate and Energy Framework" requires the member states' compliance with set EU-wide targets and policy objectives for the period from 2021 to 2030. This framework requires that by the year 2030:

- At least 40% cuts are achieved in greenhouse gas emissions (from 1990 levels)
- At least 32% share of the energy comes from renewable sources
- At least a 32.5% improvement is achieved in energy efficiency

The achievement of these climate targets by the EU-member countries is expected to involve heavy investment in renewable energy, most of which is anticipated to come in the form of offshore wind turbines. To achieve the required output, the new offshore wind developments would have to cover a significant area in the North Sea. With the east coast already very heavily trafficked by merchant and work vessels, spatial demand is expected to become an important issue and a balance is sought between attributing space to offshore wind developments and maintaining safe and effective shipping traffic. The spatial demand may also increase due to other developments with spatial requirements, such as aquaculture. It is noted however that what is currently envisaged is that in most cases there can be an efficient overlap between offshore wind and aquaculture.

The North Sea constitutes a central transport hub for all countries bordering the North and Baltic Seas, through which the vast majority of exported and imported goods to and from those countries are being shipped. It is therefore imperative that navigational safety and route efficiency is ensured as new offshore windfarm and other offshore developments are planned.

This will require effective coordination between the North Sea states' authorities, on their planning and permitting procedures for new offshore wind developments, as well as the maintenance, formation, and potential alterations to navigation routes. To facilitate this liaison between the North Sea States' authorities, a holistic analysis of the marine traffic system in the North Sea is required.

The present work is intended as a first step to set the basis for this liaison between the North Sea states. The area of concern of the subject study is presented in Figure 1.

Figure 1: North Sea – Area of present study.

2.2 SCOPE OF ABL STUDY

The scope of work for the study is split into four work packages, and includes the traffic study, liaison with authorities' representatives from the North Sea countries in terms of receiving input on future offshore renewable developments and capturing particular interests and comments, and the preparation of a final report constituting the culmination of the above. The work packages comprising the scope of the study are:

- WP 1: Traffic analysis
- WP 2: Estimate of plans for offshore renewables or other offshore installations (incl. aquaculture)
- WP 3: Description and evaluation of risks for shipping traffic arising from offshore installations according to WP 2
- WP 4: Proposals for safe traffic flows, including options for routing measures.

2.2.1 WORK PACKAGE 01

LOC performed a comprehensive traffic analysis in the complete North Sea. This analysis is focused on the observed traffic of merchant and work vessels in the study area and excludes port and fluvial areas. Also, due to the number of vessels captured in the area, the study is focused on IMO vessels, with small work, small fishing and pleasure craft filtered out of the working datasets.

Counting lines are used in the analysis to capture the relevant traffic routes. The intention is to provide an overview of the traffic volumes at different parts of the North Sea, and briefly comment on the qualitative characteristics of this traffic. Where there is a need, this information is used in further commentary in subsequent work packages.

2.2.2 WORK PACKAGE 02

LOC liaised and obtained information from the North Sea states' contacts provided by the German Federal Maritime and Hydrographic Agency (BSH) on the areas considered for new Offshore Wind Farm (OWF) developments between 2020 and 2040. The information obtained from the state authorities was supplemented with information from online databases and, where pertinent, discussions and literature that form part of the public domain. Hydrogen and oil & gas platforms to be installed or decommissioned by 2040 are considered where relevant.

It is worth noting that not all such information was provided or accessible at the time of the study, as some such developments are either still under the subject of internal debate or deemed politically sensitive by the pertinent states and thus not shared on record for the purposed of this study. The developments captured in this report represent best endeavours and best current information.

2.2.3 WORK PACKAGE 03

LOC used reasonable assumptions to forecast the marine traffic volume development in the North Sea in the next 20 years, and on this basis considered the future OWF development areas, and their potential effect on the navigation routes in the study area.

The current risk in the main traffic corridors is obtained from a high-level risk analysis performed for the base case, being the current condition, obtained from actual traffic data from 2019. The analysis model used, considers the accident types presented in the breakdown of Table 1.

Table 1: Risks to be considered in study.

Vessel to vessel collisions	Vessel groundings	Vessel allisions to fixed/floating objects
→ Overtaking collisions	→ Powered Groundings	→ Powered Allisions
→ Head-on collisions	→ Drifting Groundings	→ Drifting Allisions
→ Crossing collisions		
→ Merging collisions		
→ Bend collisions		

It is understood that different countries have different assumptions when it comes to the causation factors used in risk analyses. However, to homologise, the present assessment is using the International Association of Lighthouse Authorities (IALA) accepted factors. This facilitates a direct comparison between the identified high-risk areas and thus provides quick insight on the locations where risk is currently concentrated.

The risk analysis is then repeated using the projected traffic for 2040, to examine how the risk profile changes (i.e., if there are areas where the risk increases disproportionately compared to the rest) as a direct result of increased traffic (still on the basis of existing and authorised projects).

With the completion of this second risk analysis, the areas reflecting the future developments as identified in WP2 are added to the risk model, the traffic routes are adjusted around them, and the analysis is repeated one last time. Where there is an overlap of existing routes with the footprint of future developments, reasonable alterations are made to the routes to reflect the most likely reaction of navigating vessels and thus alteration of the traffic routes.

The outcome of this high-level assessment was presented to the stakeholders on 10 December 2020.

2.2.4 WORK PACKAGE 04

Based on the conclusions of WP1 and WP3, LOC performed a review of the areas identified to concentrate risk. Considering the requirements of rulesets as laid out by UNCLOS, IMO, COLREGS, and IALA LOC proposed options for the potential mitigation of the risk in such areas where identified.

The intention of this work package is to facilitate the conversation between authorities and their involvement laying down the foundations for further discussions. Considering the magnitude of the present study and the time constriction, additional recommendations for further work are provided as and where required.

3 METHODOLOGY

3.1 ASSUMPTIONS AND LIMITATIONS

The risk analysis is based on the current maritime traffic condition based on Automatic Identification System (AIS) data from the year 2019 and on an estimate of future traffic. The latter was projected based on the information included in the International Transport Forum (ITF) Transport Outlook 2019 published by the Organisation for Economic Co-operation and Development (OECD) [01].

Maritime traffic information was sourced through the availability of historic AIS data for the North Sea made available by BSH. Further information on the dataset is provided following sections of the present report.

Safety of Life at Sea Convention requires all vessels of 300 gross tonnage or more employed in international voyages are equipped with an AIS transceiver since 2002. In the recent years, given the improvement of technology and reduced cost of transmitter and receiver equipment, together with the introduction of an additional AIS class standard, several units with a gross tonnage <300 voluntarily became AIS-compliant. However, a certain number of vessels such as pleasure craft, military operation involved units and small (non-IMO) fishing boats were not included in the AIS historical plots, and therefore not assessed. Although this constitutes a limitation on the overall number of vessels, the erratic transit of a variety of smaller units would not be representative of the commercial marine traffic in the area of analysis.

3.2 ANALYSIS SOFTWARE

The traffic and risk analyses were performed using the IWRAP (IALA Waterway Risk Assessment Program) Mk2 Version 6.4.1.

IWRAP is a collision/grounding frequency calculation tool recommended by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA). It is also used to extract and process information from AIS data to provide a traffic description for the model area.

3.3 MODEL DEVELOPMENT

This section intends to familiarise the reader with the modelling assumptions and parameters used in developing the environment for the present study.

3.3.1 AREA BOUNDARIES

The model covers the main body of the North Sea, as depicted by the red contour in Figure 1. The model area includes part of Skagerrak, however, excludes Kattegat. The reasons for the exclusion of the latter, is the small number of OWF development prospects, and the fact that it constitutes an area with a clear passage in international waters between Denmark and Sweden that serves as the main access corridor to the Baltic.

The model area also excludes inland navigable waters as well as port approaches, harbours, anchorages, and roads. These particular areas are regulated by the pertinent port authorities. In addition, pilotage waters are subject to a regulatory regime which might differ from coastal waters and high seas, and as such, it might mislead the overall analysis of the marine traffic in said specific areas.

3.3.2 OFFSHORE WINDFARM AREAS

The first stage of the assessment, that covers the analysis of existing traffic, considers all existing OWF developments in the study area.

Existing developments comprise all offshore developments that currently occupy space in the North Sea. These are OWFs that are presently operational, and OWFs or extensions to OWFs that are currently under construction.

Existing OWFs are incorporated in the model as polygon areas representing the footprint of the developments. A full list of the OWFs that were included in the model is presented in Table 2 overleaf.

Table 2: Existing and under construction OWFs in the North Sea.

Country	OWFs
Belgium	Seamade (mermaid) Norther Thornton Bank Phase I Thornton Bank Phase II Thornton Bank Phase III Rentel Northwind Nobelwind Belwind Northwester 2
Denmark	Anholt Frederikshavn Horns Rev 1 Horns Rev 2 Horns Rev 3
Germany	Butendiek Dan Tysk Sandbank Amrumbank West Nordsee Ost Meerwind Sud/Ost Gode Wind 1 and 2 Nordsee One Borkum Riffgrund 1 Borkum Rifgrund 2 Trianel Windpark Borkum 1 and 2 Merkur Alpha Ventus Global Tech I Hohe See Albatros Bard Offshore 1 Veja Mate Deutsche Bucht Riffgat
The Netherlands	Borselle 1 and 2 Borselle 3 and 4 Borselle 5 Egmond aan Zee Prinses Amaliawindpark Eneco Luchterduinen Windpark Fryslan Westermeerwind Gemini
Norway	Test Field
Sweden	Kattegat Offshore
United Kingdom	Scotland: 2B Energy Methil Demonstration Aberdeen Offshore W/F Beatrice Offshore Wind Farm Buchan Deep Demo Neart Na Gaoithe Offshore Wind England: London Array Gunfleet Sands I Gunfleet Sands II Gunfleet Sands Demo Kentish Flats Kentish Flats Extension Thanet Greater Gabbard Scroby Sands Sheringham Shoal Lincs Dudgeon Race Bank Humber Gateway Westermost Rough Lynn Inner Dowsing Teesside Galloper Hornsea 1 Blyth Demo Phase 1 Blyth

3.3.3 METOCEAN CONDITIONS

The metocean conditions are important in terms of both determining the drifting parameters for vessels not under command (e.g., subjected to engine breakdown or blackout) following aberrant courses that can lead to a collision, as well as the potential of collision aversion through the intervention of tugs in the case of drifting vessels.

In the case of the former, the distribution of wind and current directions is important in determining the direction of drift, that takes part in the geometric probability calculation within the software. Metocean data are also significant in terms of determining the drifting speed of the vessels.

The North Sea, a semi-enclosed basin within the north-west European shelf sea, is one of the most productive regions of the world ocean.

An important factor for the marine weather of the North Sea are the inflowing water masses from the Atlantic and the continental freshwater run-off. The salty Atlantic water and the fresh water drained via a number of rivers and via the Baltic Sea from the huge hinterland of western Europe are merged and mixed by the action of the tides and of the atmospherically induced turbulence of waves and currents.

The dominant atmospheric forcing of the North Sea is provided by the spacetime distribution of the winds and the air pressure. The most energetic situation is found in winter, with strong wind blowing up to 28-30 m/s.

The general direction of the current circulation varies only little between the seasons, and it is characterized by a cyclonic (contraclockwise) pattern.

Fog is associated with wind directions of between south-east and south-west and can reduce visibility to less than 1km 3-4% of the time. Radiation fog can form for 3-6 days per month between October and April and tends to occur during the night, being dispersed by the sun on all but the coldest days (UKHO 2013).

The metocean conditions in different parts of the North Sea differ, and these in turn influence the calculated risk for drifting vessels.

For the purpose of this assessment, the North Sea area was split into 8 different areas with similar metocean characteristics, and the metocean parameters were derived for each. These areas are presented in Figure 2.

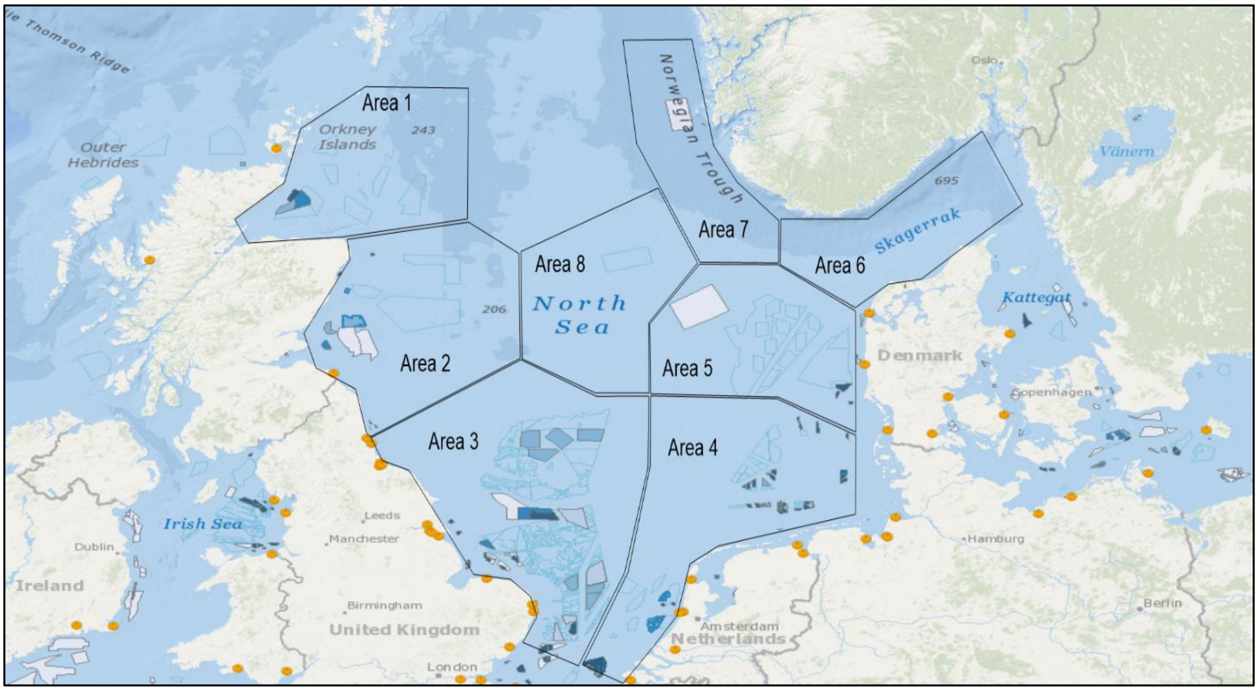


Figure 2: North Sea breakdown for metocean analysis.

Long-term offshore wind and wave time series data were collected from the ECMWF-ERA5 database.

The ECMWF (European Centre for Medium range Weather Forecasting) is an intergovernmental organization that uses state-of-the-art numerical models to deliver global weather forecasts in support of the national meteorological services. Both satellite and conventional data are daily collected from an extensive data collection network and analysed to set the initial conditions of the models. Wave data distributed by ECMWF are simulated by the spectral third generation WAM model coupled with the wind fields simulated by the global meteorological model. ERA-5 is a global atmospheric reanalysis from 1979, continuously updated up to end of 2019. Data are provided on hourly basis over a grid 0.5° x 0.5°. This data is provided over a regular grid fully calibrated and homogenized against satellite data and (where available) in-situ buoy data. An example is presented in Figure 3:

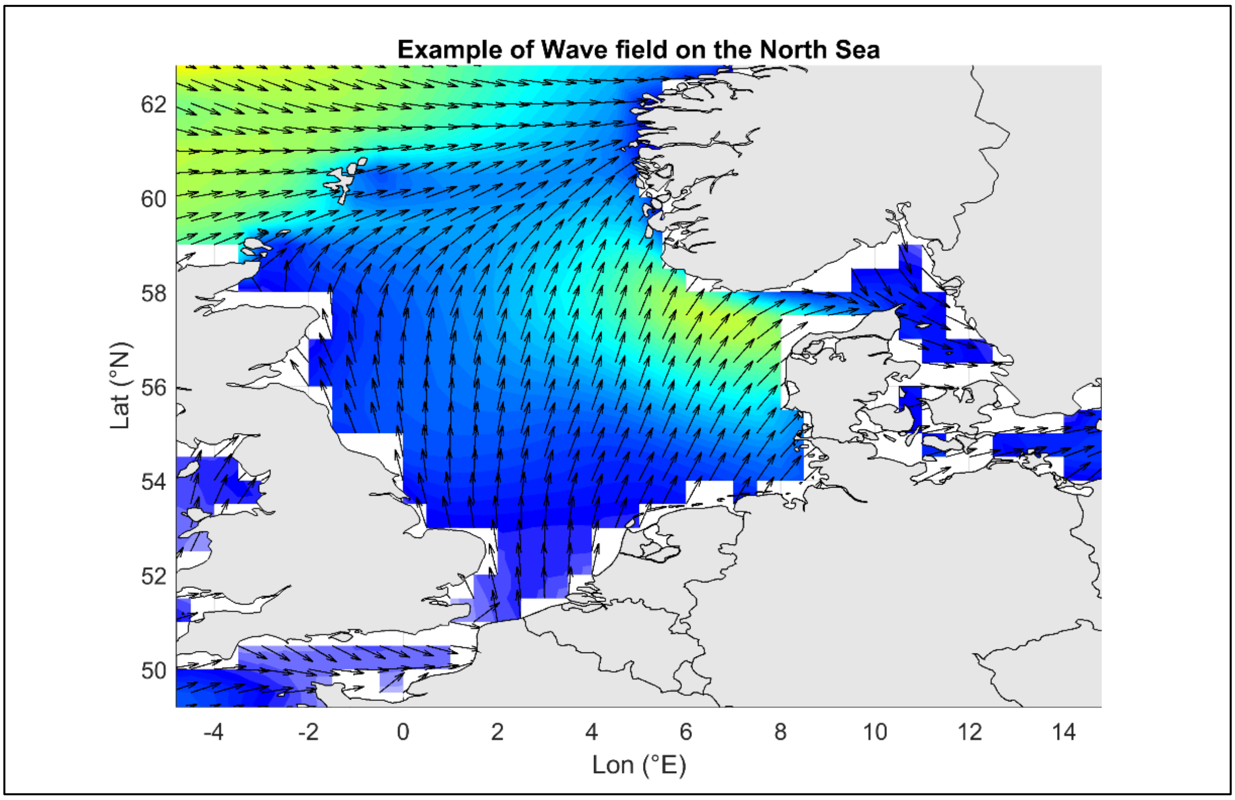


Figure 3: Example of Wave Field in the North Sea Basin.

Data on currents was obtained from historical archives of current data hindcasted by means of HYCOM numerical model (Hybrid Coordinate Ocean Model) in order to assess the typical climate regime of the selected areas. The HYCOM consortium is a multi-institutional effort funded by the National Ocean Partnership Program (NOPP), as part of the U. S. Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a primitive equation general circulation model which is isopycnal in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or un-stratified seas. It maintains the significant advantages of an isopycnal model in stratified regions while allowing more vertical resolution near the surface and in shallow coastal areas. This results to the provision of a better representation of the upper ocean physics. Surface current climate is provided on the basis of data provided by the HYCOM database. An example of the currents field in the North Sea basin is shown in Figure 4.

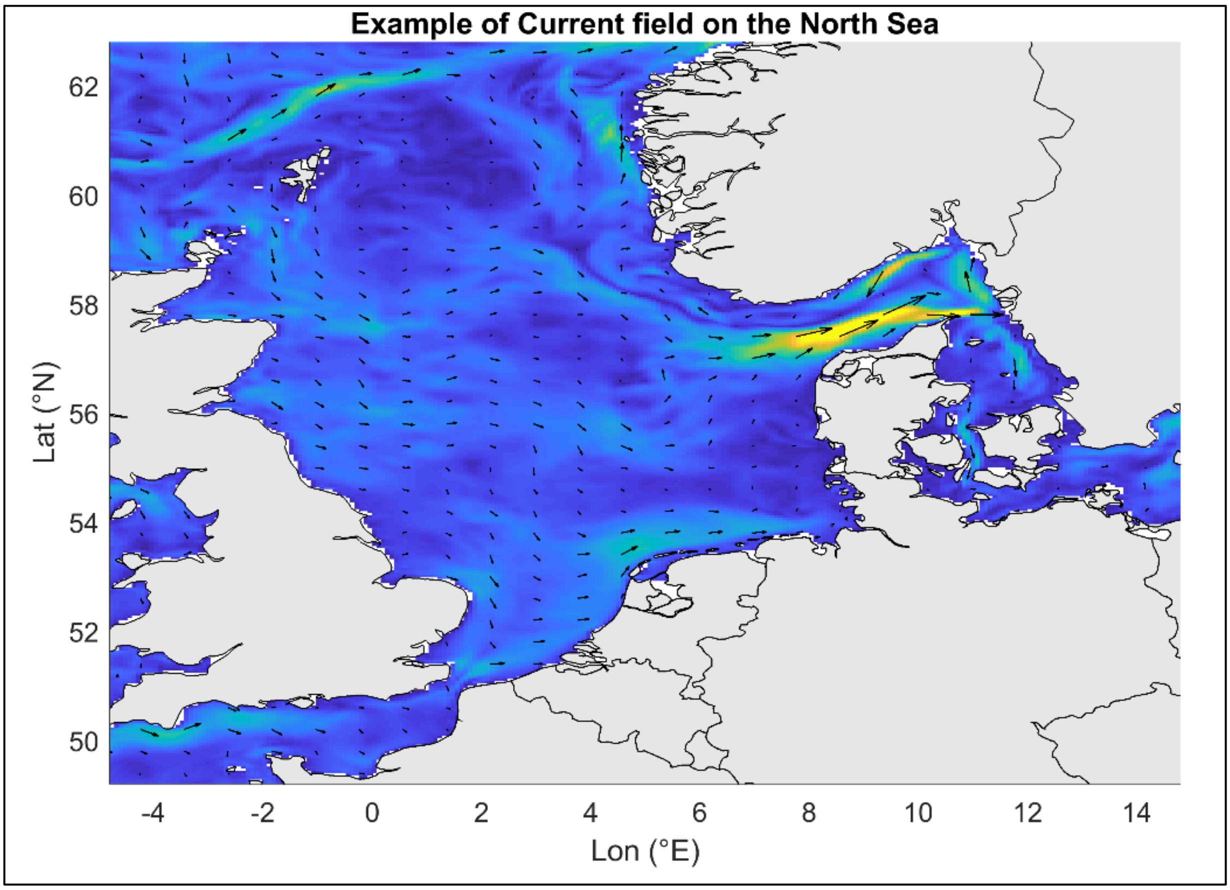


Figure 4: Example of Instantaneous Currents Field in the North Sea Basin.

Metocean parameters were analysed in order to provide seasonal statistics (in table and graphical format), suitable for a correct drifting vessel assessment, at each part of the North Sea. These derived statistics are presented in Appendix A.

For the initial, high-level risk benchmarking for the whole North Sea area, a homologated set of parameters was developed and applied throughout the model. Two separate sets of parameters were derived, one based on all 8 areas of Figure 2, and the second just on areas 3, 4, and 5 of the same figure, that carry the heaviest traffic. The latter, being the most conservative of the two was adopted for the whole model. The drift directionality and speed assumptions associated with this set are presented in Table 3.

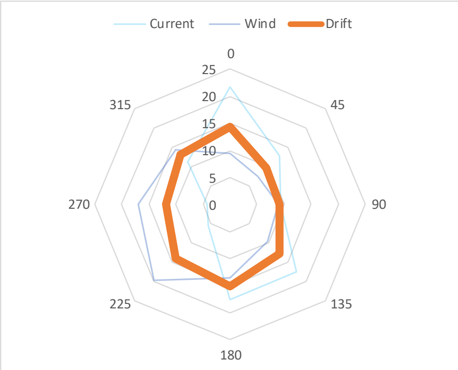
Table 3: Drift parameters applied on high-level risk analysis.

North Sea Overall

CURRENTS Dir (°N)		WIND Dir (°N)		DRIFT Dir (°N)	
0	22	0	9	0	14
45	13	45	7	45	10
90	9	90	9	90	9
135	17	135	10	135	13
180	18	180	14	180	15
225	6	225	20	225	14
270	4	270	17	270	12
315	11	315	14	315	13

Mean Speed: 0.70 (kts)

Mean Intensit 5.83 (B)
Mean Speed 11.79 (m/s)
22.92 (kts)



Drift speed 1.81

Fog in the North Sea is associated with the wind direction and temperature difference between the atmosphere and the sea. Whilst individual areas have different characteristics, on average, visibility is less than 1km during 3-4% of the time.

3.3.4 BATHYMETRY

Bathymetry is used to assess the risks of vessel grounding, for controlled and drifting vessels. However, the timeframe and magnitude of this assignment, deems a full and detailed consideration of the bathymetry non-feasible.

To address the issue of grounding risks, a single contour is included in the model, in most areas parallel to the coastline profile. In areas where known shallow waters are situated near main traffic arteries, this line is further offset from the coastline to represent these particular grounding risks. Separate contour lines were added to represent shallow areas within the main basin, at a depth of 5m, for the effect of these obstructions to be considered.

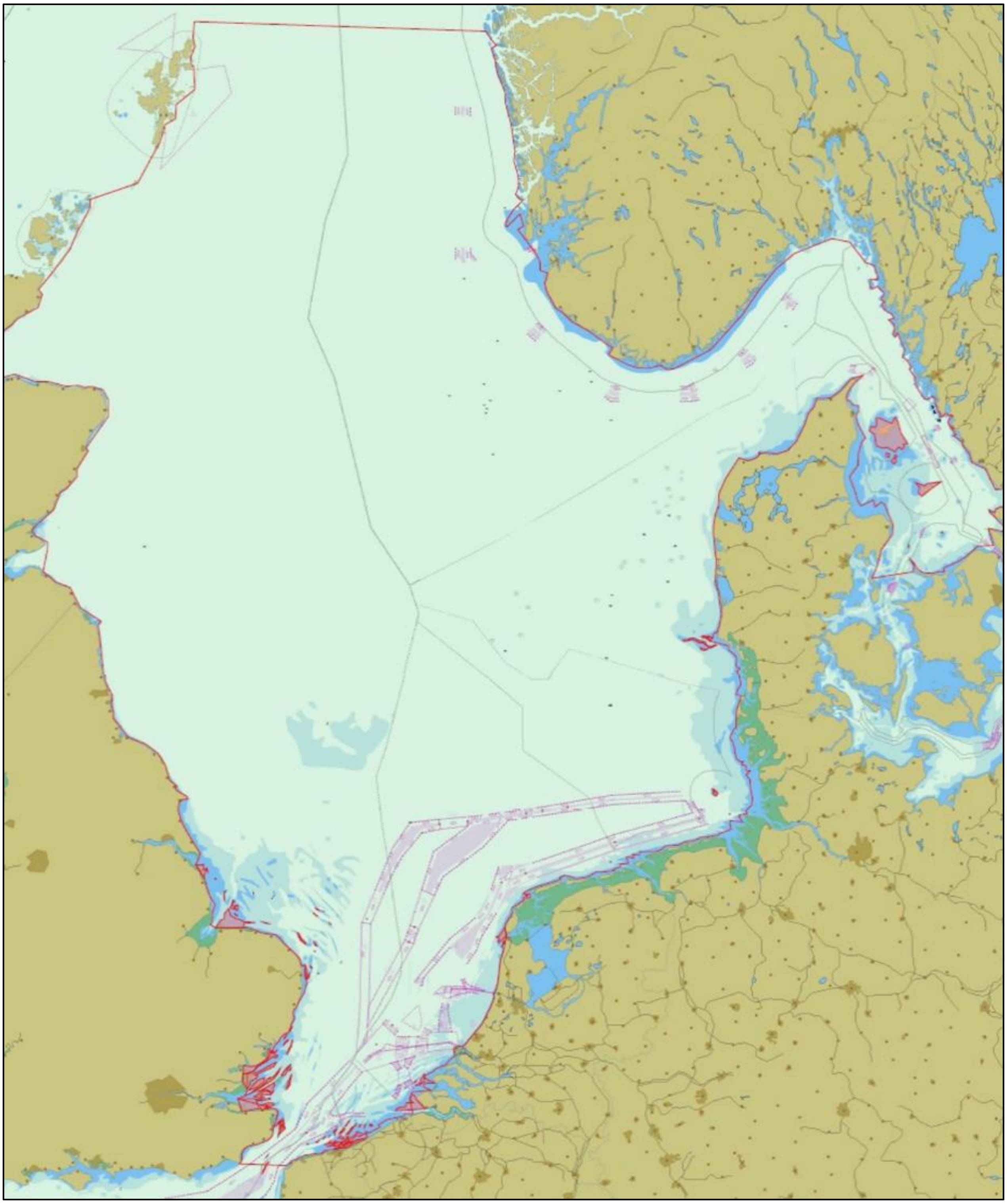


Figure 5: 5 metres bathymetry (red contour).

The IWRAP Mk2 algorithm uses bathymetric contours to determine the ability of a drifting vessels to use its anchor (depth < 7 x Draught). With the approach adopted for this study, the software conservatively assumes that a drifting vessel cannot benefit from using its anchor, thus the estimated allision and grounding risks considered are on the conservative side.

3.3.5 TUGBOAT STATIONS

Identifying Emergency Towing Vessel (ETV) tugboat stations in the area associated with the model and defining the available tugboats parameters allows the software to consider tug intervention in cases of drifting vessels, to potentially avert allisions. The study considers nine tugboat stations, based on information obtained from the public domain and North Sea costal States. These are presented in Table 1.

Table 4: Emergency tug stations.

	Tug	Base	Bollard Pull (T)	Maximum Displacement (T)	% Model Fleet
Germany	Nordic	Cuxhaven	201	268,333	99%
	Mellum	Helgoland	100	100,000	88%
	Neuwerk	Cuxhaven	113	121,667	89%
The Netherlands	Guardian	Den Helder	120	133,333	92%
	TBA 2021	TBA	130	150,000	94%
	TBA 2021	TBA	130	150,000	94%
Norway	KV Sortland	Stavanger	100	100,000	88%
	KV Bergen	Egersund	100	100,000	88%
	KV Harstad	Olen	111	118,333	88%
Sweden	Poseidon	Gothenburg	100	100,000	88%
United Kingdom	Ievoli Black	Shetlands	139	165,000	94%

In our liaison with the Dutch authorities, we were advised that two more ETVs with 130T bollard pull capacity are expected to be provided in addition to the currently deployed 120T capacity ETV. They are expected to be patrolling the area of the new OWF developments at the northern part of the Dutch EEZ. For the purpose of the study, these two ETVs were considered at assumed offshore positions.

We are aware that there is further availability of private tugs in the North Sea, and also that the United Kingdom currently considers enhancing their emergency response capability, however for the level of looking at risk in this study, using the aforementioned nine stations is a realistic approach that remains on the conservative side.

3.3.5.1 TUG AVAILABILITY AND RESPONSE TIME

In lack of more accurate information, the study assumes that the tug availability is 7 days per calendar week. However, the tug availability is conservatively assumed to be at 96% based on data from previous studies. This converts to a cumulative downtime of 15 days per year.

Report SO-ER2010.095 - Offshore wind farms - parameters for risk analyses in the approval procedure and effectiveness of collision prevention measures [02] advises that there is a 98% probability of a drifting to be tracked by the authorities using a detective combination of AIS & Radar detection.

The study assumes a response time of 30 minutes, from the time the tug receives the call to the time it mobilises. This is a reasonable response time for an ETV to set off on a rescue mission.

3.3.5.2 BOLLARD PULL CAPACITY

The capacity of ETVs is measured by their rated bollard pull which is the tractor force a tug can exert at zero forward speed in calm water conditions, with the main engine running at 100% of the maximum power output the engine can safely generate continuously.

There are different factors affecting the capacity of a tug to tow a determined object. These are primarily related to the tug's propulsion system and design, then to the nature of the tow, its size and shape, and of course the prevailing weather conditions.

Using the bollard pulls capacity above, the study set a limit to the largest vessel the tug can be effective against. This was hence used to work out the percentage of the model fleet each tug would be able to successfully intercept.

Requirements for the minimum bollard pull are defined by the DNV Rule for planning and execution of marine operations 2015 [03] as the minimum towing force required for open sea towing to maintain zero speed under the following conditions:

- Wind 20 m/s

- Head current 1 m/s[1]
- Significant wave height 5 m

For the present study, tugs are be considered effective for the weather window that is equal or milder than the above parameters.

As seen above there are several factors involved in a tow that requires an accurate assessment for a sound and safe result. However, it is possible to use a simplified formula for the rough calculation of the required bollard pull as follows [04]:

Bollard Pull = (Displacement (t) x 60 /100.000) + 40

From the above formula the maximum displacement of the tow at a given bollard pull as presented in Table 5 was calculated.

3.3.5.3 TUG SUCCESS PROBABILITY

The success probability of each tug, is calculated based on the following equation:

$Ps_{.tug}$ = (% time availability) x (% Probability of identification of drifting vessel) x (% fleet it can intercept) x (%weather window)

The calculated success probabilities for the tugs in terms of intercepting drifting vessels are presented in Table 5:

1 IMO Resolution MSC/Circ.884 “Guidelines for safe ocean towing” provides a current of 0.5 m/s as design environmental conditions.

Table 5: Tug success probability.

	Tug	Base	Bollard Pull (T)	% Model Fleet	Availability % Time	Tracking Probability %	Area(s) of Operation	Operation Window % Time	**Interception efficiency**
Germany	Nordic	Cuxhaven	201	99%	96%	98%	4, 5	99%	**92%**
	Mellum	Helgoland	100	88%	96%	98%	4,5	99%	**82%**
	Neuwerk	Cuxhaven	113	89%	96%	98%	4,5	99%	**83%**
The Netherlands	Guardian	Den Helder	120	92%	96%	98%	4	99%	**86%**
	TBA 2021	TBA	130	94%	96%	98%	4	99%	**88%**
	TBA 2021	TBA	130	94%	96%	98%	4	99%	**88%**
Norway	KV Sortland	Stavanger	100	88%	96%	98%	6,7	94%	**77%**
	KV Bergen	Egersund	100	88%	96%	98%	6,7	94%	**77%**
	KV Harstad	Olen	111	88%	96%	98%	6,7	94%	**78%**
Sweden	Poseidon	Gothenburg	100	88%	96%	98%	6	99%	**82%**
United Kingdom	Ievoli Black	Shetlands	139	94%	96%	98%	1	99%	**88%**

3.3.6 VESSELS' TRAFFIC AND AIS DATASET

LOC was provided with two separate datasets of AIS terrestrial data for the year 2019.

The first dataset was made available by Kystverket (Norwegian Coastal Administration). This dataset comprised of static and dynamic AIS terrestrial data fed into the Norwegian server by the North Sea and North European Coastal States Administrations (including Baltic sector). However, data was not reported in its raw format but in csv files (stored separate for each day) with position reports at interval of approximately 15 minutes for the dynamic data and a separate csv files of static data subdivided again per single day. Having stored dynamic and static data in separate files the combination of the two datasets in a single one turned out to be excessively laborious as the timestamp of the two files were found to be different. Dynamic data was combined with static information pulled out from Lloyds vessel database, however the trip-count produced was substantially smaller than that of the EMSA dataset.

Dynamic Data

Timestamp	OrigID	AISType	MMSI	Lat	Lon	SOG	IMO	ShipName	Callsign	ShipType	Draught	Length	Width	Destination	NavStatus
01/01/2019 00:05	SWE	1	265617170	59.305	17.43992			HARRY	SGUL						15
01/01/2019 00:05	SWE	3	230987870	60.1118	19.92473		8634754	BARO	OI 6069						5
01/01/2019 00:05	DNK	1	219798000	56.37041	8.119995		8813013	TOENNE	OUIH						15
01/01/2019 00:05	DNK	18	219004054	55.06067	10.61748										15
01/01/2019 00:05	SWE	3	235065925	57.68575	11.8865	0.1		SEABEAM	2BGN2						5

Static Data

Timestamp	OrigID	AISType	MMSI	Lat	Lon	SOG	IMO	ShipName	Callsign	ShipType	Draught	Length	Width	Destination	NavStatus
01/01/2019 00:05	DNK	5	256944000				9363053	SIDARI	9HGG9	70	13.1	225	32	NORDENHAM GERMANY	15
01/01/2019 00:05	SWE	5	219024675				9839569	DANPILOT JULIET	OX3123	50	1.5	15	5		15
01/01/2019 00:05	DNK	5	211360780					SANTA BARBARA ANNA	DBRO	36	3.7	46	8	ROSTOCK	15
01/01/2019 00:05	DNK	5	219387000				9588122	NJORD R	OYOZ2	33	4.3	111	19	DREDGING OPERATION	15

Figure 6: Sample of Kystverket data.

The second dataset was provided by the European Maritime Safety Agency (EMSA) and downloaded from the BSH server. This dataset is also comprised of daily records; however, line entries also include the state origin of the entry, AIS type, speed over ground and vessels name for most entries. This dataset also appears to have undergone some process. Whilst the reporting intervals on this dataset are denser than the Kystverket dataset, it is still not at regular intervals, and contains a notable number of degraded or warped entries.

LOC examined and worked with both datasets in an attempt to filter out irregularities and merge the two sets to improve the overall record. However, this resulted to a notable number of MMSI duplications perceived as vessel's jumps. This is most likely attributable to incomplete or corrupted NMEA sentences received with extra or missing digits in the MMSI or geographical coordinates fields with most encountered in the EMSA dataset.

Static Data

utc	port	mmsi	msg_nr	imo	callsign	name	type	dim_a	dim_b	dim_c	dim_d	eta	draft	destinatic	date_time_utc	length	width
43515.0002	661	525024412	5	9567855	YBKP2	TERAS CONQUEST	99	6	72	33	11	144704	33	LAGOS	2019-02-21T00:00:17	78	44
43515.00049	661	538005574	5	9296391	V7FA2	RIDGEBURY MARYSELENA	80	232	42	20	28	832448	144	TEMA	2019-02-21T00:00:41	274	48
43515.00068	656	373541000	5	9500754	3FNB6	HUBERT FEDRY	70	262	30	29	16	200705	176	SUEZ CAN.	2019-02-21T00:00:59	292	45
43515.00076	661	371275000	5	7900481	HO4569	SOMANG	70	47	15	8	4	1596	50	HIGHSEA	2019-02-21T00:01:06	62	12

Dynamic Data

mmsi	date_time_utc	lon	lat	status	sog
220182000	01/01/2019 23:59	8.220163333	56.70250833	0	0.021382284
230112970	01/01/2019 23:59	21.034165	60.30405667	0	0.021382284
244140089	01/01/2019 23:59	4.9127	52.37385167	0	0.001943844
244633000	01/01/2019 23:59	4.854608333	53.04338833	0	0.0485961

Figure 7: Sample of EMSA data.

The study is performed on terrestrial AIS data, and hence the coverage is significantly better near the coast and AIS stations installed offshore, with very sparse data at the centre of the North Sea basin. LOC investigated whether supplementing the dataset with satellite AIS data in the North Sea central region would improve the quality of the dataset, however it was decided that the level of improvement to be achieved would have not justified the additional cost of purchasing and handling the satellite dataset.

Where the substantial decrement of AIS data density is noted in a particular area, this is commented upon in the traffic assessment of the present report.

Based on the above, the final modelling of LOC utilises the EMSA dataset only. The combination of the two datasets (EMSA& Kystverket), as mentioned above, produced an unusually high number of duplicate MMSI that had significant impact to the quality of the trips extracted. Between the two separate datasets, the EMSA one, having a higher reporting frequency, produced a larger number of identified trips. Despite the fact that there is a notable number of MMSIs within the EMSA dataset that exhibit jumps[2] (circa 19.5% of the vessel's population), the number of jumps for the vast majority of vessels is very small and thus of acceptable quality to perform the traffic analysis.

The dataset maintained for the study is focused on merchant vessels including those regularly employed in offshore operations defined as work vessels. Units such as military, patrol vessels, search and rescue vessels, accommodation platforms, non-propelled barges, lightvessel/buoys, drilling rigs, research vessels, FSOs/FPSOs, dredgers, museum vessels, pilot vessels, salvage ships, small fishing vessels, pleasure and recreational crafts and wind turbine generators fitted with AIS transceivers were filtered out of the AIS dataset used for the present study.

Before their removal, their position and distribution in the area was reviewed for hotspots that may affect navigation, however no notable such for the level of the study were identified as these vessels generally do not follow the main shipping routes and adjust their course to avoid larger vessels. However, AIS transceiver is fitted, as required, on board of ships: <300GT engaged on international voyages; <500GT not engaged on international voyage and passenger ships irrespective of their size.

All vessels maintained in the dataset and used in the analysis bear an IMO number, namely and similarly to AIS requirement, all passenger vessels of 100 gross tonnage or more and all cargo vessels with a gross tonnage above 300 are enrolled in the ship identification scheme. In 2013, IMO adopted a resolution to allow the voluntary application of IMO number to fishing vessel of 100 gross tonnage or more[3].

An additional filtering was applied to MMSIs starting with 0 and 1 (denoting coast stations and search and rescue aircraft). Similarly, MMSIs starting with 8 (handheld devices) and 9 (freeform identity) were also purged from the dataset. A summary of the filtration process is presented in Table 6.

---

[2] AIS data position jump occurs when the information transmitted by several AIS equipment collide within the same allocated timeslot or when the transducer are located at the margin of the AIS station reception range, resulting in incomplete or corrupted information in the NMEA sentence.

[3] IMO Resolution A.1078(28).

Table 6: Data filtering Summary.

Total number of MMSI in identifiers between 2xx and 7xx	**59,038**
Removed under non-IMO vessels	42,186
Removed under vessel type	1,815
Remaining vessels in model	**15,037**

The final data timeline is presented in Figure 8 below. The sample consistency is generally uniform, with roughly 600,000 reports/day. Small inconsistencies include the ones marked in circles, where the number of samples drops on three days in July 2019 and four in October 2019. Two short data gaps are noted on the 27th of August and 27th of October.

Figure 8: Data time distribution.

Overall, there is good coverage, with the conversion of the traffic data extracted from the sets into annual traffic volumes performed with the application of an adjustment factor of 1.00 (i.e., with the gap corresponding to <1% of the timeline).

3.3.6.1 TRAFFIC GROWTH PROJECTION

For a projection of maritime traffic in the North Sea between 2020 and 2040, LOC based the analysis on the information included in the ITF Transport Outlook 2019 published by the Organisation for Economic Co-operation and Development (OECD) [01].

The report states that the global growth of the maritime freight sector is dependent on the parameters such as international trade agreements, the development of transcontinental inland routes, and changes in global energy use. Significant contributing factors to the projected traffic in the EU region are also the Economic Partnership Agreement between the European Union (EU) and Japan and the Comprehensive Economic and Trade Agreement (CETA) between the EU and Canada. They are both expected to influence the increase in trade volumes.

At the same time, the OECD report points out that “slower-than-expected growth in international trade has led to overcapacity in certain maritime transport sectors and locations. Since capital investments in the shipping industry cannot be easily recuperated, companies may seek to cut costs in other ways in order to maintain profitability. This could lead to shipping operators concentrating on a limited number of ports and routes". Should this be the case, we expect that main freight hubs in the North Sea area where the main traffic routes are directed to, may see a slight traffic increase as consolidation may eliminate some of the alternative transport routes.

Based on the current (2019) demand pathway, OECD projects that maritime freight transport is expected to grow at a compound annual growth rate of 3.3% through 2030, and 3.6% through 2050. However, this growth rate is not expected to be equally distributed globally, with the projected growths for individual parts of the world presented in Table 7 below:

Table 7: Maritime trade demand projections by region, 2015-50 in Bn. Tonne-km.

	2015	2030	2050
Indian Ocean	22.0	35.8	86.2
North Pacific	24.6	38.4	89.7
North Atlantic	**14.9**	**21.2**	**38.5**
Mediterranean and Black Sea	8.9	13.6	27.6
South Atlantic	3.0	4.9	11.6
South Pacific	2.3	3.5	7.2
Artic Ocean	<<1	<<1	<<1

The extrapolated trade demand trends, result to the chart presented in Figure 9, that sees an overall increase in maritime freight demand of 79%.

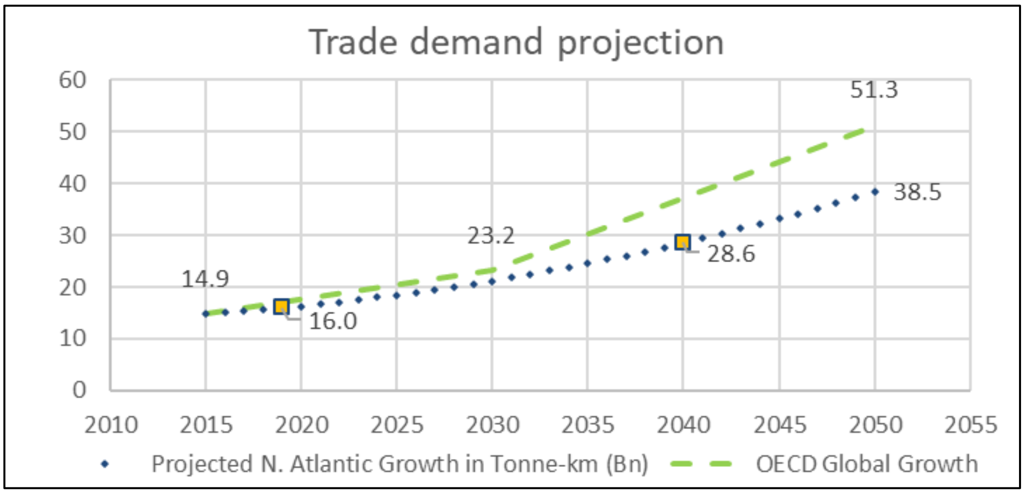


Figure 9: Extrapolated N. Atlantic trade demand growth 2019-2050.

In practice though, this 79% demand increase between now and 2040 is not expected to fully convert to additional vessel journeys, as part of it can be satisfied by changes in the size and design of merchant fleet vessels. Whilst the latter are not easily quantifiable, it is estimated that the replacement of currently ageing assets and improved efficiency of new designs, will allow an optimisation to the carrying capacity of vessels of roughly 10% without changes in size. The effect of this will reduce the required growth factor to an additional 63% on the current.

Further to that, vessels are expected to keep increasing in size, however not to the rate of increase we witnessed in the last two decades. Stock trafficking the North Sea main hubs, where spatial restrictions are expected to be a limiting factor in adapting infrastructure, is expected to undergo a milder change in dimensions compared to the overall fleet. Our estimate is that in the next two decades, this change will not exceed 5% (compared to the 10% - 15% envisaged for the global fleet). This reduces the vessels number increase requirement by a factor of 1.16.

Hence, the total adjustment factor to merchant traffic to reflect traffic in the year 2040 is expected to be an increase of 41% on the 2019 figures (i.e., equivalent to 1.65% annual increase).

When it comes to work vessels traffic, the determinant parameters for the projection are the number of offshore oil and gas facilities that remain in operation by 2040, further automation on the same facilities during that time, and the service requirements of the new offshore windfarms.

There are different viewpoints on the future of Oil & Gas facilities in the North Sea, with projections ranging from a 25% to a 70% reduction between now and 2050. This will be the result of the upgrade and increased productivity of some existing facilities and the decommissioning of others. The former should most likely reduce the need for work vessel journeys, whilst the decommissioning operations can have the opposite effect, as they involve rather complex and plant-heavy operations.

The development of the offshore windfarm industry is expected to utilise the existing and additional forecasted capacity of the construction vessels' fleet, however operation and maintenance patterns for most future OWFs are expected to change. As new developments move away from the coast into more remote offshore locations, the viability of using PSVs to carry personnel to and from the developments for daily maintenance activities reduces. The industry currently envisages that in the future, the transportation of daily maintenance personnel to the remote OWFs could be performed by helicopter, and not by sea, and heavier scheduled maintenance operations will see a marine spread of larger OSVs utilised.

Currently, the average rated capacity of installed offshore wind turbines is 7.2 MW for 2019 [05] which roughly translates to an average expected blade length of up to 75m. Our estimate is that by 2040 this is bound to increase to a number close to the largest current commercial blade length of 110m (i.e., a 46% increase). This translates to an approximate increase in vessel dimensions of 25%.

Sea Europe mentioned in their 2018 Market Forecast Report [06] that increased demand in the scope and complexity of projects may see an increase in the order of 75% for newbuild vessels globally between 2020 and 2034. This is despite the fact construction support vessels have just exited a major build cycle. However, the net change in the number of work vessels is expected to be smaller, as retirement of old units is expected to be quite significant. An increase of 40%-50% can be expected for the offshore supply and support vessels sector.

Considering the above, an overall increase in the order of 40% in the work vessels traffic between 2020 and 2040 (i.e., equivalent to 1.60% annual increase) appears to be a reasonable assumption.

3.3.7 LAYOUT OF TRAFFIC CORRIDORS

The traffic corridors used in the study were derived on the basis of the filtered AIS data and the algorithm used by the IWRAP Mk2, that composes individual AIS data points into a time series for each vessel to subsequently use proximity and speed criteria to extract the pertinent trips for each vessel. Each trip is a complete and distinct track of the vessel's movement across the area of interest, as it comes out of the points contained in the AIS dataset and contributes to qualitative and quantitative information for the assessment. However, a limitation in the identification of a trip is the period of time that lapses between two consecutive data points. In summary when the interval between the two consecutive timestamps exceeds a pre-selected value, or when due to a jump the calculated speed exceeds 100 kts, the trip terminates and restarts when parameters normalise and return within the acceptable thresholds. Thus, the quality of the trip conversion is proportional to the quality of the datasets provided. Generally, the longest the interval allowed to form a trip segment between two consecutive points, the lower the accuracy of the trip course assembled.

A density map was hence generated from the extracted trips, at a resolution of 250m x 250m. This density map is presented in Figure 10:

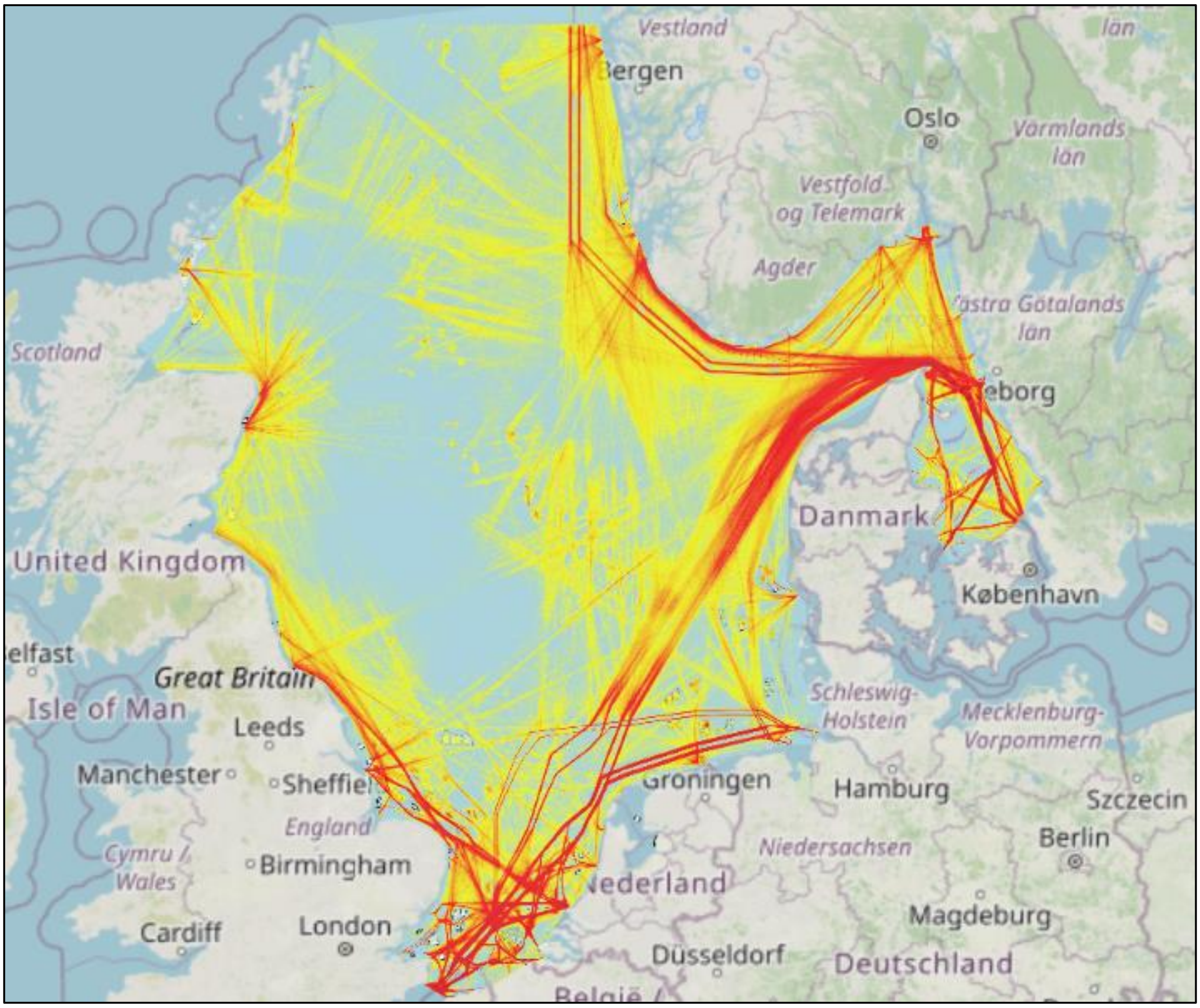


Figure 10: Density map generated for North Sea area (resolution: 250m x 250m).

Based on the traffic distribution of Figure 10, a network of traffic corridors ('legs' in IWRAP Mk2) was developed to reflect the current system in place in the area of interest to the study. Each leg was attributed a specific width, reflecting the zone in which the software looks for vessel trips to attribute to it. This was chosen on the basis of what appeared to be the requirement to cover the pertinent path as it is discernible on the density plot. A directional filter angle of 10 degrees was used as the alignment tolerance for each leg. This means that any vessel trip that intersects the leg in its defined width and has heading deviating up to 10 degrees from the direction of the leg axis is added to the distribution for the particular leg. The network of legs comprising the analysis model and the coverage achieved by the assigned leg width are depicted in Figure 11.

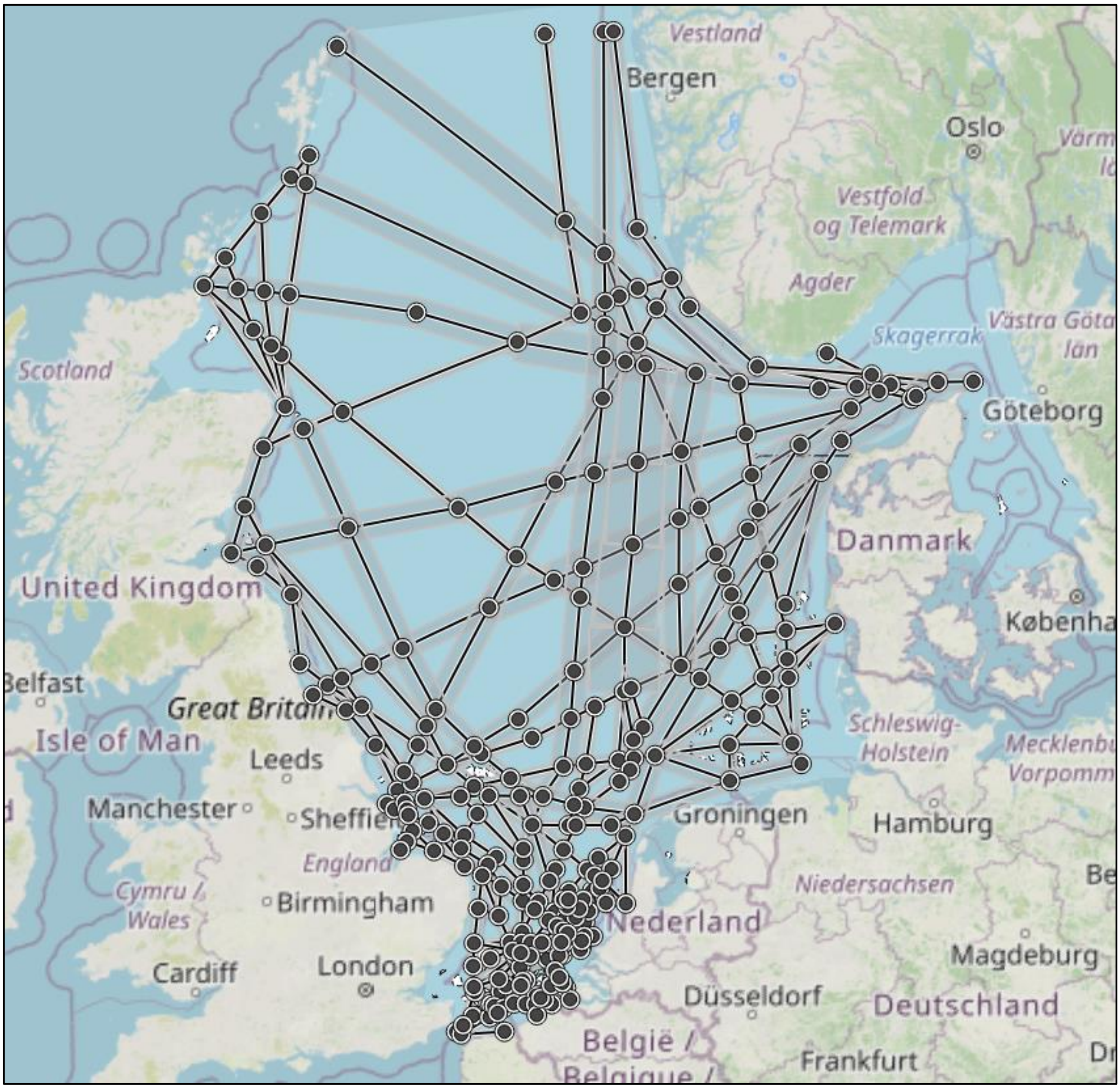


Figure 11: Coverage of tracks achieved by modelled legs

3.3.8 LATERAL DISTRIBUTION OF LEG TRAFFIC

The software used in the study, IWRAP Mk2, utilizes trips that are calculated as part of the traffic density analysis, along with the leg width and calculated true heading of the vessels to assign vessel trips to the pertinent legs. To compute the lateral distribution of vessels in the lane, it also uses the distance of the path of the trip from the axis of each leg they are attribute to it. This is numerically expressed as a composition (summation) of different distributions, which in turn is used to perform risk calculations. An example of an extracted lateral distribution of traffic on a model leg is presented in Figure 12.

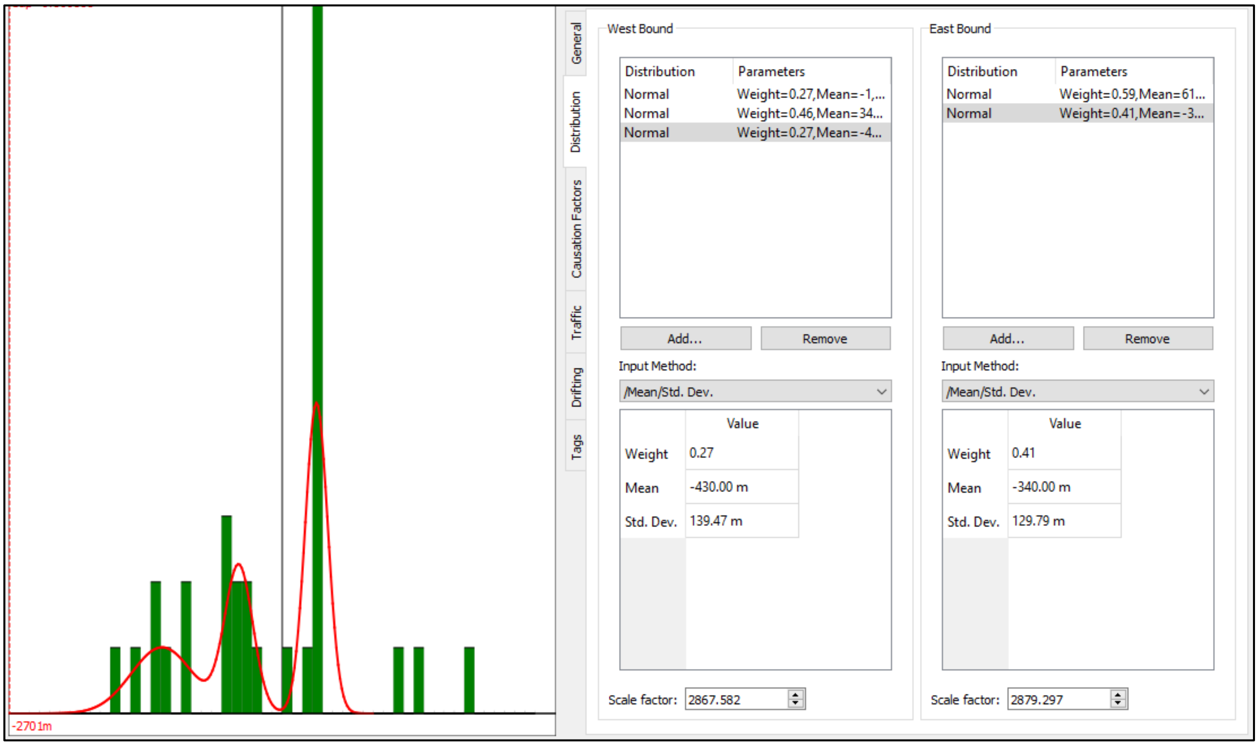


Figure 12: Example lateral distribution of traffic from IWRAP Mk2.

4 WORK PACKAGE 01 – TRAFFIC STUDY

The aim of this first work package is to derive the traffic patterns in the North Sea, identify the traffic corridors and its distribution and provide an understanding of the current use of the merchant traffic corridors in the North Sea. This is done on the basis of converting AIS datapoints into model vessel trips, and on the basis of those identified trips, the subsequent production of traffic density plots, to a 250m x 250m grid resolution.

4.1 GENERAL

The traffic density plot reflecting the existing traffic in the North Sea based on 2019 AIS data is presented in Figure 13 below:

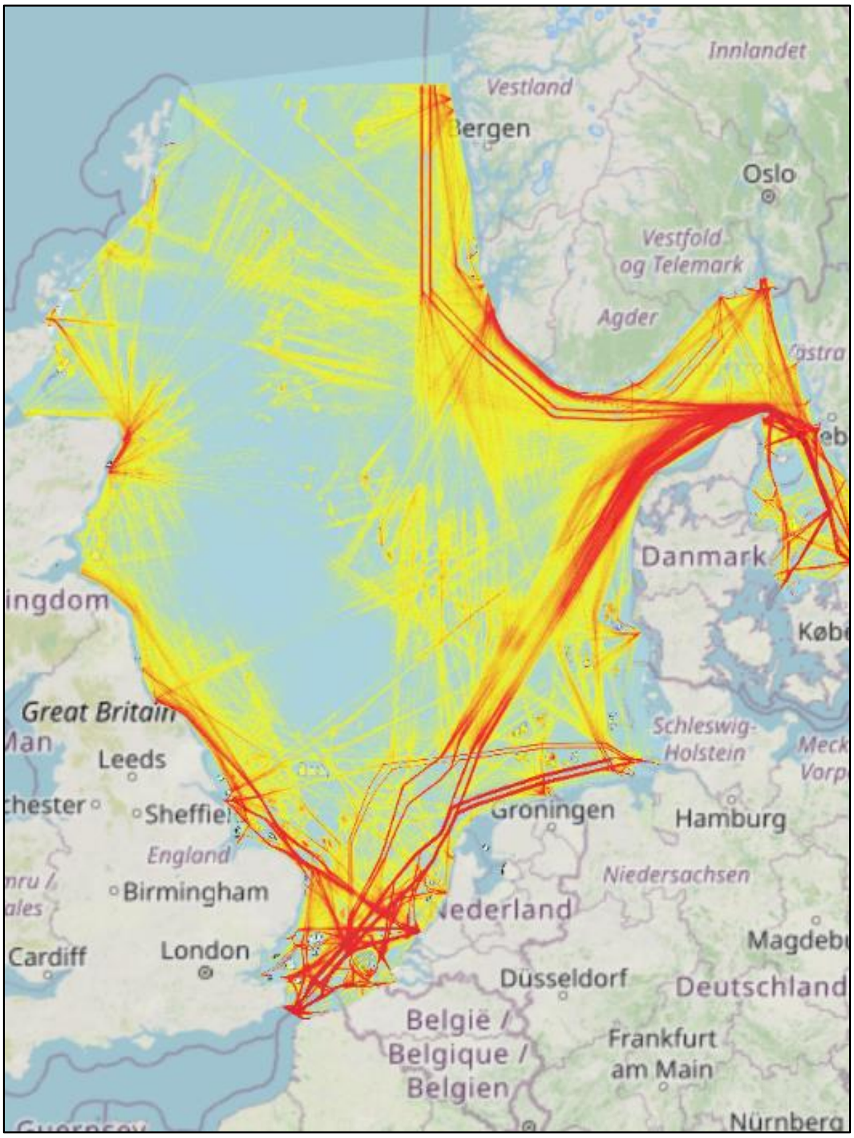


Figure 13: North Sea Traffic – Density Plot 250m x 250m.

It is clearly discernible that at the southern part of the North Sea most traffic is concentrated on to the main N-S corridors and to the corridors formed as the traffic separates to head into the northeaster main European ports. The former, ultimately merge into Route 10 (Den Helder – Skagen) at the Dutch-German border, leading into the Baltic Sea, through Skagerrak and Kattegat. The latter carry traffic to and from the Ports of Antwerp, Rotterdam, Amsterdam, Bremen, and Hamburg.

A second, high-traffic set of corridors follows the UK coast, taking trans-continental and feeder/shuttle traffic to the Thames Estuary and the ports of Felixstowe, Grimsby and Immingham, Tees and Hartlepool, and Tyne.

A third major corridor runs along the Norwegian South coast, from Skagerrak and the Baltic corridor towards the northern ports of Norway and the Northern Sea Route.

4.2 MAIN TRAFFIC DISTINCTION

Before looking into traffic volumes, it is worth pointing out that there are two, very distinct in terms of their characteristics, types of marine traffic in the North Sea. Merchant vessel and work vessel traffic.

The latter comprises all Support (OSV, ESV) and Construction vessels (CSV, PLSV) that operate in the main North Sea basin. Support vessels tend to operate out of several medium sized and large ports in the North Sea, to support the offshore wind and oil & gas industries. Work vessel traffic is presented in Figure 14 overleaf.

Construction vessels on the other hand, are predominantly based in the Netherlands and Belgium, and thus use the aforementioned main arteries of the English Channel and the Dutch coastline as they mobilise and demobilise. Subsequently they spend most of their time on trips between the project home port and the development under construction/maintenance, with medium to long durations spent in offshore operations, and repeated periodic trips between the operations sites and project home ports.

Offshore support vessels (OSVs, PSVs) sail out of specific home ports to the offshore industry, to and from specific offshore assets. They perform a single pattern of journeys to one or more assets per trip including standing-by for several days on site, and their trips usually occur in a periodic pattern, usually only disrupted by weather-related events.

Work vessels on the East coast of the English Channel and southern North Sea, mainly operate out of Oostende in Belgium, Terneuzen and Vlissingen, Rotterdam, Ijmuiden, Den Helder, Urk and Lemmer in the Netherlands. Further north, offshore vessels operate out of Delfzijl and Eemshaven in the Netherlands and to a much lesser extent Wilhelmshaven, Bremerhaven, and Cuxhaven in Germany, for operations in the German Bight. The port of Esbjerg is the main service port for the Danish offshore sector, whilst Kattegat is primarily served by the ports of Grenaa on the Danish, and

Halmstad on the Swedish side. The Norwegian offshore assets are primarily served out of Stavanger and Bergen. On the UK side, the main hub for offshore vessels is the port of Aberdeen, with the OWF sector further south served by Teesport, Grimsby, Great Yarmouth and Lowestoft, and Ramsgate.

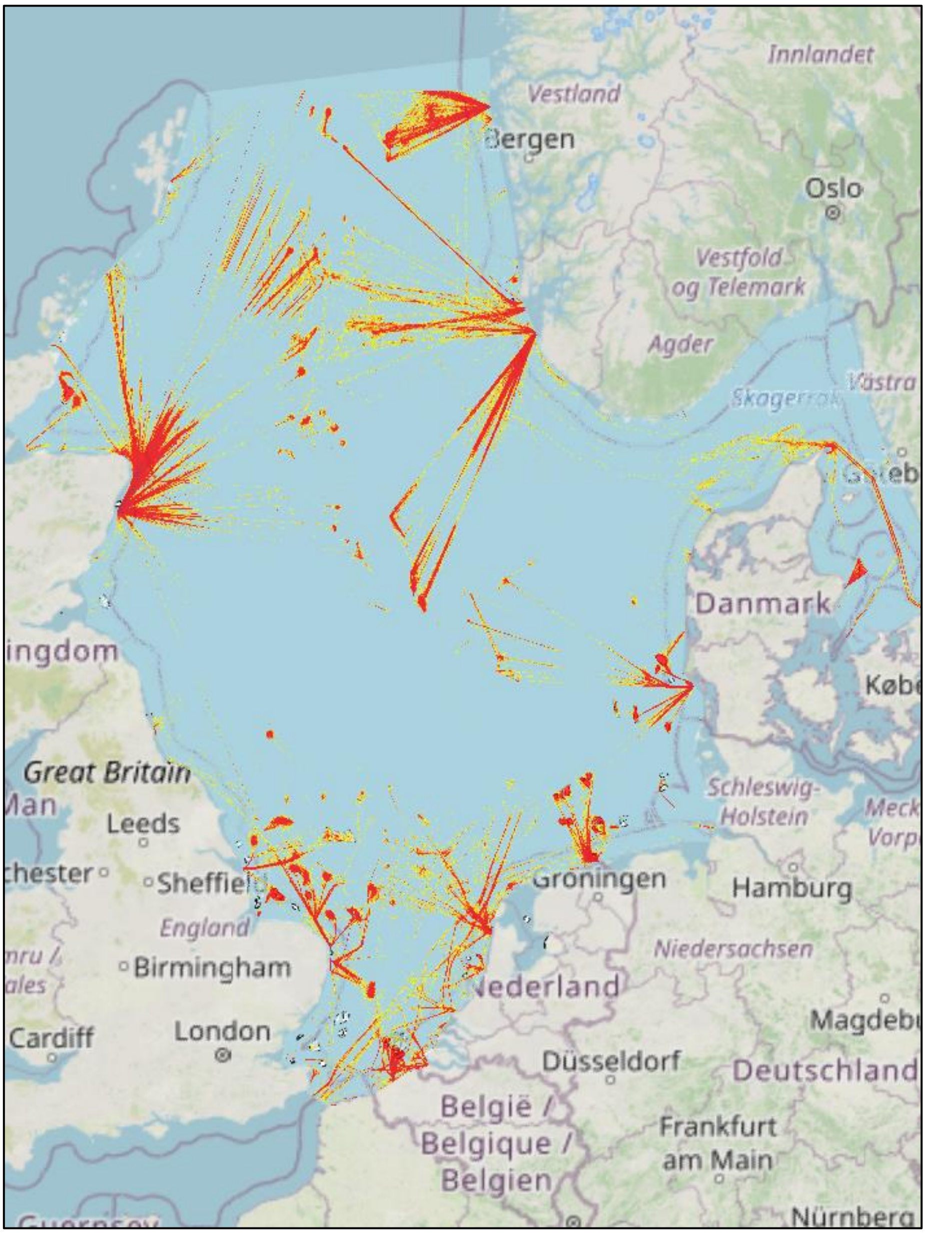


Figure 14: Work vessel traffic in the North Sea.

Merchant traffic travel on the main network of traffic routes, comprising the main traffic arteries mentioned earlier, as well as the coastal feeder roots, ant the UK-EU ports interconnection. Traffic patterns are rather consistent, with small exceptions, mainly from fishing and passenger vessels.

Trans-continental traffic uses the main traffic arteries to the large EU and UK ports, or the Baltic Sea through Skagerrak and the Kattegat. Feeder traffic uses coastal routes along the West coast of the continent and the East coast of the UK. This traffic comprises of smaller vessels with more than one stops as they navigate up and down the coastal routes.

Another major component of the regular maritime traffic across the North Sea is the link generated by Ro-Ro Pax and Passenger Ferries which operates along several routes such as those listed as follows:

- Newcastle to Stavanger, Bergen, Kristiansand, Amsterdam, and Gothenburg
- Hull to Amsterdam and Zeebrugge
- Harwich to Esbjerg, Cuxhaven, and Hoek van Holland
- Ramsgate to Ostend
- Dover to Calais and Dunkerque

Another notable traffic pattern is that of shuttle tankers running on specific routes to and from offshore oil and gas facilities, moving product to onshore terminals. All the above is discernible in Figure 15 below.

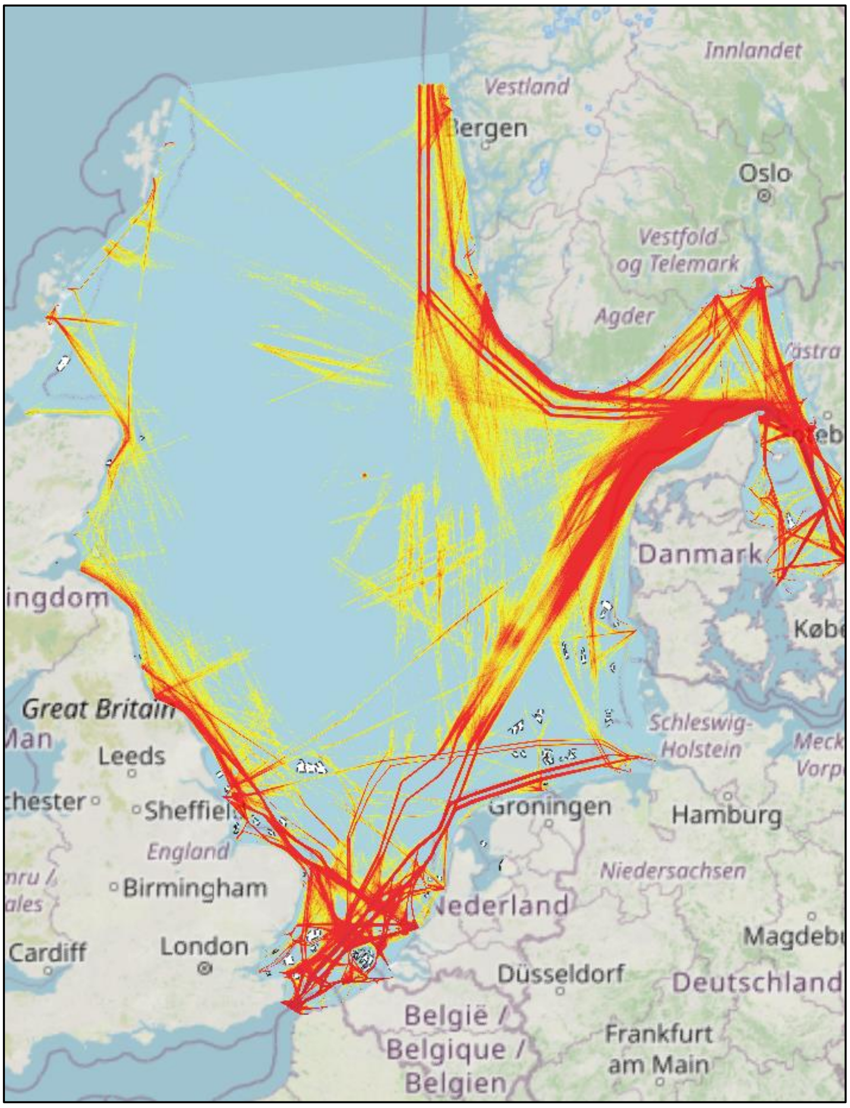


Figure 15: Merchant vessel traffic in the North Sea.

4.3 TRAFFIC VOLUME

To extract the traffic volumes associated with the vessels that comprise the dataset for the present study (refer to the exclusions discussed in 3.3.6), 17 counting lines were placed in the model. Their intention is to capture the traffic volumes and qualitative characteristics at the main corridors of the North Sea. The location of these lines is marked on Figure 16 and Figure 18. The former presents the counting lines at the southern part of the North Sea basin, and the latter at the northern part of the same.

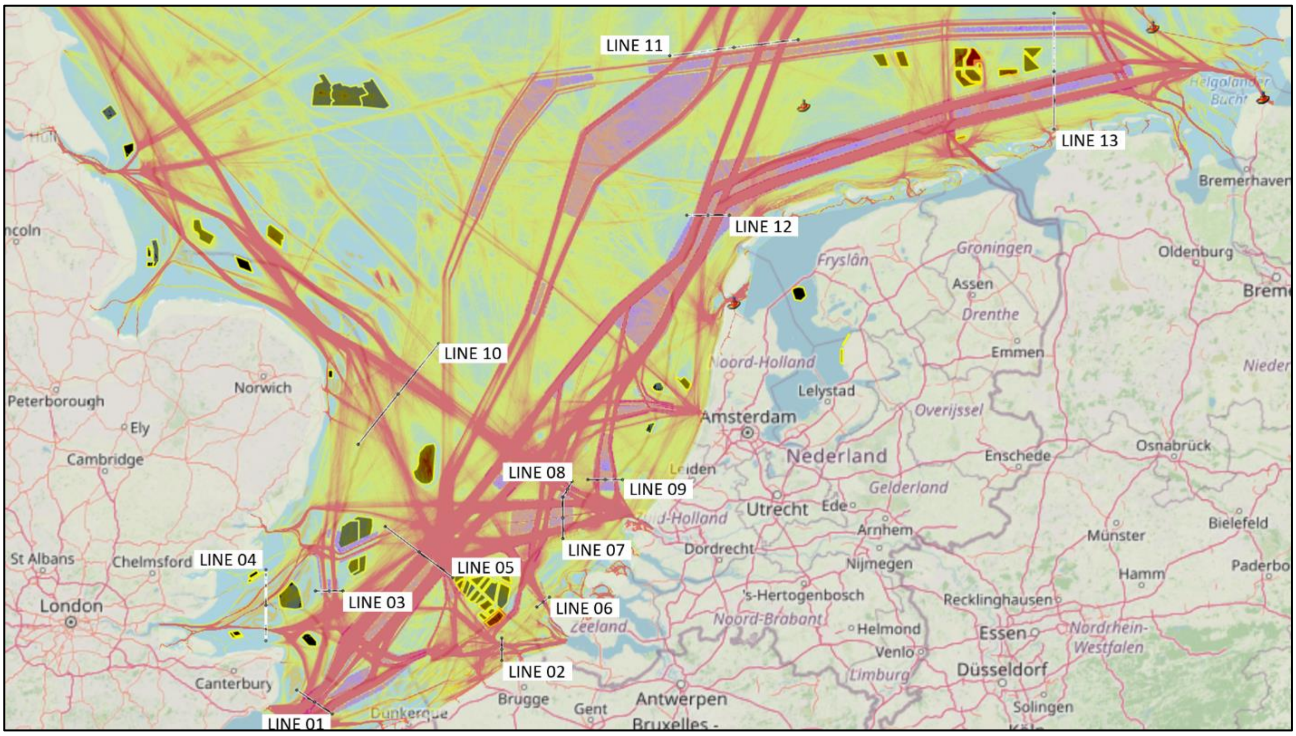


Figure 16: Traffic count lines at English Channel and German Bight.

4.3.1 COUNTING LINE 1

The first counting line was placed at the southern end of the model, and it is intended to capture the traffic that enters the North Sea through the English Channel. The geometry of the line was selected to exclude the traffic heading to Calais, Dunkerque, and Oostende as it is mainly cross-channel traffic.

The counting line picked up 66,174 trips within 2019, almost equally split between northbound and southbound crossings (33,265 vs 32,909 respectively).

The traffic mainly comprises general cargo vessels, bulk carrier, container carriers, and product tankers, with the highest number being in the medium size category. The vast majority of the large and very large vessels that cross this checkpoint are container carriers and crude oil carriers, with the former dominating the very large vessels group.

An analytical breakdown of the traffic volumes and qualitative characteristics is presented in Table 8 overleaf.

Table 8: Traffic into the English Channel, volume and characteristics.

Passageline 01 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	6589	5791	508	8547	3359	1618	1369	2752	1810	430	484	0	8	33265
Up to 50m	1		247	2					1712	8				1970
51m - 100m	1452	2	182	5083	90	636		54	79	30	120		6	7734
101m - 150m	2765	1321	57	2657	200	393	2	365	19	18	132		2	7931
151m - 200m	2217	1018	20	695	1921	267	13	1843		91	196			8281
201m - 250m	144	712	1	60	823	59	841	450		89	36			3215
251m - 300m	8	1357		46	323	215	396	40		149				2534
301m - 350m	2	514		2	2	48	117			45				730
351m - 400m		867	1	2										870
Southbound	6420	5511	562	8875	3507	1591	1272	2635	1639	397	488	0	12	32909
Up to 50m	1		262	4					1515	11				1793
51m - 100m	1411	6	209	5186	95	625	1	51	92	19	124		4	7823
101m - 150m	2703	1281	62	2853	211	373	2	350	32	14	127		8	8016
151m - 200m	2160	1002	25	726	2112	276	13	1779		91	200			8384
201m - 250m	133	702	3	60	826	54	785	412		76	36			3087
251m - 300m	11	1202		42	260	217	367	43		142	1			2285
301m - 350m	1	494		2	3	46	104			44				694
351m - 400m		824	1	2										827
Grand Total	13009	11302	1070	17422	6866	3209	2641	5387	3449	827	972	0	20	66174

4.3.2 COUNTING LINE 2

Counting line 2 is intended to capture the traffic into and out of Antwerp and Bruges-Zeebrugge using the southern approach corridor (traffic to and from Antwerp and Bruges-Zeebrugge from/to the North is captured later in the chapter). This traffic comprises of a proportion of the traffic of line 1, as well as traffic from within the North Sea, approaching Antwerp and Bruges-Zeebrugge through the Off North of Hinder TSS.

The traffic captured by line 2 comprises 44,126 trips within 2019, with slightly more Eastbound trips recorded compared to the westbound for 2019 (22,571 vs 21,555 respectively). The qualitative characteristics of the traffic are similar to those noted for line 1, with the addition of Ro-Ro traffic, that becomes the prevailing group for this corridor. Ro-Ro traffic comprises predominantly medium sized vessels, with two thirds of these vessels in the length range between 151m and 200m. This in line with the operation model for the sector, that uses specific assets to perform multiple journeys between destinations in a periodic manner.

A notable number of fishing vessels is picked up crossing the line, the vast majority of which is in the under 50m category. It is also worth noting the small number of support vessels picked up, that corroborates Figure 14.

The full breakdown of the traffic volumes and qualitative characteristics for line 2 is presented in Table 9.

Table 9: Traffic into Antwerp and Bruges-Zeebrugge from south corridor, volume and characteristics.

Passageline 02 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast ferry	Other ship	Grand Total
Eastbound	**3106**	**4624**	**552**	**2711**	**1000**	**1265**	**282**	**5958**	**2340**	**500**	**226**	**7**	**0**	**22571**
Up to 50m			351						2335	3		7		2696
51m - 100m	610		124	1346	4	372	6	82		4	45			2593
101m - 150m	1357	573	23	772	61	465	2	975	5	6	67			4306
151m - 200m	1084	793	29	485	696	273	10	3948		347	84			7749
201m - 250m	55	981	25	57	219	54	215	905		31	30			2572
251m - 300m		1277		47	20	69	49	48		81				1591
301m - 350m		465		3		32				28				528
351m - 400m		535		1										536
Westbound	**2739**	**4452**	**521**	**2682**	**754**	**1239**	**272**	**5796**	**2374**	**502**	**214**	**10**	**0**	**21555**
Up to 50m			328						2366	3		10		2707
51m - 100m	617		118	1387	5	393	7	82		4	51			2664
101m - 150m	1173	573	22	740	53	433		967	8	7	47			4023
151m - 200m	900	761	36	446	489	260	10	3885		352	87			7226
201m - 250m	49	896	17	60	185	54	207	816		30	29			2343
251m - 300m		1244		45	22	69	48	46		79				1553
301m - 350m		451		3		30				27				511
351m - 400m		527		1										528
Grand Total	**5845**	**9076**	**1073**	**5393**	**1754**	**2504**	**554**	**11754**	**4714**	**1002**	**440**	**17**	**0**	**44126**

4.3.3 COUNTING LINE 3

The third counting line is intended to capture the traffic that detaches from the main NE-SW corridor, to follow the east coast of the UK. From the information presented in Table 10, there is a total of 5,672 trips captured in 2019, with most being northbound (3,045 vs 2,267).

Traffic is dominated by container ships and general cargo ships. The container vessels noted are predominantly large to very large, sailing through the Sunk TSS into the port of Felixstowe. General cargo vessels are mostly in the coaster category serving other coastal ports.

Table 10: Traffic along the UK East Coast, volume and characteristics.

Passageline 03 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	**379**	**1284**	**77**	**1079**	**157**	**114**	**39**	**82**	**151**	**16**	**22**	**0**	**5**	**3405**
Up to 50m			38	1					144					183
51m - 100m	194		35	879	8	62		6	7	1	16		5	1213
101m - 150m	82	47	2	169	19	14		12		1	5			351
151m - 200m	89	68	2	10	112	1		61		4	1			348
201m - 250m	14	67		2	18	1	35	3		3				143
251m - 300m		616		16		33	3			7				675
301m - 350m		192		1		3	1							197
351m - 400m		294		1										295
Southbound	**179**	**985**	**72**	**632**	**55**	**60**	**10**	**138**	**109**	**18**	**8**	**0**	**1**	**2267**
Up to 50m			44						104					148
51m - 100m	134		25	480	3	35		2	5		5		1	690
101m - 150m	34	69	2	134	16	3		25			2			285
151m - 200m	9	51		8	34	2		88		3	1			196
201m - 250m	2	113	1	2	2		7	23		6				156
251m - 300m		325		8		18	3			9				363
301m - 350m		172				2								174
351m - 400m		255												255
Grand Total	**558**	**2269**	**149**	**1711**	**212**	**174**	**49**	**220**	**260**	**34**	**30**	**0**	**6**	**5672**

4.3.4 COUNTING LINE 4

Counting line 4 represents the traffic that goes into the Thames Ports, coming both from the main corridor of the English Channel as well as the UK coastal corridor. The line captures traffic through both the main approach (Princes Channel) as well as the NE approach through the Knock John channels. The recorded count for 2019 comprises 16,077 trips, balanced between eastbound and westbound crossings.

Traffic mainly comprises of Ro-Ro cargo vessels, with container traffic and general cargo completing the prevalent groups. With the exception of container vessels, that evenly cover the full range of the size spectrum, all other traffic is predominantly small to medium-large vessels.

The full breakdown of the traffic volumes and qualitative characteristics for line 4 is presented in Table 11.

Table 11: Traffic into Thames Ports, volume and characteristics.

Passageline 04 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Eastbound	789	1861	165	1667	350	132	40	2662	2	70	121	0	0	7859
Up to 50m			99						1	1				101
51m - 100m	146	14	64	1286	94	59		40	1		59			1763
101m - 150m	397	650		324	86	3		483		6	48			1997
151m - 200m	233	233	1	31	149	11		1800		17	14			2489
201m - 250m	13	231	1	8	21		39	339		43				695
251m - 300m		415		17		55	1			3				491
301m - 350m		230		1		4								235
351m - 400m		88												88
Westbound	840	1938	175	1775	349	135	38	2749	1	80	138	0	0	8218
Up to 50m			104							1				105
51m - 100m	162	13	70	1378	92	60		41	1	1	75			1893
101m - 150m	425	677		341	90	3		489		6	50			2081
151m - 200m	240	238	1	35	145	13		1868		21	13			2574
201m - 250m	13	242		7	22	1	37	351		47				720
251m - 300m		432		13		55	1			4				505
301m - 350m		250		1		3								254
351m - 400m		86												86
Grand Total	1629	3799	340	3442	699	267	78	5411	3	150	259	0	0	16077

4.3.5 COUNTING LINE 5

This counting line captures the traffic on the main NE-SW corridor at latitude 52°, ahead of the eastern approach to the Maas. It intercepts the main N-S traffic, as well as the traffic joining the main corridor from the UK through the Sunk TSS. A total of 56,821 crossings were recorded in 2019, 28,774 of which northbound, and 28,047 southbound.

The traffic presented in Table 12, predominantly comprises general cargo vessels and product tankers, with other tankers, Ro-Ros, and bulk carriers also having substantial contribution to the traffic. General cargo and product tankers are mainly noted to be in the medium size categories, with the other tanker categories comprising medium-large vessels, and most of the very large vessels registering under the container sector.

It remains the case as with line 1, that the main NE-SW corridor shows very little use by fishing vessels.

Table 12: Traffic through main NE-SW corridor at 52o Lat. Volume and characteristics.

Passageline 05 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast ferry	Other ship	Grand Total
Northbound	**5550**	**4932**	**549**	**6598**	**2858**	**1308**	**1299**	**3592**	**666**	**954**	**462**	**3**	**3**	**28774**
Up to 50m	1		257	1					604	6		3		872
51m - 100m	941	15	183	3905	127	386		84	47	6	152		1	5847
101m - 150m	2372	1593	53	2147	131	393	1	701	15	20	135		2	7563
151m - 200m	2117	810	35	483	1528	272	11	2061		404	167			7888
201m - 250m	110	208	20	31	753	24	780	713		325	8			2972
251m - 300m	7	990		26	316	215	390	33		150				2127
301m - 350m	2	499		3	3	18	117			43				685
351m - 400m		817	1	2										820
Southbound	**5424**	**4584**	**589**	**6561**	**3145**	**1300**	**1241**	**3347**	**664**	**706**	**479**	**1**	**6**	**28047**
Up to 50m	1		264	4					587	10		1		867
51m - 100m	908	19	207	3793	129	355	1	87	51	8	159			5717
101m - 150m	2288	1528	55	2194	135	395	2	640	26	13	140		6	7422
151m - 200m	2116	798	43	516	1828	288	11	1854		397	170			8021
201m - 250m	99	318	19	37	797	21	757	752		72	9			2881
251m - 300m	11	812		15	254	222	367	14		156	1			1852
301m - 350m	1	418		1	2	19	103			50				594
351m - 400m		691	1	1										693
Grand Total	**10974**	**9516**	**1138**	**13159**	**6003**	**2608**	**2540**	**6939**	**1330**	**1660**	**941**	**4**	**9**	**56821**

4.3.6 COUNTING LINE 6

Counting line 6 is intended to capture the traffic into and out of the Western Scheldt and approach to Zeebrugge using the north-western corridor. The line registered 16,851 crossings for 2019, with slightly more westbound crossings compared to the eastbound (8,573 vs 8,278 respectively).

The dominant vessel groups using this passage appear to be general cargo vessels and product tankers, with substantial but lower presence of container vessels, other tankers, bulk carriers, and Ro-Ro. There is also presence of service vessels using the corridor, most likely on their approach to Oostende. Vessel sizes using this corridor are limited to medium and medium-large sized vessels, with little to no large and very large vessels noted in the set. For more information refer to Table 13 below.

Table 13: Traffic into Western Scheldt and -Zeebrugge through the NW corridor, volume and characteristics.

Passageline 06 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Westbound	**2362**	**800**	**417**	**2835**	**419**	**674**	**11**	**557**	**306**	**16**	**165**	**11**	**0**	**8573**
Up to 50m			261	1					300	2		11		575
51m - 100m	781	122	114	1906	4	572				2	95			3596
101m - 150m	1302	339	20	800	28	102	2	7	6	3	47			2656
151m - 200m	277	254	16	124	340			218		3	23			1255
201m - 250m	2	79	6	4	47		9	331		6				484
251m - 300m		6						1						7
301m - 350m														0
351m - 400m														0
Eastbound	**2172**	**823**	**404**	**2915**	**178**	**706**	**5**	**554**	**322**	**17**	**165**	**17**	**0**	**8278**
Up to 50m			249	1					311	2		17		580
51m - 100m	822	126	116	1959	4	612			1	2	103			3745
101m - 150m	1221	396	16	840	23	94		10	10	5	39			2654
151m - 200m	129	267	23	106	144			246		4	23			942
201m - 250m		28		8	7		5	297		4				349
251m - 300m		6		1				1						8
301m - 350m														0
351m - 400m														0
Grand Total	**4534**	**1623**	**821**	**5750**	**597**	**1380**	**16**	**1111**	**628**	**33**	**330**	**28**	**0**	**16851**

4.3.7 COUNTING LINE 7

Counting line 7 is intended to capture the traffic that goes from the main NE-SW corridor to the Port of Rotterdam through the Maas West Inner TSS. The line registered 29,368 crossings for 2019, with more eastbound crossings compared to the westbound (13,404 vs 15,964 respectively).

The predominant vessel types through this checkpoint are product tankers and container carriers, with substantial general cargo and Ro-Ro traffic also using the approach. The vast majority of the vessels are of medium size group, with larger vessels noted being either gas carriers or container vessels. The latter cover the full-size spectrum, mainly as Rotterdam is the busiest container port in Europe.

There is also a smaller number of support vessels noted, as quite a few such construction and installation vessels are based in the area.

An analytical breakdown of the traffic volumes and qualitative characteristics is presented in Table 14.

Table 14: Traffic into Rotterdam via the Maas West Inner TSS, volume and characteristics.

Passageline 07 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Westbound	**3152**	**3511**	**423**	**1889**	**461**	**357**	**416**	**1793**	**390**	**700**	**311**	**1**	**0**	**13404**
Up to 50m			276						366	1		1		644
51m - 100m	805	1	92	1212	13	124			21	3	112			2383
101m - 150m	1514	1352	22	575	15	124		100	3	2	92			3799
151m - 200m	802	642	28	88	190	33	1	1415		6	100			3305
201m - 250m	26	192	5	6	124	4	187	276		677	7			1504
251m - 300m	3	459		7	117	71	174	2		8				841
301m - 350m	2	314		1	2	1	54			3				377
351m - 400m		551												551
Eastbound	**3557**	**4227**	**388**	**2395**	**799**	**403**	**851**	**1937**	**323**	**760**	**324**	**0**	**0**	**15964**
Up to 50m			248						312	2				562
51m - 100m	867	1	84	1442	17	114			10	1	116			2652
101m - 150m	1663	1366	27	773	22	130	1	107	1	1	102			4193
151m - 200m	984	724	26	149	341	38	4	1526		7	100			3899
201m - 250m	35	212	3	7	243	4	412	302		703	6			1927
251m - 300m	6	823		19	173	116	347	2		36				1522
301m - 350m	2	464		3	3	1	87			10				570
351m - 400m		637		2										639
Grand Total	**6709**	**7738**	**811**	**4284**	**1260**	**760**	**1267**	**3730**	**713**	**1460**	**635**	**1**	**0**	**29368**

4.3.8 COUNTING LINE 8

Counting line 8 is also targeted to capture traffic approaching the Rhine delta via the Maas North West TSS, predominantly used by vessels and traffic from/to the northern sector of the Norths Sea region.

The vessels profile matches that of line 7, with the absence of large and very large container carriers, as trans-continental traffic generally enters the North Sea from the South.

Volumes are approximately half of what is recorded in line 7, with a total of 16,655 trips, 8,687 of which westbound, and 7,968 eastbound. Reference is made to Table 15 below.

Table 15: Traffic into Rotterdam through the Maas North West TSS, volume and characteristics.

Passageline 08 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Westbound	**1830**	**1145**	**169**	**1013**	**334**	**320**	**1702**	**1171**	**222**	**656**	**125**	**0**	**0**	**8687**
Up to 50m			95						220					315
51m - 100m	288		41	848	5	125			2		63			1372
101m - 150m	1060	1013	21	142	4	90		52		1	28			2411
151m - 200m	442	29	8	19	96	67	12	580		9	34			1296
201m - 250m	17	14	3	3	186		627	539		644				2033
251m - 300m	23	24		1	43	38	207			2				338
301m - 350m		6					856							862
351m - 400m		59	1											60
Eastbound	**1354**	**1424**	**152**	**1117**	**174**	**220**	**1346**	**1168**	**242**	**670**	**101**	**0**	**0**	**7968**
Up to 50m			82						242	2				326
51m - 100m	261		36	970	5	86					69			1427
101m - 150m	803	1130	22	136	1	78		53			19			2242
151m - 200m	263	156	6	10	25	56	26	584		9	13			1148
201m - 250m	9	19	5	1	140		414	531		657				1776
251m - 300m	18	23			3		76			1				121
301m - 350m		10					830			1				841
351m - 400m		86	1											87
Grand Total	**3184**	**2569**	**321**	**2130**	**508**	**540**	**3048**	**2339**	**464**	**1326**	**226**	**0**	**0**	**16655**

4.3.9 COUNTING LINE 9

Line 9 represents the last gate into Rotterdam and captures the traffic through the Maas North TSS. The traffic picked up is similar in numbers to that through the Maas North West TSS corridor, with 14,971 annual crossings, of which 8,423 northbound and 6,548 southbound.

Traffic primarily comprises container ships and general cargo ships, and secondarily product tankers. The vast majority of vessels are in the medium range size. The large and very large vessels noted are container vessels, with very few exceptions. A detailed breakdown showing the qualitative characteristics of the traffic at line 9 is presented in Table 16 below.

Table 16: Traffic into Rotterdam through the Maas North TSS, volume and characteristics.

Passageline 09 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	**1405**	**2872**	**303**	**2088**	**326**	**136**	**558**	**265**	**247**	**62**	**160**	**1**	**0**	**8423**
Up to 50m			194	1					245			1		441
51m - 100m	333	1	69	1314	29	70		5	2		105			1928
101m - 150m	613	706	26	657	22	39		103			45			2211
151m - 200m	452	875	11	94	160	25	8	148		1	10			1784
201m - 250m	7	208	3	5	96	1	430	9		16				775
251m - 300m		521		13	19	1	117			35				706
301m - 350m		211		2			3			10				226
351m - 400m		350		2										352
Southbound	**1344**	**1877**	**332**	**1533**	**150**	**195**	**539**	**146**	**252**	**25**	**155**	**0**	**0**	**6548**
Up to 50m			215	1					250	1				467
51m - 100m	283	1	81	999	28	113		4	1		94			1604
101m - 150m	605	604	23	483	18	51		86	1	2	41			1914
151m - 200m	452	663	12	43	80	31	1	55		1	20			1358
201m - 250m	4	178	1	3	21		429	1		13				650
251m - 300m		133		4	3		106			8				254
301m - 350m		59					3							62
351m - 400m		239												239
Grand Total	**2749**	**4749**	**635**	**3621**	**476**	**331**	**1097**	**411**	**499**	**87**	**315**	**1**	**0**	**14971**

4.3.10 COUNTING LINE 10

Line 10 is placed offshore Norfolk UK, capturing the traffic from the Belgian and Dutch ports as well as traffic that detaches earlier from the main NE-SW route, as they merge to follow the UK east coast.

Traffic numbers for 2019 in the categories considered in the study total 14,140 and are relatively balanced in the two directions with 6,400 northbound crossings and 7,740 southbound.

Most traffic is attributable to Ro-Ro vessels, with general cargo vessels, container vessels and product tankers also appearing in notable proportions. The size profile of the vessels is generally between the small to medium-large range, with only a very limited number of large or very large gas tankers and container vessels appearing in the sample.

A detailed breakdown of the recorded crossings is provided in Table 17 below.

Table 17: Traffic at offshore Norfolk and UK N-E coastal route, volume and characteristics.

Passageline 10 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	**790**	**883**	**421**	**850**	**138**	**410**	**177**	**1681**	**167**	**791**	**45**	**47**	**0**	**6400**
Up to 50m			262	1					164	2		47		476
51m - 100m	280	87	130	688	3	264		7	2		35			1496
101m - 150m	369	743	23	144	8	135		228	1	2	4			1657
151m - 200m	126	31	6	15	109	6		763		339	6			1401
201m - 250m	10	13		2	18	1	76	683		427				1230
251m - 300m	5	4				4	42			14				69
301m - 350m							59			7				66
351m - 400m		5												5
Southbound	**928**	**1236**	**765**	**1265**	**111**	**387**	**198**	**1797**	**162**	**718**	**66**	**107**	**0**	**7740**
Up to 50m			528						160	5		107		800
51m - 100m	322	119	200	1098	1	267		37	1	1	57			2103
101m - 150m	429	986	34	145	15	111		239	1		4			1964
151m - 200m	167	108	3	21	72	5		880		306	5			1567
201m - 250m	6	14		1	22		86	641		383				1153
251m - 300m	4	5			1	4	52			20				86
301m - 350m							60			3				63
351m - 400m		4												4
Grand Total	**1718**	**2119**	**1186**	**2115**	**249**	**797**	**375**	**3478**	**329**	**1509**	**111**	**154**	**0**	**14140**

4.3.11 COUNTING LINE 11

Further north in the model, passage line 11 is set at the north side of the Friesland TSS the main NE-SW converges eastward to the German Bight located at the interface of the German and Dutch EEZ. This corresponds to the majority of the N-S traffic towards Skagerrak or the Norwegian coast.

The accuracy of the traffic estimate for line 11, and in general “Route 10” in the German EEZ (route Den Helder - Skagen between lines 11 and 15), is affected by the density of the datapoints in the area discussed earlier in the report, where signal reception is reduced due to poor coverage. The number of signals received and recorded at the North and West side of the main W-E (Friesland TSS) traffic corridor reduce substantially compared to the ones to the East and South. This effect is represented in the hot-spot diagram of Figure 17 overleaf. This interferes with the ability of the

IWRAP software to build coherent trips that are subsequently used in the calculation of traffic volumes.

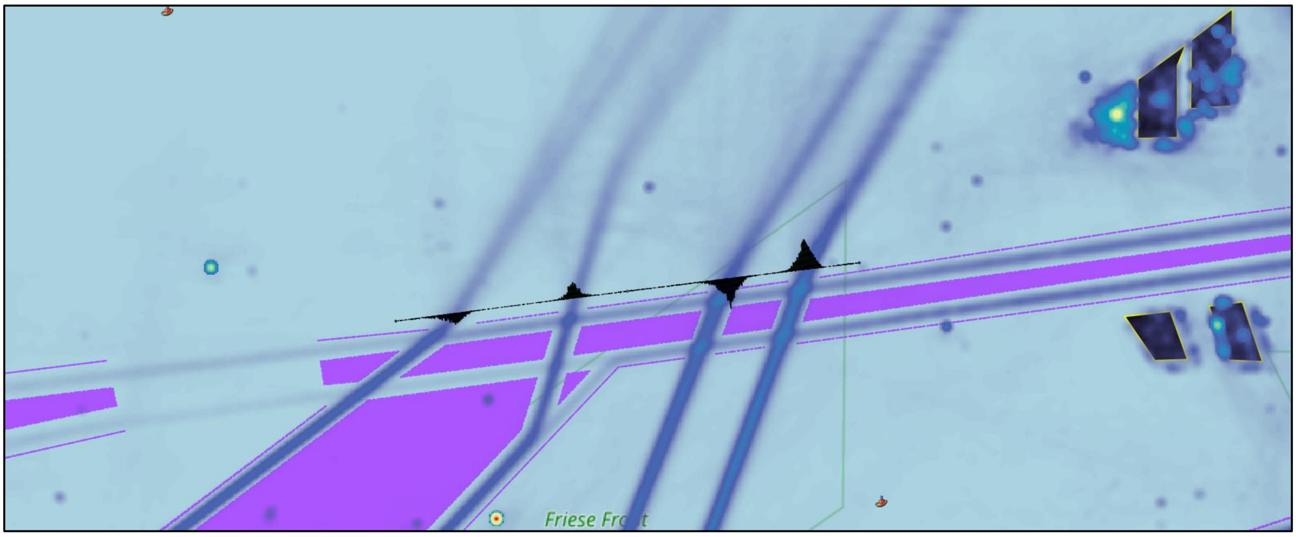


Figure 17: Data points heat-map of Friese Front area.

With the above in mind, the number of crossings recorded for line 11 in the year 2019 is a cumulative of 20,809 on both directions (12,388 northbound and 8,421 southbound). Out of these vessels, 15,382 are route-bound for Route 10 (8,196 northbound and 7,186 southbound). The present report considers route-bound vessels to be the vessels in the dataset sailing along the model legs within a course deviation of ±10°. The numbers reported are thus considered to underestimate the real number.

In the process of conducting the present study, information on traffic in the particular area was exchanged with other, more area-focused, studies commissioned by the German and Dutch authorities, that were being conducted at the same time as the present one.

The former, is a study commissioned by the German authorities to investigate navigation in the area around Route 10. It is performed on a more extensive dataset than the one used for the North Sea study, utilising terrestrial and satellite data from three additional sources to the EMSA data alone which was used in the present study. This study counts slightly above 17,000 annual trips (roughly 12% more than the present study).

The study commissioned by the Dutch authorities, that is based on the (national) NL-Coastguard AIS dataset, reports significantly higher number (almost twofold) vessel trips at the same area compared to the other two studies, reporting approximately 16,000 crossings per direction. Part of this difference may be attributable to the fact that the Dutch-commissioned study considers ±30° as the criterion for counting vessels on a track (vs the ±10° of the other two studies). An adjustment to include only vessels within ±10° course would most likely reduce the trip-count by 20% into the low

11,000s per direction. This number, remains substantially higher compared to the other two studies, and may thus be most likely relevant to a richer dataset being used.

Qualitatively, the highest in population vessel type noted on line 11 is that of general cargo vessels, of the Handy/Supra size and medium size range. There is also a large proportion of product tankers in the same size range, followed by medium-large container vessels, apart from small number of very large container carrier trips.

A detailed breakdown of the traffic qualitative characteristics is provided in Table 18 overleaf.

Table 18: Traffic at the southern end of Route 10, volume and characteristics.

Passageline 11 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	**1992**	**1573**	**319**	**3017**	**1665**	**754**	**786**	**1346**	**689**	**107**	**140**	**0**	**0**	**12388**
Up to 50m			91						679	1				771
51m - 100m	236	43	168	1529	46	303		37	10	1	38			2411
101m - 150m	817	629	37	1168	68	132		259		5	40			3155
151m - 200m	883	556	18	307	917	141	16	775		9	61			3683
201m - 250m	39	254	3	11	543	13	563	274		24	1			1725
251m - 300m	17	38		1	91	150	186	1		51				535
301m - 350m		3				15	21			16				55
351m - 400m		50	2	1										53
Southbound	**1090**	**1093**	**228**	**1723**	**1410**	**490**	**462**	**1014**	**725**	**76**	**109**	**0**	**1**	**8421**
Up to 50m			58	1					718					777
51m - 100m	125	38	123	741	20	212		10	6	1	43			1319
101m - 150m	411	366	25	716	80	84	1	106	1	1	21		1	1813
151m - 200m	528	465	19	251	846	85	4	614		12	44			2868
201m - 250m	21	188	1	13	426	3	343	284		12	1			1292
251m - 300m	5	32			38	94	111			38				318
301m - 350m		1				12	3			12				28
351m - 400m		3	2	1										6
Grand Total	**3082**	**2666**	**547**	**4740**	**3075**	**1244**	**1248**	**2360**	**1414**	**183**	**249**	**0**	**1**	**20809**

4.3.12 COUNTING LINE 12

One additional counting line, line 12, was placed to the South of line 11 at the Off Vlieland TSS, to measure traffic before the split to the East towards Hamburg. The model records a traffic volume of 31,927 vessels for 2019, out of which 19,761 sailing northbound and 12,166 southbound.

The highest number of crossings are recorded for medium size general cargo vessels, and container carriers spread almost equally between the size groups. The model also notes significant Ro-Ro cargo and small product tanker traffic.

An analytical breakdown of the traffic is presented in Table 19 below.

Table 19: Traffic at the Off Vlieland TSS, volume and characteristics.

Passageline 12 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	**1882**	**4887**	**623**	**6834**	**1473**	**630**	**44**	**2774**	**135**	**211**	**266**	**2**	**0**	**19761**
Up to 50m			263	2					130	1		2		398
51m - 100m	624	42	296	4045	120	402		96	5	3	173			5806
101m - 150m	1010	1070	49	2241	122	225	1	449		13	80			5260
151m - 200m	239	1200	13	478	816	2	3	1677		26	13			4467
201m - 250m	9	577	2	35	367		29	516		52				1587
251m - 300m		1024		29	48	1	11	36		95				1244
301m - 350m		377		2						21				400
351m - 400m		597		2										599
Southbound	**822**	**3792**	**383**	**3347**	**836**	**281**	**13**	**2244**	**102**	**175**	**170**		**1**	**12166**
Up to 50m			98	2					99	2				201
51m - 100m	338	31	239	1701	35	200	1	69	3	3	115			2735
101m - 150m	445	515	35	1211	56	74		302		8	54		1	2701
151m - 200m	37	840	9	367	494	5	1	1416		15	1			3185
201m - 250m	2	499	1	35	222		4	424		45				1232
251m - 300m		894		27	29	2	7	33		86				1078
301m - 350m		373		2						16				391
351m - 400m		640	1	2										643
Grand Total	**2704**	**8679**	**1006**	**10181**	**2309**	**911**	**57**	**5018**	**237**	**386**	**436**	**2**	**1**	**31927**

4.3.13 COUNTING LINE 13

The next counting line was placed in a N-S direction to the German Bight western approach, to cover the W-E traffic corridors into Elbe River. This single line has been modelled long enough to capture both the German Bight Western Approach and the Terschelling – German Bight TSS corridors.

The traffic for 2019 was noted to comprise of 24,636 trips through line 13, out of which 15,440 eastbound and 9,196 westbound.

Traffic predominantly comprises general cargo and container vessels, whilst secondarily there is notable product tanker and bulker traffic. Most of the dry cargo traffic consists of small Handysize vessels, with a smaller number of medium sized vessels. There is a limited number of large and very large vessels, all of the container sector.

A detailed breakdown of the traffic recorded at passage-line 13 is presented in Table 20 below.

Table 20: Traffic into Hamburg at the West of the Jade Approach, volume and characteristics.

Passageline 13 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Westbound	**1124**	**2218**	**420**	**2916**	**307**	**223**	**55**	**970**	**748**	**78**	**130**	**7**	**0**	**9196**
Up to 50m			322	15					741	14		7		1099
51m - 100m	320	12	79	1964	37	81	3	57	7	1	81			2642
101m - 150m	710	248	19	794	53	118	1	110		2	37			2092
151m - 200m	92	342		107	140	24		634		7	12			1358
201m - 250m	1	211		17	51		32	147		16				475
251m - 300m	1	595		17	26		18	22		27				706
301m - 350m		280		1			1			11				293
351m - 400m		530		1										531
Eastbound	**1974**	**3482**	**641**	**5343**	**741**	**418**	**94**	**1528**	**794**	**166**	**252**	**7**	**0**	**15440**
Up to 50m	1		531	31					785	19		7		1374
51m - 100m	561	8	80	3741	84	156	5	73	9	5	157			4879
101m - 150m	1169	485	30	1284	92	217	1	138		11	71			3498
151m - 200m	238	696		223	352	45	3	1039		28	24			2648
201m - 250m	5	315		32	174		56	243		32				857
251m - 300m		1002		28	39		28	35		57				1189
301m - 350m		365		2			1			14				382
351m - 400m		611		2										613
Grand Total	**3098**	**5700**	**1061**	**8259**	**1048**	**641**	**149**	**2498**	**1542**	**244**	**382**	**14**	**0**	**24636**

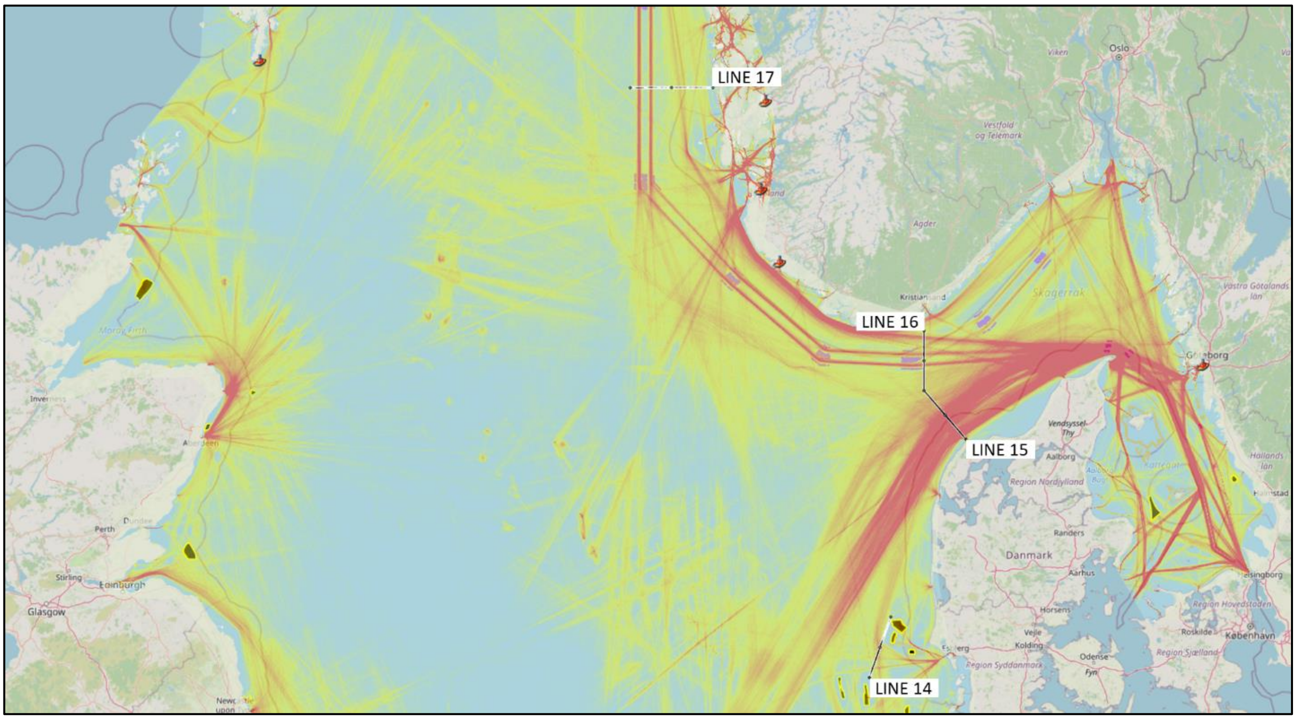


Figure 18: Traffic count lines at the Danish and Norwegian coastal zones.

4.3.14 COUNTING LINE 14

Counting line 14 is aimed to quantify the support vessels traffic out of the port of Esbjerg, travelling to the Danish offshore facilities. This is an important traffic component to quantify, as it is traffic that crosses the main NE-SW corridor (Route 10) at an area with high future OWF coverage. The geometry of the line was set in a way that excludes traffic to the Sandbank and DanTysk OWFs that do not cross the main traffic corridor. The geometries of line 14 and subsequent lines are presented in Figure 18.

The analysis of the counting line shows a total of 4,828 crossings, out of which almost a third are by support vessels. These weigh more to the westbound with 869 annual crossings versus 603 eastbound crossings noted for 2019.

A full breakdown of the traffic is provided in Table 21 below.

Table 21: Traffic out of Esbjerg, volume and characteristics.

Passageline 14 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Westbound	**109**	**314**	**869**	**476**	**100**	**40**	**2**	**606**	**148**	**19**	**16**		**1**	**2700**
Up to 50m			230	9					141					380
51m - 100m	54	3	596	329	16	29		74	7	1	14		1	1124
101m - 150m	44	179	37	117	25	10		175		6	2			595
151m - 200m	11	119	6	19	38	1		349		7				550
201m - 250m		3		2	21		1	8		3				38
251m - 300m		3					1			1				5
301m - 350m		4								1				5
351m - 400m		3												3
Eastbound	**92**	**427**	**603**	**370**	**56**	**30**		**390**	**142**	**9**	**9**			**2128**
Up to 50m			221	8					138					367
51m - 100m	36	3	349	256	11	24		23	4		9			715
101m - 150m	38	242	28	89	23	5		222		2				649
151m - 200m	18	170	5	16	13	1		135		1				359
201m - 250m		4		1	9			10		5				29
251m - 300m		3								1				4
301m - 350m		4												4
351m - 400m		1												1
Grand Total	**201**	**741**	**1472**	**846**	**156**	**70**	**2**	**996**	**290**	**28**	**25**		**1**	**4828**

4.3.15 COUNTING LINE 15

Line 15 has been placed to count the traffic from Route 10 into Skagerrak and covers approximately all traffic into Skagerrak except for that coming from the South Norway coastal corridor and TSS. The line recorded 30,369 crossings of the vessels of interest to this study for 2019. There are slightly more westbound crossings, with 16,667 against 13,702 eastbound. It is worth noting that the traffic picked up at this counting line is substantially larger than the traffic picked up at the southern end by counting line 11.

On a qualitative basis, these comprise mainly of small up to medium-large vessels, with medium vessels being the most common size. The predominant types are products tankers and bulk carriers, however there is also significant population of general cargo, container, and Ro-Ro cargo vessels. There is a small proportion of very large vessels crossing the line, almost exclusively of the container sector.

A detailed breakdown of the crossings' characteristics is presented in Table 22.

Table 22: Traffic from Route 10 into Skagerrak, volume and characteristics.

Passageline 15 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Eastbound	**2179**	**1811**	**173**	**2400**	**1970**	**478**	**869**	**1452**	**2106**	**112**	**151**		**1**	**13702**
Up to 50m	13		108	14					1994					2129
51m - 100m	251	10	40	1285	75	188		128	112	2	63		1	2155
101m - 150m	729	582	18	802	116	128	3	297		6	29			2710
151m - 200m	1139	744	6	284	1077	115	13	753		17	58			4206
201m - 250m	47	271	1	14	641	9	629	274		26	1			1913
251m - 300m		47		1	61	22	214			42				387
301m - 350m		15				16	10			19				60
351m - 400m		142												142
Westbound	**2353**	**2391**	**214**	**3399**	**2333**	**551**	**813**	**1987**	**2280**	**119**	**222**		**5**	**16667**
Up to 50m	13		132	13					2156					2314
51m - 100m	258	7	54	1728	98	217		71	122	2	91			2648
101m - 150m	681	781	20	1221	94	157	4	442	2	5	44		5	3456
151m - 200m	1350	1065	7	420	1383	138	11	986		23	85			5468
201m - 250m	49	319		16	704	9	614	487		28	1			2227
251m - 300m	2	57		1	54	15	172	1		46	1			349
301m - 350m		17				15	12			15				59
351m - 400m		145	1											146
Grand Total	**4532**	**4202**	**387**	**5799**	**4303**	**1029**	**1682**	**3439**	**4386**	**231**	**373**		**6**	**30369**

4.3.16 COUNTING LINE 16

Line 16 is the second line put in place to measure traffic into Skagerrak and is complementary to line 15. It covers the traffic into Skagerrak coming from the Norwegian coastal corridor. For the year 2019 a total of 13,974 crossings were recorded, 6,813 of which eastbound and 7,161 westbound.

Traffic comprises general cargo vessels, which is the predominant group in population, products tankers, bulk carriers, crude oil tankers and container carriers. There is also a notable population of IMO-registered fishing vessels using this corridor.

Vessel sizes are predominantly Handysize and medium size, with a relatively small number of large vessels. There is also a very limited number of very large container carrier crossings.

Detailed information on the traffic through line 16 is presented in Table 23.

Table 23: Traffic from Norwegian coastal corridor into Skagerrak, volume and characteristics.

Passageline 16 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Eastbound	**881**	**285**	**173**	**2197**	**594**	**358**	**258**	**154**	**1322**	**487**	**95**	**0**	**9**	**6813**
Up to 50m			61	42					1135	2				1240
51m - 100m	162	131	78	1365	45	122	1	6	178	5	55		2	2150
101m - 150m	480	83	21	689	29	99		101	9	6	28		7	1552
151m - 200m	202	69	12	99	425	95	6	20		355	11			1294
201m - 250m	5			2	89	5	163	26		44				334
251m - 300m	32				6	36	85	1		63	1			224
301m - 350m		1				1	3			12				17
351m - 400m		1	1											2
Westbound	**995**	**473**	**201**	**2285**	**482**	**384**	**333**	**140**	**1235**	**521**	**104**	**0**	**8**	**7161**
Up to 50m	3		79	26					960	3				1071
51m - 100m	174	141	97	1711	72	133		12	268	4	52		2	2666
101m - 150m	572	218	14	469	61	97	1	71	7	11	38		6	1565
151m - 200m	206	111	11	76	270	104	13	11		375	14			1191
201m - 250m	8			3	67	5	188	46		44				361
251m - 300m	32	1			12	43	130			65				283
301m - 350m		1				2	1			19				23
351m - 400m		1												1
Grand Total	**1876**	**758**	**374**	**4482**	**1076**	**742**	**591**	**294**	**2557**	**1008**	**199**	**0**	**17**	**13974**

4.3.17 COUNTING LINE 17

The final counting line, line 17, has been provided to measure traffic on west coast of Norway (south of Bergen). The analysis of the line shows a total of 5,364 annual crossings for 2019, 3,626 of which were northbound and 1,738 southbound. The corridor is mainly used by general cargo vessels and product takers, with smaller number of crude oil tankers, gas tankers and bulk carriers picked up.

Most vessels with the exception of some medium-large and large crude oil and gas tankers are in the Handysize and Medium size categories. The latter is also applicable for the container sector, as all vessels picked up at line 17 are feeder vessels sailing up and down the Norwegian coastline.

The detailed breakdown of the traffic recorded at line 17 is presented in Table 24 overleaf.

Table 24: Traffic on the Norwegian coastal corridor off Leirvik, volume and characteristics.

Passageline 17 Traffic

Vessel Length	Oil products tanker	Container ship	Support ship	General cargo ship	Bulk carrier	Gas tanker	Crude oil tanker	Ro-Ro cargo ship	Fishing ship	Passenger ship	Chemical tanker	Fast Ferry	Other ship	Grand Total
Northbound	**798**	**182**	**215**	**1218**	**285**	**169**	**224**	**39**	**270**	**179**	**44**	**0**	**3**	**3626**
Up to 50m	1		47	5					105				1	159
51m - 100m	119	55	115	863	22	36	1	3	165		26		2	1407
101m - 150m	556	127	27	302	22	3	1	15		8	10			1071
151m - 200m	102		25	46	110	38	1	21		16	8			367
201m - 250m	6			2	105	1	153			42				309
251m - 300m	14				26	91	68			90				289
301m - 350m										23				23
351m - 400m			1											1
Southbound	**314**	**42**	**153**	**501**	**90**	**94**	**216**	**17**	**150**	**133**	**27**	**0**	**1**	**1738**
Up to 50m			28	3					68	1			1	101
51m - 100m	35	13	94	347	13	40	1	3	81		17			644
101m - 150m	210	29	17	140	13			7	1	4	8			429
151m - 200m	59		14	11	32	30		7		19	2			174
201m - 250m	5				30		155			40				230
251m - 300m	5				2	24	53			60				144
301m - 350m							7			9				16
351m - 400m														0
Grand Total	**1112**	**224**	**368**	**1719**	**375**	**263**	**440**	**56**	**420**	**312**	**71**	**0**	**4**	**5364**

4.3.18 DETAILED LEG TRAFFIC FOR 2019

Further to the counting lines analysed above, a comprehensive model was assembled as presented in Figure 10 and Figure 11 earlier in the report, to be used in the subsequent parts of the study. The layout of that model is based on the AIS data for 2019 and the traffic recorded on its legs is provided in Appendix B. Reference for the model legs is provided from Figure 19 to Figure 23.

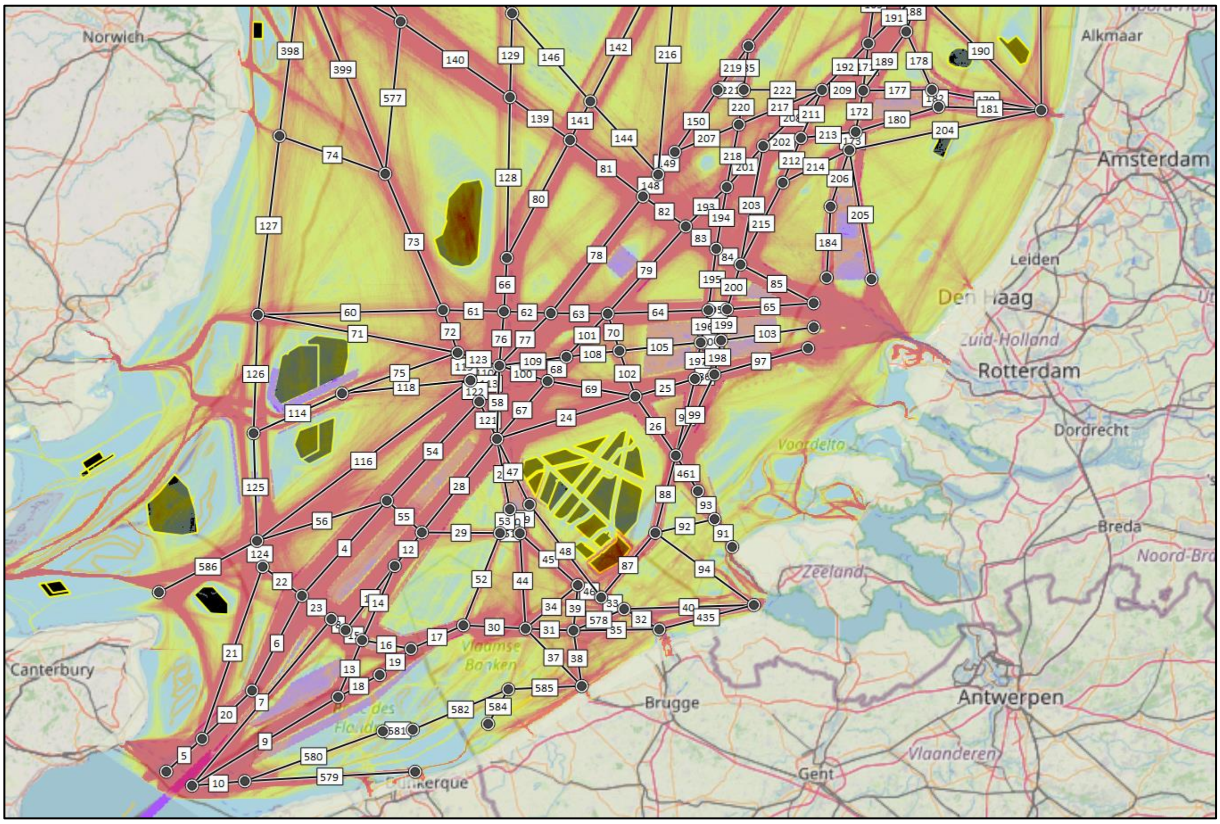


Figure 19: Model leg arrangement at the English Channel area.

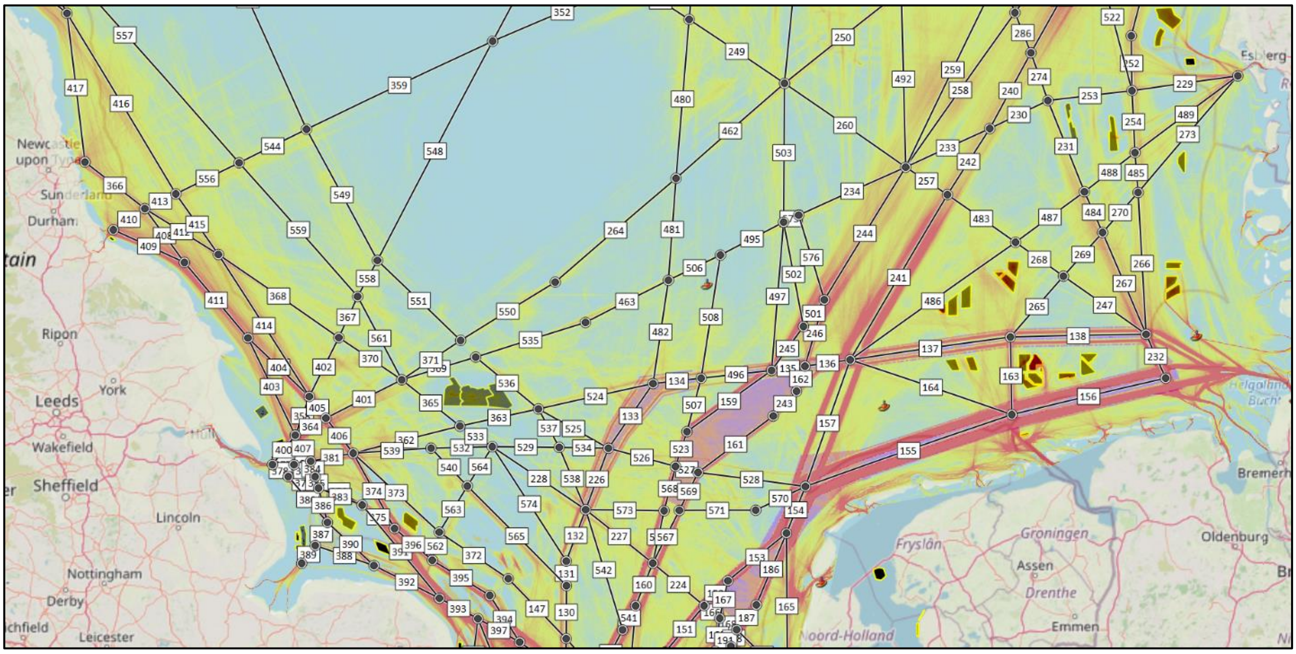


Figure 20: Model leg arrangement for Humber, Dogger and German Bight.

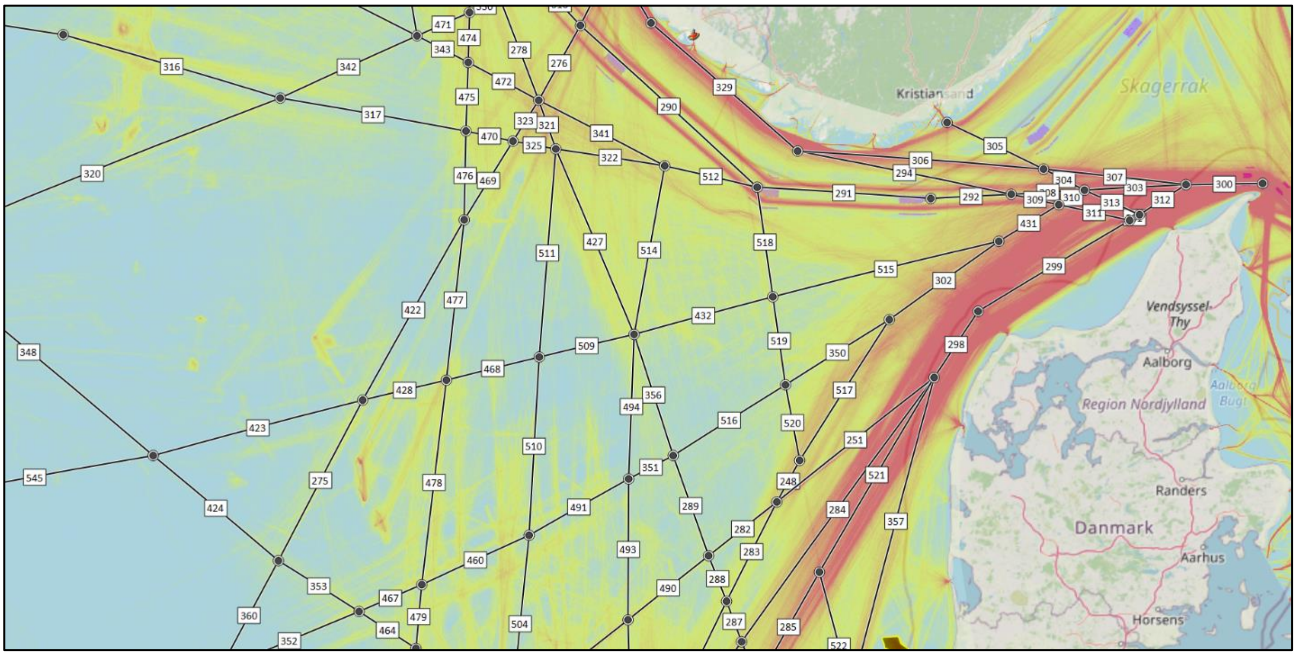


Figure 21: Model leg arrangement at the Fisher and Skagerrak areas.

Figure 22: Model leg arrangement at the Fair Isle, Viking and Utsire areas.

Figure 23: Model leg arrangement at the Cromarty and Forties areas.

5 WORK PACKAGE 02 – OWF DEVELOPMENTS BETWEEN 2020 AND 2040

The aim of this second work package, is to capture to the best possible extent, a projection on the expected offshore windfarm developments in the North Sea in the coming 20 years. LOC liaised and obtained information from the North Sea States' contacts provided by the German BSH on the areas considered for new OWF developments between 2020 and 2040.

LOC contacted representatives of the authorities of the North Sea states, explained the scope of the present study, and requested information on the OWF plans for the next two decades, to the best of their current knowledge. The information obtained from the authorities was subsequently compared and supplemented with information from online databases and, where pertinent, information from the public domain.

The study addresses all currently operating and under construction developments as the 'existing scenario', and all future developments or maritime spatial allocation for that matter as part of the 2040 'projection scenario'[4]. Existing developments are subsequently marked on the figures of this chapter with yellow outline and black shade, and future developments are marked with orange outline and blue shade.[5]

4 As "under construction" are perceived all developments that have a construction marine spread visible in the 2019 dataset.

5 Spatial information about location of existing and future developments was collected between September and October 2020.

5.1 BELGIUM

Information on Belgium's future development plans along with the pertinent shapefiles of the Belgian Maritime Spatial Plan Area are accessible at http://www.marineatlas.be/en/data.

The OWF development plans for Belgium comprise four separate zones, as presented in Figure 24. The Eastern zone, that sits between the TSS Off North Hinder and the boundary with the EEZ of the Netherlands, is the only one currently developed, albeit almost fully, with the two final OWFs under construction. The remaining three zones, Noorhinder Noord, Noorhinder Zuid, and Fairybank are sequentially placed along the North Hinder South TSS artery, with no developments taking place at the time of publication of the present report.

The aforementioned areas happen to coincide with the areas dedicated to aquaculture under the same development plan.

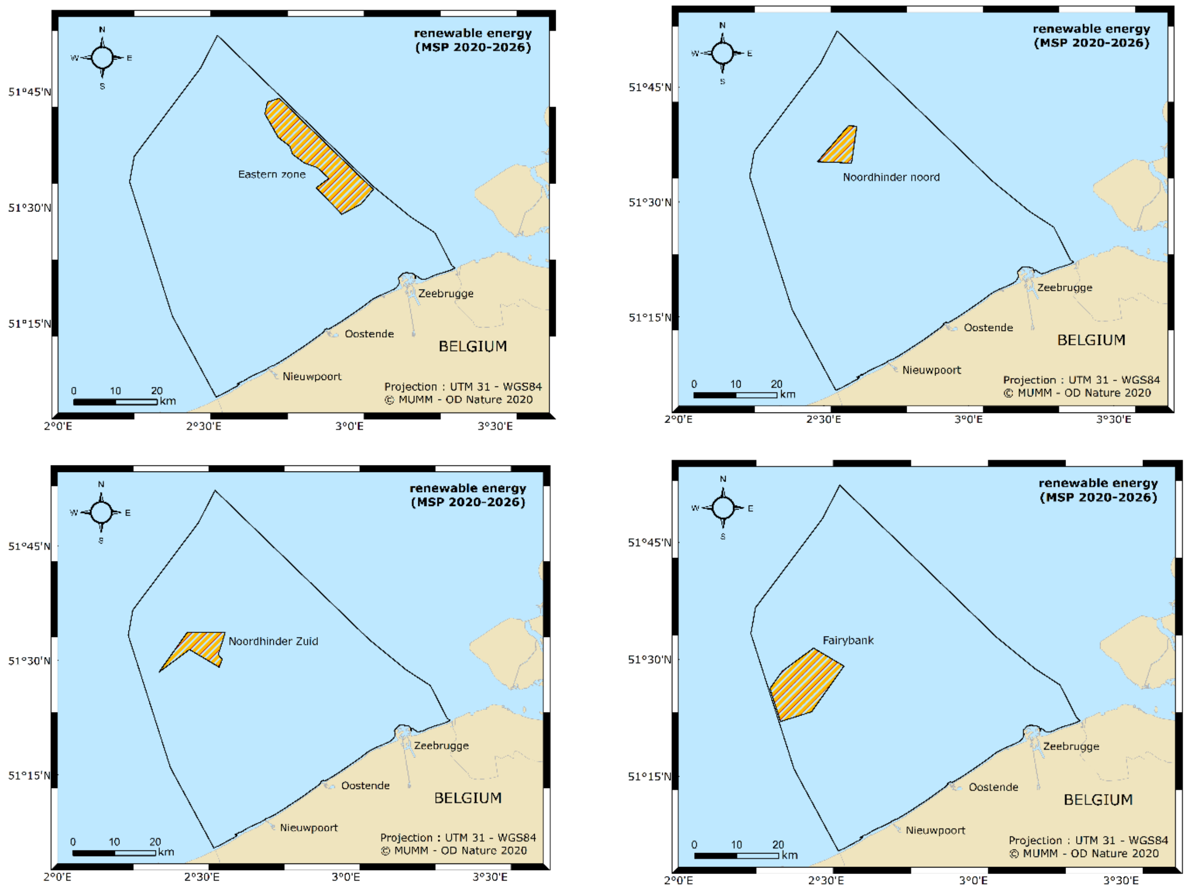


Figure 24: Belgium designated zones for offshore renewable energy.

The identified current and future OWF developments in the Belgian EEZ, are presented on a nautical chart in Figure 25 below.

Figure 25: Overview of OWF projection within Belgian EEZ.

In LOC's communication with the Federal Public Service Mobility and Transport, particular attention was given to the safety zones applicable to Belgian OWF developments and the difference with what applies to the adjacent developments within the Dutch EEZ.

5.2 DENMARK

LOC was provided with information from the Danish Maritime Authority for the Danish Marine Spatial Plan and as well as the Danish Energy Agency. The data provided was in the form of shapefiles, containing information on:

- OWF Areas and associated coordinates
- OWF Energy Islands and associated coordinates
- Offshore Oil & Gas sites
- Shipping corridors

The Danish development plan in the North Sea includes the development of two energy islands, and the allocation of extensive areas for potential use in future offshore windfarm developments. The latter are referred to as “screening areas”.

The offshore wind developments expected to take place in the near future, are the Vesterhav North and South windfarms close to the Danish west coast (see notes 1 and 2 of Figure 26) expected to be operational in the next 1-2 years, and the Thor OWF at the NE corner of the screening area (see note 3 on Figure 26).

The rest of the screening areas outlined, are considered for further OWF developments, however at the time this report was prepared, individual boundaries and form of these is unknown. Screening areas are conservatively considered as OWF space in whole, with the relevant commentary in subsequent stages of this study as required. These areas in the main North Sea basin are the Nordsoen 1, 2, and 3 (see notes 4, 5, 6 on Figure 26 respectively), Jyske Banke next to them (see note 7 on the same figure). Also, Fano Bugt to the south, and Jammerbugt to the North (notes 8 and 9 on Figure 26).

There are also four screening areas allocated at Kattegat. These are the Frederikshavn, Hessel 1, and Kattegat 1 and 2 (Notes 10-13). However, as the study is focused on the main North Sea basin, the latter are not considered in the modelling.

A similar situation applies for the two energy islands, where although the final layout and boundaries for the island developments is not yet known, the development areas are outlined, and conservatively adopted in whole in the analysis. These islands are the Vest Nordsoen large, and Vest Nordsoen small, denoted as 14 and 15 on Figure 26.

Figure 26: Overview of OWF projection within Danish EEZ.

5.3 FRANCE

LOC contacted the Centre for studies and expertise on risks, the environment, mobility, and planning (CEREMA) and was advised that there is a single French OWF project in the North Sea, located off Dunkerque (Dunkirk) close to the Belgian Border.

CEREMA provided the coordinates of the area nominated for this OWF development, however advised us that the final OWF area is expected to be smaller. For the purpose of the present study, the full area is conservatively considered as the footprint of the new development, as presented in Figure 27.

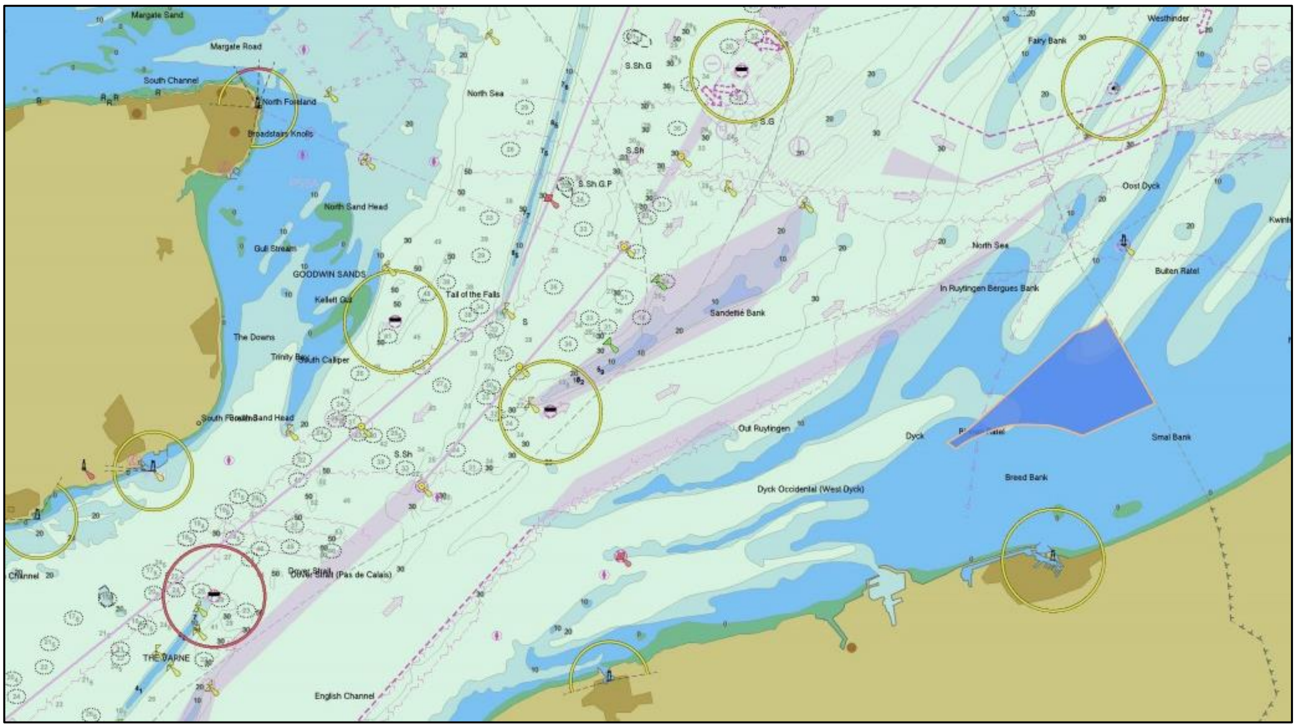


Figure 27: Overview of OWF projection within the French EEZ.

5.4 GERMANY

The Federal Maritime and Hydrographic Agency of Germany provided LOC with layouts and shapefiles of the German OWF development plan.

The plan for offshore wind in the German EEZ in the main North Sea basin comprises of 19 development areas (EN1 - EN19). These are presented in Figure 28.

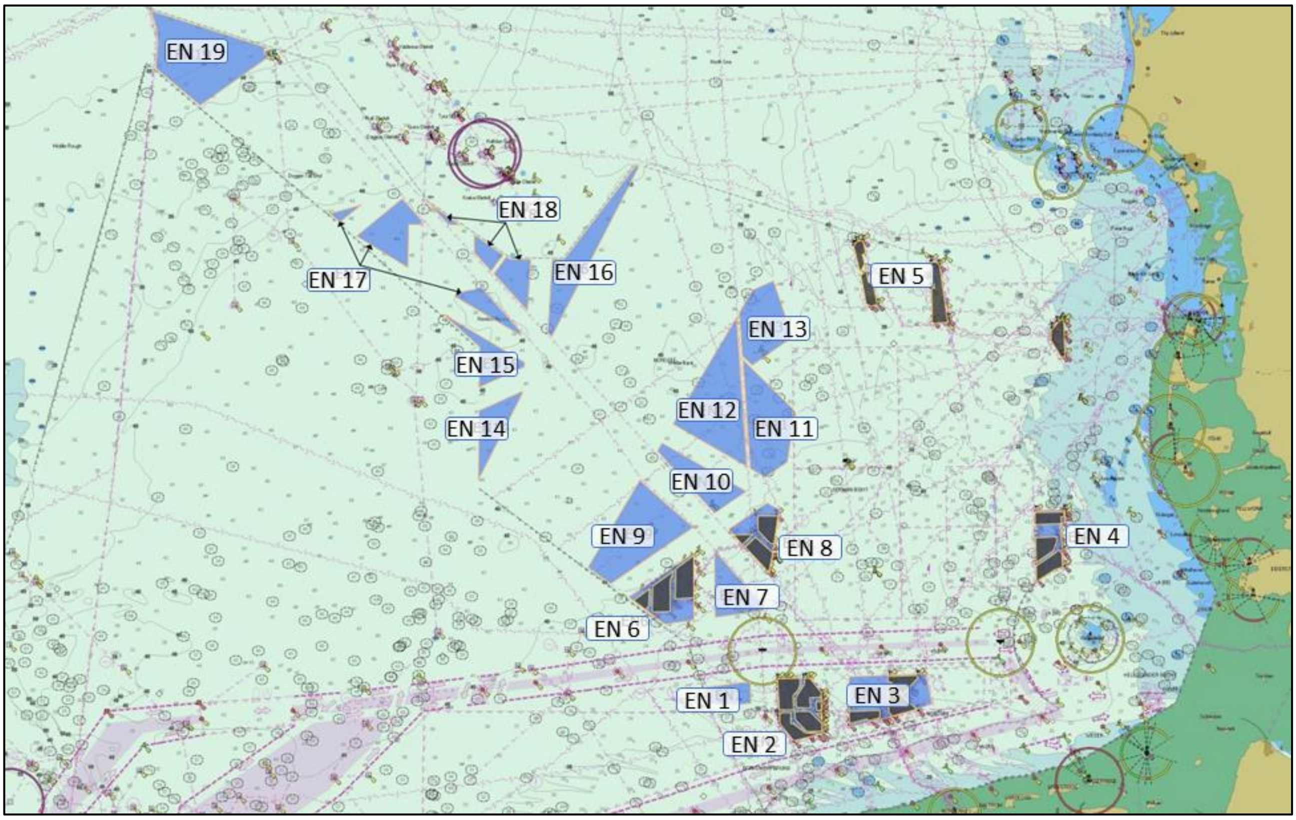


Figure 28: Overview of OWF projection within the German EEZ.

Areas EN 2 to EN 6 and area EN 8 are already partially developed, with existing windfarms covering part of their footprint. It is understood that these areas will be further developed and thus the study considers full future coverage of these areas.

5.5 THE NETHERLANDS

LOC contacted the Directorate of Maritime Affairs of the Dutch Ministry of Infrastructure and Water Management to learn that whilst there was interest and full support from the Dutch side to participate in the study, the specific aspect of offshore wind developments for the Netherlands waters constitutes a delicate subject in domestic politics and discussions on national level are still ongoing, hence there were limitations in what could be shared to public.

With these considerations in mind, LOC decided to limit the scope to using the information publicly available on databases when it comes to OWF developments in the Dutch EEZ. The list of developments is therefore not going to be exhaustive. Also, the coordinates assumed for the boundaries of the areas considered are approximate, as traced from charts and the following online map sources (http://opennauticalchart.org/).

Dutch future OWF developments appear to be taking place in two zones. The southern zone, at the border with the UK and the northern zone, at the border with Germany as shown in Figure 29 overleaf.

On the southern part of the Dutch EEZ there are two clusters of OWFs at an advanced stage of planning, Hollandse Kust Zuid and Hollandse Kust Noord (see notes 1 and 2 on Figure 29). The former comprises four development areas (with additional corridors in-between them) and is built around the existing Eneco Luchterduinen OWF in the inshore zone between the Maas and Ijmuiden approaches.

Further to the above, there appears to be five more OWF development plots at early planning stage. To the West, there are Hollandse Kust West (note 3 on Figure 29) and Ijmuiden Ver Sites 1 – 4 (note 4 on the same figure), whilst there are three further plots referred to simply as designated wind energy areas (notes 5 and 6).

For the purpose of this study, the aforementioned areas are assumed to occupy the full footprint, as it appears on the maps.

On the northern section of the EEZ, two smaller development areas appear on future development databases, both to the SW of the existing Gemini OWFs (see notes 7 and 8) along the East Friesland TSS.

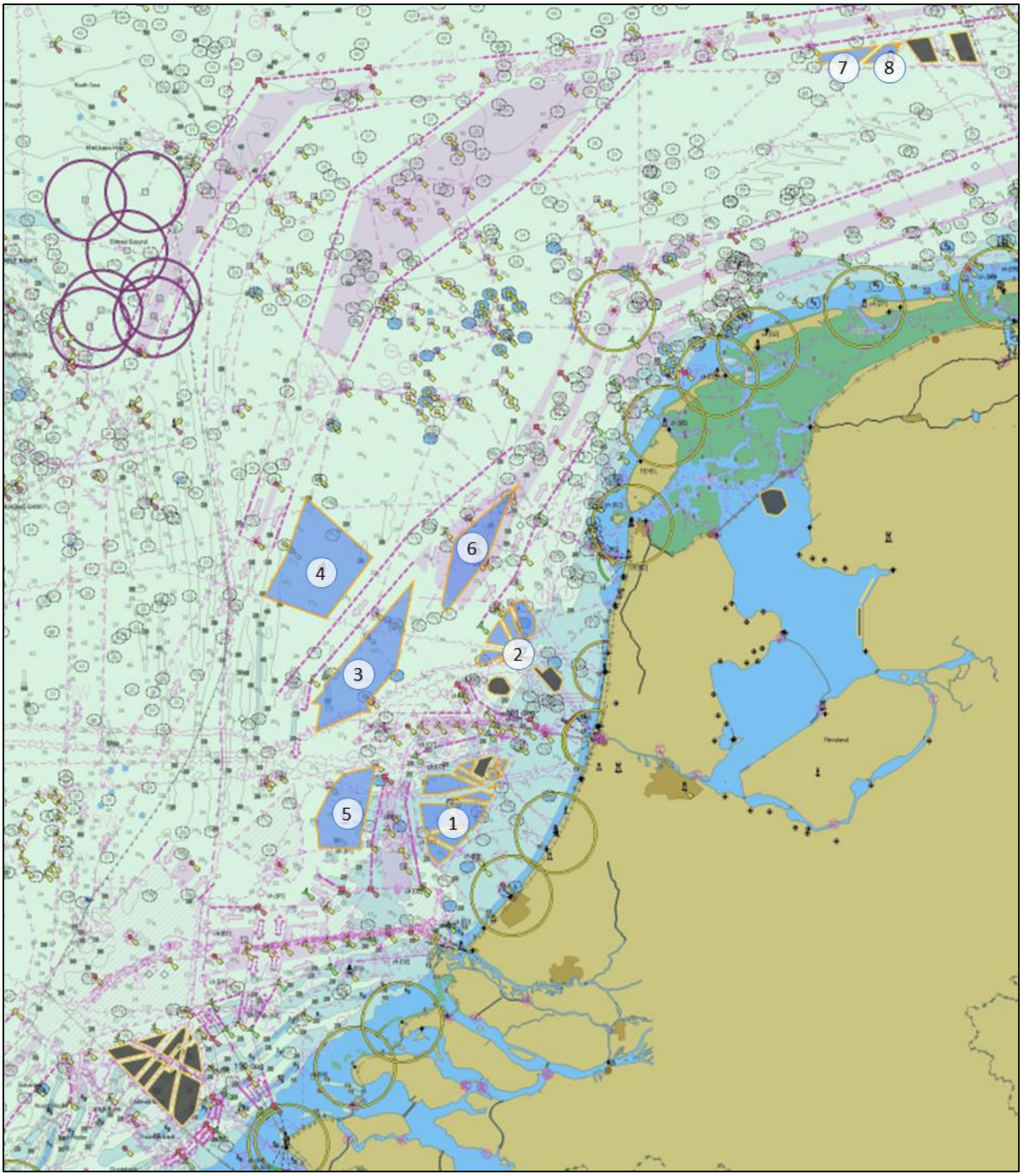


Figure 29: Overview of OWF projection within the Netherlands EEZ.

5.6 NORWAY

LOC contacted the Kystverket (Norwegian Coastal Administration) and was advised that there are a number of areas in the Norwegian EEZ that have been proposed/reserved for different type of activities. These, mostly, concern Oil & Gas, however national stakeholders have suggested to retain certain areas for offshore wind and fish farming.

Information on these suggested areas can be found at https://kart.kystverket.no/. There are three areas currently considered in the North Sea basin as presented in the screenshot of Figure 30.

Figure 30: Overview of Norwegian OWFs.

The northernmost area, Utsira Phases 1-3 (see note 1 in the above figure) also forms part of the footprint of Indrebakken a greater future aquaculture area, however there is no current information on the expected extent of utilisation of its footprint.

The other two areas are Sorlige Nordsjo 1 (see note 2) and Sorlige Nordsjo 2 (note 3). Information on the latter is that it will be developed in three phases, however there is no certainty on the timeframes.

For the purpose of this study, the three areas are assumed to occupy the full footprint as it appears on the maps.

5.7 SWEDEN

LOC contacted the Unit for marine spatial planning at the Swedish Agency for Marine and Water Management and received the relevant information with the shapefiles for existing OWF developments which are freely accessible at: https://www.havochvatten.se/data-kartor-och-rapporter/kartor-och-gis/karttjanster/karttjanster-fran-oss/havsplanering---geografiska-data.html.

The Swedish plan includes three separate areas in the Kattegat where offshore wind installations are planned. These are Galatea-Galini Nord and Sud, and Stora Middlegrund. These are situated to the West of the traffic separation scheme at Kattegat, between the main corridor and the Swedish-Danish EEZ boundaries.

Galatea-Galini Nord and Sud are marked by notes 1 and 2 on Figure 31, whilst Stora Middlegrund is marked by note 3 on the same figure. Existing Kattegat OWF is located 5 nautical miles off Falkenberg.

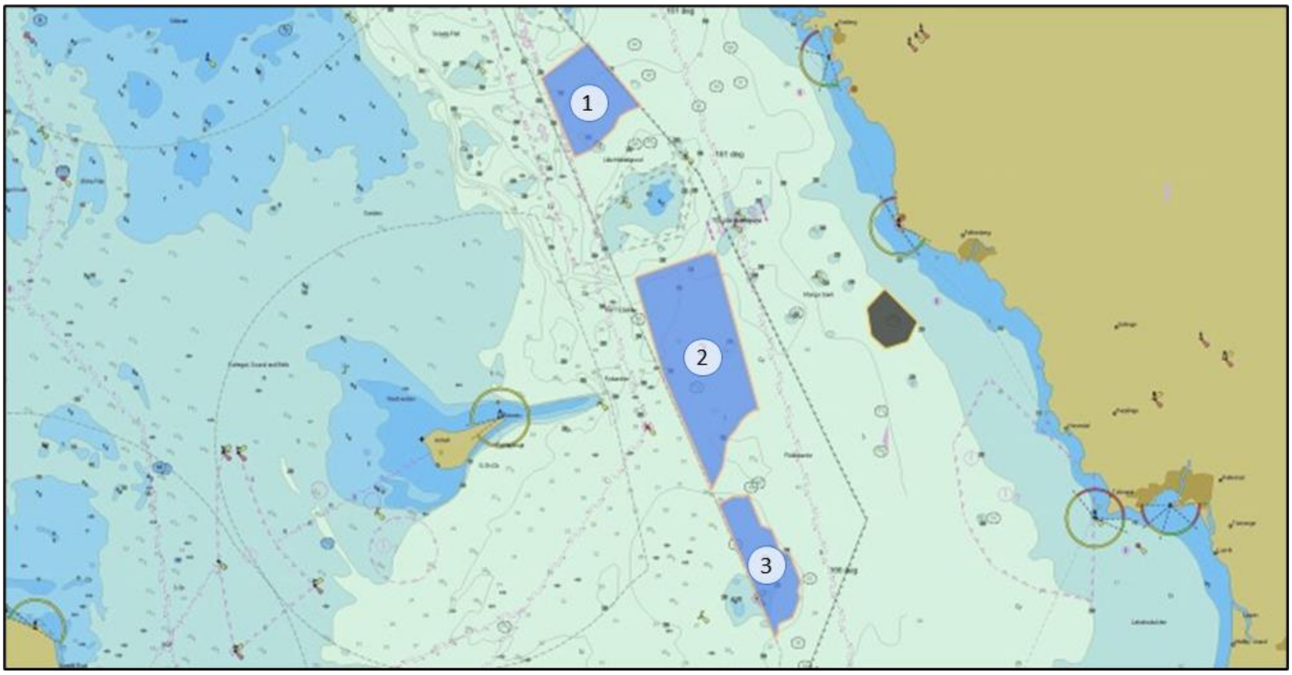


Figure 31: Overview of OWF projection within the Swedish EEZ.

5.8 UNITED KINGDOM

LOC contacted the Maritime & Coastguard Agency (MCA) to request information for the study and received the relevant information. It was pointed out by MCA that on the Crown Estate and Crown Estate Scotland websites GIS datasets are available showing current and proposed offshore wind farms. The content includes information on bidding areas for the next rounds.

The two websites may be found at https://opendata-thecrownestate.opendata.arcgis.com for England, Wales and Northern Ireland, and https://www.crownestatescotland.com/maps-and-publications for Scotland.

During the course of the study, in October 2020, the Scottish Government published their Sectoral Marine Plan for Offshore Wind Energy 2020 [07]. The present report considers the updates to the areas as per this latest information.

5.8.1 ENGLAND

The future offshore wind development plan for England is depicted in Figure 32 overleaf. It comprises 19 distinct development sites at different stages of planning, as well two broader bidding areas (yellow areas on Figure 32) where plots are available to expressions of interest.

Starting at the southernmost end of the North Sea basin, there is the upcoming extension to the Thanet OWF, denoted by 1 on Figure 32. Slightly to the North, there is the Five Estuaries project (note 2), adjacent to the existing Galloper OWF, on either side of the Sunk TSS. At the same area, there is also the upcoming North Falls OWF development (note 4).

To the north of that, East Anglia 2 and East Anglia 1 North are encountered, to the East of the UK continental shelf (see notes 3 and 5 respectively on Figure 32). The East Anglia 3 is to be developed to the North East (note 6 on the same figure) at the bifurcation point between the two main traffic corridors.

The next ones in line to the North are the Norfolk Vanguard East and Norfolk Boreas plots (marked by notes 8 and 9 on Figure 32), and to their West, Norfolk Vanguard West (marked by 7 in the same figure).

Further North, the future extension to the existing Dudgeon OWF is encountered. The development marked by 10 on Figure 32 will take place to the NW and SE of the existing windfarm.

To the North of the existing Race Bank OWF, there is another future development project, Triton Knoll (marked as 11 in Figure 32).

Figure 32: Overview of OWF projection within the UK EEZ – England.

A large development comprising three separate projects is also expected around the existing Hornsea OWF. This will comprise Hornsea 2, to be developed in three phases, Hornsea 3 and

Hornsea 4. The constituent phases of Hornsea two are shown by note 12 on Figure 32, while Hornsea 3 and 4 are marked as 13 and 14 respectively.

Further North, into the central area of the North Sea, there are four planned developments at Dogger Bank. These are the Dogger Bank – Creyke A and B (notes 15 and 16, Figure 32) and Dogger Bank – Teesside A and B (notes 17 and 18 on the same figure).

Last, there are two small demonstration areas near Blythe, marked 19 on Figure 32.

5.8.2 SCOTLAND

For offshore Scotland, the development plan is depicted in Figure 33. It comprises of 8 distinct development sites, as well as 10 draft plan options introduced under the Sectoral Marine Plan for Offshore Wind Energy.

The Moray West and Moray East developments are at the Moray Firth neighbouring the existing Beatrice OWF. They are shown as notes 1 and 2 on the map of Figure 33.

Further South at the Frith of Forth, there is a complex of five OWFs under development. The westmost one is Inch Cape (note 4 of Figure 33), neighboured by the four Sea Green windfarm areas. Sea Green Alpha, Bravo, Charlie, and Delta are named in a clockwise sequence, and marked on Figure 33 in the same sequence as 5, 6, 7, and 8.

The 10 draft plan options mentioned earlier, do not constitute final footprints of the respective developments, however, for the purposes of this study they will be conservatively considered as such. Within the North Sea basin, they are split into two groups. The East section comprising E1 to E3, and the North-East section, comprising the remaining 7. The areas are presented in Figure 33. Note that the missing section NE5 most likely corresponds to the already planned Moray developments.

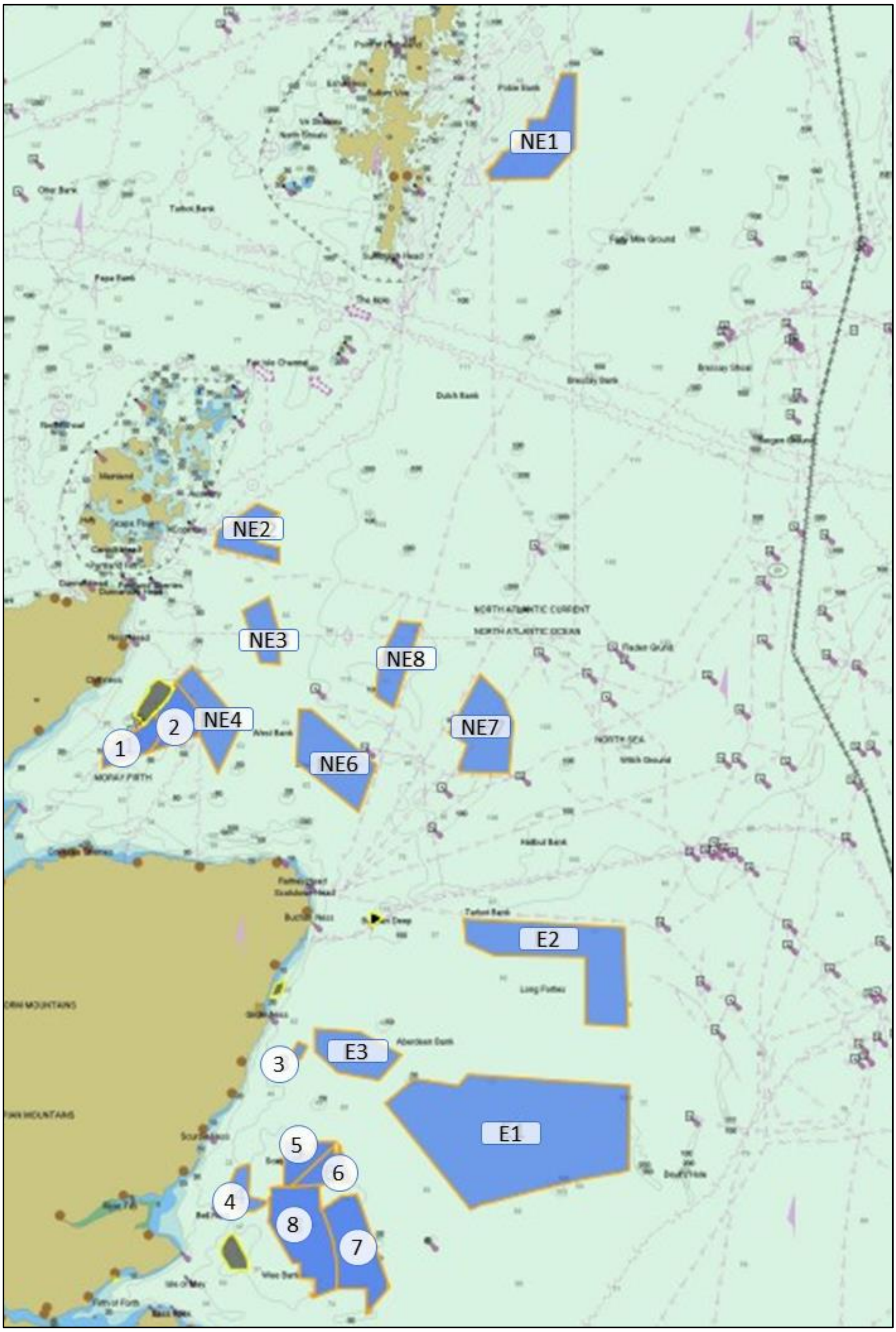


Figure 33: Overview of OWF projection within the UK EEZ – Scotland.

5.9 NORTH SEA OVERALL

The overall map of existing and future offshore wind developments identified on this study, providing an overview of the overall coverage expected between 2020 and 2040 is presented in **Error! Reference source not found.**.

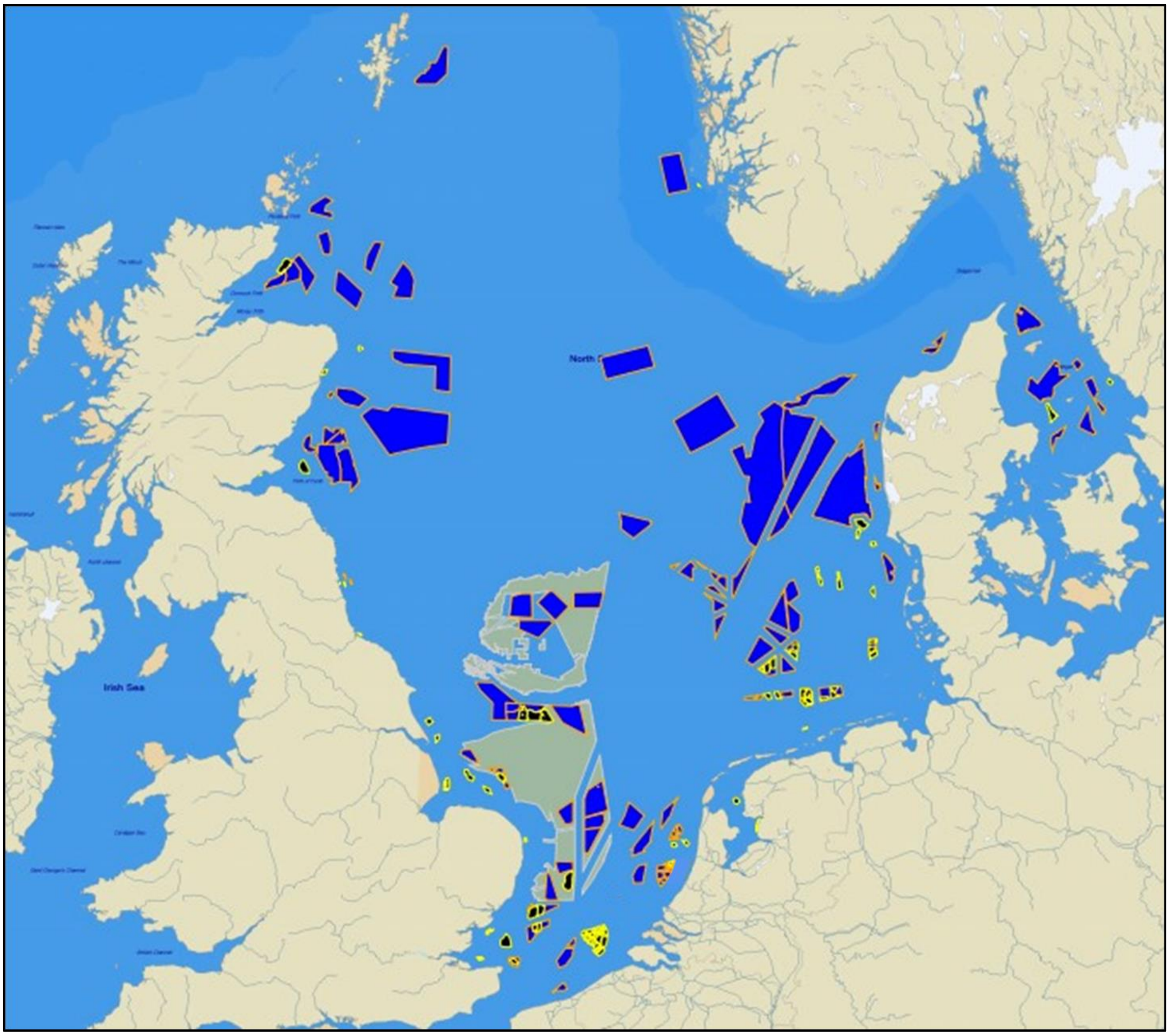


Figure 34: Overview of OWF projection for the North Sea.

6 WORK PACKAGE 03 – IMPACT OF NEW DEVELOPMENTS TO NAVIGATION AND THE RISK PROFILE

The present work package is intended to examine and discuss the impact of the foreseen renewables developments in the North Sea between 2020 and 2040 to navigation, and the navigational risk profile. This required the superposition of the new developments onto the existing traffic model of the North Sea, and where these coincide, the identification of the most likely ways in which the traffic is expected to divert around them.

However, before we proceed to this part, it is necessary to qualitatively understand the existing risk profile of the North Sea traffic corridors before the introduction of new developments and changes in vessel traffic numbers and vessel characteristics. For the former, a high level risk analysis was performed, to identify the parts of the model within the 90th percentile of risk (i.e., where the risk exceeds the risk noted at 90% of the model). Subsequently, the areas around the new developments were studied to identify their potential impact to navigation with the aforementioned hotspots into consideration.

6.1 RISK ASSESSMENT METHODOLOGY AND BASIC PARAMETERS

There are two main components to calculating collision risk.

The first is the geometrical probability (or frequency) which is related to the position of vessels on either direction of a traffic corridor (model leg), or route to a junction across each corridor, and the number of crossings. This expresses in effect the proportion of the total trips that would end to a collision if all vessels were navigating blindly (i.e., at their usual course with no reaction taken to avoid a collision). It shows the proportion of trips that would result to a collision if nobody could see one coming or act to avoid the other.

The second is the causation factor (or causation probability) which is related to the frequency in which a vessel will not take the necessary/correct action to avert a potential collision or will not diagnose the collision potential at all.

The overall collision risk is equal to the product of the two aforementioned parameters. The number of cases that would result to a collision if aversion were not possible, times the frequency of a vessel reacting to avert an incident fails.

6.2 GEOMETRICAL PROBABILITY

IWRAP Mk2 uses the trip information extracted from AIS data to derive the lateral distribution of vessel's traffic across the traffic corridors set up in the model. This distribution is converted to a summation of mathematical distributions for each leg and traffic direction, along with the geometric characteristics of each vessel in the model (length, width, draught) and the number of trips identified for each leg, it works out the geometrical probability.

For each leg, the identified number of collision candidates related to head-on, course alterations, and crossings is calculated for each vessel group and is subsequently multiplied by a causation factor.

6.2.1 CAUSATION FACTOR

IWRAP Mk2 uses a set of default 'Causation Factor' values accepted by IALA for the different collision types described above. The values of these 'Causation Factors' correspond to the mean values of the range recommended by Fujii and Mizuki [11], and are presented in Table 25. Different states/authorities may specify different values for the causation factors. However, in the context of this study using the ones recommended by IALA was the preferred option.

Table 25: Causation Factor(s).

IWRAP Mk2 Causation Factor default values	
Default Causation Factors	
Merging:	1.300 E-4
Crossing:	1.300 E-4
Bend:	1.300 E-4
Headon:	0.500 E-4
Overtaking:	1.100 E-4
Powered Grounding	1.600 E-4
Powered Allision	1.600 E-4
Area moving:	0.500 E-4
Area stationary:	0.500 E-4

A further risk reduction factor of 1.15 is considered to legs where there is a traffic-separation scheme in place, based on the work of MacDuff [12]. Where legs were only partially part of a TSS, this reduction is not considered.

6.2.2 OTHER CONSIDERATIONS

Further considerations for the risk analysis pertain to the drift speed, and repair time distribution, as these parameters both affect the recovery of a drifting vessel before a collision occurs. Drift speed is considered at 1.8 knots based on the work of section 3.3.3. The repair time distribution is assumed on the basis of a Weibull distribution with the following parameters: $\Delta = 0.90$, $\beta = 0.45$, lower bound = 0.25.

Mechanical failure is considered with a return period of 1 in 10 years for Ro-Ro and passenger vessels, and one in 1.3 years for all other vessels.

6.3 BENCHMARK RISK – EXISTING RENEWABLE DEVELOPMENTS AND 2019 TRAFFIC

The first scenario considered is the one that reflects the current navigation conditions in the North Sea. The same model and traffic distributions as reported for Work Package 2 are used under the assumptions stated in section 6.1.

Note that in the figures that follow, overtaking and head-on collision risk between vessels is denoted by the colour of the legs, crossing and merging collision risk is denoted by the colour of the waypoints. Allision risk between a vessel and the OWF developments is expressed by the colour of the OWF development boundaries, and grounding risk by the colour of the coastline or shallow areas (refer to section 3.3.4).

The current risk profile for the English Channel area is presented in Figure 35. It can be noted that the collision stress is concentrated on the main NE-SW corridor from the Dover straights TSS to North Hinder South, and the approach corridors to Antwerp-Zeebrugge and Rotterdam. There is an interval to the risk concentration between North Hinder and the Off Texel TSS, where the high concentration reappears following the TSS North.

Figure 35: Current risk profile in the English Channel.

The allision risk appears to peak at the SE sides of the Thanet, Galloper, and East Anglia One OWF on the UK side, and the external perimeter of the OWFs at the Belgian-Dutch border. Risk also appears to increase at limited parts of the circumference of the three off-Ijmuiden OWF developments, and the three existing developments off the North coast of Norfolk UK.

Grounding risk is predominantly noted in the shallows on either side of the Dover Strait, and along the French and Belgian coastline. Note that there is a number of smaller vessels that choses to navigate through these shallows, and away from the main traffic corridors, on its way to Oostende. A second area where high risk of grounding is noted is the North coast of Norfolk and the shallow banks offshore the UK.

Further north, in the central North Sea area, high risk intensity is noted at the Maas West corridor and the main NE-SW corridor between Vlieland and North Friesland (see Figure 36). High risk intensity is also noted at the Inner Sea Reach TSS on the approach to the Humber estuary in the UK.

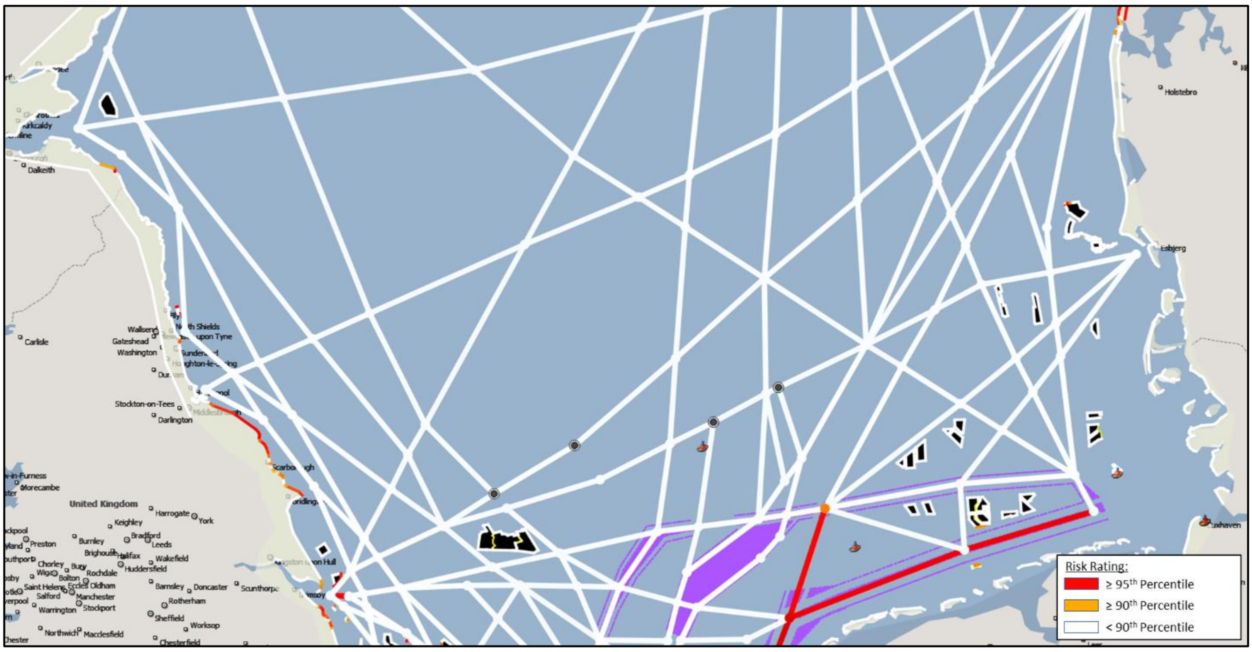


Figure 36: Current risk profile in the central North Sea area.

Allision risk appears to be rather limited in Figure 36, noted at the NE edge of the Riffgat OWF and the southern boundary of the Borkum Riffgrund OWFs in German waters, and at the SE edge of the Humber Gateway OWF in the UK. An increased risk spot is also noted at the northern edge of the Horns Rev 3 OWF in Denmark.

Grounding risk appears to be the highest at the coastline of Yorkshire in the UK. ETV availability can potentially be related to this.

At the northern part of the North Sea, the areas of high risk intensity are even more limited. Collision risk is noted in the Jammerbugt corridor, and at the Tannisbugt corridor North of Skagen, on the entrance to Kattegat (Figure 37).

No allision risk hotspots are noted on existing renewables infrastructure in the area. Grounding risk appears to concentrate on the NW Danish coastline, the Skagen coast in Denmark, and parts of the Norwegian South coast. The two most notable areas at the latter are Farsund and the coastline off Varhaug. On the UK side, risk appears to concentrate on the coast North of Aberdeen, and the cape at Tarbat Ness.

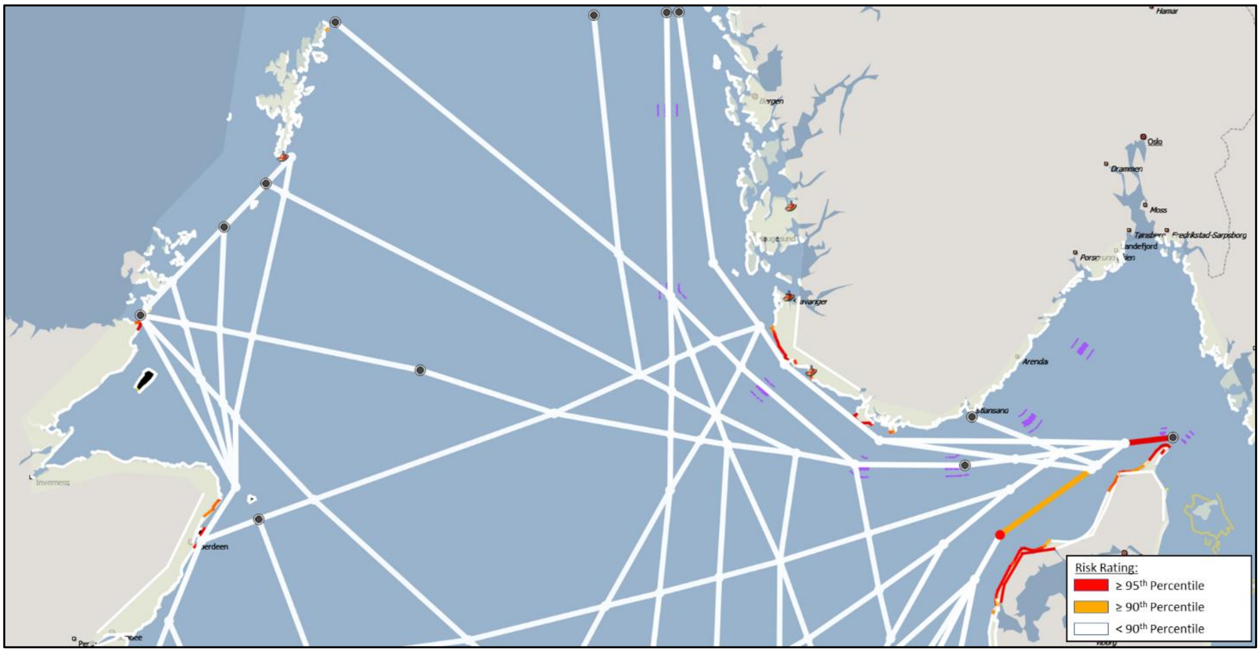


Figure 37: Current risk profile in the northern North Sea area.

Overall, most of the collision and allision risk is concentrated around the main NE-SW traffic corridor from the Dover Strait towards Skagerrak and the Baltic Sea, and the approaches to the main hub ports of Rotterdam and Antwerp. The congested space in the English Channel in conjunction with the high traffic and the shallow areas, constitutes a challenge to navigation that naturally comes with an associated increase to the risk of accidents.

6.4 EFFECT OF TRAFFIC INCREASE AND CHANGES TO VESSEL SIZES BETWEEN 2020 AND 2040

With the benchmark risk profile for current traffic established, the next step is to consider the effects of the projected increase in traffic in the North Sea for the next two decades, and evaluate its effect isolated from the geometric constraints imposed by the future offshore renewables developments.

6.4.1 TRAFFIC VOLUME INCREASE AND SIZE ADJUSTMENT

To achieve that, the growth factors on a vessel size and volume basis as projected in section 3.3.6.1 were applied to the model. The vessels database was modified to increase the dimensions of merchant vessels and passenger vessels by 5%. Namely, the following vessel categories were subjected to the 5% increase:

- Crude oil tanker
- Oil products tanker
- Chemical tanker
- Gas tanker

- Container ship
- General cargo ship
- Bulk carrier
- Ro-Ro cargo ship
- Passenger ship

Fishing vessels and fast ferries were excluded from the application of the 5% size increase, whilst support vessels were subjected to a 25% size increase (see section 3.3.6.1). Subsequent to this alteration in vessel sizes, the size distribution, as presented in Work Package 1 has been altered to match the new vessel dimensions for the calculation.

The volumes recorded on the model legs were adjusted to account for the growth factor of 41% for merchant vessels (excluding passenger vessels, the volumes of which, were maintained at 2019 values) and 40% growth factor for service vessel traffic. The traffic volume of fishing vessels and fast ferries was maintained at 2019 levels.

As anticipated, whilst the risk profile has not changed in comparison to what was presented above, the overall risk increased by a margin of roughly 50% as a result of the increased traffic volume and vessels sizes.

6.4.2 AREA OF LOW AIS COVERAGE IN THE GERMAN BIGHT

In the qualitative assessment of the risk profile yielded by the model for 2019, it was noted that most of the main NE-SW corridor assumed a high risk rating. The exception to that was the stretch of the corridor from the Dutch-German border to Skagerrak, otherwise referred to as Route 10.

As per the relevant discussion in 4.3.11, the accuracy of the traffic estimate for that part of the traffic corridor, is affected by the low density of the datapoints in the area due to poor signal coverage. The interference of this effect with ability of the IWRAP software to build trips that are subsequently used in calculations hint that the traffic volumes and therefore the risk calculated for the particular stretch, may be underestimated.

A detailed review of the recorded traffic volumes for 2019 was undertaken, considering the recorded volumes on each of the legs comprising the traffic corridor system, as well as contributing and relieving legs intersecting the main corridor, to estimate the amount of traffic that may have not been recorded as a result of the poor signal coverage. A summary of this exercise is presented in the two graphics for Northbound and Southbound traffic that comprise Figure 38 overleaf.

On the basis of this exercise, the length of the N-S corridor (Route 10) along the area in question was divided into 5 areas, with different levels of adjustment allocated to each, as presented in Figure 39. No claim is made that this adjustment would result to an accurate representation of the traffic on the corridor, as it is clearly based on gross assumptions, in an attempt to express the northbound and southbound traffic characteristics in a single value zone.

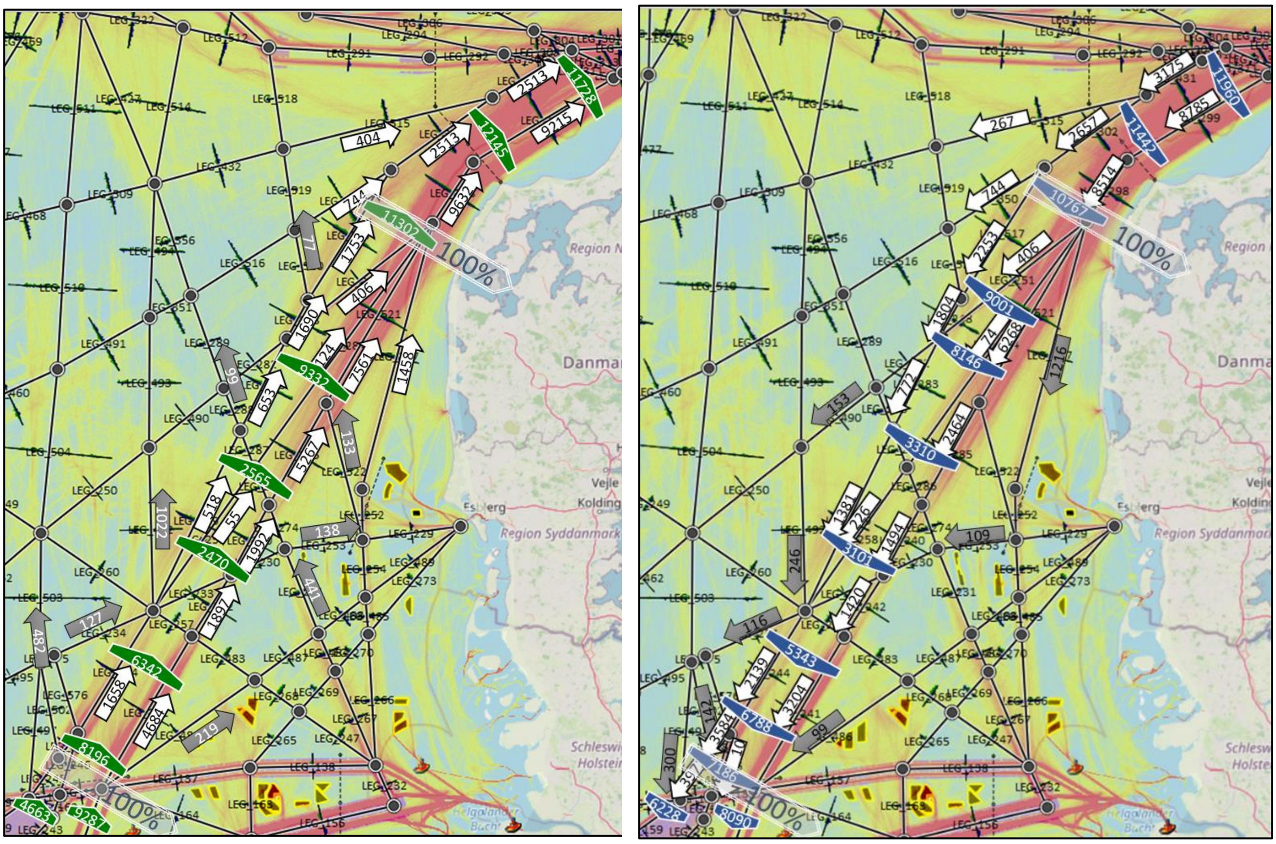


Figure 38: Northbound and Southbound traffic records along main N-S corridor in the German Bight area.

However, we believe that the traffic adjustment proposed in Figure 39 constitutes a more realistic representation of the traffic and leads to a more realistic calculation of risk on the said corridor. The percentage value shown on each zone represents the approximate proportion of the real traffic (measured at the corridor ends) we estimate it has been picked up by the model, and the values in the adjacent circles represent the traffic volume increase factor applied to the legs within each zone to compensate for the traffic loss in the benchmark model.

To keep the intervention contained in the main corridor area, no alterations were made to the crossing corridors on either side of the main traffic route.

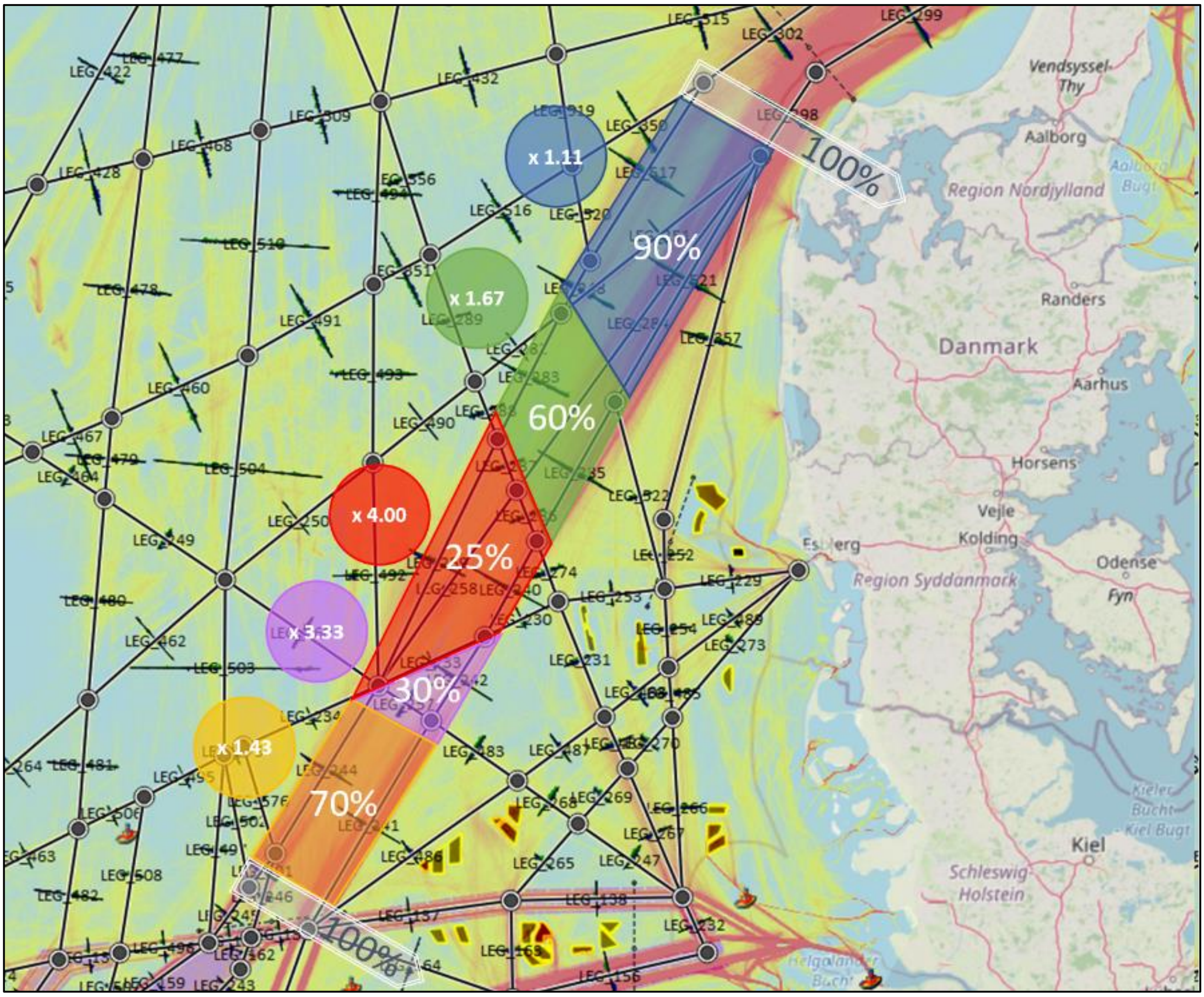


Figure 39: Deduced levels of coverage on main corridor in low signal quality reception area.

A recalculation of the risk model on the basis of the aforementioned assumptions, resulted to a slight alteration in the risk profile for the German Bight area, as presented in Figure 40. The change takes place at the northern part of the corridor, after traffic from Hamburg and Esbjerg merge with the main traffic. The current assumption and revised profile were maintained in further work.

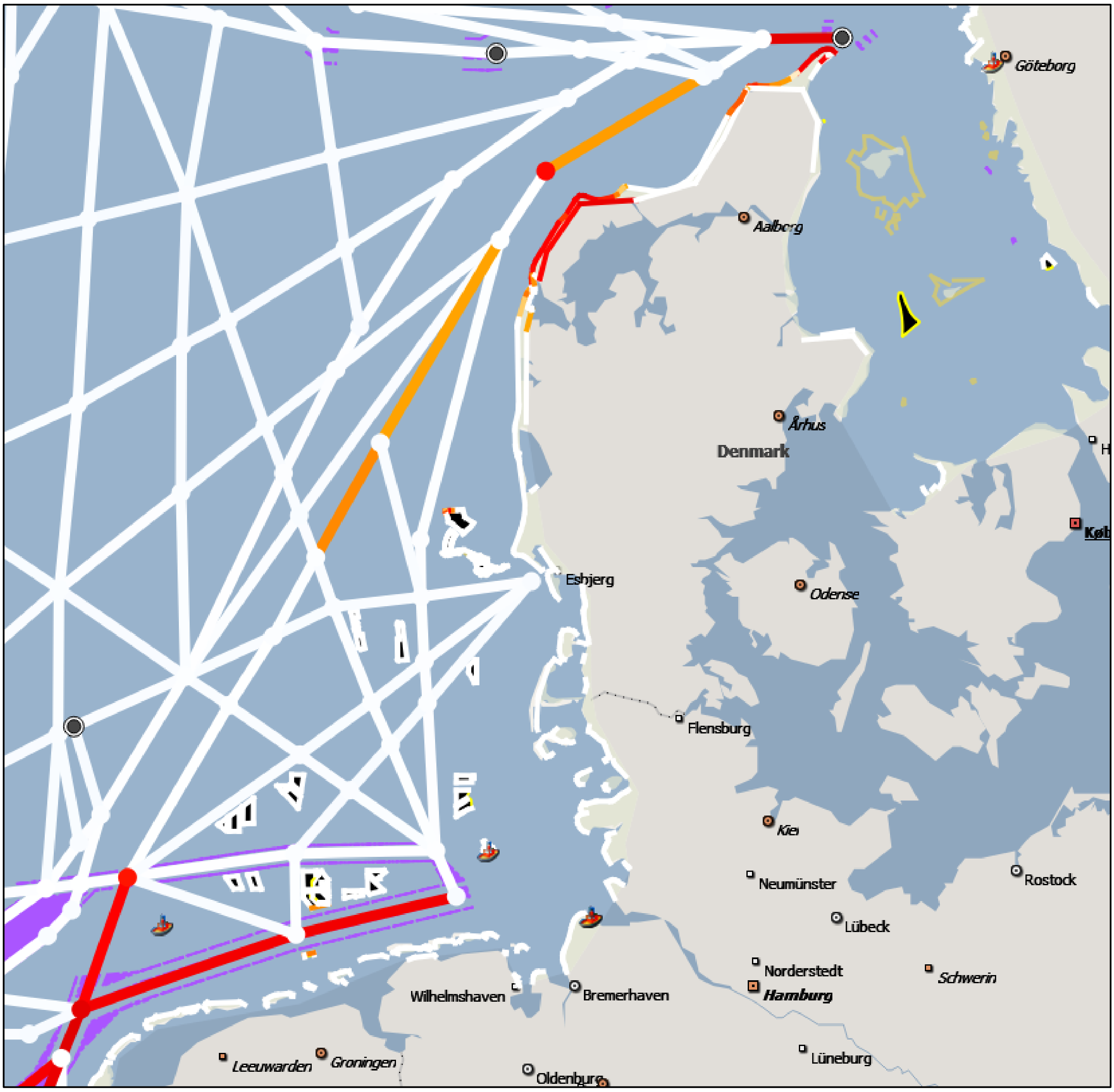


Figure 40: Revised risk profile for the German Bight.

6.5 EFFECT OF NEW OFFSHORE RENEWABLES DEVELOPMENTS AND TRAFFIC TRANSFORMATION

The introduction of the future offshore renewables developments in the model, has revealed numerous cases where the existing traffic tracks coincide with the footprint of these developments. With the introduction of a new obstacle, marine traffic has to adjust, and this is done with the adoption of the shortest and safest alternative route. Whilst the most common occurrence is that there is a single route that is found to satisfy these requirements, there are cases where different vessels (of different manoeuvrability, size, and draught) will adopt different alternative routes to circumvent the obstruction introduced. Similarly, there are cases where the two traffic directions will adopt different routes around the obstruction depending on the vessel destination and characteristics. The subsequent step in the analysis was thus to: 1) identify and study the areas where traffic routes will have to adjust, understand the navigational environment created by the new conditions, and determine the most likely route(s) traffic is expected to adopt; 2) Transform the model in line with these adjustments and repeat the risk analysis to deduce the risk profile for 2040. This considers 2040 traffic levels based on the projections discussed earlier in the report and the footprint of the foreseen offshore renewable developments.

As described above, the traffic corridors identified in the Traffic Analysis of the present report were amended to enable the forecasted deployment of the offshore installations accordingly. The risk model was revised to accommodate the anticipated changes in the traffic profile, and redetermine the risk profile in the North Sea. The re-routeing aspect of the process that resulted to the ‘route diversion’ for the model transformation is presented and elaborated upon in Work Package 4 of the present report.

6.5.1 TRAFFIC VOLUME

Where diverging legs had to merge into other existing legs (cases where traffic would follow other, existing routes) the traffic from the legs to be eliminated is added onto the traffic of the receptor legs inclusive of its qualitative characteristics (vessel types and sizes). Any minor variation in the composition and volume of traffic picked up in successive legs of a single corridor that merges with another are transferred in a way that each leg of the receiving corridor is attributed the traffic of the nearest part of the corridor to be replaced.

No traffic has been eliminated from the model. No removal of legs has been performed without transferring the traffic they bear elsewhere in the model. Where changes of direction had to be introduced (including cases where the corridor had to be split to a longer chain of legs to accommodate direction changes to fit the new layout, new legs were given the traffic properties of their adjoining legs.

Where traffic of a single corridor requiring replacement had to be split into more than one other corridor, based on the qualitative characteristics, the exact number of vessels of certain types and sizes were attributed to the destination corridors as per the assumptions of the change required.

6.5.2 LATERAL DISTRIBUTION OF TRAFFIC ACROSS CORRIDORS

In performing the transformation operations, the priority was to maintain the default lateral distribution of traffic in as many legs of the model as possible, as this is derived from the actual AIS vessels’ tracks during the traffic analysis.

This was generally maintained, with the exception of cases of corridors in areas where there was no pre-existing traffic (re-routeing), corridors the lateral distribution profile of which was not compatible with the space available following the introduction of one or more of the future offshore renewables developments, and cases where traffic had to be re-directed through existing lanes allowed between future developments.

Where maintaining the existing lateral distribution was not feasible, the approach was to allow the distribution to return to the default at the soonest following the local adjustment.

In areas where the distribution of legs had to be adjusted, two normal distribution curves were implemented. One for open sea or semi-open traffic, and one for restrained traffic. The former, is set about the axis of each leg and is of standard deviation of 1500m (i.e., 95% of the traffic moves within 3 km from the leg axis) on each direction and the latter, also set about the leg axis, is of standard deviation of 750m (i.e., 95% of the traffic moves within 1500m from the leg axis). Where the default traffic pattern of these legs naturally displayed separation of the two traffic directions, traffic on each direction was shifted away from the leg axis by 500m. The distribution patterns are presented in Figure 41.

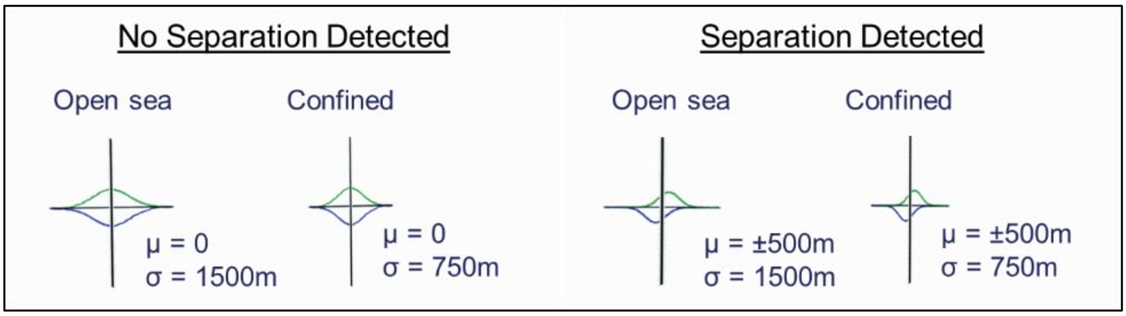


Figure 41:Lateral traffic distribution.

6.5.3 RESULTING TRANSFORMATION

A summary of the leg transformations (adjustment to the traffic corridors that were made in response to the introduction of the future offshore renewables developments) are presented in Figure 42 and Figure 43.

Black lines denote the initial traffic corridors that were identified during the traffic study, whilst the overlain red lines denote the revised corridors around the future offshore renewables developments.

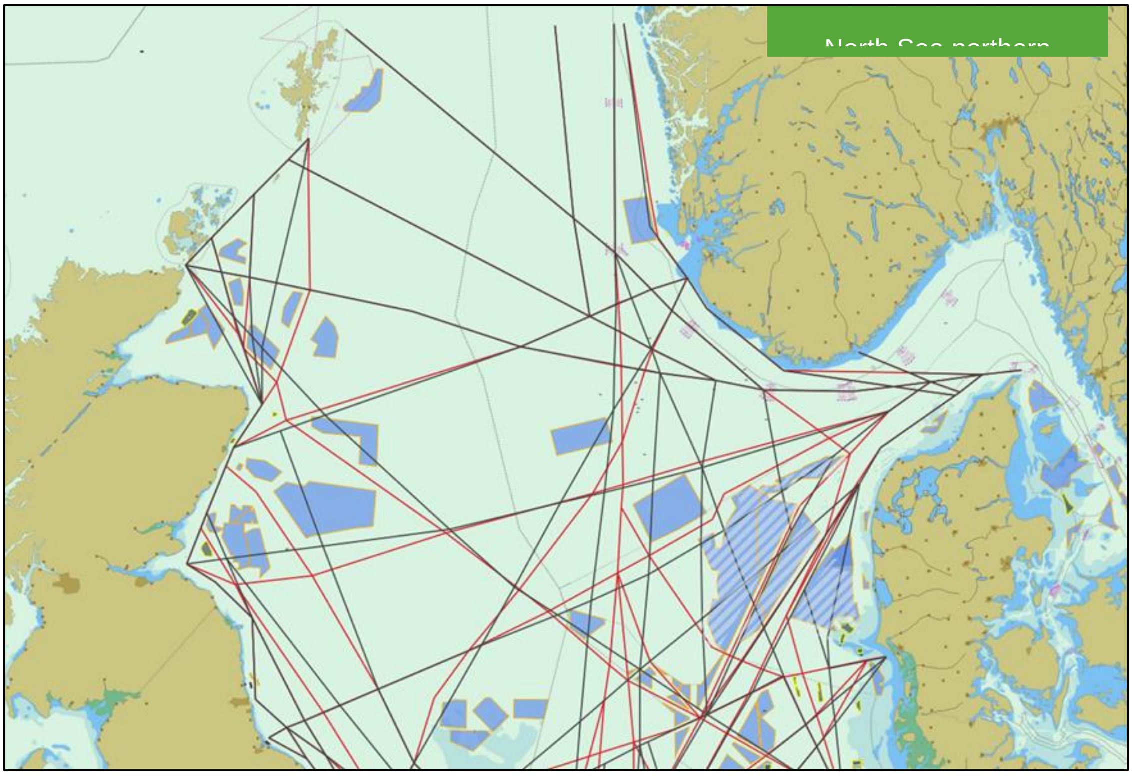


Figure 42: Route changes in the northern North Sea.

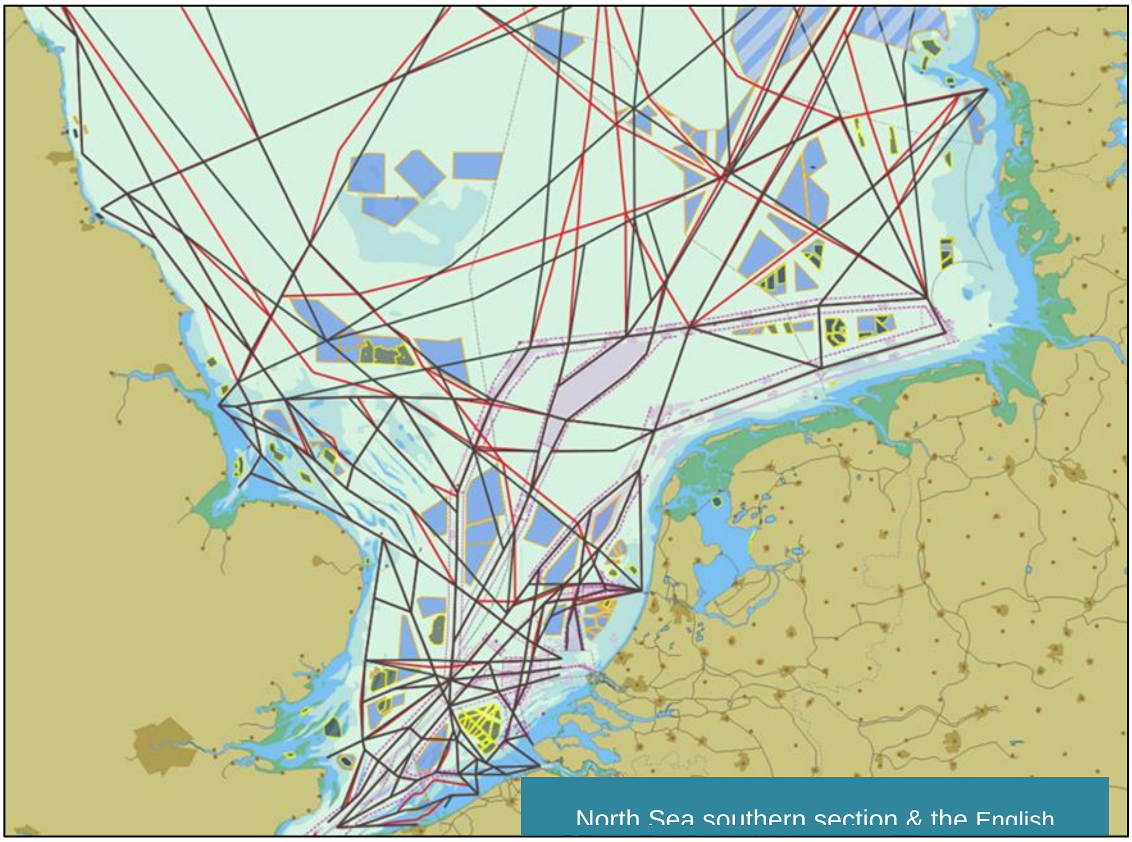


Figure 43: Route changes in southern section of the North Sea and the English Channel.

6.6 PROJECTED RISK – FUTURE DEVELOPMENTS AND PROJECTED TRAFFIC FOR 2040

Following the implementation of the changes to the model, a final run was performed to study the evolution of risk under the navigational profile expected in the North Sea for 2040. Note that this revised risk profile is not used as a means to see the absolute risk, but rather the change in the risk distribution in the model, that in turn can outline where interventions had a positive or negative effect.

The resultant risk profile for the English Channel area is presented in Figure 44. It can be noted that the collision stress remains concentrated on the main NE-SW corridor from the Dover Strait TSS to North Hinder South, and the approach corridors to Antwerp-Zeebrugge and Rotterdam. However, where northbound traffic bifurcates after the Dover Strait TSS, the risk at the western branch (northbound corridor) appears to have a lower rate of increase in the evolution of the model. This effect continues until approximately the half-way point of the northbound separation lane of the North Hinder South TSS. The intermission to the risk concentration between North Hinder and the Off Texel TSS noted in the base-case model still stands, with the concentration reappearing following the North TSS.

The re-arrangement of the traffic corridors also appears to favour the Maas North West Outer and Hinder North areas offshore of Rotterdam, as the simplification in the traffic legs appears to mitigate crossing collision risks between the main NW-SE corridor and the W-E traffic at the intersections. On the other hand, the introduction of the Norfolk Boreas and Norfolk Vanguard East developments and the route changes they involve, appear to increase the crossing collision risk at the southern termination area of the Off Brown Ridge TSS.

The allision risk appears to be generally consistent with the benchmark case. At the SE sides of the Thanet development, the risk is transferred to the corresponding sides of its future extension, and similarly for Galloper, the risk on the SE edge is to be extended to the pertinent edges of the Five Estuaries (South) and North Falls developments. For East Anglia One, also on the UK EEZ, the comparative risk intensity appears to subside, with the risk increase not as steep as of the aforementioned. With the exception of the eastern corner of the Five Estuaries (North) development, the remaining future developments in the UK EEZ in the English Channel do not concentrate risk within the model's 90^{th} percentile.

In the French EEZ, despite the fact that the future development area intercepts an existing traffic corridor through the swallows off Dunkirk, the small number of vessels do not raise a significant risk (in comparison to the rest of the model) post adjusting the traffic.

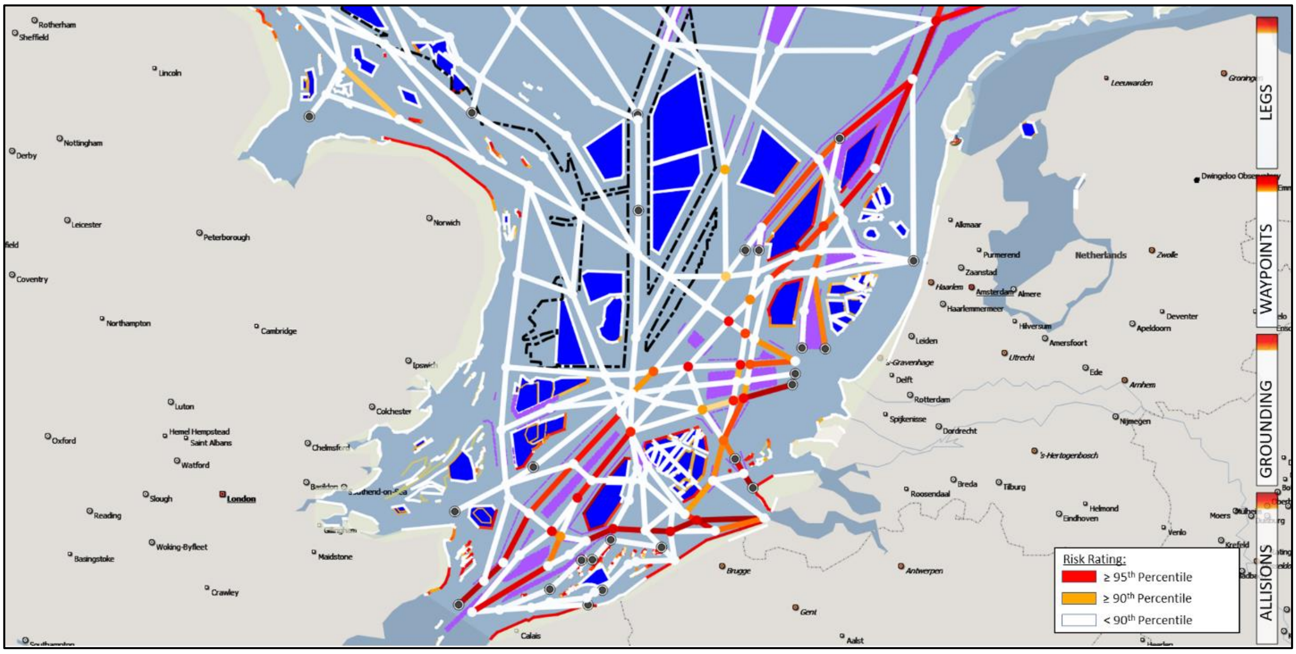


Figure 44: Future (2040) risk profile in the English Channel.

There are no notable changes at the risk profile of the perimeter of the OWFs at the Belgian-Dutch border. However, the future Belgian development zones (Noorhinder Noord, Noorhinder Zuid, and Fairybank) appear to attract high allision risk on all sides of their combined footprint, with the exception of the NE at the termination of the Off North Hinder TSS. Similarly, in the Dutch EEZ, the designated wind energy areas that are between or on the side of the lanes of the main NE-SW corridor, rate high in the allision risk potential. To the contrary, most of the Dutch designated wind energy areas in the inshore traffic zone do not show a very high allision risk profile.

Grounding risk appears to be consistent with the benchmark, in the shallows on either side of the Dover straight, and the North coast of Norfolk and the shallows banks offshore in the UK.

Further north, in the central North Sea area, high risk intensity remains at the Maas West corridor and the main NW-SE corridor between Vlieland and North Friesland. Additionally, there is an increase in the risk profile of the main NE-SW corridor along “Route 10” in the Danish EEZ north of Esbjerg, where traffic of the western and eastern track of the main corridor has to reduce its spread to navigate through the future developments. Whilst the model does not yield 90^{th} percentile risk on the southern part of ‘Route 10’ in the German EEZ, this may still be related to the low AIS reception in the area (despite the adjustment described in 6.4.2) and requires further investigation in the future.

High risk intensity is also noted at the Inner Sea Reach TSS on the approach to the Humber estuary in the UK, in line with the benchmark profile of 2019. The risk profile is presented in Figure 45.

The revised model is consistent with the benchmark when it comes to allision risk, which generally appears rather limited in terms of its extent, however it includes the highest single allision risk in the model.

The risk noted at the NE edge of the Riffgat OWF and the southern boundary of the Borkum Riffgrund OWFs, in the German EEZ, is no longer within the 90th percentile, indicating that the risk in these areas has not grown in the same rate as elsewhere in the model. Risk hotspots appear however at the SE tip of the future area EN 1 and the E tip of EN 17 further offshore, and to a lesser extent along the eastern edge of EN 16 on 'Route 10'.

The peak allision risk in the model is encountered along the western boundary of the Nordsoen I development area in Denmark, on the eastern corridor of 'Route 10', whilst to a lesser extent, high risk is noted on the NE edge of the Nordsoen II area at the other side of the same corridor. Limited areas of high risk are also discernible at the Northern tip of the Fano Bugt development and the eastern edge of the Vesterhav Syd in the Danish EEZ.

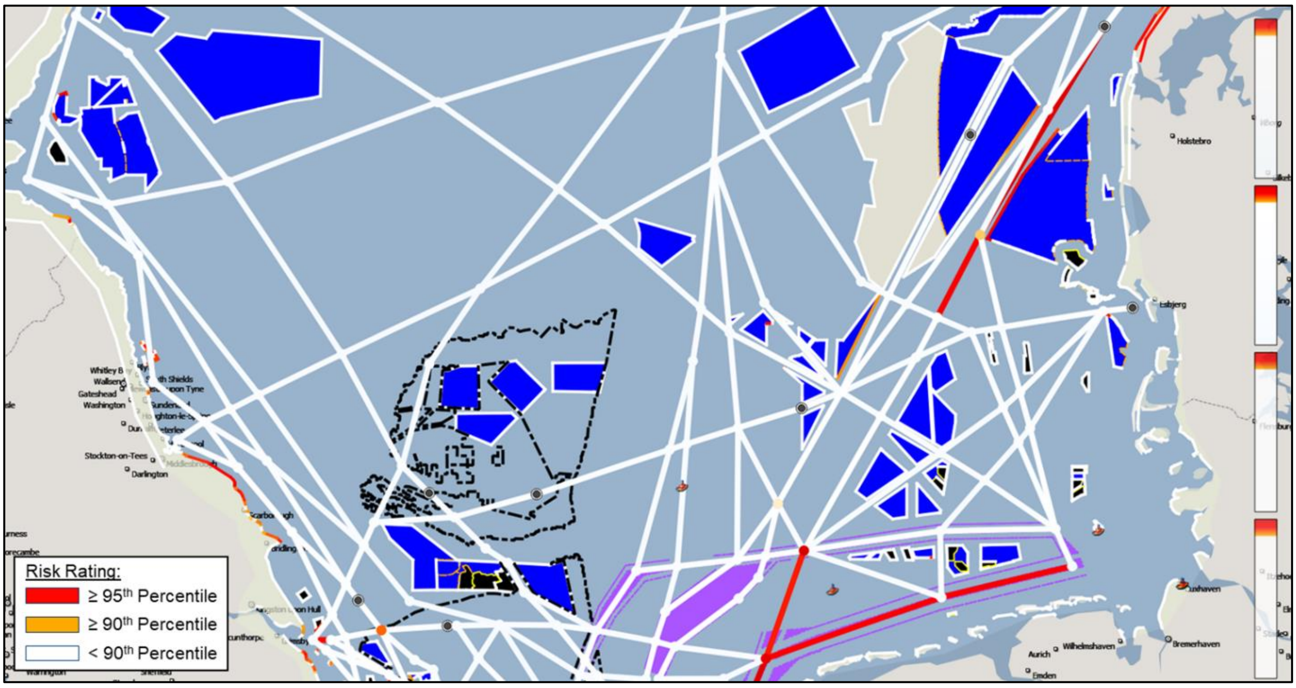


Figure 45: Future (2040) risk profile in the central North Sea area.

Within the UK EEZ, the model remains consistent in terms of the risk previously picked up at the Humber Gateway SE edge. In addition, and to a lesser extent, risk is noted at the Western edge of the Dudgeon extension (North) and the South and West edges of the Dudgeon extension to the South.

Grounding risk appears to be consistent with what was observed in the benchmark case model.

At the northern part of the North Sea, the areas of high risk intensity in terms of existing assets and routes remain in line with the limited risk areas noted in the benchmark analysis. These include the collision risk at the Jammerbugt corridor and at the Tannisbugt corridor North of Skagen, on the entrance to Kattegat (Figure 46).

Allision risk hotspots are noted on the future renewables developments of Jyske Banke and Jammerbugt. In the case of the former, the risk is limited to the NE tip of the area, whilst for the latter, risks are noted on both the NW edges, along the route to Skagerrak.

Two allision risk intensity hotspots are also noted at the North and West edges of the future Inch Cape development off Dundee in the UK.

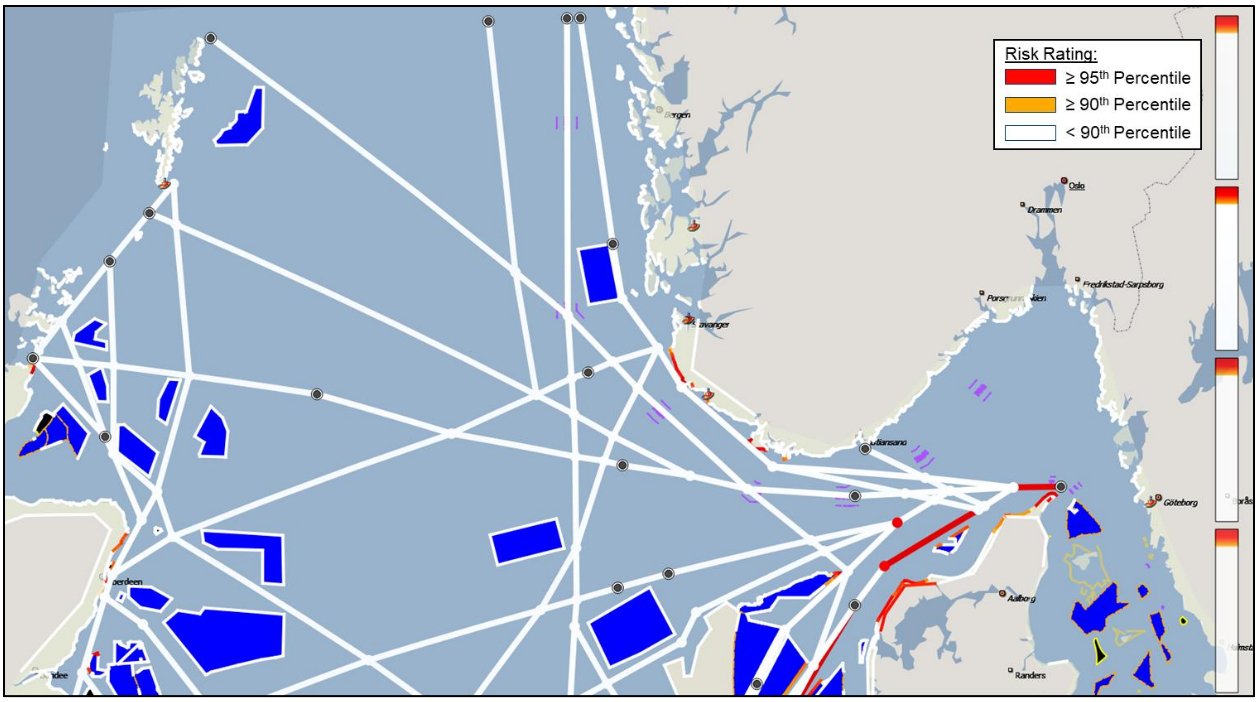


Figure 46: Future (2040) risk profile in the northern North Sea area.

Grounding risk appears to corroborate the findings of the benchmark model.

6.7 RISK ASSESSMENT SUMMARY AND RECOMMENDATIONS

The primary outcome of the present risk study is that risk intensity in the North Sea is predominantly concentrated on and around the main NE-SW traffic corridor from the Dover Strait to Skagerrak and the Baltic sea, and the approaches to the main hub ports of Rotterdam and Antwerp. The risk increases both with the introduction of additional traffic in the future projection, as well as in most cases with the introduction of offshore renewables developments that understandably reduce the space available to navigation.

Examined individually, the traffic increase is noted to have a more significant impact to the risk increase compared to the traffic routes alteration. This assumes high significance in the considerations for the adoption of future mitigation measures, as it is reliant (as any projection) on assumptions that may or may not be verified in time. This means that traffic volume, the key contributor to the risk increase studied for 2040, may develop sooner or later than that time.

It is to be understood that the present study covers a conservative scenario where all areas identified under the second work package are fully developed, which will most likely not be the case in the end.

The above underline the significance of acknowledging and understanding the fact that changes happen gradually, and thus there are opportunities for cross-country coordination and subsequent intervention and adjustment to mitigate risks. The time and sequence in which the future offshore renewables developments will materialise is expected to have a significant effect in the way navigation will adjust around them and the development of risk with time. The present study is a good first step in the identification of areas where risk is likely to concentrate and instigate the conversation on how authorities can collaborate to monitor and mitigate it, as necessary.

At individual development project scale, it is our recommendation that ahead of the approval and licencing of future developments, targeted, area-specific probabilistic navigational risk assessments are undertaken. These assessments would offer the benefit of utilising current information on vessel traffic (quantity and pattern) at the time and the actual envisaged footprint requirements for the new developments to accurately assess the impact and identify the interventions required for the viability of a development or provide justification for a decision against it.

On the larger scale, the North Sea states could benefit from the creation of an integrated policy, that may comprise pre-planned interventions performed on the basis of certain traffic volumes in the main navigational corridors, to potentially be triggered into force when traffic reaches certain thresholds. Marine traffic is not expected to stop its growth in 2040 and considering the service life (and potential life extension) of offshore renewables developments there should be a high-level plan to manage this change. Though logistically challenging, a bold proposition that could potentially be constructive, is the adoption of buffer zones on the boundaries of and parallel to the main navigation corridors, which whilst be made available for developments, however under the condition that on a common, pre-set future date, these zones can be reclaimed for navigation.

Neighbouring country authorities would benefit from promoting a collaboration regime where one would inform the other in cases where project specific or area specific studies for offshore renewables or other offshore developments are expected to change the pattern and/or qualitative characteristics of traffic that crosses into their area of jurisdiction. The risk introduced by a change does not necessarily occur at the location of the change, and it may thus well be transferred into a different jurisdiction.

The fourth work package that follows, discusses possible interventions that could be discussed as potential contingency plans for mitigating risks identified in the present study.

7 WORK PACKAGE 04 –DEVELOPING OF POSSIBLE ROUTEING MEASURES

7.1 GENERAL

The introduction of several offshore developments will undoubtedly have an impact on the current marine traffic patterns in the North Sea, one of the busiest shipping areas of the world. The level of this study, covering such an extensive area, cannot provide a definitive answer for the various amendments of the current traffic pattern that are expected to occur once the future OWFs will be deployed. The following paragraphs describe the approach followed and the relevant considerations when (and where) a diversion from the current traffic corridors as identified in the Traffic Study of the present report, is likely or necessary to take place.

The exercise performed required several assumptions, the main one is to consider all OWF future developments deployed at the same time, thus representing a snapshot of the North Sea in the year 2040. Subsequently, risk mitigation proposals were drafted based on the worst-case scenario.

A number of considerations has to be taken into account before assuming the diversion of the current marine traffic due to an obstruction caused by a new OWF development.

7.2 MINIMUM DISTANCE FROM OWF TO SHIPPING LANE

In the attempt to find common guidelines or practices already adopted on a worldwide basis, it turned out that, although several studies have been provided for a number of offshore installations, there is no common practice, and distances are adopted by individual coastal States or on a case-by-case basis.

United Nation Convention of the Law of the Sea (UNCLOS) Article 60 *"Artificial islands, installations and structures in the exclusive economic zone"* paragraphs 5 details "*… safety zones shall be determined by the coastal State, taking into account applicable international standards. Such zones shall be designed to ensure that they are reasonably related to the nature and function of the artificial islands, installations or structures, and shall not exceed a distance of 500 metres around them…."[08][08].* Therefore, the UN allow a 500m safety zone around each installation and this was considered as common ground for the present study. This article is enforced by all States during the construction phase, however, some of them do not implement the same in the operational phase of the installation.

It is noteworthy to mention that the distance between an OWF and the safe transit of a ship in the surrounding area, is not exclusively related to the capacity of the vessel to avoid such installation or the drifting distance of her towards it in an emergency situation. The way offshore installations, particularly wind farms, affect the navigation is not limited to the physical obstruction posed in the maritime space, but also the influence the installation might have on vessel's on board equipment.

One of the main and crucial components affected by the presence of OWFs is the electromagnetic waves (EMV) which are generated on board ships by several equipment such as the Radar, Radio Communication System VHF, AIS and Differential GPS. The parts of an OWF interfering with EMVs are the tower, rotating blades, and generators. Radars are affected by the reflection of towers and blades, whilst generators can deflect the electromagnetic radiations causing disturbance.

In terms of navigation and aspects related to a ship's manoeuvrability, again, there are no studies defining a common approach or at least accepted at the same level by all coastal States. For instance, some countries apply a distance corresponding to five or six ship lengths, similarly to what IMO bases the tactical diameter on, increased by 0.3 nautical miles (nm) for the evasive manoeuvre of the largest vessel expected to transit that specific passage (this was then divided in two categories of 300 and 400 metres of length over all) varying between 1.54 and 1.87 nm. Other countries account for distances based on the influence of the wake and the collapse of the wind tower to define their minimum distance form a shipping lane. Overall, it seems that the most conservative distance applied by coastal States is 2 nm with a safety zone of 500 m. [09][09]

Distance in miles (NM) of the first wind generator row from the shipping route	Factors for consideration	risk	Tolerability
< 0.25 NM (500 m)	Inter-turbine spacing only recommended for small crafts	VERY HIGH	Intolerable unless for very small craft (small leisure craft)
0.25 NM (500 m)	X band radar interference	VERY HIGH	
0.45 NM (800 m)	Vessel may generate multiple echoes on VTS radars	VERY HIGH	
0.8 NM (1481 m)	Distance from a shipping route taken by SOLAS vessels and a wind farm	HIGH	Tolerable if As Low As Reasonably Practicable (ALARP)
1.5 NM (2778 m)	S band radar interference ARPA affected	MEDIUM	
2 NM (3,704 m)	Distance between a shipping route and a wind farm	LOW	Acceptable depending on traffic density
5 NM (9,260 m)	Distance between TSS and a wind farm in restricted waters	LOW	Acceptable
10 NM (18,520 m°	Ideal distance between a TSS and a wind farm	VERY LOW	

Note:

- No wind farm must be installed in a zone situated in the extension of a traffic lane.
- Shipping routes are routes regularly used by ships, whose definition is governed by geographical and hydrographic parameters; these routes cover long distances, particularly between two TSS. These routes concern the approaches of the channels of a port as well as travel between two ports.
- The As Low As Reasonably Practicable (ALARP) concept is part of a risk management approach which consists in reducing as much as possible the frequency and severity of hazards that may affect the wind field or ships, by compensatory measures associated with the project (traffic control, enhanced maneuvering capabilities, means of assistance, specific equipment).

Figure 47: Requirements for minimum safety distances between maritime navigation and OWFs [09].

Figure 47, taken from PIANC report "*Interaction between offshore wind farms and maritime navigation*" (2018) illustrates some of the risks and the considerations to take during the evaluation of the distance between an OWF and a shipping lane.

In summary, there are no common guidelines adopted by the coastal States of the North Sea defining the process in the selection of the best optimization of the EEZ waters with the maritime spatial planning and the marine traffic. We do not expect that all future areas granted for new offshore structures will see construction and operation at the same time, there will be temporal gaps between the construction phases and most likely the marine traffic will tend to adapt accordingly. Furthermore, some of the footprint assumed in work package 2 will most likely not be wholly utilised, and additional potential routeing systems may be put in place based on the actual necessity faced at the material time. Having said that, there are some areas where the current congestion and limited room do not allow for any additional measures to be considered, for a mere passage planning purpose (namely plotting potential routeing on the electronic nautical charts) it was assumed, where feasible, a distance of 2 nm from offshore installations.

7.3 ROUTEING MEASURES

As explained in work package 3 and 7.2, several marine traffic corridors identified in WP1 were diverted avoiding future OWF footprints and transiting in safe waters whilst trying to maintain, where possible, the shortest possible route as given by the current traffic 'path'. Routeing amendments were based on an initial observation of the current traffic pattern with a projection of traffic density to 2040, and in the case of diversions, international regulations such as Colreg, IALA and IMO routeing measures were accounted for. Being aware of the difficulties in establishing new risk mitigation measures, the priority in suggesting possible measures for the routeing alternatives was considered as follows:

- Existing and forecasted traffic lanes and other routeing measures
- Establishing additional or repositioning existing Aids to Navigation
- Exclusion or Safety Zones and Areas to be Avoided
- Separation areas, in order to prohibit or restrict vessels from entering or leaving areas of offshore
- TSS
- Establishing VTS

The intention of this section is not to dictate definitive solutions, but to put best endeavours in making reasonable suggestions for routeing measures that could be adopted. It is worth considering that there are always multiple options that can deliver similar results. Our aim is to inform the relevant authorities, in a way that will facilitate a discussion between them to find common ground and potentially agree on common measures extending beyond their individual area of responsibility, looking at the North Sea as a whole and single environment.

7.3.1 WESTERN NORWAY & NORTHERN SCOTLAND

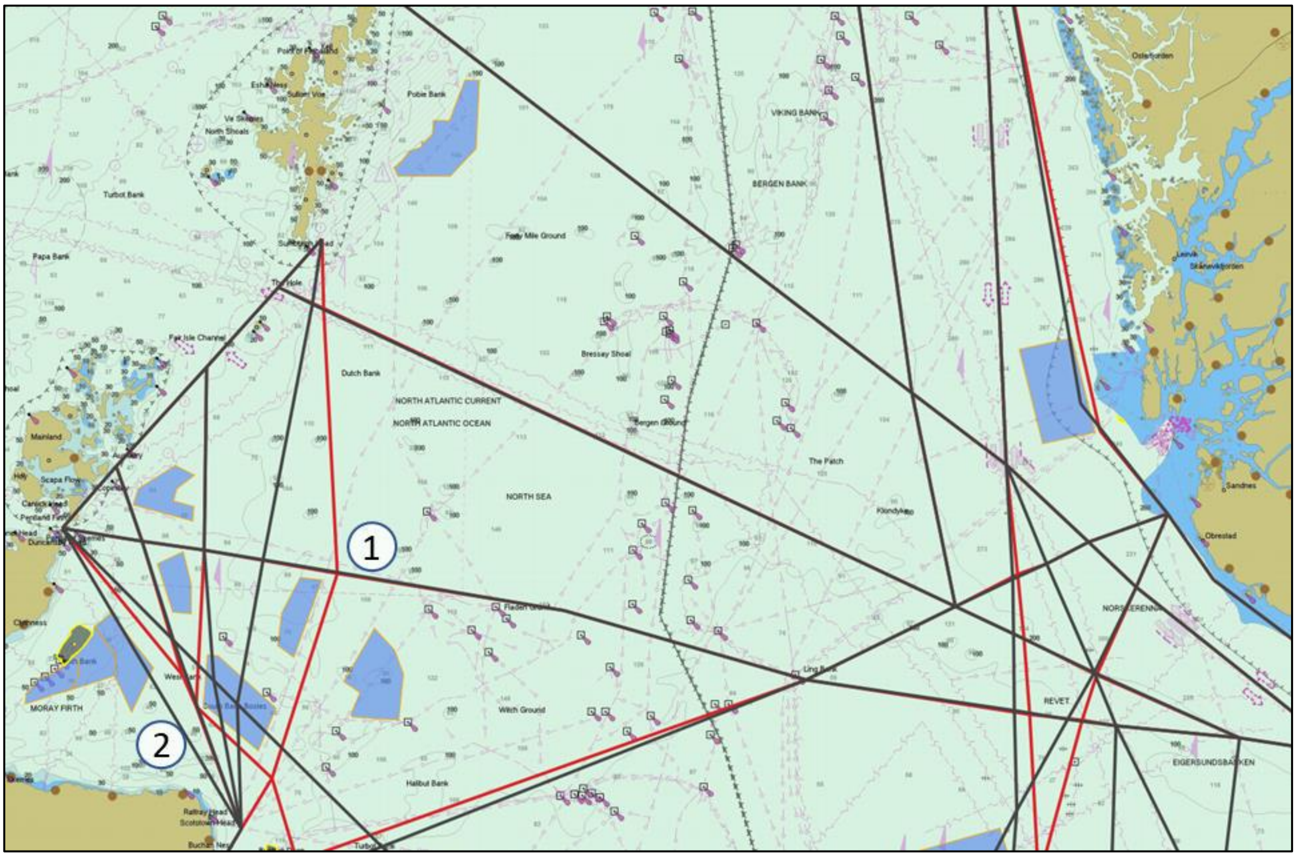


Figure 48: Western Norway and Northern Scotland route amendments.

Figure 48 illustrates the few changes required off Norway, with a single inshore passage adjustment between Utsira Island and Utsira OWF; and some adjustments necessary to accommodate the traffic in the corridors generated by the deployment of the OWFs in the Moray Firth (marks 1 & 2).

7.3.2 SOUTHERN SCOTLAND AND EAST COAST OF ENGLAND

Figure 49: Changes in routeing Southern Scotland and East Coast of England.

Moving South from Aberdeen it can be seen (Figure 49) that necessary diversions are required in the approach to Firth of Forth (1a), similarly heading South towards Ijmuiden (1b) a transit passing is required south of the Hornsea OWF group and North of the Norfolk Boreas, with attention to the offshore installations at Easternmost Rough (3b) and Coal Pit. Other adjustments are North of Dogger Bank (2) for traffic between Stavanger and River Humber; some additional negotiation off Flamborough (3b) adjusting tracks between existing installations. Getting closer to Triton & Cromer Knoll more attention is required for offshore installations and shallow waters in the area, and the last noteworthy diversion depicted in Figure 49 is the north-western bound connection between astern deep-water Route passing South of Norfolk Vanguard East (5). Overall, the passages generated by the new developments do not significantly influence the current traffic patterns as some adjustment of the routeing system is required and the increase in distances is below 5nm and therefore negligible. Essentially, the precaution that shall be put in place by the Officer of the watch (OOW) with new developments installed will not be dissimilar to what they currently have to consider in the appraisal process of the passage planning.

7.3.3 THE ENGLISH CHANNEL & SOUTHERN SECTION OF THE NORTH SEA

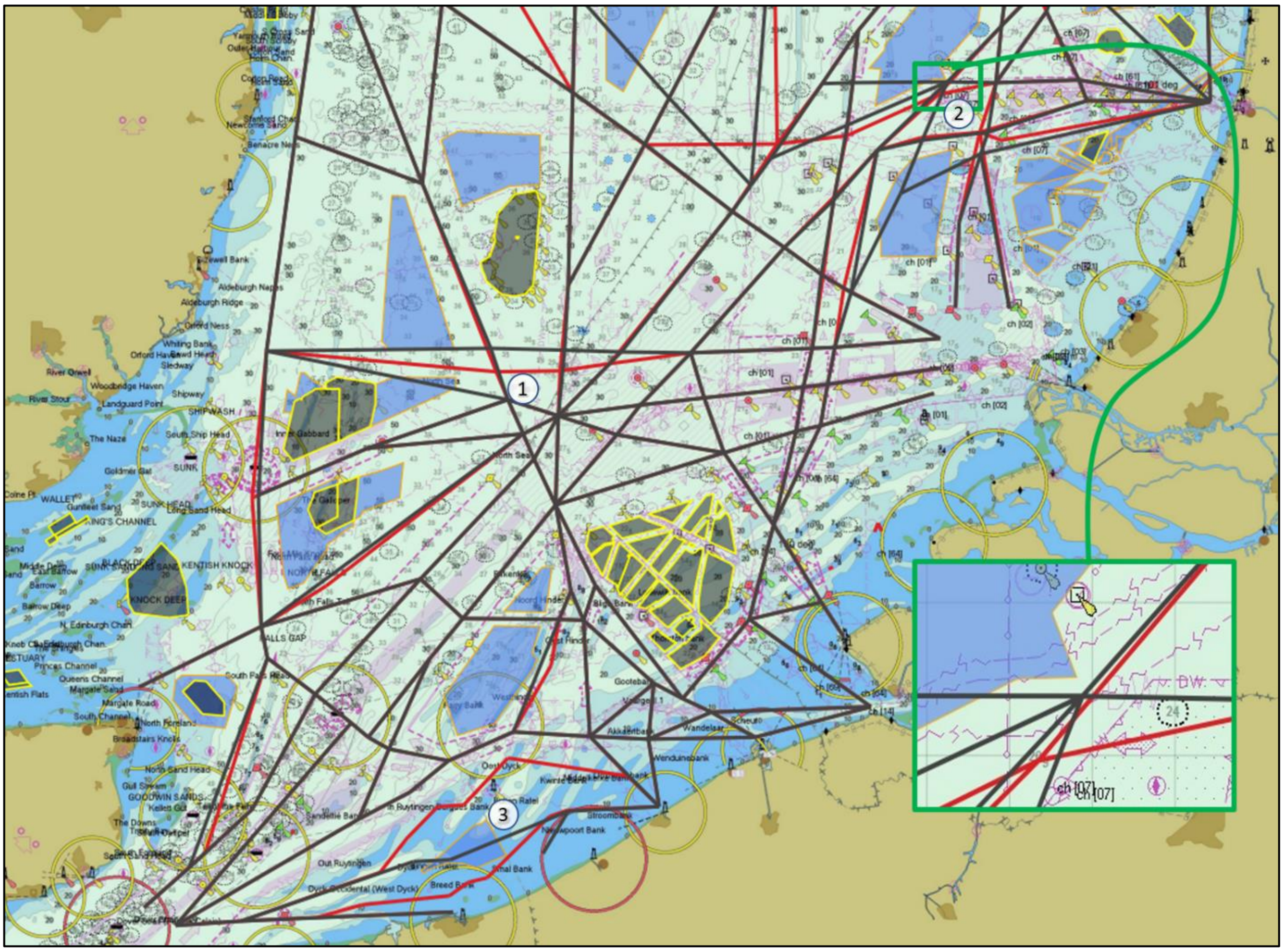


Figure 50: Routeing changes at the English Channel and Southern section of the North Sea.

Figure 50 depicts the routeing adjustments performed to the existing traffic at the English Channel and the Southern section of the North Sea. As it is shown, the whole area captured in the figure above does not allow for drastic routeing changes as most of the existing routeing is transiting within traffic separation schemes and deep-water routes. A minor adjustment is required in the passage between Five Estuaries and East Anglia 2 OWFs (1) for traffic on a UK-Maas River route.

The second notable diversion is due to the given shape of Hollandse Kust West (mark 2 and green box in Figure 50) where the eastern 'spike' at the OWF area footprint will force the traffic towards the East. In this regard, the high density of traffic with vessels approaching to IJ-Geul Pilot Station, deep draft vessels aligning with the deep-water approach of the Ijmuiden West Outer TSS, crossing of the in/out bound traffic off Amsterdam, and the N-S bound traffic the Channel - Off Texel TSS, would call for further, more detailed assessment of this area and its traffic ahead of finalising the shape of the OWF development.

Mark 3 on the same figure indicates the necessary route adjustments expected to be implemented by the traffic transiting the route Dover Strait-Oostende.

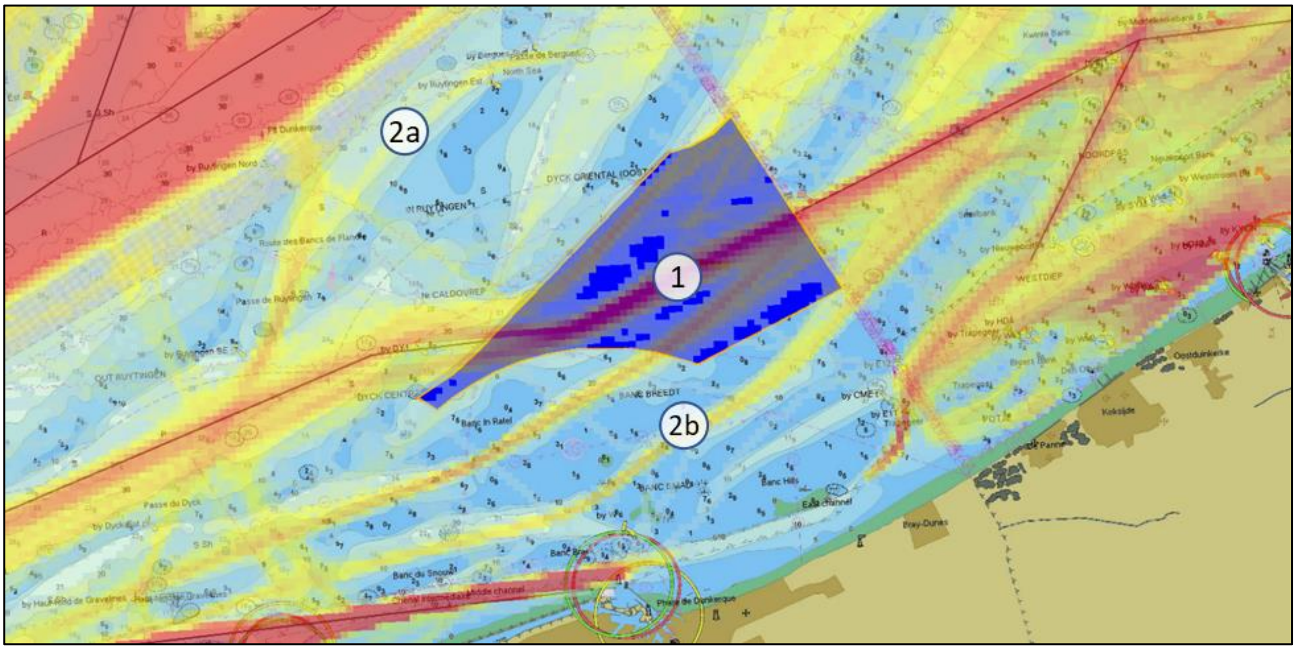


Figure 51: Dunkerque OWF with traffic density overlaid.

Figure 51 depicts the density traffic overlaid on top of the electronic nautical chart with the location of the future Dunkerque OWF. As shown, note 1 in the figure represent the traffic corridor chosen by the majority of the vessels. Said that, it is noteworthy to specify that, qualitatively, the traffic in 2019, projected to 2040, is comprised by a large number of fishing vessels, approximately 270 westbound and 210 eastbound distributed on dimensions form 0-50m of LOA, and about 40 westbound ships below 100 m LOA, and a third of the same sailing eastbound. With the installation of the Dunkerque OWF, the westbound traffic originating at Oostende would need an additional 15 nm of transit within the TSS crossing twice the main Northbound artery of traffic ex Channel.

The same Figure 51 shows two additional corridors (2a and 2b) already utilised by some traffic, with the southernmost (2b) narrower and shallower than the northern one (2a). We expect that the latter corridor will be utilised by fishing vessels with limited draft and local knowledge, whilst the Northern might be used by the limited number of ships navigating this inshore traffic zone.

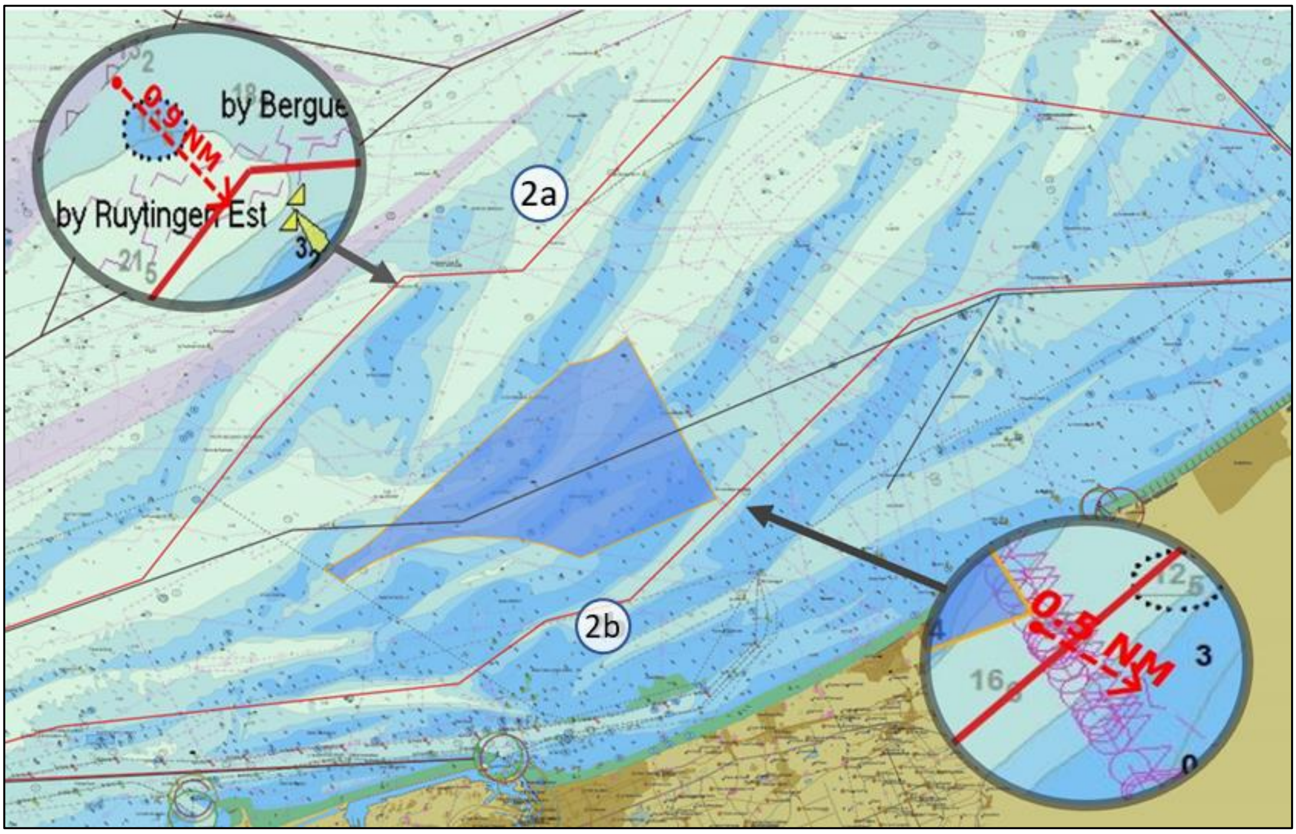


Figure 52: Alternative routeing Dunkerque OWF.

The benefit of the northern route 2a is that it ensures a depth > 5m at the Chart Datum and is lit by cardinal buoys. Again, we do not expect that a Master Mariner calling at Oostende for the first time will undertake the norther or southern alternative routes leaving the port and will most likely navigate through the English Channel TSSs. 2a should be recommended only to Masters with a reasonable knowledge of the surrounding waters.

7.3.4 NORTH EAST COAST OF THE NETHERLANDS

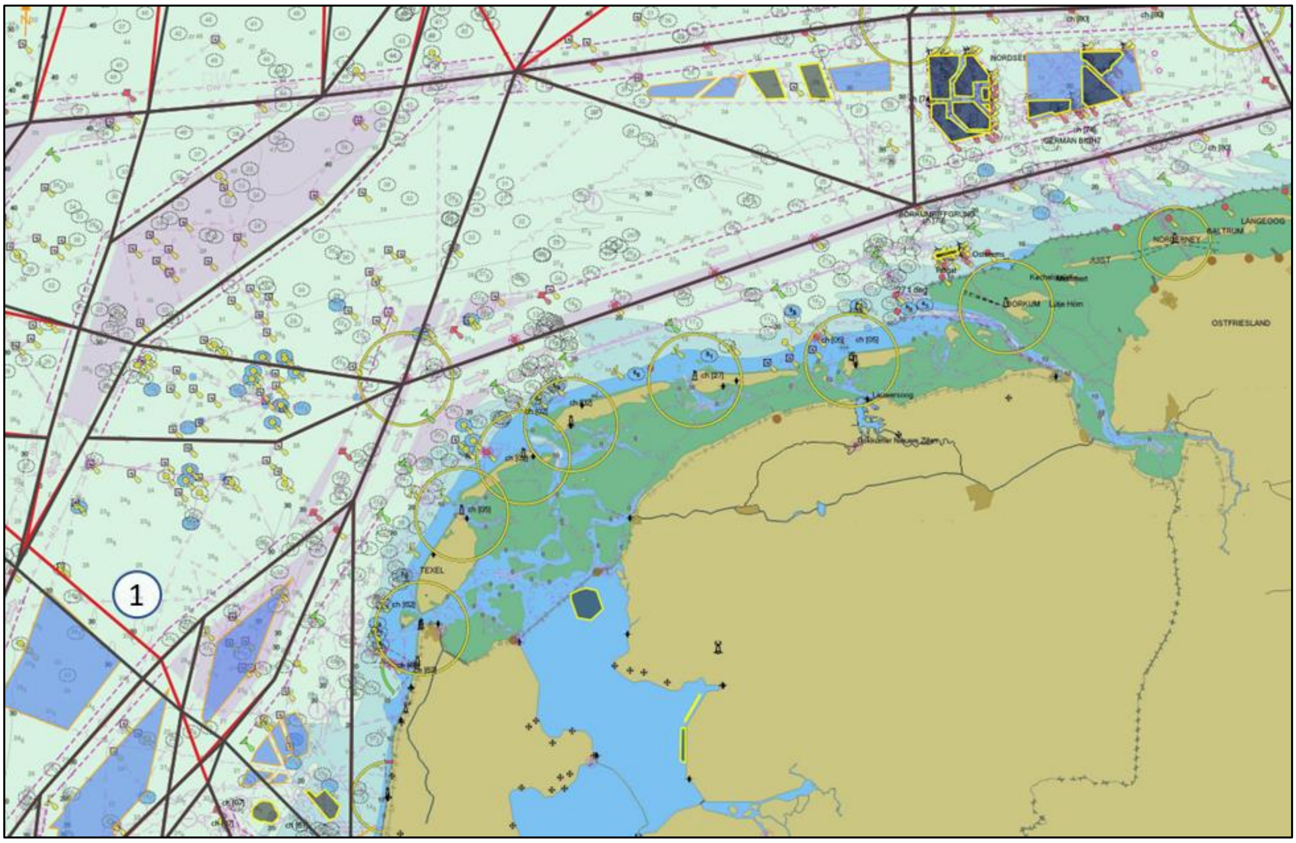


Figure 53: Northeast coast of Netherlands routeing changes.

Similarly to what described in section The English Channel & Southern section of the North Sea 7.3.3, the presence of Off North Friesland, Off Vlieland TSS to the North, the two deep-water routes to the West (Off Botney Ground and West Friesland TSS), and the Off Texel TSS to the East, converge the vast majority of the merchant traffic in defined routes that are not affected by the presence of planned future developments. The same applies for the corridors comprising the Terschelling-German Bight and German Bight western approach TSS. The expected future route adjustments are related to the vessels in-outbound Ijmuiden negotiating between Hollandse Kust West, Designated wind energy area 3 and Ijmuiden Ver Sites 1-4 whilst proceeding to/from UK ports (1).

7.3.5 NETHERLANDS, GERMANY, AND DENMARK EEZS

After the deployment of the expected OWFs in the German and Danish waters, the new footprint of the EEZs will widely affect the current marine traffic patterns generating a complex environment of corridors. As shown in Figure 54 the effect of the Danish and German OWF on the NE-SW direction is going to force traffic within certain boundaries, whilst the component NW-SE is almost shut by the future development and land reclamation areas at the West coast of Denmark.

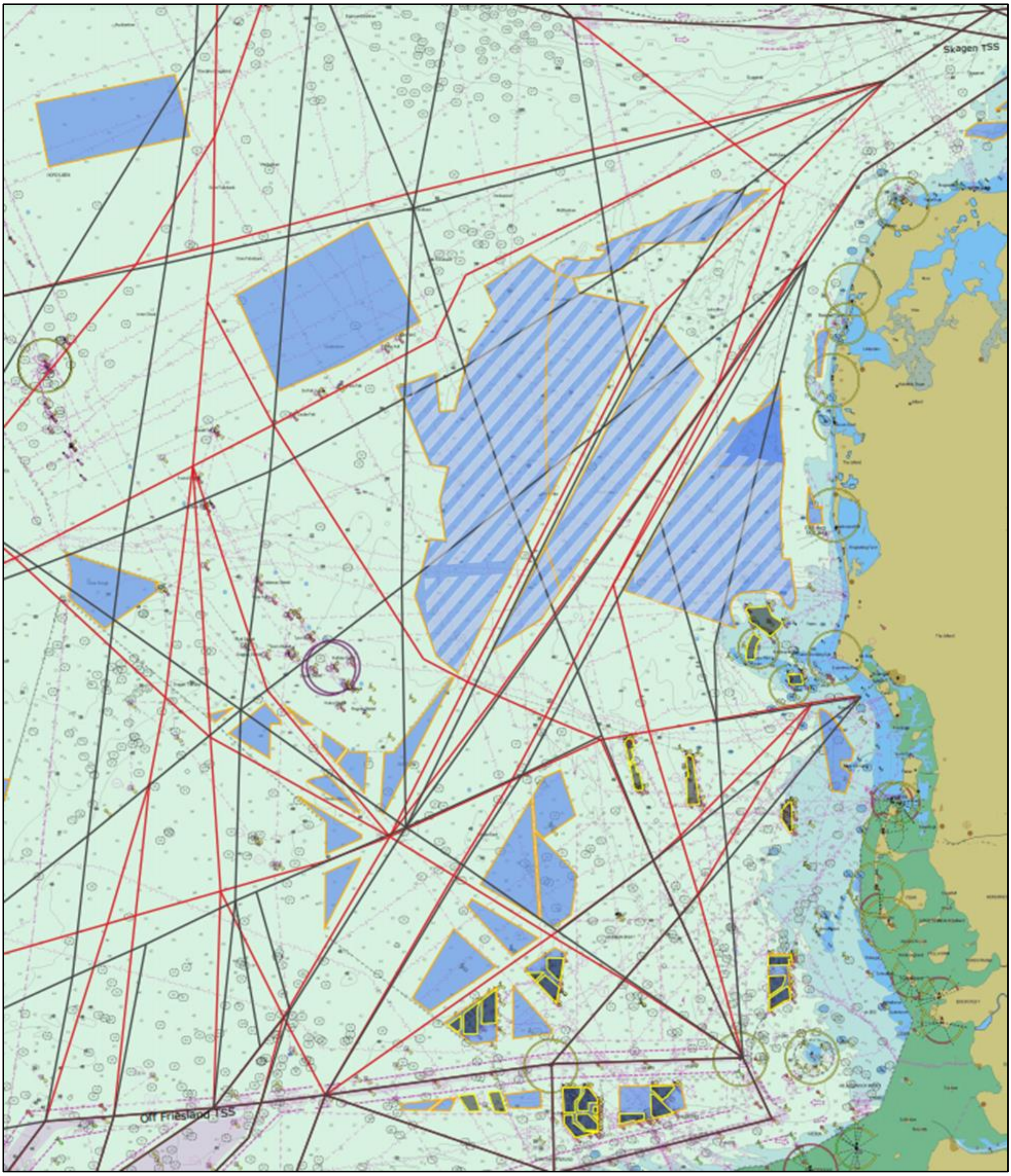


Figure 54: Re-routeing between Off Friesland TSS and Off Skagen TSS.

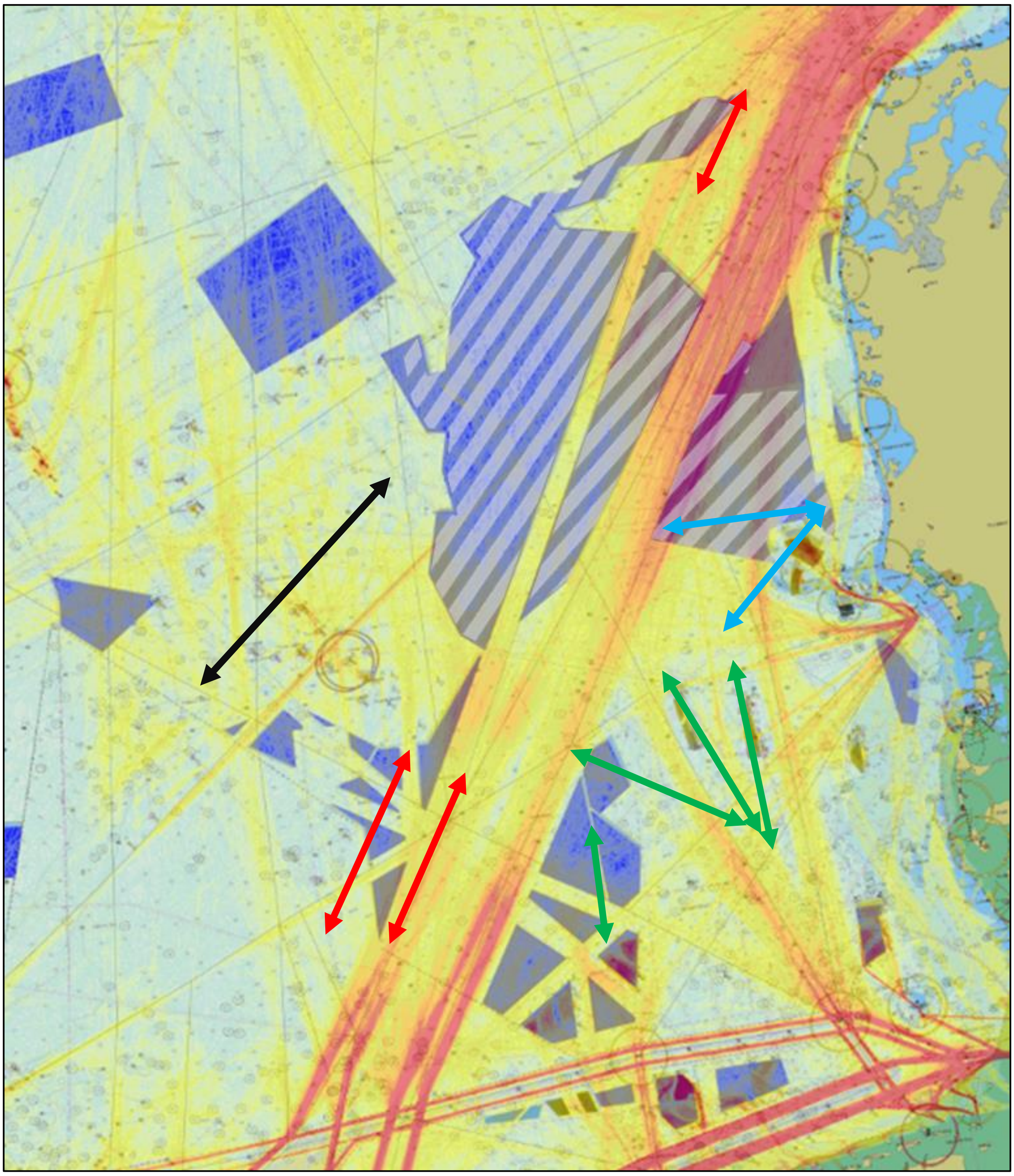


Figure 55: Traffic density map of German and Danish EEZs.

The traffic analysis requires an assessment of the existing traffic patterns. Figure 55 illustrates the traffic density indicating several main traffic components (coloured arrows) that are summarized as follows[6]:

[6] Traffic is assumed on a Northbound and Westbound direction for ease of reference only.

- (Red) traffic originated from the Channel, Belgium and Netherlands passing through Off Friesland TSS and heading towards Skagen TSS thence the Baltic Sea, this is the highest trafficked tracks of the area taken into consideration
- (Green) traffic originated from the ports in the German Bight (Delfzijl to the River Elbe ports) proceeding to Skagen TSS, Norway or UK ports
- (Blue) traffic originated from Esbjerg heading mainly towards Danish offshore facilities, then to UK ports and the Channel
- (Black) little component of traffic, mainly Ro-Ro, heading from Skagerrak to UK ports (river Humber)

The main traffic (red) is constrained by the North Friesland TSS at the South and the Skagen TSS at the North. The former comprises of the junctions of the Western deep-water route Off Botney Ground, forming parts of the Off Friesland routeing system, the recommended alternative route for tankers from North of Hinder to the German Bight (West Friesland) and the Vlieland North junction as prolongation of the Off Texel TSS on the East; the latter (Skagen TSS) include the designation of two recommended routes, Route A and Route B extending westward of the TSS, with Route A being the deep-water route with a least depth of 23 m as indicated by the Danish Maritime Authority.

The German future OWFs allow for several corridors on the NW-SE directions and a large corridor between 23 and 25 nm on the NE-SW orientation (corresponding to the passage known as Route 10). Danish OWF footprint, instead, accommodates only two corridors on the Route 10 north-easterly projection whilst does not allow for crossing in the north-westerly direction within the currently allocated renewables development areas. This forces the marine traffic to transit around the same. We are aware that the areas designated for the future installations of OWFs are not definitive and may indicate a wider and larger footprint of what will eventually be occupied. However, as explained earlier, in the present report we conservatively assume the given footprint in its entirety as an obstruction to the navigation.

By taking into account the main traffic component transiting between Friesland and Skagen, with the inclusion of the future developments, starting from the Skagen Route A and B, the easiest way to allocate traffic would be maintaining an imaginary connection between the deep-water routes south of Friesland and the deep-water Route A west of Skagen, as all are located towards the West of the observed area.

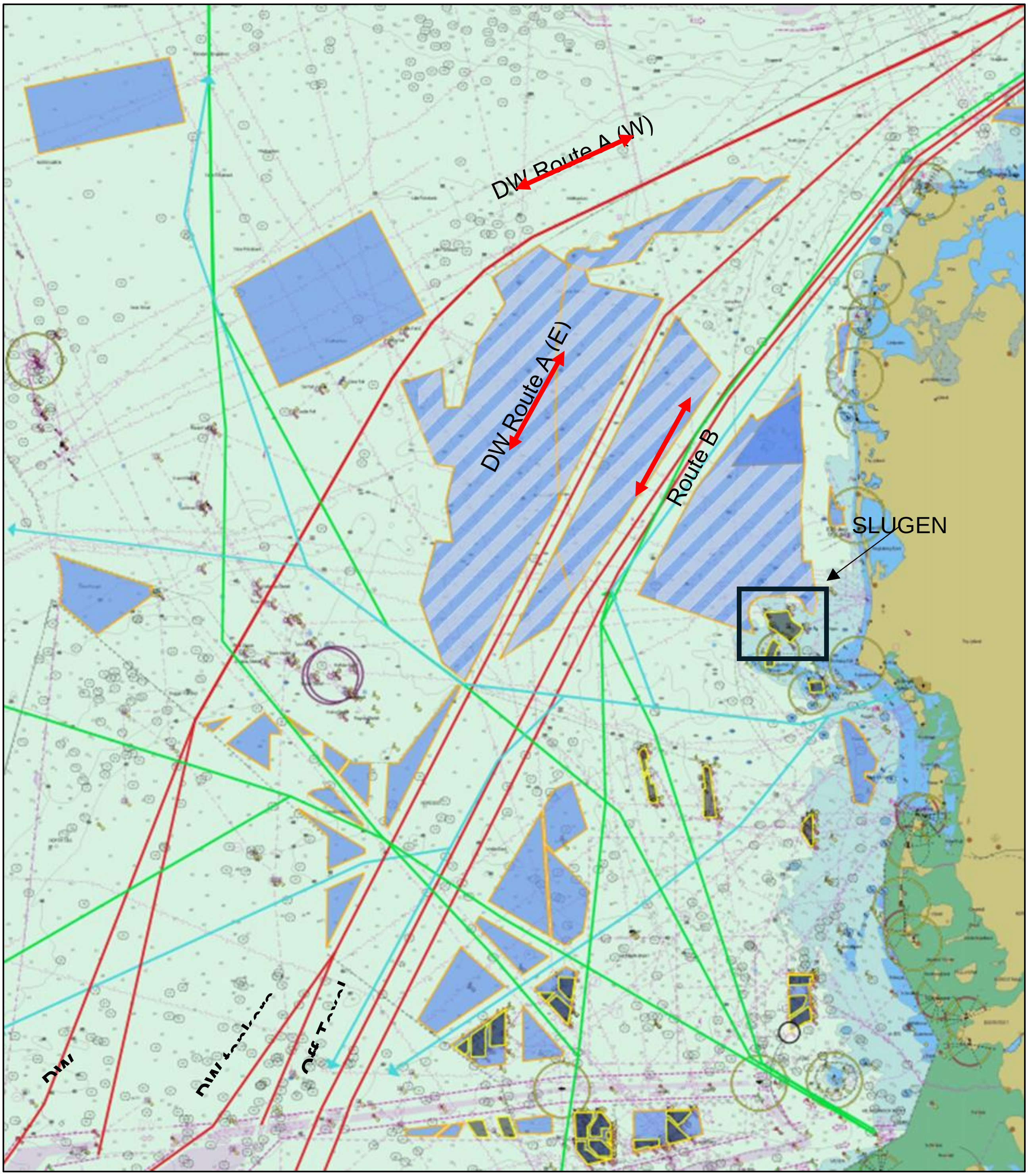


Figure 56: German Danish EEZs routeing following the introduction of the future OWF installations.

With reference to Figure 56 we can expect two separate deep-water routes to be followed by traffic on the Channel-Baltic Sea route from Off Friesland into joining Route A west of Skagen.

- Route A (W): deep-water (> 23 m) from Route A Off Skagen passing between Vest Nordsoen Large Island and Sorlige Nordsjo 2 developments and joining the western deep-water route of the south and west approach of Off Friesland
- Route A (E): deep-water (>23 m) Route A Off Skagen passing between Vest Nordsoen Large and Small Islands with a width of approximately 4 nm and 19 miles shorter than Rote A (W)

Route A (W) is longer 19 nm, which should correspond to an hour (an hour and a half at eco speed) of sea passage, with more room having the narrowest passage of 10 miles between the future Norwegian and Danish developments. We expect larger vessels transiting the west deep-water route south of Friesland will follow this track.

The deep-water Route A (E), despite being shorter, is constrained by the long passage in the channel generated between Nordsoen Large and Small Island – Nordsoen II (approximately 78 nm) with a width of approximately 4 nm. This is expected to be utilised by tankers as it is aligned with the crossing of Friesland by the mandatory route for tankers from North Hinder to the German Bight. Both deep-water routes include depths > 23 m as it is the least depth at mean low water springs indicated by the Danish Maritime Authority.

As depicted in the same figure, the second channel generated by the future OWF areas Nordsoen I and Nordsoen II in Danish waters is approximately 50 nm long and 9.7 nm wide, and it is expected to accommodate traffic between Off Texel TSS and Skagen TSS. This would include vessels calling Dutch and Belgian ports not proceeding on deep-water routes.

By looking at the chart showing the future developments, the main concern lays with the difference between the German corridor Route 10 splitting the traffic into two separate corridors in the Danish waters, requiring traffic to cross incurring in converging/diverging situations. In the attempt to identify the current area where traffic tends to alter course, a sample data was analysed observing the vessels' tracks for the month of June 2019 as illustrated in Figure 57.

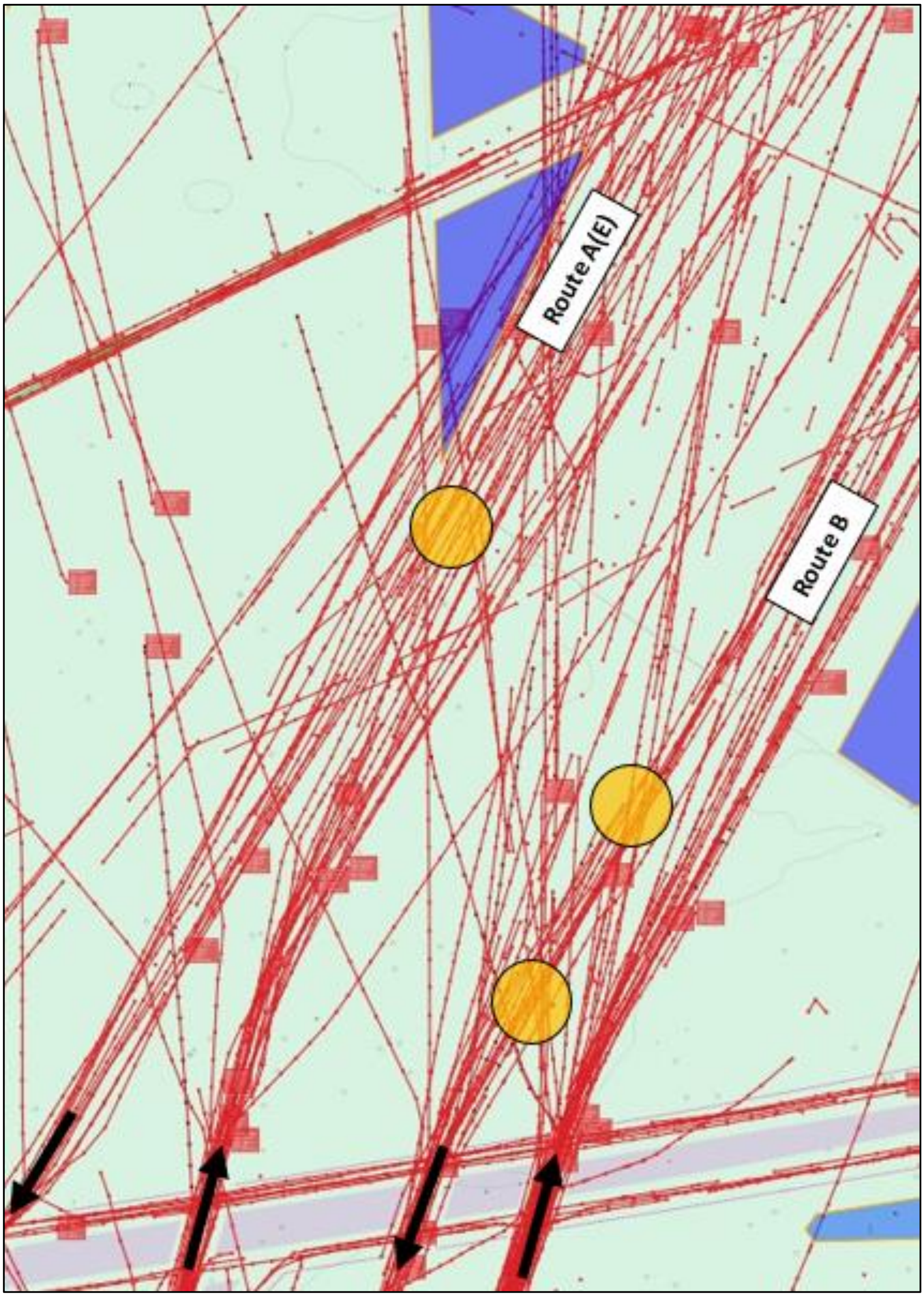


Figure 57: Sample of vessels' tracks at the southern approach of Route 10

Orange circles in Figure 57 depict the area where the current traffic crosses. Although the quality of data, as it can be seen by the intervals in the plots, evidences some gaps along the tracks, the traffic pattern is identified, and it represents a clear indication of where ships generally alter their course after leaving the North Friesland TSS.

Another important aspect, in the same figure, is the distribution of the traffic across Route A (E) and Route B. Tracks in Route A (E) are distributed in approximately 6.5 nm and tracks in Route B are spread across in approximately between 5 and 6 nm wide.

For the latter, the channel between Nordsoen I and Nordsoen II lays with similar alignment of the current traffic pattern and it is approximately 4 nm wider, this would suggest that the Route B can easily accommodate the marine traffic on the Friesland-Skagen direction.

For Route A (E) other considerations are required, the distance between the Danish developments is approximately 4 nm, therefore 2.5 miles shorter than the traffic pattern cross section. However, the South/Northbound entrances of the North Friesland TSS are 9 nm apart, thus the OOW is currently adjusting the course accordingly in order to align with the TSS entrance/exit. In addition, another aspect is the sparsity of the tracks on the western NE-SW route compared to those of 'Route B'. Moreover, as explained above, we expect a number of deep-water, and therefore larger vessels, passing westward of the Danish installations (along DW Route A (W) of Figure 56).

Based on the above considerations, the channel between Vest Nordsoen Large and Small Islands appears to have enough room to allocate the NE-SW traffic in Route A (E), considering also that the traffic along Route A (E) computed in the work package 1, resulted to be half of the traffic along Route B.

Further to the above, traffic from the German Bight will be transiting the corridors formed subsequent to the deployment of the OWFs in German waters, crossing the main artery of traffic Friesland-Skagen. The crossing should occur in dedicated areas, to be determined on the results of more thorough studies, similarly for the traffic Esbjerg/Hamburg-North Sea (green dashed line in Figure 58). In the latter it is included the traffic from/to Hamburg being the passage 20 nm shorter than the transit along the German OWFs.

We expect that with routeing recommendations and assuming that the Danish OWFs footprint in 2040 is that represented in work package 2, the traffic ex North Friesland crossing transiting Route 10 is directed to Skagen TSS (mainly), thus adjustments of the routeing can be adopted by the OOWs North of Off Friesland TSS, moreover the traffic that necessitates to cross between Route A and Route B is deep draught vessels requiring depth over 14m on the Skagen-Texel route. This crossing adjustment (aligning therefore with the intended route from B to A) can take place North of Nordsoen installations since the depth within the Danish developments is well above the least depth of Route A (23m).

Figure 58 depicts the routeing alternative based on the above considerations, however, an accurate quantitative and qualitative assessment of the traffic and available room is recommended for both Route A (E) and Route B.

It is noteworthy to mention that the option presented in the figure overleaf is not the only and definitive one, several other routeing recommendations may be applicable to the same stretch of North Sea (such as establishing a dedicated route for dangerous cargo and therefore directing a defined typology of vessels on certain tracks, establishing a TSS at Route 10, establishing two separate equal corridors NE-SW in German and Danish waters, etc).

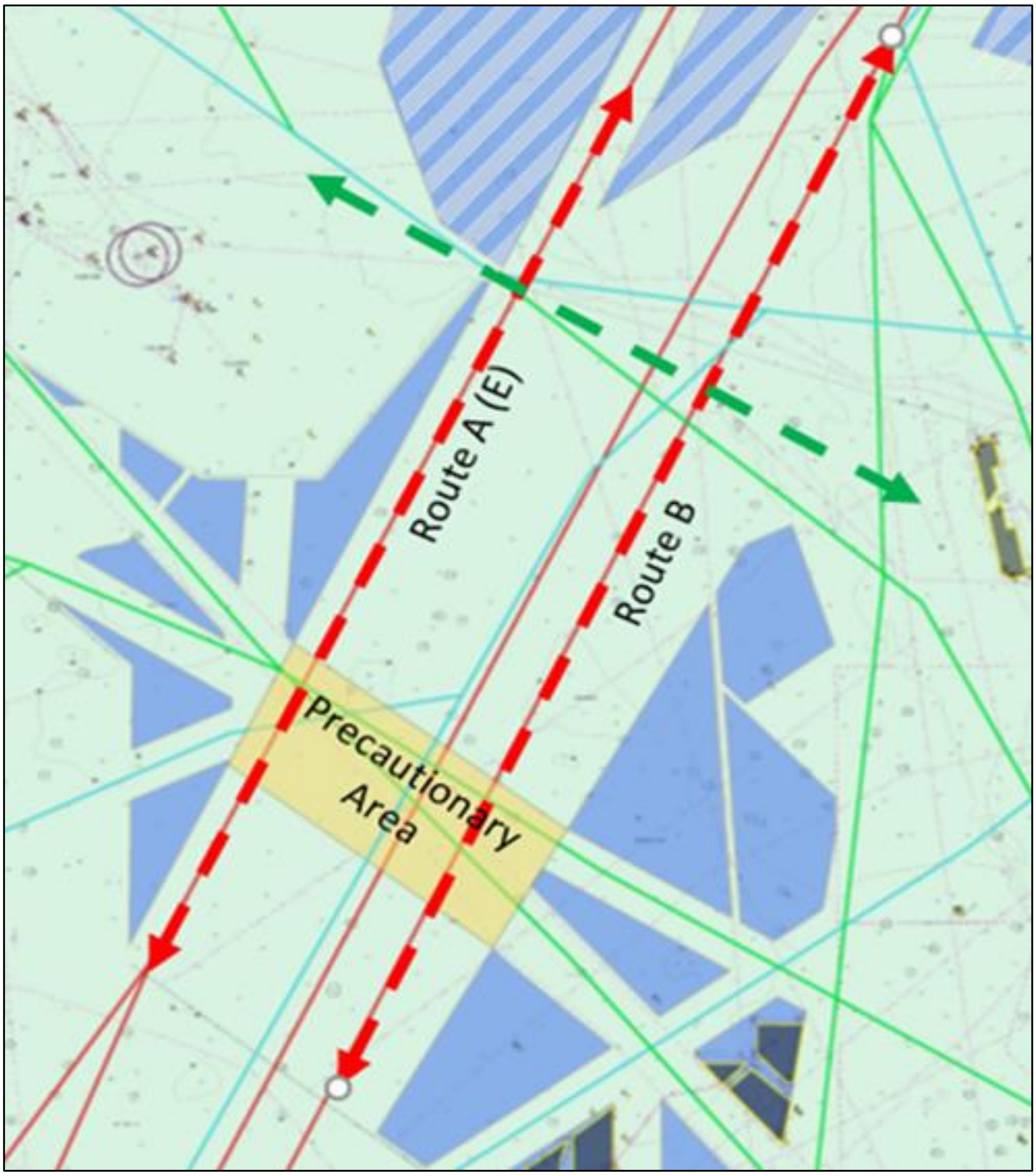


Figure 58: Routeing alternative following installation of German and Danish OWFs.

The currently considered footprint of the Danish developments will virtually close the coastal N-S bound route along the West coast of Denmark, with most of that traffic re-routeing to Route 10. Consequently, there will be a single feasible alternative for traffic, with limited draught, along the

Slugen off Blavandshuk. The Slugen is a natural channel marked with aids to navigation located approximately 6 nm NW of Esbjerg Pilot Station. It shows a depth above 14 m and a width of seven cables (see Figure 59).

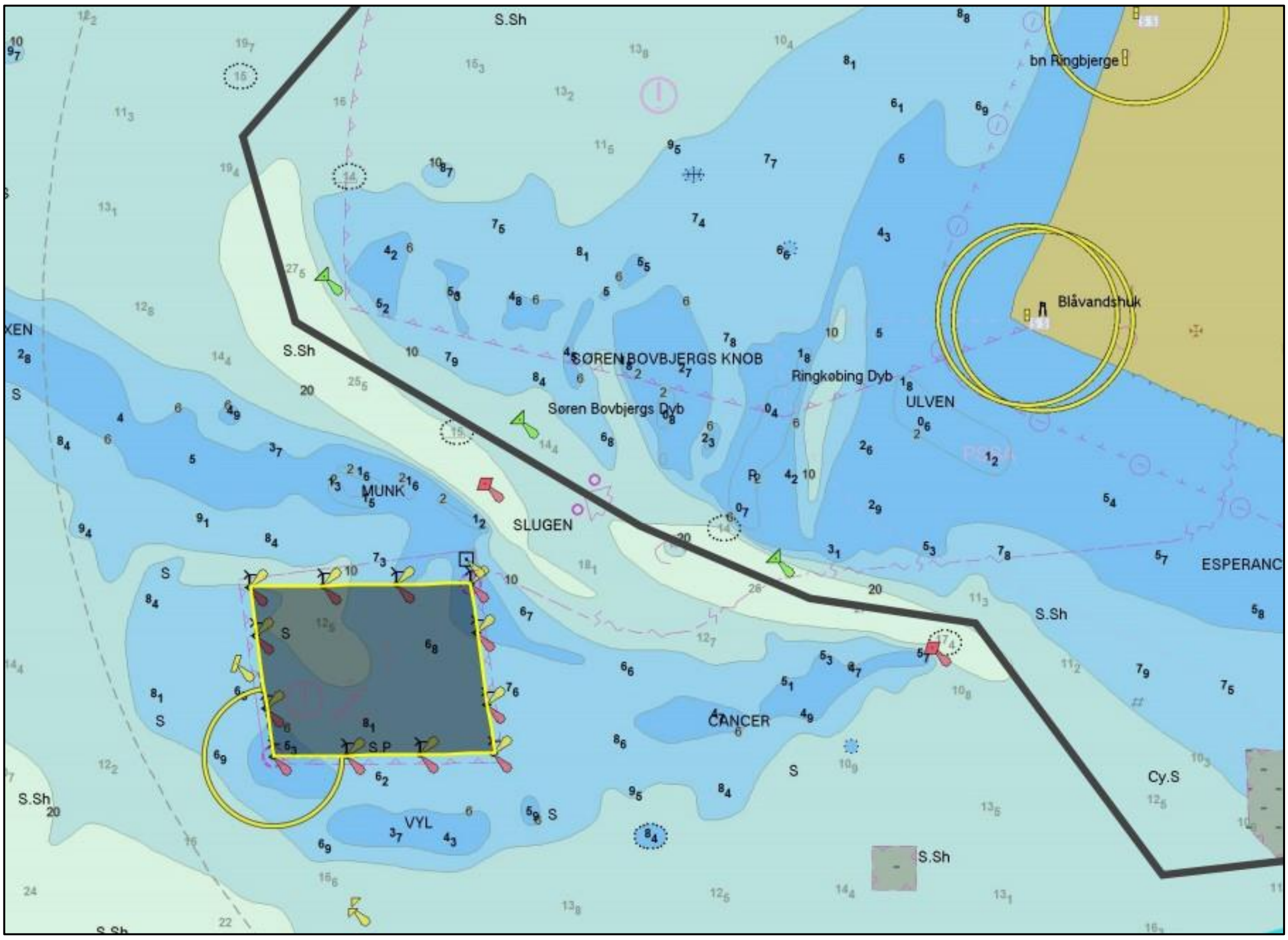


Figure 59: The Slugen - Routeing alternative for coastal traffic north of Esbjerg.

Another item of interest is the restricted passage created by the deployment of German and Danish OWFs at the EEZ border. Between the Nordsoen Large Island and the EN-16 development, the passage generated is only 1.4 nm wide, which appears to be enough for the current and future traffic projected. This passage is expected to be utilised by the ships calling at Esbjerg, therefore mainly work vessels, and those calling at ports in the river Elbe and subsequently heading to the North Sea. However, in the case of a potential significant increase in the Northern Sea Route traffic, particularly of large container vessels calling Hamburg, for instance, the narrow passage as shown in Figure 60 may not be sufficient and would thus require further assessment and potential mitigation.

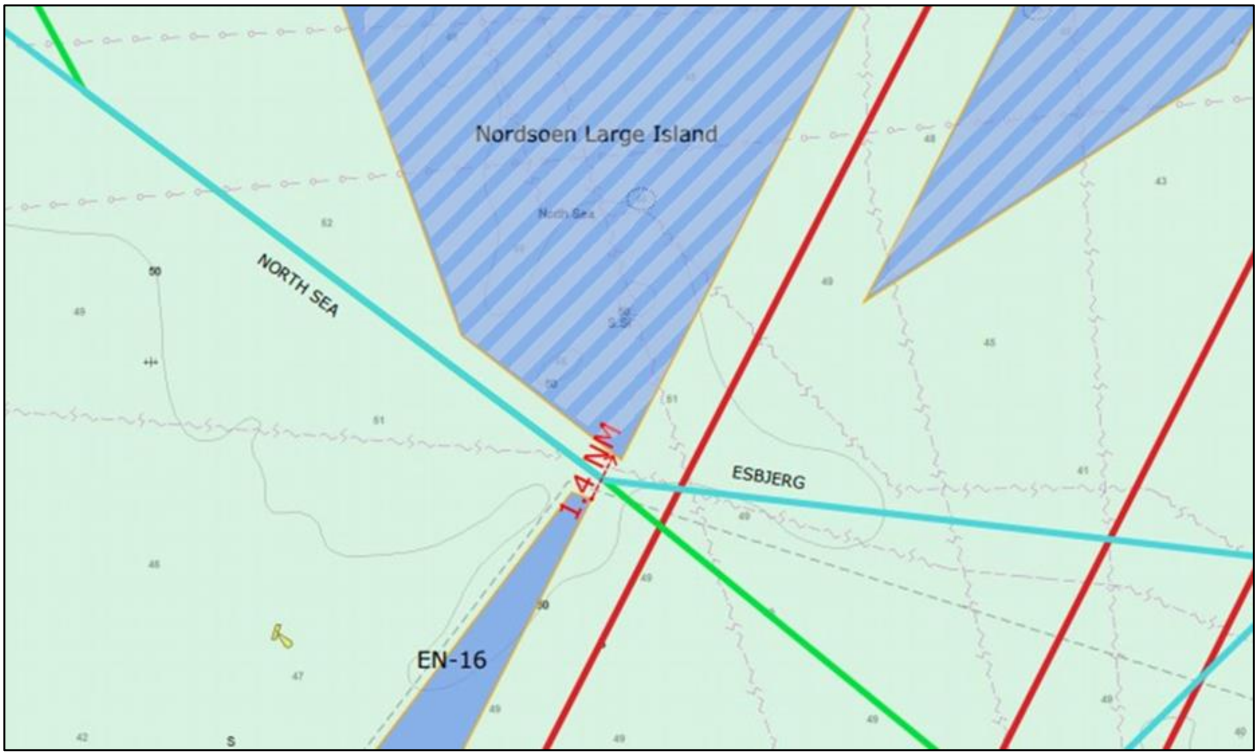


Figure 60: Narrow passage between German and Danish OWFs at the EEZ border.

7.3.6 SOUTHERN NORWAY AND THE SKAGERRAK

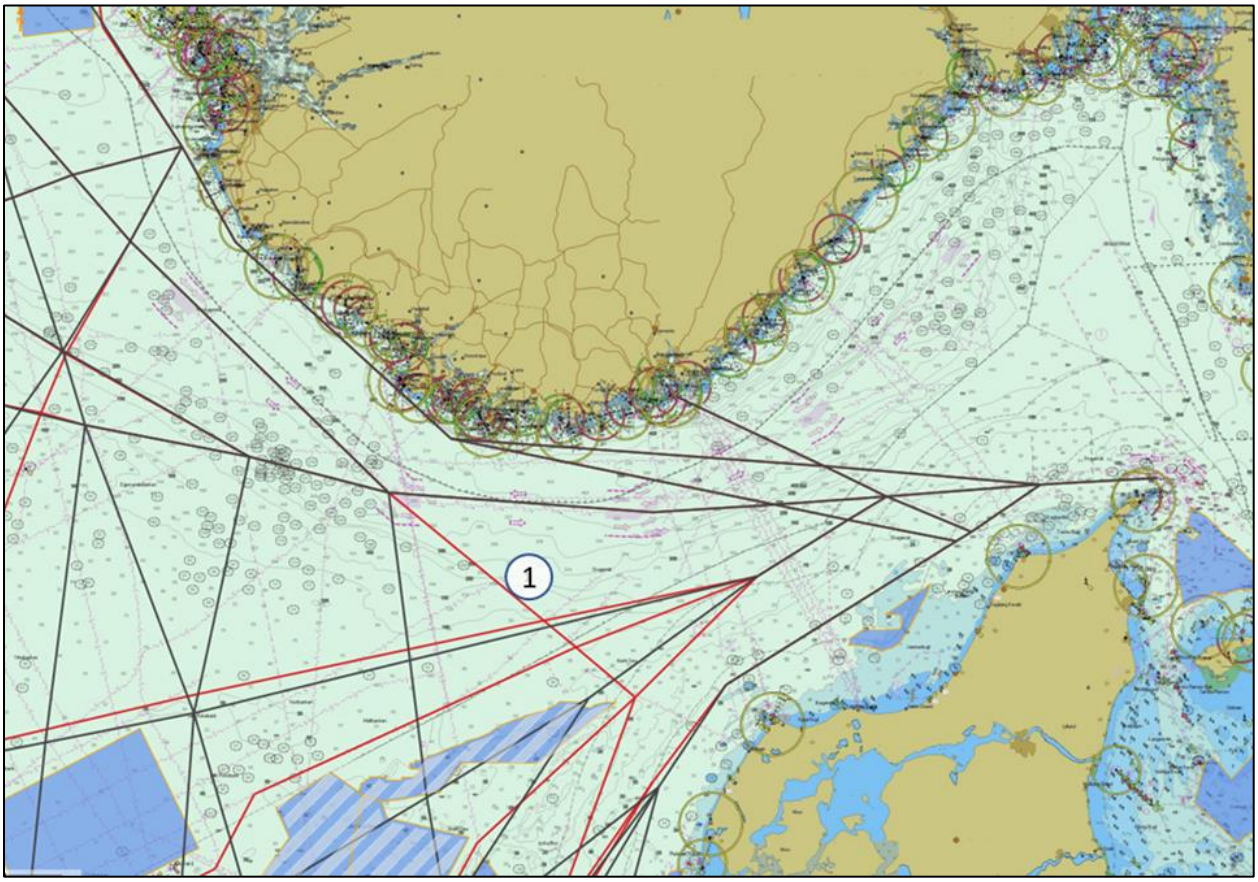


Figure 61: Southern Norway and the Skagerrak routeing changes.

Southern Norway and the Skagerrak will not be significantly affected by new OWFs, and the only notable diversion is caused by the Danish Nordsoen II area which will forces vessels coming form/to Off Farsund TSS and to/from the German Bight to keep the OWF on the West, increasing the passage length by approximately 34 nm.

7.3.7 NORTHERN SEA ROUTE (NSR)

The transpolar marine traffic between Asia and Europe is expected to increase on a year-by-year basis as the current trend indicates. The decline of the Arctic ice and the expectation for significant oil and gas discoveries in the Arctic seas, together with the consolidation of present routes from and to the far east, indicate the potential for a net magnification of the current traffic crossing the North Sea ports destined to Arctic areas.

The planned developments in the Danish, German, and Norwegian EEZs (and potentially the Dutch) will require a consolidation of this crossing N-S traffic that currently spreads across the area to the North of the North Friesland TSS into a better defined traffic corridor. This crossing will take place between the Off Friesland and Off Utsira TSSs.

In **Error! Reference source not found.** it can be seen how the traffic will adapt to the new i nstallations transiting in the bottle neck between the Sorlige Nordsjo 1 and 2 and the German development areas EN19 – EN17 (see green tracks in **Error! Reference source not found.**). There a re a number of oil rigs located at the dogger tail end at the northern part of the Dutch EEZ, which might require some little adjustment for the navigating officer, however, the overall space is enough to accommodate the increased marine traffic. The narrowest section of this corridor between the German development areas EN 19 and EN 17 is in the order of 25 miles.

Vessels to the German Bight will be required to follow the corridors between OWFs in German EEZ, and then join the main N-S artery towards the Off Utsira TSS.

The option for vessels to be transiting the Danish waters on their way to Elba, keeping the Danish offshore installation to the south (red track in **Error! Reference source not found.**) it does not a ppear to be optimal as it is approximately 17 nm longer than the corresponding route transiting through the German EEZ (green route).

Although there is currently not enough evidence to support an accurate forecast of the expected traffic volumes along the North Sea Route, the projected footprint of the offshore renewable energy installations expected for the next two decades does not seem to negatively influence a potential increase of the shipping traffic on the transpolar route within this period.

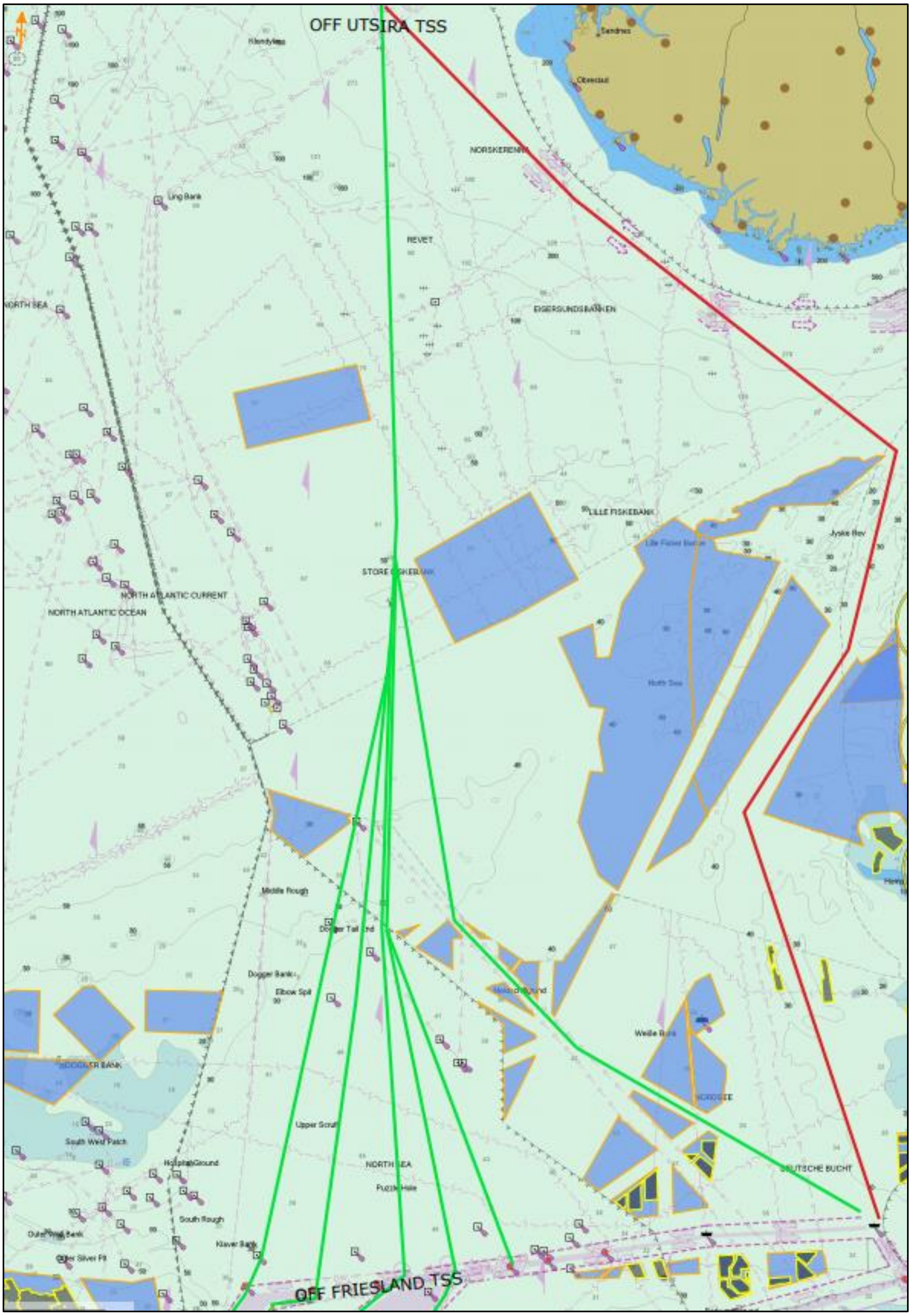


Figure 62: Northern Sea Route with future OWFs.

9 REFERENCES

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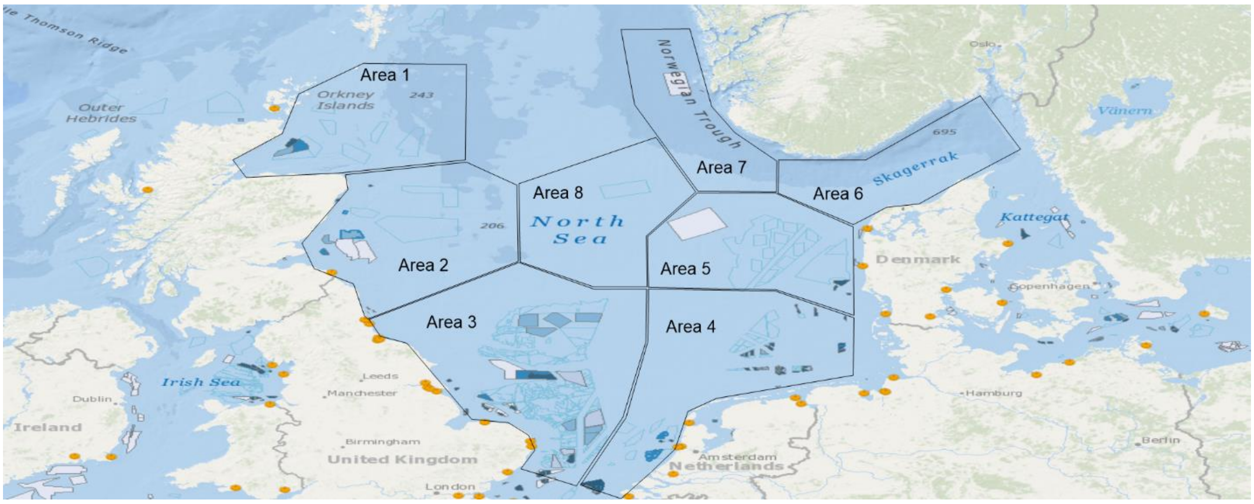
APPENDIX A

Metocean Analysis Results

As the metocean conditions in different parts of the North Sea differ, for the purpose of this assessment the North Sea area was split into 8 different areas with similar metocean characteristics, and the metocean parameters were derived from each. These areas are presented in the figure below:



The pages that follow, provide the annual frequencies and directionality associated with the currents, winds, and significant wave heights for each of the aforementioned areas.

Metocean Data, Area 1

Dir (°N)	Current (m/s) - Annual											
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**	**>1.0**	**TOT.**
0	2.24	2.69	0.82	0.12	0.01	*						5.89
45	1.85	1.31	0.24	0.06	0.02	*						3.47
90	2.52	3.80	4.03	3.61	1.92	0.72	0.17	0.03	*	*		16.80
135	3.30	7.90	6.26	3.11	1.27	0.46	0.16	0.03	0.02		*	22.49
180	3.51	6.58	3.12	0.57	0.09	0.02	0.01	*				13.92
225	3.37	4.79	1.47	0.31	0.07	0.01	*					10.02
270	3.24	6.21	4.03	1.72	0.38	0.06	0.01	*				15.64
315	2.97	5.55	2.60	0.56	0.08	0.01	*					11.77
TOT.	22.99	38.83	22.58	10.05	3.85	1.28	0.34	0.06	0.02	*	*	100.00

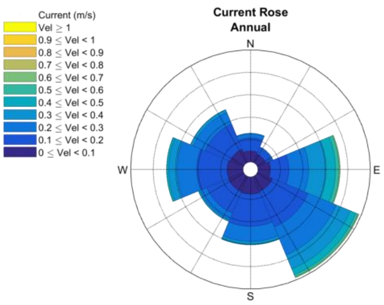
* Value lower than 0.01 %

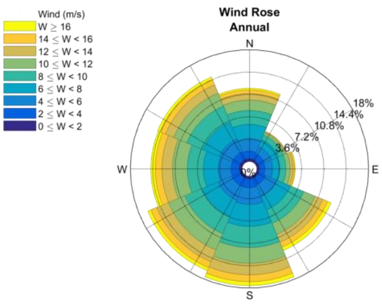
Dir (°N)	W (m/s) - Annual															
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**	**14.0**	**16.0**	**18.0**	**20.0**	**22.0**	**24.0**	**26.0**	**28.0**	**30.0**	**>30.0**	**TOT.**
0	0.46	1.27	2.01	2.34	2.22	1.64	1.01	0.56	0.21	0.05	0.01	*					11.77
45	0.40	1.04	1.27	1.22	0.80	0.35	0.16	0.08	0.02	0.01							5.34
90	0.39	0.95	1.24	1.16	0.95	0.69	0.42	0.24	0.09	0.03	0.01	*					6.17
135	0.44	1.24	1.95	2.45	2.33	1.93	1.32	0.82	0.37	0.17	0.04	*					13.06
180	0.44	1.49	2.75	3.56	3.37	2.50	1.83	1.07	0.43	0.13	0.04	0.01					17.60
225	0.44	1.52	2.41	2.82	3.03	2.84	1.99	0.97	0.39	0.10	0.01	0.01	*				16.53
270	0.45	1.41	2.09	2.41	2.58	2.36	1.69	1.02	0.46	0.16	0.04	0.01	0.01				14.69
315	0.49	1.39	2.30	2.88	2.83	2.23	1.41	0.80	0.36	0.12	0.03	0.01					14.84
TOT.	3.50	10.30	16.02	18.85	18.10	14.54	9.83	5.56	2.34	0.75	0.18	0.04	0.01				100.00

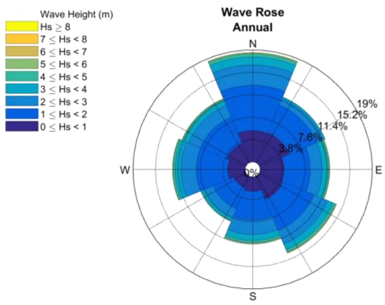
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																				
	0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**	**>10.0**	**TOT.**
0	1.08	4.33	4.40	3.26	2.11	1.29	0.83	0.52	0.32	0.18	0.11	0.07	0.03	0.01	0.01	0.01	*	*				18.56
45	1.25	4.24	3.40	1.62	0.74	0.37	0.19	0.11	0.04	0.02	0.01	*		*	*							11.98
90	0.88	3.18	2.63	1.84	1.20	0.77	0.50	0.32	0.21	0.12	0.07	0.04	0.02	0.01	0.01	*	*	*	*			11.82
135	0.80	3.48	3.39	2.29	1.54	0.94	0.61	0.41	0.24	0.15	0.09	0.05	0.04	0.03	0.02	0.01	0.01	*				14.10
180	0.32	2.17	2.83	2.04	1.44	0.94	0.62	0.40	0.23	0.13	0.07	0.03	0.02	0.01	0.01	*	*	*				11.25
225	0.33	1.85	2.21	1.58	1.02	0.60	0.33	0.16	0.09	0.05	0.03	0.01	0.01	*	*	*						8.27
270	0.52	2.48	2.99	2.33	1.61	0.98	0.62	0.35	0.20	0.12	0.07	0.03	0.01	0.01	0.01	*	*					12.31
315	0.70	2.83	2.70	2.09	1.38	0.79	0.49	0.31	0.19	0.11	0.05	0.03	0.02	0.01	0.01	0.01	*	*				11.71
TOT.	5.89	24.56	24.54	17.05	11.05	6.67	4.19	2.59	1.51	0.87	0.49	0.26	0.14	0.09	0.05	0.03	0.01	0.01	*			100.00

* Value lower than 0.01 %







Metocean Data, Area 2

Dir (°N)	Current (m/s) - Annual											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	1.43	1.37	0.36	0.09	0.02	0.01						3.28
45	2.03	4.16	3.47	1.75	0.52	0.11	0.03	0.01				12.06
90	2.59	7.89	9.18	5.98	2.42	0.56	0.09	0.01	*			28.74
135	2.38	4.13	2.18	0.77	0.24	0.06	0.02	*				9.78
180	2.46	3.38	1.47	0.36	0.11	0.03	0.02	*				7.84
225	2.77	6.68	6.00	2.69	0.68	0.15	0.04	0.01	*		*	19.01
270	2.46	5.73	4.86	2.06	0.38	0.06	*					15.55
315	1.65	1.63	0.38	0.06	0.01							3.73
TOT.	17.78	34.96	27.91	13.76	4.38	0.98	0.19	0.04	0.01		*	100.00

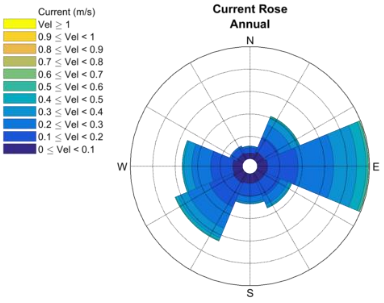
* Value lower than 0.01 %

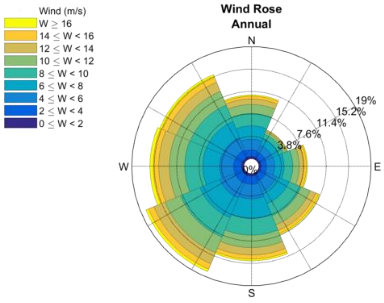
Dir (°N)	W (m/s) - Annual																
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	0.39	1.18	1.84	2.26	2.06	1.48	0.90	0.46	0.17	0.03	0.01						10.77
45	0.35	1.02	1.27	1.15	0.82	0.42	0.22	0.11	0.03	0.01	*						5.39
90	0.36	0.98	1.40	1.61	1.46	1.09	0.71	0.48	0.15	0.02	*						8.24
135	0.36	1.19	1.95	2.25	2.19	1.63	1.01	0.51	0.17	0.04	*						11.29
180	0.42	1.44	2.53	3.26	2.88	2.05	1.24	0.65	0.22	0.06	0.01	*					14.77
225	0.43	1.49	2.78	3.63	3.54	2.83	1.98	0.94	0.33	0.09	0.03	0.01	*				18.08
270	0.40	1.40	2.40	2.91	3.03	2.55	1.78	0.89	0.38	0.11	0.03	0.01	*				15.90
315	0.40	1.36	2.36	2.95	3.02	2.48	1.63	0.88	0.35	0.10	0.02	0.01					15.56
TOT.	3.12	10.07	16.52	20.01	19.00	14.54	9.47	4.92	1.79	0.45	0.10	0.02	*				100.00

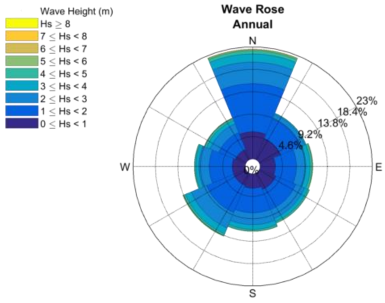
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																					
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	0.80	4.88	5.65	4.22	2.72	1.65	1.00	0.66	0.39	0.25	0.12	0.08	0.05	0.03	0.01	0.01	*	*	*		*	22.52
45	1.15	3.53	2.85	1.50	0.66	0.31	0.13	0.07	0.05	0.02	0.01	*	*	*	*							10.27
90	0.67	2.47	2.48	1.83	1.18	0.74	0.52	0.35	0.25	0.16	0.08	0.04	0.02	0.01	*	*	*					10.80
135	0.75	2.91	2.60	1.80	1.16	0.77	0.45	0.27	0.17	0.09	0.06	0.03	0.02	0.01	*							11.06
180	0.46	2.51	2.85	2.18	1.46	0.95	0.60	0.35	0.21	0.10	0.05	0.03	0.02	0.01	*							11.77
225	0.35	2.37	3.24	2.77	2.05	1.37	0.82	0.48	0.24	0.14	0.07	0.05	0.02	0.01	*	*	*		*			13.98
270	0.36	2.32	2.67	2.01	1.29	0.81	0.44	0.23	0.12	0.07	0.04	0.02	0.01	*	*		*					10.39
315	0.36	1.93	2.07	1.64	1.20	0.74	0.50	0.30	0.20	0.13	0.06	0.04	0.02	0.01	0.01	0.01	0.01	*				9.21
TOT.	4.89	22.92	24.40	17.94	11.72	7.34	4.46	2.70	1.61	0.95	0.49	0.28	0.15	0.09	0.04	0.02	0.02	0.01	*		*	100.00

* Value lower than 0.01 %







Metocean Data, Area 3

Dir (°N)	Current (m/s) - Annual											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	1.28	3.85	4.31	2.95	1.45	0.55	0.15	0.05	0.02	0.01	*	14.62
45	1.30	2.41	1.45	0.64	0.19	0.05	0.01	*	*			6.05
90	1.29	3.20	2.87	1.40	0.45	0.07	0.01	*				9.29
135	1.46	4.86	7.53	6.44	3.71	1.62	0.69	0.24	0.07	0.02	*	26.63
180	1.21	3.37	3.51	1.98	0.81	0.29	0.09	0.04	0.01		*	11.31
225	1.05	1.97	1.34	0.49	0.07	0.01	*					4.93
270	1.07	2.37	1.76	0.73	0.18	0.02	*					6.12
315	1.32	4.22	6.04	5.20	2.98	0.99	0.24	0.05	*	*		21.05
TOT.	9.98	26.25	28.81	19.83	9.82	3.59	1.20	0.38	0.09	0.03	0.01	100.00

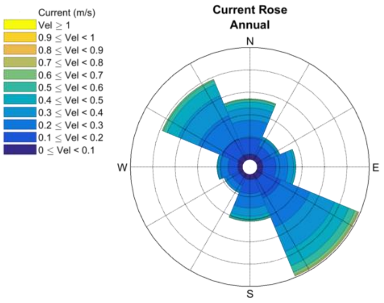
* Value lower than 0.01 %

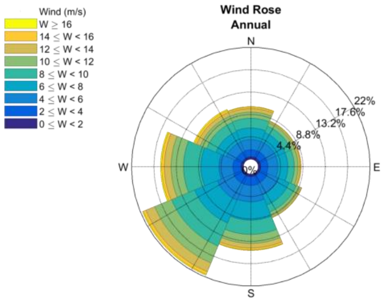
Dir (°N)	W (m/s) - Annual																
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	0.50	1.44	2.03	2.28	1.88	1.17	0.66	0.29	0.08	0.01	*						10.33
45	0.50	1.48	1.99	1.90	1.31	0.67	0.27	0.10	0.03	0.01							8.26
90	0.51	1.44	2.03	1.92	1.23	0.73	0.38	0.16	0.03	*							8.41
135	0.54	1.67	2.41	2.19	1.44	0.76	0.28	0.09	0.02	*							9.40
180	0.51	1.84	3.27	3.58	2.75	1.75	0.87	0.34	0.08	0.02	*						15.00
225	0.51	1.82	3.54	4.86	4.88	3.51	1.79	0.53	0.13	0.03	0.01						21.61
270	0.52	1.64	2.80	3.58	3.37	2.38	1.27	0.51	0.17	0.03	0.01						16.27
315	0.47	1.40	1.98	2.21	1.96	1.32	0.76	0.42	0.17	0.04	*						10.72
TOT.	4.07	12.72	20.05	22.51	18.82	12.27	6.28	2.43	0.71	0.13	0.02						100.00

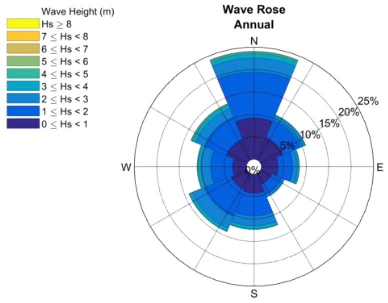
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																					
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	1.84	7.48	6.56	3.61	2.00	1.05	0.62	0.37	0.22	0.14	0.07	0.04	0.02	0.01	0.01	*		*				24.03
45	1.54	3.89	2.76	1.39	0.62	0.31	0.16	0.09	0.04	0.02	0.01	0.01	*	*								10.83
90	1.07	2.66	2.08	1.15	0.66	0.39	0.23	0.12	0.07	0.04	0.01	0.01	*									8.48
135	0.70	1.89	1.45	0.83	0.45	0.21	0.11	0.04	0.01	0.01	*	*										5.71
180	0.85	3.44	2.98	2.08	1.35	0.83	0.44	0.23	0.10	0.04	0.02	0.01		*								12.35
225	0.71	3.19	3.53	2.86	1.84	1.07	0.48	0.19	0.07	0.04	0.01	*	*									14.00
270	0.59	2.54	2.80	2.07	1.37	0.80	0.42	0.23	0.11	0.06	0.02	0.01	*	*								11.01
315	1.11	3.82	3.29	2.11	1.30	0.80	0.51	0.31	0.16	0.09	0.05	0.03	0.01	*	*							13.59
TOT.	8.41	28.89	25.45	16.10	9.60	5.44	2.97	1.57	0.79	0.43	0.20	0.10	0.04	0.01	0.01	*		*				100.00

* Value lower than 0.01 %







Metocean Data, Area 4

Dir (°N)	Current (m/s) - Annual											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	2.00	5.71	7.75	7.19	5.04	2.66	1.09	0.35	0.08	0.02	*	31.88
45	1.81	3.31	2.57	1.70	1.09	0.65	0.36	0.18	0.07	0.02	0.01	11.77
90	1.88	2.58	1.13	0.44	0.21	0.07	0.02	*	*	*		6.34
135	2.15	4.40	2.81	1.53	0.74	0.31	0.06	0.01				12.01
180	2.08	5.31	6.16	5.29	3.65	2.07	0.78	0.16	0.02			25.51
225	1.33	1.42	0.63	0.33	0.16	0.06	0.02	0.01	*			3.95
270	1.15	0.76	0.11	0.03	*							2.04
315	1.72	2.63	1.46	0.52	0.15	0.03	*					6.51
TOT.	14.11	26.10	22.63	17.03	11.04	5.83	2.34	0.71	0.16	0.04	0.01	100.00

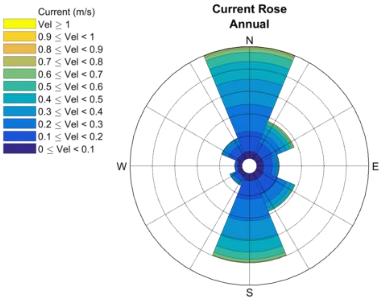
* Value lower than 0.01 %

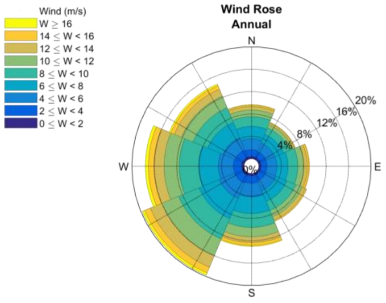
Dir (°N)	W (m/s) - Annual																
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	0.41	1.27	1.98	2.20	1.71	1.14	0.60	0.24	0.05	0.01	*						9.62
45	0.39	1.16	1.69	1.67	1.20	0.62	0.30	0.11	0.03	0.01							7.17
90	0.38	1.13	1.77	1.99	1.73	1.03	0.61	0.31	0.06	*							9.01
135	0.39	1.22	1.91	2.08	1.74	1.17	0.60	0.21	0.04	*	*						9.33
180	0.38	1.43	2.49	2.97	2.43	1.65	1.00	0.47	0.14	0.03	0.01	*					13.00
225	0.43	1.60	3.02	3.94	3.92	3.18	2.19	1.05	0.34	0.06	0.02	*	*				19.75
270	0.44	1.55	2.74	3.55	3.43	2.65	1.76	0.94	0.39	0.11	0.02	*	*				17.57
315	0.43	1.46	2.41	2.98	2.83	2.17	1.33	0.65	0.23	0.06	0.01	*					14.55
TOT.	3.23	10.81	18.02	21.37	18.98	13.61	8.38	3.98	1.27	0.28	0.06	0.01	*				100.00

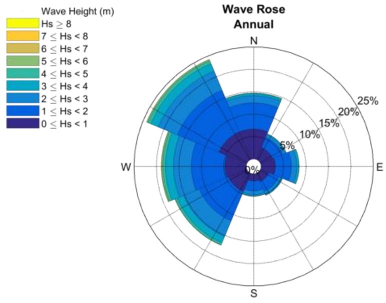
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																					
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	1.45	5.26	3.78	1.99	1.01	0.57	0.29	0.15	0.08	0.03	0.01	0.01	*	*								14.62
45	0.75	2.16	1.55	0.86	0.44	0.21	0.14	0.07	0.02	0.01	0.01	0.01	*	*								6.22
90	0.73	2.45	2.25	1.31	0.75	0.46	0.30	0.15	0.06	0.01	*											8.47
135	0.46	1.54	1.48	0.88	0.48	0.28	0.12	0.05	0.02	*	*											5.29
180	0.30	1.27	1.30	0.88	0.57	0.31	0.16	0.08	0.03	0.01	*	*	*									4.93
225	0.80	3.66	3.98	3.05	2.20	1.54	0.95	0.59	0.33	0.14	0.07	0.03	0.02	0.01	*		*					17.37
270	1.00	3.78	4.12	3.35	2.35	1.62	1.08	0.68	0.39	0.23	0.14	0.09	0.04	0.03	0.01	*	0.01					18.91
315	1.27	5.51	5.71	4.32	2.81	1.77	1.12	0.68	0.42	0.26	0.14	0.09	0.04	0.02	0.02	0.01	0.01					24.19
TOT.	6.75	25.62	24.17	16.63	10.63	6.76	4.15	2.43	1.35	0.70	0.37	0.22	0.10	0.06	0.03	0.01	0.01					100.00

* Value lower than 0.01 %







Metocean Data, Area 5

Dir (°N)	Current (m/s) - Annual										
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	4.99	7.38	3.73	1.57	0.70	0.23	0.08	0.03	0.01	*	*	18.72
45	5.90	8.72	3.82	1.52	0.50	0.17	0.08	0.02	0.01	*	*	20.74
90	5.59	5.27	1.23	0.24	0.06	0.02	0.01	*				12.41
135	5.74	6.11	1.44	0.24	0.08	0.03	*	0.01	*			13.65
180	5.54	7.46	2.38	0.47	0.08	0.01	*					15.94
225	4.08	3.32	0.67	0.10	0.02							8.18
270	3.17	1.10	0.07	0.01		*						4.35
315	3.46	2.08	0.38	0.06	0.02	0.01						6.01
TOT.	38.46	41.45	13.71	4.20	1.46	0.46	0.17	0.06	0.02	0.01	*	100.00

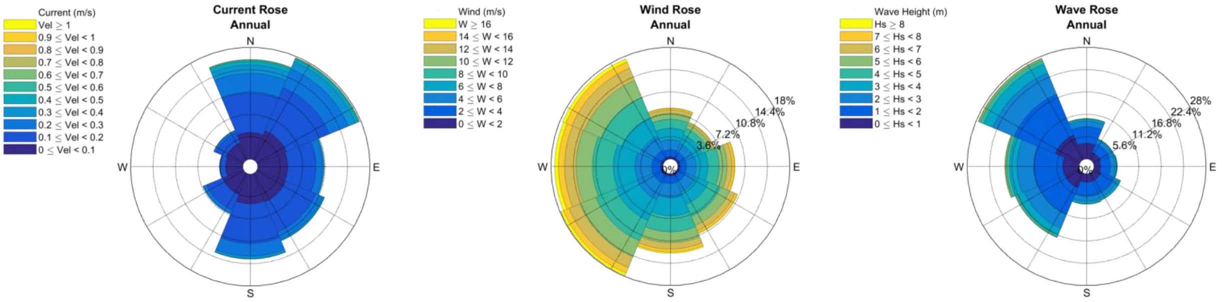
* Value lower than 0.01 %

Dir (°N)	W (m/s) - Annual															
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	0.39	1.16	1.64	1.82	1.42	0.92	0.51	0.24	0.07	0.01	*						8.19
45	0.38	1.04	1.45	1.48	1.10	0.66	0.27	0.11	0.04	0.01							6.53
90	0.36	1.05	1.59	1.91	1.81	1.25	0.76	0.35	0.10	0.01	*						9.18
135	0.36	1.15	1.80	2.18	2.11	1.54	0.90	0.36	0.10	0.01							10.52
180	0.36	1.30	2.34	2.89	2.55	1.72	0.99	0.45	0.16	0.04	0.01	*					12.80
225	0.41	1.46	2.86	3.68	3.53	2.74	1.84	0.92	0.32	0.08	0.02	*	*				17.86
270	0.43	1.45	2.77	3.47	3.33	2.62	1.79	0.95	0.41	0.13	0.04	0.01	*	*			17.38
315	0.39	1.34	2.43	3.25	3.56	2.95	2.06	1.05	0.37	0.10	0.03	*	*	*			17.54
TOT.	3.07	9.93	16.88	20.68	19.41	14.40	9.12	4.44	1.57	0.39	0.09	0.02	0.01	*			100.00

* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																				
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	0.88	3.07	2.54	1.56	0.90	0.50	0.30	0.17	0.09	0.05	0.03	0.01	0.01	*	*	*						10.10
45	0.38	1.49	1.39	1.02	0.61	0.32	0.17	0.10	0.06	0.04	0.01	0.01	*	*								5.59
90	0.29	1.33	1.46	1.05	0.62	0.47	0.27	0.17	0.11	0.03	0.02	0.01	*		*							5.83
135	0.41	1.65	1.88	1.38	0.83	0.53	0.36	0.17	0.09	0.04	0.02	0.01	*									7.36
180	0.33	1.76	1.95	1.39	0.91	0.57	0.34	0.19	0.10	0.05	0.02	0.01	*	*	*							7.63
225	0.61	3.40	3.97	3.12	2.26	1.59	1.06	0.63	0.40	0.23	0.10	0.06	0.03	0.01	0.01	*	*	*	*			17.46
270	0.72	3.44	3.92	3.30	2.46	1.67	1.13	0.73	0.48	0.28	0.15	0.11	0.07	0.04	0.02	0.01	0.01	0.01	*		*	18.55
315	1.09	5.61	6.24	4.82	3.42	2.34	1.50	0.97	0.58	0.37	0.23	0.15	0.08	0.03	0.03	0.02	0.01	0.01	*	*		27.48
TOT.	4.70	21.73	23.35	17.65	12.00	7.98	5.12	3.13	1.90	1.08	0.58	0.35	0.19	0.08	0.06	0.04	0.02	0.01	0.01	*	*	100.00

* Value lower than 0.01 %



Metocean Data, Area 6

Dir (°N)	Current (m/s) - Annual											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	2.31	1.94	0.41	0.05	0.01							4.71
45	3.32	7.38	6.96	5.53	3.81	2.76	1.86	1.19	0.57	0.32	0.28	33.97
90	3.42	8.65	7.84	3.72	1.47	0.51	0.14	0.05	0.02	0.01		25.84
135	2.25	3.63	2.28	0.84	0.21	0.03	*	*				9.24
180	1.80	1.70	0.52	0.10	0.02							4.13
225	2.09	2.69	1.47	0.71	0.48	0.27	0.11	0.04	0.02	0.01		7.87
270	2.29	3.68	2.21	1.09	0.44	0.14	0.02					9.86
315	2.03	1.71	0.47	0.13	0.03	0.01	*					4.38
TOT.	19.50	31.36	22.16	12.17	6.45	3.73	2.13	1.29	0.61	0.33	0.28	100.00

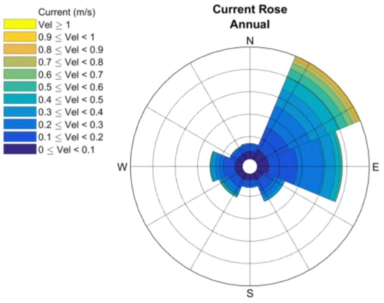
* Value lower than 0.01 %

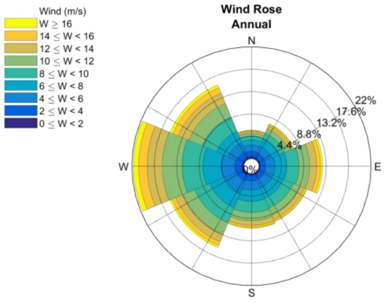
Dir (°N)	W (m/s) - Annual																
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	0.39	1.10	1.24	1.02	0.74	0.53	0.36	0.17	0.06	0.01	*						5.62
45	0.34	1.10	1.44	1.48	1.27	0.95	0.59	0.28	0.11	0.02	*						7.57
90	0.31	1.06	1.90	2.30	2.41	2.04	1.34	0.75	0.30	0.08	0.01	*					12.50
135	0.34	1.10	1.81	2.18	2.09	1.47	0.84	0.37	0.10	0.02	*						10.31
180	0.36	1.12	1.86	2.24	2.17	1.57	0.89	0.38	0.12	0.03	*						10.72
225	0.39	1.41	2.46	3.29	3.17	2.41	1.53	0.75	0.29	0.08	0.02	*	*				15.81
270	0.41	1.53	2.69	3.62	4.08	3.86	2.92	1.62	0.65	0.22	0.05	0.02	*				21.67
315	0.40	1.31	1.88	2.46	3.09	2.85	2.16	1.11	0.39	0.11	0.03	0.01	*				15.80
TOT.	2.93	9.72	15.27	18.59	19.01	15.68	10.62	5.43	2.02	0.57	0.12	0.03	0.01				100.00

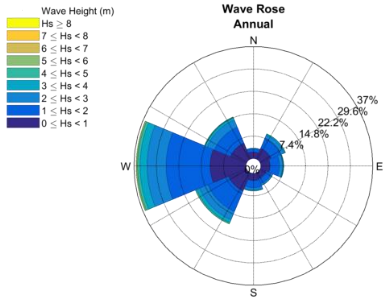
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																					
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	0.78	1.34	0.71	0.32	0.15	0.08	0.03	0.02	0.01	*	*											3.44
45	1.17	2.69	2.09	1.34	0.86	0.45	0.23	0.11	0.06	0.03	0.01	*	*									9.04
90	0.88	2.18	1.93	1.14	0.68	0.39	0.21	0.08	0.04	0.02	0.01	*	*									7.56
135	0.60	1.52	1.13	0.62	0.35	0.18	0.09	0.03	0.02	*												4.53
180	0.62	1.71	1.47	0.92	0.52	0.30	0.15	0.07	0.04	0.02	0.01	*	*									5.82
225	1.53	5.00	4.40	2.92	1.82	1.15	0.68	0.39	0.23	0.12	0.06	0.03	0.02	0.01	0.01	*		*				18.36
270	3.11	8.91	8.35	6.09	3.88	2.37	1.45	0.84	0.52	0.30	0.19	0.10	0.06	0.04	0.02	0.01	0.01	*	*	*	*	36.27
315	1.92	3.81	3.24	2.44	1.64	0.91	0.52	0.27	0.12	0.06	0.04	0.01	0.01	0.01	*	*						14.99
TOT.	10.60	27.16	23.32	15.78	9.89	5.83	3.36	1.81	1.03	0.55	0.30	0.15	0.09	0.06	0.03	0.02	0.01	0.01	*	*	*	100.00

* Value lower than 0.01 %







Metocean Data, Area 7

Dir (°N)	Current (m/s) - Annual											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	1.78	3.67	3.18	1.87	0.87	0.33	0.14	0.04	0.01	*		11.90
45	1.91	4.30	4.44	3.35	2.00	1.02	0.41	0.15	0.05	*	0.01	17.64
90	2.11	5.59	5.90	3.68	1.77	0.69	0.21	0.05	0.01	0.01	*	20.01
135	2.08	4.69	3.98	2.02	0.64	0.18	0.03	0.01	*			13.62
180	1.60	2.31	1.23	0.34	0.08	0.02	0.01					5.58
225	1.43	2.10	1.08	0.38	0.10	0.02	0.01					5.12
270	1.63	3.14	2.78	1.93	0.94	0.33	0.07	0.01	*			10.83
315	1.75	4.09	4.23	3.02	1.46	0.52	0.17	0.04	0.02	*		15.30
TOT.	14.29	29.89	26.80	16.59	7.88	3.11	1.04	0.30	0.08	0.01	0.01	100.00

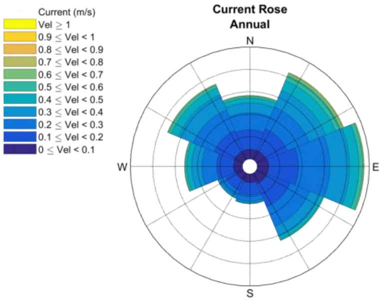
* Value lower than 0.01 %

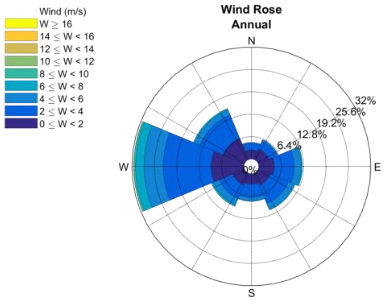
Dir (°N)	W (m/s) - Annual																
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	2.68	1.79	0.23	0.02	*												4.73
45	3.43	2.23	0.43	0.05	*												6.14
90	4.79	5.45	1.90	0.29	0.02	*											12.44
135	4.02	5.41	1.65	0.28	0.01												11.37
180	3.15	3.65	0.95	0.07	*												7.83
225	3.92	3.99	1.82	0.45	0.05	*											10.23
270	10.60	12.81	5.32	2.32	0.45	0.04	*										31.54
315	7.23	6.61	1.51	0.34	0.04	*											15.73
TOT.	39.82	41.94	13.81	3.82	0.57	0.04	*										100.00

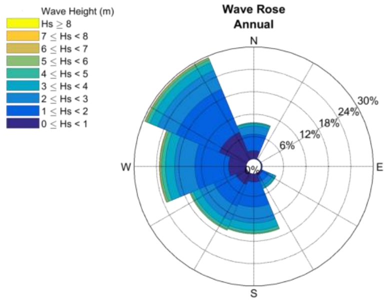
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																					
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	0.55	3.66	4.58	3.59	2.38	1.40	0.80	0.52	0.29	0.18	0.11	0.08	0.04	0.02	0.01	*	0.01	*	*			18.23
45	0.14	0.70	0.85	0.50	0.35	0.17	0.07	0.03	0.01	0.01	*	*										2.85
90	0.12	1.13	1.63	1.73	1.32	0.96	0.72	0.50	0.38	0.27	0.12	0.07	0.04	0.02	0.01	*	*	*				9.02
135	0.14	1.16	1.64	1.46	1.07	0.80	0.56	0.45	0.30	0.17	0.10	0.05	0.02	0.02	0.01							7.94
180	0.16	1.64	2.26	1.75	1.23	0.83	0.52	0.34	0.20	0.12	0.07	0.02	0.02	0.01	*	*						9.17
225	0.28	2.28	3.05	2.85	2.22	1.58	1.21	0.78	0.47	0.30	0.17	0.08	0.05	0.03	0.02	0.01	*	*	*	*		15.38
270	0.31	2.21	2.98	2.60	2.11	1.52	1.12	0.76	0.52	0.29	0.19	0.11	0.08	0.05	0.03	0.01	0.01	0.01	0.01	*	*	14.91
315	0.52	3.92	4.77	4.09	3.05	2.08	1.35	0.96	0.63	0.42	0.26	0.18	0.11	0.07	0.04	0.03	0.02	0.01	*	*	*	22.50
TOT.	2.21	16.69	21.77	18.56	13.72	9.35	6.35	4.35	2.79	1.76	1.02	0.60	0.35	0.21	0.12	0.06	0.03	0.03	0.01	0.01	0.01	100.00

* Value lower than 0.01 %







Metocean Data, Area 8

Dir (°N)	Current (m/s) - Annual											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	>1.0	TOT.
0	2.82	3.29	1.35	0.46	0.12	0.04	0.01	*				8.09
45	3.90	7.26	3.88	0.86	0.10	0.01						16.01
90	4.31	8.60	4.88	1.28	0.21	0.06	0.02	*	*			19.37
135	3.85	6.37	3.09	0.99	0.33	0.10	0.04	0.02	0.01		*	14.80
180	3.86	5.87	2.61	0.61	0.11	0.02	0.01	*	*			13.07
225	3.68	6.19	2.53	0.42	0.05	0.01						12.88
270	3.04	3.93	1.22	0.20	0.03	0.01	*					8.43
315	2.52	2.58	1.11	0.58	0.32	0.13	0.06	0.03	0.02	0.01		7.35
TOT.	27.97	44.08	20.68	5.40	1.27	0.38	0.14	0.05	0.03	0.01	*	100.00

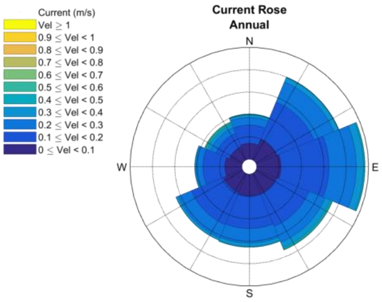
* Value lower than 0.01 %

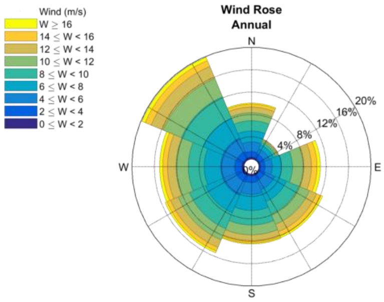
Dir (°N)	W (m/s) - Annual															
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	>30.0	TOT.
0	0.37	1.08	1.74	1.95	1.80	1.41	0.96	0.49	0.16	0.03	*						9.98
45	0.29	0.89	1.00	0.75	0.45	0.27	0.16	0.07	0.02	*							3.90
90	0.27	0.85	1.33	1.66	1.97	1.86	1.48	1.00	0.44	0.11	0.02	*					10.98
135	0.31	1.06	1.89	2.26	2.40	2.00	1.38	0.77	0.28	0.05	*						12.39
180	0.35	1.22	2.18	2.86	2.58	1.72	0.97	0.45	0.13	0.03	*	*					12.49
225	0.37	1.40	2.59	3.36	3.05	2.14	1.41	0.69	0.25	0.06	0.02	*					15.35
270	0.38	1.37	2.53	2.96	2.81	2.14	1.50	0.83	0.38	0.12	0.03	0.01					15.05
315	0.34	1.34	2.71	3.82	4.20	3.48	2.25	1.11	0.45	0.12	0.04	0.01	*				19.86
TOT.	2.69	9.19	15.97	19.61	19.27	15.02	10.10	5.39	2.12	0.52	0.11	0.03	*				100.00

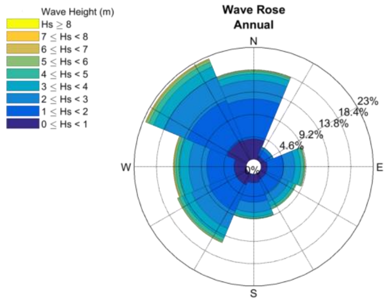
* Value lower than 0.01 %

Dir (°N)	Hs (m) - Annual																					
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	>10	TOT.
0	0.55	3.66	4.58	3.59	2.38	1.40	0.80	0.52	0.29	0.18	0.11	0.08	0.04	0.02	0.01	*	0.01	*	*			18.23
45	0.14	0.70	0.85	0.50	0.35	0.17	0.07	0.03	0.01	0.01	*	*										2.85
90	0.12	1.13	1.63	1.73	1.32	0.96	0.72	0.50	0.38	0.27	0.12	0.07	0.04	0.02	0.01	*	*	*				9.02
135	0.14	1.16	1.64	1.46	1.07	0.80	0.56	0.45	0.30	0.17	0.10	0.05	0.02	0.02	0.01							7.94
180	0.16	1.64	2.26	1.75	1.23	0.83	0.52	0.34	0.20	0.12	0.07	0.02	0.02	0.01	*	*						9.17
225	0.28	2.28	3.05	2.85	2.22	1.58	1.21	0.78	0.47	0.30	0.17	0.08	0.05	0.03	0.02	0.01	*	*	*	*		15.38
270	0.31	2.21	2.98	2.60	2.11	1.52	1.12	0.76	0.52	0.29	0.19	0.11	0.08	0.05	0.03	0.01	0.01	0.01	0.01	*	*	14.91
315	0.52	3.92	4.77	4.09	3.05	2.08	1.35	0.96	0.63	0.42	0.26	0.18	0.11	0.07	0.04	0.03	0.02	0.01	*	*	*	22.50
TOT.	2.21	16.69	21.77	18.56	13.72	9.35	6.35	4.35	2.79	1.76	1.02	0.60	0.35	0.21	0.12	0.06	0.03	0.03	0.01	0.01	0.01	100.00

* Value lower than 0.01 %







APPENDIX B

Vessel Traffic for all analysed legs of the model (2019 Data)

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
4	North	41		1	1				1					38	
4	South	20741	1190	4561	339	1016	3062	5655	2910	1181	284		388	123	32
5	East	300		6		1	3	65	1	1	101		4	118	
5	West	29230	1239	5990	450	1355	4865	8409	3342	2394	287		502	357	40
6	North	45												45	
6	South	27191	1266	5790	457	1430	4837	6785	3303	2268	374		456	188	37
7	North	5285	468	472	18	168	1542	689	1225	340	103		130	121	9
7	South	224		31	11	14	49	50	25	9			5	30	
8	East	2263	68	407	19	97	647	326	49	541	17		30	61	1
8	West	3645	77	687	52	209	1121	470	198	688	34		43	63	3
9	East	21450	858	5597	422	1333	3325	5166	1911	2187	234	1	264	137	15
9	West	37								1				36	
10	East	384	1	8		4	7	9	15		310		2	28	
10	West	58	1	2			5	7	9		20			14	
11	North	12060	927	2861	192	607	1928	2406	1931	656	184	1	217	133	17
11	South	75												75	
12	North	19910	1219	4532	345	971	2968	5323	2586	1237	250	2	353	103	21
12	South	27		1				1					1	24	
13	North	11512	488	2571	220	544	1470	4180	1017	728	92	1	177	17	7
13	South	6												6	
14	North	6874	169	1448	136	300	847	2749	537	509	42	1	116	15	5
14	South	7												7	
15	East	2005	58	334	17	90	544	348	41	495	16		40	21	1
15	West	9788	164	2002	156	639	2435	1728	513	1930	75		107	33	6
16	East	1827	48	276	16	84	442	358	33	470	15		41	43	1

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
16	West	3764	36	536	49	161	989	942	147	757	39	1	42	64	1
17	East	11866	231	2583	189	748	2538	2275	762	2179	134		131	91	5
17	West	10697	202	2295	176	696	2561	1921	573	1958	102		110	98	5
18	East	9052	147	2122	166	619	1755	1820	692	1451	111		81	84	4
18	West	34		1										33	
19	East	6492	89	1481	123	461	1183	1464	472	1046	73		62	35	3
19	West	20						1						19	
20	East	325	27	32	1	10	37	89	47	8	8		5	61	
20	West	28002	1234	5906	455	1371	4790	7633	3241	2340	320		465	209	38
21	North	1699	1	245	10	55	347	762	34	21	32		32	156	4
21	South	1141	2	175	1	41	162	509	25	36	12		37	135	6
22	East	1095	6	171	12	40	184	236	11	384	4		36	11	
22	West	607	22	96	6	26	254	54	26	102	3		9	9	
23	East	1485	12	216	22	32	385	263	23	458	4		25	45	
23	West	1516	23	222	10	50	546	232	32	286	13		50	52	
24	East	10559	482	2961	307	324	3020	1740	571	757	134		194	55	14
24	West	134	2	46	1	3	14	13	5	5				45	
25	East	12548	565	2979	299	295	3239	1969	550	1679	670		232	60	11
25	West	59		10	1		12	6	2	1			3	24	
26	North	3093	16	1199	52	374	360	730	196	67	3		89	7	
26	South	1788		570	24	175	301	495	43	86	5		80	7	2
27	North	9						1	1	1				6	
27	South	2808	36	213	17	228	255	212	107	1276	335	1	88	16	24
28	North	20187	1238	4584	352	988	2988	5428	2605	1280	248	2	358	96	20
28	South	13												13	
29	East	1261		4				1		1245			1	10	
29	West	1027						1		1019				7	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
30	East	10387	149	1851	131	628	2230	2016	551	2415	155		176	79	6
30	West	10982	179	2234	164	646	2581	2241	558	2077	106		128	62	6
31	East	11321	102	2429	166	926	1757	2282	538	2708	129		200	59	25
31	West	9509	105	1986	149	749	1507	2009	505	2181	98		161	38	21
32	East	4099	1	15	5	124	338	127	2	2995	392		21	42	37
32	West	4793	1	15	12	123	396	150	2	3555	432		15	43	49
33	East	3954	4	122	4	71	1112	76	67	2025	283		29	159	2
33	West	3565	15	65	6	56	939	71	27	1985	249		26	116	10
34	East	136		16	2	5	18	31	5	10	5	1	31	12	
34	West	2042	106	183	15	151	1064	94	109	213	43	1	43	19	1
35	East	2250		360	23	161	43	1082	12	369	5		99	96	
35	West	1743		286	19	120	31	834	7	313	4		63	66	
37	North	261		13				36	12		6		146	48	
37	South	247		10				39	12		7		127	52	
38	North	712					3	2			23	46	590	48	
38	South	716	3	4			7	5			23	48	574	52	
39	North	638				1	4				3	50	563	17	
39	South	539					10				8	42	460	19	
40	East	10125	260	1826	158	668	3724	844	768	1286	21		137	428	5
40	West	12545	265	2480	183	1001	4014	1698	734	1438	24		243	459	6
44	North	1995	27	177	11	223	242	172	67	892	55		101	4	24
44	South	407	3	13	1	12	80	37	9	187			32	10	23
45	East	2551		2		1	72	26	1	2062	319		9	59	
45	West	1439				1	1	1	2	1415			1	18	
46	East	1530					12	2		1177	218		8	113	
46	West	1191				1	3			1077	9		7	94	
47	North	1832	20	104	8	154	185	77	34	870	332	1	33	14	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
47	South	9					1						1	7	
48	North	1000		1			75	27		568	300		20	8	1
48	South	36					1			4			11	20	
49	North	871	21	169	10	101	83	40	48	234	37		53	74	1
49	South	799	16	123	6	124	32	61	52	258	22		41	64	
50	North	19						2			1		3	13	
50	South	487		2		1	12	6		299	128	1	18	11	9
51	East	624		1						616			2	5	
51	West	663		2		1		2		649				9	
52	North	35						1						34	
52	South	1123	15	110	6	129	93	132	56	460	28		66	27	1
53	North	46												46	
53	South	842	20	93	8	84	70	71	51	340	12		55	37	1
54	North	13		2			2		2					7	
54	South	20630	1179	4586	339	945	3083	5534	2876	1301	281		372	102	32
55	East	598		1						576			2	19	
55	West	543		1		1		3		520				18	
56	East	1350		2	15		13	13	15	1285	1		1	5	
56	West	1551	1	82	3	2	28	41	8	1378			3	5	
58	North	2002	335	490	28	241	38	149	527	57	55		66	11	5
58	South	699	24	124	14	61	29	65	71	232	32		28	12	7
60	East	33		7			2	12		5	6		1		
60	West	1950		25	3		65	229		1055	569		4		
61	East	39		16		1	3	2						17	
61	West	2165	7	92	4	7	119	217	2	1052	645		8	12	
62	East	21	1	4	1		5	2	1					7	
62	West	2346	13	171	16	16	172	234	5	1070	624		17	7	1
63	East	25		3			2	1	1					18	
63	West	8112	231	1932	214	209	1925	1056	289	1481	638		111	16	10
64	East	23		1				2						20	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
64	West	11014	354	2676	288	277	2833	1467	420	1726	682		231	47	13
65	East	73	1	5		1	31	4	2	1			2	26	
65	West	12448	352	3072	303	304	3302	1853	429	1723	618		393	87	12
66	North	2923	454	896	42	381	62	189	692	44	69		87	5	2
66	South	4589	830	1444	77	522	117	240	1100	48	78		113	10	10
67	North	8736	238	1448	99	272	625	3585	1185	947	134	2	116	77	8
67	South	46		3	1	1	7	10	3	10			1	10	
68	North	8903	104	1420	98	222	680	3630	1008	1391	146	2	116	62	24
68	South	11		1			2	1	1	2			1	3	
69	East	2167	69	471	18	132	120	266	35	638	389		15	14	
69	West	539	3	238	13	102	28	114	18	4	2		6	11	
70	North	595	3	285	10	100	36	77	52	9	1		18	4	
70	South	480		138	8	48	67	87	18	79	2		24	9	
71	East	1481		4	1		7	156		928	383		2		
71	West	54		4			15	23		5	6			1	
72	North	1528	8	102	5	128	145	116	11	679	298	1	30	5	
72	South	1720	17	201	10	179	193	106	13	664	308	1	21	7	
73	North	1476	2	124	2	159	149	179	3	527	310	1	19	1	
73	South	1851	19	255	7	218	215	226	5	569	314		17	6	
74	East	153	2	3	1		2	4					139	2	
74	West	199	14	11			1				1		170	2	
75	East	286		25		11	175	51	1	15	2		3	3	
75	West	711	1	106	23	13	432	86	1	29	5		13	1	1
76	North	2986	495	735	36	398	67	215	808	57	71		90	9	5
76	South	4550	772	1372	70	478	79	268	1236	54	85		111	17	8
77	North	39	1	3			5	4	12	12			1	1	
77	South	14628	381	3185	246	404	2354	4706	1466	1423	185		196	59	23
78	North	2			1			1							
78	South	8887	125	1281	102	189	1096	3343	1104	1330	175		81	33	28

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
79	North	9503	78	1387	107	219	1025	3702	1049	1613	142	1	109	43	28
79	South	3												3	
80	North	1515	263	441	23	168	118	69	360	32	19		22		
80	South	2522	428	664	46	264	110	148	776	25	38		21	1	1
81	East	3463	90	370	41	106	957	441	10	856	563		24	4	1
81	West	2503	82	235	31	74	662	282	14	743	356		22	2	
82	East	4473	172	572	77	160	1076	812	15	913	586		57	32	1
82	West	4158	226	650	72	166	881	690	61	837	492		49	29	5
83	East	4860	211	679	82	174	1100	834	23	1001	633		54	69	
83	West	5215	393	916	92	227	977	751	89	1023	584		63	95	5
84	East	5550	220	885	88	164	1244	933	55	1143	641		113	63	1
84	West	5495	407	1115	100	223	987	822	119	974	571		96	76	5
85	East	5671	190	809	90	136	1327	1024	64	1167	694		133	36	1
85	West	6922	608	1584	117	273	1125	996	240	1154	630		161	26	8
86	East	12387	545	2828	284	262	3143	1960	504	1825	732		235	56	13
86	West	37		5			6	4	1					21	
87	North	2778	26	179	14	212	1526	193	65	424	8	1	57	46	27
87	South	3417	14	327	20	211	1814	196	128	584	6		61	27	29
88	North	2609	24	173	12	169	1436	199	59	411	10	1	75	14	26
88	South	3491	12	315	16	198	1741	269	129	641	12	1	109	19	29
90	North	305		23	5	19	56	84	5	98	1		4	7	3
90	South	5687	9	678	62	227	1639	1722	122	941	20		228	11	28
91	North	7756	11	2271	173	634	800	2532	405	544	14	12	290	66	4
91	South	8045	5	2173	165	706	822	2915	178	553	16	13	375	120	4
92	East	25		1		1		1	1				5	16	
92	West	8									1			7	
93	North	8313	11	2439	177	702	846	2787	434	606	15	4	267	19	6
93	South	7577	5	2115	156	685	785	2788	171	541	14	1	285	27	4
94	East	129						1					8	120	
94	West	41											1	40	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
95	East	34	1	1		1							2	29	
95	West	11640	352	2851	281	291	2992	1644	408	1743	657		305	103	13
97	East	14318	535	3311	298	261	3914	2358	536	1920	754		367	47	17
97	West	10	1					1						7	1
99	North	6947	17	1146	120	414	1848	2065	244	799	21	1	233	12	27
99	South	943	3	151	11	54	324	209	34	107	1	1	41	7	
100	East	1479	14	88	7	28	22	183	3	761	354		6	13	
100	West	104		26	3	9	8	49	1				2	6	
101	North	8972	94	1403	95	216	775	3625	1014	1417	148	1	107	57	20
101	South	22	1	1			7	3	1	2	1		2	4	
102	North	1222	9	549	22	137	128	179	117	29	1		45	6	
102	South	516	1	141	7	44	69	111	21	73	1		34	13	1
103	East	589	229	7		76	83	4	179				1	6	4
103	West	91	31	2		3	43		2				5	3	2
104	East	474	190	4		60	30	3	176				1	10	
104	West	87	28	2		4	42		2				2	6	1
105	East	402	135	7		63	23	3	161				1	9	
105	West	82	26	1		7	41		1				1	5	
108	East	53	19	1		13	5	2	12					1	
108	West	24	10	1		1	11							1	
109	East	14		2		1	9	2							
109	West	10	3	2	1	1	1	2							
110	East	328	1	22	4		34	179	16	65			1	6	
110	West	849	9	105	70	10	298	143	31	149	7		10	15	2
113	North	108	20	18	1	17	2	7	33	2			4	4	
113	South	5714	490	1222	81	343	490	1262	1180	421	103		93	21	8
114	East	1860	17	87	10	24	917	363	6	163	244		29		
114	West	1128	6	186	33	21	626	174	4	36	18		23	1	
116	East	1534	4	230	30	9	399	433	92	301	4		19	11	2

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
116	West	1680	1	171	80	8	400	367	99	505	3		25	19	2
118	East	947	4	23	3		437	152		117	199		9	3	
118	West	166		19	1	1	110	19	2	4	7		1	2	
119	North	1532	14	84	3	107	150	112	10	688	316	1	30	17	
119	South	1598	25	169	7	118	194	83	9	643	301		29	20	
121	North	1281	18	67	3	86	161	91	14	540	249	1	25	26	
121	South	1239	13	70	4	55	183	45	11	587	229		16	26	
122	North	1480	21	76	4	105	175	107	27	607	295	1	27	35	
122	South	1447	38	93	9	91	186	47	17	615	304		21	26	
123	East	1470		20	1	3	13	167	2	861	397		3	3	
123	West	43		14			4	21	2	1				1	
124	North	802	25	65	2	15	482	149	22	15	3		8	15	1
124	South	492		52		6	188	176	11	21	1		13	24	
125	North	2966	37	342	20	77	1170	1003	94	57	16		59	86	5
125	South	2161	8	222	5	51	782	802	53	73	12		72	76	5
126	North	1666	1	234	14	75	95	901	74	73	14		80	99	6
126	South	1068	2	144	2	42	68	597	26	46	6		58	73	4
127	North	1448	2	194	15	52	118	833	16	50	5		89	68	6
127	South	1169	1	160	3	42	74	682	29	33	2		65	72	6
128	North	513	69	157	11	73	7	32	100	14	27		19	2	2
128	South	789	159	248	14	109	34	39	118	14	32		21		1
129	North	1255	203	430	26	145	18	75	232	19	45		59		3
129	South	1285	249	428	24	157	24	75	201	16	48		53	7	3
130	North	927	200	236	25	120	17	48	166	20	42		48	3	2
130	South	1367	355	386	25	177	17	69	209	23	44		54	7	1
131	North	1048	236	253	24	137	15	58	191	18	56		51	7	2
131	South	1114	346	241	20	148	13	56	167	18	43		51	9	2
132	North	1258	261	272	22	129	44	123	263	19	59		54	9	3
132	South	1440	363	281	17	154	28	164	264	28	68		62	7	4
133	North	1029	169	244	16	102	39	141	188	7	58		57	6	2

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
133	South	1185	287	210	13	124	26	159	228	15	54		49	16	4
134	East	989	88	193	17	92	59	230	86	149	35		23	14	3
134	West	959	59	171	10	57	76	356	37	161	11		10	10	1
135	East	696	10	136	13	64	40	205	49	146	1		17	14	1
135	West	2041	39	1004	44	128	129	393	61	199	7		22	11	4
136	East	1836	81	835	40	142	136	216	191	140	6		23	23	3
136	West	2086	34	999	45	143	133	408	61	207	7	1	26	18	4
137	East	2376	86	926	48	152	514	237	247	129	18		12	3	4
137	West	1974	35	937	42	127	272	337	71	120	8		19	3	3
138	East	2476	88	951	48	179	494	274	255	122	20		30	12	3
138	West	2378	46	1067	59	193	286	467	82	122	8		38	7	3
139	East	1452	14	108	17	36	428	160	4	454	223		8		
139	West	1753	37	115	19	61	460	206	5	527	307		16		
140	East	3198		222	28	80	955	538	3	932	427		12	1	
140	West	3342		261	56	151	855	589	2	890	519		17		2
141	North	2352	406	786	33	261	129	102	541	44	16		31	2	1
141	South	2107	362	581	38	226	76	117	642	21	29		14		1
142	North	2657	508	906	48	276	139	117	561	41	25		30	2	4
142	South	1678	293	490	36	196	62	96	455	15	23		9	1	2
144	North	358	41	93	2	8	64	20	11	92	12		12	1	2
144	South	457	31	132	12	6	82	38	2	120	5		21	8	
146	North	160	10	12			42	8	3	81			4		
146	South	190		24	2	1	48	11	1	97			3	3	
147	North	252		33	1	7	60	17	3	118			11	1	1
147	South	252	1	37	1	1	77	13	3	107			12		
148	North	45	4	8		2	3	5	9	1			1	12	
148	South	8770	65	1005	80	174	1093	3677	983	1421	139		84	19	30
149	North	31	2	4		2	6	2	2	3			2	8	
149	South	9182	64	1062	89	188	1152	3825	1033	1465	149		88	36	31
150	North	7						2	1	1				3	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
150	South	8159	18	502	55	173	1183	3638	877	1483	111		74	17	28
151	North	10												10	
151	South	13228	16	955	146	536	2818	5094	1068	2275	121		149	18	32
152	North	5						1						4	
152	South	13375	14	934	141	536	2817	5050	1078	2458	123		153	14	57
153	East														
153	West	15835	13	1343	228	568	4390	4923	1189	2643	204		269	7	58
154	North	20960	46	2028	307	666	4850	7822	1492	2671	221	2	650	149	56
154	South	14786	15	1114	186	387	4210	4686	1012	2420	203		431	74	48
155	East	11884	4	1041	210	257	3162	4617	523	1635	149	1	268	9	8
155	West	12674	10	1059	185	223	3179	5334	440	1782	138	1	310	5	8
156	East	12035	5	1074	211	258	2982	5120	491	1384	142	2	314	43	9
156	West	12772	12	1060	190	231	3259	5480	470	1554	153		314	41	8
157	North	9287	42	927	99	429	1814	3202	1000	1227	81		227	190	49
157	South	8090	9	577	100	458	1519	2846	924	1090	65		283	167	52
159	East	18		8										10	
159	West	6228	920	2518	135	534	196	368	1365	48	52	1	60	21	10
160	North	5759	1019	2297	108	544	235	317	1034	63	41		68	26	7
160	South	5819	862	2322	124	507	181	352	1296	48	50		52	15	10
161	East	5823	1026	2314	110	547	229	321	1072	63	39		71	25	6
161	West	9												9	
162	North	4663	949	1629	76	465	128	312	887	60	40		93	19	5
162	South	13												13	
163	North	1139	1	64	2		8	217	93	10	2	18	519	203	2
163	South	1185		66	3		8	257	54	44	3	23	514	209	4

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
164	East	122		8	1	1	2	28		61	3		17	1	
164	West	163		14	1		4	53	2	76	1		12		
165	North	813			1		74	571		27	3	1	63	73	
165	South	636					80	350		2	3		58	143	
166	East	376		11			3	17		3	293		5	44	
166	West	355	1	17	3		1	12	5		251		1	63	1
167	North	1												1	
167	South	5550	1	661	121	130	1805	1893	295	247	97		289	8	3
168	East	311		4			1	14	4	2	220		7	59	
168	West	331	1	5	1	2	1	10	3		244		5	58	1
169	North	15						4	2	1				8	
169	South	4301		484	106	134	1673	1367	133	118	20		250	14	2
171	North	647	9	85	13	7	361	103	31	6	2		20	9	1
171	South	4200		484	103	126	1603	1350	123	119	18		249	23	2
172	North	6316	25	666	126	96	2577	1906	242	253	53	1	333	33	5
172	South	4758	4	660	117	136	1725	1465	120	125	21		354	29	2
173	North	4060	17	513	81	65	1536	1249	151	163	41		215	25	4
173	South	4372	4	645	111	129	1570	1329	107	116	21		314	24	2
177	East	220	1	5	1		1	7	121				38	46	
177	West	3634	79	1519	90	71	100	961	329	83	82		186	133	1
178	North	555	3	172	7	16	30	63	156	28	19		33	26	2
178	South	1225	1	178	27	22	92	426	157	84	78		111	48	1
179	East	1560	17	340	25	21	52	392	245	33	29		244	161	1
179	West	4841	81	1720	97	89	167	1215	610	131	141		302	285	3
180	East	3498	59	1334	80	51	92	1189	292	120	96		122	61	2
180	West	12												12	
181	East	4062	63	1397	86	61	138	1272	403	178	164		173	125	2
181	West	127		2				4	3		13		80	25	
182	North	25	1	11					1				3	9	
182	South	884		155	22	18	72	329	83	55	32		82	35	1

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
184	North	2						1						1	
184	South	4383	4	596	119	125	1523	1421	98	143	24		311	17	2
185	North	2												2	
185	South	4636	2	562	84	354	1536	1208	188	619	4		72	5	2
186	North	18768	39	1911	286	621	4581	6672	1450	2540	197	2	385	29	55
186	South	5					1						3	1	
187	North	19185	43	1958	270	645	4648	6890	1406	2595	188	1	447	37	57
187	South	25						1			1		5	18	
188	North	1382	3	170	14	36	494	394	79	120	13		52	6	1
188	South	5											1	4	
189	North	5123	10	495	103	84	1878	1748	205	255	34		278	26	7
189	South	46	1	3			3	3	4	1			22	9	
190	East	584		2			1	28		1	298		21	231	2
190	West	712		17	9	3	23	135	15	8	319		23	159	1
191	East	12310	25	1140	147	531	2192	4852	912	2197	85	2	150	27	50
191	West	34					1	3	3		2		14	11	
192	North	11486	19	1039	141	513	1847	4665	840	2103	87	2	149	31	50
192	South	70		6		1	4	12	3	3	1		22	18	
193	East	9130	64	1290	100	212	1040	3534	1004	1588	123		104	44	27
193	West	90	1	13		3	9	21	3	5	3		1	31	
194	North	75	2	2	2	4	21	12	3	13			1	15	
194	South	5076	5	606	87	357	1546	1407	167	775	4		86	14	22
195	North	101		11	1	8	28	20	3	20			1	9	
195	South	5791	8	702	96	377	1635	1679	161	978	13		99	13	30
196	North	11		2	1		3	1		1				3	
196	South	7779	37	1247	118	471	2070	2224	212	1112	20	2	213	26	27
197	North	10					1	1		1			1	6	
197	South	7557	19	1184	105	453	2036	2156	191	1074	21	2	263	24	29

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
198	North	5735	24	808	113	442	1176	1885	241	879	18	1	108	12	28
198	South	23		2			3	10		2			2	4	
199	North	5404	22	751	106	398	1119	1780	220	844	19	1	104	14	26
199	South	26		3			4	11	1				3	4	
200	North	4349	12	528	91	319	903	1443	169	756	14	1	74	14	25
200	South	50		3			3	34		4			1	5	
201	North	9057	53	1225	97	233	1082	3524	949	1615	113	2	102	35	27
201	South	237	2	59	4	4	31	57	14	33	10		4	19	
202	East	1025	33	521	37	22	18	141	113	32	29		18	61	
202	West	122	1	25		1	4	23	11	4			8	45	
203	North	2742	12	416	37	315	640	795	165	313	5		31	13	
203	South	107	7	15	2	2	13	42	4	8			4	9	1
204	East	469	3	49	3	8	9	214	24	1	17		15	125	1
204	West	396		9	1	1	7	260	4	8	11		16	79	
205	North	6600	28	762	137	96	2670	2014	282	253	57	1	283	11	6
205	South	9		1									4	4	
206	North	39					2	7	1				22	7	
206	South	4581	5	693	115	140	1666	1416	105	94	23		309	14	1
207	East	140	1	12	1		38	27	5	21	5		5	25	
207	West	1095	37	539	30	11	22	187	162	30	32		14	31	
208	East	10038	18	893	92	456	1564	4056	838	1858	85	2	119	27	30
208	West	416	5	120	6	10	33	124	29	28	15		18	27	1
209	East	94	1	6	1		1	7	40				17	21	
209	West	1972	41	874	53	47	51	529	182	40	34		75	46	
211	North	805		87	31	24	187	262	26	150	1		23	8	6
211	South	137		10	1	2	8	87	3	3			12	11	
212	North	1951	8	219	59	50	322	753	42	396	8		64	5	25
212	South	161	3	22	1	3	11	84	2	7			17	11	
213	East	2489	64	1280	57	50	55	551	222	70	51		39	50	
213	West	29		7	1	1	1		3				3	13	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
214	East	579	8	66	4	6	19	403	19	7	17		7	22	1
214	West	264	4	12			12	209	5	3			4	15	
215	North	2279	13	260	67	62	410	845	59	447	11		71	7	27
215	South	196	4	27	1	2	20	94	6	13	1		15	13	
216	North	1167	231	522	21	77	22	59	200	7	9		18	1	
216	South	657	74	360	11	51	31	43	71	1			9	5	1
217	East	141	1	8	1	2	45	21	26	12	1		7	17	
217	West	1349	52	677	43	15	32	213	201	40	37		21	18	
218	North	18	2	1			1	2						12	
218	South	4862	3	596	89	369	1554	1320	175	644	4		79	27	2
219	North	6					1	2	1					2	
219	South	8267	14	435	55	165	1266	3618	871	1613	113		77	11	29
220	North	7					1							6	
220	South	4745	2	555	92	362	1570	1262	168	633	4		75	20	2
221	East	45		5	1	1	3	10	1	1			8	15	
221	West	334		155	5	21	8	81	12	5	5		22	20	
222	East	28		6	1		1	5	3					12	
222	West	646	8	251	9	27	14	230	34	5	8		31	29	
224	East	403		8			4	17	1	18	298		11	46	
224	West	373	1	20	1	2	7	15	5	1	286		7	28	
226	North	1159	237	258	17	107	43	126	228	8	64		53	16	2
226	South	1513	379	275	15	156	37	197	261	17	73		74	25	4
227	East	412		5			2	25	1	27	291		14	47	
227	West	398		6		1	5	36	6	2	291		10	40	1
228	East	245		1				6	1	3	227		3	4	
228	West	61									60			1	
229	East	822		31	1	9	1	66	17	295	1		391	8	2
229	West	351		8		4		20	7	239			70	3	
230	East	62		3				4	4	49			2		
230	West	63				2			1	59			1		

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
231	North	444	25	59		9	125	59	103	20	31		8	5	
231	South	542	17	68	7	6	173	92	102	28	43		3	1	2
232	North	2283	155	168	28	52	643	498	263	257	60		121	36	2
232	South	2639	132	159	29	53	908	526	216	391	75		107	42	1
233	East	49	1	2				2	4	39			1		
233	West	48								48					
234	East	127		4				4	4	113				2	
234	West	116						1	1	111				3	
240	North	1992	19	236	18	69	427	595	258	306	21		24	5	14
240	South	1494	5	105	18	56	298	482	205	275	16		12	7	15
241	North	4684	35	544	55	161	954	1417	650	737	31		27	42	31
241	South	3204	8	212	35	104	769	792	502	673	25		27	15	42
242	North	1897	22	239	19	65	390	559	248	292	19		18	14	12
242	South	1420	4	91	19	48	287	472	183	272	10		7	14	13
243	North	5483	968	2142	102	516	219	300	991	60	44		80	54	7
243	South	42												42	
244	North	1658	372	581	33	129	56	79	344	26	23		10	3	2
244	South	2139	391	684	42	120	77	135	617	30	21		15	6	1
245	North	11		3	1			2	1					4	
245	South	3973	695	1284	70	239	146	270	1144	44	43		26	9	3
246	North	3343	721	1257	69	255	98	166	649	45	32		38	8	5
246	South	10							1					9	
247	East	398	51	46	5	12	30	73	64	32	22		50	13	
247	West	414	57	49	7	15	69	64	78	8	25		32	10	
248	North	1690	327	549	32	112	43	162	410	20	10		16	6	3
248	South	1804	314	518	24	119	109	145	529	16	12		9	5	4
249	East	80	23	1		1	13	3	22	9	6		1	1	
249	West	144	16	4		1	50	19	36	1	12		2	3	
250	East	378		5			17	131	8	185			1	31	
250	West	394		4			7	149	9	200			1	24	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
251	East	473	3	11	1	2	27	155	22	219			1	32	
251	West	406	1	4			27	160	9	193				12	
252	North	757		29	7	6	262	190	56	167	6		20	14	
252	South	903		30	7	11	375	171	29	247	6		14	13	
253	East	138		9	1	6		21	7	82			10	2	
253	West	109		1		2		7		92			7		
254	North	937	1	37	7	13	315	290	79	162	9		13	11	
254	South	1080		39	7	18	416	275	31	256	7		23	8	
257	East	62	11	2		1	8	3	16	8	6		5	2	
257	West	79	15	1		1	23	13	21		4		1		
258	North	55	9	16	3	7		4	14	2					
258	South	226	17	82	4	4	10	11	86	7	4		1		
259	North	518	142	155	10	42	16	20	122	3	3		5		
259	South	1381	306	377	24	120	56	73	390	6	12		10	7	
260	East	76	18				9	3	20	10	11		3	2	
260	West	127	18	3			42	12	36	3	10		2	1	
264	East	100		2			4	20	5	64			1	4	
264	West	187		2		1	2	23		156			2	1	
265	North	57		1	1		1	14	1	22			13	3	1
265	South	74		2	1		1	27	7	14			16	2	4
266	North	924	1	39	12	13	297	287	75	157	13		16	14	
266	South	1128	1	49	7	10	396	336	32	261	9		18	9	
267	North	1198	76	163	9	24	317	186	269	58	61		20	15	
267	South	1561	80	204	17	33	448	299	255	106	74		13	30	2
268	East	225	38	24	1	6	23	34	45	22	17		11	4	
268	West	270	42	22	6	9	56	44	52	3	19		14	3	
269	North	61		1	1			9	1	25		1	14	8	1
269	South	36						13	2	4			10	3	4
270	North	54		1	1			14	1	20			14	2	1
270	South	41						13	3	5			14	2	4

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
273	North	255		4	5			61	5	62	2	1	112		3
273	South	139		3				41	1	43	1		45	1	4
274	North	195	8	10		1	31	50	64		24		3	4	
274	South	256	9	26	4	2	32	67	74	2	35		4		1
275	North	198	22	11	2	16	13	53	21	46	2		10	2	
275	South	167	33	8	3	11	16	20	21	45	1		7	2	
276	North	590		1		2		17	9	43	2		509	7	
276	South	530	1	2			2	6	2	48	3		461	5	
278	North	744	82	148	8	66	5	131	221	1	58		16	8	
278	South	597	74	102	6	52	38	99	156	6	31		10	22	1
282	East	102					7	36	5	49				5	
282	West	91		3			4	37	1	44				2	
283	North	653	149	184	16	36	19	60	168	8	5		7		1
283	South	772	126	198	15	54	53	62	243	6	9		4	2	
284	North	124	8	62	2	4	16	17	12	3					
284	South	74	3	18	2		9	15	26	1					
285	North	5267	98	653	58	160	1169	1409	686	898	41		35	19	41
285	South	2464	11	164	31	67	524	713	308	575	23		15	5	28
286	North	141	7	10	1	3	1	36	54		24		2	3	
286	South	195	8	20	3	3	23	50	57		27		2	2	
287	North	117	8	9		2		28	44		19		2	5	
287	South	178	5	18	1	2	18	46	58		28		1		1
288	North	99	8	10		1		25	32		16		4	3	
288	South	150	5	14	3	1	13	33	46		30		2	1	2
289	North	85	6	9		1		22	24		20		2	1	
289	South	97	4	13	2	2	13	20	26		15			2	
290	East	2016	121	552	44	202	93	467	270	24	114		43	83	3
290	West	1970	175	569	36	236	173	279	237	21	105		47	86	6
291	East	2833	167	646	57	256	153	804	447	44	120		63	66	10
291	West	2525	209	652	38	241	228	574	318	17	109		58	72	9

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
292	East	2540	128	523	41	154	156	840	402	40	95		64	85	12
292	West	2233	184	509	29	187	233	562	263	24	102		54	78	8
294	East	639			2		38	119	1	43	372		13	51	
294	West	708		2	7		22	170	11	44	354		15	83	
298	North	9632	271	1522	138	326	1795	2444	1163	1506	92		111	210	54
298	South	8514	116	1104	144	259	1575	2193	1191	1441	79		126	229	57
299	East	9215	215	1363	101	251	1454	2681	1117	1547	62		156	216	52
299	West	8785	86	882	73	211	1648	2721	1070	1604	67		166	197	60
300	East	11811	882	2189	134	393	1428	3245	2007	756	155		188	419	15
300	West	11789	968	2219	162	442	1592	2765	2168	547	158		206	544	18
301	East	8533	315	1289	106	285	1145	2583	1011	1280	54		162	248	55
301	West	8491	203	983	102	262	1319	2659	992	1404	73		178	258	58
302	East	2285	519	645	34	148	128	92	628	37	11		4	37	2
302	West	2657	530	841	43	170	194	96	715	30	4		8	22	4
303	East	4791	527	1031	67	215	561	1020	955	70	96		88	149	12
303	West	4295	566	940	70	239	425	813	805	47	109		84	188	9
304	East	80		1			3	7			53		1	15	
304	West	104					2	9			71		1	21	
305	East	115		11	4		5	25	2		56		5	7	
305	West	211		24	5		12	71	2		66		9	22	
306	East	1532		10	1		87	1249	18	9	9		34	115	
306	West	1464	1	29	6	3	102	1050	33	12	25		57	144	2
307	East	2197	37	70	5	18	138	1566	78	9	13		54	209	
307	West	1395	3	18	9	11	104	970	42	3	4		50	179	2
308	East	2711	154	540	42	152	169	895	426	35	94		78	116	10
308	West	2463	199	538	32	186	246	640	294	20	105		61	132	10
309	East	512		2	2		22	41	4	44	341		7	48	1
309	West	557			13		8	63		48	346		4	75	
310	East	2278	397	492	52	132	172	51	480	34	17		10	440	1

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
310	West	2916	536	789	68	153	184	64	651	40	9		6	412	4
311	East	717		3	34	2	21	71	24	44	376		7	135	
311	West	609	1		35		8	62	21	46	291		3	142	
312	East	4762	57	520	57	173	651	1720	371	815	29		128	193	48
312	West	4866	34	466	54	155	690	1810	361	934	38		130	155	39
313	East	219			3		4	8	1	1	89		2	111	
313	West	163		1	1			13		2	49		1	96	
314	North	1208	137	419	16	72	153	139	69	17	95		17	68	6
314	South	1218	99	451	21	61	24	257	105	27	71		16	85	1
315	East	696	14	46	18	24	16	309	155	4	2		7	100	1
315	West	678	30	52	19	14	21	340	91	4	7		6	94	
316	East	529	15	46	4	17	15	257	112	4	2		2	54	1
316	West	403	9	34	1	12	9	248	54	4	9		2	21	
317	East	242	14	22	3	15	12	89	61	2	1		1	22	
317	West	443	10	50		19	11	246	53	5	8		3	38	
318	North	1171	140	432	17	75	148	140	68	9	60		15	62	5
318	South	1252	105	467	23	62	77	264	111	17	48		13	62	3
319	East	78		3			1	8		44			19	3	
319	West	77						6		41			30		
320	East	19					1			14			4		
320	West	13							1	7			4	1	
321	North	642	76	105	6	61	4	101	201	1	57		14	16	
321	South	565	68	97	5	54	43	92	147	3	32		8	15	1
322	East	633	16	49	8	26	26	282	135	6	1		6	76	2
322	West	582	14	61	5	17	17	322	63	5	5		7	66	
323	North	592	1			4		21	9	46	2		501	8	
323	South	510		2			2	7	2	43	2		442	10	
325	East	697	20	55	8	24	39	300	144	6	2		4	94	1
325	West	605	13	64	6	18	17	334	65	5	7		6	70	
326	East	89		3			1	13	1	44	1		24	2	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
326	West	65				1		5		38			21		
327	North	980		15		26	4	32	16	44	29		803	11	
327	South	884		14		5	7	11	24	49	8		761	5	
328	North	3768	17	201	26	28	158	2152	100	85	344		194	459	4
328	South	3596	15	160	17	34	143	2230	118	75	229		186	387	2
329	East	3455	8	166	6	40	134	2075	119	61	415		165	266	
329	West	3555	10	209	18	37	153	2084	135	79	403		182	244	1
330	East	73		3			1	6		43			19	1	
330	West	72						6		41			24	1	
331	North	794	88	154	10	75	7	150	221	1	59		18	11	
331	South	643	67	132	8	53	38	119	153	7	32		14	18	2
332	North	541	3	18	3	7	120	176	19	42	15		64	72	2
332	South	519	3	37		5	147	127	25	44	5		56	68	2
333	North	1664	3	47	1		3	73	1	274	145		1101	16	
333	South	2198	1	56				79	2	286	316		1438	20	
334	North	2669	383	694	33	285	57	456	540	50	81		58	29	3
334	South	2961	402	800	46	319	140	531	474	23	121		73	29	3
335	North	857	2	164	7	5	52	490	21	6	3		44	63	
335	South	915	1	136	1	9	47	571	24	5	5		34	81	1
337	North	1084	9	153	14	2	62	710	16	8	36		52	21	1
337	South	1008		126	7	1	51	694	12	24	34		44	15	
338	East	198	7	4			81	26	3	18	33			25	1
338	West	87					62	5		5	11			4	
340	East	150	5				25	13	1	13	9		9	70	5
340	West	527	99	112	11	15	78	72	44	9	15		9	61	2
341	East	623	18	25	3	15	22	36	41	6	1		3	445	8
341	West	490	30	37	2	10	6	16	17	1	2		1	366	2
342	East	61		3			1	10		35			10	2	
342	West	72		1		2		5		40			23	1	
343	East	180	9	12		9	12	17	14	4	1		1	98	3

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
343	West	174	10	24	1	7	41	21	15	1	1		1	51	1
344	North	38	2	2		3			6					25	
344	South	46				2							1	43	
345	East	345	4	8		1	82	31	7	29	24		12	146	1
345	West	371	5	4	3		167	24	8	23	34		6	94	3
346	North	67	2	2				1	3				1	58	
346	South	29	1					1		1				26	
347	East	148	19	15	1		22	25	36	11	1		4	14	
347	West	269	18	9	1	3	64	60	74	2	12		9	17	
348	East	7	1				3		2	1					
348	West	13					6	3	4						
349	East	230	5	4		1	6	11	3	39	1		159	1	
349	West	284						10	5	42			227		
350	East	619	106	123	12	51	55	78	149	31	1		1	11	1
350	West	744	118	158	10	43	155	91	113	26	1		3	26	
351	East	110	7	19	1	14	9	33	20	3				4	
351	West	137	2	12		7	59	25	12	10			2	8	
352	East	185	11	25	3	29	21	48	28	12			3	5	
352	West	68	1	9		7	31	11		6				3	
353	East	90	20	1			18	4	28	10	6		1	2	
353	West	119	9	4			56	10	29		8		2	1	
356	North	173	17	15		30		37	48		18		5	3	
356	South	152	11	20	1	17	9	30	35		18		4	6	1
357	North	1458	2	98	15	39	396	348	104	388	11		40	16	1
357	South	1216		70	7	24	484	252	49	278	6		31	15	
358	North	306	23	47	2	6	15	96	39	58	3		14	3	
358	South	193	18	28		5	16	63	19	33	3		6	2	
359	East	35	4	8	1	7	5	4	4				1	1	
359	West	59	1	11		10	27	9					1		
360	North	36	6	4	1	1	4	5	6	5	1		3		

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
360	South	16	2	2		2	3	2		5					
361	East	1323		87	6	4	32	322	20	455		1	386	10	
361	West	1417		55	4	16	73	372	37	482			358	20	
362	East	126		6		1	7	45	4	54			8	1	
362	West	624		39		4	57	219	23	241			38	3	
363	East	88		4	1	2	1	25	6	44			5		
363	West	165		10		3	18	67	11	53			3		
364	East	566	9	52	6	8	16	180	52	236			6		1
364	West	676	5	41	3	8	15	102	28	455	1		17	1	
365	East	102				1		4		9	84		3	1	
365	West	106	1			1		3	1	1	96		2	1	
366	East	806	1	82	1	2	37	125	21	163	313		34	27	
366	West	857		85		2	77	130	29	140	324		37	33	
367	North	267	20	15		1	21	87	46	62	3		6	6	
367	South	217	14	16	4	5	17	52	30	71	2		4	2	
368	East	404	4	16		18	20	9	5	13	303		10	6	
368	West	408	14	18		16	13	8	19	15	287		13	5	
369	East	101	3	15		2	1	4	14	58	1		3		
369	West	112	7	28	1	4	7	2	16	45			2		
370	East	186		1			14	2	1	9	150		8	1	
370	West	317				1	18	3	3	1	277		11	3	
371	East	173	5	4	1	3	8	49	18	83			1	1	
371	West	220	1	8		3	19	72	5	107			5		
372	East	402		107	7	1	74	47	9	123	5		25	4	
372	West	374		102	4	2	71	46	3	124	1		19	1	1
373	East	184		1			46	8	1	122			5	1	
373	West	184		1		1	46	4	3	123			4	2	
374	North	2228		424	33	422	397	335	32	393	22		148	21	1
374	South	2794	2	599	42	459	650	343	37	450	17		163	29	3
375	East	1339		66	7	21	59	140	4	801	236		4	1	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
375	West	1428		93	6	31	65	156	4	819	243		9	1	1
376	East	2271		265	5	147	201	163	10	1143	325		9	3	
376	West	1922		244	13	128	206	157	9	925	226		11	3	
377	East	5044		654	21	237	344	774	76	1838	569	2	494	32	3
377	West	6895		982	26	283	588	1585	88	2005	793	1	490	50	4
378	East	3337		106	51	43	572	1636	13	285	417	40	156	18	
378	West	2331		69	45	9	465	1066	4	231	235	50	143	14	
379	East	694		46	6	35	34	246	3	67	230		21	6	
379	West	532		24	1	9	55	208	1	3	206	2	18	5	
380	North	1265		28	39		182	746	1	219	20	2	23	5	
380	South	2450		44	44	6	540	1356	7	218	193	4	35	3	
381	East	1260		68	3	1	25	306	12	465			372	8	
381	West	1482		69	3	4	63	443	32	510			345	12	1
382	East	2504		271	6	153	203	135	13	1210	508		2	2	1
382	West	2712		228	10	68	282	117	7	1281	712		6	1	
383	East	1118		101	7	56	71	233	4	163	470		9	4	
383	West	1658		135	5	66	113	264	6	338	717		9	5	
384	North	569		100	1	14	109	322	5	4	1		11	2	
384	South	614		108		5	150	316	7	2	1		23	2	
385	North	570		91		3	132	323	5	2	1		11	2	
385	South	572		92		3	151	295	7	1	1		20	2	
386	North	642		90	2	2	156	365	5	5	4		11	2	
386	South	604		103	3	1	154	301	7	2	4		26	3	
387	North	314		3	4			283					24		
387	South	344		3	5			316					20		
388	East	259						251					8		
388	West	297						293					4		
389	North	632		3	7			600					22		
389	South	786		3	8			746					29		
390	East	3358		174	50	9	790	1829	15	223	211		50	7	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
390	West	2951		158	47	7	696	1704	8	230	44		48	9	
391	North	1690		213	11	158	253	301	15	150	532		26	30	1
391	South	2423		401	17	359	433	368	19	395	303		87	41	
392	East	3392		93	48	9	755	2002	10	206	206		59	4	
392	West	2798		74	43	5	647	1716	7	220	33		48	5	
393	East	4229	1	464	67	350	1087	1464	14	556	196		25	3	2
393	West	4097		393	57	354	929	1364	12	659	297		26	3	3
394	North	1619		326	16	142	62	165	29	710	150		18	1	
394	South	1407		247	18	137	142	134	19	602	85		20	2	1
395	East	2848		357	23	205	234	301	28	1186	481		31	1	1
395	West	2586		454	32	222	116	276	34	1096	312		42	2	
396	East	2803		348	13	174	236	299	31	1177	491		30	3	1
396	West	2620		467	31	195	122	288	29	1120	329		37	2	
397	East	2114	1	151	26	118	916	596		122	170		12	1	1
397	West	2243		174	40	132	790	747		124	218		15	1	2
398	North	848		147	14	26	97	435	6	58	1		36	23	5
398	South	972		143	2	27	54	583	12	42			46	58	5
399	North	1234		95		145	158	166	1	409	246		14		
399	South	1511		215	9	241	195	194	1	402	241		13		
400	North	2799	173	660	23	46	215	560	287	693	5		98	37	2
400	South	2241	186	459	23	32	127	326	282	643	6		97	59	1
401	East	541	20	72	3	22	14	77	75	247	1		9	1	
401	West	866	15	105	6	20	13	125	66	494			21		1
402	North	243	11	15		2	21	87	28	61	4		11	3	
402	South	203	14	15	1	4	14	56	16	69	2		9	3	
403	North	1722	22	591	3	75	287	584	15	71	5		48	19	2
403	South	1623	38	546	3	84	278	554	24	27	3		47	18	1
404	East	1529		168	8	217	448	135	4	501	4		36	8	
404	West	1469	2	171	11	225	388	161	9	446	6		42	8	
405	North	2013		292	29	402	419	282	17	477	13		71	11	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
405	South	2273	1	330	31	374	635	260	13	528	11		71	18	1
406	North	2004		319	27	387	414	270	16	474	15		67	14	1
406	South	2244		334	30	368	618	239	15	530	13		74	22	1
407	North	789		164	3	44	131	374	15	18	1		26	12	1
407	South	846		162	2	49	195	364	6	20	3		31	13	1
408	North	779	6	288	1	4	97	234	8	85	17		29	10	
408	South	807	2	282	3	14	136	239	8	78	3		29	13	
409	East	1918	35	218	24	274	539	264	21	421			66	55	1
409	West	1901	4	262	27	321	447	256	16	430			70	67	1
410	East	427	17	152	13	104	46	54	20	3			9	9	
410	West	393	15	64	6	96	133	44	9	7			12	6	1
411	North	2979	20	691	27	303	569	651	19	538	21		100	39	1
411	South	2973	35	646	23	313	648	613	13	542	8		84	46	2
412	East	502	17	59	5	17		28	12	37	298		18	11	
412	West	458	24	23	1	4	3	27	18	32	297		19	10	
413	East	298	10	61	6	91	44	50	18	1			6	11	
413	West	425	9	63	5	101	187	38		8			7	7	
414	North	586	7	162	5	170	62	114	10	16	2		26	12	
414	South	755	10	179	18	169	191	106	12	23	8		30	9	
415	North	694	6	172	4	146	139	161	7	5	3		39	11	1
415	South	652	1	128	7	142	199	127	5	4	9		29	1	
416	North	762	7	235	7	146	150	170	6	2	4		25	10	
416	South	776	1	189	5	149	228	162	6	2	7		24	3	
417	North	672		322		48	122	112	6		10		23	29	
417	South	544	1	279		31	36	125	17	1	5		24	25	
418	East	1236	16	393	6	240	304	184	6		17		18	52	
418	West	1204	20	371	9	232	313	172	9	1	14		26	37	
419	East	1121	18	233	4	268	319	207	4		19		14	35	
419	West	1068	21	218	9	256	311	166	10	1	13		25	38	
420	East	190	5	72	6	26		45	10		7		17	2	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
420	West	232	10	62	5	25	2	105		1	7		12	3	
422	North	64		1		3	2	3	4	7			44		
422	South	59		2	1	1	3	2	4	7	1		37	1	
423	East	117	8	50	4	20		25	5		4		1		
423	West	35	1	8		7		15	1		2		1		
424	East	14					4	1	3	3	2		1		
424	West	14	1				6	4	3						
427	North	522	72	67	3	67	1	78	168		56		7	3	
427	South	327	51	59	3	33	23	53	74	1	17		2	10	1
428	East	137	8	56	4	19		25	13	1	6		3	2	
428	West	153	6	44	2	24		66	2		3		2	4	
431	East	2513	452	555	38	143	199	62	543	35	10		8	466	2
431	West	3175	599	858	66	169	209	62	756	43	5		7	398	3
432	East	152	13	56	3	20	2	32	15	1	5		1	4	
432	West	138	7	39	1	19		63	1	2	3		2	1	
435	East	5010	206	1152	223	370	384	1784	192	298	9		194	196	2
435	West	2010	196	342	178	72	4	962	9	6	3		76	162	
438	North	283						28		69	157		9	20	
438	South	139						6		32	79		6	16	
439	East	43		1	1	1	3	16	15	1				5	
439	West	52	2	4			1	25	15					5	
440	North	225						1		58	158		2	6	
440	South	117						4		29	72		3	9	
441	East	168	14	16	1	6	20	19	15	6	1		2	62	6
441	West	193	19	33	4	3	57	29	15	5	2		3	21	2
442	North	345	5	25			1	11		91	155		14	43	
442	South	381	7	15			1	5		121	190		7	35	
443	North	107		14				2		51	29		7	4	
443	South	60		2						31	18		3	6	
444	East	59	8	2			14	2	20	6	3		3	1	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
444	West	88	3	1			42	14	22				5	1	
445	North	236	5	6		6	1	3	1	36	112		49	17	
445	South	439	3	12		8		7	4	155	145		54	51	
446	North	519	6	29		2	2	11	1	121	123		206	17	1
446	South	489	5	15		3	2	9	2	160	164		119	10	
447	North	7						3			1		3		
447	South	2											2		
448	East	593	15	36	5	21	12	276	145	4	1		3	74	1
448	West	610	19	42	8	15	17	331	86	4	3		5	80	
449	East	157	3	8	3	3	4	58	55	2	1		1	19	
449	West	276	16	21	1	6	7	128	64	2	2		4	25	
450	North	213		1						57	149		4	2	
450	South	119		1				2		33	77		6		
451	North	78	1				1	2					62	12	
451	South	268	4	2		1	10	12	2	1	2		217	17	
452	North	173						5		120	30		2	16	
452	South	166						1		92	50		2	21	
453	East	92	12	6			13	12	30	8			4	7	
453	West	137	8	1			55	24	34		1		4	10	
454	East	84	10	7			12	11	28	7	1		4	4	
454	West	111	8	1			49	16	29				6	2	
455	North	143		1				6		102	22		3	9	
455	South	136						1		89	35		3	8	
456	North	76						1		56	8		7	4	
456	South	117		1			1	8	2	45	39		16	5	
457	North	196	1	1	1		2	6	1				164	20	
457	South	356	1	1			9	20	1	1	2		275	46	
458	North	257					2	2	1	3	2		241	6	
458	South	291	1	1			6	10	1	5	6		258	3	
459	North	501	2	240				66	3	3	16		124	47	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
459	South	532	2	257			1	60	7	1	14		146	44	
460	East	382	21	60	6	50	43	114	52	7			1	28	
460	West	552	7	80	6	59	195	99	25	45			8	27	1
461	North	5247	8	1664	124	443	531	1735	288	285	9		148	9	3
461	South	5417	3	1487	107	470	609	2051	139	352	11		174	12	2
462	East	196		3			19	40	3	128				3	
462	West	116		1			6	34	6	67				2	
463	East	166		4		1		4	7	145			1	4	
463	West	165		2				5	2	147			1	8	
464	East	101	26	1			17	7	31	10	6		2	1	
464	West	139	13	2			56	18	32	1	13		3	1	
467	East	417	18	66	6	80	44	116	43	5			5	34	
467	West	534	11	73	6	94	184	95	9	29			7	26	
468	East	46	4	15	3	10		6	4		2			2	
468	West	81	5	23		15		31	1		3		1	2	
469	North	453		2		7	4	21	6	34	2		358	19	
469	South	173		2	1	3	1	1	2	7	2		138	16	
470	East	695	24	59	10	25	44	281	156	6	2		4	83	1
470	West	544	13	64	2	18	13	277	59	4	8		3	83	
471	East	71		3			1	3		46			17	1	
471	West	49						2		32			14	1	
472	East	314	13	13	1	13	16	19	16	5			1	212	5
472	West	350	23	40	1	8	38	25	20	1	2		2	189	1
473	North	1277	184	302	10	190	38	219	211	38	32		45	8	
473	South	1326	227	266	20	208	102	212	195	8	52		25	11	
474	North	1225	164	284	9	192	37	214	199	40	36		41	9	
474	South	1212	194	248	16	187	83	216	179	7	47		23	11	1
475	North	1101	160	260	8	192	34	158	181	34	34		34	6	
475	South	925	158	202	12	126	66	155	135	5	38		14	13	1
476	North	785	123	171	5	146	26	95	165	2	22		25	5	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
476	South	469	69	107	4	65	41	83	63		25		5	7	
477	North	177	27	43		35	5	22	27		12		6		
477	South	165	29	32	1	32	10	24	14	1	12		4	6	
478	North	665	98	151	3	142	10	81	111	5	40		22	2	
478	South	971	160	190	8	194	18	168	152	9	49		19	4	
479	North	516	75	94		68		80	109	5	56		19	10	
479	South	711	114	105	3	106	4	155	119	8	59		25	13	
480	North	363	49	73		44		53	78	4	38		14	10	
480	South	196	33	18		26		25	47	2	30		13	2	
481	North	122	23	24		15		16	28		11		5		
481	South	252	54	27		36		45	56		17		14	1	2
482	North	213	25	39	1	14		24	75		16		16	3	
482	South	412	108	33		55	1	51	96	3	37		22	5	1
483	East	178	34	9	1	2	18	24	44	16	14		6	10	
483	West	171	27	9		1	48	30	39	2	11		2	2	
484	North	862	40	122	4	16	228	115	229	42	41		10	15	
484	South	1267	56	184	13	22	349	221	233	70	64		12	41	2
485	North	899	1	40	7	11	306	268	76	162	9		13	6	
485	South	1031		36	7	10	406	270	28	247	8		13	6	
486	East	219		10	10		7	74	3	38			27	50	
486	West	99		4	12		5	51	2	1	1		15	8	
487	East	138		6	2		4	38	4	31			53		
487	West	101		4	3		6	37	2	1	1	1	45	1	
488	East	282	1	19	4		7	76	16	62			97		
488	West	180		11	8		6	58	22	4	1	1	68	1	
489	East	601	1	33	11		6	126	34	102	2	1	281	4	
489	West	428		12	14	1	10	101	53	62	1		172	2	
490	East	110		2			8	40	3	42				15	
490	West	153		1			5	40	5	95				7	
491	East	208	16	34	3	17	23	65	33	12			1	4	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
491	West	500	6	81	4	53	173	87	25	44			8	18	1
492	North	1022	21	93	10	116	119	457	91	21	17		39	38	
492	South	246	4	22	4	42	31	99	15	1	2		13	13	
493	North	439	18	38	2	53	31	184	31	48	11		15	8	
493	South	257	6	22	2	50	39	78	21	8	1		12	18	
494	North	228	2	4	2	29	36	103	11	18	8		13	2	
494	South	115		3		23	24	47	6	4			6	2	
495	East	42		2				8	4	28					
495	West	48		1				1	1	44			1		
496	East	553	8	108	9	23	22	172	36	144	2		13	15	1
496	West	1017	40	166	12	64	80	399	28	202	2		12	12	
497	North	4				2							1	1	
497	South	300	73	51	4	116	2	18	24		3		6	3	
501	North	169	22	67		10	7	12	37	2	4			8	
501	South	3584	555	1198	69	199	138	269	1045	41	37		25	4	4
502	North	335	55	95	5	86	1	22	42		1		22	6	
502	South	13	1	1		3							2	6	
503	North	482	48	70	3	95	12	107	70	21	10		30	16	
503	South	704	60	96	10	126	37	212	28	32	12		30	61	
504	North	853	68	120	8	120	20	282	127	21	20		39	28	
504	South	716	48	74	6	102	44	253	64	34	19		28	44	
506	East	108		3		1		4	3	96				1	
506	West	135	1	1		1		1	1	127			1	2	
507	North	21		1			1	11	1				4	3	
507	South	202	18	38		9	6	50	21	49	1		6	4	
508	North	78	12	9	1	18	1	15	5	1	9		6		1
508	South	148	8	18	2	13	3	35	10	48	5		4	2	
509	East	57	5	20	3	16		5	3		1			4	
509	West	52	2	15		7		23	1		2			2	
510	North	328	18	39	2	40	7	99	66	25	14		16	2	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
510	South	819	53	85	7	111	47	302	92	58	18		34	12	
511	North	459	9	13	3	65	10	196	63	29	19		40	12	
511	South	208	3	7		17	8	83	18	41	8		16	7	
512	East	736	24	59	16	34	41	285	153	9	1		7	105	2
512	West	702	25	88	10	29	37	302	80	5	8		9	107	2
514	North	346	3	6	3	21	50	174	12	54	2		9	12	
514	South	122	1	2		4	24	72	5	1	1		2	10	
515	East	404	56	87	10	28	8	66	55	10	11		6	66	1
515	West	267	12	46	5	21	2	134	3	10	4		7	23	
516	East	146	12	24	1	19	11	35	30	8				6	
516	West	136	4	20	1	11	47	21	15	9				8	
517	North	1753	335	558	38	116	70	118	450	24	13		19	9	3
517	South	2253	371	692	35	162	152	153	626	23	15		13	6	5
518	North	70						65	1				1	3	
518	South	99		1			1	94						3	
519	North	83			1		1	81							
519	South	40					1	37			1			1	
520	North	77	1	2				72		1			1		
520	South	71		3			1	66						1	
521	North	7561	222	1207	86	270	1530	2005	998	1042	66		49	35	51
521	South	6268	80	619	86	212	1274	1822	828	1171	48		61	17	50
522	North	133		15	1	1	5	100	4	1	3		1	2	
522	South	150		8			12	121	1	2	1		3	2	
523	North	46			1		1	19	2				4	19	
523	South	6575	958	2611	143	551	208	462	1388	94	49		75	25	11
524	East	244		15	1	3	12	78	13	118			4		
524	West	262	1	38		5	31	94	2	87			4		
525	East	45	7	7		5	2	1	7	1	3		8	4	
525	West	36	12	8	1		4	1	5				4	1	
526	East	206		2				40		97			6	61	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
526	West	173		1			2	38		82			13	37	
527	East	339					2	58	1	185			29	64	
527	West	387		4			5	77		213			43	45	
528	East	166					2	37	2	110			6	9	
528	West	335	1	3			6	81		205			25	14	
529	East	84	1	1				10		70			2		
529	West	80						16		61			3		
532	East	92		4				22	1	60			5		
532	West	144		6		2		31	6	94			5		
533	East	81	1	4		6		4		4	55		6	1	
533	West	86		2		10		2	3		64		4	1	
534	East	231		3			2	28	3	188			4	3	
534	West	226						34		184			5	3	
535	East	217	1	10	1		3	9	17	163			1	12	
535	West	86		2		1	2	6	3	69			2	1	
536	East	172	37	22		22	8	8	34	15	5		15	6	
536	West	179	51	19		18	9	7	49	10	6		7	3	
537	North	127	39	20		3	8	4	34	8	4		5	2	
537	South	124	15	18	1	9	16	4	24	17			13	7	
538	North	265	59	48	1	16	27	23	48	21	6		6	9	1
538	South	293	40	56	2	27	47	22	40	29			8	22	
539	East	404	2	43	5	1	1	86	23	239			4		
539	West	594	3	66	5	4	3	190	37	265			18	3	
540	North	71	3	7	1	3	1	13	15	8	3		15	2	
540	South	74		18	2	4	9	11	6	4	2		16	2	
541	North	4275	858	1555	91	462	200	180	782	57	33		43	8	6
541	South	3704	600	1268	72	366	119	202	964	32	45		26	3	7
542	North	96	6	23			20	15	4	3	2		10	13	
542	South	83	1	3		1	34	21	1	1			8	13	
543	East	544	7	9			6	13	6	46	2		454	1	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
543	West	629	1	1	1		1	17	8	45			552	3	
544	East	256	11	51	9	61	42	54	22	1			5		
544	West	444	7	71	7	103	195	44	1	7			8	1	
545	East	8		4	1	1		1	1						
545	West	17		3	1	4		9							
546	North	314	22	4			35	116	51	44	10		9	23	
546	South	206	12	6			62	44	50	9	3		6	14	
547	North	37	3	2			3	8	10	5			3	3	
547	South	51	2				14	9	14	10			2		
548	North	19	1	2	1		2	4	2	2			5		
548	South	19	3	2		1	2	2		6	1		2		
549	North	266	36	10		7	31	49	48	43	7		32	3	
549	South	272	19	5		7	46	52	52	42	4		38	7	
550	East	312	5	16	2	2	6	52	24	200			4	1	
550	West	227		8	1	2	3	25	7	177			3	1	
551	East	66	15	3	1	2	15	2	12	1			11	4	
551	West	117	42	6	1	2	11	4	29	2	7		11	2	
552	East	72	5	19	2	11		20	7		3		5		
552	West	166	3	42	4	18		86			4		9		
553	North	127	1	14				32	1	2	9		58	10	
553	South	121	1	9			1	27		1	5		55	22	
554	North	99		17				78					4		
554	South	118		46				66					6		
555	North	158	1	78			2	65			1		6	5	
555	South	170		91	1	1	2	57					13	5	
556	East	321	11	65	8	97	43	58	24	1			5	9	
556	West	462	10	78	7	104	202	41		8			9	3	
557	North	99	10	19		48		8	2	1	3		8		
557	South	98	11	27		45	2	3	1		7		2		
558	North	185	17	7		1	11	48	28	57	3		1	12	

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
558	South	155	9	16	3	6	13	26	23	53	2		2	2	
559	North	114	7	19		65	3	7	2		2		8	1	
559	South	135	6	28	1	63	5	10	1		14		4	3	
561	North	109		10		26		38	14		1		20		
561	South	97		5	1	18		23	20	3	13		12	2	
562	North	128		1									124	3	
562	South	123						2					120	1	
563	North	87											86	1	
563	South	202						2					200		
564	North	4											4		
564	South	10											10		
565	East	418	3	185	5	35	29	55	42	27	20		15	2	
565	North	314	11	87		26	17	52	50	33	18		17	3	
566	North	66	2	9	1	12	2	6	5	1			4	24	
566	South	6288	934	2547	132	523	195	386	1353	75	50		66	16	11
567	North	5826	1026	2364	109	543	227	317	1046	63	46		64	14	7
567	South	40	7	17	1	4			4				2	5	
568	North	35		1			1	17	1				7	8	
568	South	6534	953	2610	135	549	210	442	1382	96	46		79	21	11
569	North	5893	1029	2349	115	557	236	328	1079	66	45		68	14	7
569	South	10												10	
570	East	32			1			6	4	21					
570	West	83		2			4	43	6	21			6	1	
571	East	102		2			2	70	1	9	1		17		
571	West	183		3			1	142		14			13	10	
573	East	104		3	2		1	89		1			5	3	
573	West	134						120		5			7	2	
574	North	12		1		8		1	1				1		
574	South	40		7		20		3	2		1		5	2	
575	East	129		2				9	4	114					

Leg	Dir.	Total traffic	Crude oil tanker	Oil products tanker	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fast ferry	Support ship	Fishing ship	Other ship
575	West	133					1	8	2	121				1	
576	North	7				2	2							3	
576	South	129		20		12	38	30	14	1			12	2	
577	North	146	5	70	1	11	1	22	2	16	13		1	4	
577	South	238	9	69	2	18	20	30	7	74	4		2	3	
578	East	9404	103	2115	157	772	1777	1235	539	2367	124		130	59	26
578	West	8482	111	1912	142	686	1561	1302	524	1912	114		142	48	28
579	East	1371	11	270	16	152	1	496	332	5	26		43	17	2
579	West	1392	12	280	14	165	60	451	321	4	44		35	5	1
580	East	201		7			1	5					6	182	
580	West	293		39		1	5	37		1	1		19	190	
581	East	219		7				1			1		4	206	
581	West	307		24				9					5	269	
582	East	256									1		8	247	
582	West	353						1					5	347	
584	North	89		6	3	30		36					8	6	
584	South	110		12		38		43					8	9	
585	East	335						1			1		9	324	
585	West	338						1					8	329	
586	East	1728		199	32	10	161	192	45	1080	5		3		1
586	West	306		44	10	6	68	42	27	102	1		6		

Model leg traffic for year 2019 – To be used for reference