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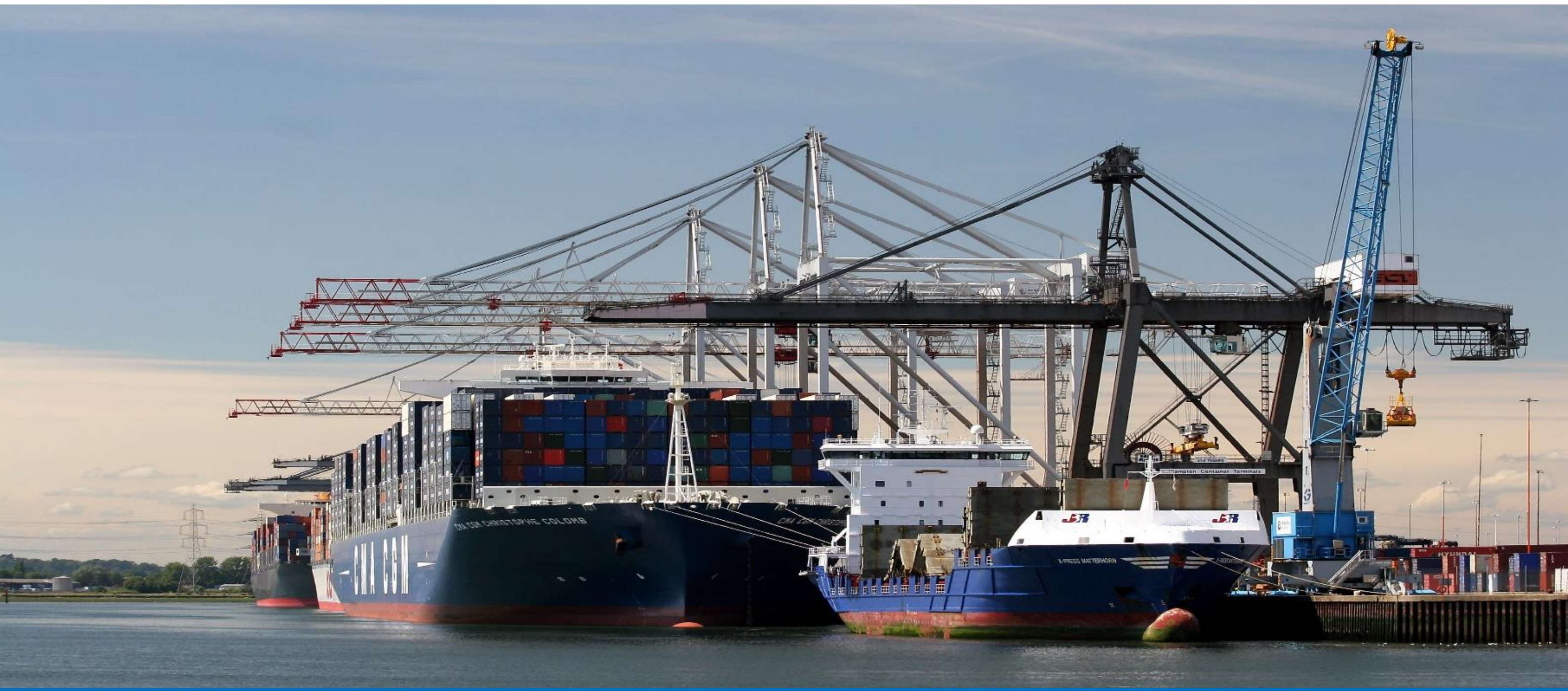
Mapping Shipping Cargo Value Technical Report (MMO1158)



MMO1158: Mapping Shipping Cargo Value Technical Report

October 2019

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Executive Summary

The maritime sector plays a critical role in the growth and development of the UK as a primary facilitator of global trade. An understanding of navigation routes and trade flows is therefore important in informing planning and management of UK seas. The MMO commissioned ABPmer to deliver Project 1158, ‘Mapping Shipping Cargo Value’ to review, develop and apply approaches to assigning value to shipping cargo flows for use across the English marine area, to support decision making. Information obtained from the project improves the evidence base for the development of marine plan policies thereby improving understanding of shipping cargo value associated with marine space use.

The calculated shipping cargo values were validated against port freight and sea passenger statistics from the major ports within the north east, south east, south west and north west marine plan areas. However, full results are only presented for the pilot area of the north east inshore and offshore marine plan areas, which is the case study area. The completed project also engaged with industry representatives to validate the approach used and the resulting outputs.

The scaled average weekly shipping cargo value within the case study area (i.e. the north east inshore and offshore marine plan areas) ranged from less than £100k to over £1 billion pounds sterling per squared kilometre per week (£/km²/wk.). The vessels with the largest cargo value were container vessels, pure car carriers and oil tankers. A comparison of the mapped shipping cargo value with the (Automatic Identification System) (AIS) vessel traffic density grid showed that further detail on shipping routes is available from the project outputs. Although the vessel traffic density grid was able to identify some routes, it did not identify all. Also, in the mapped shipping cargo value, it was possible to identify distinct routes, which served varying functions in terms of the cargo and value of the cargo being transported.

Furthermore, the mapped shipping cargo value was able to represent relative importance of different routes based on the varying value for different cargo types across the assessed north east marine plan areas. Finally, the results demonstrated the potential significance of service craft vessels, which were beyond the scope of the present project.

This project involved the use of several datasets and sources. A summary of the identified limitations included:

- the extent of AIS transmission, which had the influence of indicating no value or transits were present in the north east offshore marine plan area, which is highly unlikely to be the case
- potentially not all the applicable vessel characteristics were identified from the Lloyds data due to the nature of the available data
- a significant source of shipping value is that provided from service craft, which were not within the scope of this project. Although these vessels do not carry cargo, they serve important functions to offshore industries.

Based on the completed project, the following recommendations were identified:

- the value associated with service craft should be assessed, quantified and added to the presented shipping cargo value, in order to better represent the total shipping value across marine plan areas
- all plan areas and their associated ports should be used to determine a scaling value that is applicable to all the marine plan areas around the country.

1. Introduction

1.1 Background

The UK is one of the world's leading maritime nations. The maritime sector plays a critical role in the growth and development of the UK as a primary facilitator of global trade. The UK relies on the maritime sector for the import and export of goods and the additional value through maritime and business services (DfT, 2019). The shipping industry is a very important element in the UK economy; with the volume of goods transported by ships and demand for associated maritime services demonstrating steady growth.

At present, around 95% of British imports and exports in goods are moved by sea, including 25% of the UK's energy supply and 48% of the country's food supplies (DfT, 2019). Over 480 million tonnes of goods passed through UK ports in 2017, with the majority of this (i.e. approximately 387 million tonnes) involving international trade (DfT, 2018a). The contribution from the UK ports industry amounts to approximately £9.7 billion of direct value to the UK economy (Centre for Economics and Business Research, 2019a). In 2017, the maritime shipping sector directly supported over £47 billion in business turnover, £17 billion in gross value added (GVA) and 220,100 jobs for UK employees (Centre for Economics and Business Research, 2019b). In addition, maritime business services, including insurance and support services directly contribute approximately £2 billion GVA to the UK economy annually (DfT, 2019).

In addition to trade in goods, the UK also has a strong position in the global maritime tourism and leisure industry. The total revenue from the UK's leisure, superyacht and small commercial marine industry was estimated at £3.12 billion in 2017, with exports accounting for just over 30% of the revenue (DfT, 2019). The UK cruise sector is also a significant contributor, with approximately 1.96 million cruises sold in the UK in 2017 of which, over half started at a British port. The number of cruise passengers was four times greater in 2017 than in 2000 (DfT, 2018a).

The patterns of vessel traffic transiting UK waters have been mapped through previous Marine Management Organisation (MMO) projects, such as the MMO 1066 study (MMO, 2014b). The MMO 1066 study, plus subsequent national mapping exercises of vessel traffic has provided outputs that can be used within the marine planning process to understand the spatial distribution of vessel traffic. AIS has a range of uses for marine planning, the most important of which is the identification of sea area use. This is most frequently presented as vessel density per unit area, which summarises the use of sea areas as a scaled grid. AIS data can also be presented visually as transit lines. These are track lines created from individual vessel point positions, which form a track or 'transit' when joined together into a single line. Transit lines are normally classified into vessel type based on the information from the AIS signal. MMO 1066 study concluded that during 2012, 72% of the UK vessel transits pass through English national waters, 20% through Scottish waters and around 6% through Welsh waters with 2% in Northern Irish waters. To date, there has been no direct link of vessel traffic in UK waters with the value of the cargo transported. This project addresses the value of cargo carried by shipping.

1.2 Aims and objectives of the project

The MMO has commissioned ABPmer to deliver Project 1158, 'Mapping Shipping Cargo Value' to review, develop and apply approaches to assigning value to shipping cargo flows for use across the English marine area. The project has entailed the application of a methodology developed through the study to selected marine plan area(s) – i.e. the north east marine plan areas.
The information obtained from the project has improved the evidence base for the development of marine plan policies thereby improving understanding of shipping cargo value associated to marine space use.

The project objectives were to:

- compile a temporally referenced spatial dataset of shipping activity covering one year of data across selected marine plan area(s)
- identify, evaluate and source relevant data to determine shipping trade value
- combine the spatial data layer with the results of the value exercise to produce maps showing the value of shipping to specific geographical areas with as great a resolution as possible to enable marine plan policy development
- use stakeholder engagement to validate the robustness of the approach.

The project deliverables included:

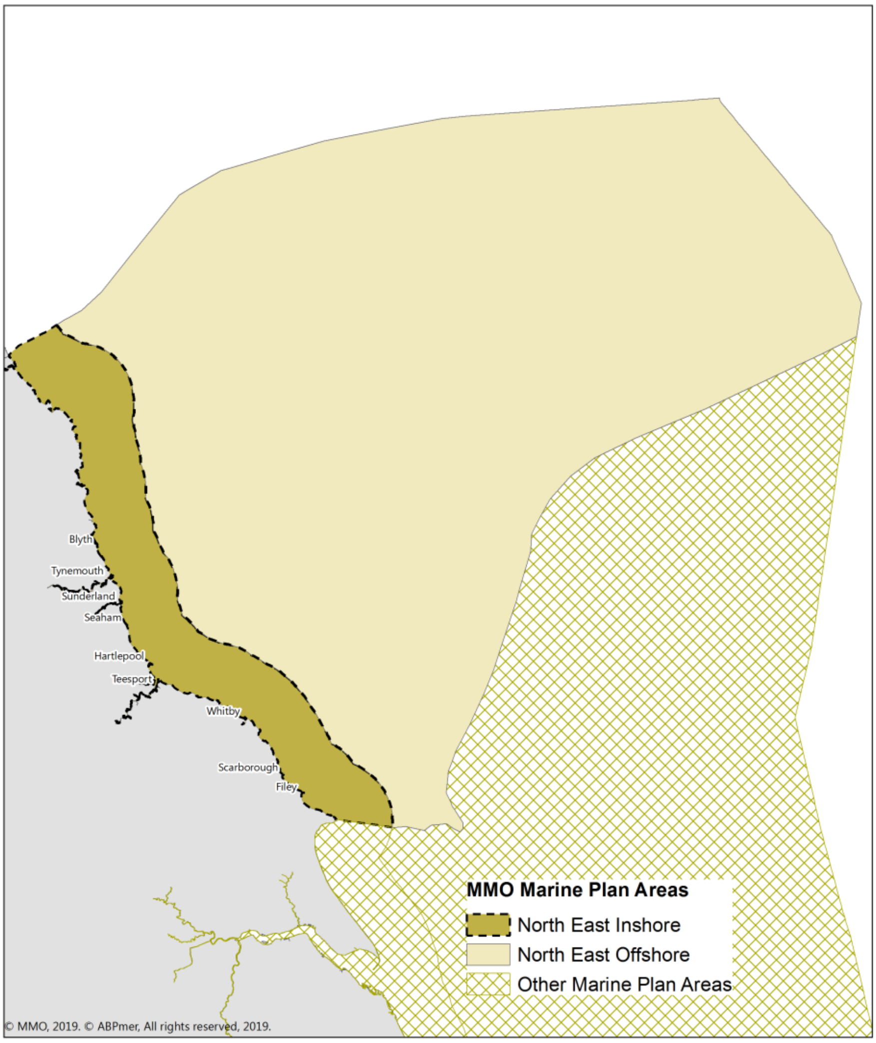
- spatial data layers of the mapped shipping cargo value, confidence assessments and associated metadata records
- a technical report (this document) which provides a detailed description of the datasets and approach used to map the shipping cargo value
- a final summary report which provides a non-technical description of the research findings.

It is important to note that the project has sought to design a method that can be used to assign cargo value to shipping across all marine plan areas. A significant proportion of this shipping is transiting through UK waters and does not land or collect cargo at a UK port. Therefore, the methodology has accounted for transitory vessels as well as those trading in UK ports.

1.3 Case study area: north east inshore and offshore marine plan areas

The case study area applied in this project is the north east inshore and offshore marine plan areas, illustrated in Figure 1. The case study area covers approximately 687 km of coastline stretching from the Scottish border to Flamborough Head in Yorkshire. It also includes approximately 56,000 km² of sea as it extends from the mean high water mark to the seaward limit of the Exclusive Economic Zone (EEZ), (MMO, 2017).

Figure 1: Case study area, the north east inshore and offshore marine plan areas.



The MMO (2019) north east marine plan draft policy highlights that:

"The north east coast ports of the Tyne and Tees provide clear corridors of shipping activity. Routes into the North Sea connect to the Baltic States, and most notably, ferry routes to the Netherlands from the Humber and North Shields. Teesport is an international asset with good deep water access and is constructing an offshore storage facility to utilise carbon capture and storage utilities. It is the largest exporting port by tonnage in England, exporting 20m tonnes per year. There are also numerous smaller ports servicing smaller vessels in the inshore plan area.

Shipping activity in the north east marine plan areas is linked to recent industrial and economic growth of areas including the automotive industry, renewable energy and the process industries."

The data and analysis approach described in Sections 2 and 4 respectively was applied to the case study area to map the shipping cargo value. The outputs from the case study area were made available for review and comment by the project stakeholders during the project workshop.

Following the project workshop, the MMO requested the method be repeated for a further five marine plan areas, namely the:

- south east inshore marine plan area
- south west inshore and offshore marine plan areas
- north west inshore and offshore marine plan areas.

The method was therefore applied across these plan areas, the benefit of which was an increased set of validation data allowing more refined scaling factors to be used (described further in Section 4.4). This technical report presents the findings relating to the case study area only, i.e. the north east inshore and offshore marine plan areas.

1.4 Stakeholders

The project made use of industry representatives in the form of a stakeholder team. The role of the stakeholders was to provide a broad view on the method and mapped shipping cargo value outputs. Several stakeholders were engaged from across the maritime sector, to ensure a range of industry expertise, from statutory advisors and industry associations to port representatives drawn primarily from the north east inshore marine plan area. The principal roles of the stakeholders were to:

- consider and comment on the proposed project approach and datasets, which were presented in a project method statement
- comment on the project results, which were presented at a project workshop (Section 1.5).

The following is the list of the stakeholders who were invited to be part of the stakeholder group.

- Associated British Ports;
- British Ports Association;
- Chamber of Shipping;
- Peel Ports Group;
- PD Ports (Tees and Hartlepool);
- Port of Sunderland;
- Port of Tyne;
- UK Major Ports Group.

Regulators/Governmental organisations associated with the project:

- Marine Management Organisation;
- Department for Transport.

1.5 Project workshop

A project workshop involving several stakeholders took place on Wednesday 17 July 2019. The purpose of the workshop was to present the project approach and output results and obtain feedback that could improve the achieved results.

During the workshop the stakeholders were able to discuss the approach that had been applied and the results obtained. As a result of the discussion, an important point raised was that shipping value should not be based on cargo carrying vessels only. It was commented that a significant source of shipping value is that provided from service craft. Although these vessels do not carry cargo, they serve important functions to offshore industries. Within the case study area, there are a number of offshore oil and gas installations and energy infrastructure which are serviced by the ports such as at Blyth. The need to consider the value from service craft is discussed in Section 7.

1.6 Report structure

The report is structured into the following sections:

Section 2:	Describes the datasets to be used in the project, along with any data processing requirements.
Section 3:	Sets out the assumptions that underpin the methodology.
Section 4:	Describes the chosen methodology for calculating and validating the shipping cargo value. It includes detailed descriptions of the process flow as well as the validation steps to be taken to ensure the accuracy of the mapped shipping cargo value
Section 5:	Presents the results, including the spatial distribution of shipping cargo value within the case study area.
Section 6:	Discusses the mapped results and identified shipping routes;
Section 7:	Presents the recommendations for applying and further developing the methodology to other marine plan areas.

2. Datasets and Coding Systems

2.1 Primary data types

In order to meet the objective of this project, a range of data types were necessary to ascertain information about vessels. This includes information about the vessel types, their associated cargo, value of the cargo and the transit of the vessels:

- shipping movement data (vessel types and number of transits)
- economic data (to determine commodities and cargoes and attaching monetary values to shipping activities and employment values)
- port activity data (port traffic categorisation, volume and value).

Due to the commercially sensitive nature of port business and shipping cargo value which is not readily available in the public domain, the scope of this project uses data which can be sourced through third party databases or from public sources. The datasets which have been intrinsic to meeting the project objectives include:

- Automatic Identification System (AIS) data
- Lloyds List Intelligence (LLI) Lloyds data
- Department for Transport (DfT) maritime statistics.

The properties of each of these datasets and the information used to estimate the shipping cargo value are considered in the following sections.

2.2 AIS data

The primary dataset used within the project is the AIS spatial data providing mapping of vessel transits within UK and adjacent European waters. AIS works by transmitting the locations and certain vessel properties to terrestrial receiver stations, which can influence the extent of observed transits when mapped. Two previous MMO projects described, examined and validated the use of the AIS data to inform the shipping characteristics around the UK, these are namely:

- ‘Spatial trends in shipping activity’, MMO Project 1042 (MMO, 2013)
- ‘Mapping UK shipping density and routes from AIS’, MMO Project 1066 (MMO, 2014a; MMO 2014b).

These projects involved data identification, stakeholder engagement, sampling, ‘cleansing’, analysis and processing to create AIS shipping data layers. The methodology proposed in this document uses AIS spatial data from 2017, which is the most recently available national dataset.

The data has been collected from the Maritime and Coastguard Agency (MCA) network of AIS receivers from around the UK. This data has been processed using the methodology identified in the MMO Project 1066 (MMO, 2014a).

The dataset combines both AIS-A and AIS-B data, where the use of the former is compulsory for some vessels and the use of the latter is entirely voluntary. AIS-A is carried by international voyaging ships with gross tonnage (GT) of 300 or more tonnes, and all passenger ships regardless of size.

Vessels below 300 GT and non-passenger carrying type are not required to carry AIS (although in practice, many do). AIS-B is carried by smaller vessels and is aimed at smaller commercial vessels, the fishing sector and recreational vessel users. Certain vessel types are permitted to turn off their AIS (for example, government or military vessels on operational duties). Therefore, the AIS system does not represent all vessel traffic.

The AIS data used in this project is a compilation of 84 days of data as collected by the MCA's receivers on the first seven calendar days of each month. This approach therefore accounts for seasonality by providing a representative 'average weekly' density grid and composite AIS transit line spatial record. As identified in MMO, (2014a), the locations of the terrestrial receiver stations does influence the extent of observed transits for the 2017, because some transits are observed to suddenly end. For these transits, the cargo value has still been determined, with a discussion of the potential extent of the transits.

The AIS spatial data for 2017 comprises approximately 36 million individual transits associated with nearly 24,000 unique vessel Maritime Mobile Service Identity (MMSI) codes for the whole of the UK. There are currently 27 different AIS message types which are used in combination to provide AIS-A and AIS-B services. For this project, decoded AIS data available as a geodatabase was used. Only a selection of the AIS data attributes were used, these are listed in Table 1 along with their applicability in the project method.

Whilst the AIS data contains information that may be used to infer the cargo type being carried, it is not considered specific enough to draw useful data for the purposes of assigning cargo value. More detailed vessel type information is available from the Lloyds data which this methodology uses to define cargo type. The MMSI was used to link the data sets together (Section 4.3).

At present, processing of the AIS data using the approach described in MMO (2014a; 2014b) results in a small number of individual transits being split into multiple unique transits. This occurs due to the way the 2017 AIS data is received from the MCA with respect to previous years. The effect of the splitting is to over-estimate the number of transits. It has little to no effect of on the mapped spatial value carried out in this work as the distance between the split transits are larger than the mapped grid cell.

The mapping approach in this project involves summing the cargo value of individual transits in each cell (see Section 4.5). It does not include the value associated with any split transit in any adjacent cells, so the value from any particular transit is only accounted for once in any grid cell.

Table 1: AIS spatial data attributes and those used in this project (MMO 1158).

AIS Attribute	Description	Applied in the Project	Study Application
AIS spatial geometry	The spatially mapped vessel transits	Yes	This is the spatial element of the vessel transits and routes. Information on the cargo value associated with a vessel is mapped to their respective transits.
MMSI	Unique vessel identifier	Yes	This is used to extract the vessel information from the Lloyds data.
Date Time Start	Transit start date and time	Yes	The date information is used to aggregate data into quarterly time scales to validate it with the available DfT maritime statistics.
Date Time Finish	Transit end date and time	Yes	
Ship Type Group	Vessel type	Yes	This is used to determine which vessel transits are mapped. Section 4.1 sets out the vessel types that are scoped in or out from the assessment.
Ship Length	Vessel length over all (LOA)	No	Information on the vessel dimensions only.
Ship Width	Vessel beam	No	Information on the vessel dimensions only.
Ship Draught (x10)	Vessel draught	No	Information on the vessel dimensions only.
Voyage Data Source		No	Not applicable
Transit Length	Length of transit	No	Not applicable
Position Density		No	Not applicable
Transit End Reason		No	Not applicable
AIS Type (1, 2, or 3)		No	Not applicable
Month (January to December)		No	Not applicable

2.3 Lloyds data

Data from LLI is a key dataset to inform this project and it is referred to as the ‘Lloyds data’ throughout the rest of this document. This dataset was used to inform the cargo on each vessel (determined from the vessel type, Section 4.2) as well as to provide the quality assurance of vessel classification.

The AIS spatial data (Section 2.2) provides information about the spatial vessel transits, while the detail about the vessel characteristics and potential cargo were interpreted from the Lloyds data as described in Section 4.2 below. The Lloyds data contains an extensive amount of technical data, contained in fields within associated tables. Information on the available fields and a description of the associated data is presented within the latest available LLI Technical Data brochure (LLI, 2017).

Four fields from within the Lloyds dataset were selected to use in the project to inform the vessel characteristics. These fields were also relevant in determining the potential cargo and were used as a match to the associated cargo value. The selected fields, description of the associated data and how the data was used in this project, is summarised in Table 2. Data associated with the four fields were procured from LLI for the unique MMSIs identified within the AIS data.

It should be noted at this stage that the vessel type information from the Lloyds data acted as a proxy for the potential cargo, in the absence of any direct information, which is described further in Sections 4.2 and 4.3.

Table 2: Lloyds data used in this project (MMO 1158).

Lloyds Data Field	Lloyds Vessel Characteristics Table	Description	Study Application
DWT	Vessels	Deadweight tonnage	Using available formulae, this measure will inform the cargo hold capacity or most vessels. This will in turn be used to estimate the value associated with a vessel carrying a particular cargo.
Vessel Type	Vessel	Decoded value of vessel type	Informs the vessel type based on the 159 vessel type variants used by the Lloyds data.
TEU Operation Capacity	Vessel capacities	Operational TEU capacity of the vessel	Informs the number of twenty-foot equivalent units (standard shipping containers) the vessel can safely carry during operation and will be used to inform the value of container vessels.
Number of Passengers	Vessel Design, Superstructure and Miscellaneous	Number of passengers the vessel can carry.	Informs the number of passengers a commercial passenger vessel can carry, which will be used to inform the value of such vessels.

Of the approximately 24,000 unique vessel MMSIs from the 2017 AIS data, the Lloyds data was able to provide vessel characteristics information for approximately 11,000. The large difference in the available vessel characteristics can be explained because the missing records related to smaller craft below 99 gross tonnes and/or privately-owned vessels not registered and accessible to Lloyds.

2.4 Standards, guidelines and economic indices

Several data sources were investigated to provide the information used to calculate the shipping value. Data was obtained about vessel types and classes, as well as cargo types and the associated commodities and unit values. The range of sources applicable to each category are summarised in the sections below, while the approach used to translate the data into shipping value estimates are described in Section 4.2.

2.4.1 Vessel type and class

For this study, the vessel types used conform to the internationally recognised StatCode 5 system (IHS Markit, 2017a; 2019) and they were cross referenced with the International Classification of Ship Types 94 (ICST 94).

The StatCode 5 coding system is an industry-standard of vessel type coding, developed by IHS Markit and approved by the International Maritime Organization (IMO). It is also used by LLI in defining their vessel types and by the DfT in providing summary statistics of cargo for varying vessel types (DfT, 2012). The code comprises five levels with each successive level containing additional detail. The first level separates vessels into two types those that are cargo carriers (Type A) and those that are working vessels (Type B). This level is what is used to scope in the vessel types for further analysis as described in Section 4.1.

Vessel types used in the Lloyds data conform to this coding system until level three, where the StatCode 5 system begins to breakdown type based on cargo, with little impact on construction of the vessel. Level four and five codes continue refinement by cargo type category (IHS Markit, 2017a; 2019).

The ICST system was developed by an *ad hoc* group of users working within the United Nations Conference on Trade and Development (UNCTAD). This included the Statistical Office of the European Communities (SOEC) and Lloyds List Intelligence (DfT, 2006). This system remains an international standard and is used by national bodies including the DfT. The groupings are based according to the construction of the vessel rather than its use at a point in time (IMAG, 1994) and do not differentiate between different cargo types. This system is comparable with the vessel types provided in the Lloyds data and is therefore referenced to the StatCode 5 method in this study.

The applied StatCode 5 vessel types, along with the associated AIS and Lloyds vessel types and the interpreted cargo are outlined in Table A.1 (Annex A). The approach used to link the vessels to cargo types is addressed further in Section 4.2.

Vessels irrespective of type are built to a specific size or DWT range and are often referred to with a specific vessel class name (for example, Handymax). These class sizes are generally consistent across different vessel types. The vessel classes identified and used in this project are summarised in Table 3. The classes are applied as it provides a consistent DWT range from which the potential cargo and capacity can be determined.

Table 3: Vessel classes and DWT range.

Class	Alternative Class Title	DWT Range	Definition
Aframax		45,000 – 79,999	The largest tanker size as defined by the Average Freight Rate Assessment system
Capemax		>130,000	Largest dry cargo size: Too large for Suez or Panama, therefore, have to transit either of the capes.
Chinamax	Valemax,	210,000 – 400,000	To fit china ports for the Brazil to China ore trade.
Handymax		40,000 - 59,999	The largest of the Handysize range of bulk carriers (superseded by the Supramax listed below)
Handysize	Laker, Logger	10,000 - 39,999	Smaller vessels able to carry bulk or packaged cargoes, Heavier built vessels in the class used for timber deck cargo
Malaccamax	VLCC	160,000 – 319,000	The largest size of vessel able to fit through the Malacca strait (25m depth), they typically have a 20.5m draught.
Panamax	Kamsarmax	60,000 - 99,999	The largest vessel size for transiting the original Panama Canal and the Panama Canal Authority (ACP)
New Panamax	Neopanamax	85,000 - 129,999	The largest vessel size for transiting the new Panama Canal locks is the Panama Canal Authority (ACP)
Post-Panamax	Super-Panamax	35,000 – 57,000	Any vessel too large to transit the Panama Canal
Q-Max		130,000 – 160,000	Specifically, a membrane type LNG vessel. The largest size for the LNG terminals in Qatar
Q-Flex		120,000 – 129,000	Smaller than the Q-Max, still within the largest gas carrier type (Q-Class)
Seawaymax		25,000 – 40,000	The largest vessel that can transit the St Lawrence seaway
Suezmax		80,000 – 159,999	The largest vessel size able to transit the Suez Canal, limited to 20.1m draught and 68m air draft

Class	Alternative Class Title	DWT Range	Definition
Supramax	Ultramax	50,000 – 59,999	Replacement of the Handymax
VLCC	Malaccamax	160,000 – 318,999	Very Large Crude Carrier (crude/dirty cargoes only).
VLGC		60,000 – 119,999	Very Large Gas Carrier (LPG)
VLOC	Capesize	160,000 – 209,999	Very large ore carrier
ULCC		320,000 – 549,000	Ultra Large Crude Carrier (crude/dirty cargoes only)
Ultramax		50,000 – 59,999	‘Geared’ bulk carrier. An upgrade to the Supramax
ULOC	Valemax, Chinamax	210,000 – 400,000	Ultra Large Ore Carrier. The largest bulk carriers, conforming to Chinamax draft and beam but may be longer

2.4.2 Commodity, cargo and capacity

Cargo type exists separately to commodity as cargo is defined by how a product is transported and commodity on what a product is (Eurostat, 2017). Cargo as a term covers many commodities of similar handling and transportation methods. Vessels have adapted to specialise in the handling of different cargoes and therefore one vessel type may be carrying a number of different commodities within a specific cargo category (introduced in Section 2.4.1 above and discussed further in Section 4.2). This complicates the process of assigning value based purely on assumed cargo types based on the vessel type description.

The approach taken in this project is to use cargo categories describing how the goods are being transported in terms of the vessel being used and are aligned to the United Nations Economic Commission for Europe (UNECE) recommendation 21 (UNECE, 1986). However, value information is only available in relation to the commodity. For this project, data was obtained for different commodities and their associated cargo from multiple sources, including but not limited to following:

- the United Nations Economic Commission for Europe (UNECE) recommendation 21 (UNECE, 1986), which provided information on cargo types and commodities
- the Reference Manual on Maritime Transport Statistics included in Eurostat, (2008; 2017), which informed the linkage between different commodities and cargo types

- the European Sustainable Shipping Forum Sub-group on Shipping monitoring, regulation and verification (MRV) draft guidance document on the determination of cargo being carried. The report summarised the range of possible cargo and the parameters to measure the cargo volume for different vessel types (European Commission, 2017).

Further information on the range of commodities and cargo types is presented in relation to each vessel type in Table A.1 (Annex A).

2.4.3 Value

Cargo values were calculated from the unit value or cost of selected commodities for 2017, which were selected to represent the global worth of the product as closely as possible. Commodities and their associated value sometimes required multiple conversions in order to ascertain the cargo value as described in Section 4.2.5. A range of sources were assessed in determining the appropriate unit value for the assessed cargo. A summary of these are provided below while more information on the unit value associated with particular cargoes and vessel types are presented for each vessel type in Annex B.

A summary of the sources reviewed to determine the unit value used in the project include but are not limited to the following:

- monthly market indices from the Organisation of the Petroleum Exporting Countries (OPEC) (OPEC, 2017a; 2017b; 2017c), which informed unit cost
- the United Nations Conference on Trade and Development (UNCTAD) review of maritime transport for 2018 (UNCTAD, 2018a) and between 1968 and 2018 (UNCTAD, 2018b), which provided a summary of trade statistics and associated cargo value information
- London Stock Exchange, shipping freight and investor reports, which all informed unit cost.

2.5 Department for Transport maritime statistics

The DfT produce a range of statistics to provide information on trends and patterns in the handling of freight traffic and (or) sea passengers at UK sea ports (DfT, 2018b). Of most relevance to this project are the port freight and sea passengers' statistics, described in Sections 2.5.1 and 2.5.2 respectively.

2.5.1 Port freight statistics

The DfT port freight statistics are based on data reported to the DfT by port authorities and shipping lines, or their agents. Within the data, ports are split into major ports and minor ports, where Major Ports are defined by DfT as those with cargo volumes of at least 1 million tonnes annually (DfT, 2018b). More detailed data is generally only available for major ports, such as breakdown by cargo type.

The port freight statistics provide estimates of tonnage of freight or cargo arriving or (and) departing from ports, aggregated over a quarter or annual time scale. The statistics were therefore unable to provide information on the monetary value associated with a single vessel transit. The port freight statistics were therefore used as an indication of aggregated cargo volumes for individual ports, which were in turn used to scale the vessel fill capacity of the AIS vessel transits and therefore the associated economic cargo value. The validation assessment of the process for ascertaining the mapped value of shipping is described further in Section 4.4.

A total of 16 DfT port freight statistic tables were appraised for their relevance to the project, these were:

- Port0101 (DfT 2018c): All UK major and minor port freight traffic, by port and year (direction filter) from 1965
- Table Port0201 (DfT 2018d): UK major port freight traffic, cargo types by year (direction filter) from 2000
- Port0202 (DfT 2018e): UK major port unitised freight traffic cargo types by year (filter by direction, international or domestic, tonnage, units or loaded units), from 2000
- Port0203 (DfT 2018f): UK major port unitised freight traffic by port and cargo type (direction filter)
- Port0204 (DfT 2018g): UK major port traffic by route and cargo type (filter by direction and year)
- Port0205 (DfT 2018h): UK major port freight traffic by top routes and year (filter by cargo type and direction)
- Port0301 (DfT 2018i): UK major port freight traffic, by port and year (filter by direction and cargo type), from 2000
- Port0302 (DfT 2018j): UK major port freight traffic, by port and route (filter by direction, cargo type and year)
- Port0303 (DfT 2018k): UK major port freight traffic by top 30 UK ports for each cargo type (year filter)
- Port0400 (DfT 2018l): Individual major ports traffic, by cargo type and international or domestic
- Port0499 (DfT 2018m): UK major port traffic, port level downloadable dataset: 2000 - 2017
- Port0501 (DfT 2018n): UK major port traffic indices1 - rolling four quarter totals, from 2000
- Port0502 (DfT 2018o): UK major port traffic, total tonnage and units1, by port, quarterly from 2009
- Port0601 (DfT 2018p): UK ports, ship arrivals by type and deadweight: 2017
- Port0602 (DfT 2018q): UK ports, ship arrivals: 1994-2017
- Port0603 (DfT 2018r): UK ports, sum of deadweight of ships arriving by type: 2017.

2.5.2 Sea passengers' statistics

All the DfT sea passenger statistics were reviewed for their applicability to the project and included:

- SPAS0101 (DfT 2018s): All UK international short sea, long sea and cruise passenger movements, by port: from 1950

- SPAS0102 (DfT 2018t): UK international short sea passenger movements, by ferry route1: from 2003
- SPAS0103 (DfT 2018u): UK international short sea passenger movements, by overseas country: from 1950
- SPAS0105 (DfT 2018v): All UK international short sea, long sea and cruise passenger movements, by type of route1: quarterly from 2009
- SPAS0108 (DfT 2018w): UK international short sea passenger movements, by UK port and overseas country: from 2009
- SPAS0201 (DfT 2018x): UK domestic sea passenger movements, by type of route: from 2003
- SPAS0202 (DfT 2018y): UK domestic sea passenger movements, by type of route: quarterly from 2009
- SPAS0501 (DfT 2018z): All UK international and domestic sea passenger movements, by UK country: from 2002.

Of the above sea passenger statistics, only table SPAS0101 (DfT, 2018s) was required as this provided the total number of passengers from commercial passenger transit ports. The sum included passengers on short sea (i.e. domestic), long sea (i.e. international) ferries and cruise passengers. As the available AIS data did not provide enough detail on the vessel journeys, there was no requirement to break down the passenger numbers by transit route, as provided in the other DfT sea passenger statistics tables.

3. Project Assumptions

To complete this project, several underlying assumptions were applied, these are:

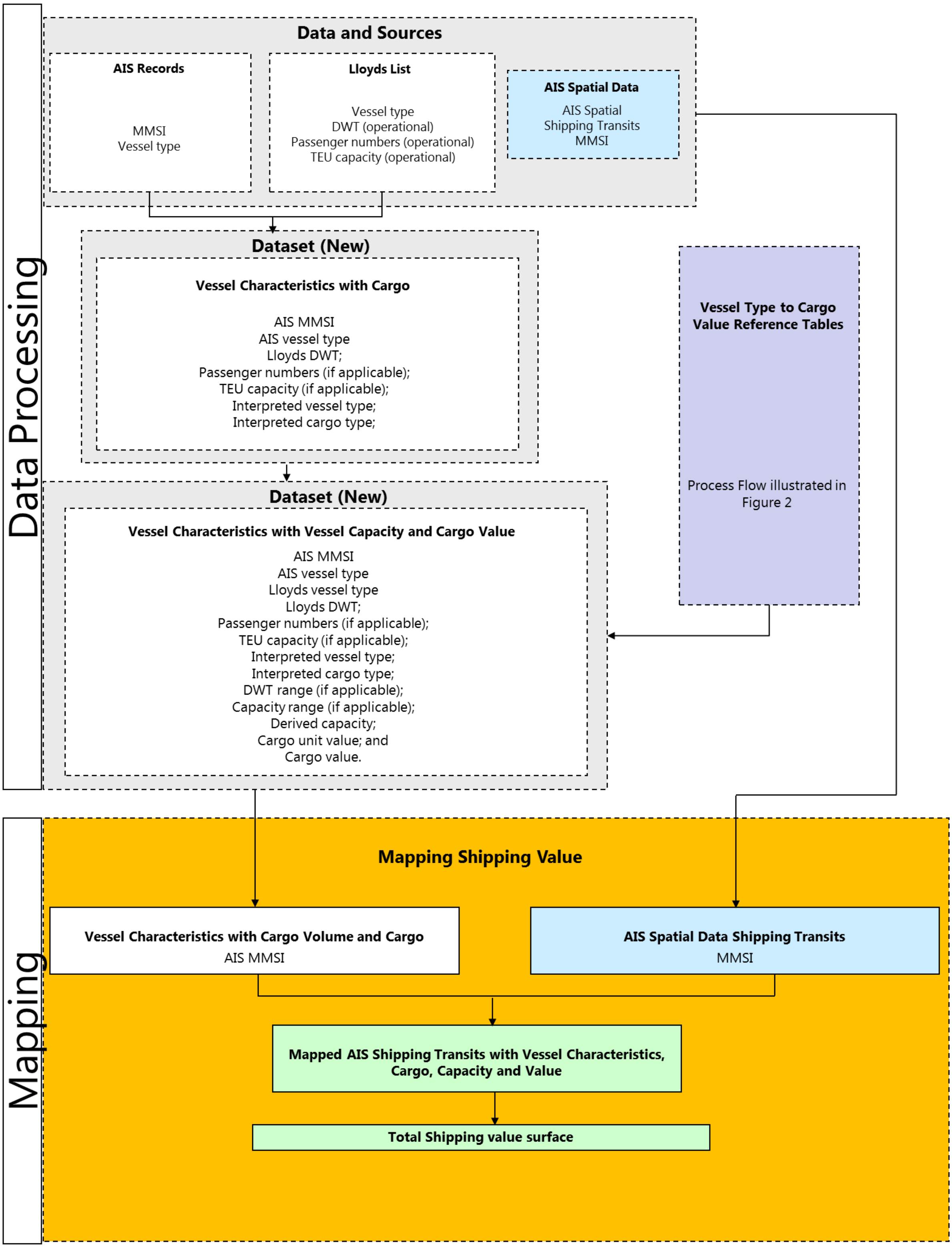
- the vessel type specified in the Lloyds register was used as a representation of the cargo type and the volume of cargo that can be carried, using the approach described in Section 4.2 below. In many instances, this was likely to be correct as vessels were built for specific functions. However, there could be cases where a refit occurred, which would have altered the vessel function and such changes were not reflected in the Lloyds data record
- the maximum operational cargo volume could be determined from the DWT. Vessel types are generally based on a construction type (which is dependent on a cargo specialisation) and is further categorised by standard design (Class). Therefore, each vessel type has an associated DWT range
- cargo types exist separately to commodity, as cargo is defined by how goods are transported and commodity on what goods are being transported (Eurostat, 2017). Vessels are also adapted to specialise in the handling of different cargoes and therefore one vessel type may be carrying several different commodities within a specific cargo type. The cargo groups that inform this study describe how the goods are being transported in terms of the vessel being used. These are aligned to the UNECE recommendation 21 (UNECE, 1986). As a vessel type can carry various commodities, the most common commodities for each vessel type class are used along with the associated unit cost to determine the cargo value
- the unit values used to calculate, and map shipping value is determined from the Standard Unit Value (SUV) for commodities. In trade a commodity has an associated SUV, therefore the unit value associated with a cargo (or the cargo unit value (CUV)) is informed by the SUV associated with the commodity or commodities that makes up a specific cargo type
- as a cargo may comprise a range of possible commodities, the associated value of a cargo may also have a range, whereas a single value is required. The method used to determine the appropriate CUV for the applied cargo, is described with respect to each vessel type in Annex B
- value is calculated for a vessel using the CUV of its cargo and the associated capacity for that cargo on a particular vessel type
- vessels may be empty or at capacity, or varying capacities in-between. Therefore, a validation exercise using DfT data has been completed to assess for varying percentage fill capacity as described in Section 4.4 below. This has helped to confirm the most appropriate percentage fill capacity to apply.

4. Approach

There are different ways of expressing shipping value. This may be in terms of the volume or weight of goods imported as a result of the shipping industry. Alternatively, it may be assessed in relation to the revenue and gross value added (GVA) generated from goods and associated services at local, regional or national scales.

The approach adopted for this project is to assess only the volume and value of cargo, goods or passengers being carried on the vessel, where the vessel properties are used to inform the cargo and the associated capacity and cargo value. It does not include or account for any additional GVA to the local, regional or national economy. The scope of the project is concerned with the assignment of cargo value to shipping and therefore has not considered vessels that provide a ‘service’. Figure 2 illustrates the process flow for establishing and mapping the value of cargo on ships within UK waters. The following sections describe in more detail, elements of the process flow and the associated analysis.

Figure 2: Process flow for mapping shipping cargo value.



4.1 Vessel type scoping

A high level scoping exercise was carried out to remove vessel types from the dataset which were not considered appropriate for inclusion in the full analysis. In this project, only Cargo carrier Type A vessels, based on the first level of the StatCode 5 coding system are scoped in for further analysis.

The scoping exercise was completed based on the vessel type properties as provided by the Lloyds data (Section 2.3). Table 4 below illustrates both the Lloyds data and the AIS vessel types associated with the scoped in Cargo carrier Type A vessels. Of the 11,000 unique MMSI records for which vessel characteristics were available for (Section 2.3), just over 8,000 MMSI records were scoped in as Cargo carrier Type A vessels. The scoped in vessels types accounted for approximately 33% of unique vessels within the 2017 AIS data and approximately 55% of the transits recorded in the data across the UK.

Table 4: Vessel types scoped in / out.

Scoping	StatCode 5 (First Level)	Example Lloyds Data Vessel Type	AIS Vessel Type	Scoping Reason
In	A	Bulk carrier Bulk ore carrier Fully cellular containership Vehicle carrier	Cargo vessels	Carries cargo or goods.
In	A	Combined chemical and oil tanker Crude oil tanker Chemical tanker Edible oil tanker Product tanker	Tankers	Carries cargo.
In	A	Ferry Passenger Roll-On, Roll-Off (Ro-Ro) Passenger (cruise)	Passenger vessels	Carries commercial passengers.
In	A	Passenger vessel	High Speed Craft	Carries service personnel in support of offshore infrastructure projects. A Crew Transfer Vessel (CTV) carrying 12 personnel is used as a representative example

Scoping	StatCode 5 (First Level)	Example Lloyds Data Vessel Type	AIS Vessel Type	Scoping Reason
Out	B	Buoy ship Pilot ship Tender Tug	Port service craft	Provides a service function, no specifically defined goods or commercial passenger.
Out	B	Dredgers	Vessels engaged in dredging or underwater operations	Maintenance dredgers provide a service function. Aggregate dredgers load a specific cargo. Differentiating them in the AIS dataset was scoped out.
Out	B	Fishing (general)	Fishing	Provides a commercial function but is scoped out of this study.
Out	B	Naval Auxiliary Vessel Naval Vessel Patrol ship	Military or law enforcement vessels	Provides a service function, with no specific cargo, goods or commercial passenger.
Out	B	Research Trawler Training Supply Survey	Non-Port service craft	Provides a service function, no specifically defined cargo, goods or commercial passenger.
Out	B	Yacht	Recreational	Does not serve a commercial function.

4.2 Establishing cargo capacity and value

4.2.1 Overview

The presented approach addresses the assignment of value to Cargo carrier Type A vessels, for subsequent assessment of the value of shipping using the AIS spatial data. The approach used in this method is to develop ‘reference tables’ for selected vessel types that associate DWT, vessel type, cargo, vessel capacity and cargo value through defined relationships. These are referred to as ‘vessel type to cargo value reference tables’ in the remainder of the report. These tables are used to assign the appropriate characteristics to each unique MMSI represented within the AIS spatial data, based on the vessel type and DWT identified in the Lloyds dataset. The approach focusses on North Western European trade to best fit the AIS data collection area.

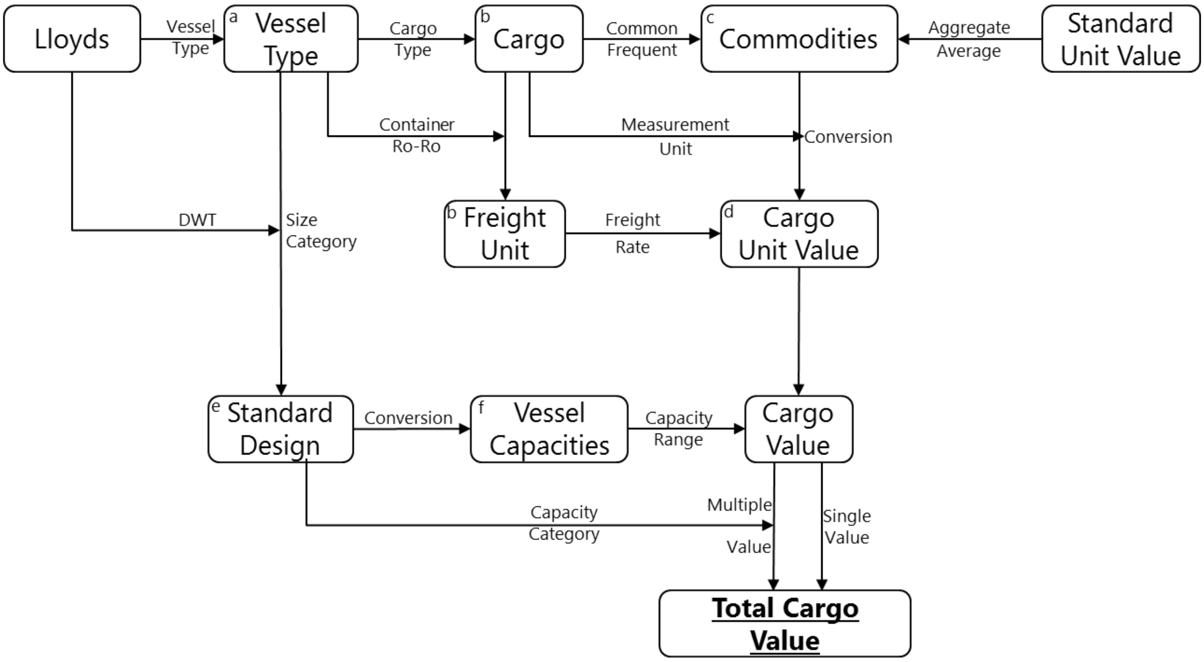
The process in deriving the vessel type to cargo value reference tables for the selected vessel types is described in this section (Section 4.2), while the process for assigning the cargo type, vessel capacity and value to each MMSI based on the Lloyds data properties is described in Section 4.3. The method used to scale back the vessel capacity because vessels are unlikely to always use their maximum capacity is described in Section 4.4. The final mapping process is addressed in Section 4.5.

The perceived limitations of the applied approach mainly relate to the quality assurance of the applied data sources. Therefore, every effort has been applied to use standards, guidelines, measures and data defined by national and international regulatory bodies. The process for establishing value and developing the tables for each vessel type may be considered in six steps. Each step uses or is informed by national or international industry or regulatory standards and commercial markets, introduced in Section 2.4. A summary of the six steps required for establishing shipping value is listed below and illustrated in Figure 3. Steps a. to d. outline how the CUV is determined and links the SUVs to each cargo and the vessel type. Steps e. and f. outline how the vessels capacities are derived, including details on the linkages between varying vessel classes, DWT and their associated cargo value.

a. Vessel Type: Defines the vessel type based on construction;
b. Cargo: Assigns commodities to cargo types;
c. Commodity: Derives the SUV for each commodity;
d. Cargo unit value: Converts the SUV of a commodity to a CUV associated with a cargo;
e. Standard design: Classifies vessel types into standard designs; and
f. Vessel capacities: Application of standard design class capacities to CUV to derive value range.

A description of the relevant industry or regulatory standards and the processing required to achieve the necessary information in each step is described in Sections 4.2.2 to 4.2.7.

Figure 3: Process flow in estimating cargo value and developing the vessel type to cargo value reference tables.



4.2.2 Step a: Vessel type

To assign value to shipping, each vessel type must first be known. In this methodology, only Cargo carrier Type A vessels based on the StatCode 5 and ICST 94 systems were scoped in. The Lloyds data identified up to 168 vessel types, of which only 50 were scoped in as Cargo carrier Type A vessels. The scoped in Cargo carrier Type A vessels, related to approximately 33% of the unique vessels represented in the AIS data (Section 4.1).

Using information on the designed cargo and vessel construction associated with the 50 scoped in vessel types (from the Lloyds data), these were grouped together to relate to the StatCode 5 level 3 vessel categories. This process reduced the number of vessel types down to 10, which comprised the “assessed vessel types” and are listed in Table 5.

The Lloyds vessel types identified for each unique MMSI from the Lloyds data were then matched to one of the assessed vessel types presented Table 5. Table A.1 (Annex A) illustrates the matching process, demonstrating the scoped in Lloyds vessel types and the associated assessed vessel types applied in this project.

Table 5: Assessed vessel types.

Assessed Vessel Types
Oil tanker
Gas carrier
Pure car carrier
Container
Ro-Ro cargo and containers (Ro-con)
Dry bulk

Assessed Vessel Types
Chemical tanker
Ferry/cruise
Ro-Ro cargo and passengers (Ro-Pax)
Specialist[1]
[1]: Specialist vessels relate to vessel types that serve niche functions and in this project are taken to be a) Livestock carrier; b) Heavy load; c) Refrigerated cargo (Reefer) and d) Nuclear fuel carrier. It is worth noting that for the north east marine plan areas only reefer vessels are applicable, although the other specialist types occur within other marine plan areas (see Section 4.4).

4.2.3 Step b: Cargo

The fourth and fifth levels of StatCode 5 which delineate vessel type by a commodity were used to develop the range of cargo types assessed as part of the project. This was completed for only the scoped in vessel types. The possible cargo types associated with the scoped in Cargo carrier Type A vessels are summarised in Table 6. The scoped in cargo types were also reviewed to determine the most common commodities associated with each cargo, which were used to establish the appropriate SUV (see Section 4.2.5).

The cargo type for each unique MMSI was interpreted from the vessel type information provided in the Lloyds data and matched to the types represented in Table 6. However, it should be noted that although multiple cargo types are identified for a single vessel type, where the detail is unavailable to identify a cargo, an aggregated cargo type and associated value has been applied instead.

As vessels have specialised into the transport of homogenous bulk cargo, the carriage of general unitised cargoes has also developed with the use of intermodal freight containers (twenty-foot equivalent units (TEU's) and Ro-Ro units). Whereas previously a vessel would have carried up to twenty different cargo types within its holds, these cargoes are now placed in freight containers or trailers and the vessel specialised in the transport of these units in bulk. Due to the complexity of freight units being carried as a cargo the allocation of commodities to a vessel becomes opaque. To address this, the unit value for a freight unit or container is determined based on an average of published estimates of cargo value per container from 2017 (IHS Markit, 2017b). Further information on the method used for freight units is provided in Annex B.1.

Table 6: Cargo types associated with the scoped in vessel types.

Assessed Vessel Types	Associated Cargo Type
Oil tanker	• Crude oil • Oil products
Gas carrier	• Liquefied natural gas • Liquefied petroleum gas
Chemical tanker	• Chemical tanker goods • Other chemical tanker goods • Chemicals

Assessed Vessel Types	Associated Cargo Type
Bulk Dry	• Dry bulk goods • Ores • Coal • Agricultural products • Forestry products • Other dry bulk goods
Container	• Large Containers • 20 ft freight units • 40 ft freight units • Freight units >20 ft and <40 ft • Freight units >40 ft
Ro-Ro cargo and container (Ro-con)	• Mobile self-propelled units • Road goods vehicles and accompanying trailers • Trade vehicles (including import/export motor vehicles) • Other mobile self-propelled units • Mobile non-self-propelled units • Unaccompanied road goods trailers and semi-trailers • Unaccompanied caravans and other road, agricultural and industrial vehicles
Ro-Ro cargo and passenger (Ro-Pax)	• Same as types for Ro-Ro Cargo • Same as types for Container • Rail wagons engaged in goods transport • Shipborne barges engaged in goods transport • Other mobile non-self-propelled units
Ferry/cruise	• Passenger
Specialist	• Live animals on the hoof (Livestock carrier) • Nuclear fuel (Nuclear fuel carrier) • Refrigerated dry bulk

4.2.4 Step c: Commodities

For each cargo type the most commonly transported commodities have been used to determine the unit value of that cargo (i.e. the CUV), based on annual global average for 2017. The SUV associated with each commodity was either directly applied or aggregated to derive the average value for the commodity range. Each SUV was given as a monetary value per unit measurement of commodity.

4.2.5 Step d: Cargo unit value

As each commodity was assigned value per unit measurement, in the instance the unit differed from the cargo unit, the associated value was converted to align with the cargo measurement. This meant that commodities sometimes required multiple conversions. For example, gas is transported as a unit per volume (m^3), but has value estimated as energy per unit (Btu). As a Btu value is not directly comparable with metres cubed, an additional conversion was required.

The commercial value of cargo (and their associated commodities) fluctuates daily based on varying economic and global factors. Therefore, the cargo value used in this project was based on the market value of constituent commodities as an annual average for 2017. The unit value for each cargo type was determined in United States Dollars (USD), which was used to calculate the cargo value as illustrated in Section 4.2.8. Prior to mapping, the USD cargo value was converted to Great Britain Pounds (GBP) sterling using an average rate for 2017, estimated to be 1.35 USD to 1 GBP.

Vessel standard designs may also have either single or multiple cargo values assigned to their classes, this is dependent on the cargo types associated with that design. A single CUV applies to vessels of a single cargo type such as container vessels where a single freight rate is used. Multiple CUVs were used where a clear division between standard design class and transported cargo is apparent, for example oil tankers. The unit values identified for the different cargo types are listed in Table 7, while a summary description of the source and any associated assumptions are included in Table C.1 (Annex C).

Table 7: Cargo unit values.

Assessed Vessel Type	Deduced Cargo	Estimated Unit Value (USD)
Oil Tankers	Oil Products	58.4
	Crude Oil	55.9
Gas Carriers	LNG	2.99
	LPG	7.82
Chemical tanker	Chemical tanker	622
Containers	Containers TEU	46,750
Dry Bulk	Major dry bulk	105.1
	Minor dry bulk	422
Pure Car Carrier	Vehicles	36,600
Ro-Con	Containers TEU	46,750
	CEU	36,600
	LM	63,318
Cruise	Cruise passenger	1,791
Ferry	Ferry passenger	312
Ro-Pax	Passenger	312
	CEU	508.3
	LM	63,318
Specialist	Livestock Carrier	262.3

Assessed Vessel Type	Deduced Cargo	Estimated Unit Value (USD)
	Heavy Load Carrier	80,000
	Refrigerated Cargo	165

4.2.6 Step e: Standard design

Vessels are built to standard designs based on the cargo to be carried and trading route. Trading routes and ports determine the limits on maximum vessel size, with economic factors influencing the most efficient size. As standard design is based on vessel size and type, this information was therefore used to categorise each vessel, assign cargo carrying capacity and derive cargo value.

Standard design classes have DWT ranges associated with them depending on vessel type. Therefore, by using the DWT and vessel type from the Lloyds data, the cargo carrying capacity (Section 4.2.7) and value (Section 4.2.5) were estimated. For each of the 10 vessel types used in this method (see Section 4.2.2), a reference table was produced outlining the standard designs within that type, and the associated DWT and cargo carrying capacities. These vessel type to cargo value reference tables are set out in Annexes D.1 to D.10 for all the assessed vessel types. To provide an example of the method an illustration for the oil tanker vessel type is presented in Table 8, as a worked example (Section 4.2.8).

4.2.7 Step f: Vessel capacities

The cargo carrying capacity was derived from the Lloyds data using the DWT and vessel type, as vessel capacities are generally based on the DWT and standard design (or construction). Vessels are built for the carriage and handling of specific cargoes. Therefore, a vessel's construction is similar within each standard design. Like the standard design, capacity was assigned as a range due to the inherent variability of ship construction and based on industry accepted values. Some vessel types have additional construction differences within standard design classes, such as gas carriers where refined product carriers are either pressurised, refrigerated or a combination. In this instance, there was no change to the deadweight ranges however, the cargo unit value (CUV) was adjusted to compensate for the difference in capacity.

In shipping, capacity units are measured depending on the type of cargo carried, as cargo is determined by the handling and transportation of similar goods the units for commodities (SUV) may vary from the cargo unit value (CUV). Therefore, in this project, the SUVs were converted to relate to the cargo unit in use in order to produce a uniform figure.

4.2.8 Worked example (establishing cargo capacity and volume)

Oil tanker vessel type

Oil tankers are a vessel type intended for the transport of oil in bulk (DNV GL, 2011). These vessels are categorised as A13 vessels under StatCode 5 (Tanker, Oil) and category 1 (Bulk Liquid Carrier, Oil tanker) under the ICST 94. The construction of a tanker is such that it can take on, carry and discharge as a chemical tanker. In addition, an oil tanker is fitted with machinery specifically for the handling of oils and their associated characteristics. Oil tankers differ from other chemical tankers in the specific requirements placed on them regarding the nature of the intended cargo (IMO, 2014).

The most appropriate approach in determining value for this vessel type was through the use of the vessel's standard design. The steps required to ascertain the cargo, capacity and value for the vessel type are described below, while Table 8 summarises the resulting reference table.

Standard Design

Oil tankers are built to six standard designs. However, the Coastal, Handymax and Panamax classes are commonly used as product carriers with larger classes used for crude oil. The associated DWT and capacity ranges were collected from various industry sources and commonly accepted values and are illustrated in Table 8. The capacity of an oil tanker is measured in barrels (bbls) with one-barrel equivalent to 42 US gallons (around 151 litres).

Cargo

Bulk liquid refers to unpackaged liquid goods that can be handled through a pipeline and stored and transported on a vessel (Eurostat, 2017). StatCode 5 separates tanker cargoes into four categories, namely liquefied gas, chemical, oil and other liquids. The most common of these is oil cargo.

Oil cargo is further divided into crude oil, oil products, bitumen and coal/oil mixture. The most commonly and frequently transported cargoes are crude and oil products. Therefore, these cargoes were selected to represent the oil tanker ship type.

Crude oil varies in type and quality. Crudes are named by the source location and grade and include over 250 products. The grading of crude oil is based on the American Petroleum Institute (API) specific gravity measurement which identifies the composition of the crude. Lighter grades (sweet crude) are of more value and heavy grades (sour crudes) of less value. Crude oils are transported from their source location in large quantities to refineries where clean oil products are produced.

Most crude oil is refined into gasoline, kerosene, diesel, fuel oil and naphtha. These products are transported in smaller quantities and have their value linked to the benchmark price of crude. Therefore, the oil products cargo type is implicitly accounted for in the estimated unit price.

Value

Crude oil value was derived from OPEC figures for the crude benchmark price. The selected crudes were representative of all grades and provide a balanced average of global crude value in 2017. A unit value of 55.89 USD per barrel was estimated, which was derived from the SUVs based on the Suezmax, VLCCs and ULCCs.

Clean product tanker value was defined from the OPEC monthly figures for refined products in 2017 and averaged to provide a representative annual value. The most common products for Western Europe were assessed to have a unit value of 58.42

USD per barrel produced. The value for clean products was derived from the SUVs based on the standard designs of Coastal, Handymax and Panamax vessels.

The two values derived for oil tankers were applied to the relevant class, capacity and value ranges detailed in Table 8. As an illustration, a vessel with a DWT of 30,000 tonnes, carrying clean product, equates to a Handymax design, with a capacity between 190,000 and 345,000 bbls, with an associated cargo value between 10.6 and 19.3 million USD.

Table 8: Oil Tanker information table.

Class (Standard Design)	Alternative Class	Cargo	DWT	Capacity (bbls)	Value (USD) (m)
Coastal	General Purpose (GP)	Product[1]	<24,999	<190,000	0 – 11.1
Handymax	Medium Range (MR)	Product[1]	25,000 – 44,999	190,000 – 345,000	11.1 – 20.2
Panamax/ Aframax	Large Range 1 (LR1)	Product[1]	45,000 – 79,999	345,000 – 550,000	20.2 – 32.1
Suezmax/ Aframax	Large Range 2 (LR2)	Crude[2]	80,000 – 159,999	550,000 – 1.9 m	30.7 – 106.2
VLCC	Very Large Crude Carrier (VLCC)	Crude[2]	160,000 – 319,000	1.9 – 2.2 m	106.2 – 123
ULCC	Ultra Large Crude Carrier (ULCC)	Crude[2]	320,000 – 549,000	2.0 – 3.7 m	111.8 – 206.8

[1] Average price per barrel in 2017 for refined products 58.42 USD (OPEC, 2017b; 2017c)

[2] Average price per barrel in 2017 for crude oil 55.89 USD (OPEC, 2017b; 2017c)

4.3 Assigning vessel and cargo characteristics to each unique MMSI

As described in Section 4.2.6 above and set out in Annex D (Table D.1 to Table D.10), the vessel type to cargo value reference tables were developed for each vessel type and used to assign the cargo capacity and value to each unique MMSI identified within the AIS data. The key elements required to achieve this were the DWT and vessel type information provided from the Lloyds data. The process used to complete this are described in Sections 4.3.1 and 4.3.2 below.

4.3.1 Assigning vessel and cargo types

Section 2.3 describes the information contained within the Lloyds data, which was obtained for each unique MMSI. This created a new dataset consisting of:

- AIS MMSI

- AIS vessel type
- Lloyds vessel type
- Lloyds DWT
- passenger numbers (if applicable)
- TEU capacity (if applicable).

This dataset was used in the scoping exercise described in Section 4.1 using the Lloyds vessel type information. This exercise scoped in only the MMSI records that were Cargo carrier Type A vessels, which resulted in just over 8,000 unique MMSI. Using the process described in step a. to determine the vessel type (Section 4.2.2), the appropriate assessed vessel type from Table 5 was assigned to each MMSI record. The cargo type was then interpreted from all the available vessel type information, particularly the Lloyds vessel type. The matching process resulted in a new dataset consisting of:

- AIS MMSI
- AIS vessel type
- Lloyds vessel type
- Lloyds DWT
- passenger numbers (if applicable)
- TEU capacity (if applicable)
- assessed vessel type
- interpreted cargo type.

4.3.2 Assigning vessel capacity and cargo value

The cargo type, vessel capacity and cargo unit value were all interpreted and added to each MMSI record using the vessel type to cargo value reference tables (Table D.1 to Table D.10, Annex D) and the assessed vessel types. As demonstrated in the reference tables the vessel capacity ranges were available for most vessel types in relation to the vessel standard design (Sections 4.2.6 and 4.2.7). The DWT provided by the Lloyds data was used to interpolate between the capacity range to derive a single estimate from which to calculate value. This process created a new dataset consisting of:

- AIS MMSI
- AIS vessel type
- Lloyds vessel type
- Lloyds DWT
- passenger numbers (if applicable)
- TEU capacity (if applicable)
- assessed vessel type
- interpreted cargo type
- DWT range (if applicable)
- capacity range (if applicable)
- derived capacity
- cargo Unit Value
- cargo value.

The properties for each MMSI record were applied to all the AIS transits for the vessel with the same MMSI. The resulting output was a dataset comprising the AIS transits across the assessed marine plan areas, with the relevant cargo capacity, unit value and total cargo value for that transit. The cargo value initially determined in USD was converted to GBP using a conversation rate of 1.35 USD to 1 GBP (Section 4.2.5).This initial result assumed that the calculated cargo value output was representative of a vessel at full capacity. Therefore, a subsequent validation exercise described in Section 4.4 was used to investigate the appropriate percentage fill for different cargo types.

4.4 Validation

4.4.1 Overview

The purpose of the validation exercise was to obtain a more representative and realistic measure of value associated with shipping cargo. Therefore, the estimated capacity from the AIS transits was compared against available DfT port freight and sea passenger statistics. This was completed for the transits arriving or departing major ports within the inshore marine plan areas.

Initially, this was carried out in the case study area only (the north east in shore and offshore marine plan areas). Following the user stakeholder meeting it was agreed to expand the method to five further marine plan areas and use the validation exercise to obtain a more representative scaling value derived from across multiple marine plan areas including the south east, south west and north west marine plan areas.

The validation involved calculating a scalar for each assessed vessel type by which to scale the estimated capacity. The DfT tables reviewed for their applicability have been introduced in Section 2.5, while this section describes how the DfT statistics were applied to determine the vessel type scalar.

4.4.2 Validation ports

The validation ports used in this project are based on major ports as identified by the DfT. These are recognised as ports with cargo volumes of at least 1 million tonnes annually and in 2017, there were 51 major ports across the UK.

Table 9 lists the 15 major ports which occurred across the four assessed inshore marine plan areas that were used in calculating the cargo capacity scalar. The information used from these ports included the weights and units counts for the DfT cargo groups and types (see Section 4.4.3 below).

Table 9: Major ports within the assessed marine plan areas used for validation.

Inshore Marine Plan Areas			
North east	**South east**	**South west**	**North west**
Sunderland	Felixstowe	Bristol	Manchester
Tyne	Harwich	Fowey	Heysham
Tees and Hartlepool	Ipswich	Plymouth	Liverpool
	Dover		

	Medway		
	London		

There were an additional 17 minor ports across the four assessed inshore marine plan areas. However, these were not used for validation due to the level of detail of the available port freight statistics and how they are determined. The statistics for the minor ports (i.e. table Port0101 in Section 2.5.1) was limited in its applicability as it only provided total cargo tonnages and did not break this information down by cargo type. This meant that if there were multiple cargo types from the AIS transits, it was not possible to ascertain what tonnage related to each cargo type. Furthermore, from discussions with the DfT, the annual statistics were not always reported by the ports as they were not required to do so, instead the statistics were estimated from historical data.

To carry out the validation, the AIS transits arriving and departing the validation ports were all selected. Table 10 summarises the number of AIS transits that were identified for each respective port during the 84-days of available AIS data. A total of 38,277 transits arriving or departing the validation ports were used for the validation exercise.

Table 10: AIS transit counts for the different vessel types that arrived or departed the validation ports.

Inshore Marine Plan Areas	Assessed Major Ports	Assessed Vessel Types										Total
		Container	Chemical tanker	Oil tanker	Gas carrier	Ro-Ro cargo and containers	Pure car carrier	Ro-Ro cargo and passengers	Dry bulk	Ferry/Cruise	Specalist[1]	
North east	Sunderland			2				1	71			**74**
	Tyne	43	13	6	2		170	150	55	22		**461**
	Tees and Hartlepool	214	276	79	227	99	15		138			**1,048**
South east	Felixstowe	426	2			138			18			**584**
	Harwich		12	2		4		125	13			**156**
	Ipswich		8					2	204	6	14	**234**
	Dover		19					1,656	10	14	18	**1,717**
	Medway	95	16	13	11	90	145		223	2	23	**618**
	London	1,358	643	245	101	2,985	171	1,994	1,529	18,265	111	**27,402**
South west	Bristol	39	33	20		54	169		146	17		**478**
	Fowey							2	42	1		**45**
	Plymouth		24	12				96	60	512	1	**705**
North west	Manchester	47	206	32	190				160	8		**643**
	Heysham					653		292				**945**
	Liverpool	269	64	85		659	14	226	228	1,353	269	**3,167**
Total		**2,491**	**1,316**	**496**	**531**	**4,682**	**684**	**4,544**	**2,897**	**20,200**	**436**	**38,277**

1: This includes livestock carrier, heavy load carrier and refrigerated cargo

4.4.3 DfT cargo groups and types

The DfT port and freight statistics contained 27 cargo types associated with seven cargo groups. The vessel types associated with the AIS transits were matched to the DfT cargo groups. Table 11 below summarises the vessel types identified from the AIS transits (arriving or departing the validation ports) and the associated DfT cargo groups and types used to carry out the validation.

Table 11: DfT cargo groups and the associated assessed vessel types

DfT Cargo Groups	DfT Cargo Types	Assessed Vessel Types
Container	• 20-foot, • Between 20-foot and 40-foot, 40-foot • over 40-foot	Container
Chemical tanker	• Liquefied gas, • Crude oil, • Oil products • Other chemical tanker products	Gas carrier Oil tanker Chemical tanker
Dry bulk	• Ores • Coal • Agricultural products • Other dry bulk • General cargo & containers < 20-foot	Dry bulk
Ro-Ro	• Import/Export motor vehicles • Other mobile self-propelled units • Unaccompanied road goods trailers & semi-trailers • Unaccompanied caravans and other road, agricultural and industrial vehicles • Rail wagons, shipborne port to port trailers, and shipborne barges engaged in goods transport • Other mobile non self-propelled units	Ro-con Pure car carrier
Ro-Ro	• Road goods vehicles with or without accompanying trailers • Passenger cars, motorcycles and	Ro-Pax

DfT Cargo Groups	DfT Cargo Types	Assessed Vessel Types
	accompanying trailers/caravans • Passenger buses	
Ro-Ro	• Live animals on the hoof	Livestock carrier
Passenger	• Passenger movements	Ferry Cruise
Other general cargo	• Forestry product, • Iron & steel products	Dry bulk
All bulk traffic	• Bulk fuels • Other bulks	Chemical tanker
Main Freight Units:	• Lo-lo main freight • Ro-Ro main freight	Container Ro-Con

4.4.4 DfT tables

Of the 16 DfT port freight statistics tables reviewed for the project (Section 2.5.1) five were considered applicable and used within the project, as these included detailed information about the major ports. The applicable port freight statistics and their relevance to the project is summarised in Table 12.

Table 12: DfT port freight and sea passenger statistics used in this project.

Applied DfT Port Freight Statistics Tables	How Applied
PORT0301 (DfT 2018i)	This table sets out the total tonnage or units for major ports on an annual basis. The data is characterised by cargo groups, which comprise several cargo types and traffic direction (i.e. inwards or outwards). This table formed a primary source of data for validation within the project as it provided information about cargo groups.
PORT0302 (DfT 2018j)	This table builds on the information presented in PORT0301, for the major ports only. It adds on data about the routing associated with the cargo, in terms of the tonnages associated with domestic and international traffic. This table was mainly used for information only.
PORT0400 (DfT 2018l)	This table presented similar data to PORT0302 for the major ports only. However, it provided the total tonnages or units associated with the individual cargo types within each cargo category and the traffic routing. This table also formed a primary source of data for validation within the project, when information was required about individual cargo types.
PORT0601 (DfT 2018p)	This table presented counts of the number of arrivals of vessels for cargo types within a DWT range. This

Applied DfT Port Freight Statistics Tables	How Applied
	table provided data associated with all ports. It was mainly used for information as the data provided was associated with vessel counts rather than tonnages or number of units.
PORT0602 (DfT 2018q)	This table presented the total count of cargo vessel arrivals on an annual basis for all ports. It was used for information only.
SPAS01 (DfT 2018s)	This table provided information on sea passengers on both domestic and international routes. It provided counts of all UK and international short sea, long sea and cruise passenger movements, by port. This table only contained data from ports with recognised short sea and long sea routes and cruise hubs.

4.4.5 Validating and scaling the estimated capacity

Implementing the approach described in Section 4.3 assumed that the cargo capacity associated with the vessel was always full and at its maximum. It was not considered realistic that all vessels would be at their maximum cargo capacity. There was a requirement to scale back the cargo capacity to a more representative value. To achieve this, information was queried from the DfT port freight statistics to obtain the total tonnages and units count for the cargo groups at the 15 validation ports. The port freight statistics were assessed against the sum of the cargo capacities for all the transits with the associated vessel type. As the available AIS information was only representative of 84 days of traffic, the method used were scaled up to a year to compare with the DfT total tonnages or unit count.

As generally expected, the cargo capacities (determined from the AIS transits at the validation ports, using the approach described above) significantly overestimated the actual cargo tonnages moving through the ports. Therefore, the margin by which the cargo capacities were overestimated for each DfT cargo group was determined for each validation port. An average was then calculated across the 15 validation ports to determine a cargo capacity scaling factor for the respective vessel type. The cargo capacity scaling factors calculated for the assessed vessel types are summarised in Table 13.

Table 13: Calculated cargo capacity scaling.

Assessed Vessel Types	Calculated Cargo Capacity Scaling[1]
Container	4.48
Chemical tanker	2.50
Oil Tanker	2.50
Gas Carrier	2.50
Ro-Ro cargo and containers (Ro-con)	6.07
Pure car carrier	6.07

Assessed Vessel Types	Calculated Cargo Capacity Scaling[1]
Ro-Ro cargo and passengers (Ro-Pax)	9.78
Dry Bulk	1.95
Ferry/Cruise	1.12
Container	1.95
Specialist: Reefers[2]	1.95
Specialist: Livestock carrier[3]	6.07
Specialist: Heavy load carrier[4]	1.95

[1]: Cargo scaling parameter presented to two decimals places but applied with greater precision within the analysis.
[2]: The reefers vessel type refers to refrigerated vessels and were treated as dry bulk when applying the scaling.
[3]: The livestock carrier vessel type was treated as Ro-Con when applying the scaling.
[4]: The heavy load carrier vessel type refers was treated as dry bulk when applying the scaling.

The calculated scaling parameter was used to scale back the cargo capacities for all the AIS transits across the seven assessed marine plan areas. This used the appropriate scalar for the respective vessel type. The employed scaling generally applied the assumption that on average the vessel transits were operating at lower cargo capacity fill than the available maximum. The shipping cargo value was then calculated based on the scaled capacity and the associated SUV (Section 4.2), which was repeated for all the transits across the seven assessed marine plan areas.

4.5 Mapping

4.5.1 Mapping the vessel characteristics and value

The output from the data processing (Sections 4.1 to 4.3) and validation (Section 4.4) was a dataset of vessel characteristics, with the associated scaled cargo capacity and value of the cargo. This data was created for all the scoped in unique MMSI as identified from the 2017 spatial AIS data, i.e. the approximately 8,000 records.

The next step was to map the information using the spatial geometry information associated with 2017 AIS spatial data. This was achieved using the MMSI as the identifier to link between the AIS spatial data and the vessel characteristics and shipping cargo value dataset. The mapping exercise was completed using Geographic Information System (GIS) software, termed ‘ArcGIS’. The result was the 2017 AIS vessel transits, with additional attribute information comprising the vessel characteristics, scaled cargo capacity and shipping cargo value.

4.5.2 Creating the total shipping value maps

Mapping the shipping value involved creating a surface of gridded cells at a spatial resolution of 1 km. Using functionality within the ArcGIS software, the surface was created using the available 2017 AIS transit routes with the associated vessel characteristics, scaled cargo capacity and shipping cargo value data.

The approach to create the shipping value surfaces followed the approach used to create the AIS shipping density surfaces applied in the MMO project 1066 (MMO, 2014a). However, for this project, it was the calculated cargo values that were mapped.

The project objectives required the total value of cargo on vessels in UK waters, therefore, each grid cell comprised the sum of the cargo value from all transits. Furthermore, as the AIS data was representative of 84 days of data, i.e. the first seven calendar days of each month, the calculated total cargo values were scaled up to be representative of a full year of data. This again follows the same processing steps used in creating the AIS shipping density surfaces (MMO, 2014a).

The available AIS shipping density surfaces for the UK are presented at average weekly. To enable a direct comparison of the shipping cargo value with the shipping density, the value information was processed and presented at the same time scale, following the same process as in MMO (2014a).

5. Results

This section summarises the shipping cargo value results obtained prior to applying the representative capacity scalar and after scaling. The results are presented for just the case study area, i.e. the north east inshore and offshore marine plan areas.

5.1 Shipping transit counts

Within the north east marine plan areas, there were over 100,000 AIS transits, represented in the traffic density grid (Figure 4). Of the total number of transits, only 37% of these were in scope for analysis and used in the project. This meant that up to 63% of AIS transits within the north east marine plan areas related to out of scope vessels including service craft, fishing and recreational vessels. During the project workshop however, it was identified that service craft make significant contributions to ‘the value of shipping’. In recent years, this has been particularly important for ports servicing the offshore renewable industry, plus those ports who are traditional supply bases for the oil and gas offshore industry. Figure 4 provides a view of all vessel transits within the north east marine plan areas, presented as an average ‘weekly density grid’.

Figure 4: AIS density grid of all AIS transits across the north east marine plan areas.

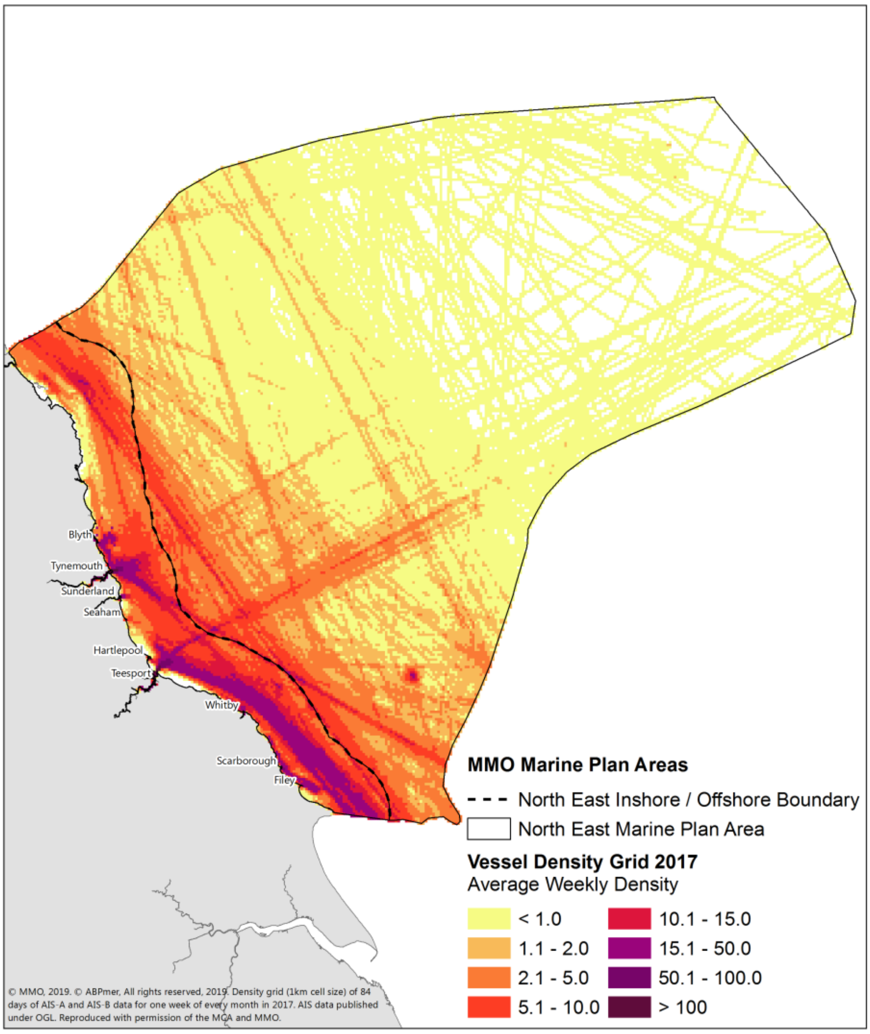


Figure 4 identifies clear patterns of vessel use, including the ports of (north to south); Blyth, Tyne, Sunderland, Seaham, Hartlepool, Tees, Whitby, Scarborough and Filey. Transitory traffic routes can also be seen running offshore in an approximate north west/south east direction. Applying the methodology within this study, the scoped in (assessed vessel types) directly transiting into or out of ports within the north east marine plan areas by vessel type is shown in Table 14. These transits account for a small proportion of the scoped in transits across the marine plan areas.

Table 14: AIS transit counts by assessed vessel types.

Assessed vessel types	Sunderland	Tyne	Tees Hartlepool	Blyth	Seaham
Container		43	214	34	
Chemical tanker		13	276		
Oil tanker	2	6	79	10	
Gas carrier		2	227	1	
Ro-con[1]			99		
Pure car carrier		170	15		
Ro-pax[2]	1	150			
Dry bulk	71	55	138	34	52
Ferry/Cruise		22			
Sum	**74**	**461**	**1,048**	**79**	**52**
[1]: Ro-Ro cargo and containers [2]: Ro-Ro cargo and passengers					

5.2 Maximum shipping cargo value

For the vessels arriving or departing the north east ports, the maximum value, based on the maximum capacity fill is summarised in Table 15. The estimated sum of the cargo value (i.e. maximum value) arriving or departing the ports, based on 84-days of AIS data, ranges from circa £60 million up to circa £17 billion.

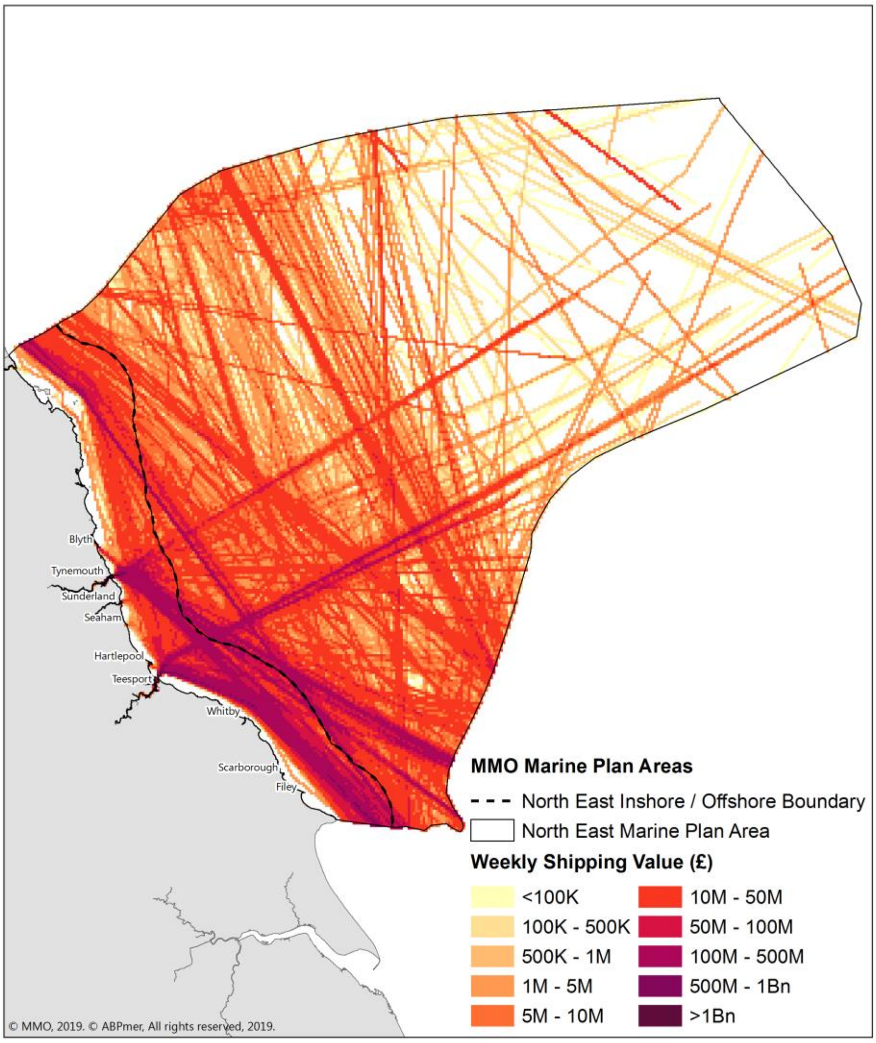
Table 15: Estimated value (£ sterling) of cargo for ports within the case study area before scaling cargo capacity, value based on 84-days of AIS data and stated to the nearest million (000,000).

Assessed Vessel Types	Sunderland	Tyne	Tees Hartlepool	Blyth	Seaham
Container		£1,188	£6,521		
Chemical tanker		£57	£1,192		
Oil tanker	£3	£7	£2,767	£20	
Gas carrier		£0.04	£11	£0.06	
Ro-con[1]			£4,047		
Pure car carrier		£13,584	£2,490		
Ro-pax[2]	£6	£1,198			
Dry bulk	£155	£250	£458	£64	£60
Ferry/Cruise		£44			
Sum	**£164**	**£16,328**	**£17,487**	**£84**	**£60**
[1]: Ro-Ro cargo and containers [2]: Ro-Ro cargo and passengers					

Figure 5 presents the mapped shipping cargo values as an average weekly shipping cargo value grid. The represented cargo value in each grid cell equates to pounds sterling per squared kilometre per week (£/km²/wk.). For ease in the remainder of the report, the cargo value across all the grid cells are referred to in monetary units.

The north east ports handle a range of cargo group types, with the ports at Tyne, Tees and Hartlepool handling the largest cargo value. Within the inshore marine plan area, the estimated average weekly of cargo value is up to £500 million (Figure 5). Locally to the port at Tyne and Tees and Hartlepool, the average weekly shipping value is up to £1 billion (Figure 5), which has been calculated for vessel transits in or out of these ports. Elsewhere across the marine plan areas, particularly in the offshore plan area, the average weekly maximum value of cargo is up to £50 million (Figure 5).

Figure 5: Maximum cargo value across the north east marine plan areas

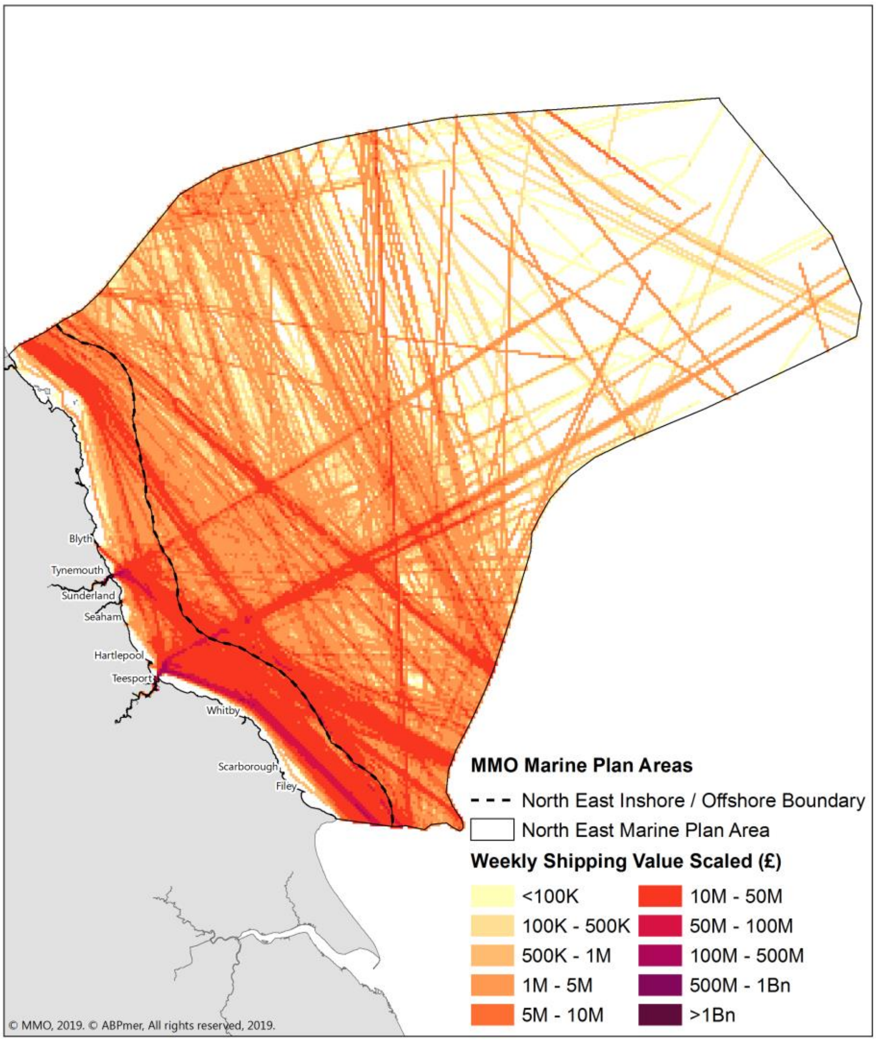


The movement of vessels across the marine plan areas can be noted along shipping routes. These include routes for vessels transiting through the marine plan areas in an approximate north west/south east direction both inshore and further offshore. It is worth noting that further offshore, at the furthest extent of the offshore marine plan area, the termination and breaks in value lines is a result of the AIS data capture as described in Section 2.2. For these transits, they are most likely to continue to the offshore marine plan area boundary.

5.3 Scaled shipping cargo value

As discussed in Section 4.4.5 vessels are unlikely to be at 100% cargo capacity. Therefore, the maximum capacity was scaled down using port tonnage, passenger and unit statistics from DfT. This scaling has been applied to assessed vessel types and presented in Table 15. The appropriate scaling for each assessed vessel type is set out in Table 13 and was applied to the capacity for all transits across the marine plan areas. The scaled value for cargo arriving and departing the north east inshore marine plan areas ports is set out in Table 16, while the scaled value across both the inshore and offshore marine plan areas is illustrated in Figure 6.

Figure 6: Scaled cargo value across the north east marine plan areas



The scaled value (Figure 6) demonstrates very similar spatial patterns of cargo value for ports across the inshore marine plan area, as the maximum value (Figure 5). The scaled cargo value ranges between £31 million just over £4 billion (Table 16). The greatest value is again observed to occur within the north east inshore marine plan area in relation to routes that originate or terminate in the ports at Tyne and Tees and Hartlepool (Figure 5). Based on the completed analyses, the largest assessed type value is that of container vessels, pure car carriers, and oil tankers (see Table 16). This is also reflected in patterns of value across the marine plan areas for each assessed vessel type (Figure E.1 to Figure E.10 Annex E). These show the widest distribution of vessels across the north east marine plan areas are in relation to oil tankers (Figure E.3) and dry bulk vessels (Figure E.5). However, the greatest value is in relation to containers (Figure E.1), pure car carriers (Figure E.7) and oil tankers (Figure E.3).

Table 16: Estimated value (£ sterling) of cargo for ports within the case study area after scaling cargo capacity, value based on 84-days of AIS data and stated to the nearest million (000,000).

Assessed Vessel Types	Sunderland	Tyne	Tees Hartlepool	Blyth	Seaham
Container		£265	£1,457		
Chemical tanker		£23	£478		
Oil tanker	£1	£3	£1,109	£8	
Gas carrier		£0.02	£4.30	£0.03	
Ro-con[1]			£667		
Pure car carrier		£2,239	£411		
Ro-pax[2]	£0.6	£123			
Dry bulk	£79	£128	£235	£33	£301
Ferry/Cruise		£40			
Sum	**£81**	**£2,820**	**£4,360**	**£41**	**£31**
[1]: Ro-Ro cargo and containers [2]: Ro-Ro cargo and passengers					

6. Discussion

In completing the mapping of shipping cargo value for the north east marine plan areas, three aspects were analysed, namely:

- determination of value routes based on shipping cargo value
- vessel density comparison with value routes across the marine plan areas
- the influence of offshore infrastructure on the spatial distribution on the mapped shipping cargo value and the potential contribution from service craft.

The above points are discussed in the following reports sections.

6.1 Shipping routes

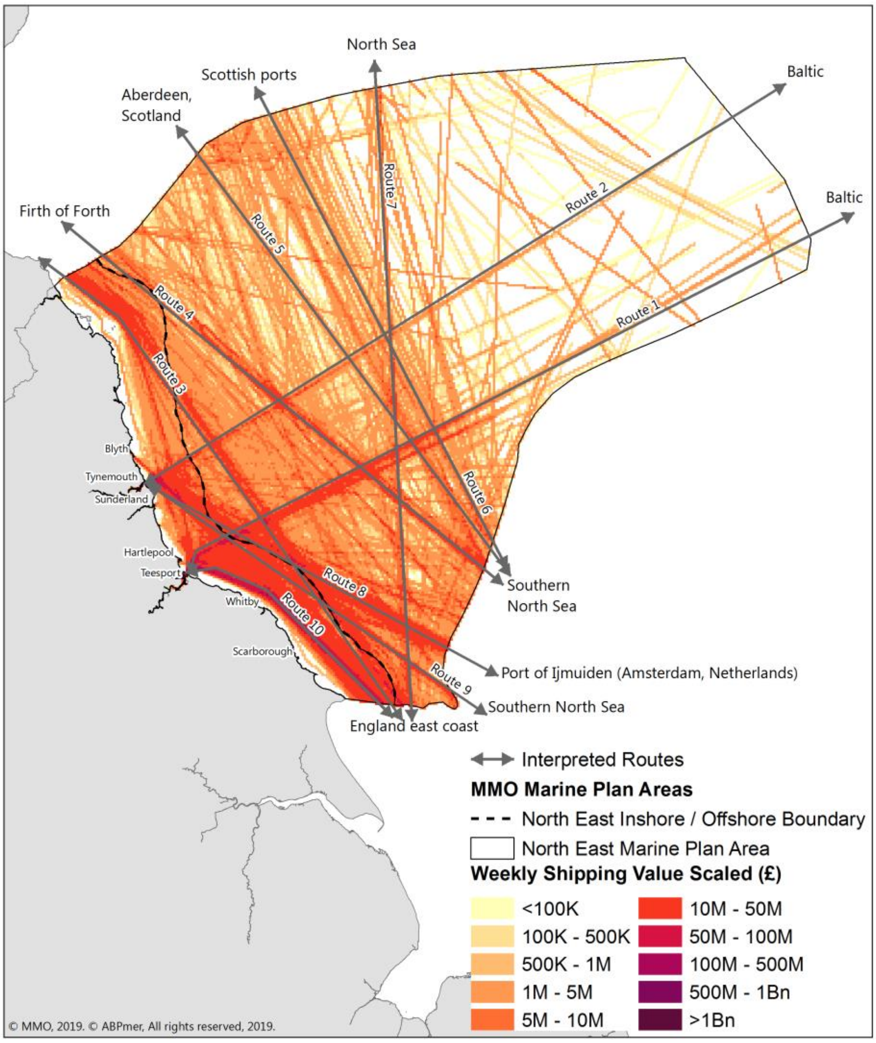
A review of the mapped shipping cargo value (i.e. the scaled value), Figure 6 indicates a number of clear shipping routes, based on the calculated value of cargo carried by shipping. Ten routes have been identified and are included in this commentary these are listed below and are depicted in Figure 7. The routes were identified based on the presence of higher cargo value transits surrounded by lower value transits and the orientation of the transit vectors. The identified routes are considered to relate to locations where the greatest value cargoes are shipped or is the composite of multiple cargo types being carried along the same route, thereby increasing the value. The identified routes focused around:

- vessels arriving or leaving the Major Ports within the case study area, from domestic and international destinations
- coastal transiting vessels, most likely transiting between UK ports
- international transiting routes.

The identified routes illustrated in Figure 7 are:

Route 1: Tees and Hartlepool to the Baltic
Route 2: Tyne to the Baltic
Route 3: East coast inshore transitory traffic linking east coast English ports (i.e., Humber Estuary) to east coast Scottish ports (i.e., the Firth of Forth)
Route 4: East coast offshore transitory traffic linking southern east coast English ports (i.e., East Anglia) to east coast Scottish ports (i.e., the Firth of Forth)
Route 5: Southern North Sea (through the marine plan areas) and east coast Scotland (i.e., Aberdeen)
Route 6: Southern North Sea (through the marine plan areas) and other east coast Scottish ports
Route 7: England east coast (through the marine plan areas) and the North Sea
Route 8: Tyne and Port of Ijmuiden (for Amsterdam), Netherlands
Route 9: Tyne to the wider Southern North Sea
Route 10: Tyne and Tees and Hartlepool feeders along the east coast of England

Figure 7: Interpreted shipping routes based on the calculated shipping value



The identified routes serve varying functions in terms of the cargo and value of the cargo being transported. Routes 1, 2, 8, 9 and 10 run between the major ports of Tyne and Tees and Hartlepool with other locations within the UK and Europe. A review of the routes in relation to the value maps for each vessel type (Figure E.1 to Figure E.10, Annex E) show that the routes relate to the movement of different cargo types.

Route 1 between the Tees and Hartlepool and the Baltic relate to the movement of containers (Figure E.1) and chemical tanker (Figure E.2). Route 2 between Tyne and the Baltic is more in relation to the transport of dry bulk (Figure E.5) and the export of cars (Figure E.7). Route 8 is principally due to the ferry service between Newcastle (Tyne) and Port of Ijmuiden (for Amsterdam) (Netherlands) represented in the Ro-Pax value (Figure E.8).

There are also feeder routes from Tees and Hartlepool towards the east coast of England, in relation to the movement of containers (Figure E.1) and Ro-Con vessels and their associated cargo (Figure E.6). Other cargoes along this same route, which provide sum cargo values between £50 million and £500 million relate to the transport of cars from the Tyne (Figure E.7), oil and gas transport to and from Tees and Hartlepool (Figure E.3 and Figure E.4 respectively) and dry bulk (Figure E.5).

For the routes transiting through the marine plan areas (i.e. Routes 3 to 7) with east coast transitory traffic to/from Scotland relate to the transport of gas, chemical tanker, oil, cars, dry bulk and containers. The largest cargo shipping value from transitory vessels through the marine plan areas relates to the movement of oil (Figure E.3).

Due to the representation of value in Figure 6, only transits with the greatest values were identified as routes. This meant there were a number of additional shipping routes, identified for individual cargo types, that were not identified in the sum of the average weekly shipping cargo (Figure 6). An example of this occurs in relation to the movement of cruise vessels (Figure E.9). Therefore, further work could entail identifying the individual routes for each cargo type in order to address particular questions.

6.2 Vessel density versus shipping value

This study has sought to assign cargo value associated with commercial shipping to AIS data representative of vessel usage. The presumption is that different patterns of sea area use may become apparent when the value associated with the cargo carried by shipping is presented. In order to answer this question, a comparison of the vessel traffic density (Figure 4) and the scaled shipping value (Figure 6) was completed.

Figure 4 identifies an intensity of vessel transits along the coast with notable routes depicting approach areas to ports with up to 100 vessel transits per week. Further offshore, there are fewer transits with some areas showing less than 10 transits per week. In terms of shipping cargo value, the same or similar value range are observed to occur across the whole marine plan areas. Although there are still areas of higher value close to the coastline, with cargo value up to approximately £50 million, these are not just restricted to the coast. The most common shipping value ranges between £5 and £10 million and is widely distributed across the marine plan areas (Figure 6).

A number of the shipping routes illustrated in Figure 7 (Section 6.1) can clearly be recognised within the vessel traffic density grid (Figure 4). This is particularly the case for the routes closer to the coast, including Routes 1, 2, 3, 4, 6, 8 and 10 (Figure 7), noting that for Route 1 only the section closer to the coast is identifiable. Although, these routes can be identified in Figure 4, there is no further way to determine what cargo type the transits relate to, which is what Figure 6 and Figure E.1 to Figure E.10(Annex E) all inform. Routes 5, 7 and 9 are not evident within the vessel traffic density grid (Figure 4), although these routes have an average weekly shipping cargo value of up to £50 million. Therefore, these routes are mostly represented by fewer, but greater cargo value shipping movements. It can therefore be concluded that the distribution patterns relating to shipping cargo value, are notably different in some areas, compared to transit information alone. The use of shipping cargo value patterns therefore provides an additional layer of information that can be used for spatial planning.

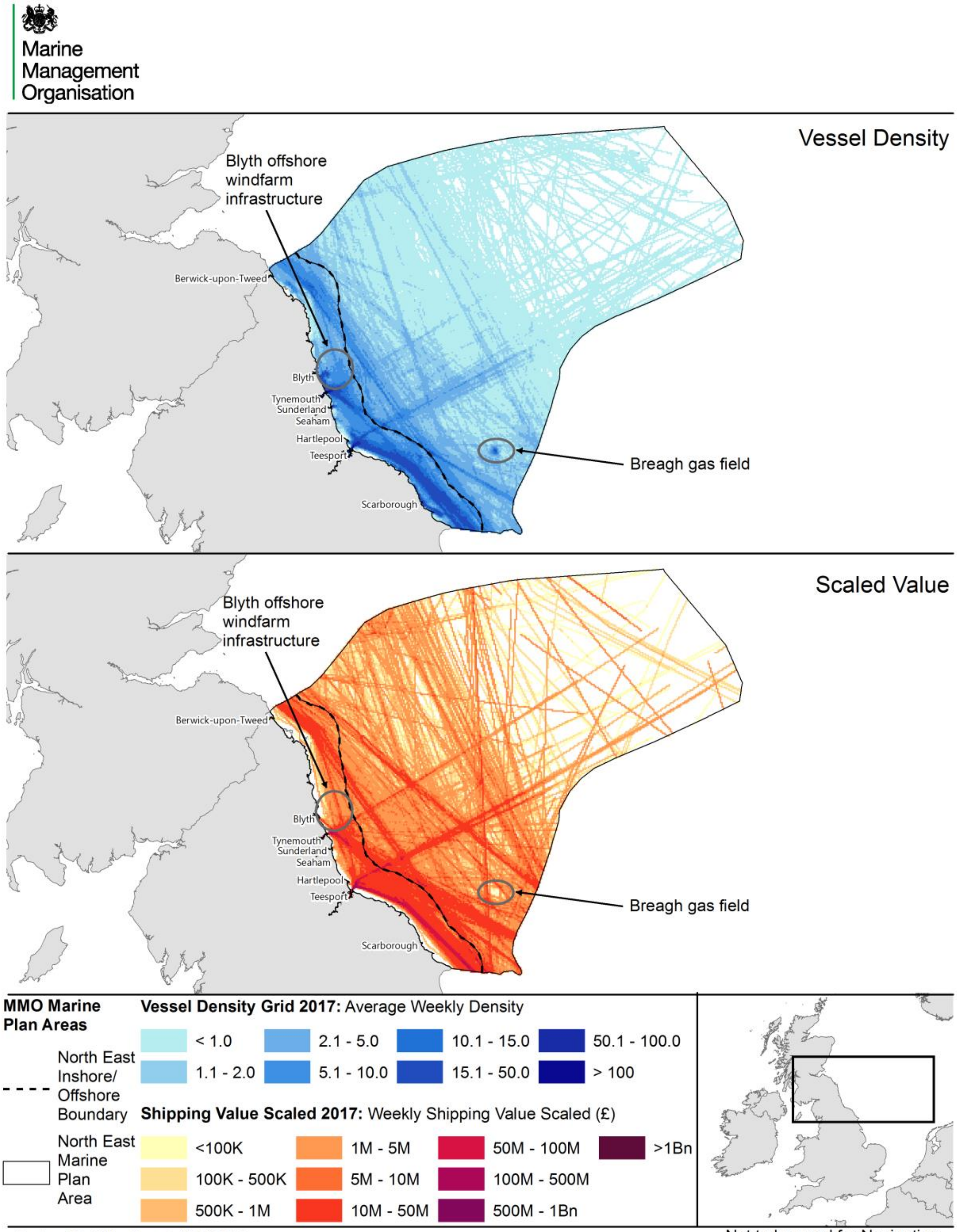
The presented vessel traffic density grid (Figure 4) and shipping cargo value maps (Annex E) would all seem to suggest transits stopping within the offshore marine plan area. However, as explained in Section 2.2, this is due to the extent of the AIS transmission, rather than the end of a journey. It can therefore be assumed that similar value would continue to extend towards the offshore marine plan area boundary.

6.3 Influence of offshore infrastructure on value

Figure 6 demonstrates the value associated with shipping carrying cargo, however this does not include a component related to the value of service craft. To further highlight this disparity, Figure 8 presents a comparison of vessel transit data for 2017, alongside the calculated value of cargo for shipping. Two geographic areas are highlighted, one relating to the Breagh Gas Field and the other related to the Blyth Offshore Wind Farm (OWF) demonstration and Phase 1 site.

For both offshore infrastructure sites, the vessel density over the same period appears as a high density traffic area. These are emphasised on Figure 8a as locations with a vessel density in excess of 100 transits per week, which occurs due to service craft activity between their home ports and the gas field and/or OWF. Conversely, within the same locations, the calculated shipping cargo value is a lot less than the immediate and surrounding area (Figure 8b). In discussions with the project's stakeholders, it was noted that the service craft industry provides considerable value in enabling the offshore wind farm operation in the area. Although the vessel density suggests this (Figure 4 and Figure 8a), the scaled value does not represent this (Figure 5 and Figure 8). It can therefore be concluded that service craft should be further considered to provide a representation layer of value and routeing to complement that which has been provided within this study.

Figure 8: Surface infrastructure effects on AIS a) shipping density and b) cargo value



Date of Publication: 24/09/2019
Coordinate System: ETRS 1989 UTM Zone 30N
Projection: Transverse Mercator
Datum: ETRS 1989

Not to be used for Navigation.

6.4 Confidence review and study limitations

This section provides a confidence review of the datasets and analysis approach applied in the project. It also considers any potential limitations with the completed work, which provides the basis for the recommendations presented in Section 7 below.

Section 2.2 mentioned that the processing of the AIS data sometimes resulted in a single transit being broken into multiple parts. This meant that the number of transits over an area tends to be over-represented. However, this did not translate to the mapped shipping cargo value because of the way the transits were identified within each grid cell. The only limitation that arose in relation to the AIS data is the termination of vessel transits in the offshore marine plan area. This is more to do with the transmission of AIS, which is a line of sight process. Up to the horizon, estimated to be up 50 nautical miles from the coast, AIS broadcast can be received at terrestrial receiver stations (depending on atmospheric conditions too). Beyond this point broadcasts may not be received at UK terrestrial receivers, which is basis of the dataset used in this project comprises. This therefore means that in the offshore areas of the mapped shipping cargo value, areas depicting no value or transits, actually have transits but there is no AIS reception due to the lack of receivers.

A second limitation associated with the applied datasets is to do with the information from the Lloyds data discussed in Section 2.3. As stated in Section 2.3 of this report, approximately 24,000 unique vessel MMSIs were identified from the AIS data for the UK. However, the Lloyds data was only able to provide vessel characteristics information for approximately 11,000 vessels. The large difference was mainly considered to relate to smaller craft below 99 gross tonnes and/or privately-owned vessels not registered and accessible to Lloyds. From these excluded vessels, it could be that there were Cargo carrier Type A vessels, albeit a small number, for which the Lloyds data had no information for and therefore were not included in the analysis.

Annex B provides a more detailed description of the data sources, assumptions and methods used in determining the appropriate vessel characteristics and associated CUV for each of the assessed vessel types. It also briefly considers the difficulties in deriving the estimates which underpin the calculated cargo value and project outputs. The approach uses information that is publicly and readily available for 2017 and has applied expert judgment in determining the cargo types and their associated value for the respective vessel types. Therefore, with additional and updated data in terms of commodities, unit values and trade statistics, it may be that more refined estimates of value can be obtained. It is also noted that the data underlying the commodity values (and hence the cargo values) fluctuated daily based on time and local and global market conditions. This fluctuation (including the occurrence of any skew or ‘spikes’) was inherently included within the applied CUV as it was based on the annual average commodity values.

An associated point is the fact that the project approach aggregates vessel types, commodities and cargo types into groups that have similar properties. Section 4.2.2 and Table A.1 (Annex A) illustrate how the ten assessed vessel types were obtained from the 70 vessel types identified in the Lloyds data. In addition, Table 6 and Table 11 demonstrate how the assessed cargo types were defined and assigned to the assessed vessel types. The aggregated groups were what the standard design and unit values were then assessed on. Therefore, it may be that with further refinement of the vessel and cargo types into sub-categories, slightly different unit value properties would be determined, which would in turn influence the estimated shipping cargo value. However, this is not considered to be a limitation of the project approach, instead it would be a means to investigate the sensitivities of the underlying data and the resulting influence on the shipping cargo value. There could be any number of refinements and iterations on grouped vessel and cargo types, however expert judgement was what was used to determine the optimal grouped categories used in this project.

The final point to note is the influence of service craft on shipping value. This was a vessel type that was not within the scope of the project from the outset. However, in undertaking the project, it was recognised that this vessel type makes a significant value contribution to ports, including one of the minor ports assessed within the case study area. This project only truly reflects shipping cargo value, to fully represent the value of shipping in its entirety, the value from service craft needs to be accounted for. This forms part of the recommendations discussed in the Section 7 below.

7. Recommendations

The following recommendations are made in relation to study and its outputs:

- it is recommended that Service Craft are considered, and a value layer provided to represent this category of vessels. This will require specific research to determine unit values applicable to Service Craft

- this study presents the shipping cargo value. As a subsequent research study, it would be useful to consider the value-added contribution of cargo types at specific ports. Some cargoes are finished goods that are in their intended end form (for example, a vehicle) and have a high monetary value but less contribution to the value of the supply chain, whereas raw products may have lower tonnage values but much greater potential for onward value. It is recommended that this aspect of the study is further investigated to allow the assignment of value based on the cargoes' potential economic contribution.

8. References

8.1 Data, reports and publications

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9. Abbreviations and acronyms

£/km²/wk.	Pounds sterling per squared kilometre per week
ACP	Panama Canal Authority
AHDB	AHDB Beef & Lamb
AIS	Automatic Identification System
API	American Petroleum Institute
bbl	Barrels
BMT	BMT Ltd
BSSL	BSSL Global Ltd
CABU	Bulk/Caustic Soda Carrier
Cebr	Centre for Economics and Business Research
CEU	Car Equivalent Units
CLEANBU	Bulk/Oil/Chemical Carrier
CNG	Compressed Natural Gas
CPA	Classification of Products by Activity
CTV	Crew Transfer Vessel
CUV	Cargo Unit Value
DfT	Department for Transport
DNV	DNV GL
DWT	Dead Weight Tonnage
ECHEMI	ECHEMI Ltd.
EEZ	Exclusive Economic Zone
EIA	Energy Information Administration
ETH	Ethanol
EU	European Union
EUR	Euros
FAO	Food Association Organisation
FCL	Full Container Load
FEU	Forty-Foot Equivalent Unit
GBP	British Pound
GIS	Geographical Information System
GP	General Purpose
GT	Gross Tonnage
GVA	Gross Value Added
IHS	IHS Markit

ICST	International Classification of Ship Types
IMAM	International Maritime Association of the Mediterranean
IMO	International Maritime Organization
LCL	Less than Container Load
LCTC	Large Car Truck Carrier
LGC	Large Gas Carrier
LI	Large Intermediate
LLI	Lloyds List Intelligence
LM	Lane Metre
LNG	Liquid Natural Gas
LOA	Length Over All
LPG	Liquid Petroleum Gas
LR	Large Range
MBtu	One thousand the British Thermal unit
MCA	Maritime Coastguard Agency
MmBtu	Metric Million British Thermal Unit
MMO	Marine Management Organisation
MMSI	Maritime Mobile Service Identity
MR	Mid-Range
MRV	Monitoring, Regulation and Verification
MT	Metric Tonne
NGC	Natural Gas Composite
NGL	Natural Gas Liquid
NM	Nautical Mile
NTNU	Trondheim Norwegian University of Science and Technology
NW	North west
OBO	Bulk/Oil Carrier
OOG	Out of Gauge
OPEC	Organization of the Petroleum Exporting Countries
OWF	Offshore Wind Farm
Pax	Passenger
PCC	Pure Car Carrier
PCTC	Pure Car and Truck Carrier
PNTL	Pacific Nuclear Transport Limited
PSSC	Passenger Ship Safety Certificate

Ro-Con	Ro-Ro cargo and containers
Ro-Pax	Ro-Ro cargo and passengers
Ro-Ro	Roll on / Roll off
SOEC	Statistical Office of the European Communities
SOLAS	International Convention for the Safety of Life at Sea
SUV	Standard Unit Value
TEU	Twenty-Foot equivalent Unit
UK	United Kingdom
ULCC	Ultra Large Crude Carrier
ULCS	Ultra Large Container Ship
ULOC	Ultra Large Ore Carrier
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
US	United States
USD	United States Dollar
VLCC	Very Large Crude Carrier
VLGC	Very Large Gas Carrier
VLOC	Very Large Ore Carrier

ANNEXES

A. Interpreted Vessel and Cargo Types

This annex sets out the vessel types applied in this project, along with the relevant and more detailed StatCode 5 (level 4) and Lloyds data vessel types, which were used to determine the associated cargo for the applied vessel types.

Table A.1: Vessel information used to determine the cargo types for the assessed vessel types.

Applied Vessel Types[1]	StatCode 5 Level 4	Lloyds Data Vessel Types[2]	Associated Cargo Types[3]
Oil Tanker	Crude Oil Tanker Oil Products Tanker Bitumen Tanker	Shuttle Tanker Crude Oil Tanker Crude/Oil Products Tanker Products Tanker Tanker (unspecified) Asphalt/Bitumen Tanker	Crude Oil Oil products
Gas Carrier	LNG Tanker LPG Tanker CO2 Tanker	LNG Tanker CNG Tanker Combination Gas Tanker (LNG/LPG) LPG Tanker CO2 Tanker	Liquefied gas
Chemical tanker	Chemical Tanker Chemical/Oil Products Tanker Wine Tanker Vegetable Oil Tanker Edible Oil Tanker Beer Tanker Latex Tanker Water Tanker Fruit Juice Tanker Molasses Tanker Glue Tanker Alcohol Tanker Caprolactam Tanker	Molten Sulphur Tanker Chemical Tanker Chemical/Products Tanker Wine Tanker Vegetable Oil Tanker Edible Oil Tanker Beer Tanker Latex Tanker Water Tanker Fruit Juice Carrier Refrigerated Molasses Tanker Glue Tanker Alcohol Tanker Caprolactam Tanker	Chemical tanker goods Other chemical tanker goods
Dry Bulk	Bulk Carrier Ore Carrier	Bulk Carrier Bulk Carrier, Laker Only	Dry bulk goods Ores Coal Agricultural Products

Applied Vessel Types[1]	StatCode 5 Level 4	Lloyds Data Vessel Types[2]	Associated Cargo Types[3]
	Self-Discharging Bulk Carrier Cement Carrier Wood Chips Carrier Urea Carrier Aggerates Carrier Limestone Carrier Refined Sugar carrier Powder Carrier Coal/Oil Mixture Tanker Bulk/Liquid Carrier Bulk/Oil Carrier Ore/Oil Carrier Refrigerated Cargo Ship	Bulk Carrier (with vehicles on deck) Ore Carrier Bulk carrier, Self-discharging Bulk Carrier, Self-discharging. Laker Cement Carrier Wood Chips Carrier Urea Carrier Aggerates Carrier Limestone Carrier Refined Sugar carrier Powder Carrier Coal/Oil Mixture Tanker Bulk/Oil Carrier (OBO) Bulk/Caustic Soda Carrier (CABU) Bulk/Sulphuric Acid Carrier Bulk/Oil/Chemical Carrier (CLEANBU) Ore/Oil Carrier Refrigerated Cargo Ship	Other dry bulk goods Forestry products Chemical tanker goods Other chemical tanker goods Dry bulk goods Ores Coal Agricultural Products Other dry bulk goods
Container	Container Ship Passenger/Container Ship	Container Ship (Fully Cellular) Container Ship (Fully Cellular/Ro-Ro Facility) Passenger/Container Ship	Large Containers 20 ft freight units 40 ft freight units Freight units >20 ft and <40 ft Freight units >40 ft
Pure Car Carrier	Vehicles Carrier	Vehicles Carrier	Mobile self-propelled units Road goods vehicles and accompanying trailers Trade vehicles (including import/export motor vehicles) Other mobile self-propelled units Mobile non-self-propelled units

Applied Vessel Types[1]	StatCode 5 Level 4	Lloyds Data Vessel Types[2]	Associated Cargo Types[3]
			Unaccompanied road goods trailers and semi-trailers Unaccompanied caravans and other road, agricultural and industrial vehicles
Ro-Ro Cargo and Container (Ro-Con)	Ro-Ro Cargo Ship Container/Ro-Ro Cargo Ship Landing Craft	Rail Vehicles Carrier Ro-Ro Cargo Ship Container/Ro-Ro Cargo Ship Landing Craft	Mobile self-propelled units Road goods vehicles and accompanying trailers Trade vehicles (including import/export motor vehicles) Other mobile self-propelled units Mobile non-self-propelled units Unaccompanied road goods trailers and semi-trailers Unaccompanied caravans and other road, agricultural and industrial vehicles Rail wagons engaged in goods transport Shipborne bares engaged in goods transport Other mobile non-self-propelled units Large Ro-Ro containers 20 ft freight units 40 ft freight units Freight units >20 ft and <40 ft Freight units >40 ft
Ro-Ro Cargo and Passenger (Ro-Pax)	Passenger/Ro-Ro Cargo Ship Passenger/Landing Craft	Passenger/Ro-Ro Ship (Vehicles) Passenger/Ro-Ro Ship (Vehicles/Rail) Passenger/Landing Craft	Mobile self-propelled units Road goods vehicles and accompanying trailers Passenger cars, motorcycles and accompanying trailers/caravans Passenger busses

Applied Vessel Types[1]	StatCode 5 Level 4	Lloyds Data Vessel Types[2]	Associated Cargo Types[3]
			Trade vehicles (including import/export motor vehicles) Other mobile self-propelled units Mobile non-self-propelled units Unaccompanied road goods trailers and semi-trailers Shipborne port-to-port trailers engaged in goods transport Other mobile non-self-propelled units
Cruise	Passenger Ship Passenger (Cruise) Ship	Passenger Ship Passenger/Cruise	Passengers
Specialist	Livestock Cargo Carrier Barge Carrier Heavy Load Carrier Nuclear Fuel Carrier Pulp Carrier Refrigerated vessel	Livestock Carrier Barge Carrier Heavy Load Carrier Heavy Load Carrier, semi-submersible Yacht Carrier, semi-submersible Nuclear Fuel Carrier Nuclear Fuel Carrier (with Ro-Ro facility) Pulp Carrier	Variable depending on type. Cargo examples include: Live animals on the hoof Dry bulk

1: Vessel types applied in this study and is based on the StatCode 5 Level 3 vessel types.
2: StatCode 5 Level 5 vessel types, which are broadly the same as the Lloyds data vessel types.
3: Cargo types as defined by UNECE, (1986) and used by the DfT. The cargo types are linked to the vessel types based on Eurostat, (2017).

B. Determining the Cargo Capacity Value for each Vessel Type

This annex describes the approach and data sources used to establish the cargo capacity and value for each of the assessed vessel types, based on the information introduced in Section 4.2.

B.1. Container (Fully Cellular)

B.1.1. Construction

Fully cellular container vessels are specifically designed for the transportation of freight containers. Typical vessel arrangements include:

- cell guides for each column of containers
- lashing bridges above beck level for securing
- large open hold spaces
- torsion box to improve vessel strength (due to open holds)
- independent power system for refrigerated containers
- high accommodation block and bridge to allow for deck storage
- split accommodation and engine stacks.

Container carrier construction is based on the specific traits of the cargo intended for transport. Freight containers are a cargo amongst themselves and have a range of standard sizes and configurations, the standard freight container is 20 ft in length and used as a benchmark measure for vessel capacity that is a twenty-foot equivalent unit (TEU).

B.1.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting container vessels include:

- port handling facilities
- global manufacturing areas
- intermodal trade routes.

Freight containers are treated as a cargo of themselves with standard types including, refrigerated containers, hazardous containers, tank containers and other out of gage types. Containers may be used to ship either single or multiple commodities with the exact content's unknown to the vessel. Main global routes are used by the largest vessels with smaller types being used to transport containers from hub ports to smaller locations within a region.

B.1.3. Value

The commodities contained within each container are known to the shipper with only information on weight and hazardous materials provided to the vessel and port. As the commodities are generally unknown, the appropriate SUV could vary significantly due to the following:

- the type and range of commodities
- the market conditions and trade route influencing commodity value
- the loaded state of each container, which may be a full container load (FCL) or a less than container load (LCL).

The number of variables involved for each container results in a significant spread of value ‘per container’ when trying to assign value to container carrying vessels. The approach used to determine an appropriate SUV for container vessels is to use available published information on the average container value from an insurance perspective. Specifically, this project uses information presented in IHS Markit, (2017b) and takes the average container value from two vessels discussed in the research study. IHS Markit, (2017b) also provides the value associated with a FCL TEU of the top ten and bottom ten expensive commodities. However, these commodities were not used as they skewed the value estimates and were not considered to be fully representative of goods imported or exported from the UK.

B.1.4. Sources

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B.2. Chemical Tanker

B.2.1. Construction

Chemical tankers are specifically designed for the transportation of bulk liquids, with a vessel either carrying many different parcels of liquid segregated in individual tanks or single large homogenous liquid cargoes. Single cargo vessels are of a simple design, similar to oil tankers whereas parcel tankers are complex with tanks and pumping arrangements designed for cargoes with specific qualities. Typical vessel arrangements include:

- complex cargo piping systems
- cargo manifold
- specialist tank coatings and materials
- cargo tanks cleaning systems
- steam generators.

Chemical tanker construction is based on the specific traits of the cargo intended for transport. These cargoes are often hazardous, especially when carried in bulk and alongside other such cargoes. Package tankers have many segregated tanks and piping systems with less deadweight to vessel size than a single hold chemical tanker.

B.2.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting chemical tankers include:

- shore infrastructure (receiving facilities in port)
- shore processing facilities and transport
- consumer demand
- regional trade routes.

Vessel size and capacity is linked to its purpose in the trade of the cargo. The trade of chemical tanker is often influenced by the availability of ports with appropriate infrastructure for the handling of cargoes, particularly parcel tankers and the requirement to maintain segregation of cargo when loading and unloading. Due to the requirement for chemical manufacture or the small quantities of valuable chemical tanker cargoes and available ports for handling cargoes much of the trade is in smaller coastal vessels Global trading chemical tankers can hold as many as 20 different cargoes and require larger ports of call.

The demand and supply of chemical tankers is specific to a region and a nation as these cargoes often support other industries. Global single chemical tankers may transport palm oil from South America to the NW Europe where it is bottled and transported by road freight to other areas. Parcel tankers may transport several chemical products from a factory in the south of the UK for use in manufacture in the north of the UK.

B.2.3. Value

To apply an SUV to chemical tankers the three most common chemical tanker types have been selected, each type has had commodities of that type averaged and applied to give a total chemical tanker average value for 2017.

Chemicals

The value for chemicals has been derived from the average of organic and inorganic compounds, namely methanol and sulphuric acid. Sulphuric acid is the most commonly traded global chemical with the price given from a global source with methanol the most commonly traded chemical in the EU.

Edible Oils

The most commonly transported oils are Palm oil and Soybean oil, these commodities have been used to derive an average value for edible oils in 2017.

Biofuel

The price for biofuel has been derived from the 2017 average of biodiesel as the most imported biofuel to the UK. This price has been converted from dollars per kilogram into dollars per m^3 using the biodiesel density at atmospheric pressure for 15.5 degrees centigrade.

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B.3. Oil Tankers

B.3.1. Construction

Oil tankers are chemical tankers specifically designed for the transportation of crude and product oil. Typical vessel arrangements include:

- large single or longitudinally segregated cargo tanks
- inert gas systems
- cargo piping arrangements
- cargo manifold.

Oil tanker construction is based on the specific traits of the cargo intended for transport. Crude oil is transported in large homogenous volumes and products in smaller quantities often with different grades held in adjacent tanks.

B.3.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting oil tankers include:

- level of crude oil production at source
- quality of crude oil production at source impacting the refining process
- Suez Canal vessel size constraints
- Panama Canal vessel size constraints
- refinery port vessel size constraints
- storage facilities at refinery sites.

Vessel size and capacity is linked to its purpose in the trade of the cargo. Crude oil is transported in the largest quantities possible for its route between extraction site and refinery or hub port. Once refined the products produced are stored until shipped, the quantity and number of products fluctuates depending on the quality of the crude oil used. Oil tankers are built to specific sizes and corresponding capacities, those of a size typical for the carriage of crude oil have been assigned the crude oil Standard Unit Value (SUV), those of a smaller size are assigned the SUV for products.

B.3.3. Value

Crude oil is extracted at source and transported to global hubs, the quantity and quality of oil at these hubs is used as a benchmark for global pricing of crude and refined oil products. The benchmark price of crudes from the OPEC for 2017 has been averaged to give the value assigned to vessels over Long Rang 1 (LR1) size (OPEC, 2017b; 2017c).

The value of refined products is based on the quality and quantity of crude oil, however, the fluctuation in price associated with refined products is influenced by regional production. Where crude oil is shipped globally to refineries, product produced at these refineries is most frequently shipped within the region. Regional influence on the value of products include; storage facilities, regional demand for different products and grade and the economic pricing construct of the area. The value used is averaged from the most common refined products from the north west European refineries for 2017 as reported by OPEC (OPEC, 2017b; 2017c).

B.3.4. Sources

OPEC, (2017b). OPEC monthly oil market report. Annual report 2017 to inform the crude Oil benchmark price.
https://www.opec.org/opec_web/static_files_project/media/downloads/publications/MOMR%20December%202017.pdf

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https://www.opec.org/opec_web/static_files_project/media/downloads/publications/MOMR%20December%202017.pdf

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B.4. Gas Carriers

B.4.1. Construction

Gas carriers are chemical tankers specifically designed for the transportation of gas in liquid state by either compression, refrigeration or a combination of these. Typical vessel arrangements include:

- large insulated tanks of high quality thermal resistant material
- inert gas and vapour lines
- cargo manifold
- refrigeration plant
- spherical or cylindrical tanks of heavy construction.

Gas carrier construction is based on the specific traits of the cargo intended for transport. Liquid Natural Gas (LNG) is transported in large refrigerated homogenous volumes with other Natural Gas Liquids (NGLs) in smaller quantities liquefied by either compression or a combination of compression and refrigeration.

B.4.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting gas carriers include:

- level of natural gas production at source
- quality of natural gas production at source impacting the refining process
- Suez Canal vessel size constraints
- Panama Canal vessel size constraints
- refinery port vessel size constraints
- storage facilities at refinery sites.

Vessel size and capacity is linked to its purpose in the trade of the cargo. LNG is transported in the largest quantities possible for its route between extraction site and refinery or hub port. Once refined the NGLs produced are stored until shipped, the quantity and number of products fluctuates depending on the quality of the natural gas used.

Gas carriers are built to specific sizes and corresponding capacities, those of a size typical for the carriage of LNG have been assigned the LNG Standard Unit Value (SUV), those of a smaller size are assigned the SUV for NGLs.

B.4.3. Value

Natural gas and crude oil are extracted at source and transported to global hubs, the quantity and quality of gas and crude oil at these hubs is used as a benchmark for global pricing. The annual price of LNG from the Henry Hub in 2017 has been used to give the value assigned to vessels of midsize and over.

The value of NGLs is based on the quality and quantity of natural gas, however the fluctuation in price associated with NGLs is influenced by regional production. Where natural gas is shipped globally to refineries, NGLs at these refineries are most frequently shipped within the region. Regional influence on the value of NGLs include; storage facilities, regional demand for different products and grade and the economic pricing construct of the area. The annual price of composite gas product from the Henry Hub in 2017 has been used to give the value assigned to vessels of Handy size and below.

B.4.4. Sources

US EIA, (2019a). Natural Gas. Annual price for LNG for 2017.
https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm

US EIA, (2019b). Annual price for Natural Gas Composite (NGC) for 2017.
https://www.eia.gov/dnav/ng/hist/ngm_epg0_plc_nus_dmmbtum.htm

Natgas, (2019). Liquefied Natural Gas Chain. Information on natural gas.
http://www.natgas.info/gas-information/what-is-natural-gas/lng

US EIA, (2019c). Natural gas conversions.
https://www.eia.gov/tools/faqs/faq.php?id=45&t=8

B.5. Dry Bulk

B.5.1. Construction

Dry bulk carriers are specifically designed for the transportation of dry unpackaged cargoes in bulk. Single or multiple cargoes are carried in large unsegregated holds and range from small coastal vessels to the largest vessels afloat. Typical vessel arrangements include:

- large capacity holds
- cargo hold covers, watertight
- derricks and cranes (geared) for self-loading/unloading
- bilge and temperature alarms
- large ballast pumps
- hardened deck for deck cargoes

Dry bulk carrier construction is based on the specific traits of the cargo intended for transport. Dry bulk carrier capacity is often limited by the weight of the cargo, with either spot weight damaging the fabric of the vessel or density of the homogenous cargoes bringing the vessel to its load line with space remaining in the hold. Loading and unloading of cargoes is often by use of heavy plant equipment such as grabs, diggers and conveyors, cargo in trimmed before sailing to reduce spot loading and chance of cargo shift at sea.

B.5.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting dry bulk carriers include:

- navigable seaways
- port navigational constraints
- port handling facilities.

The largest dry bulk vessels are built to ship minerals, ores and grain on global routes, this cargo is most cost effective in large quantities and used for base manufacture, these cargoes are known as major bulks. The SUV for major dry bulk is assigned to vessels of Panamax size and above.

Minor dry bulks cover a large range of cargoes and represent first level manufactured products such as, steel products, forest products and fertiliser. Minor bulks are transported in smaller vessels which may include more than one cargo, these cargoes are of a higher unit value and produced in smaller quantities than major bulks. The SUV for minor bulks is assigned to vessels of Supramax size and below.

B.5.3. Value

To apply an SUV to dry bulk carriers an average value for major bulks in 2017 has been applied to vessel of Panamax size and above. Vessels of Supramax size and below have been assigned the average value for the most common minor bulks in 2017.

Major bulks

Major bulks include Iron ore, Coal and Grain, the average annual global price for these cargoes has been used to give a value per tonne of 105.1 USD.

Minor bulks

The most commonly transported minor bulks are steel products, agribulks and sugar, the average annual global price for these commodities has been used to give a value of 422 USD/tonne.

B.5.4. Sources

OPENSEA.PRO, (2019). Minor Bulks Review. Information on major and minor bulks
https://opensea.pro/blog/minor-dry-bulk-commodities

Statista, (2019b). Annual price in 2017 for Iron Ore
https://www.statista.com/statistics/282830/iron-ore-prices-since-2003/

Statista, (2019c). Annual price in 2017 for Coal
https://www.statista.com/statistics/214236/thermal-coal-prices-since-2003/

Statista, (2019d). Annual price in 2017 for steel products
https://www.statista.com/statistics/214246/world-steel-prices/

Statista, (2019e). Annual price in 2017 for Soya beans
https://www.statista.com/statistics/675817/average-prices-soybeans-worldwide/

B.6. Ro-Ro Container (Ro-con)

B.6.1. Construction

Roll-on roll-off container vessels are specifically designed for the transportation of cars, lorries and containers. Typical vessel arrangements include:

- integrated vehicle ramp
- ventilation systems on vehicle decks
- deck cranes and derricks (geared)
- cell guides and lashing bridges for containers
- deck fixing points for containers
- large open hold spaces with central longitudinal separation.

Ro-Ro container vessels are either purpose built or ro-ro vessels which have been fitted to accommodate containers, therefore the TEU or Car Equivalent Units (CEU) capacity of these vessels can vary greatly. Standard vessel design includes vehicle decks with loading and unloading via integral ramps and container freight unit capacity on the main deck. These vessels have a capacity measured on their container caring ability in TEUs and amount of vehicle deck space measured in lane metres and CEUs.

B.6.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting Ro-Ro container vessels include:

- port infrastructure (weigh bridges, hard standings)
- intermodal trade routes
- road freight links.

Ro-Ro container vessels take a range of unitised cargoes such as road goods vehicles, break bulk on unaccompanied trailers and containers. Trade routes encompass multiple port visits within regions and established global routes. Ro-Ro container vessels are adaptable in terms of the cargo carried and trade routes taken.

B.6.3. Value

The value applied to ro-ro container vessels is based on three parts; the vehicle carrying capacity CEU, the roll-on, roll-off freight units in lane metres LM and the container carrying capacity TEU. As the vehicle decks can be used for either cars or freight the CEU and LM value is set at a ratio of 50/50 with the TEU value applied as an addition.

Car Equivalent Units (CEU)

Ro-Ro Container vessels are not used for private automobiles or considered ferries, therefore, it is evaluated that the CEU value should be that of a new vehicle as with PCCs, the value used is based on the average annual price of a new car in the EU for 2017.

Lane metre

The Freight unit value applied to LMs is evaluated using statistics from the port of Dover:

- 2,601,162 freight units in 2017
- estimated £122 billion trade in goods
- equating to 46,902 GBP per unit.

Containers

The commodities contained within each container are known to the shipper with only information on weight and hazardous materials provided to the vessel and port. The value of commodities transported in containers is not known and availability of open source data to enable investigation into the average value of commodities per container is not sufficient to provide an SUV.

In order to provide an SUV, container freight units have been treated as cargo with their worth being assessed by the value to ship and not on the value of commodities within each unit. The freight rate used is the annual price for 2017 on the Far East-Europe market.

B.6.4. Sources

UNCTAD, (2018a). Far East-Europe container freight rate
https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf

Statista, (2019f). Annual price in 2017 for new cars in the EU
https://www.statista.com/statistics/425095/eu-car-sales-average-prices-in-by-country/

Port of Dover, (2019a). Road freight prices from the port of Dover
https://www.doverport.co.uk/about/performance/

Wathne, (2012). Cargo stowage methodology for ro-ro vessels
https://core.ac.uk/download/pdf/52099717.pdf

B.7. Pure Car Carrier (PCC)

B.7.1. Construction

This includes PCC and pure car truck carrier (PCTC). This vessel type is specifically designed for the transportation of cars, lorries and other roll-on roll-off goods. Typical vessel arrangements include:

- integral vehicle ramp
- ventilation system on vehicle decks
- adjustable deck levels
- large open hold spaces with central longitudinal separation
- flat sided and square bowed design.

Pure car carriers are designed to accommodate roll-on, roll-off cargoes in high volume without accompanying drivers. Their deck space is assessed in lane metres and car equivalent units (CEU) in order to determine vehicle capacity. Adjustable deck heights allow for high and heavy units (plant and agricultural machinery) to be loaded as required to maximise capacity.

B.7.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting pure car carriers include:

- port infrastructure (weigh bridges, hard standings)
- vehicle manufacturing sites
- port navigational constraints.

Pure car carriers are not often below a certain size due to the economic conditions favouring high production of vehicles and fast trade routes requiring large capacity vessels. Trade routes often required part loading or unloading at several port calls within a region before transiting on a global route.

B.7.3. Value

Pure car carriers are built for the trade in new cars and vehicles, due to the regional influence of trade routes the value used for the SUV is based on the average annual price of a new car in the EU for 2017. As the capacity of pure car carriers is measured in CEUs the larger and more valuable high and heavy cargo is not specifically captured but accounted for by the size to value ratio of roughly 2 to 1.

B.7.4. Sources

Statista, (2019f). Annual price in 2017 for new cars in the EU
https://www.statista.com/statistics/425095/eu-car-sales-average-prices-in-by-country/

B.8. Ro-Ro Passenger (Ro-Pax)

B.8.1. Construction

Roll-on roll-off passenger vessels are specifically designed for the transportation of cars, lorries and passengers. Typical vessel arrangements include:

- integrated vehicle ramp
- ventilation systems on vehicle decks

- large open hold spaces with central longitudinal separation
- passenger foot bridge
- passenger accommodation areas.

Ro-Ro passenger vessels are designed to transport road freight units, private vehicles and passengers. The design of these vessels includes large vehicle decks with passenger accommodation above. Vessel capacity is measured in-lane metres LM, car equivalent unit CEU and passenger capacity.

B.8.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting ro-ro passenger vessels include:

- port infrastructure (weigh bridges, hard standings)
- intermodal trade routes
- road freight links
- season.

Ro-Ro passenger vessels are most often employed on short sea routes that connect regional freight links and allow private passenger transport. Seasonality affects the trade with passenger numbers fluctuating during holiday periods. The price associated with Ro-Ro passenger vessels fluctuates daily due to competition and demand on certain routes with open source data limited due to company confidentiality.

B.8.3. Value

The value applied to ro-ro passenger vessels is in three parts the car carrying capacity in CEU, the roll-on, roll-off freight units in lane metres LM and passenger numbers. As the vehicle decks can be used for either cars or freight the CEU and LM value is set at a ratio with passenger numbers applied as an addition.

Car Equivalent Units (CEU) value

A car with two passengers equals 81 GBP pp. This is based on the 2019 price for the Newcastle to Port of Ijmuiden (for Amsterdam) route. This route has been chosen due to the route being of an intermediate short-sea passage and best fits as an average value. Historic data is not available as an open source for these values.

Lane metre value

The Freight unit value applied to LMs is evaluated using statistics from the port of Dover:

- 2,601,162 freight units in 2017
- estimated £122 billion trade in goods
- equating to 46,902 GBP per unit.

Passenger value

Foot passenger value is based on the ticket price for the Newcastle to Port of Ijmuiden (for Amsterdam) route. This route has been chosen due to the route being of an intermediate short-sea passage and best fits as an average value. Historic data is not available as an open source for these values.

Ratios

Ratios between foot passengers, CEU and LM cargo for Ro-Ro Passenger vessels is based on the statistics from the port of Dover for 2017:

- road haulage vehicles (freight) = 2,601,162
- tourist Cars (non-freight) = 2,180,611
- coaches (non-freight) = 79,638
- foot passengers = 5%.

Total units are therefore 4,861,411 with the ratio between the two 53% to 47%. Whereas LM and CEU cargo is played off at the given ratio, foot passengers are set as a percentage of all passengers, at 5%. As LM are a measure of the cargo value in each unit the passenger value of accompanying driver is not included, this is taken into account with the total passenger percentage:

- road haulage vehicles (freight) passengers = 22%
- foot passengers = 5%
- total passengers = 27%.

This figure is not adjusted for unattended cargo freight units which may be present. In summary the following figures are used for calculating value of Ro-Pax vessels:

- passengers = 27% of total passengers at 312USDpp
- non-freight = 47% of total CEU at 508.3 USD/CEU
- freight units = 53% of total LM units at 63,318 USD/LM unit.

A lane metre unit is set at 16.5m for ro-ro passenger vessels based on the DfT maritime statistics analysis.

B.8.4. Sources

Port of Dover, (2019a). Port of Dover numbers
https://www.doverport.co.uk/about/performance/

Port of Dover, (2019b). Port of dover trade value and unit value
https://www.doverport.co.uk/about/news/port-of-dover-announces-fifth-consecutive-record-y/13341/

DfT port level statistics to inform freight proportion
https://www.gov.uk/government/statistical-data-sets/port-and-domestic-waterborne-freight-statistics-port#port-level-statistics

- DfT, (2018i). Table Port0301. Freight traffic by port and year

- DfT, (2018j). Table Port0302. Freight traffic by port and route
- DfT, (2018k). Table Port0303. Freight traffic by top 30 UK ports for each cargo type
- DfT, (2018l). Table Port0400. Individual major ports traffic, by cargo type and international or domestic.
- DfT, (2018m). Table Port0499. UK major port traffic: port level downloadable dataset
- DfT, (2018aa). Table Port0304. Map of UK ports by traffic, cargo and route type.

Fusco, et al., (2016). RoPax vessel size and freight price relationship https://pdfs.semanticscholar.org/8933/4a97f31997908908592bab66d7700314b719.pdf

Wathne, (2012). Cargo stowage methodology for ro-ro vessels https://core.ac.uk/download/pdf/52099717.pdf

B.9. Cruise Vessels

B.9.1. Construction

Cruise ships are specifically designed for the transportation of passengers. Typical vessel arrangements include:

- large superstructure
- passenger accommodation areas
- side shell gates and gangways for passenger access
- on-board recreational features.

Cruise ships are designed to accommodate and carry passengers with capacity specified in the vessels Passenger Ship Safety Certificate (PSSC). Vessel design maximises the space available for on-board activities and accommodation.

B.9.2. Trade

The size and capacity of a vessel is constrained by the nature of the cargo to be transported and the route on which the vessel trades, such constraints impacting cruise ships include:

- weather conditions
- season
- port navigational constraints
- port infrastructure and security.

Cruise ship trade is seasonal and affected by weather conditions and passenger demand during holiday periods, the ticket price and on-board spending of passengers fluctuates within these periods.

B.9.3. Value

The SUV value used for cruise ships is derived from the global average of passenger expense per day, taken from cross industry actors and based on a seven-day cruise. The value includes ticket price and on-board spending.

B.9.4. Sources

Cruise Market Watch, (2019). Passenger expense breakdown for 2017
https://cruisemarketwatch.com/financial-breakdown-of-typical-cruiser/

B.10. Specialist

Specialist vessels are those on unique trades, these vessels have not been divided into separate size categorise and have had an individual value applied.

B.10.1. Livestock carrier

An analysis of livestock carriers has determined that the average head of cattle transported is 4000, this has been accomplished through fleet analysis of operators. The value assigned is based on the head price of all prime cattle in the UK for 2017. Price per head equals 194.3 GBP.

Source

AHDB, (2018). UK Cattle Yearbook
http://beefandlamb.ahdb.org.uk/wp-content/uploads/2018/10/UK-Cattle-Yearbook-2018.pdf

B.10.2. Heavy load carrier

The most frequent heavy load vessel activity based around the UK is for the development and operation of offshore windfarms. These vessels are often used for the transportation of infrastructure, construction of infrastructure and maintenance of sites.

Due to the inherent nature of heavy load, out of gauge (OOG), or project cargo the value of goods can range from several thousand to many millions with each passage a unique price. With the instability of assigning value to a cargo the choice to value the use of the vessel is used. The time charter average of a typical heavy load vessel is used.

The charter rate for a heavy load vessel used for offshore renewables is taken at 80,000 GBP per day, based on research conducted in 2013.

The length of time required per charter is set at the minimum time of 1 month. Between 1 and 3 months is used by offshore windfarms for emergency maintenance activities. 30 days is used as a monthly value
80,000 x 30 = 2,400,000 GBP/Ship

Source

Dalgic, et al., (2013). Vessel charter rate estimation for offshore wind O&M activity
https://www.researchgate.net/publication/265972473_Vessel_charter_rate_estimation_for_offshore_wind_OM_activity

B.10.3. Nuclear fuel carrier

Nuclear fuel carriers are ocean going vessels with a small valuable cargo carried at infrequent intervals on global routes.

Capacity is derived from the figures of Pacific Nuclear Transport Limited vessels and is set at 20 flasks, each flask holds 2.5 tonnes equating to 50 tonnes per vessel

The price used is from the world nuclear association Uranium market spot price for 2017 and is 20.10 USD per pound of Triuranium octoxide (U_3O_8).

- 1 metric tonne (MT) = 2204.62 pounds
- 2204.62 x 50 = 110,231 pounds/Ship
- 110,231 x 20.10 = 2,215,643.1 USD/Ship.

Source

World Nuclear Association, (2019). Price per USD per pound
http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspx

B.10.4. Pulp carrier

Pulp carriers are specifically designed to transport wood pulp for the manufacture of paper products. The trade has specific routes between supplier and manufacturing sites.

The value applied to pulp carriers is based on the average monthly price for 2017 from European agricultural statistics; 875 USD per metric tonne.

The most common size of wood pulp carrier has been assessed through fleet analysis and is deemed to be the panama design with a capacity of 70,000 MT

The value assigned to pulp carriers is therefore 70,000 x 875 = 61,250,000 USD/Ship

Source

Index Mundi (2019). Wood pulp index
https://www.indexmundi.com/commodities/?commodity=wood-pulp&months=120

B.10.5. Refrigerated cargo vessel (Reefer)

Refrigerated cargo vessel are known as reefers, they are used for fast transportation of fruit from tropical areas to temperate climates. These vessels have large refrigerated holds capable to carrying unpackaged of palatized cargoes with modern reefers also accommodating container deck cargoes.

The capacity of a reefer is based on a fleet analysis and is given in cubic feet, pallet and FEU numbers. The average reefer capacity has been determined at 604,195 Cf, 5,046 pallets and 170 FEUs.

Bananas are the most commonly transported commodity and has been selected to determine cargo value. Figures for the carriage of bananas are:

- 1080 boxes per container
- 54 boxes per pallet

The food and agriculture organisation of the United Nations banana market review 2017 gives a European market value of 122 EUR per tonne, this equates to:

- 1 box = 19 Kg
- 19 x 54 = 1,026 Kg/pallet
- 1,026 x 5,046 = 5,177 tonnes/ship
- 5,177 x 122 = 631,594 EUR/ship or 852,652 USD/Ship

Container = 1080 box/FEU = 20.5 t

- 20.5 x 170 FEUs = 3,485 x 122 = 425,170 EUR
- 425,170 + 631,594 = 1,056,764 EUR x 1.35 = 1,426,631 USD/Ship.

Source

BSSL Global, (2019). Type of cargo
http://bsslglobal.nl/wp-content/uploads/2016/03/BSSL-GlobalDoc-1.pdf

FAO, (2018). Banana Market Review.
http://www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/Bananas/Documents/web_Banana_Review_2018_Final_DV.pdf

C. Summary of Cargo Unit Values

This annex sets out the cargo unit value determined for the cargo types associated with the assessed vessel types, including the source information and the applied assumptions.

Table C.1: Cargo unit values for the applied cargo types

Assessed Vessel Type	Deduced Cargo	DfT Cargo Group	Estimated Unit Value USD	Assumptions	Source information
Oil tankers	Oil products	Liquid Bulk	58.42	Price per barrel in 2017 for refined products 58.42 USD.	Selected values are from the Rotterdam refinery and cover the six most commonly produced products (OPEC, 2017b; 2017c).
	Crude oil		55.89	Price per barrel in 2017 for crude oil 55.89 USD.	Selected values are from the benchmark price of OPEC for both basket and other crudes in 2017 (OPEC, 2017b; 2017c).
Gas carriers	LNG		2.99	Price per MBtu for LNG is 2.99 USD. (conversion rate given at 24.0 mmBtu/M³) = price per m³ of 71.76 USD.	LNG is taken from Henry Hub spot price data for 2017 as this is a major global crude indicator. Value is in MMBtu and converted to price per m³ using 24.0 MMBtu per m³.
	LPG		7.82	Price per MBtu for LPG is 7.82 USD (conversion rate given at 27.2 mmBtu, as an average of refrigerated and pressurised) = price per m³ of 187.68 USD.	LPG is taken from the Natural gas liquid (NGL) composite price for 2017 as this covers both wet and dry forms of NGL from a large global section. NGL prices follow crude prices. Value is in MMBtu and converted to price per m³ using the average of pressurised and refrigerated conversions of 27.2 MMBtu per m³.

Assessed Vessel Type	Deduced Cargo	DfT Cargo Group	Estimated Unit Value USD	Assumptions	Source information
Chemical tanker	Chemical tanker and chemicals		622	Average of biofuels, edible oils, chemicals given as 622 USD/m³.	A report from the NTNU sets out chemical tanker cargoes and their commodities. https://pdfs.semanticscholar.org/d487/90ee6c1a1113c90e8325f4391184588599af.pdf.
Containers	Containers		46,750	Price per TEU based on the average between the estimated TEU value from insurance assessments.	Information published by IHS Markit on vessel accumulation and cargo value estimation IHS Markit, (2017a).
Dry bulk	Major dry bulk	Dry Bulk	105.10	Price per tonne of major dry bulk is 105.1 USD/T.	Major and minor bulks are split by vessel class. Major bulk price is an average of the top three major bulks commodities.
	Minor dry bulk		422	Price per tonne of Minor dry bulk is 422 USD/T.	Minor bulks are an average of the top four minor bulks commodities.
Pure car carrier	Vehicles	Ro-Ro (specific cargo types)	36,600	Average UK car retail price for 2017 = 30,500 EUR converted with 2017 rate of 1.2 = 36,600 USD/CEU.	
Ro-Con	Container		46,750	TEU capacity is set at the same container rate of 46,750 USD/TEU.	
	CEU		36,600	CEU capacity is used for automobiles, valued at 36,600 USD/CEU.	

Assessed Vessel Type	Deduced Cargo	DfT Cargo Group	Estimated Unit Value USD	Assumptions	Source information
	LM		63,318	LM is used for freight units, with a Ro-Ro factor of 14.6m per unit at 63,318 USD/LM.	Lane Metre values have been derived from a report by the NTNU: https://core.ac.uk/download/pdf/52099717.pdf.
Cruise	Cruise passenger	Passenger	1,791	Average value of a cruise passenger is 1,791 USD/Pax based on a 7 day cruise.	The average passenger expense per day measured globally from cross industry actors, based on a 7 day cruise. This is a global figure.
Ferry	Ferry passenger		312	Pax unit set at average ticket price for geographical area at 312 USD per person at 27% of passenger total.	
Ro-Pax	Passenger	Ro-Ro (specific cargo types)	312	Pax unit set at average ticket price for geographical area at 312 USD per person at 27% of passenger total.	Ro-Ro rates vary seasonally. Passenger value is based on ticket cost and on-board spending. Passenger percentage is that of foot passenger (5%) plus passenger vehicle and lorry drivers at (25%) equalling 27% of a vessels total passenger carrying capacity.
	CEU		508.30	CEU capacity is used for automobiles at an annual average ratio, the figure is 508.3 USD/CEU at 47% of cargo units.	CEU value is that of a standard car ticket price plus on-board spending for two passengers per car. Ratio between freight and non-freight vehicles is based on statistics from the port of Dover for 2017.

Assessed Vessel Type	Deduced Cargo	DfT Cargo Group	Estimated Unit Value USD	Assumptions	Source information
	LM		63,318	LM capacity is used for freight units, with a Ro-Pax factor of 16.5m per unit at 63,318 USD/unit at 53% of cargo units.	Freight unit per LM based on a study by NTNU. Value of freight unit is based on statistics from the port of Dover with trade in goods divided by number of freight units through the port.
Specialist	Livestock carrier	Dry bulk	262.30	Value is by head of prime cattle in the UK for 2017.	
	Heavy load carrier	Ro-Ro (specific cargo types)	80,000	Value is a day charter rate, based on the charter of a renewables heavy load carrier. Charter rate is of the minimum period of 1 month (30 days).	
	Refrigerated cargo vessel	Dry bulk	165	Value based on the UN banana market review of 2017, the EU value equals 122 EUR per tonne.	

D. Cargo Value Reference Tables

This annex sets out the cargo value reference table for each vessel type. Each reference table demonstrates the linkages between the vessel size, DWT, cargo capacity and unit value, which are then used to estimate the cargo value for each vessel and transit. The application of the reference tables is described in Section 4.2.8.

D.1. Container

Table D.1: Container reference table

			DWT		Capacity (TEU)		
Class (Standard design)	**Alternative Class**	**Cargo**	**Lower**	**Upper**	**Lower**	**Upper**	**Unit Value[1]**
Handy	Feeder (Small)	Fully cellular container ship	10	14,999	0	999	46,750
Handy	Feeder	Fully cellular container ship	15,000	29,999	1,000	1,999	
Sub Panamax	N/A	Fully cellular container ship	30,000	39,999	2,000	2,999	
Panamax	N/A	Fully cellular container ship	40,000	99,999	3,000	7,999	
New Panamax	Neopanamax	Fully cellular container ship	100,000	149,999	8,000	14,499	
ULCS	N/A	Fully cellular container ship	150,000	220,000	14,500	18,000	

[1]: Price per TEU based on average TEU cargo value as identified in IHS Markit, (2017b).

D.2. Chemical Tanker

Table D.2: Chemical tanker reference table

			DWT		Capacity (m³)		
Class (Standard design)	Alternative Class	Cargo	Lower	Upper	Lower	Upper	Unit Value[1]
Smalls	Coastal	Variable	10	5,999	0	6,999	622
Regional, Short sea tankers	Small intermediate	Variable	6,000	9,999	7,000	9,999	
Intermediate	Workhorse	Variable	10,000	14,999	10,000	15,999	
LI	Large Intermediate	Variable	15,000	19,999	16,000	21,999	
Flexi	Modern Class	Variable	20,000	24,999	22,000	29,999	
MR	Mid-Range	Variable	25,000	34,999	30,000	39,999	
Super	MR Super-segregator	Variable	35,000	49,999	40,000	54,999	
Super	LR Super-segregator	Variable	50,000	120,000	55,000	130,000	
[1]: Average of biofuels, edible oils, chemicals given as 622 USD/m³							

D.3. Oil Tanker

Table D.3: Oil tanker reference table

			DWT		Capacity (bbls)		
Class (Standard design)	Alternative Class	Cargo	Lower	Upper	Lower	Upper	Unit Value
Coastal	General Purpose (GP)	Oil product	10	24,999	0	189,999	58.42[1]
Handymax	Medium Range (MR)	Oil product	25,000	44,999	190,000	344,999	
Panamax/Aframax	Large Range 1 (LR1)	Oil product	45,000	79,999	345,000	614,999	
Suezmax/Aframax	Large Range 2 (LR2)	Crude oil	80,000	159,999	615,000	1,890,999	55.89[2]
VLCC	Malaccamax	Crude oil	160,000	319,999	1,900,000	2,190,999	
ULCC	Ultra Large Crude Carrier	Crude oil	320,000	549,000	2,200,000	3,700,000	
[1]: Oil product, price per barrel in Dec 2017 for refined products 58.42 USD (OPEC, 2017a; 2017b)							
[2]: Crude oil, price per barrel in Dec 2017 for crude oil 55.89 USD (OPEC, 2017a; 2017b)							

D.4. Gas Carrier

Table D.4: Gas carrier reference table

			DWT		Capacity (m^3)		
Class (Standard design)	Alternative Class	Cargo	Lower	Upper	Lower	Upper	Unit Value
Small Semi Ref	ETH Gas	LPG	10	3,999	0	4,999	7.82[1]
Semi Ref	ETH Gas	LPG	4,000	6,999	5,000	9,999	
Handysize Gas	LNG/LPG	LPG	7,000	9,999	10,000	19,999	
Midsize Gas	Small scale LNG	LNG	10,000	29,999	20,000	39,999	2.99[2]
LGC Gas	Med max LNG	LNG	30,000	69,999	40,000	59,999	
VLGC	Lower conventional LNG	LNG	60,000	119,999	60,000	199,999	
Q-Flex	Upper conventional LNG	LNG	120,000	129,999	200,000	219,999	
Q-Max	Q-type (LNG)	LNG	130,000	160,000	220,000	270,000	
[1]: Price per MBtu, conversion rate given at 27.2 mmBtu, as an average of refrigerated and pressurised. Price per m^3 is 187.68							
[2]: Price per MBtu, conversion rate given at 24.0 mmBtu/m^3. Price per m^3 is 71.76							

D.5. Dry Bulk

Table D.5: Dry bulk reference table

			DWT		Capacity (tonne)		
Class (Standard design)	Alternative Class	Cargo	Lower	Upper	Lower	Upper	Unit Value
Handysize	Small Handysize	Minor dry bulk	10	24,999	0	24,999	422[1]
Seawaymax	Large Handysize	Minor dry bulk	25,000	39,999	25,000	39,999	
Handymax	Small Handymax	Minor dry bulk	40,000	49,999	40,000	49,999	
Supramax/Ultramax	Large Handymax	Minor dry bulk	50,000	59,999	50,000	59,999	
Panamax	Kamsarmax (Fertiliser, Mineral ore)	Major dry bulk	60,000	99,999	60,000	99,999	105.1[2]
New Panamax	Post Panamax (Fertiliser, Mineral ore)	Major dry bulk	100,000	129,999	100,000	129,999	
Capesize	Mini Capesize (Fertiliser, Mineral ore)	Major dry bulk	130,000	159,999	130,000	159,999	
VLOC	Capesize/Newcastlemax (Coal)	Major dry bulk	160,000	209,999	160,000	209,999	
ULOC	Chinamax/Valemax (iron ore)	Major dry bulk	210,000	400,000	210,000	400,000	
[1]: Price per tonne of minor dry bulk is 422 USD/T							
[2]: Price per tonne of major dry bulk is 105.1 USD/T							

D.6. Ro-Con

Table D.6: Ro-Con reference table

			DWT		Capacity (varying)		
Class (Standard design)	**Alternative Class**	**Cargo**	**Lower**	**Upper**	**Lower**	**Upper**	**Unit Value**
Coastal		Container	10	6,999	0	199	46,750[1]
Short-sea			7,000	9,999	200	399	
Deep-sea			10,000	24,999	400	1,999	
Panamax			25,000	34,999	2,000	2,499	
Post-Panamax			35,000	57,000	2,500	3,800	
Coastal		Unaccompanied vehicle	10	6,999	0	199	36,600[2]
Short-sea			7,000	9,999	200	399	
Deep-sea			10,000	24,999	400	1,999	
Panamax			25,000	34,999	2,000	2,499	
Post-Panamax			35,000	57,000	2,500	3,800	
Coastal		Lane metre freight units	10	6,999	0	199	63,318[3]
Short-sea			7,000	9,999	200	399	
Deep-sea			10,000	24,999	400	1,999	
Panamax			25,000	34,999	2,000	2,499	
Post-Panamax			35,000	57,000	2,500	3,800	
[1]: Price per TEU based on average TEU cargo value as identified in IHS Markit, (2017b)							
[2]: CEU capacity is used for automobiles at an annual average ratio, the figure is 508.3 USD/CEU at 47% of cargo units							
[3]: Lane metres capacity is used for freight units, with a Ro-Pax factor of 16.5m per unit at 63,318 USD/unit at 53% of cargo units							

D.7. Pure Car Carrier

Table D.7: Pure car carrier reference table

			DWT		Capacity (CEU)		
Class (Standard design)	Alternative Class	Cargo	Lower	Upper	Lower	Upper	Unit Value[1]
Handysize	PCTC	Vehicles	10	5,999	0	2,499	36,600
Handysize	PCTC	Vehicles	6000	14,999	2,500	4,499	
Panamax	PCTC	Vehicles	15,000	17,499	4,500	5,499	
Panamax	LCTC	Vehicles	17,500	24,999	5,500	6,999	
Post Panamax	HERO	Vehicles	25,000	29,999	7000	8,499	
Post Panamax	HERO 2	Vehicles	30,000	50,000	8,500	12,000	
[1]: Average UK car retail price for 2017 = 30,500 EUR converted with 2017 rate of 1.2 = 36,600 USD/CEU							

D.8. Ro-Pax

Table D.8: Ro-Pax reference table

			DWT		Capacity (varying)		
Class (Standard design)	**Alternative Class**	**Cargo**	**Lower**	**Upper**	**Lower**	**Upper**	**Unit Value**
Inshore		Passenger	10	499	0	899	312[1]
Coastal			500	2,999	900	999	
Shot-sea			3,000	5,999	1,000	1,999	
Deep-sea			6,000	8,999	2,000	2,499	
Large Deep-sea			9,000	15,000	2,500	4,000	
Inshore		Accompanied vehicles	10	499	0	99	508.3[2]
Coastal			500	2,999	100	299	
Shot-sea			3,000	5,999	300	1,299	
Deep-sea			6,000	8,999	1,300	1,999	
Large Deep-sea			9,000	15,000	2,000	3,000	
Inshore		Lane metre freight units	10	499	0	99	63,318[3]
Coastal			500	2,999	100	149	
Shot-sea			3,000	5,999	150	199	
Deep-sea			6,000	8,999	200	299	
Large Deep-sea			9,000	15,000	300	500	
[1]: Passenger unit set at average ticket price for geographical area at 312 USD per passenger at 27% of passenger total							
[2]: CEU capacity is used for automobiles at an annual average ratio, the figure is 508.3 USD/CEU at 47% of cargo units							
[3]: Lane metres capacity is used for freight units, with a Ro-Pax factor of 16.5m per unit at 63,318 USD/unit at 53% of cargo units							

D.9. Cruise

Table D.9: Cruise reference table

			DWT		Capacity (Pax)		
Class (Standard design)	Alternative Class	Cargo	Lower	Upper	Lower	Upper	Unit Value[1]
Small		Passenger	10	1,999	0	399	1,791
Small-mid		Passenger	2,000	4,999	400	799	
Midsize		Passenger	5,000	7,999	800	1,999	
Large		Passenger	8,000	9,999	2,000	2,999	
Mega		Passenger	10,000	20,000	3,000	7,500	
[1]: Average value of r a cruise passenger is 1,791 USD/Pax based on a 7 day cruise							

D.10. Specialist

Table D.10: Specialist vessel type reference table

		DWT		Capacity (Varied units)		
Class (Standard design)	Cargo	Lower	Upper	Lower	Upper	Unit Value
Livestock Carrier	Livestock	10	2,800	0	4,000	262
Heavy Load Carrier	Variable	10	10,000	0	30	80,000
Refrigerated Cargo Vessel	Refrigerated dry bulk	10	17,100	0	8,662	165

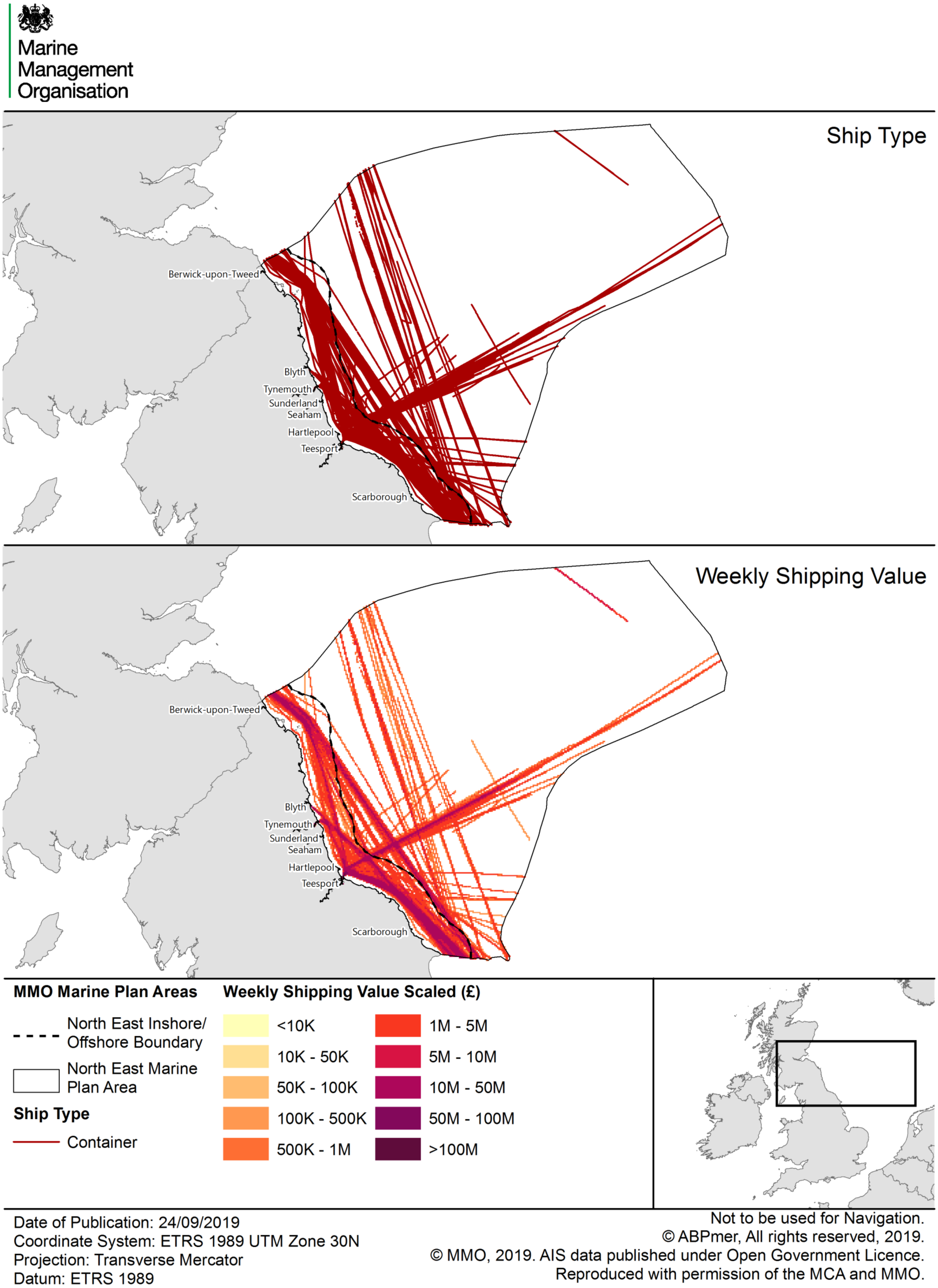
E. Scaled Shipping Cargo Value by Vessel Type

This annex illustrates the scaled shipping cargo value across the case study area for each of the assessed vessel type, along with a representation of the underlying AIS transits that were used to inform the value.

- container
- chemical tanker
- oil tanker
- gas carrier
- dry bulk
- ro-con
- pure car carrier
- ro-pax
- cruise
- specialist vessels (refrigerated vessel).

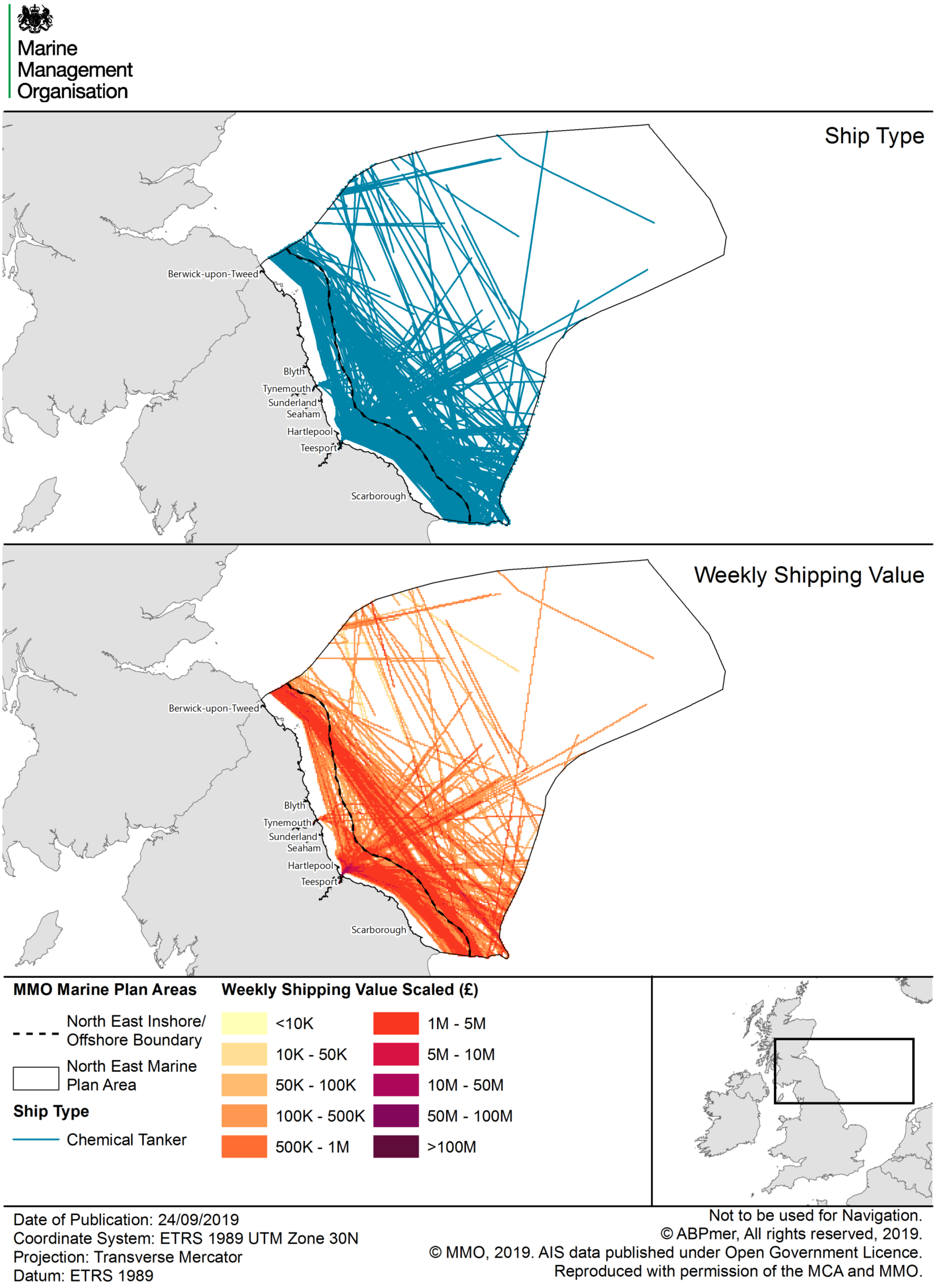
E.1. Container

Figure E.1: Scaled shipping cargo value and AIS transits for the container vessel type.



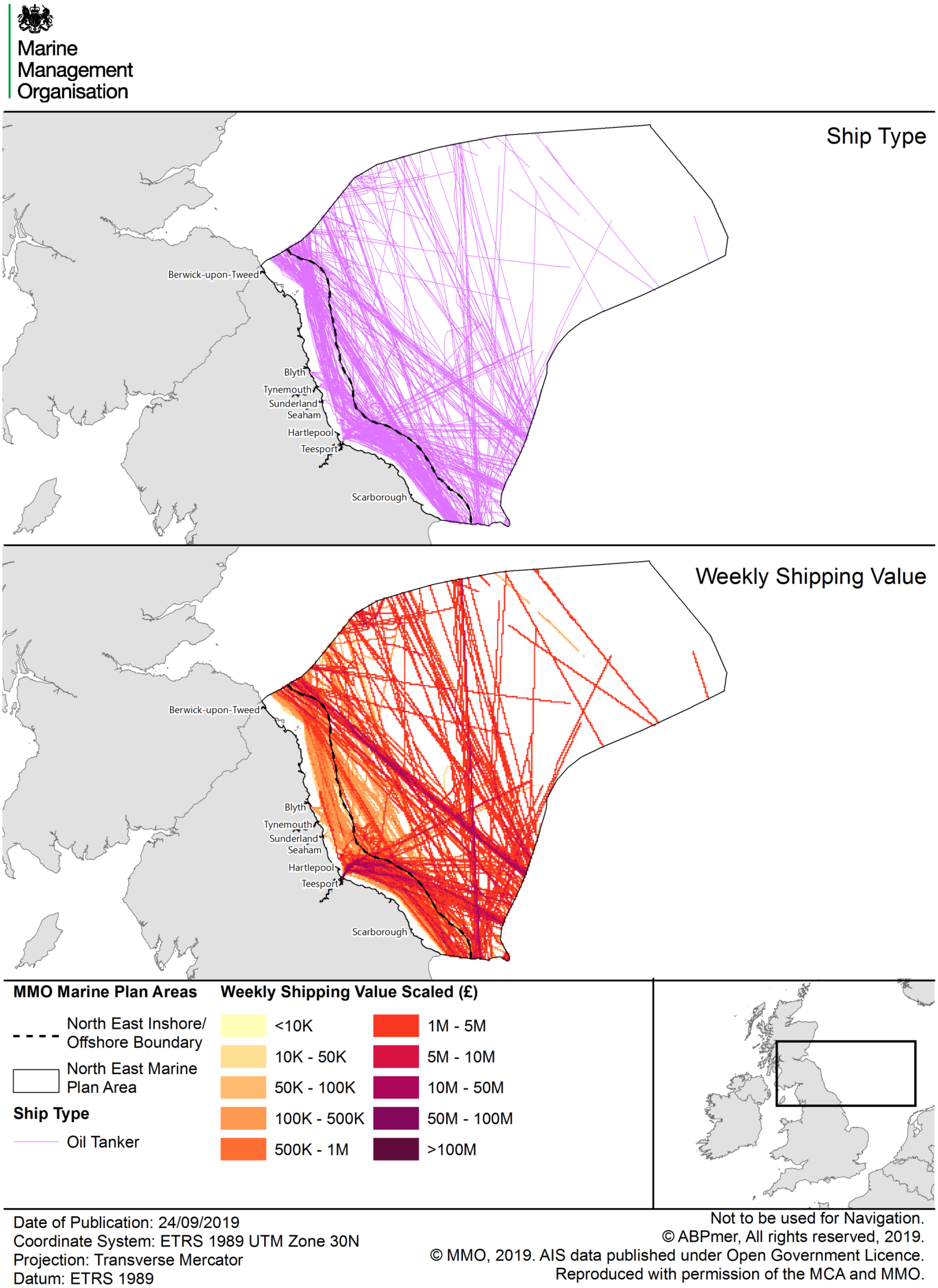
E.2. Chemical Tanker

Figure E.2: Scaled shipping cargo value and AIS transits for the chemical tanker carrier vessel type.



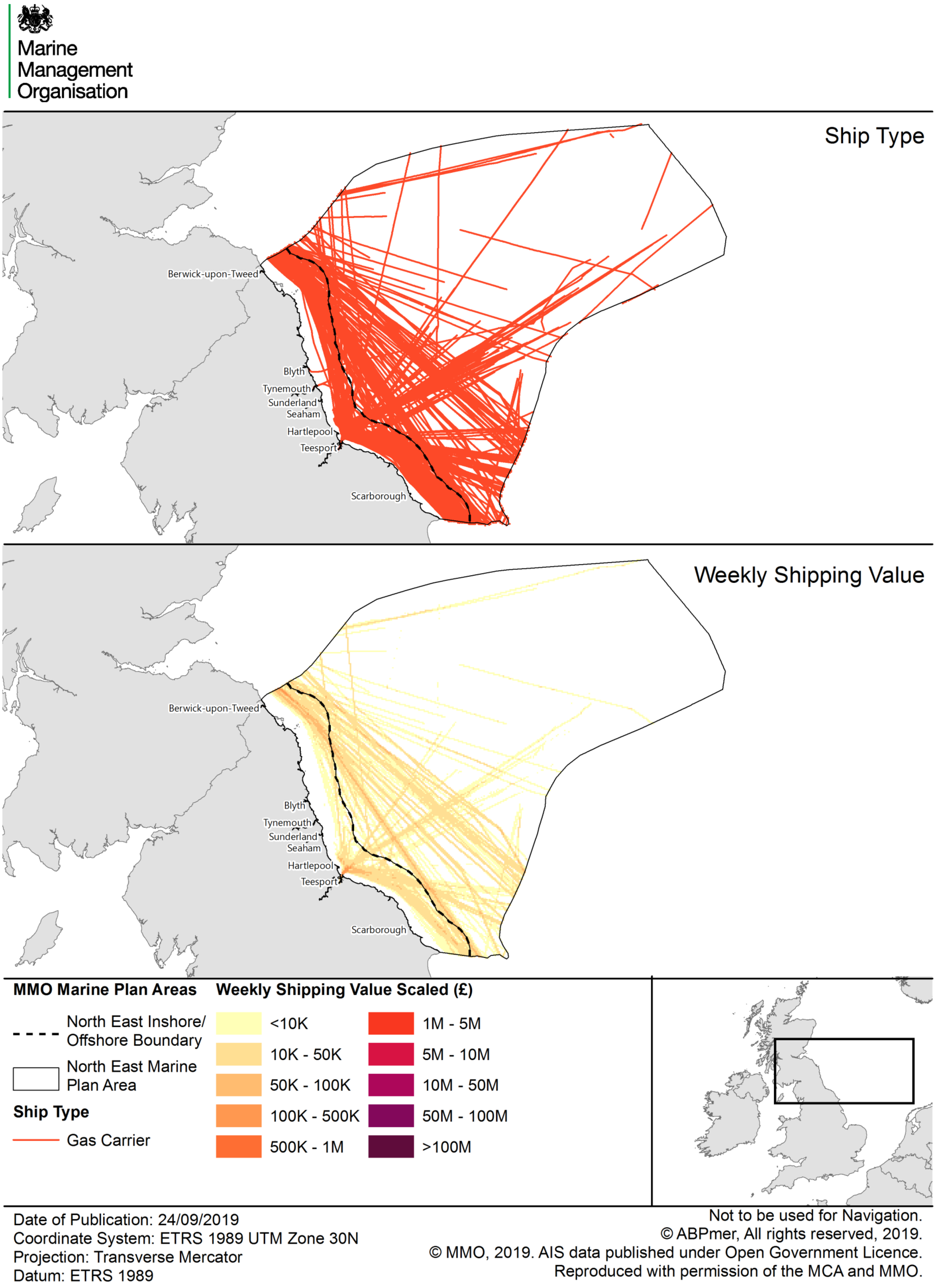
E.3. Oil Tanker

Figure E.3: Scaled shipping cargo value and AIS transits for the oil tanker carrier vessel type.



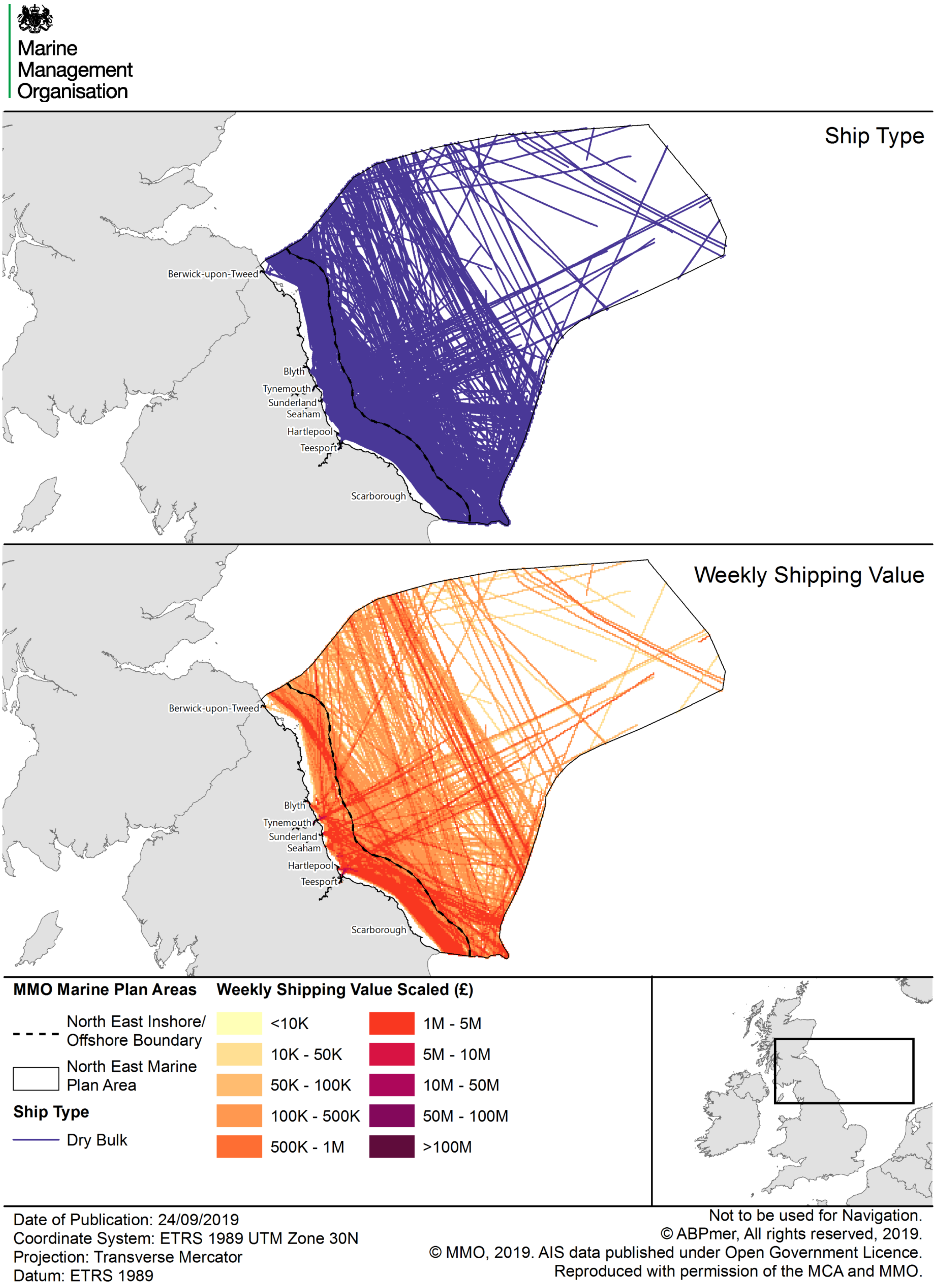
E.4. Gas Carrier

Figure E.4: Scaled shipping cargo value and AIS transits for the gas carrier vessel type.



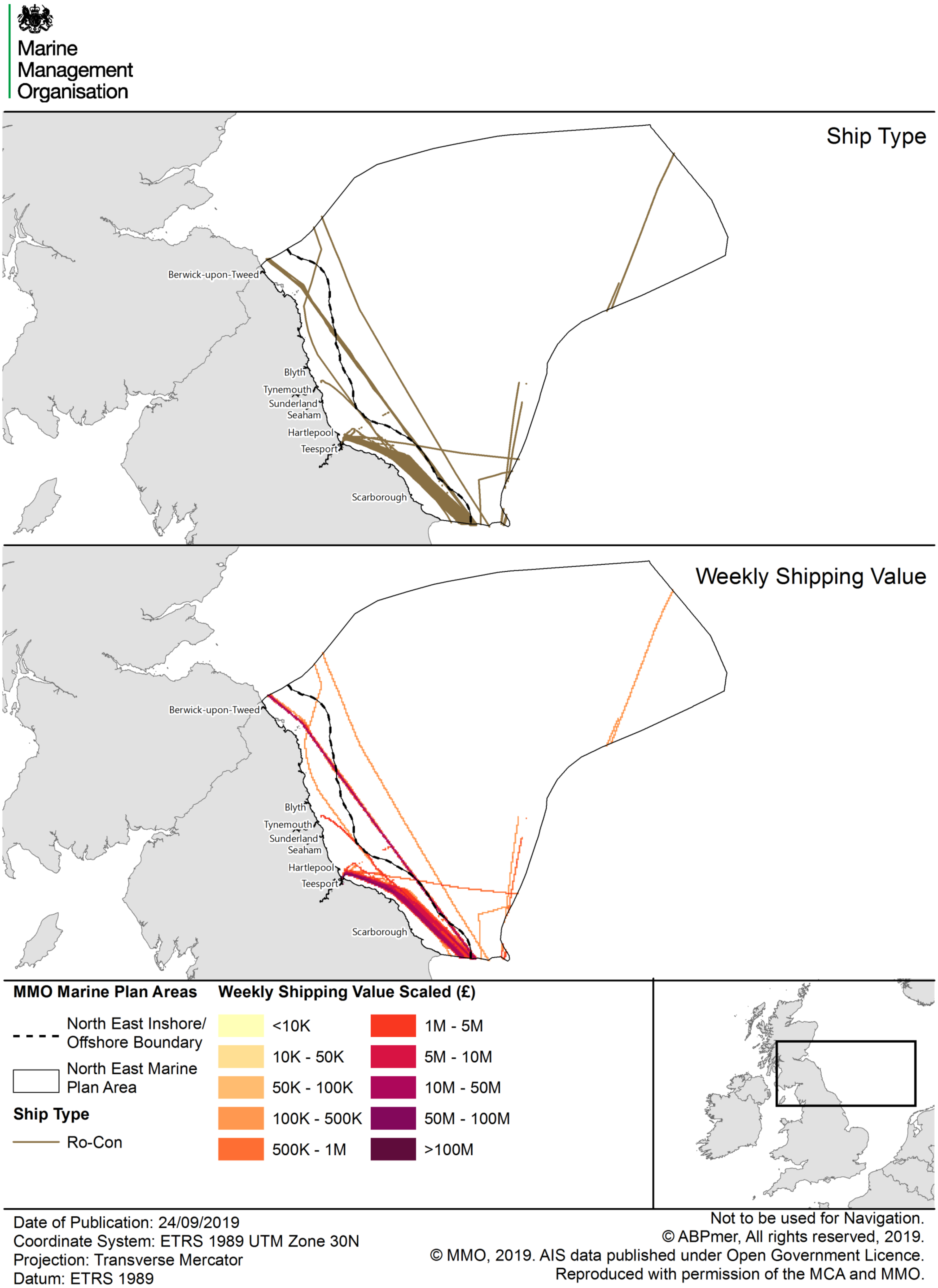
E.5. Dry Bulk

Figure E.5: Scaled shipping cargo value and AIS transits for the dry bulk vessel type.



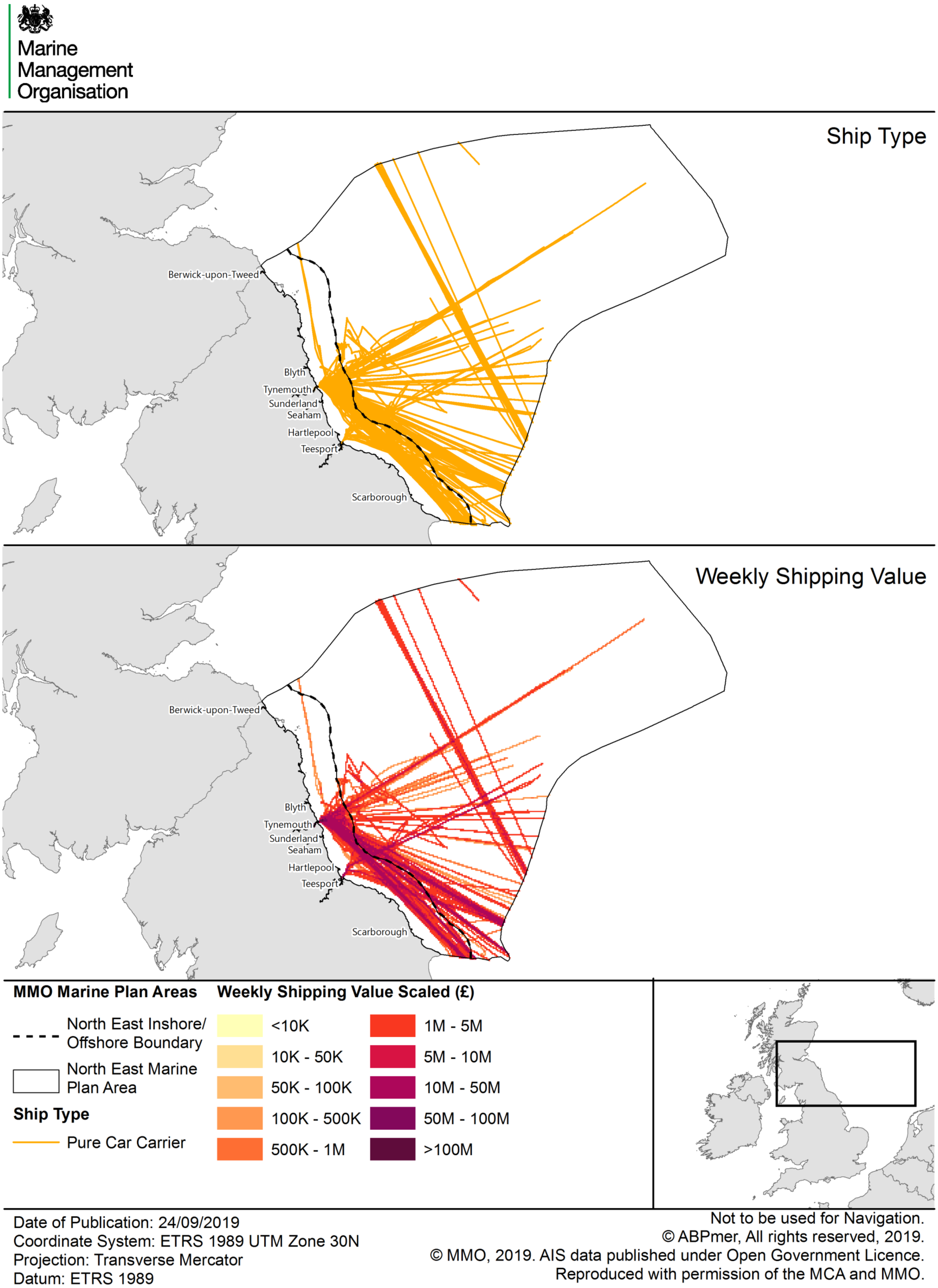
E.6. Ro-Con

Figure E.6: Scaled shipping cargo value and AIS transits for the Ro-Con vessel type.



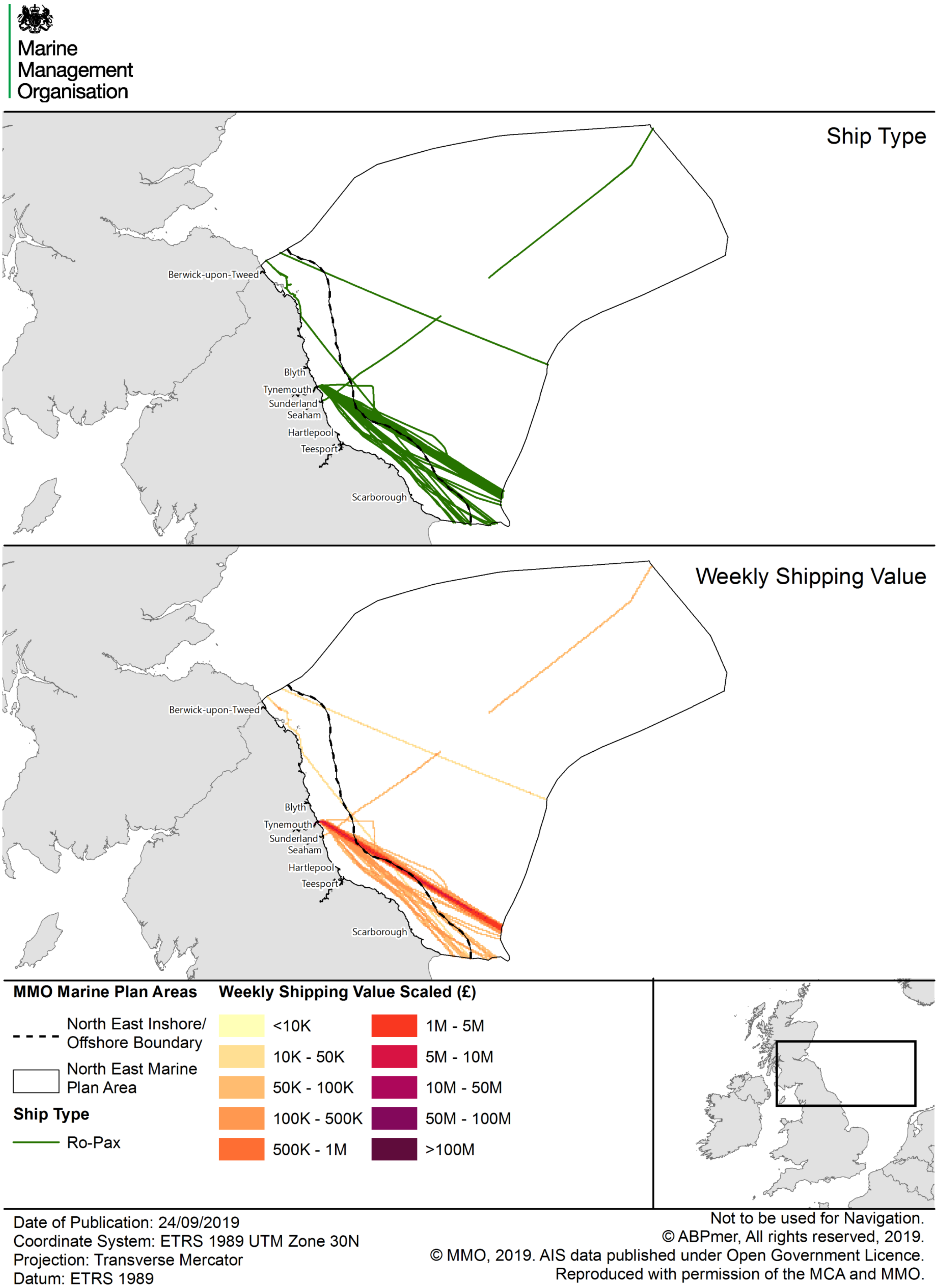
E.7. Pure Car Carrier

Figure E.7: Scaled shipping cargo value and AIS transits for the pure car carrier vessel type.



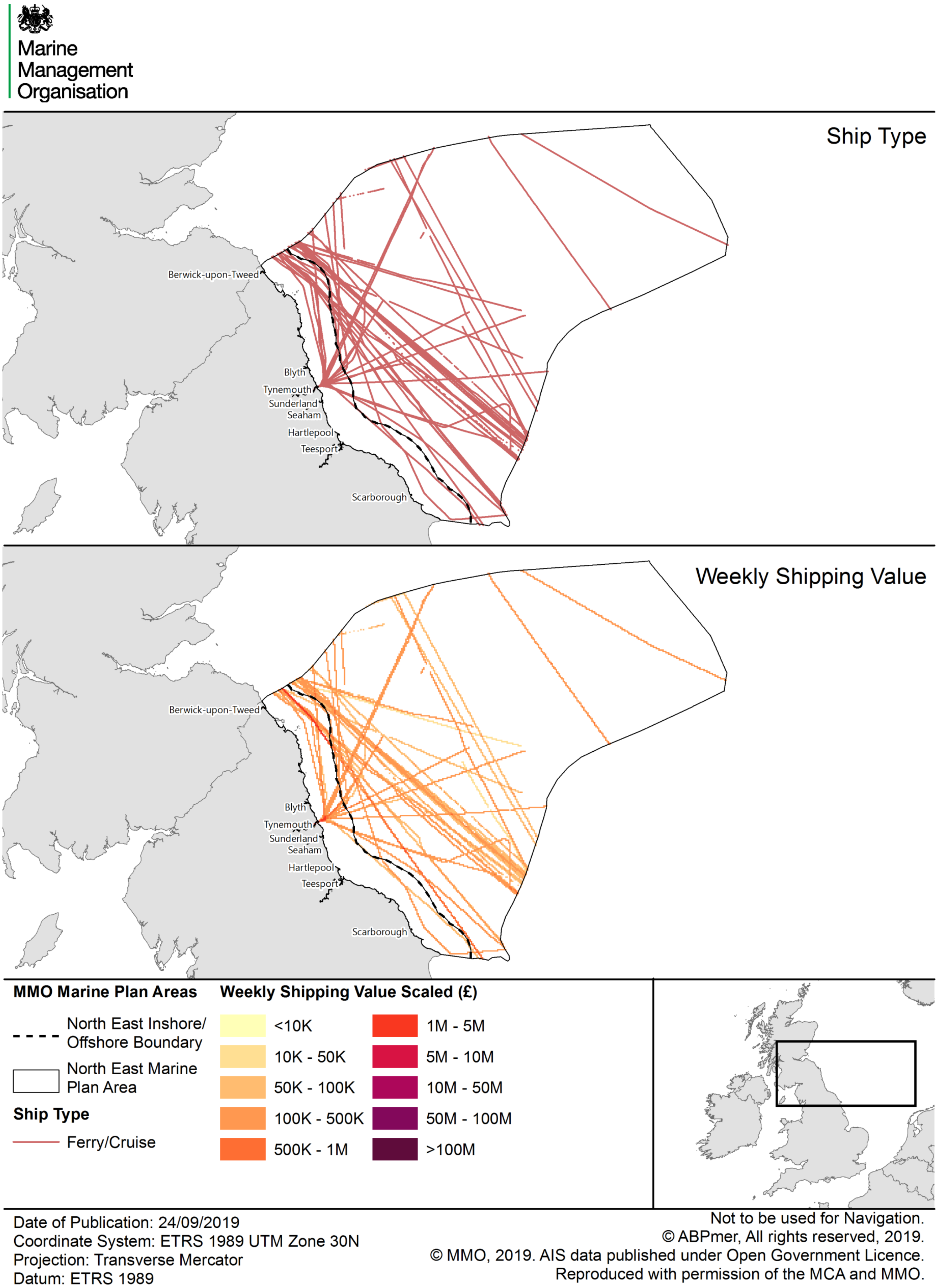
E.8. Ro-Pax

Figure E.8: Scaled shipping cargo value and AIS transits for the Ro-Pax vessel type.



E.9. Cruise

Figure E.9: Scaled shipping cargo value and AIS transits for the cruise vessel type.



E.10. Specialist Vessels (Refrigerated Vessel)

Figure E.10: Scaled shipping cargo value and AIS transits for the specialist (refrigerated vessel) vessel type