Cargo and cargo streams

D9.1

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Author	Dragos Totolici ICE dragos.totolici@icepronav.ro

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Executive Summary

The purpose of this document is to identify and select potential locations for the Transport&Logistics@Sea hub and to describe location specific cargo and cargo streams.

For regular port services six potential locations have been defined, see Ch.2 for details. They have been ranked from a Transport&Logistics hub perspective using a Multi Criteria Analysis (MCA).

The top three ranked locations are (see Ch.5 for additional information):

- Thessaloniki - best overall
- Constantza - best regarding the added value of a platform that shall take over future planned developments
- Hamburg, Amsterdam and Antwerp - best from a logistical hotspot point of view

Expected cargo flows at these locations are (see Ch.4 for details):

- Thessaloniki - Dry Bulk and/or Unitized
- Constantza - Dry Bulk
- Antwerp - Dry Bulk and/or Unitized

Other functions, in addition to the Transport&Logistics, that can be expected at each of the locations are very dependent on the overall design and basic engineering but regardless of the selected location the following are expected:

- Living aspects, either temporary or permanent are expected to be present.
- At the very least, energy generation and storage for the required day-to-day operations shall be provided. Locations with offshore wind farms nearby are preferred so Constantza, with its development plan and locations with access to the North Sea (i.e. Hamburg, Amsterdam and Antwerp) wind farms would be ideal. Proximity to an offshore wind farm would make the Transport&Logistics hub also suitable for a windmill O&M platform.
- Food production and storage would be ideal, but the other aspect take precedence on the Transport&Logistics hub.

Table of Contents

1 Introduction

The goal of the Transport&Logistics@Sea hub is to establish offshore regular port services and to integrate the offshore platform in the transport chain operating and coordinating seagoing and inland navigating vessels for different cargos (bulk, containers, LNG etc.). To move or take over regular onshore port services like transhipment, distribution and storage onto an offshore platform requires consideration of the possible location, type(s) of suitable cargo (dry, liquid bulk, containers, LNG), the cargo streams, ship types, the environmental as well as local social and political boundaries.

For a location to be of interest for Transport&Logistics@Sea, a specific need for an offshore logistic hub must exist. Reasons why an onshore port cannot provide the desired service or quality of service are:

- Insufficient depth of water, limiting the draught of ships that can be handled
- Lack of quay space resulting in long berth waiting times
- Lack of storage and handling space
- Poor connection to inland waterway transport

The opportunity to resolve one or more of these issues using an offshore platform will be one of the criteria for location selection. Other criteria will be defined to rank the possible locations. Constraints are also defined and applied to guarantee the feasibility of platforms at the selected locations.
Furthermore, a logistic hub at the platform must also fulfil the requirements of the other functions at the platform; the resulting cargo streams for these activities must be identified.

- O&M services for the Energyhub@Sea
- Feeding, harvesting, processing and bringing products to the market for Farming@Sea
- People and provisions for Living@Sea

1.1 Objective

Summarizing, the aim of this report is:

- to identify several possible locations for further study
- to identify and quantify the cargo streams for those locations
- to identify ship types that can be used for selected locations and cargo streams

1.2 Methodology

Location selection

The location selection is based on the following steps:

- define the constraints that a location must satisfy
- define the criteria and scoring method for the locations
- score each proposed location on the criteria
- select the three highest scoring locations for Transport&Logistics@Sea

Cargo streams

For each of the three selected locations the cargo streams will be determined; first a qualitative analysis is executed to determine the type(s) of cargo, then a quantitative estimation is done for the size of the cargo streams.

Ship types

For the cargo type and cargo streams at each of the selected locations, the existing ship types that can be used for transport to and from the hub will be identified.

2 Location selection

Two types of aspects are considered for the location selection. First, the constraints, which are the mandatory characteristics considered for choosing the location of the platform. Secondly, the criteria that can be used to judge the suitability of a location compared to other locations. Criteria are presented in four groups: Regular port service criteria (Transport&Logistics, detailed in Annex 1) and general criteria (Energy, Framing and Living). The criteria are scored for each location and the weighted sum of all scores per location determines the total score of that location.

2.1 Constraints

- Location: European Union, Territorial waters, Exclusive Economic Zone, International waters

Location shall be inside the borders of EU, but also including Norway (Horizon 2020 and Space@Sea partner). There will be no exception to this, as the projects main beneficiaries are the European Union (and partners) and its citizens. To better understand what is meant by the borders of the EU in the context of this project, the following definitions apply:
Territorial Waters: up to 12 nautical miles from the country shore where the country has full sovereignty over the waters (the coastal state has jurisdiction both above and below the water surface).

Exclusive Economic Zone or EEZ: up to 200 nautical miles from the country shore where the country has "sovereignty rights" (the coastal state has jurisdiction only below the water surface). The water surface and above is considered as International Waters. Part of the EEZ is the contiguous zone which is defined as a band of water extending from the outer edge of the territorial sea to up to 24 nautical miles from the shore, within which a state can exert limited control for preventing or punishing "infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea". See Figure 1 and Figure 2 below for EU and Norway EEZ respectively.

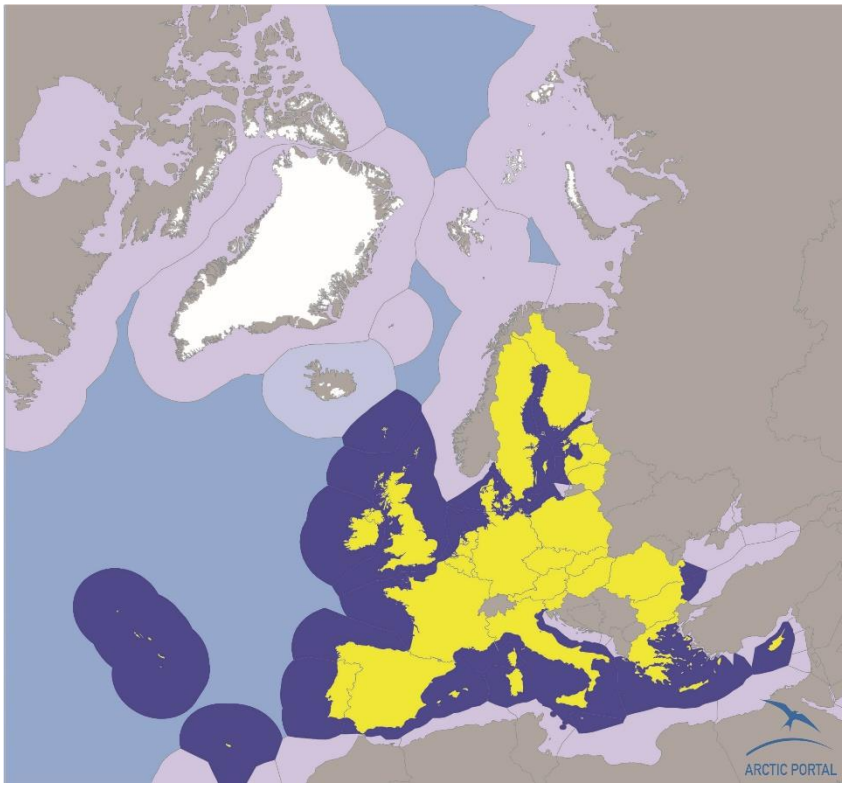

Figure 1 European Union EEZ

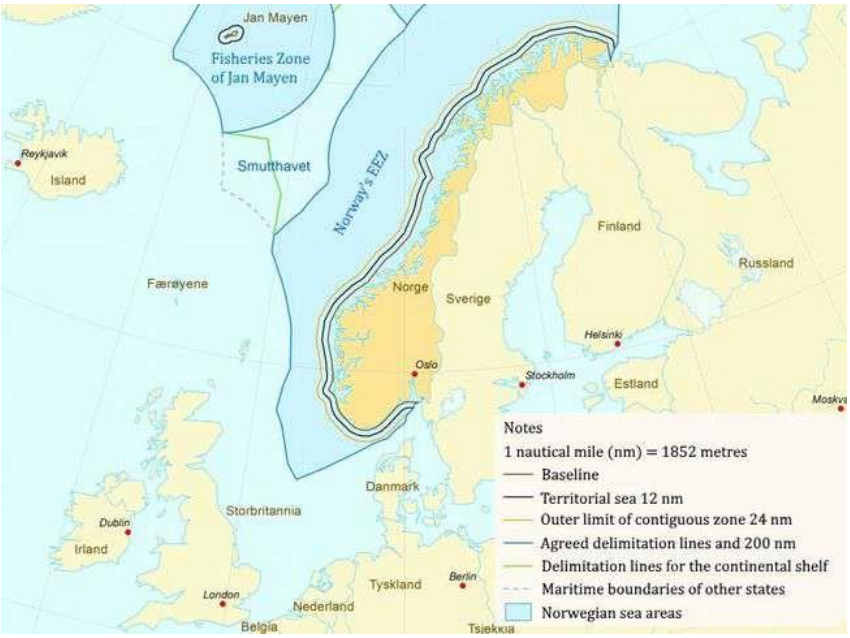

Figure 2 Norway EEZ

International Waters (trans-boundary waters or high seas): any bodies of water (or their drainage basins) that transcends international boundaries, everything outside the EEZs (international waters have no sovereignty, all states have the freedom of: navigation, overflight, fishing, oil and gas drilling, deep sea mining, laying cables and pipelines, research, etc.).

Continental Shelf: the area of seabed around a large land mass where the sea is relatively shallow compared with the open ocean. The continental shelf is geologically part of the continental crust.
As the platform shall be designed with both above and under water facilities and equipment in mind, the choice of zone boils down to either a country's territorial waters or on the high seas.

- Political climate

The political climate is the aggregate mood and opinions of a political society, which is generally regarded as either changing (unstable) or in equilibrium (stable). Only locations in countries with a stable political climate are considered.

- Seismic / Volcanic activity

Zones where seismic or volcanic activity resulting in possible tsunamis or in other ways interfering with the day-to-day activities of the platform should be avoided unless these calamities can be quickly and safely mitigated. Only locations in countries with a low or no risk of seismic and volcanic activities are considered.

2.2 Transport&Logistics criteria summary

- Cargo types

The platform shall cater exclusively for maritime cargo. For details about each type of maritime cargo see Annex 1. The selection of cargo shall be the determining factor in the transport and logistics module design alongside the necessary facilities to fulfil the requirements of Living, Farming and Energy hubs.

- Ship types

Highly dependent on the point above, facilities to accommodate specific ship types shall be provided. This can be a temporary stopping point (loading/unloading, provisioning) or a permanent key side for vessels in use for regular (maintenance) work at the Farming and Energy hubs.

- Added value to location

The platform should strive to cover current and future need of existing nearby ports and/or cities. This would make reason from an economic standpoint and thus attract future investors to the project.

- Vicinity of logistical hotspots

Logistics is the management of the flow of things between the point of origin and the point of consumption to meet customer requirements.
Proximity near logistical hotspots would make the most sense from economical and industrial standpoints. However, a logistical hub could come with disadvantages to the quality of life of people living on the platform as there would probably be little space for buffer zones between industrial and living spaces.

- Navigation and routes

Ease of navigation to and from the platform without disrupting existing trade and leisure sea routes is a limiting factor. Also, ease of access to inland connections from the platform location and linking to the existing Short Sea Shipping routes are factor to take into consideration when deciding on the location.
If you have no or poor inland waterway connection an offshore floating island is less feasible as you will then need to tranship twice, once offshore to a smaller vessel bringing the cargo to land and once in the port to the road/train connection.

2.3 General criteria (other criteria)

- Wind/Wave energy generating potential (Energyhub@Sea)

Waves are most commonly caused by wind. Wind-driven waves, or surface waves, are created by the friction between wind and the water surface. As wind blows across the surface of the water, the continual disturbance creates a wave crest. These types of waves are found globally across the open oceans, seas and along the coast.
For the sole purpose of generating energy from wind and waves the zones with the highest (as engineering technologies allows) winds and waves are preferable. However, such zones could be unsuitable for other platform activities, i.e. Living, Farming, Logistics like crane operations, etc.

- Fishing / Aquaculture hotspots (Farming@Sea)

Aquaculture is the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other aquatic organisms. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish. Marine culture refers to aquaculture practiced in marine environments and in underwater habitats. Commercial fishing is the activity of catching fish and other seafood for commercial profit, mostly from wild fisheries.

Zones where aquaculture can be undertaken effectively shall be a must for and self-sustainable platform (not so much for a Transport&Logistics focused hub), while the proximity to commercial fisheries could be beneficial if it complements, or at the very least doesn't interfere, with the ongoing fishing activities.

- Living / Social Appeal (Living@Sea)

Permanent living on a self-sustaining "water city" could prove a challenge with regard for the human psyche. To combat this the platform should be capable of accommodating facilities to cater to all the needs one would require on land. In complement to this, the platform should be capable of regular transport of its inhabitants to land on a regular basis, or in case of emergencies that would require evacuation to land. The main attraction for living at sea on this platform after the novelty wears off should be its capability to simulate on land living as accurately as possible.

2.4 Multi criteria analysis (MCA) and weight factors

The multi criteria analysis of locations will be undertaken with focus on the Transport&Logistics criteria listed above. The criteria shall have a base rating that factors how the location fairs strictly regarding to the specific criterion. This score shall range from 0 to 10 in increments of 1 (higher is better). All base criteria shall start with a base rating of 5 and be given marks ranging from -5 to +5.

Additionally, the criteria shall be ranked, considering some to be more important than others. Therefore, a weight factor for each criterion is proposed, ranging from 0 to 10 in increments of 1 (0 means not important while 10 means the most important). This will complement the base rating for each criterion.
The final mark for a specific criterion shall be calculated as follows: final score = base rating x weight factor.
The sum of all criterion final scores for a specific location shall give the total rating of that location. The maximum score possible for one location is 100. The following table presents the base ratings and weight factors of each criterion.

Criterion	Base Rating	Weight Factor
Cargo types	5	3
Ship types	5	3
Added value to location	5	2
Vicinity of logistical hotspots	5	1
Navigation and routes	5	1

Table 1 Criteria Base ratings & Weight factors

Proposed ports
To evaluate the potential for various forms of transport and logistics solutions using an offshore transhipment hub, including the feeder and hinterland logistics as well as the possibility to use the hub as a base port for O&M activities on renewable energies, a total of six (6) ports have been considered taking into consideration access to the three (3) major seas around the EU (Black, Mediterranean and North seas) and availability of relevant information for each location. The chosen locations, including a brief description and potential for the Transport&Logistics hub, are as follows:

- Constantza, Romania (Black Sea)

This location was considered mainly due to the numerous planned development projects that could be integrated into the Space@Sea project and specifically into the Transport&Logistics@Sea.
Future projects included in the Constantza port masterplan after 2020 are:
  - Development of an artificial Island to extend existing territories by approx. 150 ha.
  - Development of an LNG terminal to cover expected future demand increase and to decrease dependency on Russia and a LNG bunkering station investment
  - Development of a Wind farm field and wind power plant
  - Barge Terminal expansion

- Genova, Italy (Mediterranean Sea)

The Port of Genoa is Italy's main cargo-handling port and the busiest port of Italy by cargo tonnage.
The Port Authority of Genoa is committed to expanding the intermodal functions of the port and making the Port of Genoa a major connection point for freight handlers using rail and roadways between Northern Italy and Southern Europe.

- Thessaloniki, Greece (Mediterranean Sea)

The Port of Thessaloniki has one of the largest passenger terminals in the Aegean Sea basin and is recently being upgraded, as Thessaloniki is slowly turning into a major tourist port for cruising in the eastern Mediterranean.

- Hamburg, Germany (North Sea)

Deepening of the river Elbe for large vessels is controversial for ecological reasons. In part due to cooperation with Lower Saxony and Bremen to build a new container port (JadeWeserPort) in the deep waters of Jadebusen in Wilhelmshaven, Hamburg withdrew from this plan after a change of government in 2001.
Ships with a maximum draft of 12.80 metres can arrive and leave the port irrespective of tide at any time. Using the tidal surge for covering the stretch of river from North Sea as far as Hamburg, drafts of up to 15.10 metres are possible. Making allowance for the tide, in the other direction drafts of up to 13.8 metres are feasible.

- Amsterdam, Netherlands (North Sea)

The port area is located just 10 minutes from Amsterdam's city centre, as well as being close to Schiphol Airport. This makes further developments problematic regarding the storage of hazardous substances, odour and noise.
The port's development plan comprises strategic key objectives that make Amsterdam a viable candidate for the Space@Sea project. Also, proximity to the North Sea windfarm fields could prove advantageous for an O&M hub.

- Antwerp, Belgium (North Sea)

Antwerp has little scope for further westward expansion. The northern (right bank) docks already reach the Dutch border, and on the left bank Belgium has a nuclear power plant downstream of the Deurganck dock.
The Netherlands has territory on the south bank of the Scheldt, so the Port of Antwerp does not control the outer estuary of the river as it reaches the sea.
Maximum allowed ship draft is 16 m (upriver) and 15.2 m (downriver).

3 Cargo streams

The decision of suitable locations for Logistics@Sea at the Space@Sea island shall be based on the analysis of cargo flows. However, to develop an economically viable concept, the characteristics of the carriers must also be considered. Therefore, an analysis of the current situation in inland waterway transport, sea-river transport and shortsea shipping has been performed and is summarized in the following pages. A lot of data on waterway structures, fleets and transported cargo can be found for inland waterway navigation, but much less for shortsea shipping and sea-river transport.

3.1 Inland waterway transport

Nowadays approximately 19,000 vessels including passenger ships and lighters operate on the European network of inland waterways with its total length of about 40,000 kilometres. These waterways are divided into navigable rivers, which may be free flowing or regulated with weirs and locks, lakes and artificial canals. The inland waterway network in Europe is categorised by the European Conference of Ministers of Transport (French: Conférence européenne des ministres des Transports, CEMT). These CEMT classes for large navigable waterways range from I to VII with increasing size. Class I to III are of minor or regional importance while class IV to VII allow larger vessels and international importance. The following table gives a simplified overview of the waterway types and corresponding vessels. Class I to III differ slightly for waterways east of Elbe.

Class	Motor vessels				Pushed convoys				Height under bridges
	Length	Width	Draught	Capacity	Length	Width	Draught	Capacity	
	[m]	[m]	[m]	[t]	[m]	[m]	[m]	[t]	[m]
I	38.5	5.05	1.8 – 2.2	250 – 400					4.0
II	50 – 55	6.60	2.5	400 – 650					4.0 – 5.0
III	67 – 80	8.20	2.5	650 – 1000					4.0 – 5.0
IV	80 – 85	9.50	2.5	1000 – 1500	85	9.5	2.5 – 2.8	1,250 – 1,450	5.25
V a	95 – 110	11.40	2.5 – 2.8	1500 – 3000	95	11.4	2.5 – 4.5	1,600 – 3,000	5.25
V b					172	11.4	2.5 – 4.5	3,200 – 6,000	5.25
VI a					95	22.8	2.5 – 4.5	3,200 – 6,000	7.0
VI b	140	15.0			185	22.8	2.5 – 4.5	6,400 – 12,000	7.0
VI c					270 195	22.8 33.0	2.5 – 4.5	9,600 – 18,000	9.1
VII					285	33.0	2.5 – 4.5	14,500 – 27,000	9.1

Table 2 Classification of European inland waterways

For most intra-European transport tasks, the transport mode (i.e. waterway, rail or road) is chosen based on the following main criteria:

- Speed
- Flexibility
- Costs including capital lockup
- Safety
- Timeliness / Regularity
- Availability (Weather sensitivity)

The weighting of these decision criteria differs according to the origin/destination relation and the type of cargo. Containerized fast moving consumer goods have other requirements than dry or liquid bulk and heavy project cargo.

While inland waterway transport (IWT) has an intrinsic advantage in energy efficiency and related costs as well as safety the other performance indicators must be evaluated case by case. IWT is mostly depending on further transport modes, since the waterway network is usually not suited for door-to-door delivery. This also implies additional transport costs for cargo handling. Therefore, the modal split of transported goods in different countries is highly dependent on the available infrastructure. Figure 3 of the French waterway authority VNF gives a good overview of the European inland waterway network including the assignment to the CEMT classes. A more detailed map is provided by the UNECE and includes information on water depth and height under bridges.

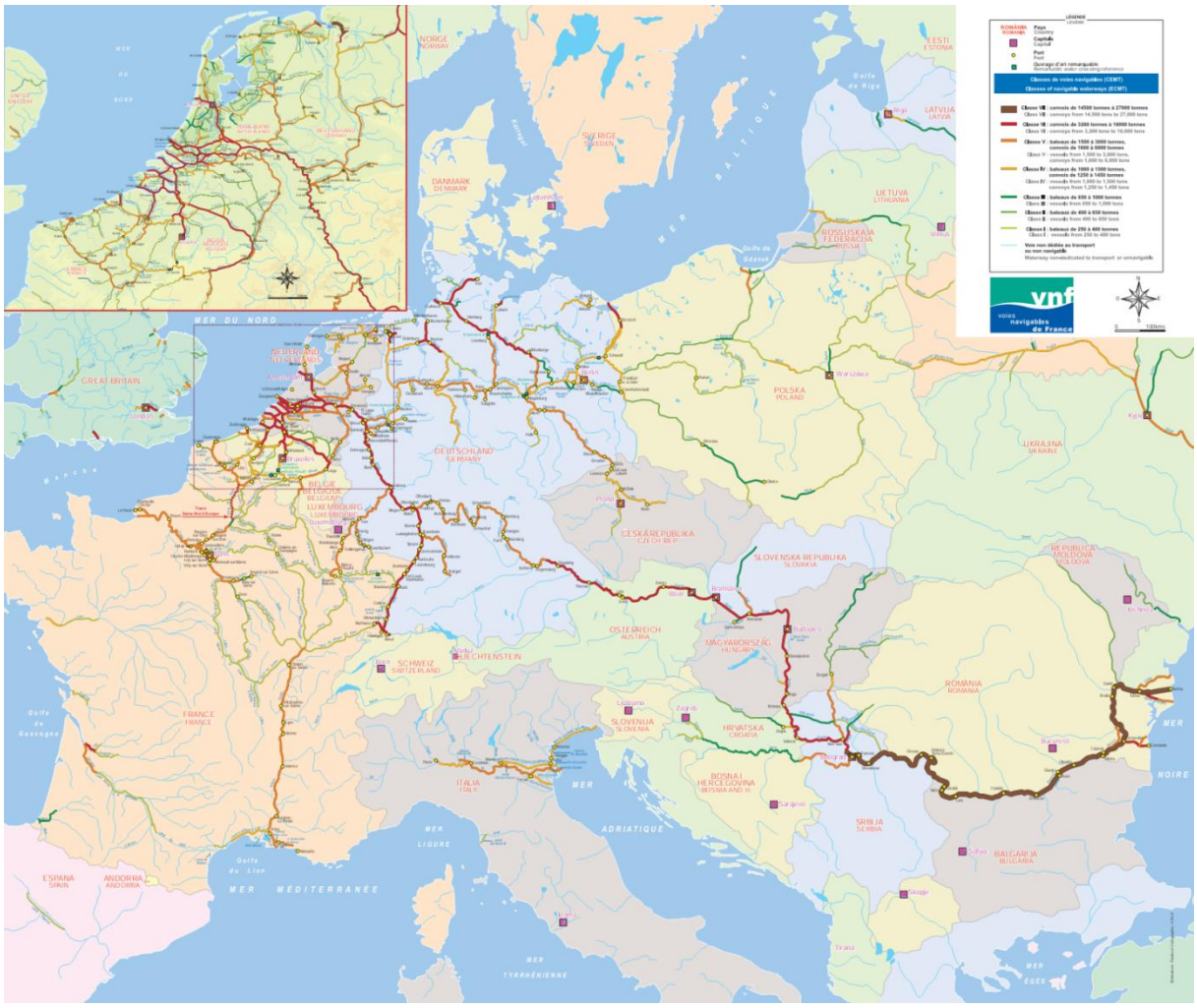

Figure 3 European inland waterway network (Ref.[22])

The variety of boundary conditions of the waterways like water depth, width, lock size and bridge height have caused a huge variety of vessels in the existing fleet. This is even increased by the extreme longevity of the vessels, which may be lengthened or even widened within their life span. The average age of German cargo vessels today is 45 years (Ref.[23]). Serial production of inland ships is virtually non-existent. The growing number of coupled convoys (i.e. vessels that can sail alone or with up to three lighters) adds to the complexity of the fleet. Several national and international databases (like the German waterway authorities, the IVR Ships Information System, the European hull database) exist and try to categorise the fleet with slightly different criteria and deviating numbers.

Country	Dry cargo vessels	Tanker vessels	Push boats	Tugs	Cargo lighters	Tank lighters	Total
Rhine countries							
Belgium	806	216	94	10	230	8	1,364
Germany	916	419	285	140	789	44	2,593
France	860	44	93	0	383	47	1,427
Luxembourg	8	16	11	0	0	2	37
Netherlands	3,993	1,240	649	479	1,135	51	7,547
Switzerland	17	55	0	2	4	3	81
Total	6,600	1,990	1,132	631	2,541	155	13,049
Central and Eastern Europe							
Bulgaria	26	4	38	13	161	5	247
Croatia	8	5	10	32	98	21	174
Hungary	78	2	26	53	300	4	463
Moldova	8	5	1	10	26	0	50
Austria	6	5	10	0	54	15	90
Poland	109	2	-	-	431	0	542
Romania	75	4	183	69	984	97	1,412
Serbia	62	5	40	82	345	37	571
Slovakia	26	4	41	1	119	32	251
Czech Republic	44	0	-	-	145	0	223
Ukraine	44	3	73	15	472	22	189
Total	486	39	422	275	3,135	233	4,212
TOTAL Europe	7,086	2,029	1,554	906	5,676	388	17,261

Table 3 Overview of the European inland fleet per country (Ref.[24])

Generally, inland vessels are not allowed to navigate outside of the inland waterways. Some exceptions are defined by local authorities and requirements from classification societies. The United Nations Economic Commission for Europe (UNECE) tried to standardise the requirements for vessels operating in estuaries and areas with moderate waves regarding strength, stability and freeboard by the definition of zones 1, 2 and 3. Zone 1 implies significant wave heights $H_{1/10}$ of up to 2.0 m while zones 2 and 3 are limited by 1.2 and 0.6 m respectively. An excellent and more detailed overview of the non-uniform status quo of sea-river solutions is given by Vantorre et al. (Ref.[25]). Today the number of inland vessels certified to operate in these areas and even the number and size of the areas where their navigation is allowed are very limited.

3.2 Sea-River Shipping

Sea-River vessels are ships that are built, certified and equipped according to the international regulations for sea-going ships. To navigate in suitable inland waterways these vessels must fulfil corresponding rules additionally and to match the boundary conditions in general dimensions. Besides draught and lock sizes the most important limitation in most regions is the air draught to allow passing under bridges and overhead cables. Table 4 lists some of the requirements for ships navigating on inland waterways or at sea. Vessels linking these areas must fulfil both. Crewing requirements, boat master certificates and exhaust gas emission limits also are different.

Inland Ship	Sea Ship
Length, breadth, (air) draught	Structural strength
Stern anchor	Stability
River radar	Sea keeping behaviour
Directional gyroscope	Freeboard
Blue board	Tonnage certification
Manoeuvrability	Lifesaving appliances
Stopping ability	Load securing equipment
Foldaway masts	Spare parts
Lowerable deckhouse	Approved materials
Noise emission	Int. rules
Local regulations	

Table 4 List of main requirements differing for inland and sea-going ships

Sea-river transport is only possible on inland waterways of sufficient size and access to the sea. According to the European River-Sea-Transport Union (ERSTU, Ref.[26]) in Western Europe the following waterways are suited for sea-river transports:

- Rhine (Netherlands, Germany)
- Thames, Humber, Forth (United Kingdom)
- Albert-Canal-Route (Belgium)
- Seine to Paris, Rhone to Lyon (France)
- Guadalquivir to Seville (Spain)
- Göta Alv, Trollhättan and Södertälje Canal (Sweden)
- Saimaa Canal and Finnish Lakeland (Finland)
- Lower Danube (Romania)
- Sea of Azov and Black Sea, Caspian Sea with connected rivers

According to the market analysis of the CCNR annually 90-100 million tonnes of cargo are transported by means of sea-river transport. Transported cargo comprises agricultural and forest products as well as bulk cargo. Also, metal products, semi-finished products, papers, waste and scrap, project and heavy goods as well as dangerous goods are typically transported by low air-draught sea-river vessels. Today these transports have a minor share in Western and Southern Europe and containers are rare in sea-river cargo flows. The importance is much higher in Russia. In 2017, 641 Russian-flagged sea-river vessels are registered in the Russian Maritime Register of Shipping. Typical deadweight capacities of the sea-river vessels are in the order of 2000 DWT (excluding Eastern Europe). In Scandinavia ice classes may be required. In the Rhine area, lowerable deckhouses are advantageous. In Russia, the focus is on small draught ships (Ref.[27]).

A special solution for sea-river transports was developed to connect the Jade-Weser-Port to the river Weser. The seaport of Wilhelmshaven is the only deep-water harbour independent on tides in Germany and the easternmost of the north range. In the past, coal and oil were transhipped at Wilhelmshaven which is also the most important base of the German navy. Due to its location, it is ideal for the handling of container ships of the newest generation and therefore has excellent prospects. Since the construction and completion of the Jade-Weser-Port in September 2012, port facilities with a capacity of 2.7 million TEU are available. Further extensions are planned. A large share of the cargo will be transported to Scandinavia and further east to the Baltic. Currently, the hinterland accessibility is limited to trains (60%) or trucks (40%) as there is no direct access for inland vessels.

To avoid a traffic collapse on the roads in case of increasing transhipping, the port must be re-structured, covering all three modes of transport. The inland ship as a transport mode is essential for transports to the hinterland. No direct link to inland waterways is available nor can be realised soon. The route concerned leads to the Weser estuary, via a short maritime area. Usual sea-going inland ships are not competitive at the given bridge heights and water depths in the large inland share of the relations. Existing solutions of seagoing ships with another transhipment to dedicated inland vessels in Bremen are beneficial only at very deep hinterland penetration depths. Therefore, there is a need for a completely new ship design which is seaworthy and at the same time can be used efficiently on the inland waterways.

Within the German joint research project BiWi (Ref.[28]) a solution was developed based on the pusher barge principle with a special hydraulic coupling. At sea, suitable pushing vessels or tugs shall be used to propel a seagoing barge. In inland navigation, a conventional canal pushing vessel is used and, ideally, pushes several barges at the same time. The major challenge within the project was the sea-keeping and manoeuvring behaviour of the coupled combination of pusher and barge in a seaway. The multi-objective design optimisation and a limited permit for certain environmental conditions aimed at an economic and safe solution operational with a minimum weather down time. Despite the challenging boundary conditions of the Weser the concept was successfully tested up to significant wave heights of 2.5 metres (Figure 4). Although developing a transport concept connecting SSS to IWT is not part of Space@Sea, reference is made here for possible future developments or connected projects.

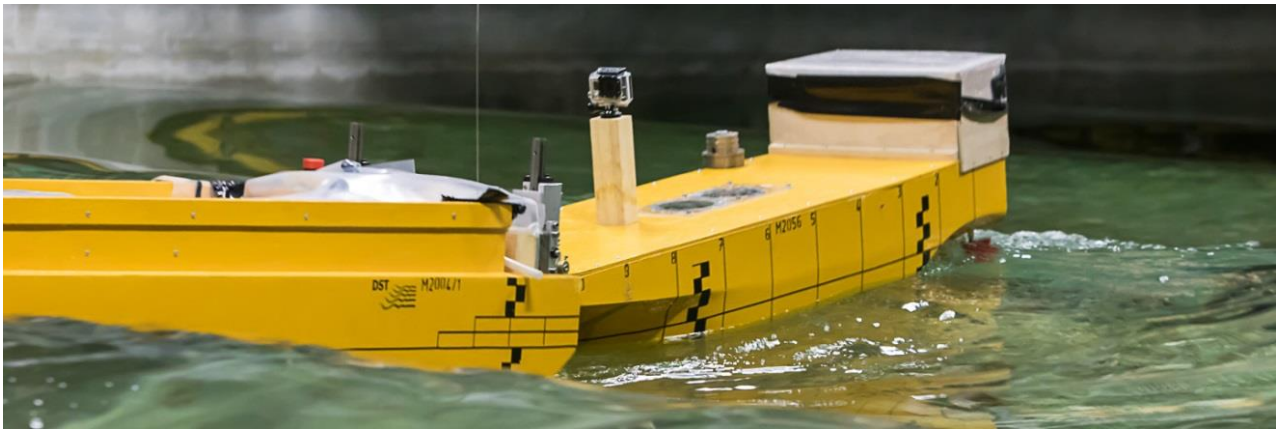

Figure 4 Picture of the BiWi convoy in scaled model tests

3.3 Shortsea Shipping

To achieve the goals of greenhouse gas emissions by transport and to shift freight from the road to rail and maritime transport the European Union promotes Shortsea Shipping (SSS). In recent years shortsea shipping promotion centres (SPC) were established in most EU countries with sea ports. However, today data for SSS is still not as extensive as for inland navigation and even the terminology is often not consistent. Maritime transport, SSS and sea-river shipping are often separated from each other differently, making it difficult to gather and evaluate data and statistics. Additionally, the definition of SSS can vary locally. To clarify the meaning of SSS in the context presented herein, the following EU definition is used (Ref.[29]):

> "*Short Sea Shipping means the movement of cargo and passengers by sea between ports situated in geographical Europe or between those ports and ports situated in non-European countries having a coastline on the enclosed seas bordering Europe. Shortsea shipping includes domestic and international maritime transport, including feeder services along the coast, to and from the islands, rivers and lakes. The concept of shortsea shipping also extends to maritime transport between the Member States of the Union and Norway and Iceland and other States on the Baltic Sea, the Black Sea and the Mediterranean.*"

Some data on cargo flows can be found in various data bases and sources with different levels of details and geographic coverage. Some of them are freely available (Eurostat, Trans-Tools3, ETIS) some are not (MDST, Prognos, Astra). A summary of transport statistics for SSS with recent data is provided by Eurostat (Ref.[30]). Figure 5 shows the distribution of freight transported by SSS per sea region. Figure 6 (Ref.[31]) shows the main SSS corridors including the cargo flows from and to individual countries.

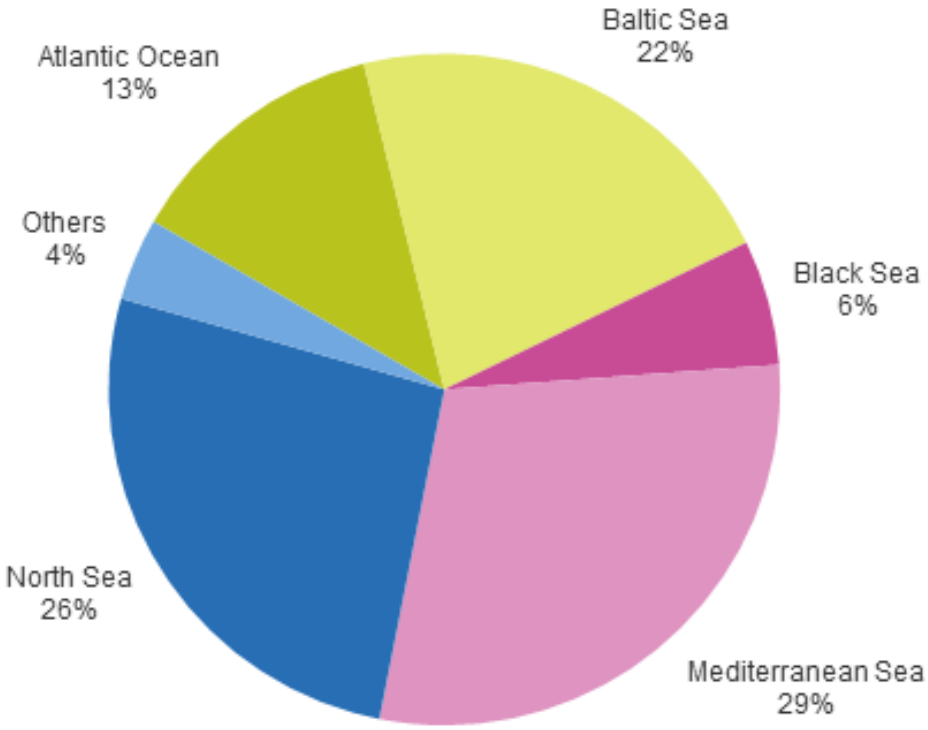

Figure 5 EU-28 Short Sea Shipping (SSS) of goods by sea region of partner ports in 2015 (in % of total gross weight of goods transported)

Cargo and cargo streams

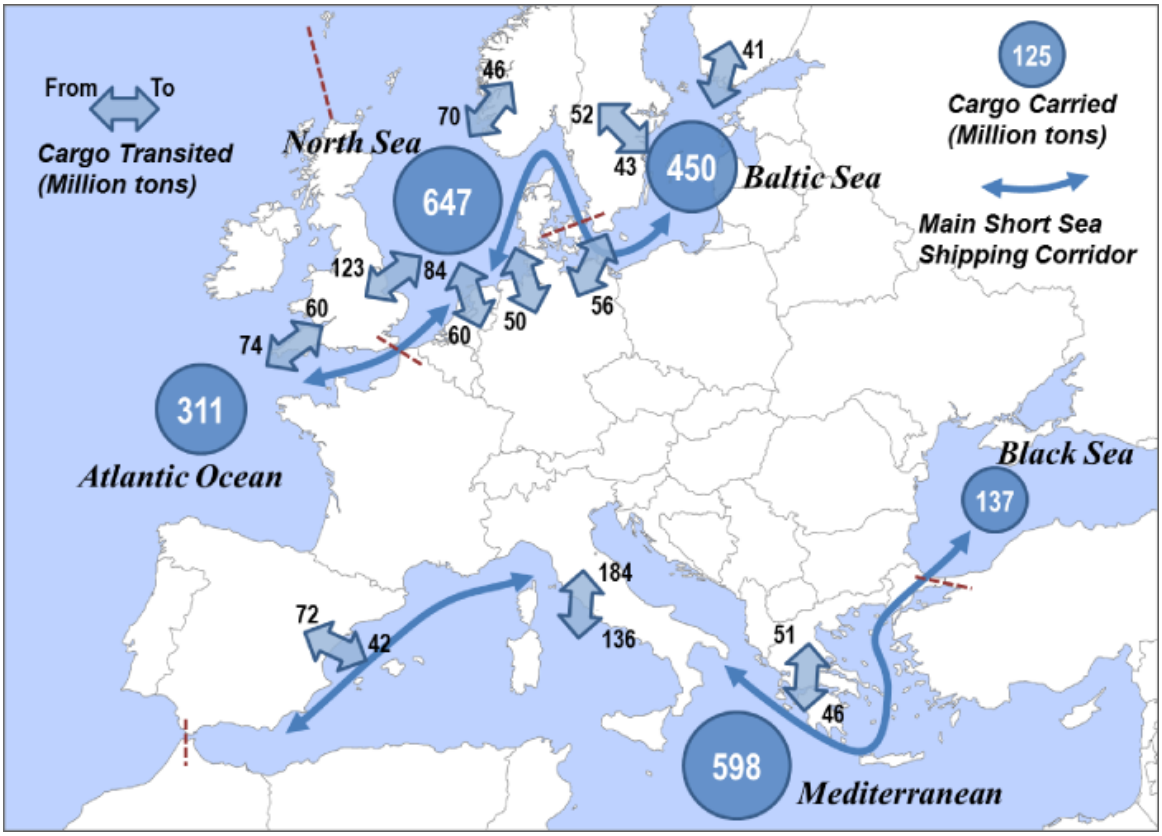

Figure 6 Cargo flows in European SSS

An overview of the shortsea shipping fleet is given in Table 5. Russia holds the highest number of shortsea shipping vessels, followed by Germany and Norway. For the twelve (12) listed countries, the fleet consists of a total number of 7,205 vessels.

Residence of shipowner	Number of ships
Russia	1,265
Germany	1,199
Norway	930
Netherlands	737
Turkey	612
Greece	601
UK	522
Denmark	338
Italy	333
Ukraine	265
Spain	211
Sweden	192
TOTAL	7,205

Table 5 Distribution of the SSS fleet per country (Ref.[32])

4 Scoring the locations

The following data was gathered and summarized from resources Ref.[1]-[7].

4.1 Port of Constantza

4.1.1 General

The Port of Constantza is located at the crossroads of the trade routes linking the markets of the landlocked countries from Central and Eastern Europe with the Transcaucasus, Central Asia and the Far East. It is the main Romanian port on the Black Sea, playing a highly important role as the transit node for the landlocked countries in the Central and South-East Europe.

Being a maritime port location and a river port location at the same time, it serves as a hub for the container traffic in the Black Sea and for cereals in Central and South-East Europe. In addition, the Port of Constantza lies at the Danube-Black Sea Canal and, thereby, connects the port to the Lower Danube. With its low costs, its important cargo volumes, its quattro modal connection and land availability, future growth of the port can be expected. This applies even more when global transport routes may shift in favour of the strategically advantageous position of Constantza.

4.1.2 Cargo

The traffic at the Port of Constantza has grown steadily over the ongoing decade. The total traffic has grown from roughly 46 million tons in 2011 to more than 59 million tons in 2016. Similar developments can be seen for the sub-sections, maritime traffic (from 37 to 46 million tons) and river traffic (from 9 to 13 million tons), as well as for the different transport directions, import (from 15 to 19 million tons) and export (from 16 to 21 million tons). When looking at container traffic, the picture does not change: a growth from 6.5 million tons in 2011 to 6.9 million tons in 2016 been recorded which roughly translates into 662,000 TEU (2011) and 711,000 (2016), respectively.

The following table ranks cargo flows (in metric tons) by type, from lowest to highest in the port of Constantza. For a more detailed description of each cargo type see Annex 1.

Neo + Break Bulk [t]	3,675,141
Unitized [t]	6,897,354
Liquid Bulk [t]	13,662,917
Dry Bulk [t]	35,189,409
TOTAL [t]	59,424,821

Table 6 Port of Constantza cargo flows (2016)

By a large margin, the most transited cargo in Constantza port is Dry Bulk (60% of the total cargo capacity). At the other end, the least transited cargoes are Neo + Break Bulk at around 6% of the total cargo flow.
Constantza port has an annual operation capacity of approx. 120 million tons per year which is at least double the maximum cargo flow rates of 2016 or earlier.

Storage, handling and cargo transfer capabilities of Constantza port reflect its focus on dry bulk cargo. The port has:

- 4.7 million tons storage for Ore, Coal, Coke (45,000 tons/day unloading rate; 2,000 tons/h barge loading rate)
- 100,000 tons storage for Chemicals & Fertilizers
- 350,000 storages for Agribulk

Considering mainly that the port of Constantza has yet to reach its maximum cargo operation capacity, it will get **-1 points** deducted from the cargo criterion base rating.

4.1.3 Ship types

Constantza Port has a handling capacity of over 100 million tons per year and 156 berths, of which 140 berths are operational. The total quay length is 29.83 km, and the depths range between 8 and 19 meters.
These characteristics are comparable with those offered by the most important European and international ports, allowing the accommodation of tankers with capacity of 165,000 DWT and bulk carriers of 220,000 DWT, covering almost all cargo types (development of new LNG focused terminals and bunkering stations is a priority, see following sub-chapter).

Also, the port of Constantza has excellent hinterland connections via an elaborate interior waterway network.
Based on the above, Constantza port shall receive **+1 points** more than the base rating on this criterion. Constantza can benefit from the platform accommodating larger vessels and providing cargo transfer support towards the hinterland.

4.1.4 Location added value

Constantza port has an extensive and ambitious development plan as follows:

<u>Modernization of port infrastructure, by providing deeper approach channels and basins and by increasing the navigation safety</u>: To ensure safe navigation conditions for ships in the port of Constantza, N.C. Maritime Ports Administration S.A. Constantza has promoted an investment regarding: dredging works for the designed depth of port basins and channels in the port of Constantza; increasing the depth of the "work port" and its access fairway, located in the Constantza South Port; dredging at berths. (**+1 points**, as the platform could take over larger ships without any further changes to the existing port).

<u>Development of a specialized berth in a high depth zone (Berth 80)</u>: The purpose of the project is to raise the port competitiveness and to enhance the handling capacity of dry bulk cargo (cereals). The project will create a base for increasing the cargo flux and improving the actual placement of the Port of Constantza as a hub in cereal trading. (**+1 points**, additional cargo flux can be taken over by the addition of the platform).

<u>Development of LNG Terminal</u>: The objective of the project is to establish the position of Constantza Port as hub for the LNG import/transit in the Black Sea region and for the landlocked Danube countries, to decrease the dependency of the national energy supply on Russian natural gas monopoly and transit problems (Ukraine), to cover the LNG supply for the expected increase of LNG fuelled vessels and to boost the LNG fuel not only for shipping and transportation sector but also for other purposes as energy source for residential, commercial and industrial sectors. (**+1 points,** LNG terminal could be provided by the platform).

<u>LNG bunkering station at Berth no. 99</u>: The objective of this project is to cover the potential demand of the LNG as a clean and economical fuel for shipping, to boost LNG as transport fuel, especially for IWT, by means of providing the Port with modern bunker facilities close to the Black Sea – Danube Canal. Also for the Constantza Port is necessary to fulfil the clean fuel strategy of the EU Commission which requires the installation of LNG refuelling stations (fixed or mobile) in all 139 maritime and inland ports at the Trans European Core Network by 2020-2025. (**+1 points**, same as above).

<u>Development of artificial Island</u>: The Island (the platform of the artificial island) has an area of 22.1 ha and represents a territory resulted from fillings with soil excavated from Danube-Black Sea Canal. Works foreseen in the present project will generate a total area of new territories of approx. 150 ha. (**+1 points**).

<u>Wind power plant</u>: This project is in the direction of research, promotion, development and use of new forms of renewable energy technologies retaining carbon dioxide emissions. (**+1 points**, a platform with offshore O&M shall benefit the offshore wind farm).

<u>Barge Terminal - Second Stage:</u> The purpose of the investment is creating new mooring areas for barges, tugs and pushers. The project consists of completing the mooring quay used for pushers and tugs on the West side of river-

sea channel by building a quay at the Northern end of the existing quay on berth no. 100 and arrangement of the quay used for waiting barges. (**0 points**).

The above, recommend Constantza port as a suitable location for a future floating island to cover these expansion plans, thus receiving the maximum of **+5 points** more than the base rating on this criterion.

4.1.5 Logistical hotspot proximity

The traditional transport routes remain the major ones for the Port of Constantza despite the growing integration within the national and European transport networks. However, the recent economic growth has let Constantza emerge to the main depositing and distributing center for Central and Eastern Europe. With the capability of handling any type of cargo and offering multimodal transportation services, the hinterland of Constantza Port supports the port regarding the produced, consumed and forwarded goods to/from the port. It includes a vast region in the Central and Eastern Europe. During the last decade, the Port of Constantza efficiently served the flows of goods that arrive or depart from/to Constantza. By their own account, the hinterland of the Port of Constantza encompasses all countries neighboring the Danube river and further countries in Southeast Europe, including Germany, Czech Republic, Slovakia, Austria, Hungary, Serbia, Bulgaria, Moldova, and - finally - Romania itself.
Currently Constantza and Romania may not belong to the top locations considering logistical feasibility. Nevertheless, some attractive logistical advantages are low cost labor and regulatory environment. For a more detailed view on logistics see Annex 1). In addition, upcoming developments and shifts on the global level, such as OBOR train and upcoming increase in vessel traffic to Greece and Southeast Europe, may change the picture tremendously in a couple of years.

Regarding logistical hotspot proximity, Constantza port receives **-3 points** deducted from the base rating on this criterion.

4.1.6 Navigation and routes

The main world container lines provide a fast and efficient connection between Constantza Port and the most important ports of the world. Direct services linking the Port of Constantza and Far East ports in the last years, have had as a result the changing into a hub for the Black Sea Region and a distribution centre for Central and Eastern Europe.

Ferry services provide a fast and direct link on the West-East axis, within the TRACECA Transport Corridor, connecting the European Transport Network with Central Asia. Regular ferry services ensure the transport of different type of commodities to and from Georgia and Turkey. At the beginning of 2006, a Ro-Ro line is connecting Mediterranean ports with the Port of Constantza.
Considering that Constantza is a gateway port to Central Asia and has good inland waterway connections, **+2 points** are given for this criterion.

4.1.7 Energy, Farming & Living potentials

So far, in Romania the saltwater fish beluga (Huso huso) and sturgeon (Acipenser ruthenus, A. stellatus, A. guldenstaedti) are being cultivated. Currently, marine aquaculture in Romania is at its initial stages, a single mussel farm being registered farming Mediterranean mussel (Mytilus galloprovincialis), even though certain studies suggest that there is interest and there are possibilities for developing this sub-sector (Ref.[14]).
The average annual wave power around Constantza is about 5 kW/m, the 100-year value / Mean value ratio is about 8 to 10 (see Annex 1 Figure 21 and Figure 22). As there are possibilities for farming and energy, at least service personnel will require accommodation on the island.

4.2 Port of Genoa

4.2.1 General

The Port of Genoa is a major Italian seaport and belongs to the biggest ports in the Mediterranean Sea. Ranked second after the Port of Triest, it belongs to the busiest and largest ports of the country. Dating back to ancient times as a natural port in the Mandraccio Bay, it serves as a transport hub for the entire Italian industry.

Genoa, together with Savona and Vado are the most important Italian gateway port: supply point for the industries of Northern Italy, transit channel for exports of Made in Italy products and for trade between Southern Europe and the rest of the world. Within a radius of 600 km you can easily reach important European regions: Switzerland, Germany (i.e. Bavaria and Baden-Württemberg), and Austria. However, the customers of the port also come from Spain, the Netherlands, Poland and Hungary.

The Port of Genoa is a one-stop multi-purpose seaport with over 20 private terminals that can accommodate any type of vessel and cargo. Cargoes handled in the Port of Genoa include containers, general cargo, liquid and solid bulk, metals, forestry products, perishable goods, petroleum products, and passengers. Several companies in the Port of Genoa also provide maritime services like vessel repair and environmental management.

By its own account, more than 150 scheduled services connect the Port of Genoa to major ports worldwide. The Port of Genoa is located near important industrial production areas in Italy and Europe. The Port Authority of Genoa is committed to expanding the intermodal functions of the port and making the Port of Genoa a major connection point for freight handlers using rail and roadways between Northern Italy and Southern Europe.

4.2.2 Cargo

The following table ranks cargo flows (in metric tons) by type, from lowest to highest in the port of Genoa. For a more detailed description of each cargo type see Annex 1.

Unitized [t]	370,282
Dry Bulk [t]	1,454,506
Neo + Break Bulk [t]	3,766,704
Liquid Bulk [t]	7,152,722
TOTAL [t]	**12,744,214**

Table 7 Port of Genoa cargo flows (2016)

The most transited cargo in the port of Genoa as of 2016 is Liquid Bulk, approx. 56% of the total cargo flow. At the other end, the least transited cargoes were Containers at around 3% of the total cargo flow.
The Liquid Bulk handling and storage capacity is:

- Approx. 20 million tons (550 vessels) / year (2011 data)
- Approx. 340,000 m^3 overall Liquid Bulk storage capacity in its 6 terminals

Altogether, the port of Genoa has more cargo handling and storage capabilities than the recent cargo flows. Therefore, for this criterion **-1 points** reduction from the base rating is given.

4.2.3 Ship types

The port of Genoa can accommodate the following ships:

- Container terminals (ships up to Superpost Panamax: L x B x D of 397m x 57m x 27.5m, 100,000-160,000 DWT, 7,000-10,000 TEU)
  - Total quay length of approx. 2000 m
  - Depth of 14.5-15 m

- Dry Bulk & Break Bulk terminals (solid bulk up to Handysize: L x B x D of 180m x 27m x 10m, 15,000-35,000 DWT; multipurpose up to Panamax: L x B x D of 294m x 32.3m x 12.5m, 60,000-75,000 DWT)
  - Total quay length of approx. 6700 m
  - Depth of 10-12 m
- Liquid Bulk terminal (Suezmax: L x B x D of 320m x 64m x 20m, 180,000-190,000 DWT)
  - Can handle ships up to 330 m in length, 14.1 m draft and 260,000 DWT

Based on the above, Genoa port shall receive **+1 points** above the base rating on this criterion. Genoa can benefit from the platform accommodating larger vessels and providing cargo transfer support towards the hinterland.

4.2.4 Location added value

The new breakwater of the Sampierdarena Basin: The work is the central point of the organization's long-term planning, responding to a fundamental need to adapt the system of maritime access to the Sampierdarena Basin, to the navigability and evolution needs of the larger vessel and to the technical interferences with the take-off and landing procedures at the adjacent airport. (**+1 points**, as the platform could take over larger ships without any further investments in the port).

Completion of the interventions in progress for the upgrading and qualification of the capacity offered by the Genoa-Savona system. Among the most significant infrastructural interventions planned are:

- The project for the supply of electricity to ships via the Voltri port network. The intervention meets the objective of improving the quality of the air and to reduce noise pollution in port areas and in neighbouring areas through the construction of the plants necessary for the power supply of ships from the national electricity grid as envisaged in the program of actions implementing the plan for the rehabilitation and protection of air quality; for the reduction of greenhouse gases; (**-1 points**, a platform of this caliber, however green, would have some negative impact on the environment nearby).
- In the two-year period 2018-2019, work will be carried out to complete the container terminal in Calata Bettolo and Ronco-Canepa. (**-1 points**, work already started and it will be more detrimental to stop and give the functionality to a future platform than to finish as is).
- The realization of the multipurpose platform of Vado Ligure which will determine significant economic-social benefits, strengthen the system of Ligurian ports and completing the available offer with a gateway facility suitable for hosting new generations of ships, of ever-increasing size, in terms of seabed and dock productivity.
  The project involves the construction of a platform of approximately 210,000 m^2, designed to accommodate a container terminal of 700/800,000 TEU, equipped with a straight dock of 700 m in length, with two berths with high draft (one in root at -15 m and one in the head at -22 m). This also includes the construction arrangements for a possible future power supply to ships on the quay (cold ironing).
  Work is under way, with a physical progress of about 45% and the start of the activity of the terminal, on a first operational phase, is expected by the end of 2018. (**-1 points**, see above).

Considering the above, a score of **-2 points** is given regarding a platform added value to this location.

4.2.5 Logistical hotspot proximity

The Port of Genoa in the province of Liguria serves as a transport hub for the Italian industry, including the automotive industry, the agricultural exports and manufacturing sites (e.g., of FMCG). With the Northern Italian enterprises being the major customers for imports and the regional farmers the main exporters, the port stands on stable feet with respect to its customer base.

Being the southern end of the so-called Blue Banana (or Manchester–Milan Axis), the Port of Genoa serves a huge hinterland corridor across Western and Central Europe with a population of around 111 million. Moreover, the Port of Genoa represents the southern end of the TEN-T axis no. 24 between Rotterdam, Netherlands, and Genoa, Italy. Especially, the multimodal use of the transport axis, e.g. with inland vessels and rail, has received increased funding and elevated political support in recent years.
A score of **+1 points** is given for this criterion.

4.2.6 Navigation and routes
The Port of Genova is Italy's largest seaport. Ships from all over the world have it on their routes. All kinds of goods are being handled here. In addition, there are also shipyards as Fincantieri for newbuilding, repair and wrecking. The port has a hinterland connection via rail and road, as there are no suitable rivers for inland shipping.
A score of **+3 points** is given for this criterion.

4.2.7 Energy, Farming & Living potentials
In the Mediterranean Sea around Genova there are aquacultures for mussels and the gilt-head bream.
The average annual wave power around Genova is about 5 to 10 kW/m, the 100-year value / Mean value ratio is about 8 to 10 (see Annex 1 Figure 21 and Figure 22). As there are possibilities for farming and energy, at least service personnel will require accommodation on the island.

4.3 Port of Thessaloniki
4.3.1 General
The Port of Thessaloniki is located at the central-west side of the urban agglomeration of Thessaloniki city, at the northern part of Greece. More precisely, it is located on the inner part of the Bay of Thermaicos, on the northern section of the Eastern Mediterranean Sea. Approach of the ships is accomplished through a natural channel of substantial depth, not needing thus any further deepening.

It is directly connected to the most important national motorway and railway networks, while it is also linked to the road – rail Pan European Corridor X, part of Europe's TEN-T axes. It is settled near the city centre, about 25 km from Thessaloniki's international airport and very close to commercial, agricultural, business and industrial centres of the adjacent areas. Apparently, the port may provide a combination of transport means: road, rail and air transport combined with maritime.

The geographical coverage of the port is international, national and regional in terms of the extent that transport chain affects origin and destination of transport, respectively. The port services 5% of passenger and 95% of freight national maritime flows (ThPA Statistical Data Report, 2011).
A priority of the development plan is the expansion of the port's infrastructure with deeper quays, to provide services to bigger ships carrying containers or conventional cargo.

4.3.2 Cargo
The following table ranks cargo flows (in metric tons) by type, from lowest to highest in the port of Thessaloniki.
For a more detailed description of each cargo type see Annex 1.

Neo + Break Bulk [t]	582,352
Dry Bulk [t]	2,980,562
Unitized [t]	3,458,563
Liquid Bulk [t]	7,078,150
TOTAL [t]	**14,099,627**

Table 8 Port of Thessaloniki cargo flows (2016)

The focus of the port is on Liquid Bulk cargo, which amounts to roughly 50% of all cargo flow in 2016. At the other end, the least transited cargoes were Neo + Break Bulk at around 4% of the total cargo flow.
As per the freight profile, the total tonnage for 2011 was estimated at some 10 million tons including liquid and dry bulk, as well as general cargo (e.g. Ro-Ro) and container traffic (TEUs). The freight traffic is handled in two terminals, one for containers and one for conventional cargo. Especially for container traffic, 46,7% of total TEUs flow represents exports from Greece to several other countries. Also, 42,4% reflects imports of cargo and about

10,8% is associated with transit flows. As per multimodality, 94,8% of total TEUs is transported via road-maritime routes and the rest (5,1%) via rail maritime.

The Port of Thessaloniki's Container Terminal, located in the western part of Pier 6, is 550 meters long and 340 meters wide with alongside depth of 12 meters. Part of the Free Zone, the Container Terminal covers about 254 thousand square meters and has capacity for on-site storage of 4.7 thousand TEUs and for 336 plugs for reefer containers. The Port of Thessaloniki's Container Terminal is equipped with state-of-the-art technologies and modern container-handling equipment. Further, the terminal is linked to the nation's rail networks by a double-track railway. The terminal is also equipped with a high-tech management information system supporting excellent real-time services.

Conventional cargo is handled in the Terrestrial Zone of Thessaloniki's port in an area extending on a total surface of approximately 1,000,000 m² with quay length of 4,000m and depth up to 12m. It handles:

- Community cargo from/to EU member states and
- Community/domestic cargo from/to Greek harbours.
- General Cargo (steelwork products, metal sheets, timber, marble, pallet cargo, tobacco, fruits, etc.)
- Solid Bulk Cargo (minerals, ores, coal, solid fuel, cereals, feed stuffs, fertilizers, cement, scrap)
- Liquid Bulk Cargo with pipelines (spirits, chloroform, asphalt, chemicals, mineral oils, wine)
- Ro-Ro vehicles

The conventional cargo handling equipment consists of:

- 44 rail-mounted power-driven cranes, with a lifting capacity of 40 tons.
- Two Gottwald HMK 260 EG mobile harbour crane, with a lifting capacity of 100 tons
- Two mobile cranes, with a lifting capacity of 120 and 150 tons respectively
- Numerous other cargo-handling equipment (derricks, forklifts, platforms etc.)

The port also has installations suitable for liquid fuel storage and is in proximity to the international, natural-gas pipeline.

Storage facilities at the Port of Thessaloniki offer the following:

- 85,000 m^2 of warehouses
- 12,000 m^2 of sheds
- 500,000 m^2 of outdoor storage
- Silos with capacity for 20,000 tons

The port plans on expanding its container and dry bulk terminals (see details on the next page) and because of this it receives a cargo criterion score of **+2 points** from the base rating considering these two developments could be taken over by the platform.

4.3.3 Ship types

The port of Thessaloniki can be reached by ships up to Post-Panamax Size:

- Container terminals
  - Total quay length of approx. 550 m
  - Depth of 12 m
- Bulk Cargo terminals
  - Total quay length of approx. 4000 m
  - Depth of 12 m

The Container Terminal can berth ships with a draught of 12 m and has an on-site storage capacity of 5,000 TEUs in ground slots. Four cranes can load/unload two Post-Panamax ships at a time.
Based on the above, Thessaloniki shall receive **+2 points** more than the base rating on this criterion. Thessaloniki can benefit from the platform accommodating medium to large vessels.

4.3.4 Location added value

The French group CMA CGM has announced plans to restore the historic role of Thessaloniki, not only as the second largest port in Greece but as the most important port in South-eastern Europe. Apart from smaller investment for immediate improvement of processes, larger investment for a strategic re-alignment of the port are also currently under planning. This announcement is closely linked to the ongoing transformation process as part of which more and more ports are connected to the Chinese "One Belt One Road" initiative and, thus, increase the dynamism in the region.

Container Terminal Expansion: The project consists of the expansion of the quay No 26 of the Container Terminal of the Pier No 6 to acquire deeper berths to serve the envisaged cargo volumes (the container terminal is planned of being expanded by 36 ha). The project includes:

- Marine works concerning the longitudinal extension of the Quay No 26 by 650m (including land reclamation and backfilling)
- Pavements and drainage works for the new Terminal yards and the existing areas of the Container Terminal
- Electromechanical installations (high voltage, area lighting, network supply of gantry cranes, low voltage installations, etc.)
- General dredging to -16.5m (Mean Sea Level - MSL)
- New building works (service offices, fuel station, security control)

Construction of Dry Bulk Terminal: The project consists of the expansion of the quay No 24, which constitutes the eastern part of Pier 6, to acquire deeper berths to serve the envisaged dry bulk cargo volumes. The project includes:

- Marine works concerning the longitudinal extension of the Quay No 24 by 350 m (including land reclamation and backfilling)
- Pavements and drainage works for the new land areas and the existing areas of Quay No 24
- Electromechanical installations (high voltage, area lighting, network supply of cranes, low voltage installations, etc.)
- General dredging to -16.5 m (Mean Sea Level - MSL)
- New building works (terminal gate complex; fertilizer, cement and clinker warehouse)

These two expansions have been considered in the cargo criterion and therefore **the base rating here shall remain unchanged**.

4.3.5 Logistical hotspot proximity

Being the second largest port of Greece, the port of Thessaloniki serves as a major gateway for the Balkan hinterland and Southeast Europe. In addition, the port is major transshipment hub in the Aegean-Black Sea area bas it is used by other Balkan countries like Serbia, Montenegro, Macedonia (FYR), and Albania.

In prospect of the upcoming global developments around new transport routes like "One Belt, One Road", in which the so-called "21st Century Maritime Silk Road" is particularly important to Greece, Thessaloniki is one of the preferred locations to enter the European Union with extra-European cargo from the East. Just like other Greek and Black Sea ports, the Port of Thessaloniki may become a so-called "bridge to Europe" and a faster way to reach many destinations in Central and Eastern Europe with a lower number of handlings.

It is located 1km from the Passenger Railway Station and 16km from the city's International Airport.
Considering the above, the port of Thessaloniki receives **+2 points** above the base rating for this criterion.

4.3.6 Navigation and routes

The hinterland connection of the container terminal is a double track railway to the national railway networks.
Almost all shipping lines such as MSC, Maersk, Evergreen, COSCO, CMA CGM, ARKAS, ZIM, Hapag Lloyd, and others have the port of Thessaloniki on their routes.

The main customers of the conventional cargo terminal are Feni (mainly transports nickel ore and solid fuel), AEE Chalivos (transports mainly iron and steel products), Sidenor.

Considering the locations hinterland connections and future development prospects (see chapter above), Thessaloniki receives a score of **+1 points**.

4.3.7 Energy, Farming & Living potentials
In the Mediterranean Sea, the farming of the gilt-head bream (Sparus aurata) is quite common. Also, other species as the tuna (Thunnus alalunga) are being kept in aqua cultures.

The average annual wave power around Thessaloniki is lower than kW/m; the 100-year value / Mean Value Ratio lies between 10 to 12 (see Annex 1 Figure 21 and Figure 22).

As there are possibilities for farming and energy, at least service personnel will require accommodation on the island.

4.4 Port of Hamburg

4.4.1 General
Port of Hamburg, the largest seaport in Germany, lies between the North Sea and the Baltic Sea. It is the second biggest container port in Europe and the 11th biggest in the world. Spread over 7,250ha, it is an important port for cargo transport between Central and Eastern Europe. It can be accessed from the North Sea through the Elbe River.
The Port of Hamburg is a universal port capable of handling all kinds of goods. It offers a range of services for handling cargo, customs clearance, quality control, storage and packing or distribution. A total of 320 berths are available at the port.

4.4.2 Cargo
The following table ranks cargo flows (in metric tons) by type, from lowest to highest in the port of Hamburg. For a more detailed description of each cargo type see Annex 1.

Neo + Break Bulk [t]	10,200,000
Liquid Bulk [t]	14,200,000
Dry Bulk [t]	22,000,000
Unitized [t]	91,700,000
TOTAL [t]	138,100,000

Table 9 Port of Hamburg cargo flows (2016)

The focus of the port is on Container cargo, which amounts to roughly 70% of all cargo flow in 2016. At the other end, the least transited cargoes were Neo + Break Bulk at around 7% of the total cargo flow. Around 9,000 ship calls per year, almost 300 berths and a total of 43 kilometres of quay for seagoing vessels, more than 2,300 freight trains per week, four state-of-the-art container terminals, three cruise terminals and around 50 facilities specialized in handling roro and breakbulk and all kinds of bulk cargoes, along with about 7,300 logistics companies within the city limits - these are just a few of the factors making the Port of Hamburg to one of the world's most flexible, high-performance universal ports. 136.5 million tons of cargo crossed the quay walls of Germany's largest seaport in 2017. That included around 8.8 million standard containers (TEU). Hamburg is accordingly the third largest container port in Europe and in the 18th place on the list of the world's largest container ports.

Storage facilities (a total of 7.4 million m^2 of hard-surface terminal areas) at the Port of Hamburg:
- 2,800,000 m^2 of covered storage
- 150,000 m^2 of air-conditioned covered storage

- 350,000 m^2 in inland customs territory
- Silos with capacity for 700,000 tons
- 2,200,000 m^3 liquid cargoes
- 3,600,000 m^3 refined liquid cargoes

The port plans on expanding its container terminal (see below Ch.0) and because of this it receives a cargo criterion score of **+1 points** from the base rating considering this development could be taken over by the platform.

4.4.3 Ship types

There are about 320 berths and 41 kilometres of quays in the Port of Hamburg. Of these, some 199 berths handle general and bulk cargo. There are 83 berths for coastal shipping, 145 berths at dolphins, and 38 berths reserved for container and bulk cargo vessels. Alongside depths at the berths in the Port of Hamburg range from 7 to 17 meters. Within the Port of Hamburg are 55 landing facilities, 177 bridges, 170 kilometres of roads, and 350 kilometres of rail tracks.

While the Port of Hamburg is about 100 kilometres from the North Sea on the River Elbe, it can accommodate the world's biggest bulk carriers and container ships.

Ships of the following dimensions (L x B x T) have access to the port of Hamburg:

Container (Post-Panamax):	400 m x 52 m x 16 m
Multipurpose / Ro-Ro:	275 m x 50 m x 13m
Passengers:	350 m x (T)13 m
Bulk (Post-Panamax):	390 m x 45 m x 15 m

Based on the above, Hamburg port shall receive **-2 points** more than the base rating on this criterion. Hamburg is well suited to accommodate a wide range of ship types and sizes and thus would have little or no benefit from a logistical platform regarding this criterion.

4.4.4 Location added value

The port of Hamburg has the following developments planned or underway:

- Capacity of the Eurogate Container Terminal Hamburg is to be extended towards Bubenday Ufer. The expansion will enable the terminal to handle six million TEUs per annum. Construction is scheduled to be carried out between 2015 and 2019 (**0 points**).
- Area of the Container Terminal Tollerort will be expanded and two additional berths will be constructed in future (**0 points**).
- A new terminal is also being planned for cruise liners (**+1 points**).

To enable the Port of Hamburg to achieve the forecasted handling potential, sufficient capacities must be available. Due to spatial restrictions, the Senate of Hamburg and the port industry assigned priority to the subsequent areas of action:

- Upgrading existing infrastructure and superstructure
- Increasing productivity at the terminals
- Restructuring areas in the port (port expansion to the inside) (**+1 points**, a floating platform covering this future need would prove very beneficial)
- Developing further site potentials (**+1 points**, further development could be taken over by the presence of the platform).

According to the Association of Hamburg Port Operators the existing capacities and capacity expansions will be sufficient to cope with predicted cargo volumes between now and 2025. Additional berths for large ships can be built in the Steinwerder area. Further capacities will be available in the port expansion area in the long term (**+1 points**).

The approval of the River Elbe channel deepening will ensure that the Port of Hamburg will increase its market share in the large-ship size segments, or prevent the loss of it, and thus maintain its position as a shipping hub for

traffic from and to Asia, Hamburg's most important overseas container trade area, representing over half of the total cargo volumes handled. (**-1 points**, it is considered the approval means the physical work would start soon and the prospect of a future platform is out of question as this would hinder both operations and economical aspects of the region).

Another major development area of the Port of Hamburg is the so-called smartPORT scheme - a project which consists of an energy wing and a logistics wing. The projects aim is turning the Port of Hamburg into a logistics hub with smart energy consumption with less emissions and a lower carbon footprint as well as intelligent operations in terms of flows of cargo, traffic and infrastructure by means of a so-called intermodal Port Traffic Center (**+1 points**).

Considering the above, the port of Hamburg receives **+4 points** above the base rating for this criterion.

4.4.5 Logistical hotspot proximity

Hamburg is the entry gate to Germany, the largest economy of the European Union and the fourth largest of the entire world. The port constantly belongs to the top three (3) seaports of Europe and connects to all parts of the world, especially China. Hamburg is also one of the world's 20 largest and busiest ports.

With its dense network of around 120 worldwide liner services, the Port of Hamburg performs an essential role for the foreign trade of Germany and the neighboring countries of Europe. The large majority of 1,000 seaports worldwide are served directly from Hamburg. Others are served indirectly per transshipment.

In addition, the Port of Hamburg has a strong focus on the countries neighboring the Baltic Sea as well, (North)-Eastern Europe and the Russian Federation. Extensive road connections as well and multimodal offers with more than 1,300 freight trains per week and the position as Germany's second biggest inland port add to the picture.

Considering the above, a rating of **+5 points** is given for this criterion.

4.4.6 Navigation and routes

The Port of Hamburg's well-developed hinterland network ensures excellent links to Europe and makes Hamburg a very attractive hub for many companies. Hamburg meets the growing cargo handling volumes and the ever-increasing demands on the environment with well-developed infrastructure for rail, inland-waterway vessels and trucks as well as with environmentally-friendly port management. In 2015 a total of around 100.9 million tons was handled in hinterland services of the Port of Hamburg. Approx. 45% of the goods were transported by rail, 12% by inland-waterway vessel, and 43% by truck. For the first-time rail has been the most important mode of transport, ahead of trucking.

Navigation to/from the port of Hamburg is extensive and developed and thus it receives a score of **+4 points** for this criterion.

4.4.7 Energy, Farming & Living potentials

There are aquacultures for mussels in the area around Hamburg. Other aquaculture is in the biosphere conservation area "Nationalpark Hamburgisches Wattenmeer" not possible.

The average annual wave power around Hamburg is about 10 to 15 kW/m; the 100-year Value / Mean Value Ratio is between 6 and 7 (see Annex 1 Figure 21 and Figure 22).

As there are possibilities for farming and energy, at least service personnel will require accommodation on the island. Additionally, the urban area Hamburg is constantly growing; so, in the far future there might also Living@Sea for other people than service personnel be possible.

4.5 Port of Amsterdam

4.5.1 General

The Amsterdam port region is one of the world's most important logistics hubs. With more than 97 million tonnes of cargo transhipment per year, it belongs to the five largest seaports of Western Europe's. The strategic and central location in Europe makes the port easy to access and ensures excellent connections with all major European markets.

4.5.2 Cargo

The following table ranks cargo flows (in metric tons) by type, from lowest to highest in the port of Amsterdam. For a more detailed description of each cargo type see Annex 1.

Unitized [t]	600,000
Dry Bulk [t]	8,700,000
Neo + Break Bulk [t]	27,300,000
Liquid Bulk [t]	42,600,000
TOTAL [t]	79,200,000

Table 10 Port of Amsterdam cargo flows (2016)

The focus of the port is on Liquid Bulk cargo, which amounts to roughly 55% of all cargo flow in 2016. At the other end, the least transited cargoes were Containers at around 1% of the total cargo flow.

The port receives a cargo criterion score of **0 points** from the base rating.

4.5.3 Ship types

The Port of Amsterdam's North Sea Canal facilities at Ijmuiden contain a total 7.2 kilometers of quays and alongside depths varying from 6.5 to 16.5 meters and can accommodate ships up to Panamax (L x B x T of 294m x 32.3m x 12.5m; 60,000-75,000 DWT). The 31 quays in the Amsterdam Harbor total over 25 kilometers in length and have depths varying from 4 to 15 meters.

Passenger Terminal Amsterdam has 600 meters of quays with alongside depth of 10.5 meters, and vessels can moor both port and starboard. There is room for ships of up to 330 meters to turn in the terminal, and the port has moveable gangways that adjust in height from 2.1 to 11.7 meters.

The Felison Terminal is located at the Port of Amsterdam's North Sea Canal entrance. Built to resemble a ship, the terminal offers open-water berths that are ideal for cruise ships and ferries. The quay is 235 meters long with alongside depth of 8.5 meters, suitable for larger cruise ships and ferries. With capacity for 1500 passengers at a time.

Additionally, the finalization in 2019 of the biggest sea-lock in the world (500 meters long, 70 meters wide and 18 meters deep), would accommodate the biggest ships (L x B x T of 475m x 65m x 14m).

Considering the above, the port receives a criterion score of **-2 points** from the base rating as there would be no added benefit for this criterion. Amsterdam port can currently accommodate and handle the largest ships.

4.5.4 Location added value

The Port of The Future: In 2030, the Amsterdam port region will be a dynamic metropolitan port that combines the strengths of the port, city and the region. Optimally linking these cores creates cross-pollination, synergy and innovation. We are developing a port that offers increasing added value for its customers and the surrounding area. A world-class business climate, development and innovation, jobs and revenues, quality of life and circularity are key concepts in this regard. We believe that the access the port offers can always be quicker, smarter and cleaner.

This will enable the port to continue to be a place where cooperation constitutes the driving force for innovation in the twenty-first century (**-1 points**, the presence of the platform could interfere with current development plans and have both negative impact on social and economic aspects).

Upscaling of sustainable energy: The aim is to play an active role in the energy transition by increasing the capacity to generate and store sustainable energy. (**+1 points**, transfer future developments to the platform).

Averijhaven: To pass through the sea lock, vessels must be positioned no deeper than 13.75 metres. The port of Amsterdam wants to introduce a quay and mooring on the seaward side of the locks at IJmuiden where sea-going vessels can lighter their bulk cargo. The large vessels will then be positioned higher in the water and will be able to proceed through the lock to Amsterdam. The quay will also enable a better service to the offshore 'wind' and 'oil/gas' sector, helping to diversify port activities. (**-1 points**, this is currently close to finishing and therefore no added value from the platform is expected).

"Biobased" and circular economy: The supply of fossil fuel is finite. The goal of the Amsterdam port is to allocate 25 hectares of land in the port to new biobased and circular activities by 2020. (**+1 points**, reduce inland expansion by the platform presence).

Plug & play plots: The construction of 'plug & play' plots and quays allows customers to set up business quickly and immediately commence their activities. This project, aimed at customers that do not require a long-term environmental permit, is designed to intensify utilization of the available space in the port area. The first two 'turn-key' plots were made available in 2016. (**+1 points**, intensification of port activities could be redirected to the platform to beneficial impact on social aspects).

Sea Lock: A new large sea lock is being constructed at the entrance of the North Sea Canal at IJmuiden that will provide access to the Amsterdam port region. The new lock will be 500 metres long, 70 metres wide and 18 metres deep, making it the world's largest sea lock. Construction began in January 2016 and the new lock will be available for shipping at the end of 2019. From then on, the port of Amsterdam will be accessible 24 hours a day (**0 points**, it was considered for ship types above).

Considering the above, and considering as of 2019, the development of new wind farms adjacent to the Amsterdam-IJmuiden offshore region for this criterion, Amsterdam port receives a maximum of **+2 points** above the base rating for this criterion.

4.5.5 Logistical hotspot proximity

The Port of Amsterdam is the second largest port in the Netherlands and focuses strongly on bulk cargo. Therefore, the hinterland of the Port of Amsterdam is the same as for Rotterdam, Antwerp, and Zeebrugge, i.e., the Blue Banana area with its 111 million inhabitants. The Port of Amsterdam is one of Europe's most important junctions for multi-modal transportation. With 85 million tons of transshipments per year, the Port of Amsterdam handles all kinds of cargoes, including dry and liquid bulk, general cargo, and containers. The Port of Amsterdam offers excellent connections with inland waterway, rail, and road networks.

More than 33% of the goods moving through the Port of Amsterdam are carried by inland shippers. Its proximity to the River Rhine gives the Port of Amsterdam access to the industrial and consumer markets in the Netherlands, Austria, German, and Switzerland. Coastal, or short-sea, transport is growing in popularity, and the Port of Amsterdam has long had strong maritime connections with Scandinavia, Russia, Great Britain, and Baltic Sea ports. The tideless Port of Amsterdam serves intercontinental shippers as well. Large ocean-going vessels can reach the port in less than three hours (from the North Sea to the docks), and the terminals can accommodate ships with as much as 13.7 meters of draft.

The increasing volume of dry bulk cargoes handled in the Port of Amsterdam includes biomass coal, agricultural bulk, sand and gravel, and granite. The Port of Amsterdam also handles liquid bulk cargoes that include oil products, special chemicals, and biofuels.

From the above and considering Annex 0, Amsterdam port receives **+5 points** above the base rating for this criterion.

4.5.6 Navigation and routes

The Port of Amsterdam has rail connections to the major rail networks in Europe, and it has its own marshalling yards with connections to main lines. The International Amsterdam Airport, Schiphol, serves over 240 international destinations, and it is just 20 minutes from the Port of Amsterdam. The port is located on the A10 and A9 motorways and, through these, directly to Europe's international highway network. The Port of Amsterdam is working with Schiphol to develop an area for logistics service providers, Atlaspark. The park will be located centrally for the convenience of companies needing five or more hectares that transport goods by both water and air. Therefore, these companies can more easily coordinate their cargo assembly and handling activities for greater efficiency and cost savings.

The port of Amsterdam can handle all types of goods. About 45% of all maritime transport is short sea shipping (see Ref.[30]). There are several projects with other ports such as Fujairah, Hong Kong, Côte d'Ivoire, Aruba, Bonaire and Galveston (USA).

Berth	**Maximum water depth [m]**	**Maximum operational breadth [m]**	**Maximum operational length [m]**	**Goods**
Afrikahaven	15.50	66	300	Oil products, Chemical products, Coal
Amerikahaven Buoy 2	14.65	-	185 or less	Oil, chemicals, scrap metal, building materials and containers
Averijhaven	19.50	45	310	Dry Bulk
Coenhaven	10.50	-	-	Building materials, scrap metal, oil and chemicals
Franse Boeien	7.00	-	195	
Hornhaven Buoy 2	15.50	33 (53 with exemption)	230	Oil and chemicals, food, building materials and scrap
Mercuriushaven Buoy 1	15,50	260	-	Oil and chemicals, building materials, scrap, food and wood
Mercuriushaven Buoy 5	14.65	-	-	
Mercuriushaven, Houtveemkade	11.50	-	-	
Neptunushaven, Quay	10.50	-	-	
Vlothaven kade paal 14-37	12.50	25	-	
Vlothaven Buoy 6	15.50	42	260	
Suezhaven Ferry 3	-	33	165 (188 with permit)	Ro-Ro

Table 11 Port of Amsterdam Berths

Considering both aspect of logistics and ease of transport to/from Amsterdam, this criterion receives a score of **+5 points**.

4.5.7 Energy, Farming & Living potentials

There are aquacultures for mussels in the area around Amsterdam. The average annual wave power around Amsterdam is about 5 to 10 kW/m; the 100-year Value / Mean Value Ratio is between 5 and 6 (see Annex 1,

Figure 21 and Figure 22).

As there are possibilities for farming and energy, at least service personnel will require accommodation on the island. As in all Benelux countries the space for living is short; therefore, a potential for Living@Sea in the future can be seen here.

4.6 Port of Antwerp

4.6.1 General

Thanks to its location 80 kilometres inland within Europe, Antwerp offers the fastest and most sustainable connection with the European hinterland. The volume of freight loaded or unloaded in Antwerp has doubled over the past 20 years to more than 214 million tonnes. This makes Antwerp by far the largest port in Belgium and the second-largest port in Europe.

4.6.2 Cargo

The following table ranks cargo flows (in metric tons) by type, from lowest to highest in the port of Antwerp. For a more detailed description of each cargo type see Annex 1.

Dry Bulk [t]	12,641,954
Neo + Break Bulk [t]	14,372,980
Liquid Bulk [t]	69,242,417
Unitized [t]	117,909,607
TOTAL [t]	**214,166,958**

Table 12 Port of Antwerp cargo flows (2016)

The focus of the port is on Container cargo, which amounts to roughly 55% of all cargo flow in 2016. At the other end, the least transited cargoes were Dry Bulk at around 6% of the total cargo flow. The following table shows the unloading and unloading in million tonnes from destinations all over the world.

DESTINATION	UNLOADING	LOADING
Europe	48.2	29.1
Middle and Far East	16.6	18.4
North and Central America	16.2	16.5
Near East	12.2	15.9
Africa	8.1	17.4
South America	8.3	5.6
Pacific region	0.8	0.8

Table 13 Port of Antwerp worldwide cargo flows (loading/unloading)

The ports focus has and will remain Unitized cargo as further development plans are prioritizing this over all other cargo types. Therefore, the port receives a cargo criterion score of **+1 points** from the base rating.

4.6.3 Ship types

For the port of Antwerp, the only restricting factor is the tide. At high tide ships with a draught up to 16m and a length of 360 m and above can reach to port. The maximum ship sizes dependent on the tide can be seen in the following picture.

IMPROVED SEA ACCESS: TIDE-DEPENDENT
(greater draughts and wider tide windows)

LOA	< 340 m	340 m – 360 m
Before the deepening		
Incoming	15.56 m	14 m
Outgoing	14.80 m	14 m
After the deepening		
Incoming	16 m	16 m
Outgoing	15.20 m	14.50 m

> 360 m upon approval trial voyages (check out www.vts-scheldt.net)

TIDE-INDEPENDENT

Before the deepening
11.80 m
After the deepening
13.10 m

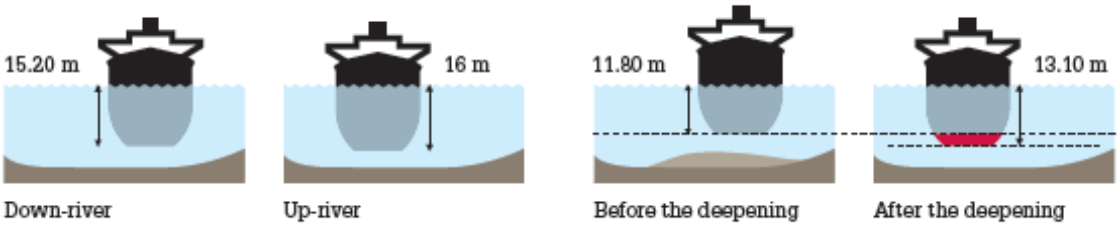

Figure 7 Port of Antwerp tide restrictions

To allow access to the port to the biggest container vessels, the Scheldt was deepened in 2010. Thanks to this deepening, Ultra Large Container Ships (ULCS) now also have access to the port of Antwerp. They can safely call at the port and utilize their full cargo capacity. The number of 10,000 + TEU vessels calling the port of Antwerp in 2015 amounted to 370 units. This number increases every year.

A score of **-2 points** is given for this criterion as there would be no major benefit of a platform regarding ship types.

4.6.4 Location added value

Because of the deepening of the navigation channel in the Western Scheldt it is now possible for ships to sail upriver with a maximum draught of 16.0 metres and downriver with a maximum of 15.2 metres. (**-1 points**)

The need for additional container capacity has been recognised by the Flemish government, and the Port Authority also considers it necessary for the Antwerp port area to have additional container capacity by 2022. As of 19 April 2017, there are eight alternatives on the table, three of which include a Saeftinghe dock.

The main concerns for the near future are providing room for further growth of the port and ensuring the necessary additional container handling capacity. (**+1 points**, if growth trend continues, a platform can take over all developments).

Deurganck dock lock: To meet the demands of constantly larger ships the Port of Antwerp is working on different projects. In 2011, construction started on a second sea lock on the Left bank. The lock will be as wide and long as the Berendrecht lock on the Right bank, but it will be deeper. It will be the biggest sea lock in the world with a length of 500 m, a width of 68 m and a depth of 17.80 m.

Considering the above, this criterion receives **no added score**.

4.6.5 Logistical hotspot proximity

The Port of Antwerp boasts the best logistical services among European seaports. Many multi-national companies have established depots within the Port of Antwerp and carry out their distribution activities from there. The Port of Antwerp offers many companies that support cargo distribution with services that include preassembly, stock control, labelling, after-sales service, quality control, and maintenance. Port of Antwerp freight handlers also provide sophisticated electronic tracking systems to assure efficient logistics chain management.

The Port of Antwerp is a gateway to the European continent. For international freight shipping, the Port of Antwerp is the second busiest port in Europe and the tenth busiest in the in the world. Located centrally in northwest Europe, the Port of Antwerp is ideally situated with connections with Europe's major industrial centres and consumer markets. Just as for the other ZARA ports, the Port of Antwerp serves the Blue Banana region and has built strong ties with several partners, above all with Port of Duisburg, the largest inland port of the world.

For cargo going to overseas destinations, the Port of Antwerp's major trading partners were the United States, Turkey, United Kingdom, and Russia. In addition, the Port of Antwerp is home to over 200 freight forwarding companies. Many stevedoring companies serve almost 15 thousand ocean-going vessels and 57 thousand barges each year. The Port of Antwerp offers 160 kilometres (258 miles) of quays and more than 5.4 million square meters (1.3 thousand acres) of covered storage space. In fact, the Port of Antwerp has more covered storage than all other ports in northwest Europe combined.

Therefore, a maximum score of **+5 points** is given for this criterion.

4.6.6 Navigation and routes

The Port of Antwerp is one of the most important ports in Western Europe. Therefore, ships from all over the world have this port on their routes. In addition, there is a good hinterland connection via rail, road, pipeline and IWT.

Considering both aspect of logistics and ease of transport to/from Amsterdam, this criterion receives a score of **+5 points**.

4.6.7 Energy, Farming & Living potentials

The average annual wave power around Antwerp is about 5 to 10 kW/m; the 100-year Value / Mean Value Ratio is between 5 and 6 (see Annex 1,

Figure 21 and Figure 22).

In the area there is also a possibility to have mussels in Farming@Sea. As there are possibilities for farming and energy, at least service personnel will require accommodation on the island. As in all Benelux countries the space for living is short; therefore, a potential for Living@Sea in the future can be seen here.

5 Result of Multi Criteria Analysis

5.1 Summary

Below is a summary table for the viability (with focus on the transport and logistics aspect) of the locations selected and analysed in Ch. 4 for accommodating a floating island. A high score reflects how a specific location/port benefits from the presence of a Transport&Logistics hub nearby. A low score means that the location has little or no added benefit from such a floating hub.

Criteria	Weight factors	Port of Constantza	Port of Genova	Port of Thessaloniki	Port of Hamburg	Port of Amsterdam	Port of Antwerp	Top Port / Criterion
Cargoes	3.0	(5) – 1	(5) – 1	(5) + 2	(5) + 1	(5) + 0	(5) + 1	Port of Thessaloniki
Ship types	3.0	(5) + 1	(5) + 1	(5) + 2	(5) – 2	(5) – 2	(5) – 2	Port of Thessaloniki
Added value to location	2.0	(5) + 5	(5) – 2	(5) + 0	(5) + 4	(5) + 2	(5) + 0	Port of Constantza
Logistical hotspot	1.0	(5) – 3	(5) + 1	(5) + 2	(5) + 5	(5) + 5	(5) + 5	Port of Hamburg/ Amsterdam/Antwerp
Navigation & routes	1.0	(5) + 2	(5) + 3	(5) + 1	(5) + 4	(5) + 5	(5) + 5	Port of Amsterdam/Antwerp
Total score	10.0	59	50	65	64	58	57	Port of Thessaloniki/ Amsterdam/Antwerp

Table 14 Port Viability Summary

The MCA analysis shows the following locations could benefit the most from the presence of a Transport& Logistics hub:

- **Thessaloniki** is the most suitable location overall, benefiting about most of the criteria.
- Regarding **cargo** the top location is **Thessaloniki**
- Regarding **ships** the top location is **Thessaloniki**
- Regarding **added value** the top location is **Constantza**
- Regarding **logistics** the top locations are **Hamburg**, **Amsterdam** and **Antwerp**
- Regarding **navigation and routes** the top locations are **Amsterdam** and **Antwerp**

5.2 Conclusions

Although Thessaloniki resulted in being the best choice overall, there are some considerations to be accounted for:

- For this analysis, each location was taken as a separate entity. Of note is that the North Sea locations are very close together and therefore one platform could facilitate all at once.
- Energy, Farming and Living aspects, if integrated in the Transport&Logistics hub, could have a significant impact on the location selection. For a brief description of these see Annex 2.
- Other boundaries/limitations were not accounted for, e.g. Metocean data at each location, social and political boundaries, etc.

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[32] "European Short Sea Fleet Renewal: Opportunities for shipowners and shipyards" - N. Wijnolst und F. Waals
[33] "Customer growth strategies: Europe's most desirable logistics locations"; available: https://www.prologis.com/sites/corporate/files/documents/2017/10/prologis-research_europes-most-desirable-logistics-locations.pdf

Annex 1 Transport&Logistics criteria detailed description

General

Maritime transport can be defined the transport of people (passengers) or goods (cargo) by water. Sea transport routes play an important role in maritime transport and many "shortcuts" have been provided to facilitate faster and safer trading routes over the years.

An integral part of maritime transport is represented by port facilities, which take and distribute the cargo and/or passengers.

The Transport&Logistics@Sea hub aims to simulate port facilities and shall cater to the following aspects:

- Fulfil the needs of the beneficiaries, which lack desired quality of service:
  - Insufficient depth of water
  - Berth waiting time due to lack of quay space
  - Lack of storage space
  - Outdated or insufficient mechanical equipment
  - Poor interface to inland waterway transport
- Fulfil the requirements of the other functions
  - O&M services for the Energyhub@Sea
  - Handling equipment for Farming@Sea
  - Living@Sea

Port services description

A port is a facility for receiving ships and transferring cargo. They are usually situated at the edge of an ocean, sea, river, or lake. Ports often have cargo handling equipment such as cranes (operated by longshoremen) and forklifts for use in loading/unloading of ships, which may be provided by private interests or public bodies. Often, canneries or other processing facilities will be located nearby. Harbour pilots and tugboats are often used to manoeuvre large ships in tight quarters as they approach and leave the docks. Ports which handle international traffic have customs facilities.

Ports and harbours conduct four important functions:

- Administrative: ensuring the legal, socio-political and economic interests of the state and international maritime authorities are protected
- Development: ports are major promoters and instigators of a country's or wider regional economy
- Industrial: major industries process the goods imported or exported in a port
- Commercial: ports are international trade junction points where various modes of transport interchange; loading, discharging, transit of goods

Cargo

Regarding cargo, each location shall be analysed considering the following:

- Transited cargo types / year
- Cargo operation capacity / year
- Cargo storage and/or handling/transfer capabilities

Categories

Marine cargo can be divided into two major categories Packed (General Cargo) and Unpacked (Bulk Cargo), see Figure 8.

Break bulk

Break bulk cargo is typically material stacked on pallets and lifted into and out of the hold of a vessel by cranes on the dock or aboard the ship itself. The volume of break bulk cargo has declined dramatically worldwide as containerization has grown. One way to secure break bulk and freight in intermodal containers is by using Dunnage bags.

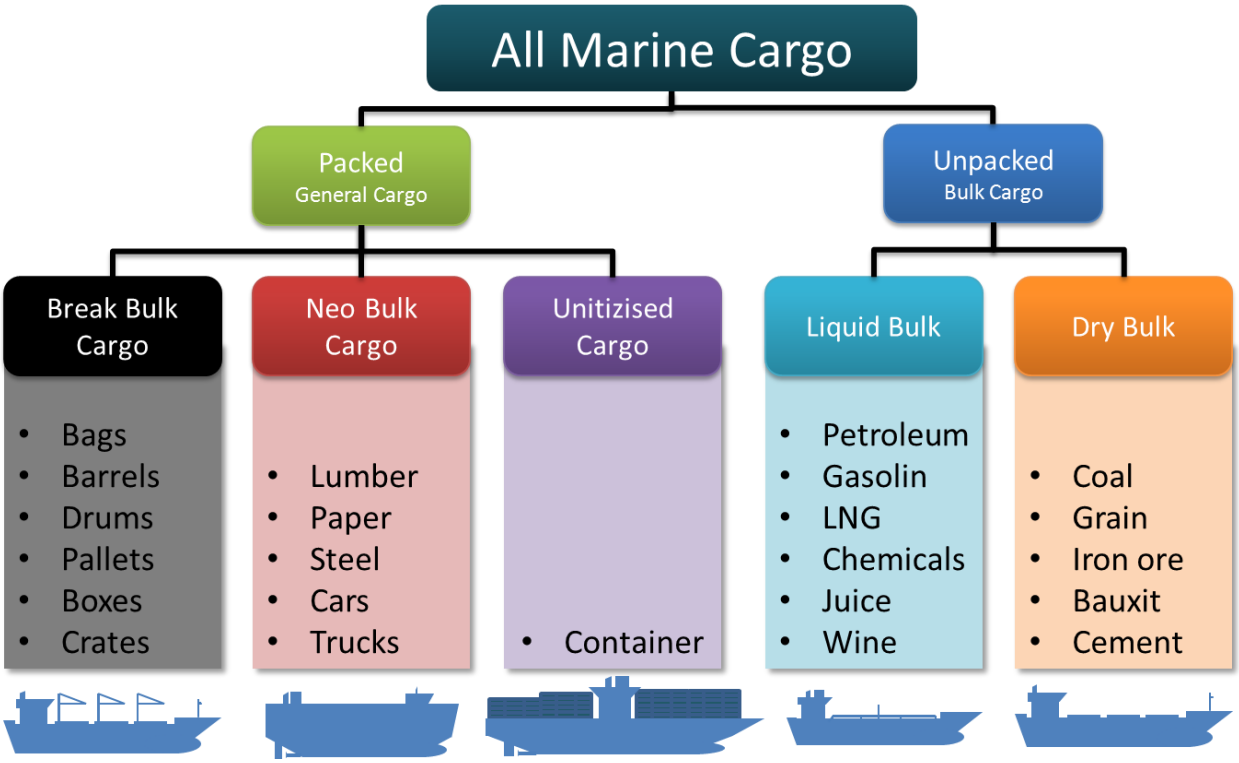


Figure 8 Marine Cargo Overview [Ref. http://www.shippipedia.com/wp-content/uploads/2010/09/Cargo1.png]

Neo-bulk

Neo-bulk cargo comprises individual units that are counted as they are loaded and unloaded, in contrast to bulk cargo that is not counted, but that are not containerized. Automobiles are handled at many ports and are usually carried on specialized roll-on/roll-off ships.

- Ro-Ro mobile units
  - Mobile self-propelled units: road goods vehicles and accompanying trailers, passenger cars, motorcycles and accompanying trailers/caravans, passenger buses, trade vehicles (including import/export motor vehicles), live animals on the hoof, 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, shipborne port-to-port trailers and shipborne barges engaged in goods transport, other mobile non-self-propelled units
- Other cargo: forestry products, iron and steel products, paper, other general cargo.

Unitized

Unitized cargo is typically cargo that is packed in containers. Containers are the largest and fastest growing cargo category at most ports worldwide. Containerized cargo includes everything from auto parts, machinery and manufacturing components to shoes and toys to frozen meat and seafood.

- Large containers
  - 20 ft. freight units (tare weight: 2 t, cargo weight: 22 t)
  - 20 ft. reefer containers (tare weight: 3-4 t, cargo weight: 23-24 t)
  - 40 ft. freight units (tare weight: 4 t, cargo weight: 26.5 t)
  - freight units > 20 ft. and < 40 ft.
  - freight units > 40 ft. (40 ft. Hi-Cube container: 4.2 t tare weight, 26.3 t cargo weight)

    * The category "large containers" includes containers having a length of 20 feet or more. Smaller containers are included in the category "other cargo". As a rule, the container figures are limited to lift-on lift-off containers (Lo-Lo).

Liquid bulk
Liquid bulk is typically liquefied gas, crude oil, oil products, other liquid bulk goods.

- Density ranges for liquid bulk
  - Liquefied gas: from 0.32 t/m^3 up to 0. 46 t/m^3 (LNG); from 0.52 t/m^3 up to 0.58 t/m^3
  - Crude oil: from 0.8 t/m^3 up to 0.97 t/m^3
  - Oil products: from 0.7 t/m^3(aviation gasolines) up to 0.95-1 t/m^3 (lubricating oil)
  -

Dry bulk
Dry bulk is typically ores, coal, agricultural products (e.g. grain, soya, tapioca), other dry bulk goods.

- Density ranges for dry bulk
  - Grain: from 0.6 up to 0.8 t/m^3
  - Ore: from 0.6 up to 3.0 t/m^3
  -

Other useful definitions

- Bulk cargo, such as salt, oil, tallow, and scrap metal, is usually defined as commodities that are neither on pallets nor in containers. Bulk cargoes are not handled as individual pieces, the way heavy-lift and project cargoes are. Alumina, grain, gypsum, logs, and wood chips, for instance, are bulk cargoes.
- Project cargo and the heavy lift cargo include items like manufacturing equipment, air conditioners, factory components, generators, wind turbines, military equipment, and almost any other oversized or overweight cargo which is too big or too heavy to fit into a container.
- Dunnage airbags/bags consist of closed chambers made from an elastic film filled with air. When at rest, only the static load generated by the weight of the package contents bears upon the cushioning. When dynamic loads occur, these are absorbed by compression of the cushion. Introduced around 1970, dunnage bags provide convenient and cost-effective cargo stabilization in ISO sea containers, closed railcars, trucks, and oceangoing vessels.

Weight

The total gross weight of goods handled in EU ports is estimated at just above 3.8 billion tonnes in 2015, an increase of 1.3 % from 2014. The EU port freight activity seems to have resumed on a slight path towards recovery in 2014 (Figure 9).

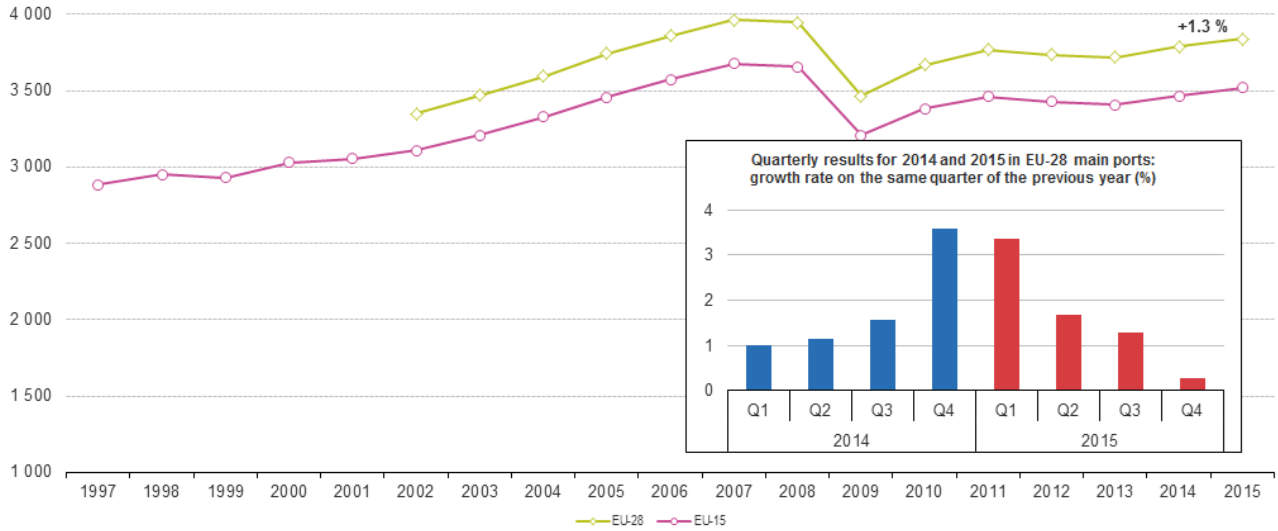
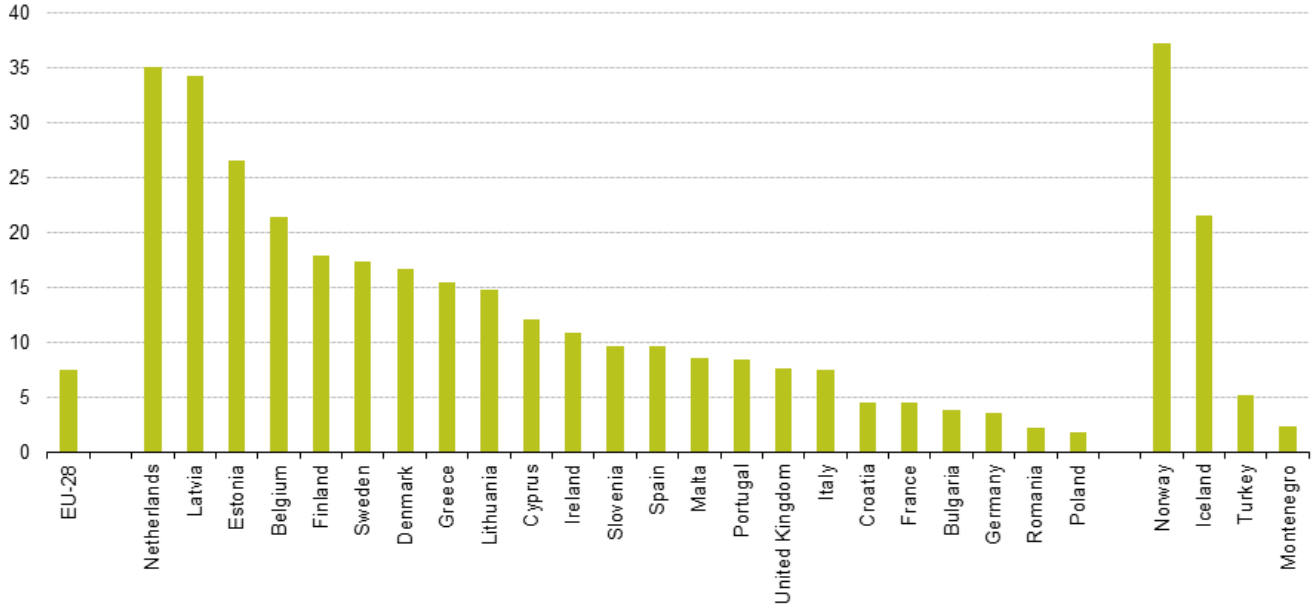


Figure 9 Gross weight of seaborne goods handled in all ports, 1997-2015 (in million tonnes)

The Netherlands remained the largest maritime freight transport country in Europe in 2015; while Rotterdam, Antwerpen, Hamburg, Amsterdam and Algeciras maintained their positions as the five largest freight ports. The location of the largest EU freight ports is reflected in the national figures for gross weight of goods handled in maritime ports per inhabitant (Figure 10).



Note: The Czech Republic, Luxembourg, Hungary, Austria, Slovakia and the EFTA countries Liechtenstein and Switzerland have no maritime ports.

Figure 10 Gross weight of seaborne goods handled (inward and outward) in all ports in 2015 (in tonnes per inhabitant)

Among the EU member states, the seaborne freight-per-capita ratio varied from 35.1 tonnes per inhabitant in the Netherlands to 1.8 tonnes per inhabitant in Poland in 2015. The EU-28 average was 7.5 tonnes per inhabitant. However, the EFTA country Norway recorded the highest ratio of the countries reporting maritime data to Eurostat, with 37.3 tonnes of seaborne goods handled per inhabitant in 2015.

Value

Liquid bulk goods accounted for 38% of the total cargo handled in the main EU ports in 2015 (Figure 11), followed by dry bulk goods (23%), containerised goods (21%) and goods transported on Ro-Ro mobile units (12%).
The largest volumes of liquid bulk goods were handled in the Netherlands (278 million tonnes), followed by the UK (194 million tonnes) and Italy (186 million tonnes).

The Baltic country of Estonia recorded the highest share of liquid bulk goods as a percentage of the total tonnages passing through its main ports in 2015, mainly reflecting large volumes of outward movements of oil products to the United States of America (USA).

	Share in % of total cargo handled in main ports					Total cargo handled in main ports (million tonnes)
	Liquid bulk goods	Dry bulk goods	Large containers	Ro-Ro Mobile Units	Other cargo	
EU-28	**38.0**	**22.9**	**21.2**	**12.3**	**5.6**	**3 772.5**
Belgium	31.0	13.5	40.7	8.6	6.3	**241.2**
Bulgaria	45.3	37.1	8.3	0.8	8.5	**27.2**
Denmark	37.0	27.5	6.6	25.0	3.9	**84.6**
Germany	15.2	24.5	42.5	12.5	5.3	**296.2**
Estonia	54.0	16.0	5.5	13.9	10.6	**31.5**
Ireland	25.2	30.6	14.2	28.2	1.9	**49.3**
Greece	39.6	20.7	24.8	13.4	1.5	**148.6**
Spain	37.6	22.8	29.2	4.7	5.6	**447.0**
France (')	46.0	25.9	13.3	12.2	2.6	**296.4**
Croatia	47.4	34.9	9.5	2.1	6.1	**15.9**
Italy	41.4	13.5	21.2	19.7	4.2	**449.5**
Cyprus	33.4	34.7	27.0	2.1	2.7	**7.4**
Latvia	37.6	47.9	5.8	3.6	5.0	**66.5**
Lithuania	42.0	38.6	8.4	5.9	5.1	**43.1**
Malta	36.6	19.4	19.4	17.3	7.2	**3.7**
Netherlands	46.9	24.2	18.1	3.2	7.7	**594.3**
Poland	27.4	36.6	19.7	11.3	5.0	**68.8**
Portugal	39.0	22.6	29.1	1.0	8.3	**85.3**
Romania	27.0	51.2	12.8	0.6	8.5	**43.6**
Slovenia	16.5	35.5	36.2	4.6	7.2	**19.9**
Finland	33.4	25.7	10.2	18.3	12.5	**96.9**
Sweden	37.6	17.8	7.8	26.5	10.3	**169.7**
United Kingdom	40.0	21.4	13.0	21.4	4.2	**485.7**
Iceland	:	:	:	:	:	**:**
Norway	50.8	38.1	3.2	2.0	6.0	**184.4**
Montenegro	:	:	:	:	:	**:**
Turkey	34.0	38.6	20.1	2.1	5.3	**411.6**

Note: main ports are ports handling more than 1 million tonnes of goods annually. (:) not available.
(') Partially estimated by Eurostat.

Figure 11 Gross weight of seaborne goods handled (inward and outward) in main ports in 2015 by type of cargo (in % of total cargo handled)

With 144 million tonnes, Dutch ports also handled the largest volumes of dry bulk goods in the EU in 2015, followed by the UK with 104 million tonnes. Even so, the tonnages of dry bulk goods handled in both the Netherlands and the UK in 2015 were lower than the 159 million tonnes reported by the candidate country Turkey. Romania had the highest share of dry bulk goods as a percentage of the total tonnages in 2015, mainly reflecting large volumes of outward movements of agricultural products from its ports.

Containers were the dominant type of cargo handled in German and Belgian ports in 2015, with shares of 43% and 41% respectively of the total cargo passing through the ports of the two countries. The largest volumes of containerised goods, however, were handled in Spanish and German ports, with 130 million tonnes and 126 million tonnes, respectively. The two top container countries were followed by the Netherlands with 108 million tonnes and Belgium with 98 million tonnes of containerised goods.

The share of Ro-Ro units in the total tonnage of goods was the highest for Ireland (28%), Sweden (27%), and Denmark (25%), reflecting the importance of Ro-Ro ferry traffic in the seaborne transport of these countries. In tonnage terms, the United Kingdom (104 million tonnes) and Italy (88 million tonnes) recorded the largest EU volumes of goods transported on Ro-Ro mobile units in 2015.

Handling

General: A lot of terminal or port cargo handling equipment is provided to facilitate movement of the cargo to and from the ship's side and the transit shed, warehouse, barge, railway wagon or road vehicle. These include two-wheeled hand barrows and four-wheeled trucks either manually or mechanica1ly propelled, and mechanically or electrica1ly propelled tractors for hauling four wheeled trailers. Ro-ro trailers are moved by tug-masters or ro-ro tractors. There are also belt conveyors mechanically or electrically operated, or rollers, all perhaps extending from the quayside to the transit shed, warehouse, railway wagon or road vehicle. Containers are loaded and unloaded by means of the quayside container cranes, i.e. container gantries also called shiptainers.

Transtainers or stacking cranes, straddle carriers, van carriers, front and side loading fork-lift trucks are used for moving and stacking containers within the terminal up to five-high, i.e. five containers one above the other. Mechanically powered straddle carriers are designed to distribute containers on the quay and on the terminal.
Fork lift trucks (FLT) are mechanically or electrically operated and fitted in front with a platform in the shape of two prongs of a fork; lifting capacity varies from 1 to 45 tons. Clamps for reels and bales are provided on some fork lift trucks.

On the docks various types of dockside cranes, level-luffing cranes, mobile cranes etc. are used for moving and lifting packages. All the vertical cargo movements are conducted by the lifting gear (lift-on/lift-off equipment). Roll-on/roll-off cargoes, i.e. containers and heavy loads on trailers, roll on and off the ro-ro ship via stern, bow or quarter ramps. They are lifted to various decks on board by means of scissor-supported platforms.

Bulk cargo handling: So far as dry bulk cargoes are concerned, handling facilities may be in the form of power-propelled conveyor belts, usually fed at the landward end by a hopper (a very large container on legs) or grabs, which may be magnetic for handling ores, fixed to a high capacity travelling crane or travelling gantries. These gantries move not only parallel to the quay, but also run back for considerable distances, and so cover a large stacking area, and are able to plumb the ship's hold. These two types of equipment are suitable for handling coal and ores. In the case of bulk sugar or when the grab is also used, the sugar would be discharged into a hopper, feeding by gravity a railway wagon or road vehicle below. Elevators or silos are normally associated with grain. They may be operated by pneumatic suction which sucks the grain out of the ship's hold.

Liquid cargo handling: The movement of liquid bulk cargo, crude oil and derivatives, from the tanker is undertaken by means of pipelines connected to the shore-based storage tanks. Pumping equipment is provided in the tanker storage plant or refinery ashore, but not on the quayside. In view of the dangerous nature of such cargo, it is common practice to build the special berths a small distance from the main dock system on the seaward side. Oil cargo is discharged from the ship’s tanks, via the cargo piping system to the main ship’s manifold usually situated amidships, on either port or starboard side. From there by means of shore-based loading arms oil is transferred to the shore manifold and is then distributed to shore-based storage tanks on the oil terminal. The loading arm hose must be flanged oil-tight to the ship’s manifold so that oil spills can be avoided.

General cargo handling: Regarding general cargo (goods, merchandise, commodities), also referred to as break bulk cargo, almost 90 percent of all such cargo in most liner cargo trades today is containerized. General cargo is handled by cranes on the quay, floating cranes or by the ship's own cargo gear (deck cranes, derricks, etc.).

Attached to such lifting gear is a shackle which links the crane or derrick with the form of cargo-handling equipment being used. For most lifts, a hook is used. There are numerous types of tools or loose gear that can be attached to the shipboard or shore-based lifting gear. They include the sling or strop, which is probably the most common form of loose gear. Such equipment, generally made of rope, is ideal for hoisting strong packages, such as wooden cases or bagged cargo, which is not likely to sag or be damaged when raised. Similarly, snotters or canvas slings are suitable for bagged cargo. Chain slings, however, are used for heavy slender cargoes, such as timber or steel rails. Can or barrel hooks are suitable for hoisting barrels or drums. Cargo nets are suitable for mail bags and

similar cargoes that are not liable to be crushed when hoisted. Heavy lifting beams are suitable for heavy and long articles such as locomotives, boilers or railway passenger coaches. Cargo trays and pallets, the latter being wooden or of steel construction, are ideal for cargo of moderate dimensions, which can be conveniently stacked, such as cartons, bags, or small wooden crates or cases.

Storage: Storage is a process of storing products, e.g. raw materials, semi-finished or finished products at different times and space during all the phases of the logistics process. Storage and inventory are closely related aspects of logistics, in that while warehousing refers to the storage process of products, inventory deals with the quantity of products stored. Storage facilities are needed because:

- When the rate of cargo delivery is higher than the direct delivery by transport modes, there is a need for storage of excess cargo (high cargo throughput)
- To achieve economies of scale during shipment of cargo and the production of products, many industries import or export more cargo that needs to be stored. This is why many warehouses are often located where mostly various modes of transportation starts or ends
- To obtain discounts on excess quantity purchased, imported or exported
- To maintain a reliable source of supply to growing demand especially in cases of fluctuation in delivery times and prices

The sizes of warehouses are dependent on the customer service level, the higher the service level the more warehouse space needed. The failure to provide adequate storage capacity for cargo traffic has often created congestion problems, consequential loss in traffic and therefore reduction in revenue.

There are two main types of cargo storage:

- Open space cargo storage which applies to cargo that is not sensitive to degradation by environmental conditions e.g., rain, wind, heat from sun or out-door cold conditions like snow.
- Closed space cargo storage, which keeps cargo in a specially built covered area to protect it from being damaged by harsh environmental conditions
  * Cargo storage can further be divided into two categories of storage periods, transit (short term) storage and long-term storage. Transit storage areas are often located close to the quay apron in ports while long-term storage (warehousing) is located away from sensitive port activities. A shed can be explained as a building used for the purpose of receiving, storing and handling of various types of cargo in transit, while a warehouse is a building designed and used for the storage of cargo over a longer period.

There are two main factors which determine the size and shape of storage spaces:

- Product Characteristics: the type, weight, number, shape, size and packaging of cargo influences the size of the warehouse
- The stock layout and handling systems: the type and layout of handling systems are important factors, others of equal importance, are equipment space, utilization ratio, the number and size of aisle space and offices

Cargo storage areas, sheds or warehouses, need to be efficiently managed to improve the cargo turn round, reduce dwell time and thereby reduce congestions in ports. Establishing a good cargo-flow pattern by adopting a uni-directional traffic pattern, avoiding of crossing points in cargo delivery and storage by segregating import cargo from export. A good way to increase storage capacity is the effective use of vertical space coupled with the operation of appropriate selected equipment in both open and closed storage areas.

A typical general cargo berth in a port could use as much as 60% of its land area for storage purposes. Estimating the demand for storage facilities shall takei nto account the following:

- Type of storage needed: factors like customer demands, type of cargo and its packaging, time cargo will be stored, special cargo storage requirements like ventilation or temperature control, the need for weather protection, need for cargo segregation and security
- The dwell time of expected cargo: This is how long the cargo is expected to stay in the storage area
- The Space Needed to Store Cargo: It is important to consider the dimensions of both the cargo and storage areas, the stowage and stacking factors i.e. how high it can be arranged without damage to lower cargo, its container and pavement floors

- Other things to consider are the usable storage area, the broken stowage allowance and lastly the type of segregation between consignments

In conclusion, there are various reasons why cargo is stored in ports, the size of storage areas depends largely on the level of customer services, the product characteristics, the layout of the port and the cargo handling systems used in ports.

Ship types

Ship types for each location shall take into consideration:

- Limitations regarding overall ship dimensions
- The type of cargo to be handled / transported
- Sea river connections
- Short sea shipping

General Cargo Carriers

General cargo vessels are the most basic dry cargo carrying vessel; they are used to carry loose and irregular cargo which is not suitable for container, Ro-Ro, bulk or specialist heavy lift vessels. Stevedores will secure cargoes to these vessels using custom fittings often welded to the ships hold. General cargo vessels are often fitted with rigging for winches which are used to load and unload cargo to the vessel hold(s).
As per Appendix A of Ref.[8] the following regression formulas apply for tankers:
DWT [tons] versus Loa [m]: DWT = 0.0094 * Loa^2.8552
DWT [tons] versus B [m]: DWT = 0.9078 * B^3.1268
DWT [tons] versus T [m]: DWT = 389.6 * e^(0.397*T)

Bulk Carriers

Bulk carriers are used to transport loose dry cargoes such as ore, grains and cement which often have a high weight to cost ratio making ocean transportation by other methods / vessel types inefficient. Bulk carriers are large vessels which are usually divided into separate cargo holds, covered by hatches. The largest operating bulk carrier is the MS Ore Brasil at approx. 400,000 DWT (14,000 TEU @ 14 t/container) and L x B x T = 362 x 65 m x 23 m.

Figure 12 Largest operating bulk carrier (MS Ore Brasil)

The average size range among bulk carriers is between 35,000 and 59,000 DWT, Handymax size (around 40% of the total bulk carrier worldwide fleet).
As per Appendix A of Ref.[8] the following regression formulas apply for bulk carriers:

Lbp [m] versus DWT [tons]:	Lbp =	7.60301 * DWT^0.300155
B [m] versus DWT [tons]:	B =	1.0559 * DWT^0.309724
D [m] versus DWT [tons]:	D =	0.584268 * DWT^0.310795
T [m] versus DWT [tons]:	T =	0.480719 * DWT^0.298295

Container Vessels

Container ships transport an estimated 52% of all global ocean trade and are specifically designed to transport ISO standardised shipping containers, these include 10, 20, 40 & 45 ft. standard containers, high-cube containers, open-top containers, flatrack and platform containers (these are used for oversized cargo), tank containers (for liquids / gasses) and refrigerated containers which require a power source to provide temperature control. The largest operating container ship is the MSC Oscar at approx. 200,000 DWT (14,000 TEU @ 14 t/container) and L x B x T = 395.4 x 59 m x 16 m.

Figure 13 Largest operating container ship (MSC Oscar)

The average container ship can hold approx. 3,500 TEU.
As per Appendix A of Ref.[8] the following regression formulas apply for container ships:

Lbp [m] versus DWT [tons]:	Lbp =	3.54132 * DWT^0.388442
B [m] versus DWT [tons]:	B =	1.55219 * DWT^0.284381
D [m] versus DWT [tons]:	D =	0.299394 * DWT^0.38902
T [m] versus DWT [tons]:	T =	-17.1581 + 2.72338 * ln(DWT)

Tankers

A tanker (or tank ship or tankship) is a merchant vessel designed to transport or store liquids or gases in bulk. Major types of tankship include the oil tanker, the chemical tanker, and gas carrier. Tankers also carry commodities such as vegetable oils, molasses and wine. The largest operating tanker ships (ULCC's) are the TI Europe and TI Oceania at approx. 440,000 DWT and L x B x T = 380m x 68 m x 24.52 m.

Figure 14 Largest operating tankers (TI Europe & TI Oceania)

The average size range among tankers is between 280,000 and 320,000 DWT with around 400 vessels worldwide. As per Appendix A of Ref.[8] the following regression formulas apply for tankers:

Lbp [m] versus DWT [tons]: Lbp = 6.86408 * DWT^0.307233
B [m] versus DWT [tons]: B = 0.962394 * DWT^0.324898
D [m] versus DWT [tons]: D = 0.45914 * DWT^0.330623
T [m] versus DWT [tons]: T = 0.45011 * DWT^0.303134

RO-RO

RO-RO or roll-on/roll-off vessels are ships designed to carry wheeled cargo, they come in different forms depending on the need, including vehicle ferries, cargo vessels (which are used for truck trailers, railroad cars etc.) and car carriers which are the most prominent. Ro-Ro vessels are loaded/ unloaded using single or multiple loading ramps. The Mark V class RO-RO vessel(s) built for the Norwegian shipping company Wilhelmsen and its corporate associate Wallenius are currently the largest in the world with an L x B x T = 260 m x 32 m x 11 m.

Figure 15 Largest operating RO-RO (Mark V Wilhelmsen)

As per Appendix A of Ref.[8] the following regression formulas apply for RO-RO ships:

DWT [tons] versus Loa [m]: DWT = 0.0128 * Loa^2.6718
DWT [tons] versus B [m]: DWT = 1.0914 * B^2.8253
DWT [tons] versus T [m]: DWT = 43.364 * T^2.6673

Other ship types

Passenger / Cruise Ships: Passenger vessels range from small ferries to large cruise ships capable of carrying more than 6,000 passengers. Passenger vessels such as cruise ships are fitted with hotel-like interiors and include facilities such as restaurants, shops, cinemas and swimming pools.
As per Appendix A of Ref.[8] the following regression formulas apply for passenger/cruise ships:

L/B versus Lbp [m]:	L/B = 1.3644 * Lbp^0.3003
B/T versus Lbp [m]:	B/T = 2e-06 * Lbp^2 + 0.0026 * Lbp + 3.5401
Speed v [kn] versus Lbp [m]:	v = 2.9545 * Lbp^0.3621

Offshore Tug / Supply Ships: Anchor Handling Tug Supply (AHTS) vessels are mainly built to handle anchors for oil rigs, tow them to location, anchor them up and, in a few cases, serve as an Emergency Response and Rescue Vessel (ERRV).
A Platform supply vessel (PSV) is a ship specially designed to supply offshore oil and gas platforms. The primary function for most of these vessels is logistic support and transportation of goods, tools, equipment and personnel to and from offshore oil platforms and other offshore structures.
As per Appendix A of Ref.[8] the following regression formulas apply for offshore tug/supply ships:

L/B versus Lbp [m]:	L/B = -0.0006 * Lbp^2 + 0.0851 * Lbp + 0.7841
B/T versus Lbp [m]:	B/T = 2.1368 * Lbp^0.0745
Total Power ME [kW] versus Lbp [m]:	ME = 781.47 * e^ (0.0333 * Lbp)

Fishing Vessels: A fishing vessel is a boat or ship used to catch fish in the sea, or on a lake or river.
As per Appendix A of Ref.[8] the following regression formulas apply for fishing vessels:

L/B versus Lbp [m]:	L/B = 1.8006 * ln(Lbp) – 2.367
B/T versus Lbp [m]:	B/T = 0.0002 * Lbp^2 – 0.0268 * Lbp + 3.2082
Reefer capacity RC [ft.^3] versus Lbp [m]:	RC = 7.9873 * Lbp^2.0778

Vessels per Port growth in the EU (2010-2015)

EU ship categories:

- Liquid bulk: oil tanker, chemical tanker, LG tanker, tanker barge, other tanker
- Dry bulk: bulk/oil carrier, bulk carrier
- Container: full container
- Cargo, specialised: barge carrier, chemical carrier, irradiated fuel, livestock carrier, vehicle carrier, other specialised
- Cargo, non-specialised: reefer, Ro-Ro passenger, Ro-Ro container, other Ro-Ro cargo, combination carrier general cargo/passenger, combination carrier general cargo/container, single-decker, multi-decker
- Passenger: passenger (excluding cruise passenger vessels)
- Cruise passenger: cruise ships only
- Offshore activities: offshore supply
- Other: dry cargo barges, tugs, miscellaneous, unknown type of vessel

EU Growth Rates

The number of vessels calling in the main EU ports in 2015 is estimated at just above 2.2 million, an increase of 1.7 % from the previous year (Figure 16). In the same period, the estimated gross tonnage (GT) of the vessels calling in EU ports grew by 3.3% to 16.4 billion GT (Figure 17). As a result, the average size of vessels calling in the main EU-28 ports increased by 1.6% to about 7 400 GT in 2015 (Figure 18).

Cargo and cargo streams

Port	2010	2011	2012	2013	2014	2015	2015 By type of vessel (%)									Growth rate 2014-2015 (%)	Growth rate 2010-2015 (%)
	Total	Total	Total	Total	Total	Total	Liquid bulk	Dry bulk	Con-tainer	Cargo, spe-cialised	Cargo, non-spe-cialised	Pas-senger (excl. cruise)	Cruise pas-senger	Offshore activities	Other		
EU-28	2 254 112	2 281 603	2 210 494	2 133 637	2 187 560	2 224 608	9	3	4	1	67	15	1	0	1	+1.7	-1.3
Belgium	28 812	28 306	26 795	25 000	24 540	24 806	26	2	18	25	22	0	1	0	7	+1.1	-13.9
Bulgaria	3 168	3 566	3 648	3 620	3 354	3 067	21	19	12	0	48	0	0	0	0	-8.6	-3.2
Denmark	356 657	349 133	348 391	344 186	361 601	288 400	1	1	1	1	95	1	0	0	0	-20.2	-19.1
Germany	107 197	114 431	111 989	118 586	114 480	111 445	2	3	7	0	65	20	0	0	1	-2.7	+4.0
Estonia	25 370	28 483	28 474	30 504	29 390	30 162	3	4	1	0	3	88	1	0	0	+2.6	+18.9
Ireland	12 818	11 615	11 378	11 712	11 759	11 841	9	3	10	2	73	0	1	0	1	+0.7	-7.6
Greece	486 956	530 366	511 951	466 727	506 620	474 796	2	0	1	0	85	10	1	0	1	-6.3	-2.5
Spain	122 845	151 452	148 794	141 044	148 828	161 490	8	4	9	1	41	35	2	0	1	+8.5	+31.5
France (*)	46 967	45 023	44 800	46 444	48 876	50 726	14	6	10	3	49	11	2	0	6	+3.8	+8.0
Croatia	195 262	207 995	205 040	202 537	195 657	231 582	0	0	0	0	46	52	1	0	0	+18.4	+18.6
Italy	518 666	485 000	437 058	411 167	409 438	510 351	20	4	2	0	61	10	1	0	3	+24.6	-1.6
Cyprus	2 743	2 606	2 324	2 366	2 219	2 097	16	2	31	10	31	4	3	3	0	-5.5	-23.6
Latvia	6 872	6 998	7 404	6 638	6 483	6 018	21	54	9	0	0	13	1	0	1	-7.2	-12.4
Lithuania	4 526	4 766	4 857	4 418	4 325	4 211	14	9	14	0	61	0	1	0	1	-2.6	-7.0
Malta	23 030	23 043	22 600	22 882	23 288	24 310	0	1	11	0	86	0	0	0	2	+4.4	+5.6
Netherlands	44 535	37 160	36 637	35 452	34 997	35 160	32	6	18	1	40	0	0	3	0	+0.5	-21.1
Poland	16 316	15 748	15 300	14 716	14 543	15 318	13	11	8	1	48	17	1	0	1	+5.3	-6.1
Portugal	12 230	12 125	11 137	12 351	12 264	12 944	18	4	32	3	31	6	6	0	0	+5.5	+5.8
Romania	1 822	4 749	4 678	4 593	4 320	4 191	16	62	14	3	3	0	1	0	0	-3.0	+130.0
Slovenia	2 039	1 996	1 980	1 941	1 915	2 086	11	8	33	4	35	0	2	0	8	+8.9	+2.3
Finland	34 682	34 784	33 818	32 673	32 175	31 457	8	2	7	1	73	5	1	0	3	-2.2	-9.3
Sweden	78 357	80 518	77 345	78 262	77 636	76 455	7	6	3	1	77	4	0	0	0	-1.5	-2.4
United Kingdom	122 242	101 740	114 096	115 818	118 852	111 695	13	2	7	3	66	0	0	7	2	-6.0	-8.6
Iceland	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Norway	33 372	57 061	60 381	72 195	69 209	64 390	13	18	5	7	38	0	0	18	1	-7.0	+92.9
Montenegro	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Turkey	64 003	64 542	65 008	65 831	64 437	62 846	14	43	14	2	11	14	2	0	1	-2.5	-1.8

Note: main ports are ports handling more than 1 million tonnes of goods or 200 000 passengers annually. (:) not available.
(*) Provisional estimates.

Figure 16 Number of vessels in main ports by type of vessel (based on inward declarations)

Port	2010	2011	2012	2013	2014	2015	2015 By type of vessel (%)									Growth rate 2014-2015 (%)	Growth rate 2010-2015 (%)
	Total	Total	Total	Total	Total	Total	Liquid bulk	Dry bulk	Con-tainer	Cargo, spe-cialised	Cargo, non-spe-cialised	Pas-senger (excl. cruise)	Cruise pas-senger	Offshore activities	Other		
EU-28	15 780 665	16 106 037	16 015 390	15 886 074	15 919 134	16 446 222	8	4	17	3	56	5	6	0	1	+3.3	+4.2
Belgium	553 413	568 104	554 009	564 064	566 748	590 135	12	2	40	33	10	0	2	0	1	+4.1	+6.6
Bulgaria	23 310	26 272	28 701	31 726	31 269	29 121	33	25	17	2	22	0	0	0	0	-6.9	+24.9
Denmark	1 074 535	1 058 660	1 072 400	1 074 814	1 038 752	1 017 921	3	1	2	1	90	0	2	0	0	-2.0	-5.3
Germany	1 067 908	1 133 238	1 172 132	1 169 484	1 176 255	1 167 622	3	3	31	0	57	2	2	0	2	-0.7	+9.3
Estonia	264 421	302 077	310 969	338 541	332 248	329 955	5	2	2	0	3	83	6	0	0	-0.7	+24.8
Ireland	228 836	222 399	223 203	208 831	221 238	229 775	4	3	4	3	80	1	4	0	0	+3.9	+0.4
Greece	1 152 027	1 148 240	1 101 625	1 125 152	1 177 159	1 226 086	5	2	9	3	67	1	12	0	0	+4.2	+6.4
Spain	1 735 395	1 885 820	1 881 947	1 773 652	1 866 870	2 091 665	12	8	21	2	33	14	10	0	0	+12.0	+20.5
France (*)	1 126 527	1 018 768	1 157 591	1 247 257	1 253 231	1 398 864	9	4	23	4	48	6	5	0	1	+11.6	+24.2
Croatia	269 803	271 884	263 616	272 531	262 810	316 769	2	1	4	0	67	11	15	0	0	+20.5	+17.4
Italy	2 917 716	3 091 955	2 765 166	2 469 842	2 261 879	2 299 642	8	2	16	0	60	1	13	0	0	+1.7	-21.2
Cyprus	39 260	37 394	32 758	32 321	28 632	29 772	11	1	44	19	10	6	8	1	0	+4.0	-24.2
Latvia	71 684	82 410	90 074	85 348	82 285	76 890	26	34	9	0	0	26	4	0	0	-6.6	+7.3
Lithuania	52 910	59 038	60 336	57 797	59 588	60 030	23	14	14	0	44	0	4	0	0	+0.7	+13.5
Malta	186 573	194 820	197 257	215 998	215 796	235 263	1	1	52	1	43	0	0	0	1	+9.0	+26.1
Netherlands	740 132	691 592	718 774	717 891	725 845	762 542	28	13	32	1	25	0	0	1	0	+5.1	+3.0
Poland	158 472	160 040	164 421	165 848	183 624	186 708	8	10	15	0	64	1	2	0	0	+1.7	+17.8
Portugal	162 986	174 942	177 259	198 978	210 034	236 398	15	6	40	5	10	3	21	0	0	+12.6	+45.0
Romania	29 108	46 251	50 191	51 899	52 766	52 262	18	41	32	1	6	0	2	0	0	-1.0	+79.5
Slovenia	35 109	41 532	39 366	38 943	40 348	48 842	6	12	47	0	29	0	5	0	1	+21.1	+39.1
Finland	701 096	707 641	710 893	740 747	731 142	713 145	4	1	4	1	86	2	2	0	0	-2.5	+1.7
Sweden	1 140 379	1 147 066	1 132 317	1 134 734	1 163 980	1 184 969	4	2	3	1	87	1	2	0	0	+1.8	+3.9
United Kingdom	2 049 065	2 035 894	2 110 388	2 169 675	2 236 636	2 161 848	8	3	13	5	69	0	1	1	0	-3.3	+5.5
Iceland	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Norway	213 282	273 739	288 760	402 750	337 553	315 988	30	18	8	3	22	0	0	19	0	-6.4	+48.2
Montenegro	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Turkey	549 769	604 832	658 668	682 390	696 756	745 015	18	21	33	3	14	2	7	0	0	+6.9	+35.5

Note: main ports are ports handling more than 1 million tonnes of goods or 200 000 passengers annually. (:) not available.
(*) Provisional estimates.

Figure 17 Gross Tonnage (GT) of vessels in main ports by type of vessel (in 1000 GT, based on inward declarations)

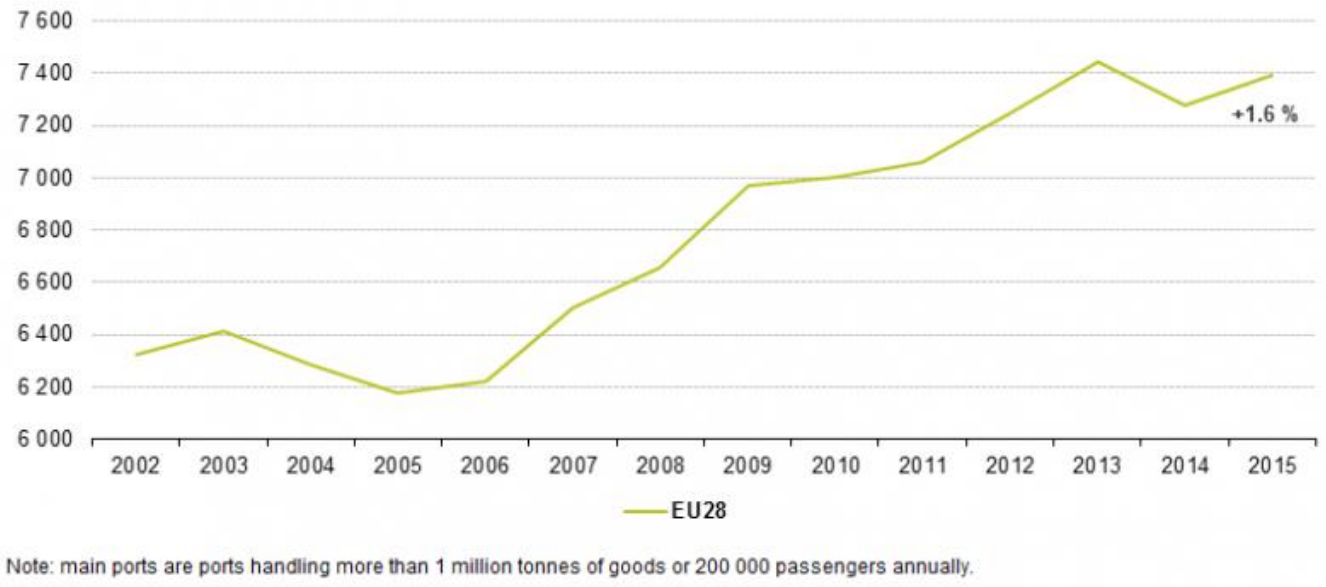


Figure 18 Average Gross Tonnage (GT) per vessel in EU-28 main ports (based on inward declarations)

Italy saw both the highest number of port calls and the largest gross tonnage of vessels making port calls in 2015 (510 000 vessels with a combined gross tonnage of 2.3 billion GT). Greece had the second highest number of port calls (475 000 vessels), followed by Denmark (288 000 vessels). On the other hand, the UK recorded the second largest gross tonnage after Italy of vessels calling at its main ports in 2015 (2.2 billion GT), followed by Spain (2.1 billion GT).

Vessels in the category "Cargo, non-specialised" (which includes Ro-Ro vessels) made the highest share of calls in main EU ports in 2015, followed by liquid bulk vessels and container vessels. The non-specialised cargo vessels also had the highest share of the combined gross tonnage of the vessels calling in main EU ports, followed by container vessels and liquid bulk vessels. However, cruise ships had by far the largest average gross tonnage of vessels calling in EU main ports in 2015, followed by container vessels and specialised cargo vessels.

For passenger vessels, there are substantial differences in the average size of vessels making port calls in various countries, with some countries, like Germany, Croatia and Italy, having many small passenger vessels calling in their main ports. A similar variation is found for container vessels. Due to a dominance of feeder services, some countries, like Ireland, have a low gross tonnage for container vessels even though the number of vessels is quite high. In other countries, like Bulgaria, Germany, France, Malta and the Netherlands, the average size of container vessels calling in the main ports is much higher, reflecting a higher share of deep-sea oriented container transport or the presence of hub ports.

Location added value

The added value of the Space@Sea platform regarding the Transport&Logistics hub shall consider:

- Added value considering future relevant developments that could be taken over by the Space@Sea platform
- Added value of services currently underdeveloped or non-existent at each location

Value added development

Value added development considers the location needs for new facilities regarding economic, social and political needs.

Value added services

These days, the commercial success of a port could stem from a productivity advantage in traditional cargo-handling service, from value-added service, or from a combination of the two. Productivity advantages come mainly from economies of scale and economies of scope, suggesting that the most productive ports will be those that are equipped to handle large cargo volumes and/or significantly reduce unit costs through efficient management.

Shippers and carriers select individual ports not only based on their cargo handling service capabilities, but also on the benefits they are capable of "delivering". Unless a port can deliver benefits that are superior to those provided by its competitors in a functional aspect, port customers are likely to select ports based merely on price. This fact raises the question of how a port can achieve value differentiation.

Studies show that the most successful ports are those that not only have a productivity advantage in cargo-handling services, but that also offer value-added services. Both logistics companies and shippers agree that value added services in logistics centres are important in supply chain management, and this tendency is expected to continue in the future. Figure 19 shows that value-added logistics (VAL) services encompass far more roles and functions than the existing services. In many cases, these services overlap or include third-party services, such as inventory management, inspection, labelling, packing, bar coding, order picking and reverse logistics etc. The pressures of VAL services in the logistics chain have increased the demands of logistics centre behind port areas.

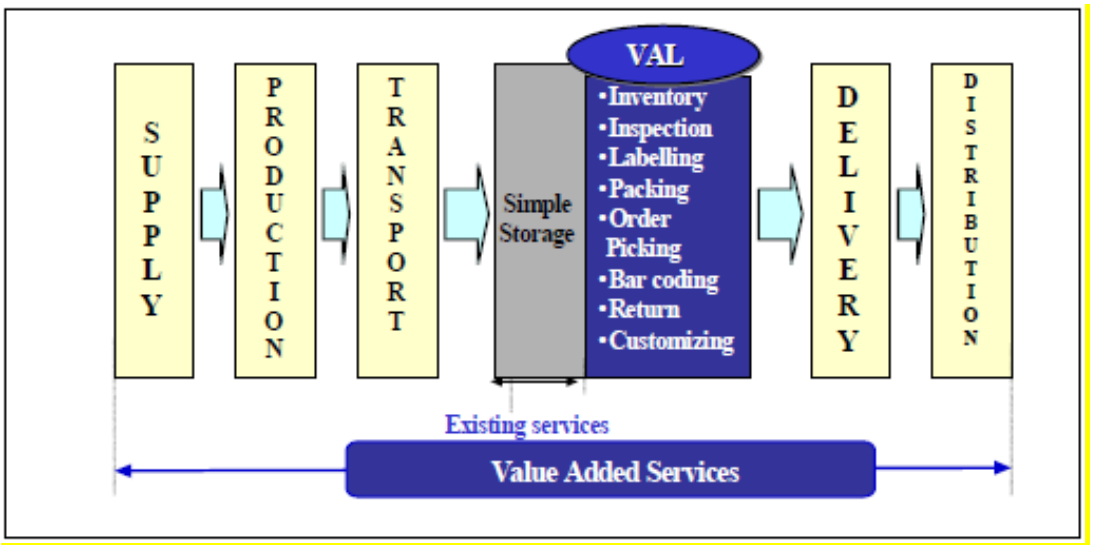


Figure 19 VAL service of logistics centres in port area

The main VAL activities are:

- Receiving goods, breaking shipments, preparing for shipment, returning empty packaging;
- Simple storage, distribution, order picking;
- Centralizing and customizing, adding parts and manuals;
- Assembly, repair, reverse logistics;
- Quality control, testing of products;
- Installing and instruction;
- Product training on customer's premises;

Assembly: "Assembly" is often cited as the semi-manufacturing function of logistics centres behind port areas. With a decrease in the travelling frequency between factory and warehouse, the shipper's interest in assembly activities seems poised to increase considerably. Supporting this trend, a new type of logistics centre, called a "manufacturing type warehouse," is emerging throughout the world to provide assembly facilities for customers dispatching cargo.

Packaging: Logistics centres have been introducing packaging functions as well.

Localizing and Customizing: In international logistics, shippers are placing greater emphasis not only on the quality of goods but also on customer needs and country requirements. Recognizing this new shipper's demand for customizing some shippers have resorted to providing these services by offering unique offers.

Installation and instruction: Recently, installation and instruction services have emerged as important functions in logistics centres. Shippers have either independently or jointly designated some space in the logistics centres for installing goods at the warehouse, which they have received from the suppliers. Some logistics centres have also become involved in education and instruction and turned themselves into similar customer service centres for end users.

Quality control and testing of products: Recently, logistics centres have been providing quality control and product testing services in addition to assembly services. Quality control and product testing services are expected to prosper both globally and domestically.

Product training on customer's premises: Increasingly, customers are demanding that logistics centres provide product-training services on their own premises. This trend is particularly noticeable in the case of electronics companies. Customers are using logistics centres to offer more flexible service offerings and reduce the cost of personnel training.

Bonded exhibition: To increase the distribution function, especially for bonded products, port authorities should examine the possibility of building exhibition facilities. It should be said, however, that the exhibition should be arranged systematically to avoid their being confused with warehouse facilities.

Logistical hotspot proximity

According to a recent study (Ref.[33]) conducted in 2017 the most desirable logistic locations in Europe have the following characteristics:

- Immediate access to major consumption centres is paramount
- Major population centers with the highest consumption are increasingly important
- Importance of overall costs was comparatively low
- Importance of labour, whether by proximity as in Western Europe (like the Netherlands) or by cost as in Poland

Table 15 Top logistics locations

PROXIMITY to major consumption centres	REGULATORY environment	LABOUR availability	TRANSPORTATION infrastructure	Total costs/VALUE PROPOSITION
1. Germany	1. Netherlands	1. Poland	1. Netherlands	1. Netherlands
2. Netherlands	2. All Other CEE	2. Netherlands	2. Germany	2. Poland
3. Belgium	3. Poland	3. All Other CEE	3. Belgium	3. All Other CEE
4. United Kingdom	4. Germany	4. Germany	4. France	4. Germany
5. France	5. United Kingdom	5. Belgium	5. Poland	5. Belgium

Note: all other Central and Eastern Europe (CEE) includes Czech Republic, Slovakia, Hungary, Romania, Slovenia, Romania, Turkey and Russia

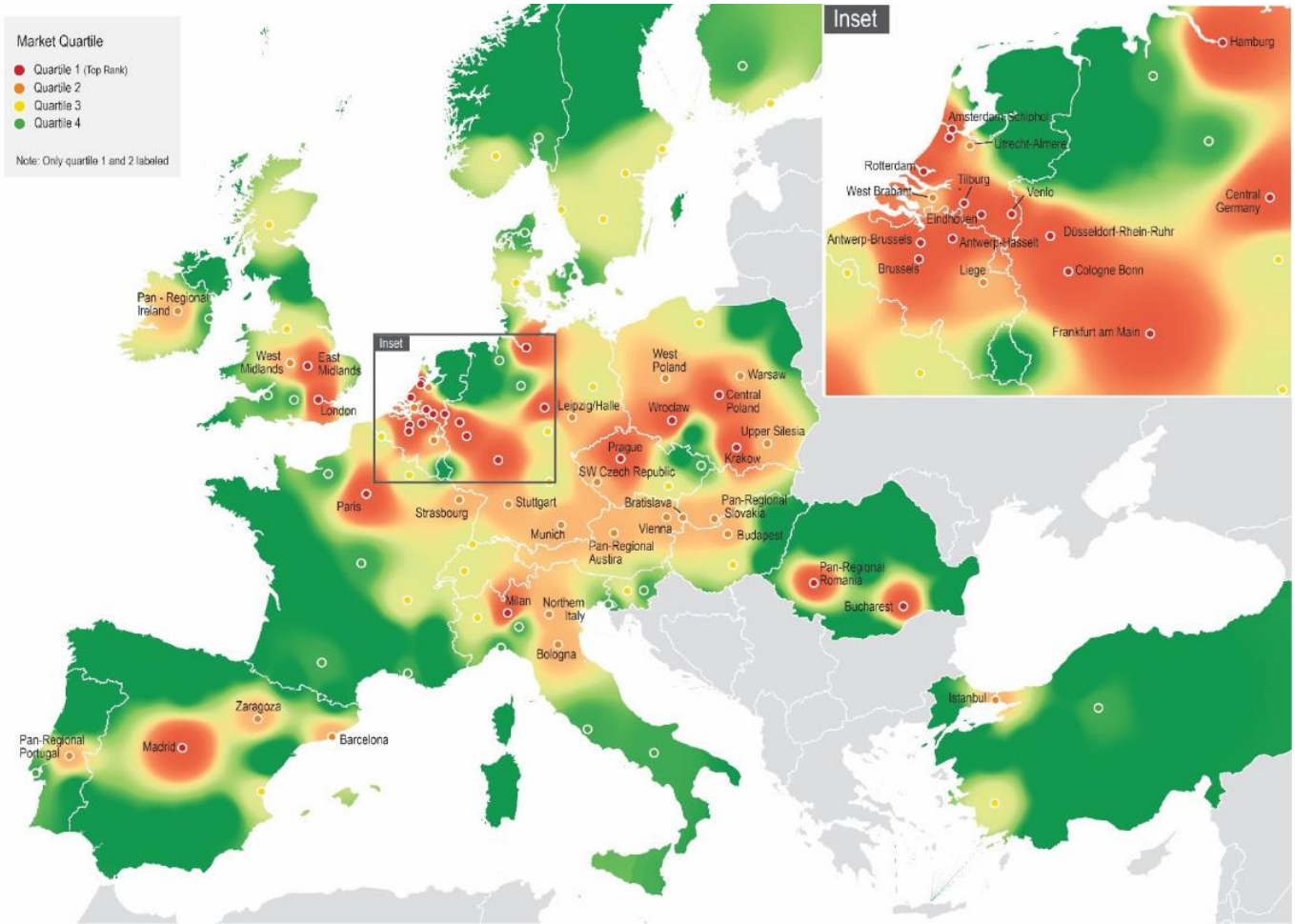


Figure 20 Europe's Most Desirable Locations by Market

The logistic appeal of a location shall consider also accessibility to and from said location.

Navigation and routes

Economic viability of the logistics requires the minimisation of cargo handling costs and the prevention of additional changes of the carrier. Cargo that is transhipped from one sea-going vessel to another sea-going ship (e.g. containers from a large intercontinental ship to Feeders/short sea vessel) can be implemented straightforward. If the destination is in the hinterland and can be reached by sea-river ships or inland vessels, it is required that these vessels can (and permitted) operate between the island and the connected inland waterway for at least 300 to 330 days per year. Only few inland vessels are designed to operate in the well-defined zone 1 (Hs<=2.0 m) or zone 2 (Hs<=1.2 m).

Countries like the Netherlands, Romania, Bulgaria, Belgium and Germany have a very good waterway network and therefore a higher share of inland navigation compared to other European countries.

Unless the Space@Sea multiuse island is located close to a suitable entrance to the inland waterway network with appropriate wave climate the existing inland fleet will hardly be able to access the Logistics@Sea hub.
Details for IWT, SRS, and SSS can be found in Ch.3.

Annex 2 Cargo streams for Energy, Farming and Living @Sea

Ocean wave energy data

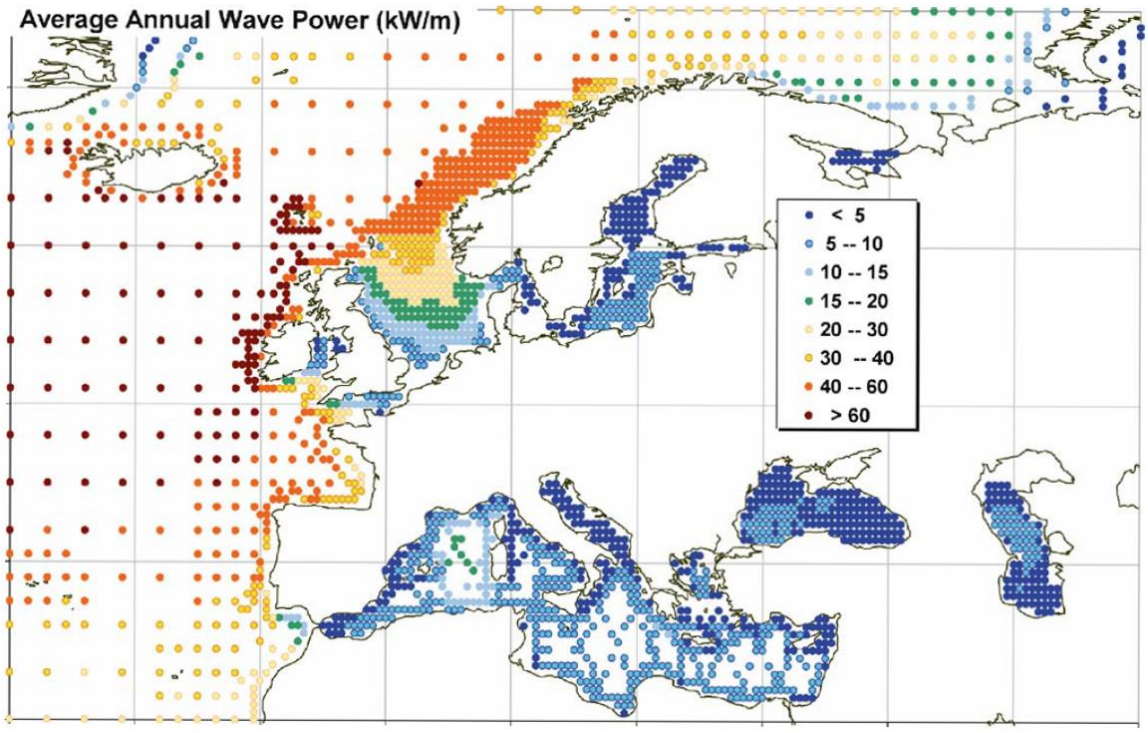


Figure 21 Average Annual Wave Power in kW/m
(Source: João Cruz, Ocean Wave Energy - Current Status and Future Perspectives, 2008 Springer-Verlag Berlin Heidelberg)

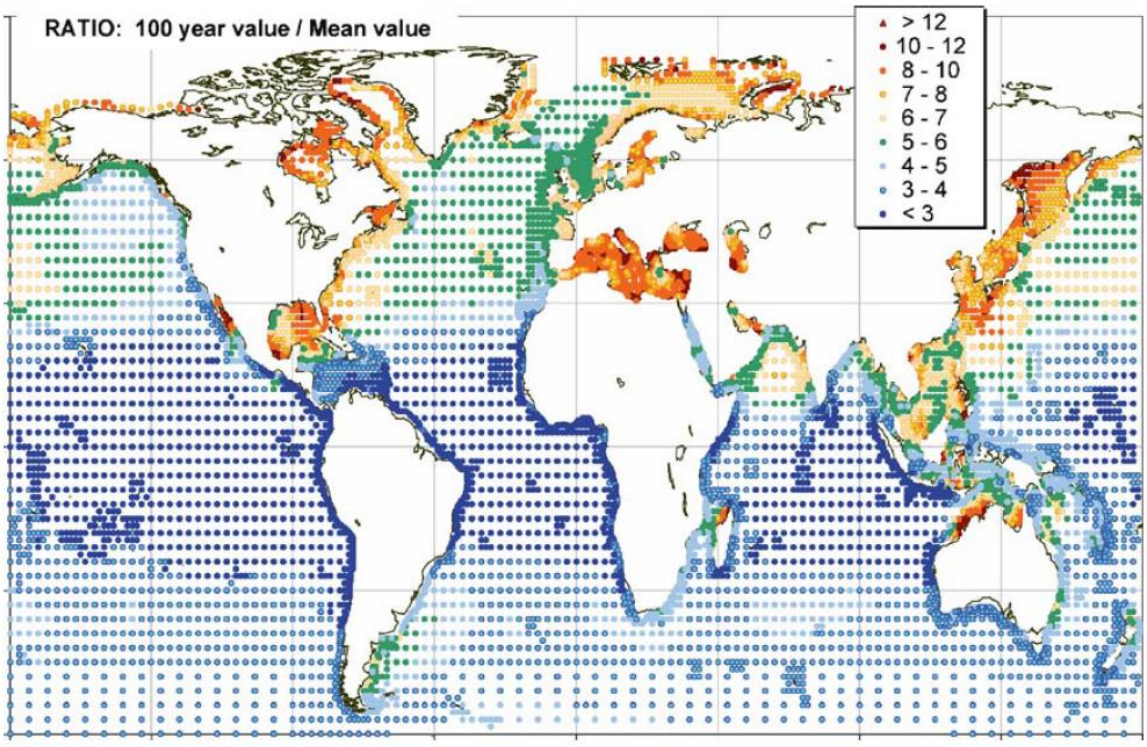


Figure 22 100 Year Value/Mean Value
(Source: João Cruz, Ocean Wave Energy - Current Status and Future Perspectives, 2008 Springer-Verlag Berlin Heidelberg)

1. Energy

Cargo streams for regular port services: This chapter of the report deals with taking over regular onshore port services for the installation of wind farms by investigating the possibility to replace onshore terminals by a floating hub designed out of smaller standardized floating modules. This is done by defining boundary conditions for the logistical process needed for the installation of wind turbines. Thereby, different wind turbines and their foundations have been considered as well as state of the art installation and transport vessels. However, a configuration of a concrete module has been performed at first, to be able to check the feasibility of the concept for this application.

General assumptions and boundary conditions: It has been prescribed that the module will be in the shape of a triangle and produced out of concrete. To estimate how many modules of which size are needed for a logistical hub for the installation of a wind farm, a first design of the module has been done to be able to predict the load capacity and deck space of one module. The density of the concrete has been defined as 2400 kg/m^3 and the water density has been defined as 1025 kg/m^3. This leads to a weight of 2806t for a complete module with side length of 50m and a maximum displaced volume of 10825m^3 for a complete submerged module with a height of 10m. Based on the overall weight and the density of the water, this module has a draught of 2.5m and therefore a freeboard of 7.5m. The maximum load capacity of this design is 8290t and the maximum deck space is 1083m^2.

Foundations for offshore wind turbines: Every offshore wind turbine is placed on top of a foundation. Most of the state of the art offshore foundations for wind turbines, like spar buoys and fixed bottom solutions, will be equipped with a wind turbine after being installed at the wind farm. For the logistic hub designed within this project it has been assumed that the hub will be used for the installation of wind turbines on bottom fixed foundations of the monopile type. These foundations are composed out of two main parts. The base is a steel pile which is equipped with the transition piece. The logistic hub will be designed so that it can be used for the installation of the foundations and the wind turbines within the same period. Since the hub is composed out of several smaller modules it can be adjusted easily for wind farms based on other foundations like for example spar buoy or jacket foundations. The hub will then be reduced by the modules that have been assigned to the logistics of the foundation installation.

Storage of wind turbine components: For the calculation of the needed deck space as well as the distributed load on the modules the 10 MW DTU Reference Wind Turbine have been chosen. Since one requirement for the logistic hub is that no assembly shall be performed on the hub, the tower will be delivered to the hub as one unit and the hub will already be connected to the nacelle. This leads to the following components that must be stored on the hub for each wind turbine: Tower, nacelle with hub, blades, monopile and transition piece.

- There are two possible orientations for the tower, monopile and transition piece during storing: Upright position: Smaller required deck space (0.5 times); higher distributed load (8 times); no rotation needed during handling; larger cranes needed for handling
- Vertical position: Larger required deck space; lower distributed load; greater floating stability

Based on the lower loads and greater floating stability, the vertical position has been chosen for the ongoing planning. The masses, needed deck space, outer dimensions and corresponding loads on the deck of the modules are presented for all components in Table 16. The red marked values are estimated ones. For calculating the required deck space, it has been assumed that all three blades of one turbine will be stored on top of each other, so that only the projected area of one blade is needed to store all of them.

Components	Amount	Mass [t]	Area [m^2]	Length [m]	Width [m]	Height [m]	Load [kPa]
Tower	1	605	955	8.3	8.3	115	6.22
Nacelle(+hub)	1	552	510	34	15	15	10.62
Rotor blade	3	41	865	86.5	10	5	1.39
Monopile	1	850	560	8	8	70	14.89
Transition Piece	1	500	249	8.3	8.3	30	19.70

Table 16 Design parameters of the DTU 10 MW for the horizontal storage of tower, monopile and transition piece

Transport to, from and on the logistic hub
The transport processes regarding the logistic hub can be separated into three steps:
- From onshore logistics to the hub → performed by Multi-Purpose Heavy Lift Vessels (MPHLV)
- Relocate the components on the hub → performed by cranes like "CAL" or "HLC" by Liebherr
- To the wind farm for installation → performed by Wind Farm Installation Vessels (WFIV)

The size of the mentioned vessels is a major factor in the design process of the logistic hub, because the amount of wind turbine and foundation components that can be carried to and from the hub defines the dimensions of the hub. Since the 10 MW DTU wind turbine is larger than every wind turbine that has been installed offshore by now, the largest currently available installation vessels have been considered as reference vessels. The largest VFIVs currently in operation are the Pacific Orca and its sister ship the Pacific Osprey. These ships are, based on the available deck space and load capacity (6,600t), capable of carrying up to four wind turbines of the type DTU 10 MW or their monopile foundations. These ships have a length over all 161m and are equipped with cranes capable of lifting to 1200t on their own. Therefore, they are capable of transporting and installing all components as well as to lift them from the hub on to the ship. Two examples for MPHLVs are the HHL Kobe and the HHL Lagos from Hansa Heavy Lift. These vessels are approximately of the same length as the Pacific Orca (169m) and have sufficient lifting and crane capacities.

Since the on-board cranes of the ships can't reach all parts of the hub, on the hub logistics are necessary as well:
- Heavy lift vehicles / gantry cranes etc. → must move from one module to each other
- Large cranes like the "CAL" (up to 1,700t) or "HLC" (up to 5,000t) → positioned on individual modules

Since there currently is no knowledge about the connection of the modules, it has been decided that the on-hub transport of the components will be performed by large cranes. As the crane manufacturers do not publish detailed information on the lifting capacities with respect to the corresponding outreach, it has been assumed, for a first estimation of the number of modules needed, that the Heavy Lift Cranes of Liebherr can lift the heaviest component of around 850t up to distances of around 80m. It is more efficient to use a rectangular shaped hub, because the number of cranes needed for the same number of modules is decreased in comparison to a triangle shaped hub. An exemplary arrangement for the hub with large cranes is given:
- Large rectangular shaped hub → 3 cranes for 49 modules (each crane on a single module)
- Large triangle shaped hub → 4 cranes for 49 modules (each crane on a single module)

Offshore wind installation cargo streams
Under the assumption that all components can be produced and transported to the hub in a time windows smaller or equal to the time of the installation, the hub will be designed to have enough storage space for one turbine and one foundation installation vessel. Since larger installation vessels are to be expected in the future and multiple installation vessels could be used parallel, the first outlay will be made for four and eight turbines plus foundations.

Based on this number of turbines, the hub needs to provide a minimum of 12,554 m^2 of storage area. The pure projected area needed to store all components is not all space that is needed. One the one hand additional space for commissioning areas is needed and on the other hand not the complete area of a module can be used. The latter is especially based on the triangle shaped geometry of the modules combined with the mostly rectangular projected area of the wind turbines and foundations components. For the preliminary design of the hub, the actual usable area has been defined as 80% of the theoretical available area. The commissioning area has been defined as 40% of the minimal storage area needed for the components themselves. Table 17 gives an overview of the needed modules (except crane modules) and different areas for a hub capable of storing four or eight wind turbines plus monopile foundations.

No. of turbines	No. of modules	Theoretical maximum area	Maximum usable area	Needed storage area	Needed commissioning area	Needed total area	Reserve
4	**21**	22,733 m^2	18,187 m^2	12,554 m^2	5,022 m^2	17,576 m^2	611 m^2
8	**41**	44,384 m^2	35,507 m^2	25,108 m^2	10,043 m^2	35,151 m^2	356 m^2

Table 17 Numbed of modules based on the needed area

Another important aspect, besides the storage area, is the weight load on the modules. Based on the total weight of all components of 10520t and a 10% safety factor to include loads from other parts like storage facilities and bearings, the averaged load on each module is approximately 549t for the four-turbine design. For the eight-turbine design its 562t per module. Based on the preliminary design of the modules at the beginning, each module can carry up to 8290t. Equipped with this load, the draught of each module will increase from 2.5 to 3.0m. Even through the loads will not be spread equally on all modules, the load will be no problem, because the deck space area is a lot more critical than the weight.

The highest distributed load, as calculated previously, is approximately 20 kPa for the transition piece. Based on the previous estimations and calculations, a floating hub to be used for the offshore wind farm cargo streams can be designed out of 21 or 41 triangle shaped modules with an edge length of 50m. By designing the hub in the shape of a larger triangle, this would lead to a hub with an edge length of 250m and 25 modules for four turbines and 350m edge length and 49 modules for eight turbines. This number of modules is over dimensioned. With a rectangular shaped design, this problem can be remedied.

Even through it is possible, based on the available storage area, the load capacity etc., to design a floating logistic hub with triangle shaped modules, rectangular modules would be more suitable for the logistic process within the wind farm installation. This is mainly due to the mostly rectangular shaped elements within the supply chain. Another aspect that needs to be considered is the investigation of the hydrodynamic stability of the modules with the turbines and monopiles being stored either upright or horizontally. The bearing of the components of multiple modules that each have their own motions, needs to be investigated as well.

Service cargo streams for the Energyhub@Sea
General assumptions and boundary conditions

Wind park operated area (5x 60 wind turbines; 10-15MW; distance between turbines → 7 times rotor diameter):
- 460km² for 10 MW turbines (enclosed in a square area: 21km side length) and
- 700km² for 15 MW turbines (enclosed in a square area: 26km side length)

Transport conditions:
- Land ←→ hub: Generally performed by ships (in emergency cases with a helicopter)
- Transport of goods in 6/8 feet containers (crane needed on quay; Hall doors must be 2.4m x 2.4m large)
- Hub ←→ turbines: Performed by Crew Transport Vessels (CTV) – Two boats as a minimum requirement

Assumptions for stock need O&M
The estimated stock needs of the O&M hub are based on a wind turbine design like the Siemens 8MW. All numbers are extrapolated for turbines with 10MW. The drive train of this turbine is **gearless**. All listed quantities, parts, probabilities of failures and maintenance actions are related to this type of turbine and are theoretical and rough assumptions.
Level of stocks should be sufficient for a half year of maintenance. Kept in stock are all parts and operating materials, which are needed for regular maintenance and typical repairs.
Additionally, some extensive and periodic extra service works will happen after a defined number of years. Especially the changing of pitch/azimuth gear oil, generator coolant and the changing of pitch accumulators can be consolidated in service campaigns for all turbines in the park. Bigger and heavier parts are stored on pallets on the hall floor, other goods in storage racks. Biggest stock parts are azimuth drives with a weight of 2 tons. All bigger spare parts must be delivered on demand.

Offshore Wind O&M service cargo streams
Regarding the bad weather conditions in winter times, no regular maintenance will happen, the level of stocks should be sufficient for a half year of maintenance. The O&M cargo streams can be divided in three main groups: Operating materials, wear parts and repair & exchange parts.

Operating materials are gear box oil, hydraulic oil, bearing grease and coolant fluids. For the exchange of operating materials different strategies are possible. One way is to change the materials periodically after a defined number of years. Another way is to make regular analyses for a status detection after which the decision for

changing or not can be made for every individual turbine. Particularly striking is the big amount of material in this group. For generator and converter systems in total 2000 up to 3000 litres of coolant can be assumed per turbine. A coolant storage tank for all 300 turbines would have the size of 900m³, if the complete amount should be held in stock. A precautionary measure strategy could work with a vessel, used as stock carrier during the change campaign for the three or four months' time, which are needed for this action. Minor operating materials like grease and a useful reserve of oil and coolant are held in normal stock. Without coolants and gear oil a need of ca. 28 tons of material is assumed for the stock to cover a half year of maintenance. The net storage volume is 30m³.

Wear parts are brake pads, rechargeable battery packs, hydraulic hoses, filters, collecting bottles for bearing grease Analogous to the coolants and the gear oil the accumulators have a limited lifetime and must be changed either after a defined period or after detection of reduced capacity. For regular changes, a period of 5 years can be set. The amount for the complete park is around 100 tons. Also in this case a regular exchange campaign could be useful with a storage on an extra vessel, even perhaps in combination with a coolant exchange action. A smaller amount of rechargeable batteries should be held in stock. Filters must be changed more often, brake pads depending on the actual state of wear, hydraulic hoses after a defined number of years. Without rechargeable accumulator packs a need of ca. 22 tons of material is assumed for the stock to cover a half year of maintenance, the net storage volume is 44m³.

Repair & exchange parts are parts which can break or fail, for example drive units, converters or other electronic units, lubrication systems, hydraulic systems, bolting's, rotor locks, brakes, heat exchanger, coolant pumps, crane parts and smaller secondary steel parts. These components lifetime should be sufficient for the turbines lifespan. But, component failure will happen due to bad quality, handling or maintenance errors. There is no defined point of failure, so the frequency must be assumed:

- lubrication systems, slip rings every 5th turbine in lifetime
- pitch and azimuth drives, pump systems, heat exchanger, hydraulic systems every 10th turbine in lifetime
- complete switch boxes, rotor locks, brake callipers every 20th turbine in lifetime

A more detailed calculation with listed 30 items shows a need of approx. 24 tons of repair & exchange parts in the stock to cover a half year of repair services, the net storage volume is 24m³. **In total** 150 tons of standard O&M goods with a net volume of 200m³ must be delivered from land to the O&M hub per year and brought back to the land as normal waste, scrap or hazardous waste. The capacity of the storage hall must be sufficient for 75 tons respectively 100 m³ of material

Dimensions of the stock hall

Based on a maximum storage height of 2m the floor area of the stock hall can be calculated to a minimum of 450m^2. An additional container stowage area of 72m^2 included.

Fuel depot for CTVs and helicopter

With nine hours of operation per day, a fuel consumption of 130 litres per hour, 3 CTVs, 25% of emergency reserve and a storage covering of 30 days a tank with a capacity of 135m³ is needed. This tank could be placed in the basic module. For helicopters, a smaller amount of one or two cubic meters kerosene is needed.

Personnel on the hub

In the summer months, the number of persons living on the hub will reach its maximum. The period for planned work organization is set to 200 days per year. In the other time, all service activities are depending in a high grade on the weather conditions. A minimum staff with two service teams is sufficient in this months. 2-person maintenance teams will work in 14-day shifts 12 hours every day, carrying out works like scheduled inspections, maintenance assignments, repair services, but also simple control system rests in the turbine. Every action is related with shipping time up to 1 hour per way. All tasks together result in 40 team hours per year and turbine. Taking also the typical waiting times into account, six teams are needed to fulfil the basic maintenance work in the offshore wind park. For extra campaigns like coolant changing or retrofit work 3 additional teams are assumed, so the maximum number of service crew members is 18 persons. For park operating and service organization 6 technicians will work in the office on the hub. The board and lodging staff a team of 6 persons is responsible for food, laundry and cleaning. The hub should accommodate 36 persons in summer.

Space for accommodation
For a rough calculation of the required space per person a needed area of $12m^2$ for a single room with bath, $10m^2$ for corridors, stairways etc., $1m^2$ for a health room and $3m^2$ for food stock and house service can be assumed. $2m^2$ for a locker room per worker and $10m^2$ for an office room per technician are needed as well. This leads to a total amount of $1044m^2$ for a crew of 36 inhabitants.

Cargo streams for the O&M staff
With an overall daily consumption of 125 litres of water and 4kg of food and drinks per person $135m^3$ water and 4.3 tons of food are required per month. The food & water storage should cover 30 days in summer. The needed amount of water can either be gained by use of a water desalination system or it can be stored in a tank in the base module, combined with a water disinfection unit. The later brings a higher investment and operating costs, but the fresh and waste water do not have to be carried between hub and coast. Additionally, the question of the deposit or disposal of the remaining waste water must be solved than.

Buildings on the module
An equilateral triangle with 50m edge length has a theoretical surface of $1083m^2$. With a 4m wide quay strip around the buildings, a base area of $566m^2$ is available for hall and accommodation. With the calculated values, the storage hall ($500m^2$) fits on this space. The accommodation building ($1044m^2$) must have two floors. The bottom of this building is placed above the maximum wave height and can vary from region to region. Stock hall and accommodation building are connected via three columns. Inside the columns are stairways and lifts for transportation of goods. The helicopter landing deck is positioned on the roof of the building. A direct access to the building is possible via hatches on the top of the columns. Outside the buildings some safety barriers against waves, wind and spray could be helpful. The module area must be surrounded by a security fence along the quay wall. Goods and persons are protected than against going overboard. The same applies for all higher areas.

Immersion depth and freeboard of the module
All masses must be evenly distributed around the centre axis of the whole module system.
In a very rough model all items were predesigned to have a first impression of the behaviour of the swimming system. The total mass of all components is 1899t leading to an immersion depth of 4.3m and a freeboard of 5.7m. The centre of mass (CoM), related to the quay surface of the module, of the buildings is 9.9m and from the overall system it is 1.3m. The CoM above the Mean Sea Level (MSL) is 7.0m. This shows that an additional load of 700 tons is possible in this model until the immersion depth reaches 50% of module height.

Outstanding issues
During the predesign of the cargo streams of the O&M hub some questions arose which could have an immense influence on the design work. Especially the maintenance regulations and the need of parts highly depends on the type of turbine. Also, the requirements given by the turbine supplier determine the basic data for the dimensioning of structures and processes.

2. Farming

Aims
The platform application of Farming@Sea aims to develop sustainable aquaculture process chains for several aquaculture activities, including the culturing of microalgae, seaweeds, mussels, fish and integrated systems (IMTA). A floating island may be used exclusively for aquaculture purposes, or may aquaculture may be integrated with other applications, including transport and logistics, living at sea, and the use as an energy hub.
Products will be considered that will be brought to the ("global") market. Additionally, products may be supplied to the local community of the floating island, assuming it will be inhabited.

Production process
Several steps in the production process can be distinguished, including:
- Installation of culture systems
- Stocking / inoculate culture systems with organisms
- Feeding and maintenance activities
- Harvesting
- (Pre-)processing
- Storage
- Transporting
- Producing end-products
- Bring to the market

Cargo & Cargo Streams Specific for Farming@Sea
For each process step as described above, human capacity, infrastructure, goods, technology and finances are required. This implies that several cargo and cargo streams can be identified for each process step and its requirements.

Several options for aquaculture are possible to apply at floating islands, and most promising business cases yet need to be selected for further elaboration. Therefore, no information on cargo and cargo streams can be quantified yet, but can, however, be qualitatively described.

Several configurations of aquaculture systems are possible:
1. On top (on deck) of the floating modules;
2. In between the modules (in open spaces within the island);
3. In modules with open space;
4. Outside the floating modules, either connected to it, or independent.

Regarding operations and working personnel, a floating island may be used in different settings:
1. The floating island can be used like a ship, i.e. it will serve as a working space that enables operations needed for stocking and harvesting;
2. Some processing can take place on the floating island, including preparations for installing equipment (nets, ropes, cages, PBR-collectors ...), stocking of systems (with small fish, seaweed, microalgae etc.), and processing of harvest (e.g. cleaning, drying, extraction, etc.) to (semi)finished products;
3. Aquaculture systems (including also microalgae cultivation systems) will used that require full time control by trained personnel.

For the description of cargo and cargo streams, we will consider the latter setting, assuming a most comprehensive lay out of aquaculture applications. This would provide a long list of potential cargo and cargo streams.

Specific platform cargo, cargo storage and cargo handling equipment for Farming@Sea

Installation of culture systems	Cranes, synthetic pools/tanks (on-deck culture systems), nets, lines, pumps, compressors, water filter system (both inlet and outlet water), oxygen generator / supply system, CO_2 supply system, tubing system for liquid streams
Stocking / inoculate culture systems with organisms	-
Feeding and maintenance activities	Feeding equipment / installation(s), storage of feed (tanks), workshop with equipment
Harvesting	Cranes, centrifuge, pumps
(Pre-)processing	Cooling equipment (0-4°C), drying (seaweed)
Storage	Freezer, coolers, containers
Transporting	Crane, (freeze/cool) containers

Table 18 Farming@Sea specific cargo related equipment

Farming@Sea cargo streams between shore and platform

Relevant processes:

- Feed and stocking (of culture organisms)
- Maintenance consumables (such as chemicals, gases)
- Harvest (organisms and/or (pre-)processed products derived from organisms
- Transport of juveniles to farming facilities

Cargo streams between platform and Farming@Sea area (if outside of platform)

Relevant processes:

- Installation / maintenance: nets, lines, floats, mooring system(s), flexible floating tubing modules
- Feed and stocking (of culture organisms)
- Harvest: organisms and/or (pre-)processed products derived from organisms
- Transport of juveniles to farming facilities in sea (fish and other farming organisms)

3. Living

The platform application Living@Sea aims to develop quality living space offshore whilst creating value to a specific economy specifically society (and ideally also the environment). Depending on the final design, the concept will entail different building blocks focusing on different needs of the future inhabitants. The final design however is dependent on the final location of Space@Sea. Two scenarios are possible:

1. With a project location near the shore, Living@Sea could serve as an extension of an already existing city. Near shore, the concept could help existing cities to deal with a challenge that increasingly challenges European coastal conurbations; namely how to combat space scarcity. Space scarcity can be induced by many aspects and measured in various ways. The main drivers are economic and demographic reasons as well as natural hazards and climatic trends. As extension of one of the many European coastal cities that already now or within their near future will need to act accordingly (see location analysis in WP7), Living@Sea could fulfil its primal assignment of providing value to a local economy/society by creating additional affordable living space.

2. A "people will follow work" scenario focuses on providing attractive living space for offshore personnel as by instance for the offshore personnel of the concepts Logistics@Sea, Farming@Sea or Energyhub@Sea. Here value will be created to the offshore industry itself by reducing transportation costs of the offshore workers for going on and off every 2-3 weeks but also for the workers itself. As offshore work places, usually are in noticeable distance from existing civilization the idea is to create quality living space where work already exists. This follows the historic way of how cities emerged. By instance London (GB), but also Amsterdam (NL) emerged from their previous function as trading centres/port cities to some of the most important European cities of our 21st century. In this scenario, the dimensioning of Living@Sea could start off from the number of offshore personnel required by the function it should be combined with, namely Logistics@Sea, Aquaculture@Sea or Energyhub@Sea and extrapolated to a concept where the living quarters are foreseen to entail space and facilities for a family's everyday life.

The difference certainly lays in the fact that to be inhabited land does not exist yet as well as that essential facilities cannot be put up by the workers or families itself but need to be designed by external forces. This fact imposes many risks and challenges on the project.

Taking these aspects into account it becomes clear how important it is to integrate future potential inhabitants into the design process from the very early stages. In this manner, it will be possible to develop design guidelines which provide real added value to the knowledge on how attractive communities until entire cities offshore should be build. To succeed in designing an extendable concept modularity and flexibility of the island and its building components will play a big role in the design. Examples for Living@Sea will be drawn from the organization of already existing successful cities on land. The challenge thus lays in determining in how far the selected location and its climatic and oceanic environment poses restrictions on the concept. The overall aim of Living@Sea is to develop a design which provides attractive and comfortable living space whilst ensuring safety of the inhabitants at any given moment in time.

Cargo & Cargo Streams Specific for Living@Sea

This chapter provides an overview over the required cargo streams of the function Living@Sea. This information gives insights into the main cargo streams which need to be considered when creating a logistic hub in proximity to a living island. Also, it can be used as input for the determination if a combination of Logistics@Sea and Living@Sea would provide an interesting business case.

There are several options available which different functions should be implemented in the Living@Sea concept. These functions are dependent on different aspects such as: The final location of the project, the requirements of future inhabitants, design restrictions imposed by the offshore environment and many more. Different functions will have a different impact on the quantities of the cargo streams. Therefore, information on cargo and cargo streams at this point will be described solely quantitively.

In general, the cargo streams of Living@Sea can be split up into two main phases:

1. cargo streams necessary in the construction phase of the superstructure; and
2. cargo streams for regular port services. The cargo streams required for the set-up phase of the floating platforms itself are excluded from the enumeration.

Supply needs for Living@Sea

Cities are complex socio-technical systems, consisting of different subsystems with intertwined technological and institutional elements. This complexity triggers that cities are in constant need for supplies which can all be back related to the needs of the people that inhabit the space. These fundamental needs are required to support societal goals and entail the same for every human on earth; namely support (e.g. provision of food), protection, affection, understanding, participation, relaxation, expression and freedom.

Some of the activities to sustain these fundamental needs, called the urban services, can be materialized. They create the different layers of the built environment which include:

- superstructure/space
- over ground infrastructure
- technical/physical infrastructure
- data and ICT related infrastructures
- other generic systems (e.g. food system, other materialistic needs)

These layers in turn evolve in a range of supplies which are necessary to our concept Living@Sea and imply:

- superstructure/space
  - buildings (building hull, interior/furniture, building systems etc.)
  - machinery/tools/materials for construction/setting up of building blocks
- over ground infrastructure (transportation to move people and freight)
  - mode of transport of people and goods (bike, car, busses, lorries, boats etc.)
  - infrastructure (roads, cargo hub, harbour, helideck etc.)
    - partly possible to be covered by combining Living@Sea with Logistics@Sea
  - fuel etc. to carry out services and maintain services (such as public and private transport)
  - maintenance tools and replacement material
- technical/physical infrastructure
  - energy system (electricity, gas, direct and indirect energy carriers)
    - constant energy supply (possibility to be covered by combining Living@Sea with Energyhub@Sea)
  - water system (supply related water flows e.g. drinking, secondary or waste water)
    - fresh water (drinking water, toilet water etc.)
  - waste and waste water treatment/sanitation infrastructure
    - waste collection system for different waste water streams, solid waste fractions (organic and inorganic waste flows, mixed (grey) waste))
    - supply to set-up/operate/maintain waste treatment system
  - replacement material for energy, water, waste systems
- data and ICT related infrastructures
  - technology and hardware provision for data and ICT set up/operation/maintenance
- other generic systems
  - food system Farming@Sea
    - regular food and drink supply
    - other materialistic needs/provision of goods (e.g. medical equipment, safety control equipment, leisure goods, goods for educational system etc.)

As Living@Sea aims at being as close as possible to already existing cities the supply chain of Living@Sea will also be very similar to the supply chain of present city examples. Furthermore, all facilities will need personnel to carry out regular platform services. However, personnel are not included in the above enumeration.

Cargo streams for the people living on the platform

The supply needs of Living@Sea (see Ch.0) can be translated into different cargo streams which will be shown in the following. The combination of Living@Sea with Logistics@Sea in the form of a cargo terminal proves to be interesting as a cargo hub provides effective transportation for cargo to load and unload the import and export goods required for Living@Sea. Moreover, a cargo port could provide additional storage space for replacement/maintenance elements of the different buildings, energy, water waste as well as other generic systems such as the food system. The time span and with it the necessary storage capacity will, depending on the distance of the location to the shore as well as the local climate and wave condition, vary greatly.

Overall, Living@Sea will experience less cargo streams than a normal city due to the focus of its function on accommodation space. This excludes supply needs and a flow of goods for primary production, secondary processing, raw materials and the generic industry. In general Living@Sea will be dependent on imports from the closest civilization as the concept itself is not expected to produce goods in the proper sense.

Two different cycles for supply needs can be determined for Living@Sea. At the beginning of the project in the construction phase the cargo hub will experience an increased usage and highest loads of Living@Sea as machinery and prefabricated elements must be imported to set up the island. Therefore, it must be kept in mind that a logistic hub needs to be dimensioned accordingly. In the running operation of Living@Sea the cargo streams will be fewer and will primarily focus on the provision of goods needed to keep the water, waste, energy, ICT and food system going.

Prospective Living@Sea cargo streams:

- superstructure/space
  - shipping of building elements/materials/machinery/vehicles/tools/equipment to Space@Sea, transport of goods from cargo port to Living@Sea, building/operation/maintenance of the units/designed urban spaces
  - machines for installation (e.g. crane vessels (C/V), offshore construction vessels (OCVs) etc.)
  - storage area
    - refilling replacement/maintenance of building elements/materials
    - filling up/exploitation of storage space for ground infrastructure, technical/physical infrastructure, other generic systems etc.
- over ground infrastructure (transportation to move people and freight)
  - import of transport modes of people and goods Logistics@Sea (e.g. private (car, bike), shuttle vehicles to the shore (e.g. waterbus, transportation ship, etc.))
  - import of components to construct infrastructure (e.g. roads, cargo hub, harbour, helideck, etc.)
- technical/physical infrastructure
  - energy system
    - import of energy system/components for setting up/operation/maintenance of own energy system (possibility that it will be (partly) covered by combining Living@Sea with Energyhub@Sea)
  - water system
    - components for setting up/operation/maintenance of the water system
  - waste and waste water treatment/sanitation infrastructure
    - components for set up/operation/maintenance/of waste and waste water treatment system
- other generic systems
  - food system (partly possible to be covered by combining Living@Sea with Farming@Sea)
    - regular (weekly) import of food and drinks
  - other materialistic need/provision of goods
    - import of goods for medical equipment, safety control equipment, leisure goods, educational system, etc.

Annex 3 Port of Constantza details

The Port of Constantza is located at the crossroads of the trade routes linking the markets of the landlocked countries from Central and Eastern Europe with the Transcaucasus, Central Asia and the Far East. It is the main Romanian port on the Black Sea, playing a highly important role as the transit node for the landlocked countries in the Central and South-East Europe.

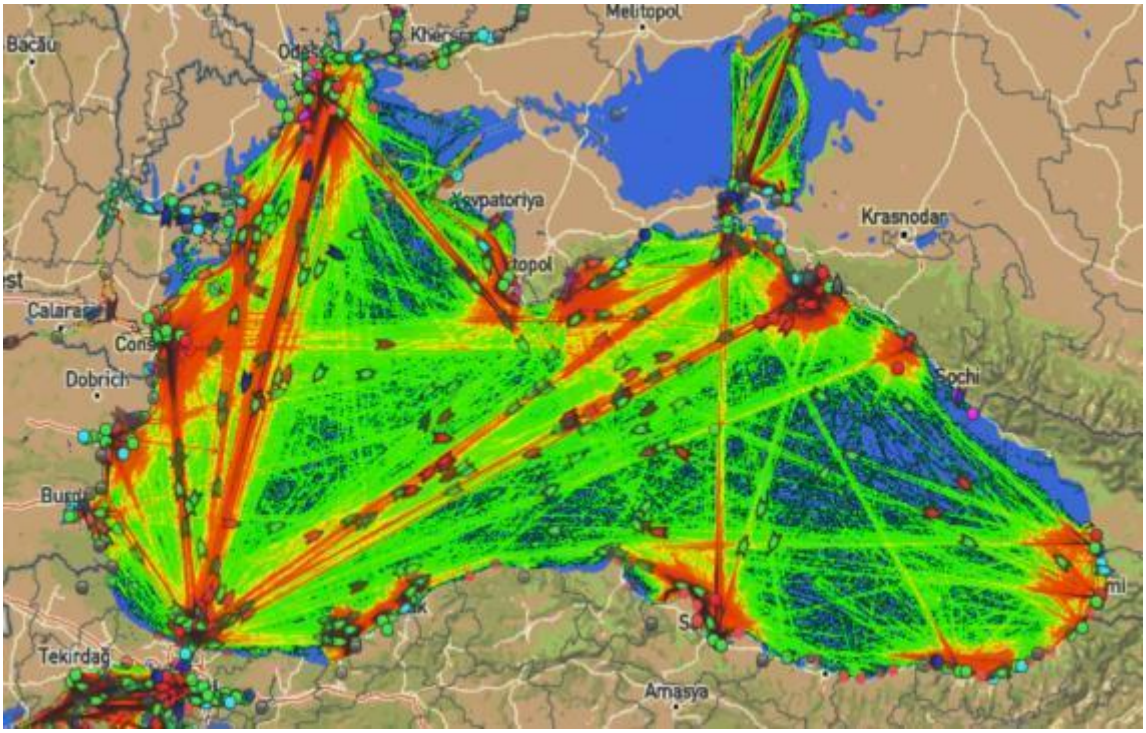


Figure 23 Shipping routes in Black Sea, using traffic density in the period 2015-2016

Colour code:

- Red – very high shipping density
- Orange-high shipping density
- Yellow-Average density of sea traffic
- Green-Low Density of Maritime Traffic

Constantza Maritime Port

The main key points of Constantza as a maritime port:

- A hub for the container traffic in the Black Sea.
- A hub for cereals in Central and South-East Europe.
- Good connections with all means of transport: railway, road, river, airway and pipelines.
  - Pan European IV Transport Corridor
  - Pan-European VII (Danube) Transport Corridor
  - Pan European IX Transport Corridor
  - TRACECA Corridor
- Modern facilities for passenger vessels.
- Land availability for future expansion.
- Starting January 1st, 2007, the Port of Constantza has become a port with Customs facilitations.
- These characteristics are comparable with those offered by the most important European and international ports, allowing the accommodation of tankers with capacity of 165,000 dwt and bulk-carriers of 220,000 dwt.

Constantza River Port

The port is 85nM from the Danube's mouth by the sea and is also linked to it by the Black Sea- Danube Canal, being a transhipment point for the cargo sent from or bound to the landlocked countries in Central and Eastern Europe, which represents one of the main key points of Constantza Port. Due to low costs and important cargo volumes that can be carried, the Danube is one of the most advantageous modes of transport, an efficient alternative to the European rail and road congested transport. The Port of Constantza has a dedicated barge terminal in the Southern part, close to the connection with the Danube.

Port Connections, Rhine – Danube Core Network Corridor

Section: Wien/Bratislava–Budapest–Arad–Braşov/ Craiova–Bucureşti–Constanţa–Sulina.
This corridor will provide the main east–west link between continental European countries, connecting France and Germany, Austria, the Czech Republic, Slovakia, Hungary, Romania and Bulgaria all along the Main and Danube rivers to the Black Sea by improving (high speed) rail and inland waterway interconnections.

Figure 24 Trans-European Transport Network (TEN-T)

Railway Connection

The port offers direct access from every terminal to the national and European railway network, through its own 300 km long railway system. Improvement works on the railway line between Constantza and Bucharest will ensure competitive transit times, providing easier access to the Central European markets. The three main priorities at the core of the Danube Strategy are:

1. Transport
2. Environment
3. Economic Development

Hinterland

The hinterland of Constantza Port supports the port regarding the produced, consumed and forwarded goods to/from the port. It includes a vast region in the Central and Eastern Europe. During the last decade, the Port of Constantza efficiently served the flows of goods that arrive or depart from/to the Central and Eastern Europe, including: Austria, Czech Republic, Slovakia, Hungary, Serbia, Bulgaria, Moldova and Ukraine. Although many political and economic changes have taken place in this area and have influenced its evolvement significantly, the traditional transport routes using the Port of Constantza have remained unchanged, due to the competitive advantages of the port.

The economic growth recorded during the last years in the Central and Eastern Europe countries entitles Port of Constantza to act as the main depositing and distributing centre for this region. The Port of Constantza is a multimodal transport centre for any type of cargo and an important trade gateway for the Central/Eastern Europe and for the Black Sea Countries. The integration within the national and European transport networks makes the Port of Constantza the perfect choice for the cargoes dedicated to the landlocked countries located at the heart of Europe.

Infrastructure Development, Project to be submitted for financing under Large Infrastructure Operational Programme 2014-2020 (LIOP)

To ensure safe navigation conditions for ships in the port of Constantza, N.C. Maritime Ports Administration S.A. Constantza has promoted an investment regarding dredging works for the designed depth of port basins and channels in the port of Constantza, increasing the depth of the "work port" and its access fairway, located in the Constantza South Port and dredging at berths:

- Infrastructure works for the development of specialized terminals in Constantza Port South;
- Expansion to 4 lanes of the road between Gate 7 and the junction of "Road Bridge at km 0+540 of the Danube-Black Sea" objective with the road connecting Gate 9 and Gate 8 towards the Northern part of Constantza Port;
- Extension to four lanes of the road between Gate No. 10 and Gate no. 10bis and systematization of area behind Gate no. 10 of Constantza Port;
- Modernization of energetic system in the Port of Constantza;
- Modernization of water and sewage system in the Port of Constantza;
- Development of a specialized berth in a high depth zone (Berth 80);
- Doubling the railway between Agigea Lock and Port Constantza South and systematization of the coupling point at Agigea Lock;

Future projects included in the Port Masterplan after 2020 (to be funded under operational programme)

- Road bridge across the link canal (Flyover)
- Development of artificial Island in the Port of Constantza
- Development of LNG Terminal in the Port of Constantza
- Wind power plant in the Port of Constantza
- Barge Terminal - Second Stage
- LNG bunkering station at Berth no. 99

Project submitted under Connecting Europe Facility - Transport (2016 Call)

The objective of the project is to Protect - Upgrade the infrastructure and the environment in the Constantza Port.

Projects submitted under other European programmes

- CIVITAS PORTIS project
- DAPHNE - Danube Ports Network (Danube Transnational Programme)

Port Statistics

Traffic

CARGO	TONS
Liquid Bulk	13,662,917
Dry Bulk	35,189,409
Containers	6,897,354
General Cargo	3,675,141
TOTAL	59,424,821

Table 19 Total Traffic by Category

TONS	YEAR					
	2011	2012	2013	2014	2015	2016
Maritime Calls	4,872	5,057	4,833	4,771	4,605	4,331
River Calls	8,074	9,405	9,280	10,053	9,765	10,185
TOTAL	12,946	14,462	14,113	14,824	14,370	14,516

Table 20 Ship Calls

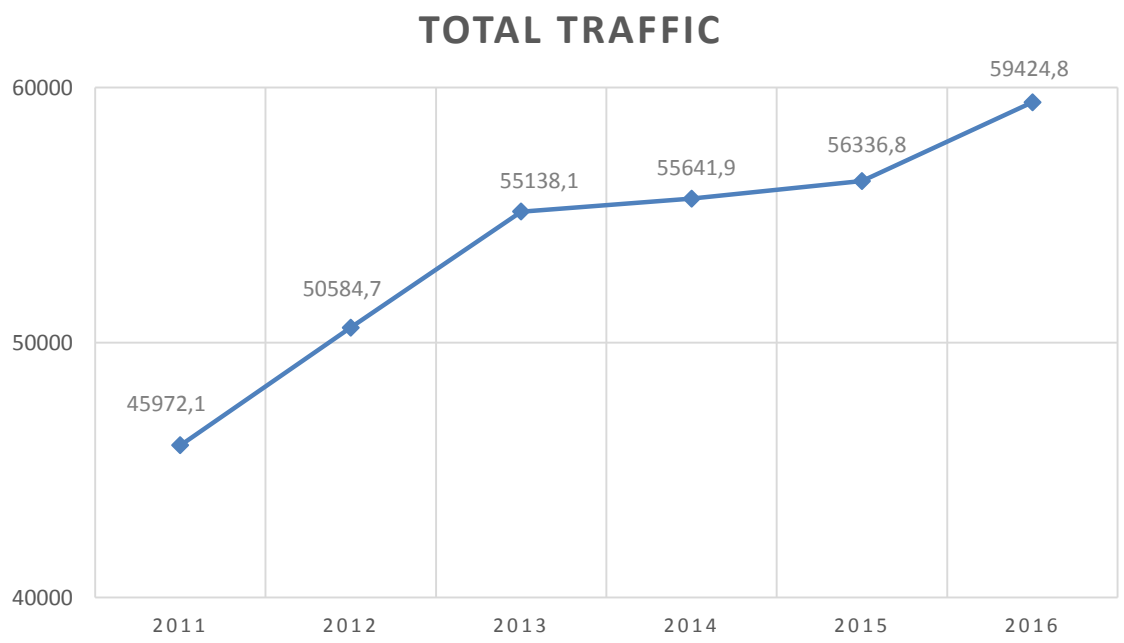


Figure 25 Total Traffic (Thousand Tons)

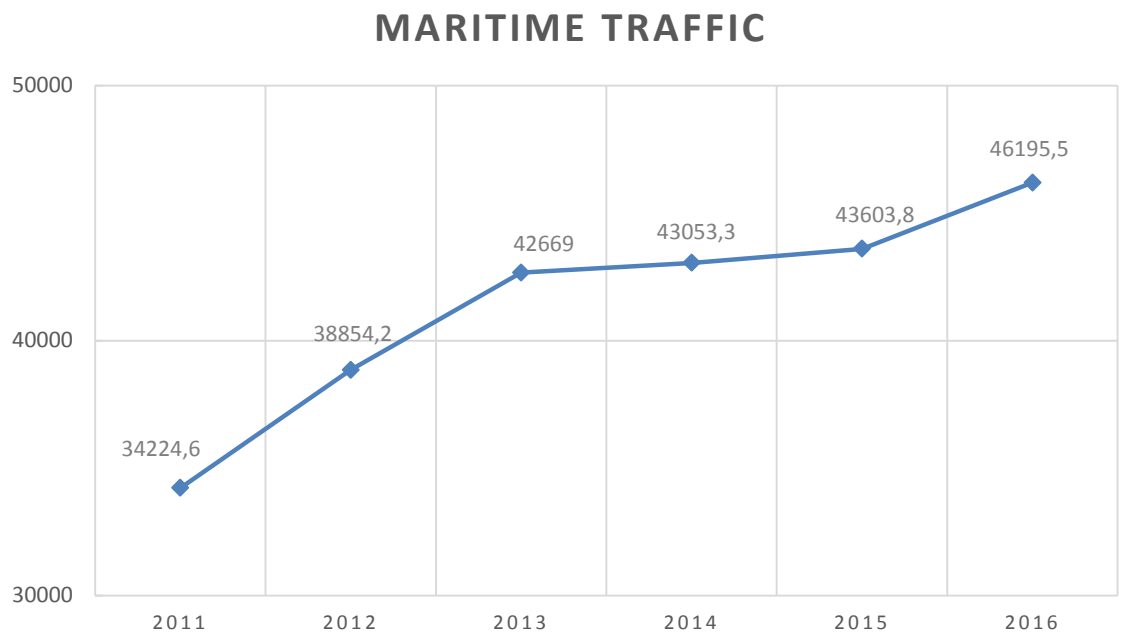


Figure 26 Maritime Traffic (Thousand Tons)

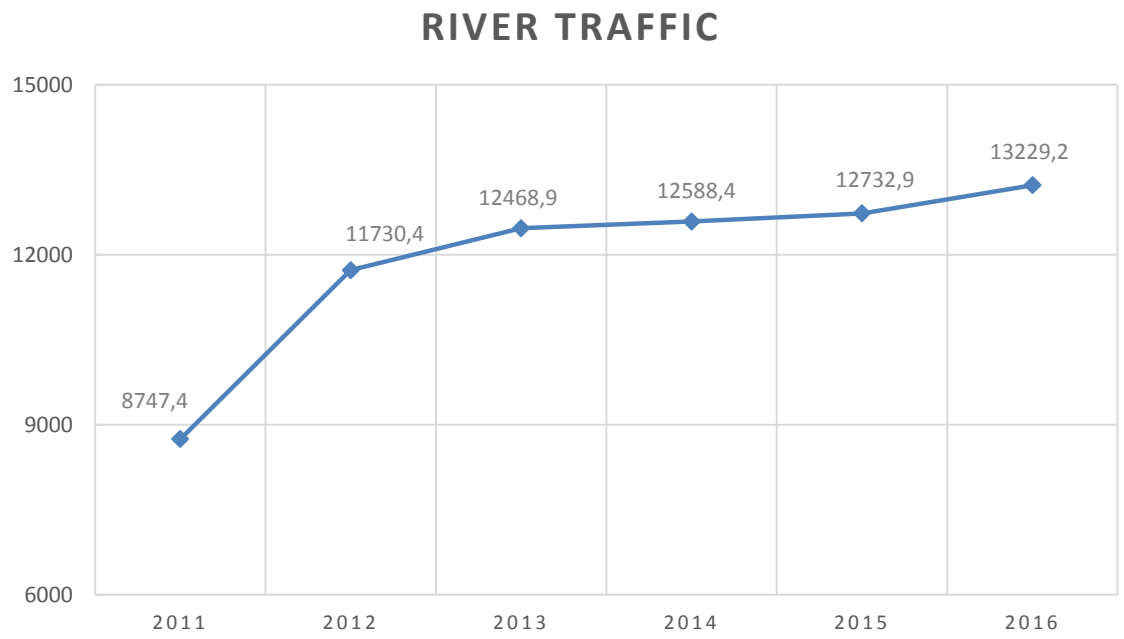


Figure 27 River Traffic (Thousand Tons)

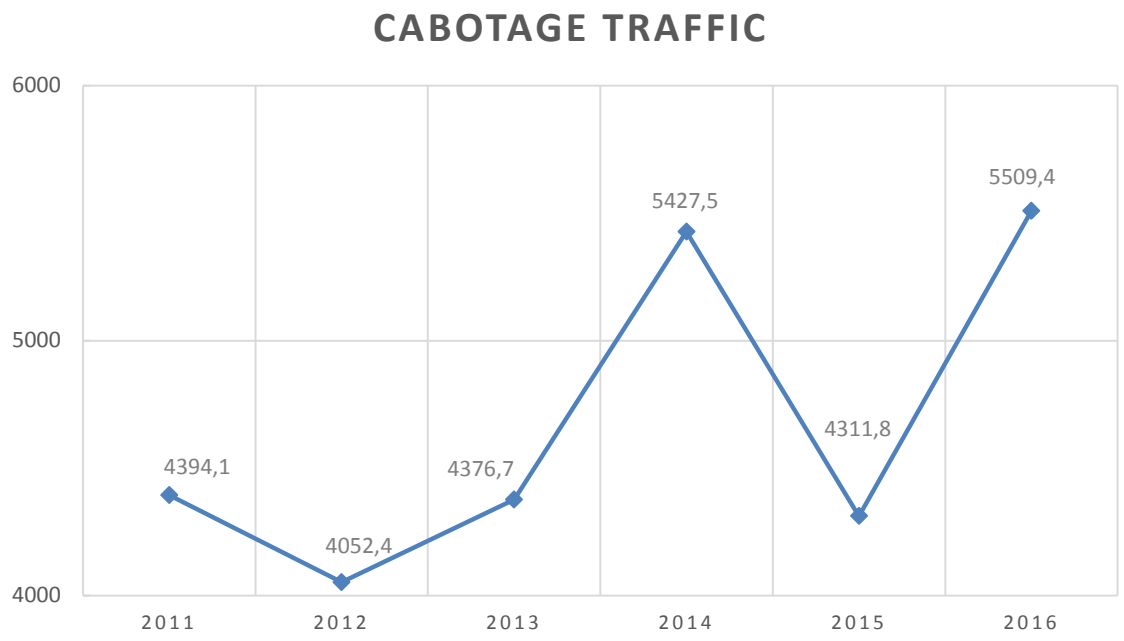


Figure 28 Cabotage Traffic (Thousand Tons)

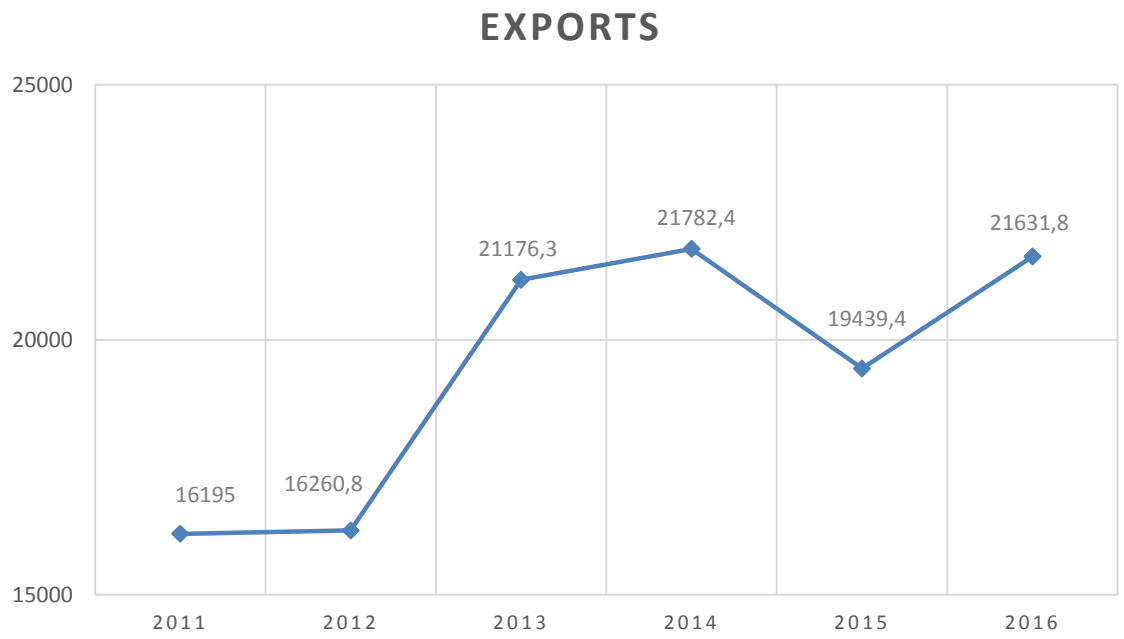


Figure 29 Exports (Thousand Tons)

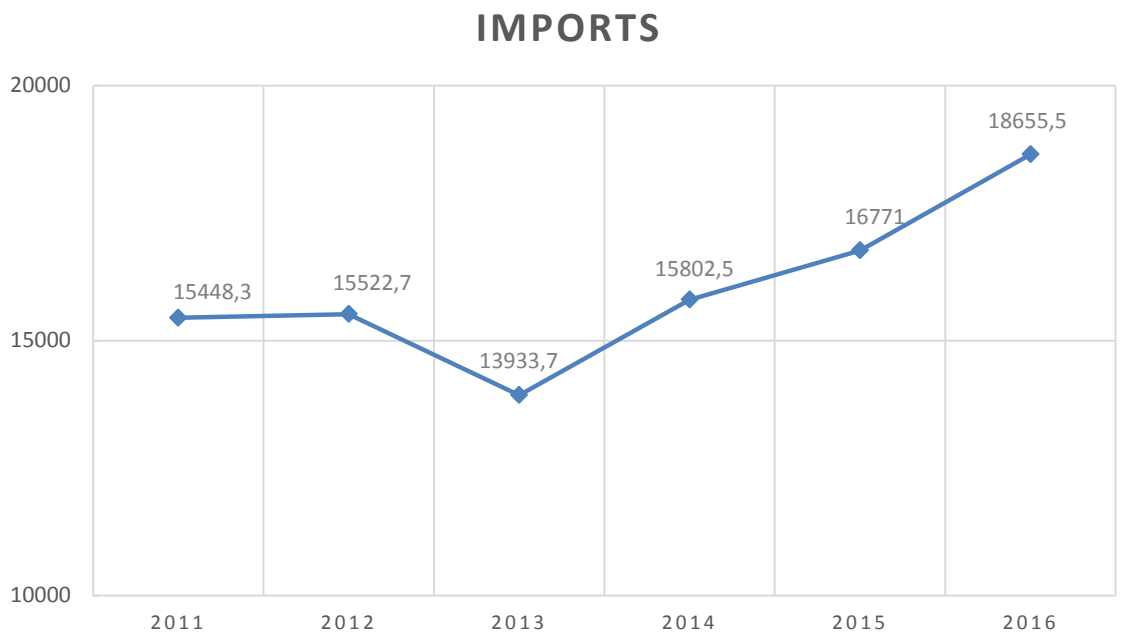


Figure 30 Imports (Thousand Tons)

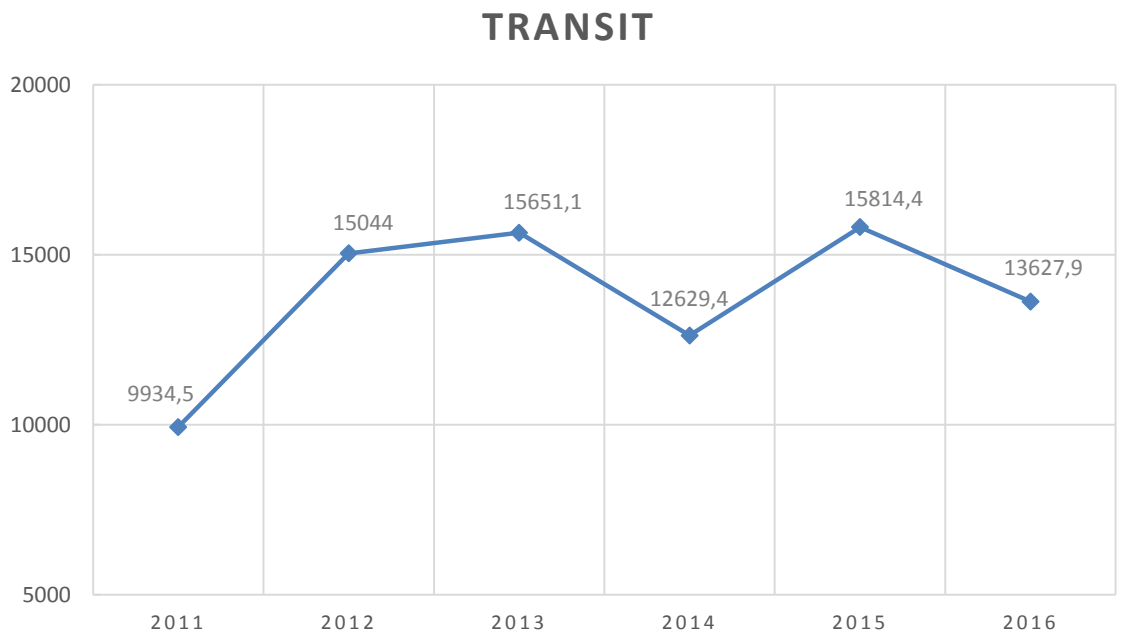


Figure 31 Transit (Thousand Tons)

Containers

	YEAR					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Containers	414,096	423,081	399,372	408,990	420,793	434,439

Table 21 Containers (Units)

	YEAR					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Unloaded	2,997,224	2,988,931	2,656,498	2,775,710	2,875,364	3,315,696
Loaded	3,520,443	3,691,176	3,886,856	4,003,174	3,992,200	3,858,558
TOTAL	6,517,667	6,680,107	6,543,354	6,778,884	6,849,564	7,174,254

Table 22 Containers (Tons)

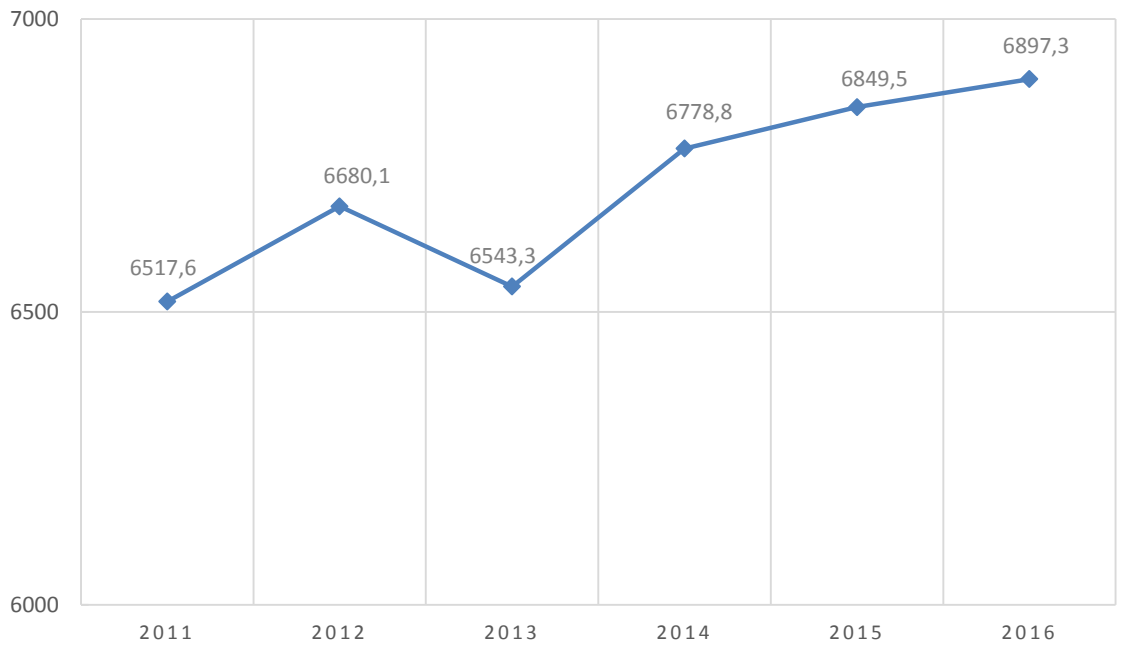


Figure 32 Containers (Thousand Tons)

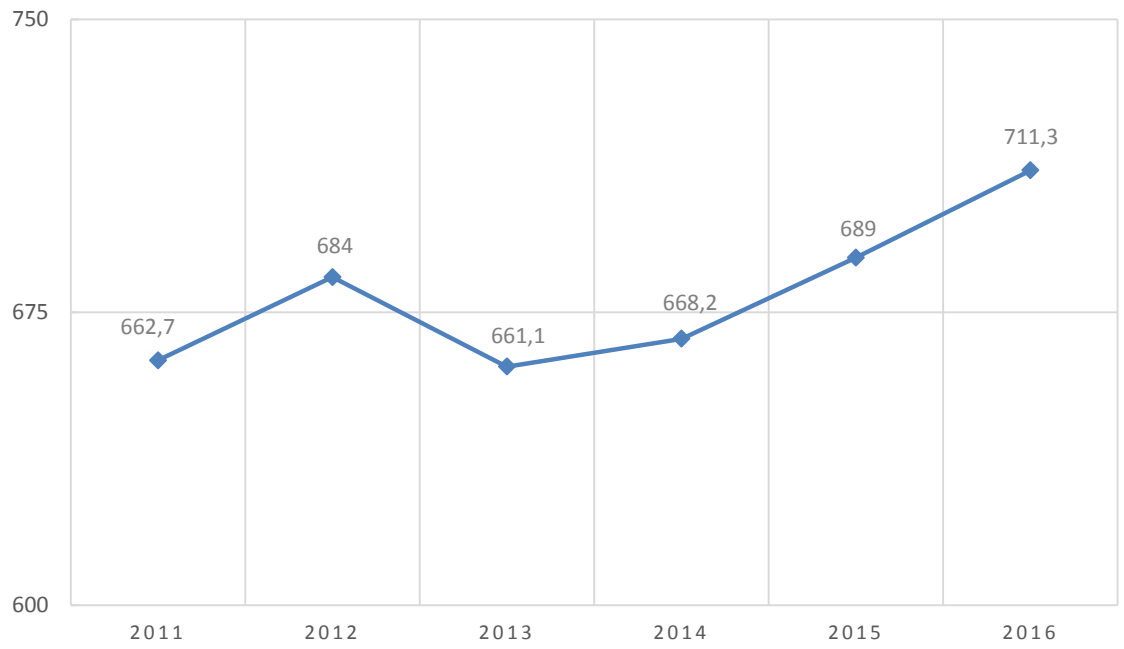


Figure 33 Containers (Thousand TEU's)

Ships by type

TONS	YEAR					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Cargo	2,879	2,692	2,525	2,143	1,971	1,812
Passenger	44	52	68	95	37	17
Port container	577	651	579	578	610	684
Tank	632	673	636	719	668	665
Bulk Carrier	401	439	533	555	589	607
Others	341	550	492	681	730	546
TOTAL	4,874	5,057	4,833	4,771	4,605	4,331

Table 23 Arrivals of Sea-Going Vessels by Type of Ship

	YEAR					
	2011	2012	2013	2014	2015	2016
Cereals	9,534,972	12,628,340	15,261,789	17,420,547	19,616,118	20,393,803
Cellulose and waste paper	7,639	25,832	45,684	63,451	65,189	78,058
Cement building materials	328,160	547,769	349,422	265,413	140,997	169,874
Chemical products from coal/tar	115,487	131,411	134,144	72,962	108,478	102,331
Solid mineral fuels	3,151,964	3,504,331	2,890,793	2,157,731	3,207,635	2,226,771
Crude oil	5,534,289	5,042,697	5,396,525	6,750,866	6,593,434	7,487,357
Food stuff and animal feed	525,758	497,245	563,137	416,089	764,390	796,547
Glassware and ceramic products	38,591	64,588	48,740	8,066	2,001	2,959
Iron ores scrap	4,731,028	6,888,094	9,676,268	5,501,674	2,750,024	2,594,201
Leather textile / other products	64,825	172,811	398	0	0	0
Livestock sugar beet	22,817	49,245	64,993	58,690	61,382	93,299
Machines transport equipment	355,904	369,418	437,955	365,651	363,638	356,800
Metal products	2,189,071	1,871,458	1,593,497	1,888,533	2,062,785	2,047,544
Metalwork	1,558	2,833	7,485	5,124	429	3,545
Miscellaneous	6,529,296	6,958,497	6,544,679	6,782,263	6,850,355	6,897,358
Natural and chemical fertilizers	2,015,114	2,153,597	1,763,452	1,742,245	1,842,646	2,927,072
Non-ferrous ores and scrap	2,609,918	2,643,509	2,325,828	2,551,646	3,109,993	3,158,060
Oil products	3,600,332	3,999,621	3,820,247	4,714,318	5,165,550	5,653,512
Oil seed oleaginous fruits/fats	1,932,248	736,300	1,932,875	2,478,251	1,951,341	2,918,535
Other chemical products	1,484,861	1,029,540	906,680	1,151,105	525,026	619,988
Potatoes other fresh vegetable	38,062	20,604	15,171	11,734	6,488	5,696
Raw or processed minerals	218,748	318,400	304,694	316,140	293,295	334,379
Wood and cork	941,453	928,522	1,053,601	919,411	855,578	557,132
TOTAL	45,972,095	50,584,662	55,138,057	55,641,910	56,336,772	59,424,821

Table 24 Cargo Type (Tonnes)

Passenger traffic

	YEAR					
	2011	2012	2013	2014	2015	2016
Passengers	23,878	34,010	54,226	64,861	35,574	8,629
Passenger Vessels	43	52	68	95	37	17

Table 25 Passenger Traffic

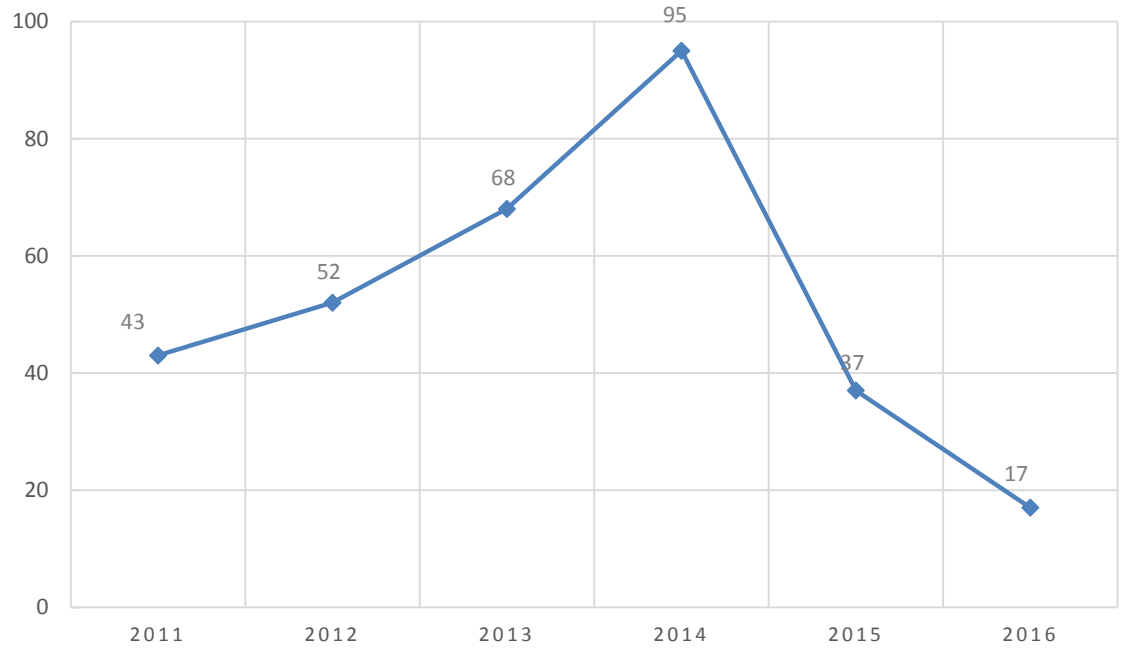


Figure 34 Passenger Vessels

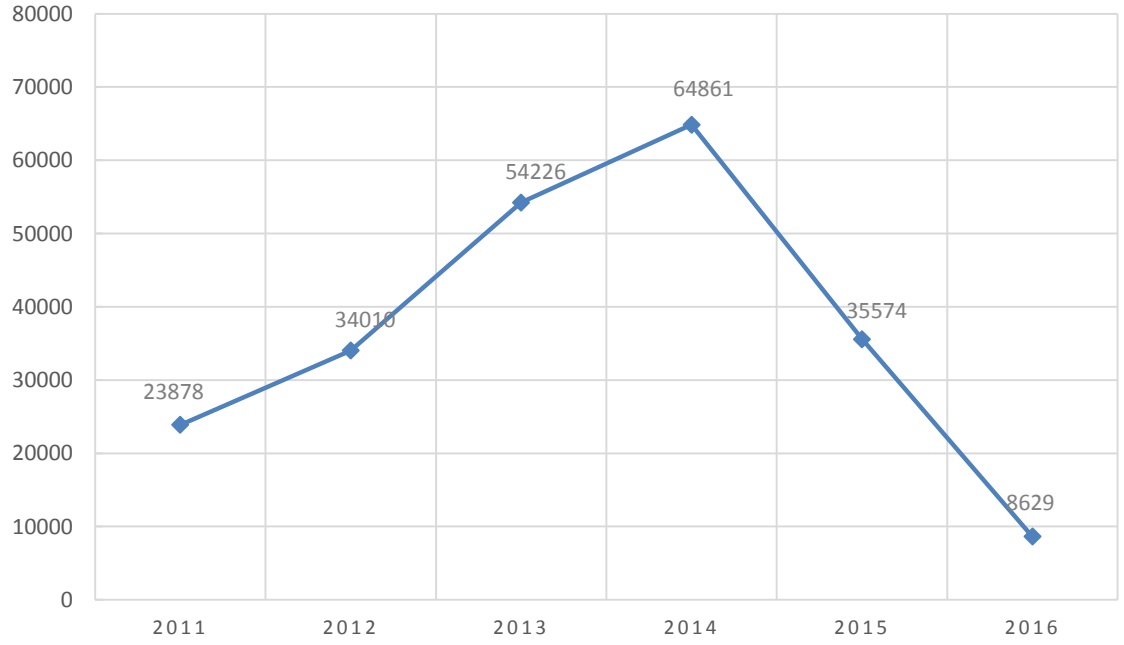


Figure 35 Passengers

Annex 4 Trans-European Transport Network (TEN-T) Corridors

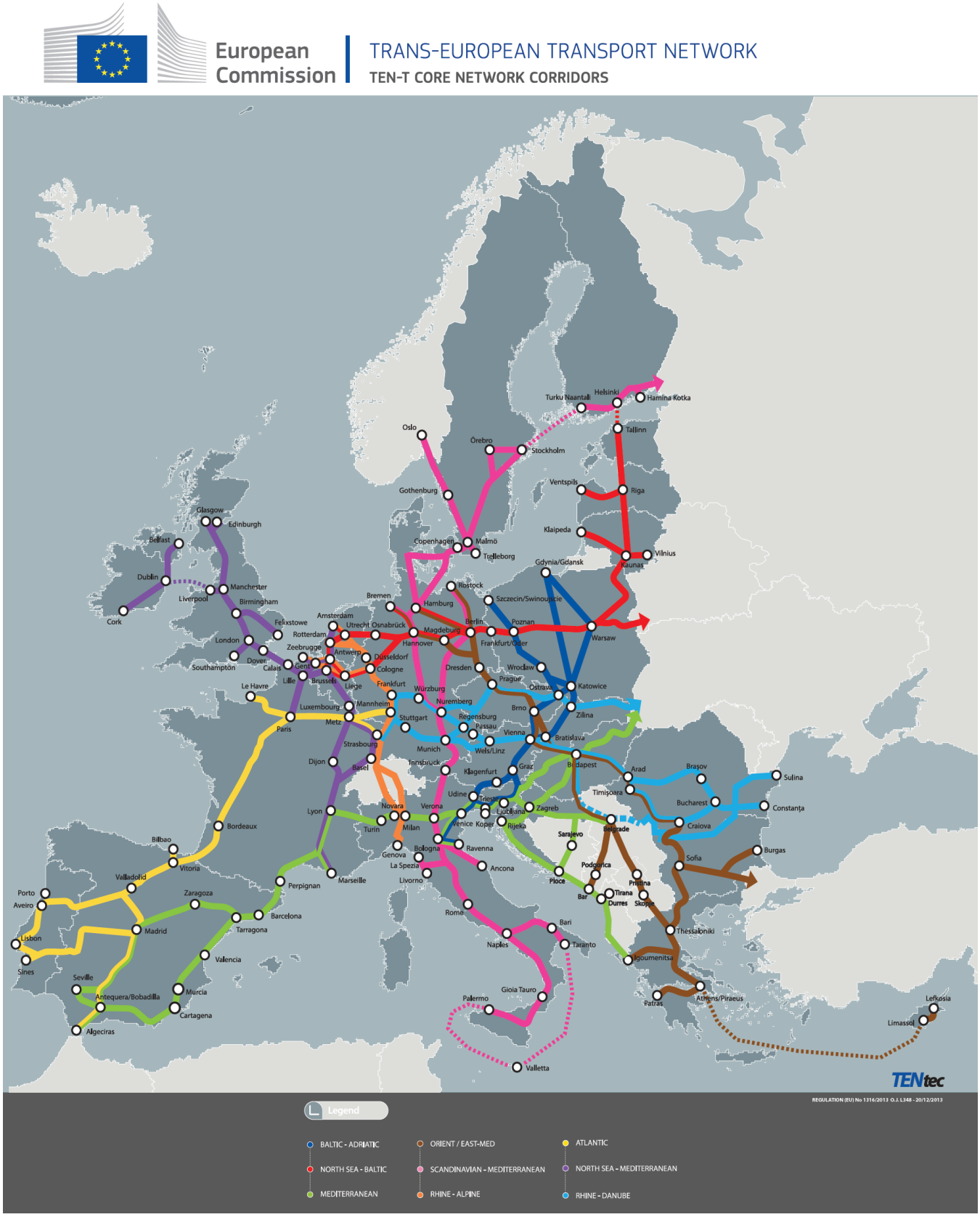


Figure 36 Trans-European Transport Network (TEN-T) Corridors