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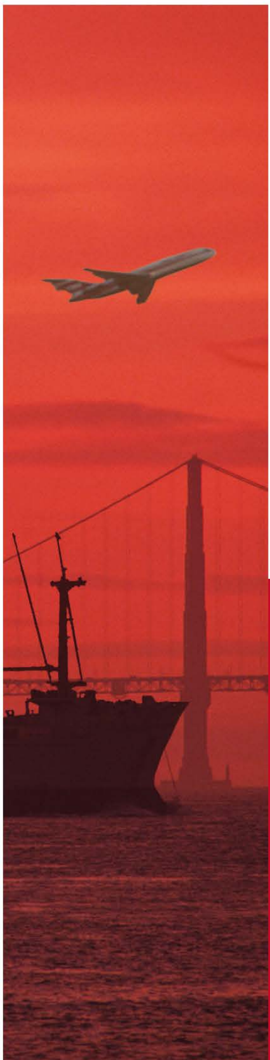

Agriculture and Rural Development

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Research for TRAN Committee - The EU Maritime Transport System: Focus on Ferries

STUDY

EN

2016

European Parliament

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STUDY

This document was requested by the European Parliament's Committee on Transport and Tourism.

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LINGUISTIC VERSIONS

Original: EN

ABOUT THE PUBLISHER

To contact the Policy Department or to subscribe to its monthly newsletter please write to: poldep-cohesion@europarl.europa.eu

Manuscript completed in November 2016.

Print	ISBN 978-92-823-8807-5	doi:10.2861/65075	QA-02-16-176-EN-C
PDF	ISBN 978-92-823-8806-8	doi:10.2861/657769	QA-02-16-176-EN-N

This document is available on the Internet at:
http://www.europarl.europa.eu/supporting-analyses

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Abstract

This study provides a concise overview of passenger ferries as part of the EU Maritime Transport System, focussing on their role in contributing to multimodality. It outlines the ferry industry from a wide perspective, with analysis across spatial scales, from urban to long distance, and with respect to its implications within an economic context. Technological developments and innovations are addressed in view of applicable environmental Regulations.

IP/B/TRAN/IC/2016-022 2016

PE 573.423 EN

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SPECIAL ACKNOWLEDGEMENT

The authors of the study gratefully express their appreciation to Shippax for using the data of the ferry industry, reported in the referenced publications.

LIST OF ABBREVIATIONS

BWM	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CEF	Connecting Europe Facility
CIN	Compagnia Italiana di Navigazione
CNG	Compressed Natural Gas
CNIT	Conto Nazionale delle Infrastrutture e dei Trasporti
CO_2	Carbon Dioxide
cst	Centistoke
DMA	Danish Maritime Authority
DNV	Det Norske Veritas
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECA(s)	Emission Control Area(s)
ECG	Association of European Vehicle Logistics
EEDI	Energy Efficiency Design Index
EMSA	European Maritime Safety Agency
EP	European Parliament
EPRS	European Parliament Research Service
EU	European Union
GHG	Greenhouse Gas
GT	Gross tonne
HAM	Humid Air Motors
IFO	Intermediate Fuel Oil

IGF International Code of Safety for Ships using Gases or other Low-flashpoint Fuels

IMO International Maritime Organisation

INEA Innovation and Networks Executive Agency

ISTAT Istituto Nazionale di Statistica

kWh kilowatt-hours

LNG Liquefied Natural Gas

LSA Life-Saving Appliance

MARPOL International Convention for the Prevention of Pollution from Ships

MDO Marine Diesel Oil

MEPC Marine Environment Protection Committee

MIT Italian Ministry of Infrastructures and Transport

MoS Motorways of the Sea

MSC Maritime Safety Committee

NM Nautical Mile

NO_x Nitrogen Oxide

OECD Organisation for Economic Co-operation and Development

PSC Public Service Contract

PM Particulate Matter

PSO Public Service Obligation

PT Public Transport

Ro-Pax Roll-on/roll-off passenger ship

Ro-Ro Roll-on/roll-off ship

SEEMP Ship Energy Efficiency Management Plan

SNCM	Société Nationale Maritime Corse-Méditerranée
SOLAS	International Convention for the Safety of Life at Sea
SO_x	Sulphur Oxides
TCRP	Transit Cooperative Research Program
TEN-T	Trans-European Transport Networks

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EXECUTIVE SUMMARY

This study analyses the specificities of the ferry industry in the light of European Union (EU) environmental, safety and services provisions in force. Future developments are discussed by addressing key issues such as technological uptakes, congestion reduction possibilities, safety and competition with other infrastructures and services.

The analysis shows that EU maritime passengers are mainly carried by domestic or intra-EU ferry services that are concentrated in three regions: the Baltic, the North Sea and the Mediterranean. The routes operated have remained relatively unchanged over the years; more than half are in the Mediterranean, whose fleet outnumbers the other two regions in terms of both size and capacity, although the ferries are older.

Since 2000, the ferry industry has been undergoing a gradual consolidation and operators have concentrated on their own region only, optimising routes, fleet and exploiting vessels' economies of scale. Overall mediocre performance has been influenced by the abolition of the duty-free regime, competition in the form of fixed links and low-cost airline carriers, and variations in fuel cost. The economic recession hit the ferry industry too, and the current operators' performance usually reflects the situation of the economy of the region where their core business is located. The overall contraction of fleet size and capacity confirms that the industry's development lacks dynamism: newbuilding activities concentrate on fleet renovation, and both the second-hand market and chartering are on the decline.

With regards to technological developments, retrofitting work is experimental and transitional. As soon as propulsion system technologies and equipment prove to be viable to meet the requirements of the Emission Control Areas (ECAs) in the long term, retrofitting may intensify, although building new ferries might be more economical. In this respect, limits for Sulphur Oxides (SO_x) are having an important impact on the ferry industry supply side, especially on technologies relying on Liquefied Natural Gas (LNG), methanol, hybrid and electric power.

However, the actual number of ferries delivered with new propulsion systems and compliant with environmental rules is significantly below initial predictions (Lloyds Register, 2012; DNV, 2013). Abatement technologies (i.e., scrubbers) are developing faster than expected. Technology uptake also involves energy-efficiency measures and the compliance with the International Convention for the Control and Management of Ships' Ballast water and Sediments (i.e., the Ballast Water Management (BWM) Convention), once ratified.

Within the Schengen area, there are no specific checks for EU citizens travelling by ferry. When travelling to non-Schengen EU States, EU citizens have to show ID entering the country at arrival and undergo normal cross-border checks. Before boarding the vessel passengers are normally checked by the ferry operator staff to verify their identity against the details on the ticket purchased (i.e., time, day and connection). Every port is different and ferry operators may conduct checks according to own embarkation processes.

In urban areas, ferries are integrated with land-based Public Transport (PT) operators along critical connections, and they serve a variety of needs. Ferries contribute to multimodality of passengers (i.e., commuters and tourists) and their flexibility to adapt service routes according to the needs is an advantage, especially where fixed links providing access to urban areas are congested. In addition to integrated ticketing, improvements to reliability, speed, frequency, or faster boarding times may be key factors in diverting passengers towards ferries. Ferries operating on a regional, national and international (i.e., cross-border) scale show different characteristics that change according to geographical and economic contexts. The value of a ticket is connected to the pricing policy of the ferry operator and it follows the approach used in the airline market: it is the result of the analysis of competitive prices, elasticity of demand and potential for market segmentation. As part of larger networks, the ferry industry must also cope with developments of infrastructures and services in the form of competition with fixed links and low-cost airline carriers.

KEY FINDINGS

- EU maritime passengers are mainly carried by domestic or intra-EU **ferry services** that are **concentrated in three regions: the Baltic, the North Sea and the Mediterranean**.
- More than **half of the routes are operated in the Mediterranean**, whose fleet **outnumbers the other two regions** in terms of both size and capacity, although **the ferries are older**.
- Since the year 2000, the ferry industry has been undergoing a **gradual consolidation**. The mediocre **overall performance of the ferry industry has been influenced** by the abolition of duty-free regime and variations in fuel cost.
- Ferries also face **competition in the form of fixed links and low-cost airline carriers**.
- Further to the economic crisis, **operators' performance usually reflects the situation of the economy of the region where their core business is located**.
- **The development of the fleet lacks dynamism**. Newbuilding activities may intensify to meet the requirements of Emission Control Areas (ECAs). Actual numbers of ferries with alternative propulsion systems are significantly below initial predictions.
- Technology uptakes also involve **shore side power supply, energy-efficiency measures and compliance with the International Convention for the Control and Management of Ships' Ballast Water and Sediments.**
- **The value of a ferry ticket is directly connected to the pricing policy of the ferry operator.** The calculation of ticket prices follows the approach used in the airline market.
- **In urban areas, ferries provide services along critical connections** and serve a variety of needs. **Their flexibility is an advantage** where fixed links providing access to **urban areas are congested**.
- **Ferries** operating on a regional, national and international (i.e., cross-border) scale **show different characteristics**.

1. INTRODUCTION

The objective of this study is to provide a concise overview of passenger ferries as part of the European Union (EU) Maritime Transport System, focussing on the role they play in contributing to the multimodality of EU transport.

The study provides an outline of the passenger ferry industry from a wide perspective and touches upon topics such as history, relevant statistics and trends, environmental impact and congestion and safety issues. The ferry industry is analysed across spatial scales, from urban areas to long distance shipping, and with respect to implications within the economic contexts in which the ferry industry operates. This study addresses technological developments and innovations in view of the environmental and safety Regulations in force. When changing the scale, the characteristics of both the ferries and the transport demand differ significantly. Ferries in urban areas are integrated within Public Transport (PT) systems and serve mostly passengers, on routes operated with small vessels. In the context of longer distance ferries, transport demand may include both passengers and freight, using larger vessels.

The document is organised as follows.

After a brief history, Section 2 discusses relevant trends regarding traffic volumes, routes operated, fleet evolution and composition, and goes on to present an overview of projects funded with EU grants under the Trans-European Transport Networks (TEN-T) and the Connecting Europe Facility (CEF) programmes.

Section 3 concerns safety aspects related to risks, Regulations and records. An overview of the major safety accidents compares the safety levels of EU and non-EU countries over the last two decades.

Section 4 focuses on technological developments and innovations, especially in the light of compliance with environmental and safety provisions. The topics analysed consider:

- the propulsion systems,
- the countries' green credential,
- the shore side power supply,
- solar and wind energy,
- energy and efficiency measures, and
- the ballast water treatment systems.

Section 5 presents an overview of the ticketing schemes, analysing ferries used in long distance services and in urban areas and at this scale their integration with other Public Transport (PT) modes.

Section 6 enlarges the scope of the analysis to highlight the characteristics of ferries operated on different scales, when they are in competition with other infrastructures and services and the characteristic features of cross-border passenger ferries.

Section 7 concludes the study by addressing the questions which emerged with regards to the EU Maritime Transport System.

The three Annexes in the final part of the document set out tables and figures, according to the order of the previous Sections.

2. THE FERRY INDUSTRY IN THE EU

2.1 Brief history

The construction of the first ferry dates back to 1850, when the "Ro-Ro"[1] ferry pioneer "Leviathan" was designed in Scotland to ship freight wagons across the Firth of Forth[2] to the markets of Edinburgh and southern destinations. Although shaped as a perfunctory-looking craft, the concept was highly innovative, thanks to the ability to move goods in great quantities and with minimal labour. In the early days of the industry, "train ferries" showed the potential of multimodal transport with the railway sector.

Although some examples of "car ferries" are reported in the first half of the twentieth century[3], the ferry industry only took an important step forward during the post-war years. In the late '50s, international tourism benefited from softened passport Regulations which increased opportunities for holidays, and the ferry industry thrived throughout the '60s until the oil crisis which was triggered by the Yom Kippur war (1973).

Increased bunker cost compelled the ferry industry to look for economies of scale and "jumbo ferries" were created to carry greater volumes on fewer keels. The '90s marked another golden period, when ferries looked more like cruise vessels. In the European Union (EU), the abolition of the duty-free regime on intra-EU waters in 1999[4], the completion of new inter-European fixed links and more recently the economic downturn have forced the ferry industry to focus more on transport activities, especially freight, and cease non-profitable services. The trend in fleet design shows an increase of the number of decks for vehicles (i.e., cars, buses and trucks)[5] (Shippax, 2009). "Cruise ferries" with plenty of cabins are no longer in demand. Currently, the industry focuses on "Ro-Pax" operations (Shippax, 2013), which are conventionally defined as a "ferry sailing across open waters, providing regular services between fixed ports, accommodating more than 12 passengers, carrying cars and commercial vehicles (excluding open-deck-only vessels) and having a displacement of more than 1 000 gross tonnes (GT)".

In 2013, the total number of passengers in transit in EU ports was 400 million, in line with the previous year. Unlike the freight sector, in which 60% of goods are unloaded and 40% loaded, the difference between passengers embarking and disembarking in EU ports is small. EU maritime passengers are mainly carried by domestic or intra-EU ferry services: about 58% of maritime passengers are transported between ports within the same country (Eurostat, 2015)[6].

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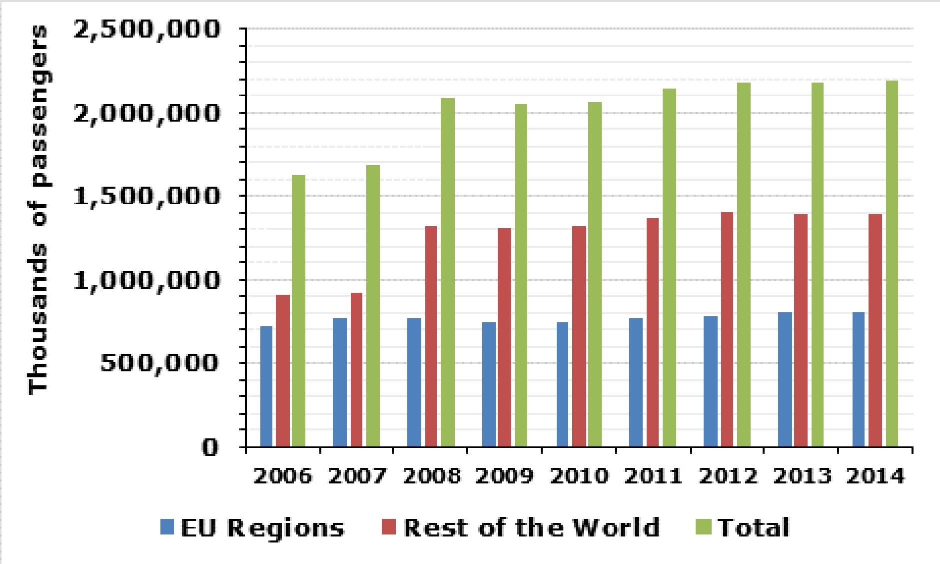
1. "Ro-Ro" is an acronym for Roll-on/Roll-off. Roll-on/Roll-off ships used to carry only wheeled cargo. Vehicles are loaded/unloaded by means of built-in ramps through the stern (i.e., back side), or the bow (i.e., front side) as well as the sides. The first "Ro-Ro" service started in 1946, when a regular service between Tilbury and Rotterdam was operated by the Atlantic Steam Navigation, who chartered three tank landing crafts from the Royal Navy. With the end of the war, tank landing crafts became surplus to requirements of the Navy and it was relatively cheap to start a "ro-ro" service (Shippax, 2007).
2. Coastal water inlet in Eastern Scotland, corresponding to the estuary of the Forth river, which flows into the North Sea.
3. Besides the Turkish "Suhulet" which carried cargo and pack animals on the Bosphorus (1869), there was the Canadian flagged "Motor Princess" (1924), and the European vessels "Artificer" (1928), "Heimdal" (1930), "Djursland" (1934), "Kronprinsessan Ingrid" (1936) and "Peter Wessel" (1937) (Shippax, 2009).
4. Council Directives 91/680/EEC(1) (EC, 1991) and 92/12/ECC(2) (EC, 1992) relate to the abolition of the intra-EU duty-free regime. On 30 June 1999, duty-free shopping was abolished for intra-EU air and ferry travellers (see also EC, 1998a; EC, 1998c).
5. In terms of vehicles, the load capacity of a ferry is measured in lane metres.
6. In general, countries with coastlines, islands and island regions (e.g., Greece, Italy, Spain and Croatia) tend to have connections with both a large volume of maritime passenger transport and a high domestic share. Countries with regular ferry connections to other EU countries, like Belgium, Estonia, Ireland, Latvia, Lithuania, the Netherlands, Poland, Finland, Sweden and UK, tend to have higher shares of intra-EU transport.

2.2 Regions and routes

In Europe, passenger ferries are concentrated in three regions that generate an important share of global traffic, namely the Baltic, the North Sea and the Mediterranean[7] (see Figure 1 below and in Annex I: Table 6 to Table 9 as well as Figure 10 to Figure 12).

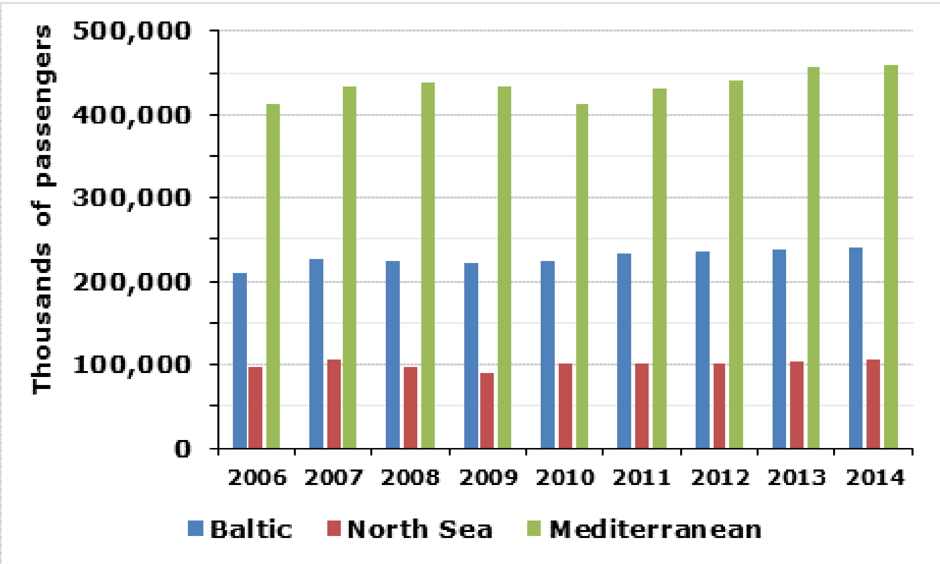
Figure 1: Passengers of ferries traffic volumes worldwide



Source: Elaboration of the authors from Shippax publications

Amongst these, the Mediterranean shows the highest share of passenger volume (see Figure 2 below), while the Baltic region is the top–ranked region concerning vehicles (i.e., cars, buses and trailers) (see Annex I: Table 10 to Table 13 as well as Figure 13 to Figure 15).

Figure 2: Passengers traffic volumes in the EU regions



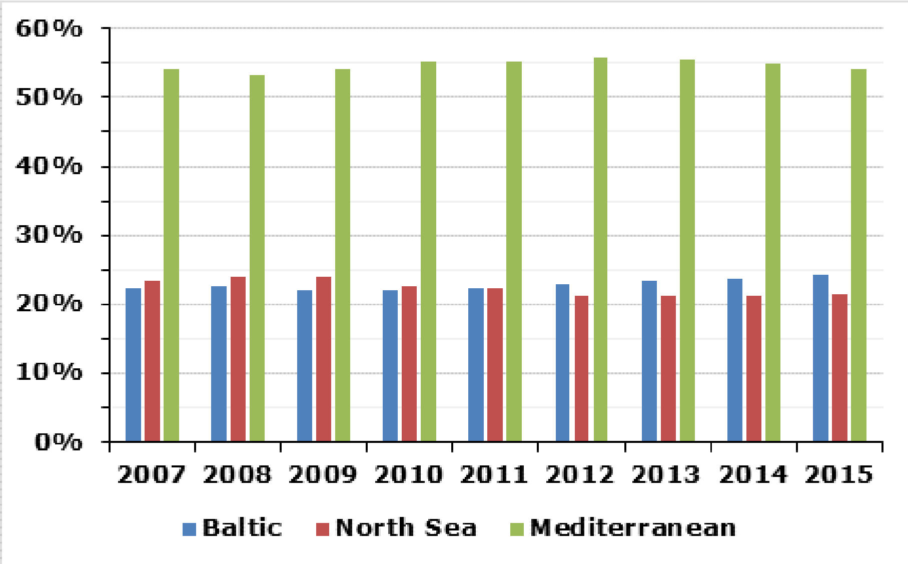
Source: Elaboration of the authors from Shippax publications

7 Outside Europe, ferries are intensively used in Japan. North America shows quite a significant number of ferries, while in the Caribbean there are few. In South America, Africa and Oceania, ferry services are confined to few routes.

For all three regions, the total number of routes operated has remained relatively unchanged over the last few years, with an upward trend that peaked in 2011, followed by a similar decline thereafter (see also Table 5 in Section 6.3.1).

Within the EU, more than half of the routes are operated in the Mediterranean (see Figure 3 below and in Annex I: Table 14). Since 2011, the Baltic region has surpassed the declining trend of the North Sea region (see Annex I: Table 15 to Table 17 as well as Figure 16 to Figure 18).

Figure 3: Shares of routes operated in the EU regions



Source: Elaboration of the authors from Shippax publications

With regards to routes with neighbouring countries, the routes trends in the North Sea and Mediterranean regions remain relatively unchanged. In the Baltic region, the routes between EU Member States and with neighbouring countries have been decreasing, while domestic routes have significantly increased[8].

The reductions of routes between EU Member States in the North Sea and those with EU neighbouring countries in the Mediterranean are exceptions[9].

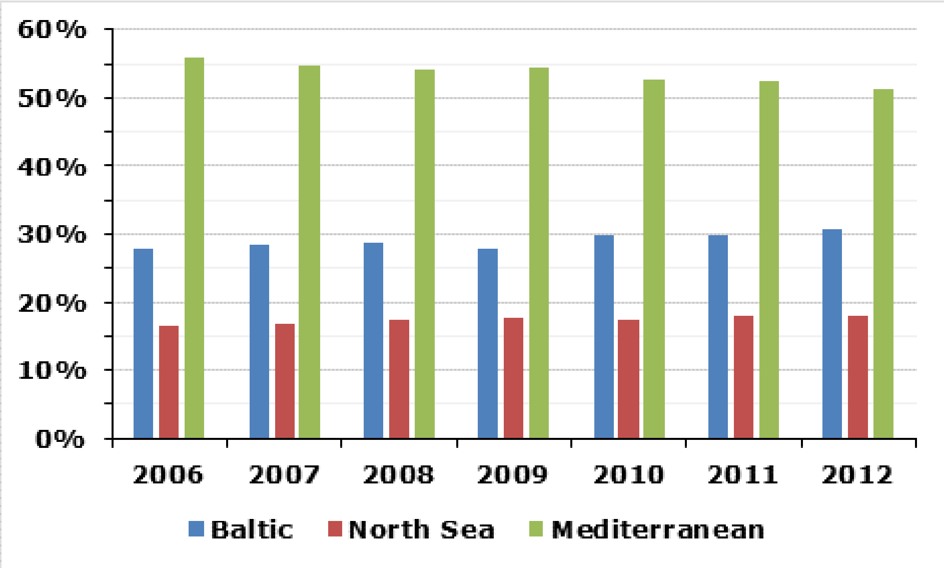
The fleet of the Mediterranean region outnumbers that of the other two regions in terms of the number of ferries, GT, beds and vehicles capacity (see Figure 4 below and in Annex I: Table 18 to Table 21 as well as Figure 19 to Figure 21). On the other hand, the fleet is older: Mediterranean ferries are on average 22 years old (in line with the global figure), while those on the Baltic Sea and the North Sea are 16 and 14 years old, respectively. EU fleet differentiation with respect to route length[10] is consistent with global figures (Shippax, various publications).

[8] Due to increased competition and persisting stagnation of the economy of the region, ferries operations have been optimised (i.e., re-routing) to absorb financial outcomes not in line with expectations. (Shippax, 2015). See also Section 2.3.

[9] They reached a peak in 2011, benefiting from some services operated with North African countries.

[10] Figures on short, medium and long distance ferries refer to the period 2006-2009. Approximately half of the total fleet operates on short distance routes.

Figure 4: Share of the number of ferries amongst EU regions



Source: Elaboration of the authors from Shippax publications

2.3 Performance trends

Since 2000, the ferry industry has been undergoing a gradual consolidation process during which operators providing services to local/regional traffic flows and located close to the area of operation exploited some competitive advantages (i.e., more efficient operations and cost savings by using vessels' economies of scale). In fact, excluding a few failed attempts, EU operators have hardly developed their business beyond one region, as shown by the declining trend of intra-EU routes and the increased number of domestic routes (COWI, 2015; Shippax, 2013).

Over the last couple of decades, the performance of the ferry industry has been influenced by the abolition of duty-free regime and the competition of low-cost airline carriers[11], especially with respect to price-setting strategies. The introduction of fixed links (such as the Channel Tunnel between the UK and France or the Øresund link between Denmark and Sweden) and the 2008 peak in fuel cost were also important challenges for the industry.

The economic recession hit the industry in 2008 and continued until 2011, the year when volumes of passengers and trailers started to recover to pre-crisis levels with a mixed performance amongst the operators.

Today, the performance of the operators usually reflects the economic situation in the region where their core business is located. In this respect, the operators in the UK, Ireland and Denmark show quite good results, since the economy is recovering well. On the other hand, those having their core business in Finland, Estonia and Greece suffer more due to stagnation of the countries' economies.

Lastly, the crisis of the economy that hit the Mediterranean region made people generally less inclined to travel. Domestic ferry statistics pertaining to Greece are significant in this respect. Between 2008-2013 passenger numbers decreased by 9.98 million (-22.6%) and cars by 640 thousand (-30.4%) (Interferry, 2014a; Shippax, 2015).

[11] See Section 6 and Annex III.

A non-exhaustive picture[12] of the ferry industry's performance in terms of revenues and employees shows that the majority of employees are gathered in EU regions (i.e., approximately 70%). The economic recession had a greater impact on employee numbers in the EU compared to worldwide numbers (-11% against -7% in 2008). The trend of the number of mergers and takeovers provides another indication of the economic impact of the recession: after 2008, many routes ceased to exist, several operators declared bankruptcy and the credit crunch made restructuring and grouping activities take a step back in the business (see Table 1 below)[13].

Table 1: Reported revenues, employees and number of merges and acquisitions in the ferry industry

Year	Number of operators reporting revenues	Total reported revenues [€ million]	Employees in EU ferry industry	Employees in the ferry industry worldwide	Number of merges and acquisitions
2006	22	5 260	n. a.	n. a.	n. a.
2007	22	5 770	64 033	95 794	15
2008	25	6 760	71 949	103 069	8
2009	22	8 403	64 043	95 804	6
2010	25	7 857	n. a.	n. a.	6
2011	28	8 197	72 964	104 188	7
2012	27	9 350	73 910	105 064	2

Source: Elaboration of the authors from Shippax publications

2.4 Development of the fleet

Figures on EU regions over the period 2006-2012 show a maximum of 722 ferries operating in 2007 which subsequently decreased to 671 in 2012 (-7%). Looking at the figures in more detail, the Baltic and the North Sea show an increase, whereas the -12% reduction of the Mediterranean fleet seems to be essentially due to the recession[14] (see Table 18 in Annex I).

Historically, worldwide delivery of new ferries shows a cyclical trend (Shippax, 2013), declining from 21 new ferries in 2008 to only 10 in 2014 (-52%). Moreover, newbuilding activities concentrate on replacing older ferries, thus confirming an overall capacity contraction (see Table 22 in Annex I).

The trend of the second-hand market has decreased along similar lines. The number of ferries sold and purchased has decreased from 38 in 2008 to 17 in 2014 (-55%). The number of

[12] Detailed figures of the industry's overall financial performance are incomplete and hardly made available. In addition, they are based on different accounting procedures. What's more, figures may be influenced by other non-core activities included in revenues and profit reports.

[13] The operators of the northern regions appear stronger; this may be due to greater stability of the market. The operators of the Mediterranean region are arguably more exposed to recent socio-political instability.

[14] The available capacity also depends on ferries laid up, either for reservation or scrapping, but the few figures available are not sufficient to draw any conclusions. It is worth observing that the intensity of scrapping activities is influenced by the price of steel: scrapping was intense before the steel crisis of 2008 (Steel Benchmarker, 2016) because of the high steel price and dropped off afterwards. The Emission Control Areas (ECAs) Regulation is expected to restart scrapping activities.

ferries chartered also gives an insight into the reduced intensity in this segment of the market: after the peak of 38 contracts reached in 2012, this segment has slowed down to 30 contracts signed in 2014.

The number of ferries for which conversion works[15] were planned nearly halved, from 10 to 6, in the four-year period between 2011 and 2014. In the light of the Emission Control Areas (ECAs) Regulation (see Section 4), retrofitting works undergone are experimental and transitional. As soon as emissions abatement technologies and equipment redesign proves to be viable in the long term, retrofitting work may intensify in years to come. However, the state of the market suggests that conversions are not long-term solutions, particularly for older ferries, and newly built units might be more economical in meeting the ECAs' requirements.

2.5 Investments under TEN-T and CEF programmes

A number of specific projects addressed to the maritime mode have been financed under the Trans-European Transport Networks (TEN-T) and the Connecting Europe Facility (CEF) programmes[16]. The investments identified are listed and described in Annex I: Table 23 and Table 24.

The investments funded under both programmes can be ascribed to technological uptakes in order to be compliant with the provisions laid down in Directive 2012/33/EC (EC, 2012), to reduce the emissions of air pollutants and to develop the Motorways of the Sea (MoS).

MoS are the maritime dimension of the TEN-T and consist of short-sea routes, ports, associated maritime infrastructure and equipment, and facilities enabling short sea shipping between at least two ports, including hinterland connections. MoS seek to promote multimodal efficient transport, reduce congestion on land, support the uptake of more sustainable transport modes, increase efficiency and allow peripheral regions to be better accessible (EC, 2013d).

In the view of the ECAs and MoS development, projects in which ferries are integrated amount to approximately €1 billion (since 2008 to date), €306 million[17] of which are EU grants for studies and works. In particular, the funds granted have been addressed to environmentally-friendly and sustainable actions (e.g., innovative fuels and related infrastructures), new building of ships and Sulphur emissions abatement retrofits.

These opportunities have benefited the ferry industry and many operators, although it is not possible to define precisely to what extent funds granted can be attributed specifically to the ferry industry. The budgets provided in project descriptions are in aggregate form. Investments in projects involving the ferry industry are mixed with interventions on port facilities (e.g., infrastructures and storage of alternative fuel propulsion systems), or included in investments allocated to more than one type of ship (e.g., general cargo, barges and tugboats).

[15] Conversion works of a ship may include a wide range of activities such as: retrofitting of propulsion and abatement systems, or change of internal layout (e.g., the reduction of the number of rooms to accommodate more lane metre capacity for vehicles).

[16] The TEN-T Programme was established by the European Commission to support the construction and upgrade of transport infrastructure across the European Union. Since 2014 it is replaced by the CEF fund.

[17] Values calculated in Euro 2015.

3. SAFETY RISKS, REGULATIONS AND RECORDS IN THE FERRY INDUSTRY

3.1 Safety risks

The most important risks associated with the use of "Ro-Pax" vessels are: loss of lives, human injury and material damage. These risks may materialise in a catastrophic accident, which is often the result of a chain of events. They have a mix of causes and different levels of severity, but they also vary depending on the area of navigation, i.e. open seas, coastal areas, internal basins, rivers, etc. Safety risks may be based on human error (i.e., design and manoeuvring), mechanical failures, fire and weather conditions (e.g., fog and wind)[18]. There are two aspects to the technical safeguards that may be deployed against safety risks: (i) prevent the accident from happening and (ii) mitigate the effects[19].

Technical safeguards are not specifically associated with ferries (e.g., different ships may run aground under the same weather conditions). However, ferries may be subject to large scale flooding of cargo decks which affects the stability of the vessel (e.g., Estonia and Herald of Free Enterprise), (Tagg, 2014; Cichowicz et al., 2016) or fires on board that are not caused directly by the ship (e.g., a fire from a truck).

3.2 Safety Regulations

As regards safety rules in force, ferries in international trade (i.e., between two Member States) are governed by international Regulations, such as the International Convention for the Safety of Life at Sea (SOLAS Convention; IMO, 1974)[20], and European Union (EU) rules. This is the most important international treaty on ship safety in a seaway. It provides technical measures for survival in case of accidents (i.e., measures related to construction, equipment and operation)[21].

Another important SOLAS Regulation is the "Safe Return to Port Regulation"[22]. With regard to ferries, where the design is mainly driven by the required amount of lane meters within cargo spaces, it is estimated that the implementation of the provisions concerning the SOLAS "Safe Return to Port Regulation" has contributed to an increase in building costs of approximately 2% to 5% (Shippax, 2011)[23].

The SOLAS Convention is also the main reference framework for life-saving appliances and arrangements (e.g., life boats and life jackets)[24]. The International Life-Saving Appliance (LSA) Code lays down specific technical requirements (MSC, 1996).

[18] van Dorp et. al (2001), SAFER EURORO (2003) and Morfitt (2007).

[19] They are treated separately as their contributions to safety risk reduction are distinct and not comparable. The difference between these two concepts is that by preventing risks the probability or frequency of an accident occurring is reduced, whilst by mitigating risks the consequences of the accident are reduced.

[20] The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships. In a successive development of the convention, Resolution MSC.Res.216(82), a harmonized probabilistic standard method of calculation was introduced for damage stability (i.e., risk of flooding) and made applicable to ferries having their keel laid down since 1 January, 2009. This improved survivability, making upgrades in compliance with the new vertical extent of damage Regulations and in particular for new large ships over 200 meters (Tagg, 2014). The SOLAS Convention has been amended and updated on several occasions.

[21] The International Maritime Organisation (IMO) recognised the need to also consider ferries which do not come under the SOLAS Convention, namely those vessels that are operated inland, or solely on domestic routes.

[22] See Regulations II-1/8-1, II-2/21 and II-2/22.

[23] Besides the additional costs for firefighting measures, life-saving appliances and initial surveys, the cost can be as low as €100 000 for a large ship (EC, 2015).

[24] See Chapter III of the SOLAS Convention.

Safety standards for domestic transport (i.e., between ports of the same Member State) depend on each flag State and EU rules. The most extensive EU legislative provision is Directive 2009/45 (EC, 2009b) provides safety rules and standards for passenger ships[25] and where applicable, it is based on the standards of the SOLAS Convention[26] (EC, 2015).

Within the European Commission's legislative framework, three other pieces of legislation contain important rules. Directive 2003/25 (EC, 2003a) concerns stability requirements for ferries (see Annex I of the Directive). Strengthened stability requirements were introduced for Ro-Pax vessels operating on international services to and from Community ports[27]. Directive 2006/336 (EC, 2006b) implements the International Safety Management Code and lays down rules on safety management and the safe operation of ships by setting out maintenance procedures and shore-based safety management systems. Directive 2009/16 (EC, 2009a) provides rules and procedures for port control inspections and the detention of ships, to reduce the selective use of ports of destination for the avoidance of proper controls regarding safety levels[28].

3.3 Safety records

3.3.1 Safety records in EU countries

Over the last two decades (i.e., 1996-2016), 43 ferry accidents have been identified in total in the EU. The four main events took place in the Mediterranean region (the accidents involving the Superfast 3 (1999), the Express Samina (2000) and the Norman Atlantic (2014)[29]) and in the Baltic Sea (the accident involving the Sleipner (1999)). Out of 127 deaths related to ferry accidents during this 20-year period, these four main incidents were responsible for 97% of these deaths (123 people). As illustrated in Table 2 below, fire was the main cause of incidents (i.e., 18 cases or 42%), 8 of which started on the cargo deck.

Table 2: Incidents related to ferries in the EU (1996-2016)

Region	Number of accidents		Cause										Casualties					
			Human error		Mech. failure		Fire		Weather		Unknown		Deaths		Injured		Missing	
	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%
Baltic Sea	13	30	3	27	1	25	7	39	1	17	1	25	17	13	28	26	0	-
North Sea	13	30	2	18	1	25	7	39	3	50	0	0	0	0	47	43	0	-
Mediterranean	17	40	6	55	2	50	4	22	2	33	3	75	110	87	34	31	0	-
Total	**43**	**100**	**11**	**100**	**4**	**100**	**18**	**100**	**6**	**100**	**4**	**100**	**127**	**100**	**109**	**100**	**0**	**-**

Source: Elaboration of the authors from EuroTest (2014), Shippax publications, Marine Accident Investigation Branch (2003)

Before these events, other dramatic accidents involving ferries in the EU occurred in 1987 (Belgium, "Herald of Free Enterprise"), 1991 (Italy, "Moby Prince") and 1994 (Estonia-Sweden, "Estonia") (IMO, 2016a) (see Table 25 in Annex II).

[25] Stability requirements and phasing-out of Ro-Pax vessels are provided in Article 7, by making reference to Directive 2003/25 (EC, 2003a).
[26] In addition, Directives 1999/35/EC and 98/41/EC provide for specific EU rules that apply to Ro-Pax ships.
[27] The measures were also introduced to enhance the safety measures applied to certain categories of vessel operating on domestic services, under the same sea conditions, to achieve a uniform level of safety.
[28] The inspections ensure that statutory requirements issued by a flag State are fulfilled, in particular related to: construction, subdivision and stability, machinery and electrical installations, loading, fire, maximum number of passengers, life-saving appliances and the carriage of dangerous goods, radio communications and navigation.
[29] Thirteen persons died, including two rescue operators of Albanian tugboats.

3.3.2 A comparison of safety records with non-EU countries

With respect to non-EU countries, a distinction is worth making between developed and developing countries. In non-EU developed countries, only 5 accidents occurred over the last 20 years (see Table 26 in Annex II).

Non-EU developing countries show a number of accidents comparable with the EU[30], but the number of deaths is significantly higher (i.e., 4 063). The causes are mostly related to human error (7 of which for overload), fire and weather conditions (see Table 27 in Annex II).

3.4 Responsibility in the case of an accident

In accordance with international maritime law, the shipowner is primarily responsible for accidents and safety on board of a ship. The day-to-day responsibility lies with the master, who should observe the shipowner's reporting procedures.

Shipowners are also responsible for ensuring adequate means and organisational measures on safety, consistent with international and national laws and Regulations (ILO, 1996)[31]. Shipowners ensure that the design of ships takes into account relevant international and national laws, Regulations, standards and codes of practice. Within the European Commission's legislative framework, Regulation 392/2009 (EC, 2009c) lays down the regime relating to liability and insurance for the carriage of passengers by sea, as set out in the relevant provisions of the Athens Convention of 1974 (United Nations, 1974) and the IMO Reservation and Guidelines for Implementation of the Athens Convention (IMO, 2014a).

[30] In the list of EuroTest (2014), the source of each accident is not known, therefore uncertainty exists on the level of homogeneity of the final information across all the entries mentioned. The available data appears to refer to serious accidents only; other accidents are not reported (e.g., those with a lower level of severity). This may be why the number of accidents in the EU are comparable with those in non-EU developing countries.

[31] For example on the operation of ramps, vehicles access doors, vehicles inspection before boarding, possible ingress of water, defective doors closure, lashing points of vehicles, gas detection in cargo decks.

4. TECHNOLOGICAL DEVELOPMENTS IN THE FERRY INDUSTRY

Technological developments concern three main areas, namely: Sulphur Oxides (SO_x) limits according to the Emission Control Areas (ECAs), energy efficiency measures and ballast water treatment systems. Technology plays a central role in making the ferry industry cost-effective, more efficient and to ensure compliance with environmental rules. Technology uptake also depends on the degree to which a technology is implemented given that financial and information costs tend to decrease as technologies mature. While the development of propulsion systems are crucial for the operators[32], history also shows that major technology updating in shipping is driven primarily by regulatory changes. As already mentioned in Section 2.4, the European maritime sector is subject to efficiency, sustainability and emission control Regulations.

4.1 Technologies of the propulsion systems

The International Maritime Organization (IMO) set up SO_x limits for marine fuels, *as per* the International Convention MARPOL Annex VI: Regulations for the Prevention of Air Pollution from Ships.

The limits for SO_x in fuel oil entered into force under the MARPOL Convention[33] to prevent air pollution from ships[34]. Emission controls apply to all fuel oil, combustion equipment and devices on-board and include both main and all auxiliary engines together with items such as boilers and inert gas generators (IMO, 2016c). These requirements were adopted in the revised MARPOL Annex VI in October 2008, which entered into force in July 2010 (IMO, 2016d) (see Table 3 below)[35].

Table 3: The limits for SO_x in fuel oil and step changes over the years

Outside ECAs	Inside ECAs
4.5% prior to 1 January 2012	1.5% prior to 1 January 2010
3.5% on and after 1 January 2012	1.0% on and after 1 January 2010
0.5% on and after 1 January 2020[36,37]	0.1% on and after 1 January 2015[38]

Source: ECG (2013)

32 Fuel consumption accounts for a large share of operating costs: for a typical Baltic operator, fuel cost ranks as the second-largest item (16%). The other costs refer to: cost of goods (22%), staff (15%), marketing/administration (11%), port and stevedore (10%), ship operation (8%), depreciation/amortisation (8%), net finance (6%) and other (4%) (Shippax, 2013).

33 The MARPOL Convention entered into force on 19 May 2005 and has been ratified by 75 States/parties.

34 Specifically under Regulation 14.

35 Also Nitrogen Oxide (NOx) emissions are regulated through the MARPOL Annex VI, which puts a limit on emissions from marine engines. The revised MARPOL Annex VI of 2008 applies only to new ships and is divided into three tiers based on the date of construction and operational area. Feasible solutions include: Exhaust Gas Recirculation, Selective Catalytic Reactors, Water injection - Humid Air Motors (HAM)/Water in Fuel and Liquefied Natural Gas (LNG).

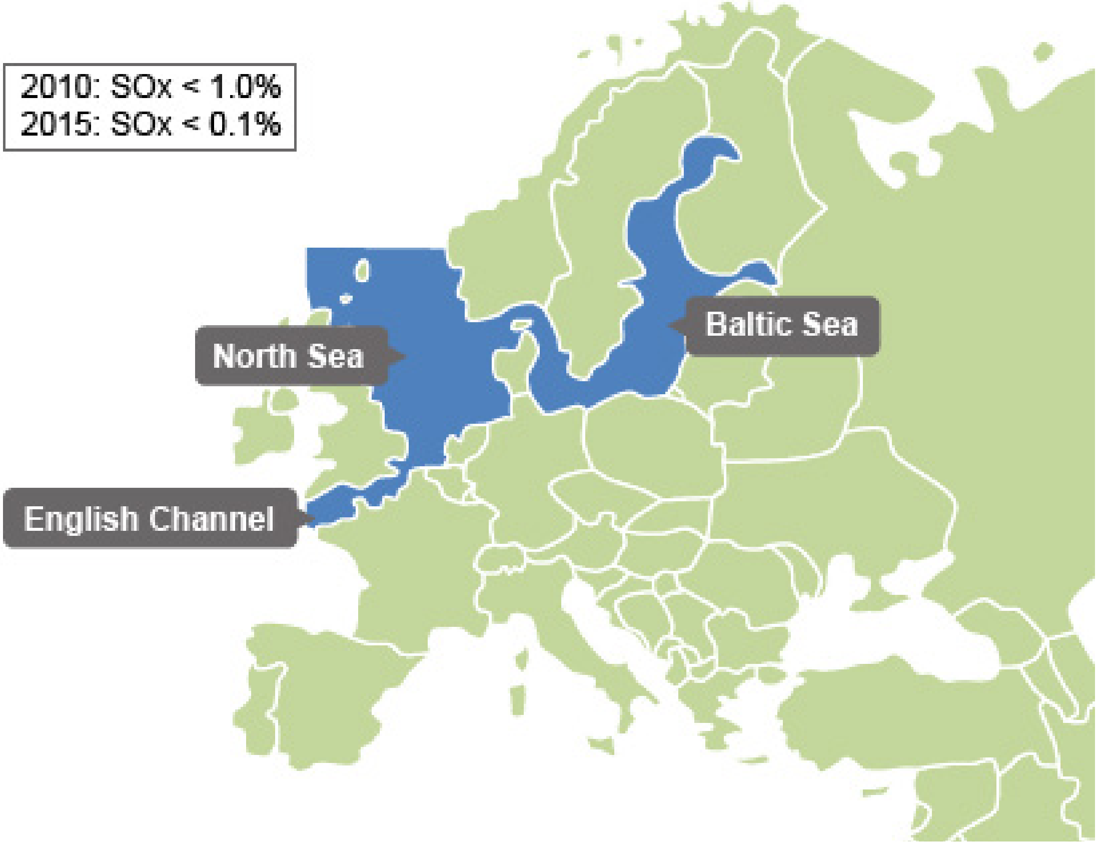
36 Depending on a review by the Marine Environment Protection Committee (MEPC), to be concluded in 2018, on the availability of the required fuel oil, this date could be deferred to 2025 (Hughes, 2011).

37 Including "Ro-Pax" ferries only in Member States' territorial seas, as established by Directive 2005/33/EC (EC, 2005).

38 Including ships at berth and inland waterways.

In the European Union (EU), the ECAs limits concern the Baltic[39] and the North Sea (including the English Channel)[40], which is where large parts of the European maritime traffic are concentrated (see Figure 5 below). The MARPOL Annex VI does not cover the Mediterranean, yet there is no indication about when the Regulations will come into force in other regions[41].

Figure 5: SO_x Emission Control Areas



Source: IMO (2016b)

During the past 20 years, the EU introduced subsequent steps to regulate the Sulphur content in liquid fuels to reduce emissions. Directive 93/12/EEC (EC, 1993) established lower limits for Sulphur content in gas oil, Directive 99/32/EC (EC, 1999a) set limits for Sulphur content in heavy fuel oil and gas oil (including marine gas oil), Directive 2005/33/EC (EC, 2005) entered into force following MARPOL Annex VI and established limits of Sulphur content of marine fuels. Finally, the EU laid down mandatory IMO rules on marine fuels through Directive 2012/33/EU (EC, 2012).

The regulatory shift towards low Sulphur fuel is one of the developments that is expected to have the largest impact in terms of the reduction of emissions and the increase of operating costs. Although, technology options depend heavily on fuel prices and their relative differences (DNV, 2012), the applicable limits for SO_x are having an important impact on the ferries' technologies of the propulsion systems.

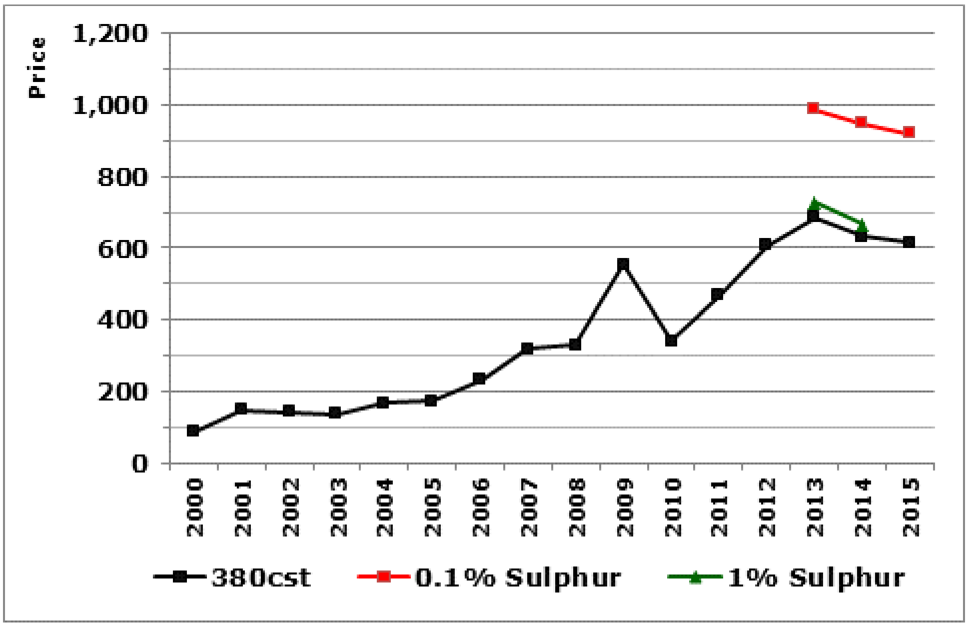
[39] As defined in Annex I of MARPOL (SO_x only).
[40] As defined in Annex V of MARPOL (SO_x only).
[41] The other regions are North America (covering designated coastal areas off the United States and Canada) and the United States Caribbean Sea area (around Puerto Rico and the United States Virgin Islands), as defined in Annex VI of the MARPOL Regulation (SO_x, NO_x and Particulate Matter (PM)).

To be compliant with the current provisions, the operators are faced with five possibilities:

- Use Marine Diesel Oil (MDO) (0.1% SO_x);
- Retrofit by installing so-called "scrubbers" (i.e., an exhaust-gas cleaning system);
- Adapt ships to cleaner propulsions such as Liquefied Natural Gas (LNG), or methanol which may reduce SO_x and Particulate Matter (PM) emissions by 99% (Shippax, 2015);
- Build all-gas ships;
- Consider electricity (i.e., in form of battery/hybrid) as an alternative.

MDO (0.1% SO_x) is costly. Records obtained on bunker prices show that it costs between 36% and 50% more than Intermediate Fuel Oil (IFO) 380cst[42] and low Sulphur fuels (i.e., 1% Sulphur) (see Figure 6 below)[43].

Figure 6: The evolution of bunker price (USD/tonne)



Source: Worldscale (2016)

As a consequence of the price of MDO (0.1% SO_x), after-treatment solutions can be used, for example scrubbers. They were initially reported as a technology with a rather limited track record (DNV, 2012) and more suitable for small ships. However today, scrubbers are developing faster than expected, with more than 200 confirmed projects (DNV, 2015)[44].

Another alternative option to the use of MDO (0.1% SO_x) is the use of LNG with appropriate engines[45]. However, there are technical challenges to overcome due to the low temperature

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42 Centistoke (cst) is a measure of density and kinematic viscosity of a fluid (e.g., fuel). Kinematic viscosity is a property that relates the shear stress in a fluid to the angular rate of deformation.

43 According to Meech (2011), the availability of MDO would be limited. If the world fleet was to convert to low-sulphur distillate fuels by 2020, the current production would not meet marine bunker demand as the refinery industry would need to produce an additional 4 million barrels/day.

44 Scrubbers installations on ferries and Ro-Ro vessels experienced their highest uptake in mid-2014 with about 60 cases, accounting for 49% of the total scrubbers fitted (EGCSA data in Fathom, 2015).

45 According to Lloyds Register (2012), LNG is a promising option for deep-sea shipping to comply with Sulphur-content limits. LNG-emissions-abatement rates are: SOx 100%, Carbon Dioxide (CO_2) 10-20% and NOx up to 80-90%.

at which LNG must be transported[46]. The need to use cryogenic tanks reduces load capacity by between 2% and 4% (Shippax, 2014) and poses constraints for their adequate and safe location. These factors, together with high LNG bunker prices, are detrimental and strongly influence the pace of development. Consequently, mid-term forecasts on numbers of LNG-fuelled ships by 2025 vary broadly, from almost zero to nearly 2 000 new-build LNG ships[47].

Real figures on LNG ferries delivered over the period 2000-2015 are significantly lower; 23 units are reported in operation, which corresponds to 2% of the Ro-Pax fleet (Graugaard, 2013; Shippax publications).

Geographically, LNG demand was forecast mostly from the Baltic and North Sea regions (DMA, 2012). However, minor progress can be observed on the shore side, where only 7 European seaports are open for general LNG bunker business today (TRI-ZEN, 2015)[48]. In this respect, the European Commission has launched a comprehensive strategy, which involves in particular the European Maritime Safety Agency (EMSA) and representatives from the industry. The Trans-European Transport Networks (TEN-T) programme aims at a €10 billion investment in the build-up of alternative fuels infrastructure in all major European seaports to offer LNG bunkers by 2020 and inland waterways port by 2025 (EC, 2013c).

Methanol is already used in several industrial processes and has the potential to become a competitive marine fuel. Engine manufactures can provide different types of methanol-powered engines, and conversion from diesel to dual-fuel is less expensive than conversion to LNG (Stena, 2013)[49]. The handling cost is lower because methanol is liquid at room temperature and needs neither cryogenic nor pressure tanks (Stena, 2013; Shippax, 2015). However, the interest to invest in methanol is uncertain because the main restriction is the limited established logistics for supplying vessels with fuel (Lundgren and Wachsmann, 2014).

Gas-powered ships are usually equipped with conventional back-up power[50]; however, some examples of all-gas vessels exist: two ferries belonging to the Norwegian operator Norled[51] have reserves of Compressed Natural Gas (CNG) for emergencies (Remontova, 2013; Shippax, 2015). This example shows how ferries can be adapted to run greener operations.

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46 Having a low flashpoint, the use of LNG as a fuel poses a set of safety challenges, which need to be properly managed (the flashpoint is an indication of how easy a chemical may burn; materials with low flashpoint are more flammable; LNG's flashpoint is -188 °C). The International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (i.e., the IGF Code) (IMO, 2015) aims to provide an international standard for ships operating with gas or low-flashpoint liquids as fuel. The basic philosophy is to provide criteria to minimise the risk to the ship, its crew and the environment, with respect to the nature of the fuel. As part of the ongoing work programme to improve passenger ship safety, the Maritime Safety Committee (MSC) approved draft amendments to SOLAS Regulation II-2/13 to extend the requirements for evacuation to all passenger ships (not just Ro-Pax vessels). The amendments to SOLAS Chapter II-1 (Construction – Structure, subdivision and stability, machinery and electrical installations) and a new Part G Ships using low-flashpoint fuels are expected to enter into force on 1 January 2017.

47 According to Lloyds Register (2012), the total number of new-build LNG ships by 2025 ranges from 13 to 1 936 depending on the scenario assumed (assuming (i) change of LNG bunker price, (ii) the propensity to build new LNG ships and (iii) shift of low Sulphur limits to 2023). As a consequence, the LNG bunker demand for deep-sea trades ranges from 0.7 to 66 million tonnes/year by 2025. On the other hand, the DNV (2012) study forecast 1 000 LNG ships and from 8 to 33 million tonnes/year of LNG, by 2020 (depending on the growth of the economy, marine fuel oil and LNG price and regulatory and stakeholder pressure on the environment).

48 This is discussed further in Section 4.2.

49 A conversion kit to methanol includes: cylinder heads, fuel injectors, fuel pumps, high pressure pipes, ventilation systems (methanol has a flashpoint at +11°C; the ventilation system prevents any leakage from entering the engine room atmosphere), inerting system and fuel tanks. Beyond cryogenic storage, conversion to LNG also includes entablatures and replacement of crankshaft (i.e., the mechanical part of the engine converting the reciprocating motion of the pistons to the rotational motion of the propeller).

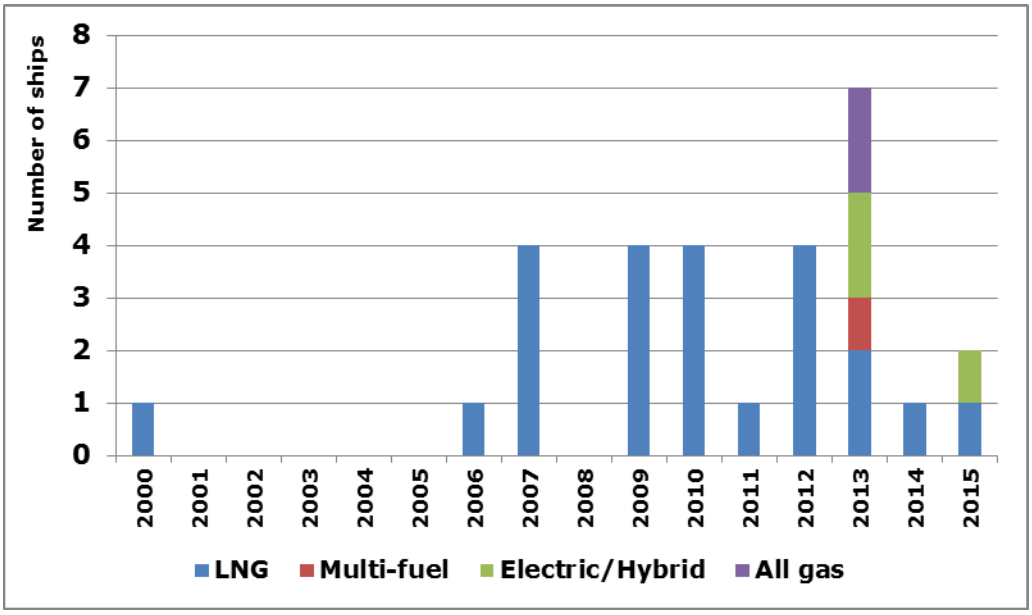
50 Backup diesel fuel option to ensure fuel availability (Maritime Cyprus, 2014).

51 Ferries Ryfylke and Hardanger.

The electrical propulsion system is already a reality in the ferry industry. Norled's aluminium catamaran "Ampere"[52], weighing half of a conventional equivalent, operates on the 30-minute Lavik-Oppedal crossing in Norway, approximately 3 Nautical Miles (NM). Batteries are recharged at the docks after each trip, in 10 minutes (Shahan, 2015), during disembark operations. In the case of Norway, it is estimated that a potential of 50 routes could be operated with electric ferries (Siemens, 2015). Substantial drop in battery cost and improved energy storage capacity would allow hybrid systems to be considered as a real option when ferries are operated with large variations in power demand and along short-run coastal routes[53]. As an example, since 2013, the Scottish operator Caledonian MacBrayne operates two hybrid ferries and experience showed fuel reductions of 38% (batteries are charged overnight from a shore-side connection) (Maritime Battery Forum, 2015).

Figure 7 below shows the distribution of the ferries with new propulsion systems delivered over the period 2000-2015.

Figure 7: Ferries delivered with new propulsion systems



Source: Graugaard (2013) and Shippax publications

4.2 A comparison of the countries in terms of green credentials

The Baltic and the North Sea ferry industries are greener in comparison to the Mediterranean area. This is led by the key drivers of (i) ECAs limits, (ii) Norwegian Nitrogen Oxide (NOx) fund[54] and (iii) Norwegian government requirements on improved environmental performance for ferry route concessions. Out of 23 LNG-fuelled Ro-Pax ferries in operation,

[52] Ferry characteristics: 80 meter length and 20 metre wide, with a load capacity of 120 cars and 360 passengers. The batteries have a combined capacity of 1 000 kWh.

[53] The deployment of fully electric ferries may have a further positive impact towards greener ferry services. Ongoing research and development efforts in this field are developing medium-sized Ro-Pax ferries to operate on medium–range connections (i.e., 10 NM), which involves going well beyond current technical limitations (E-Ferry, 2016). The E-ferry project is considering connections such as Soeby-Fynshav (10.7 NM) and Soeby-Faaborg (9.6 NM) in the Danish part of the Baltic Sea connecting the island of Aeroe (Ærø) to the mainland. The improved operational profile of the electric ferry implies an extended sailing range between charging periods thanks to larger battery capacity and higher charging power capacity, allowing for shorter berthing time at ports.

[54] The NO_x fund is an agreement between 15 Norwegian business organisations and the Ministry of the Environment. Affiliated enterprises are entitled to exemptions from the Norwegian fiscal NO_x tax of NOK17.33/kg NO_x. The Fund has about €75 million/year to support NO_x reducing measures. Over the period 2011-2017, 6% of the budget has been allocated to engine modifications in ships (Høibye, 2014).

21 are from Norway and 1 is from Denmark and Germany, respectively. In addition, one dual-fuel ferry is operated by a Finnish operator, two hybrid units in Scotland and one electric ferry in Norway (Shippax, 2013; DNV, 2014; Maskinmesteren, 2015).

With regards to the penetration potential of electric ferries, the three Scandinavian countries were found to be in the range of 65-80% of their existing domestic ferries. The share was smallest in Denmark and highest in Sweden, while by numbers the Norwegian market is definitely the largest (DNV, 2014). The Baltic and North Sea are also well positioned as far as LNG fuel supply is concerned, since all 7 ports identified for general LNG bunker business are in these regions, namely 3 in Norway and 1 each in Belgium, Denmark, Finland and Germany (TRI-ZEN, 2015).

Further studies would be needed to analyse the potential of other European markets, especially that of Greece and the coastal areas of the Netherlands and Germany (Green Ferry Vision, 2015).

4.3 Shore side power supply

Since Directive 2005/33/EC (EC, 2005), all ships at berth in EU ports have to use MDO (0.1% SO_x), which means that electricity is also becoming an option for shore-side connections. This option reduces both air and noise emissions in ports located within urban agglomerations and industrial areas (Cleanship, 2013; EBRD, 2013)[55]. Fourteen out of twenty Baltic Sea ports have planned shore-side electricity facilities within the next 10 years (Cleanship, 2013).

4.4 Solar and wind energy

Both solar and wind energy offer fuel-free power production without any emissions for auxiliary services, while a ship is in operation, both at berth and at sea (DNV, 2012 and IRENA, 2015). They have received quite a bit of interest despite having been implemented only to a limited extent. Their high level of complexity in terms of design and operation which, in turn, influences implementation cost lead to a high abatement cost per ton of CO_2[56].

4.5 Energy-efficiency measures

Technology updates involving energy-efficiency measures differ from emission abatement technologies as they aim to reduce fuel consumption rather than emissions directly. The first formal Regulations were adopted in 2011 with the Marine Environmental Protection Committee (MEPC) Resolution MEPC.203(62).

Increasingly stringent requirements for ships (IMO, 2011) were set through the Energy Efficiency Design Index (EEDI) that will be the major driver for energy innovations.

The EEDI was initially applied to conventional vessels[57]. After a two-year period of transition, the index has been expanded to also include "Ro-Pax" vessels (Deltamarin, 2011; IMO, 2013). The EEDI aims to stimulate efficient designs, indirectly leading to reduced Carbon

55 This option is recommended where air quality or noise limits are exceeded (EC, 2006a).

56 According to DNV (2012), solar panels and wind generators show the highest cost per tonne of CO_2 averted (i.e., more than USD200/tonne) and considered for auxiliary power only, they show the lowest contribution to the total CO_2 potential abatement reduction (in millions of CO_2 tonnes/year). Besides, a survey conducted in this study assessed the likelihood of implementation of a set of technology options in existing and new ships, and solar and wind energy ranked last.

57 Bulk carriers, gas carriers, tankers, container ships, general cargo ships, refrigerated cargo ships and combination carriers. But not applicable to a ship having diesel-electric propulsion, turbine propulsion or hybrid propulsion systems, except for cruise passenger ships and LNG carriers.

Dioxide (CO_2) and Greenhouse Gas (GHG) emissions. Energy-efficiency measures are grouped into four categories:

(i) reduction in ship resistance,

(ii) increase in propulsive efficiency,

(iii) increase in power-production efficiency, and

(iv) reduction in auxiliary consumption (DNV, 2012)[58].

The initial formulation has been redrafted because new ferries were being treated like deep-seagoing ships (e.g., operating on trans-ocean routes), meaning that, previously, the only way a new ferry could comply was to increase the size and reduce the speed, which would be an operational limitation on many routes[59] (Interferry, 2014b).

The Ship Energy Efficiency Management Plan (SEEMP) was designed to directly stimulate more energy-efficient operational practices. The SEEMP applies to all existing and new ships above 400 GT, hence including ferries. Energy-efficient operational practices can be grouped into three categories: (i) enhanced technical and operational management, (ii) enhanced logistics and fleet planning and (iii) port-related (Bazari and Longva, 2011).

4.6 Ballast water treatment systems

Another issue likely to have a significant regulatory impact is the implementation of the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments, also known as the Ballast Water Management (BWM) Convention (IMO, 2004). Shipping has been identified as a major pathway for introducing potentially harmful species (aquatic organisms) to new environments. The BWM Convention aims to prevent this from one region to another. The BWM Convention has not been ratified yet (IMO, 2016c), but a strong demand can be expected on IMO-approved BWM treatment systems[60]. The Convention applies to every ship above 400 GT operating on an international route, regardless of the distance (UK P&I, 2015; IMO, 2016c). This means that even a ferry on a very short distance trip (e.g., 10 NM) has to install treatment equipment, despite the low probability of spreading harmful species (Interferry, 2014b). To avoid the installation of treatment systems and conventional ballast tanks, the concept of a ballast-free ship has been developed, in which ballast water flows through longitudinal pipes (i.e., open ballast tanks) in the double bottom of the ship (Godey et al., 2014)[61].

58 Amongst these, the most likely to be achieved are hull optimisation and waste heat recovery for new ships and propulsion devices, while auxiliary system improvements are more likely on existing ships (DNV, 2012).

59 This is due to the fact that even though a larger vessel could enter into operation, it could not increase the cargo volume (e.g., passengers) on that specific route, leaving the new, larger vessel to operate at partial capacity (Deltamarin, 2011).

60 The BWM treatment systems involve a filtration process, which separates particles from the water flow using membranes and hydro cyclones. The physical process of filtration is the main mechanism of the BWM system and may have a large power demand. Technologies are emerging from different areas of the industry; however, there is limited operational experience with regard to all systems with inherent technological uncertainty (DVN, 2012), and there are also concerns about the shortage of shore treatment facilities (UK and P&I Club, 2015).

61 However, this needs investigation with respect to an increase in hull resistance and sections of the pipes where water may remain stagnant and lead to a deposition of sediments.

5. TICKETING IN THE FERRY INDUSTRY

5.1 Average ticket price

The value of a ferry ticket is directly connected to the pricing policy of the ferry operator. In general, the ticket price charged to passengers depends on a number of variables, such as the route (including the level of competition in the market or with other transport modes, and ports' berthing rates), type of passenger accommodation (e.g., cabin or reclining chair), category of accompanying vehicle (e.g., classified by length) and season (e.g., summer peak). Tickets usually include a discount on the inbound ticket for round trips and incentives to increase demand for off-peak services.

A desk-based review of the literature[62] has revealed that there have been few previous studies conducted to analyse the average price per kilometre. In order to provide current insights into this question, a non-exhaustive sample of fifty routes operated in the European context have been put together and analysed[63]. Table 4 below summarises the average ticket price per kilometre[64], sorted by three ranges of distance.

Table 4: Ranges of ferries ticket prices [€/km]

Range	Distance [km]	Minimum price per km [€]	Maximum price per km [€]	Average price per km [€]
Short	< 100	1.73	4.32	2.74
Medium	100-300	0.96	3.01	1.73
Long	> 300	0.48	2.71	1.06

Source: Elaboration of the authors from Shippax (2015) and www.aferry.com

5.1.1 Existing disparities amongst Member States

In order to investigate disparities across the European Union (EU), the routes of the sample used have been analysed separately in relation to the Baltic, the North Sea and the Mediterranean regions. Figure 8 below shows that there is a downward pattern of the ticket price per kilometre of the routes operated[65]. There are only a few differences discernible between the three regions considered, with the exception of the routes operated in the Mediterranean to North African countries, which appear as the most expensive.

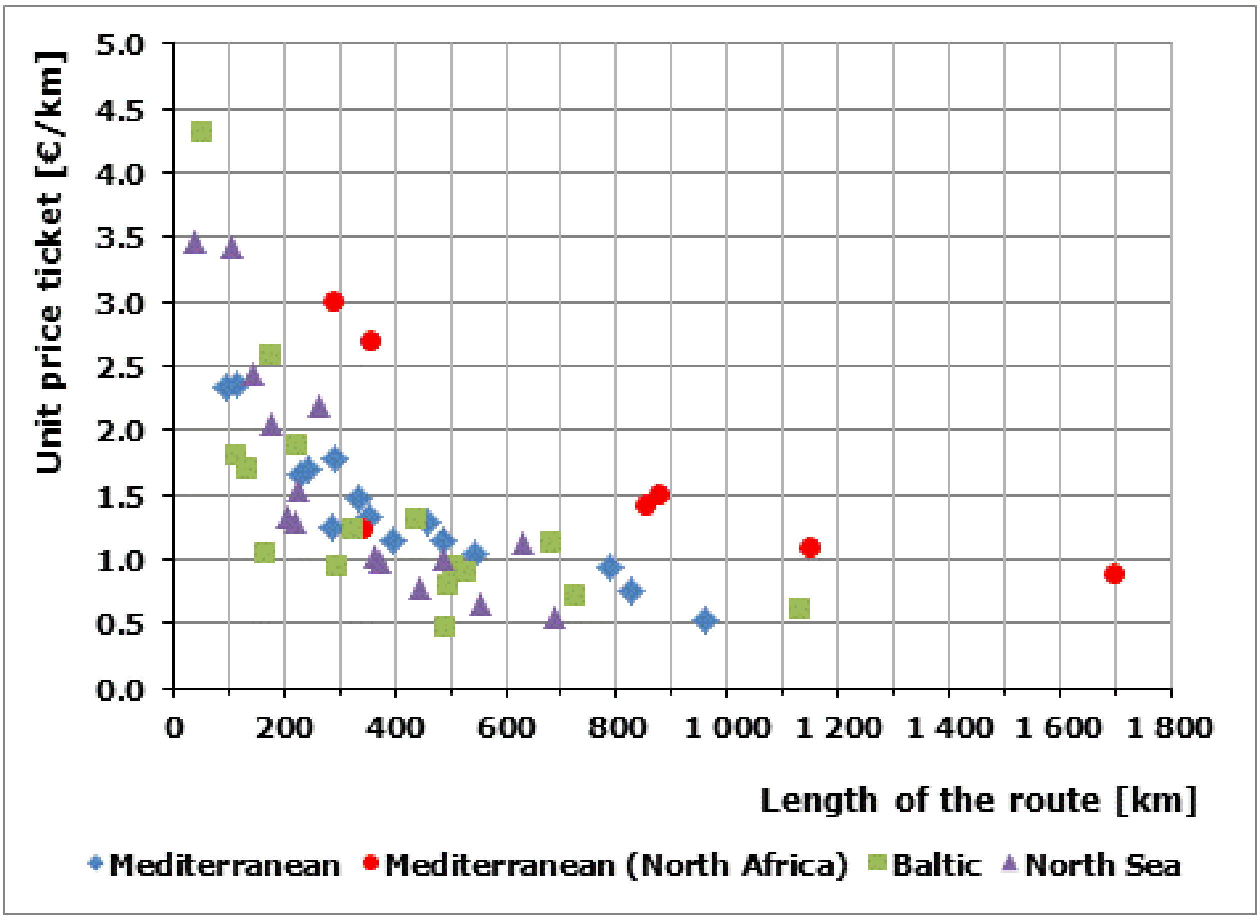
62 See for example: Kapsa and Roe (2006), Mathisen and Jørgensen (undated) and Carrese et al. (undated).

63 The sample assembled is not representative of the universe of routes operated as it does not cover all the operators and the actual level of competition. For these reasons, the values observed are indicative only and should be generalised with caution.

64 According to data availability with respect to the time schedule of the service, the purchase of the tickets was simulated by assuming a journey of four persons (i.e., two adults and two children under 18), travelling with a car and in off-season (i.e., in mid-September). For each route considered, the price per ticket assumed was the lowest displayed.

65 See also Carrese et al. (undated) on the analysis of cost per mile of ferry services operated in the Tyrrhenian Sea between Italy, Corsica and mainland France. The cost per mile observed in 2014 and 2015, with respect to two groups of five routes each, decreases with the total length of the round trip (assuming two adults travelling accompanied by a car and with a seat booking rather than cabin accommodation).

Figure 8: Variation of ferry ticket prices by length of route



Source: Elaboration of the authors from Shippax (2015) and www.aferry.com

5.1.2 Ticket price evolution within the passenger ferry industry over the last two decades

In the light of competition from low-cost airlines, fixed links and volatile oil prices, the passenger ferry industry has come under increasing cost pressures and ticket prices have been adapted consequently. At present, the calculation of ticket prices is the result of the analysis of competitive prices, elasticity of demand and potential for market segmentation.

Online ticketing has helped to cut costs and increase sales of many operators. Ferry ticket prices have followed the approach used in the airline market, by becoming extremely flexible and susceptible to regular change, for example according to the proximity of the departure date. In general, tickets sold and availability of offers have become more transparent to users. Moreover, operators have also formed alliances with land-based services to offer packages including transport links, hotels and tourist attractions in order to promote business (Shippax, 2015).

More advanced customer relations management have increased total revenues, for instance, by way of active marketing and ancillary services when the passenger is already on board (Shippax, 2012). Moreover, loyalty programmes introduced by some operators offer money off (typically 10%) and discounts on various departures (Shippax, 2014). Revenues earned from a wide range of other services sold are used to cross-subsidise ferry services (e.g., prices of other services are set at a higher level in order to compensate for losses at the basic price set) (Kapsa and Roe, 2006).

5.2 Integrated ticketing

Water and land-based Public Transport (PT) services may be provided by different operators and thus require cooperation and communication amongst them to maintain good multimodal connections. To achieve a seamless transfer of users, from the customer's perspective, arrangements have to be put in place to integrate the different fare schemes.

There are very few studies available that have attempted to isolate the impact of the introduction of integrated ticketing *per se* (Booz&Co, 2009; EP, 2012; TCRP, 2013; EP, 2014). The experience in PT shows that its implementation requires great effort as operators need to agree on standards, arrangements, interfaces and revenue sharing. In the context of multi-operator PT, in which each operator plays a different role, integrated ticketing is almost impossible to achieve (EP, 2014). Indeed, integrated ticketing predominantly exists only within agencies or providers that operate both water and land modes (TCRP, 2012).

In addition to integrated ticketing, improvements on reliability, speed, frequency, or faster boarding time may help to divert commuters towards ferries more successfully. For tourists, integrated ticketing schemes could be better exploited, for instance in the form of "tourist travel passes" that provide access by way of PT to entertainment venues (e.g., exhibitions, festivals, cultural events) and other sites of touristic interest.

6. THE FERRY INDUSTRY AT DIFFERENT LEVELS

6.1 Urban

In several urban areas of the European Union (EU), ferries provide services along critical connections for communities of all sizes and serve a variety of needs. Many ferry services have been integrated with land-based Public Transport (PT) for decades, ensuring that passengers can easily reach their destinations without using private cars. At the same time, in cities with waterfront areas (i.e., ports or rivers) ferries are an effective tool to expand urban mobility options, providing new capacity to congested road networks.

In general, ferries serve both commuters dwelling in suburban areas and tourists looking for sightseeing opportunities. Their service is important to connect remote urban communities (e.g., on an island), urban communities for which an overland journey is longer (e.g., a gulf or a harbour), or where the construction of a fixed link is not possible (e.g., too wide a river or lake).

Land-use patterns, residential and employment density and road network layout are all variables that influence ferry availability, frequency and coordination with land-based PT. The flexibility of ferries is an advantage where transport demand relies extensively on congested fixed links to provide access to urban areas. An appropriate layout of ferry terminals may facilitate their integration with land-based PT. On the water-side, the infrastructure design should avoid lengthy berths and walking time to reach land-based services. On the land side, buses require appropriate bays to load/unload. Land access/egress pathways are other important elements to successfully integrate ferries with metro/tram stops, or trains stations (Urban Design in Planning, 2007).

Elements that make ferries and land transport operations seamless which proved useful to communities with waterfronts or which transformed their waterways into part of the PT system include the integration of the urban PT system and the improvement of urban accessibility with fast suburban services. Please see Table 28 in Annex III where practical cases of ferries in urban areas are presented.

6.2 National and regional

EU Regulation 3577/92 (EC, 1992b; "Cabotage" Regulation) liberalised maritime transport by granting freedom to provide services within a Member State to community ship-owners operating ships registered in a Member State and flying the flag of a Member State[66].

Where revenues are insufficient to make the services economically viable, operators receive government subsidies. In this case, special care needs to be taken as subsidies can fall under EU restrictions on State Aid. Tendering procedures have been introduced to promote efficiency and reduce costly subsidies (Rehmatulla, 2014). Ferry tendering is covered by two EU public procurement Directives: 2004/17/EC (EC, 2004a) and 2004/18/EC (EC, 2004b).

On a regional scale, for example along indented coastlines or inside archipelagos with numerous fjords and islands, ferries may supplement the road network. Local authorities rule and services are operated like in the case of PT provision. Operators are, either publicly owned (e.g., by a regional government), or licensed private companies, providing subsidised

[66] The Regulation allows provision of services subject to Public Service Obligations (PSOs) in the interest of maintaining adequate cabotage between the mainland and its island regions and/or providing funding to operators who provide PSOs, through entering into Public Service Contracts (PSCs) (Baird and Wilmsmeier 2011).

services in the form of a temporary monopoly (Roueche, 1981; Odeck and Bråthen, 2007). A non-exhaustive list of regional cases is presented in Table 29 in Annex III.

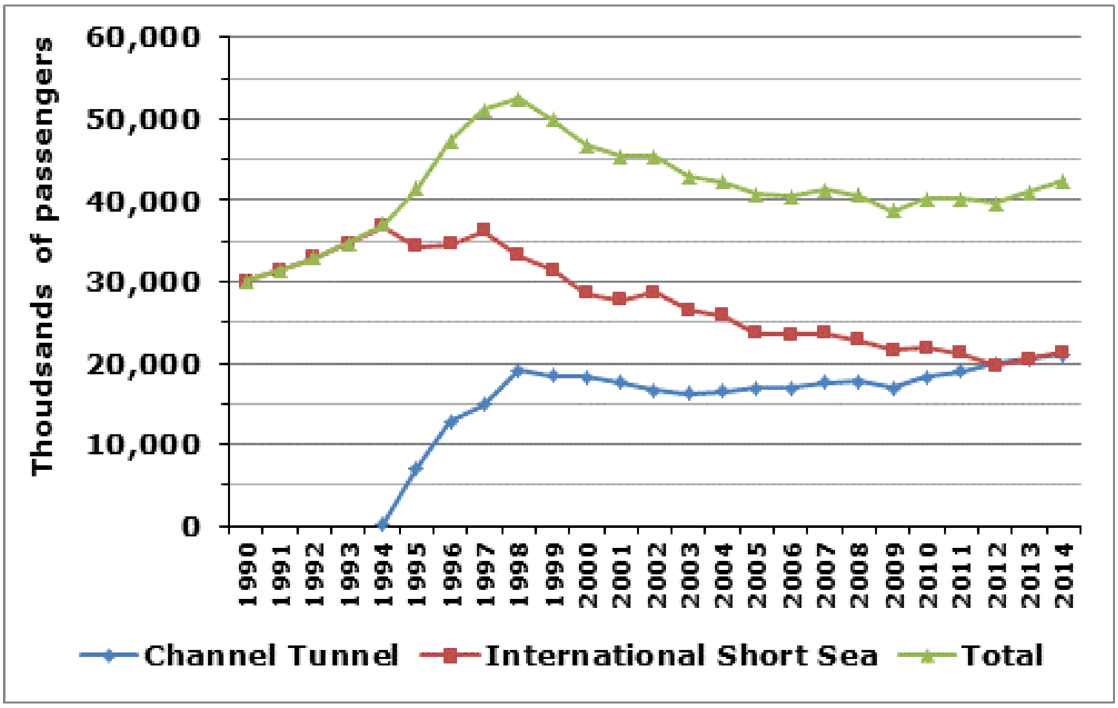
On a national scale, socio-economic purposes justify connections with island regions. With a view to ensuring territorial continuity and integration, governments subsidise some services (Chlomoudis et al., 2007; Rehfisch, 2007; MVA, 2010). Services are contracted to operators (private or publicly owned), may be non-exclusive, and the authorities are at liberty to procure other services on the same routes. A non-exhaustive list of national cases is presented in Table 30 in Annex III.

6.3 Cross-border

On an international scale, physical characteristics and economic context differ again. Operators have to cope with distinct requirements, providing services either while competing amongst themselves (e.g., on prices in the Baltic, Shippax 2014), or within the maritime sector (e.g., short-sea Ro-Ro), or even with other modes.

As part of large transport networks, ferries have to cope with developments in infrastructures and services. As regards infrastructures (i.e., fixed links), ferries may be either replaced[67] or they may operate in competition[68] (see Figure 9 below). Concerning the services provided, ferries may face competition by the aviation sector, especially low-cost carriers. A description of these cases is presented in Table 31 in Annex III.

Figure 9: Traffic comparison between the Channel Tunnel and International Short Sea journeys[69] in UK (thousands of passengers)



Source: Department for Transport of UK (2014)

[67] E.g., in 1997, when the Storebælt crossing system replaced the ferries in Denmark.
[68] For example, such as the case of the Channel Tunnel or the Øresund link.
[69] This is the sum of the traffic of ports of Thames and Kent and South, East and West regions.

In the European regions a significant number of international connections are operated to Schengen and non-Schengen countries. According to the Schengen Agreement (1985) and the Schengen Implementing Convention (1990)[70], cross-border passengers travelling via seaports are exempt from checks only if an internal border amongst contracting parties (countries) is crossed with regular ferry connections (i.e., a connection within the Schengen area). The current Schengen area covers 26 countries, namely the non-EU countries of Iceland, Norway, Switzerland and Liechtenstein (non-EU Schengen States) plus the EU Member States, with the exception of the UK and Ireland (non-Schengen EU States) and of Cyprus, Bulgaria, Romania and Croatia (Schengen candidate countries).

Checks are carried out at internal cross-border seaports only if (i) public policy, or national security, so require for a limited period of time and if deemed appropriate to the situation (EC, 2010; EC, 2016a)[71] and (ii) if ports do not have separate Schengen and non-Schengen handling areas. In these cases, security checks may be carried out at cross-border seaports to verify a person's identity, but only on the basis of police information about possible threats to public security or suspected cross-border crime.

The Schengen contracting parties share a common external coastal border, along which seaports are located. Passengers crossing an external cross-border seaport are subject to checks by the competent authorities in accordance with uniform principles, within the scope of national powers and national legislation, and taking into account the interests of all contracting parties[72].

Recently, cross-border seaports have become not only entry points of people travelling for work and leisure, but also for those seeking refuge from war and persecution. According to the European Commission's biannual report on the functioning of the Schengen area (EC, 2013e), in 2012 the majority of irregular cross-border transits detected took place on the EU external sea border (59%). An example of this is the high number of stowaways on board of ferries to Italy[73]. This situation has led to the temporary reintroduction of internal cross-border checks, which directly involve some ferry connections (EC, 2016a)[74].

6.3.1 Trends of cross-border ferry connections

According to the available data, certain trends of cross-border ferry connections can be observed over the period 2006-2014 for the Baltic, the North Sea and the Mediterranean

[70] The Schengen area was founded in 1985 when Belgium, France, Germany, Luxembourg and the Netherlands signed the Schengen Agreement. It set out the gradual abolition of checks at common borders. The agreement was supplemented by the Implementing Convention (1990) on the final abolition of internal border controls and accompanying measures. The convention strengthened external border checks, defined procedures for issuing uniform visas, established the Schengen Information System, increased police cooperation at internal borders and improved actions against drug trafficking. The Schengen Agreement was integrated into the EU legal framework with the Treaty of Amsterdam (1999) and Regulation 562/2006 (EC, 2006c). The entry into force of the Treaty of Lisbon (2009) made further changes to EU Justice and Home Affairs policies and to the Schengen *acquis*. Other relevant pieces of legislation are Regulations 1683/95, 539/2001, 693/2003, 1931/2006, 767/2008 and 810/2009.

[71] Internal cross-border checks for security reasons were reintroduced in Finland (from the 9th to the 21st of October 2006 and from the 13th to the 29th of November 2006) at the ports of Helsinki, Hanko and Turku; in Germany (from the 6th to the 8th of June 2007) at the sea border; in Finland (from the 24th of November to the 5th of December 2008) at the ports of Helsinki and Turku; in Germany (from the 20th of March to the 5th of April 2009) at the sea border; in Italy (from the 28th of June to the 15th of July 2009) at the sea borders and in Malta (from the 9th of November to the 31st of December 2015) at the sea passenger terminal.

[72] See Article 6 of the Schengen Convention (1990).

[73] During July-September 2012, Greece reported more than half of the detected irregular cross-border transits; this situation changed following the launch of Operation Shield. During October-December 2012, Italy reported 31% of cases detected (4 231 persons), followed by Greece, (30% or 4 035). There was also an increase in cases detected at the Greek sea border with Turkey.

[74] In November 2015, Denmark and Norway reintroduced internal checks. They focussed on ports with ferry connections (e.g., with Germany), due to the big influx of persons seeking international protection.

regions. Cross-border connections can be sorted into Schengen and non-Schengen connections and compared to domestic connections.

Over the nine-year period observed, the total number of cross-border connections decreased, especially in the Schengen area (-31.3%), due to the situation of the economy (Shippax, 2009), the competition with fixed links[75] and low-cost airline carriers (Shippax, 2012) and overcapacity (Shippax, 2013) (see Table 5 below). In this respect, cross-border connections operated in the three regions show negative trends, with the exception of the North Sea Schengen area (unchanged) and the Baltic non-Schengen area (positive), although both representing a tiny share of traffic (around 5%) in the respective areas. In the North Sea and the Mediterranean the number of cross-border connections is much lower than the domestic ones, while in the Baltic the number of cross-border connections has been surpassed by domestic services only in 2011.

Table 5: Type of connections operated

Type of connection		2006	2007	2008	2009	2010	2011	2012	2013	2014	var. % 2006-2014
Baltic											
Domestic		72	82	86	99	105	116	118	127	127	+76.4%
Cross-border total		136	132	122	109	106	106	103	100	100	-26.5%
Cross-border	*Schengen*	*127*	*118*	*109*	*97*	*93*	*91*	*89*	*88*	*87*	*-31.5%*
	Non-Schengen	*9*	*14*	*13*	*12*	*13*	*15*	*14*	*12*	*13*	*+44.4%*
Total		**208**	**214**	**208**	**208**	**211**	**222**	**221**	**227**	**227**	**+9.1%**
North Sea											
Domestic		146	146	145	142	145	142	139	142	141	-3.4%
Cross-border total		74	81	79	71	66	64	62	61	61	-17.6%
Cross-border	*Schengen*	*13*	*17*	*18*	*15*	*13*	*12*	*12*	*14*	*13*	*0.0%*
	Non-Schengen	*61*	*64*	*61*	*56*	*53*	*52*	*50*	*47*	*48*	*-21.3%*
Total		**220**	**227**	**224**	**213**	**211**	**206**	**201**	**203**	**202**	**-8.2%**
Mediterranean											
Domestic		309	318	328	330	318	335	340	347	341	+10.4%
Cross-border total		196	183	177	185	200	206	185	176	166	-15.3%
Cross-border	*Schengen*	*61*	*54*	*51*	*49*	*50*	*51*	*46*	*41*	*38*	*-37.7%*
	Non-Schengen	*135*	*129*	*126*	*136*	*150*	*155*	*139*	*135*	*128*	*-5.2%*
Total		**505**	**501**	**505**	**515**	**518**	**541**	**525**	**523**	**507**	**0.4%**
Total of all the regions											
Domestic		527	546	559	571	568	593	597	616	609	+15.6%
Cross-border total		406	396	378	365	372	376	350	337	327	-19.5%
Cross-border	Schengen	*201*	*189*	*178*	*161*	*156*	*154*	*147*	*143*	*138*	*-31.3%*
	Non-Schengen	*205*	*207*	*200*	*204*	*216*	*222*	*203*	*194*	*189*	*-7.8%*
Total		**933**	**942**	**937**	**936**	**940**	**969**	**947**	**953**	**936**	**0.3%**

Source: Elaborations of the authors from Shippax publications

[75] For example the crossings of the English Channel, between UK and France, and the Øresund Strait, between South West Sweden and East Denmark.

6.3.2 Cross-border and passport checks

According to the European Commission (2002), there are no specific checks for passengers travelling by ferry. As for the other transport modes, the abolition of internal cross-border controls for EU citizens meant an end to the requirement to show a valid ID (i.e., passport or identity card)[76] within the Schengen area.

Before boarding the vessel passengers are normally checked by the ferry operator staff to verify their identity against the details on the ticket purchased (i.e., time, day and connection). Every port is different and ferry operators may conduct checks according to own embarkation processes. A distinction is done between foot passengers, which are controlled individually and passengers travelling by car, bus, or truck, which are controlled at the vehicle. When travelling to non-Schengen EU States, EU citizens have to show ID entering the country at arrival and undergo normal cross-border checks.

[76] For non-EU citizens, the length of stay and the country of origin specify the entry conditions into the Schengen area. Non-EU citizens must hold a valid passport and apply for a short-term visa provided they come from certain third countries and intend to stay for less than three months (EC, 2001; EC, 2009e). A long-term visa, or residence permit, is needed for a longer stay. It is up to the Schengen countries to set their own requirements for issuing a long-term visa or resident permit.

7. CONCLUSIONS

Since 2000, the ferry industry has been undergoing a gradual process of consolidation. The trends observed show that the Emission Control Areas (ECAs), the abolition of the duty-free regime, the competition from fixed links and low-cost airline carriers and the escalation of bunker prices have influenced the operations in the industry.

Today, operators' performance usually reflects the situation of the economy, especially that of the region where their business is located. This means that if the economy has been recovering well, operators show quite good results, and if the economy remains stagnant, operators suffer more. In general, operators have concentrated their activities in one region only and have optimised their fleet by exploiting vessels' economies of scale. The contraction of routes operated and overall fleet (i.e., size and capacity) confirms such tendency. This also shows that the ferry industry is flexible and inclined to adapt its potential to negative or positive variations in transport demand.

For many years, the European Union (EU) has been a leader in technology regarding passenger ships. Notwithstanding the fact that today South Korea, Japan and China are dominant in shipbuilding activities, the EU's position can be characterised as one of a niche player. European shipyards have a high degree of specialisation and high-tech qualities (Ecorys, 2009; EC 2013d) and European equipment suppliers provide sophisticated technical solutions (EC, 2011; BALance, 2015). If supported by the demand of the industry, this competence can be exploited to make the ferries an attractive investment opportunity and, at the same time, more efficient and cost-effective in their compliance with the ECAs' requirements.

Alternative propulsion systems (such as Liquefied Natural Gas (LNG), methanol, hybrid and electric systems) have the potential to replace bunker fuel, especially for short sea shipping. However, high investment costs have reduced the predicted number of LNG ships, and the interest to invest in methanol is uncertain (although less expensive than LNG, the main limitation is the logistics for supplying fuel). All-gas, hybrid and electric ships are limited to a few examples (their take-up is promising on short-run routes, but clearly linked to the technological development of energy-storage capacity).

Energy-efficiency measures may stimulate a more efficient design of ferries, thereby indirectly reducing Carbon Dioxide (CO_2) and Greenhouse Gas (GHG) emissions. These are viable solutions to increase propulsive and power production efficiency and reduce auxiliary consumption. Electricity is an option for shore-side connections, which reduces air and noise emissions in ports within urban and industrial areas. Finally, the Ballast Water Management (BWM) Convention, which has not yet been ratified, is expected to produce a strong demand on treatment systems in the long term. In parallel, an innovative concept of a "ballast-free ship" has been developed to avoid the installation of treatment systems and conventional ballast tanks.

Since 2008, the EU has granted €306 million to the maritime sector, with a number of projects under the Trans-European Transport Networks (TEN-T) and the Connecting Europe Facility (CEF) programmes. The funds granted have concerned the development of Motorways of the Sea (MoS) to promote multimodal efficient transport, building of new ships and technical uptakes, in particular emissions abatement retrofits and cleaner fuels, to achieve the goal of "zero emission/zero waste ships" as described in the EU's Maritime Transport Strategy until 2018 (EC, 2009d). However, it is not possible to define precisely to what extent funds granted can be attributed specifically to the ferry industry.

With regards to services, the ferry industry is by nature multimodal and differs depending on the scale of operations. The characteristics of both the ferries and the transport demand change significantly.

In urban areas, ferries are integrated with land Public Transport (PT) to expand urban mobility. They can contribute to improving the multimodal experience of passengers, as part of PT systems where different modes coexist (i.e., buses, trains, trams). At this scale, they serve suburban commuters and tourists, by operating small vessels. The frequency and coordination with land PT depend on land-use, residential and employment patterns, and the road network layout. Ferries' flexibility to adapt to serve routes according to needs is an advantage compared to congested fixed links in urban areas. Integrated ticketing predominantly exists only if providers operate both water and land modes. Many good examples already exist in EU cities, such as Marseille, Lisbon, Stockholm, Gothenburg, Rotterdam and Venice. For tourists, integrated ticketing schemes could provide access to PT with entertainment venues and sites of interest (e.g., using "tourist travel passes").

On a regional scale, along indented coastlines or inside archipelagos with numerous fjords and islands, ferries may supplement the road network. Transport demand may include both passengers and freight, using larger vessels. On a national scale, socio-economic reasons justify connections with islands and island regions. Furthermore, in some specific cases, the ferry industry operates in competition with fixed links (e.g., the Channel tunnel and the Øresund link) and with low-cost airline carriers. Governments subsidise the services to ensure territorial continuity and integration.

The value of a ferry ticket is directly connected to the pricing policy of the ferry operator, which, in general, depends on a number of variables (the route, the type of passenger accommodation, the category of accompanying vehicle and the season). It is also the result of the analysis of competitive prices, elasticity of demand and potential for market segmentation. Prices have followed the approach used in the airline market, by becoming extremely flexible and susceptible to regular change, for example according to the proximity of the departure date.

There are no specific checks for passengers travelling by ferry. As for the other transport modes, the abolition of internal cross-border controls for EU citizens meant an end to the requirement to show a valid ID within the Schengen area. Taking into account the experience gained since the adoption of the Cabotage Regulation (EC, 1992b), the framework for providing connections with islands, island regions and intra-EU passenger transport could be promoted, with measures to facilitate better quality ferries and appropriate terminals.

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ANNEX I: RELATED TO SECTION 2

Table 6: Passengers of ferries traffic volumes worldwide (thousands)

Year	EU regions	Rest of the[77] World	Total
2006	718 358	911 216	**1 629 574**
2007	765 276	916 656	**1 681 932**
2008	761 494	1 319 444	**2 080 938**
2009	743 732	1 308 342	**2 052 073**
2010	738 775	1 317 288	**2 056 063**
2011	766 287	1 372 520	**2 138 807**
2012	778 615	1 400 779	**2 179 394**
2013	797 738	1 385 493	**2 183 231**
2014	805 009	1 388 426	**2 193 434**

Source: Elaboration of the authors from Shippax publications

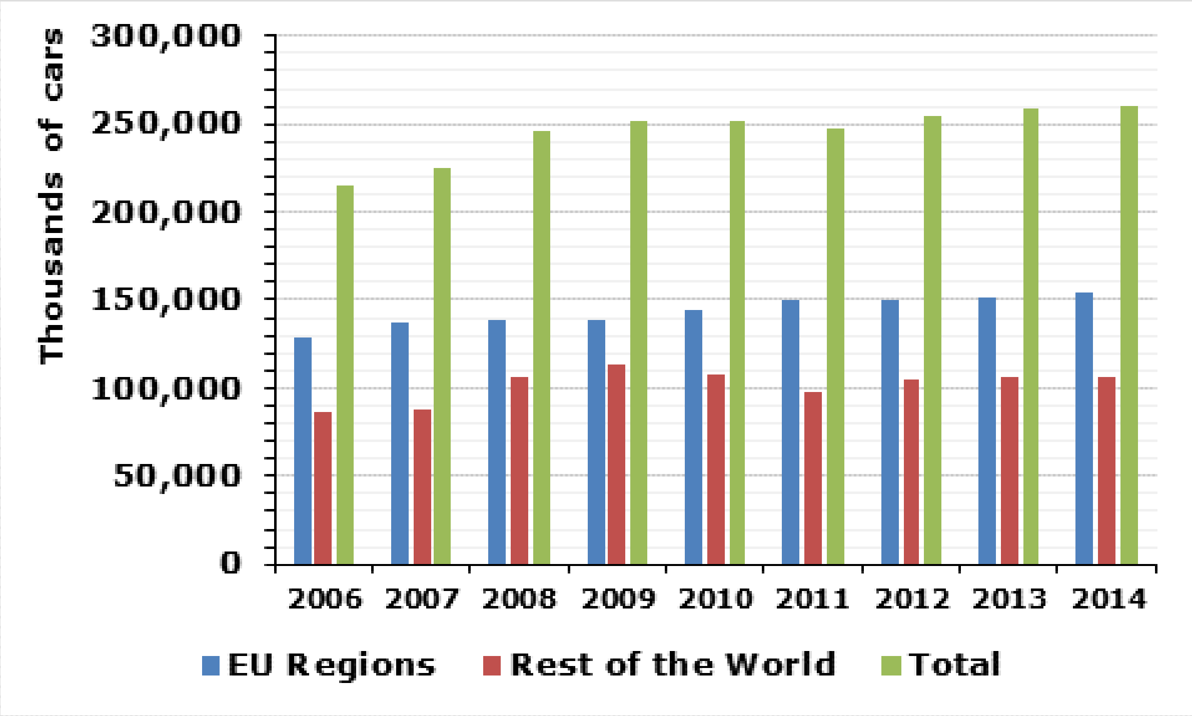
Table 7: Cars of ferries traffic volumes worldwide (thousands)

Year	EU regions	Rest of the World	Total
2006	128 553	85 922	**214 475**
2007	137 622	87 602	**225 224**
2008	139 099	106 698	**245 797**
2009	139 108	112 853	**251 960**
2010	143 775	107 722	**251 498**
2011	149 513	97 596	**247 109**
2012	149 783	104 150	**253 932**
2013	151 803	106 605	**258 407**
2014	153 769	106 712	**260 481**

Source: Elaboration of the authors from Shippax publications

[77] The category Rest of the World includes: Africa, America, Central Asia, Pacific and South East Asia. It is worth noticing that over the period considered the passengers have grown more in the Rest of the World (477 210 thousands) than in the EU (86 651 thousands). The demand in the EU regions is recovering after the crisis of the economy. In the rest of the world the passengers' transport demand is driven by the remarkable growth in Asia (392 381 thousands). For example, in China the demand in Bo Hai and the rest of the Yellow Sea regions have grown, due to the connections with South Korea and Japan (Shippax, 2015).

Figure 10: Cars of ferries traffic volumes worldwide



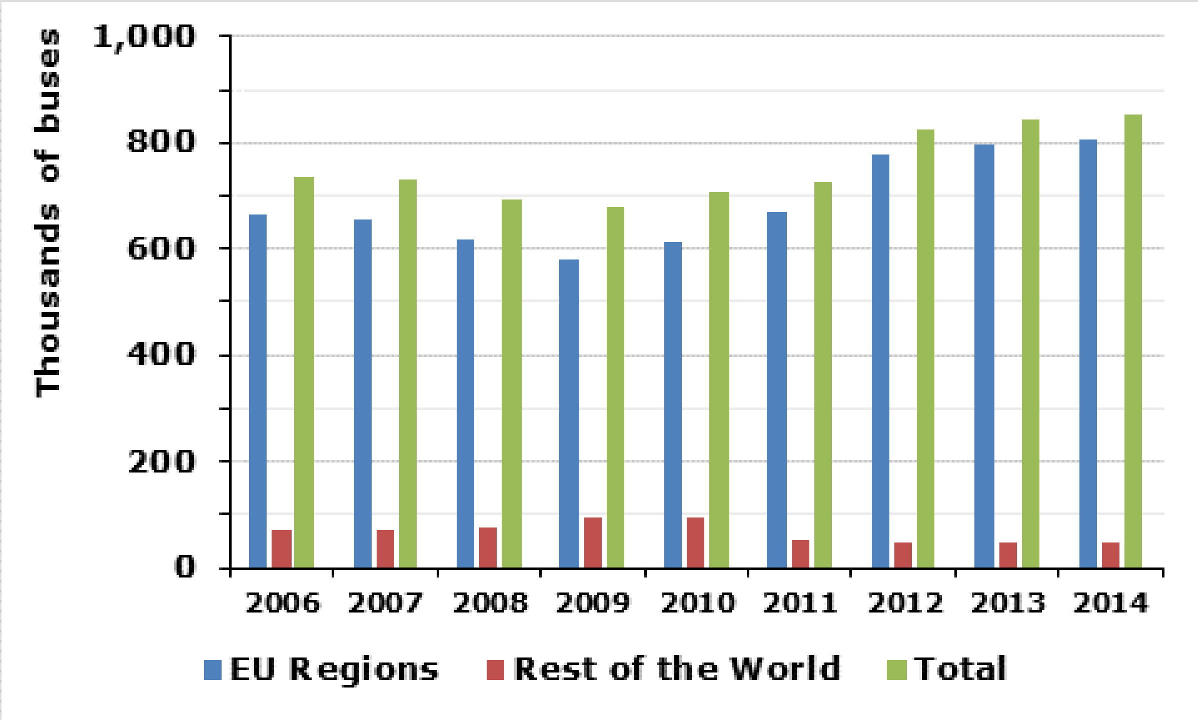
Source: Elaboration of the authors from Shippax publications

Table 8: Buses of ferries traffic volumes worldwide (thousands)

Year	EU regions	Rest of the World	Total
2006	663	73	**735**
2007	656	74	**730**
2008	616	75	**691**
2009	581	96	**677**
2010	612	94	**705**
2011	670	54	**724**
2012	778	49	**827**
2013	795	48	**843**
2014	805	47	**853**

Source: Elaboration of the authors from Shippax publications

Figure 11: Buses of ferries traffic volumes worldwide



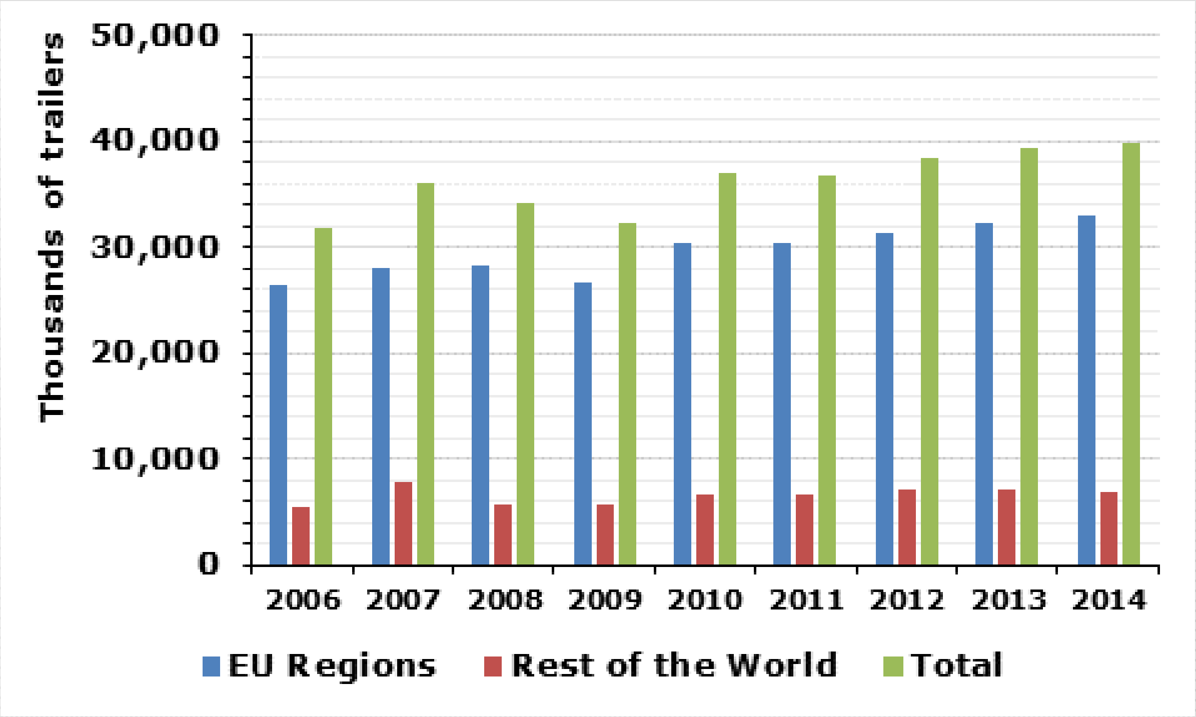
Source: Elaboration of the authors from Shippax publications

Table 9: Trailers of ferries traffic volumes worldwide (thousands)

Year	EU regions	Rest of the World	Total
2006	26 429	5 401	**31 829**
2007	28 100	7 876	**35 975**
2008	28 314	5 757	**34 071**
2009	26 600	5 578	**32 179**
2010	30 445	6 521	**36 967**
2011	30 332	6 539	**36 871**
2012	31 315	7 083	**38 398**
2013	32 204	7 151	**39 355**
2014	32 978	6 952	**39 930**

Source: Elaboration of the authors from Shippax publications

Figure 12: Trailers of ferries traffic volumes worldwide



Source: Elaboration of the authors from Shippax publications

Table 10: Passengers traffic volumes in the EU regions (thousands)

Year	Baltic	North Sea	Mediterranean	Total
2006	211 018	95 893	411 447	**718 358**
2007	225 683	105 779	433 814	**765 276**
2008	224 960	97 146	439 388	**761 494**
2009	220 777	89 093	433 862	**743 732**
2010	224 880	101 802	412 093	**738 775**
2011	233 065	102 773	430 448	**766 287**
2012	234 904	102 711	441 000	**778 615**
2013	237 672	103 745	456 320	**797 738**
2014	240 026	105 242	459 741	**805 009**

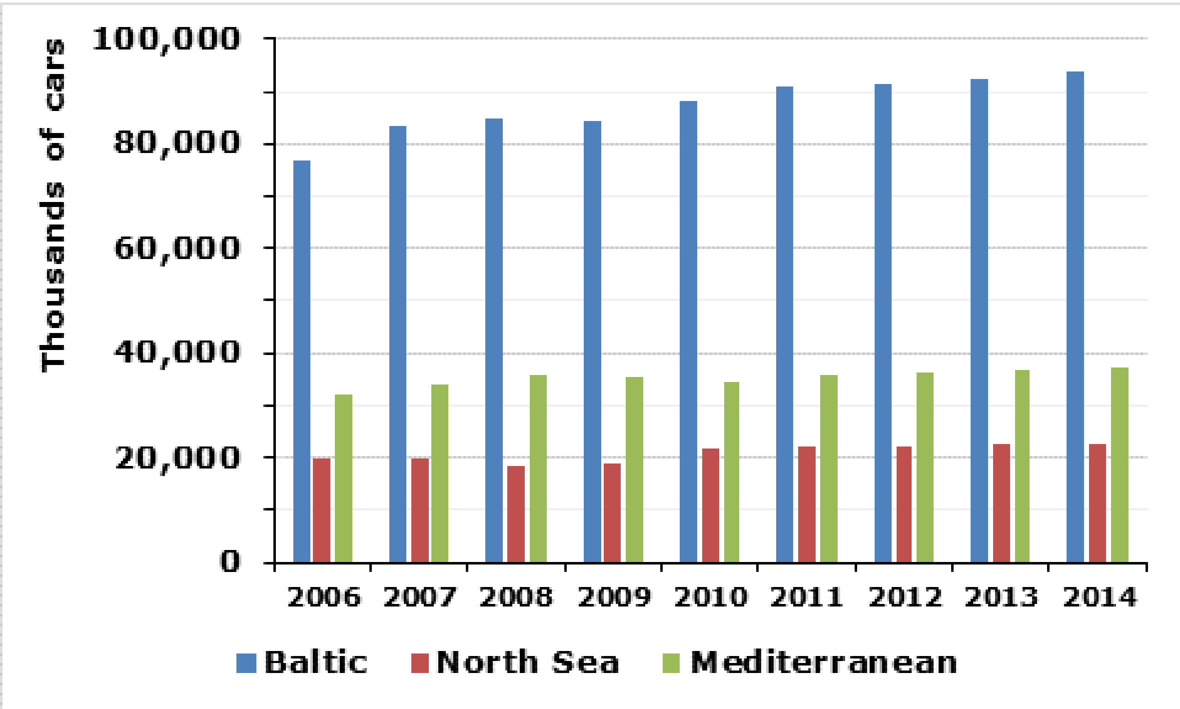
Source: Elaboration of the authors from Shippax publications

Table 11: Cars traffic volumes in the EU regions (thousands)

Year	Baltic	North Sea	Mediterranean	Total
2006	76 837	19 654	32 062	**128 553**
2007	83 541	19 942	34 140	**137 622**
2008	84 684	18 494	35 921	**139 099**
2009	84 506	18 988	35 614	**139 108**
2010	87 946	21 550	34 279	**143 775**
2011	91 145	22 353	36 015	**149 513**
2012	91 383	22 111	36 289	**149 783**
2013	92 430	22 530	36 842	**151 803**
2014	93 713	22 822	37 234	**153 769**

Source: Elaboration of the authors from Shippax publications

Figure 13: Cars traffic volumes in the EU regions



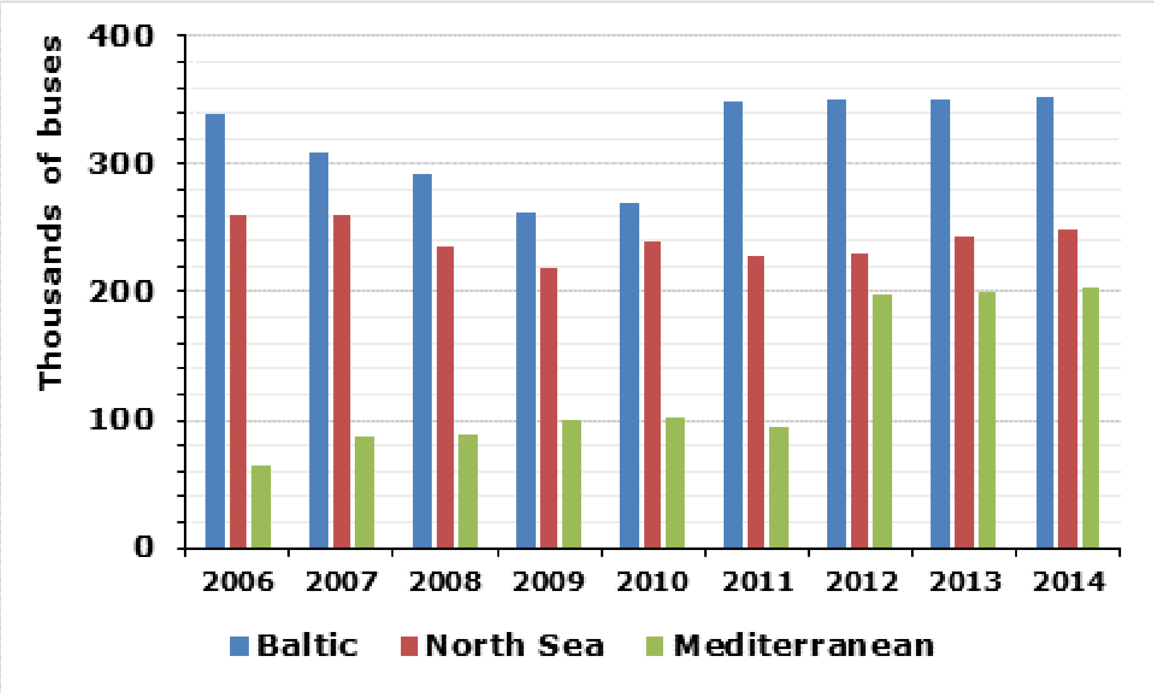
Source: Elaboration of the authors from Shippax publications

Table 12: Buses traffic volumes in the EU regions (thousands)

Year	Baltic	North Sea	Mediterranean	Total
2006	339	260	64	**663**
2007	309	259	87	**656**
2008	292	236	89	**616**
2009	261	220	101	**581**
2010	269	240	102	**612**
2011	348	228	94	**670**
2012	350	229	199	**778**
2013	351	244	200	**795**
2014	353	250	203	**805**

Source: Elaboration of the authors from Shippax publications

Figure 14: Buses traffic volumes in the EU regions



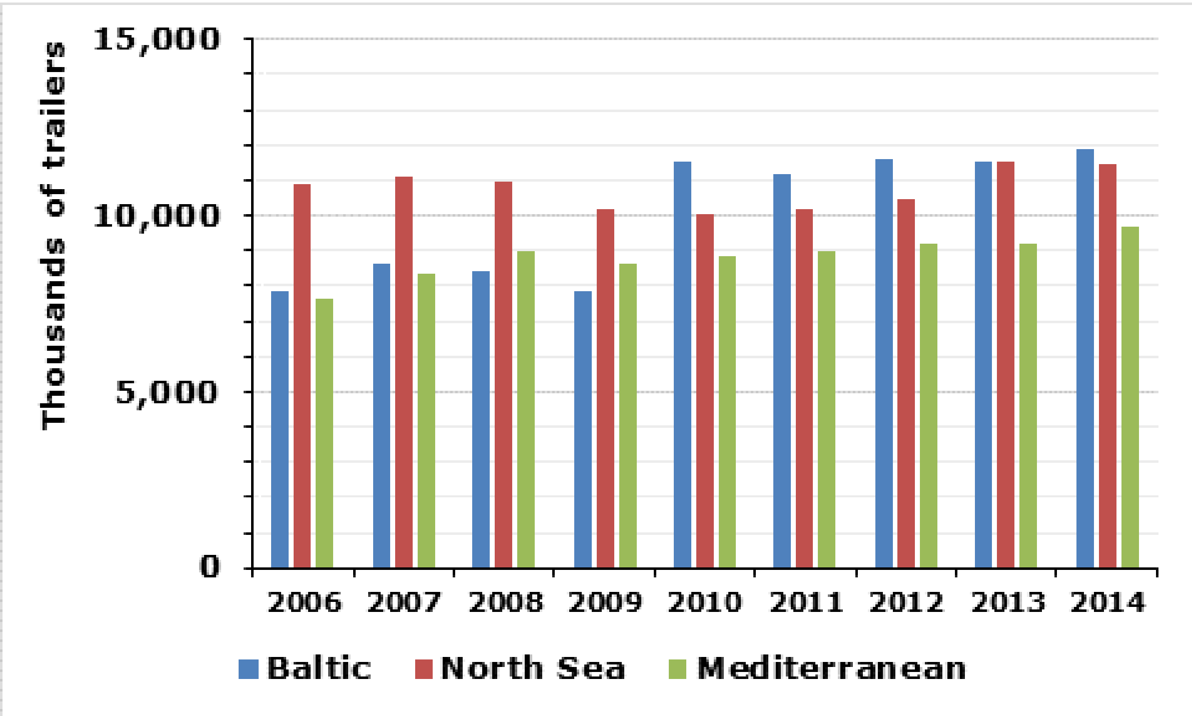
Source: Elaboration of the authors from Shippax publications

Table 13: Trailers traffic volumes in the EU regions (thousands)

Year	Baltic	North Sea	Mediterranean	Total
2006	7 882	10 920	7 627	**26 429**
2007	8 657	11 089	8 353	**28 100**
2008	8 389	10 944	8 982	**28 314**
2009	7 834	10 150	8 616	**26 600**
2010	11 556	10 075	8 815	**30 445**
2011	11 170	10 174	8 987	**30 332**
2012	11 613	10 486	9 216	**31 315**
2013	11 518	11 499	9 187	**32 204**
2014	11 852	11 433	9 692	**32 978**

Source: Elaboration of the authors from Shippax publications

Figure 15: Trailers traffic volumes in the EU regions



Source: Elaboration of the authors from Shippax publications

Table 14: Shares of routes operated in the EU regions

Year	Baltic	North Sea	Mediterranean	Total
2007	22%	24%	54%	**100%**
2008	23%	24%	53%	**100%**
2009	22%	24%	54%	**100%**
2010	22%	23%	55%	**100%**
2011	22%	22%	55%	**100%**
2012	23%	21%	56%	**100%**
2013	23%	21%	56%	**100%**
2014	24%	21%	55%	**100%**

Source: Elaboration of the authors from Shippax publications

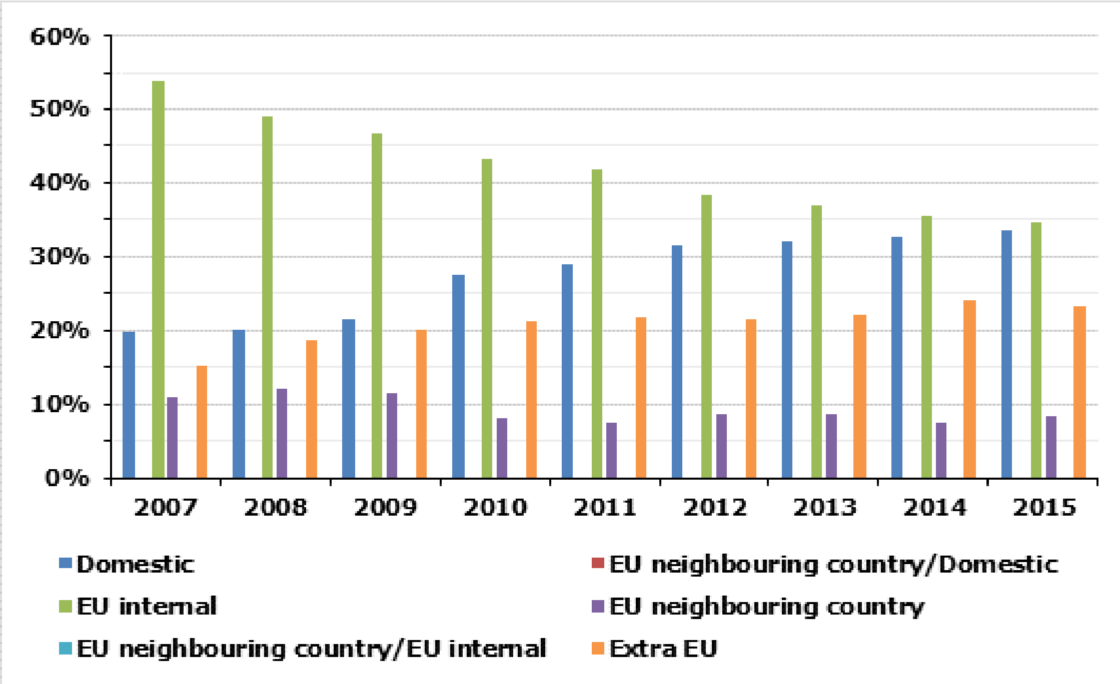
Table 15: Shares of routes operated in the Baltic region[78]

Year	Domestic	EU neighbouring country/Domestic	EU internal	EU neighbouring country	EU neighbouring country/EU internal	Extra EU	Total
2007	20%	0%	54%	11%	0%	15%	**100%**
2008	20%	0%	49%	12%	0%	19%	**100%**
2009	22%	0%	47%	12%	0%	20%	**100%**
2010	27%	0%	43%	8%	0%	21%	**100%**
2011	29%	0%	42%	8%	0%	22%	**100%**
2012	32%	0%	38%	9%	0%	22%	**100%**
2013	32%	0%	37%	9%	0%	22%	**100%**
2014	33%	0%	36%	7%	0%	24%	**100%**

Source: Elaboration of the authors from Shippax publications

[78] Domestic includes routes within an EU Member State. EU neighbouring country/Domestic includes routes of countries that have become part of the EU within the period considered. EU internal includes routes amongst EU Member States. EU neighbouring country/EU internal includes routes of countries that have become part of the EU to countries outside the EU. Extra EU includes routes of countries outside the EU.

Figure 16: Shares of routes operated in the Baltic region



Source: Elaboration of the authors from Shippax publications

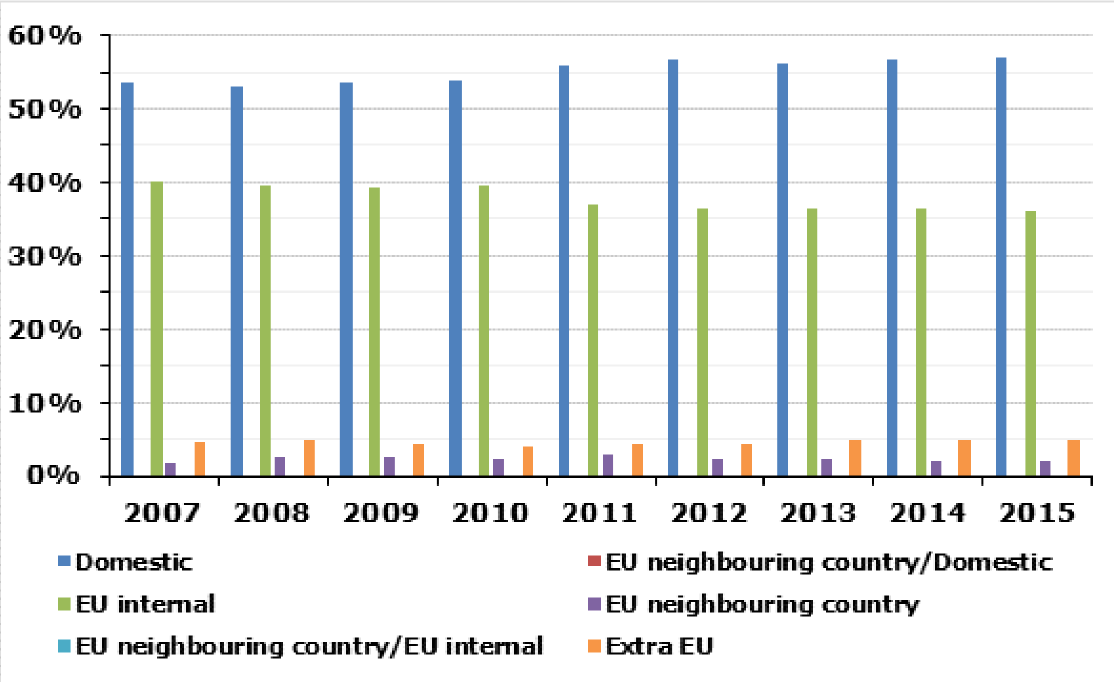
Table 16: Shares of routes operated in the North Sea region[79]

Year	Domestic	EU neighbouring country/Domestic	EU internal	EU neighbouring country	EU neighbouring country/EU internal	Extra EU	Total
2007	54%	0%	40%	2%	0%	5%	**100%**
2008	53%	0%	40%	3%	0%	5%	**100%**
2009	54%	0%	39%	3%	0%	4%	**100%**
2010	54%	0%	39%	2%	0%	4%	**100%**
2011	56%	0%	37%	3%	0%	4%	**100%**
2012	57%	0%	36%	2%	0%	4%	**100%**
2013	56%	0%	36%	2%	0%	5%	**100%**
2014	57%	0%	36%	2%	0%	5%	**100%**

Source: Elaboration of the authors from Shippax publications

[79] Domestic includes routes within a EU Member State. EU neighbouring country/Domestic includes routes of countries that have become part of the EU within the period considered. EU internal includes routes amongst EU Member States. EU neighbouring country/EU internal includes routes of countries that have become part of the EU to countries outside the EU. Extra EU includes routes of countries outside the EU.

Figure 17: Shares of routes operated in the North Sea region



Source: Elaboration of the authors from Shippax publications

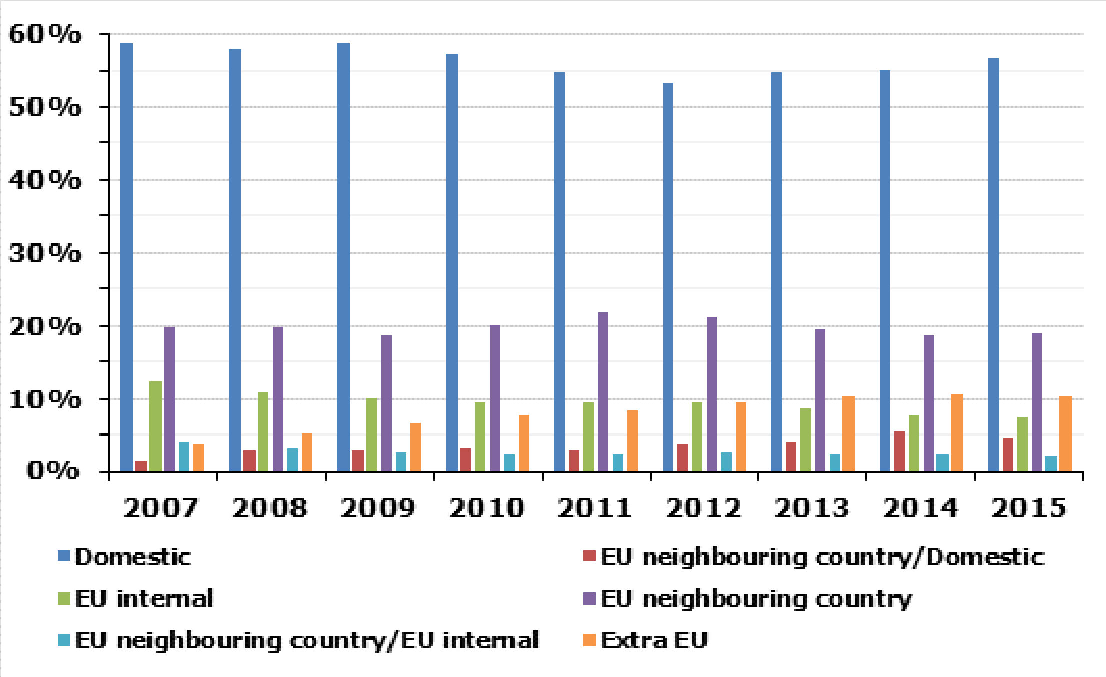
Table 17: Shares of routes operated in the Mediterranean region[80]

Year	Domestic	EU neighbouring country/Domestic	EU internal	EU neighbouring country	EU neighbouring country/EU internal	Extra EU	Total
2007	59%	1%	12%	20%	4%	4%	**100%**
2008	58%	3%	11%	20%	3%	5%	**100%**
2009	59%	3%	10%	19%	3%	7%	**100%**
2010	57%	3%	9%	20%	2%	8%	**100%**
2011	55%	3%	10%	22%	3%	8%	**100%**
2012	53%	4%	9%	21%	3%	10%	**100%**
2013	55%	4%	9%	20%	2%	10%	**100%**
2014	55%	6%	8%	19%	2%	11%	**100%**

Source: Elaboration of the authors from Shippax publications

[80] Domestic includes routes within a EU Member State. EU neighbouring country/Domestic includes routes of countries that have become part of the EU within the period considered. EU internal includes routes amongst EU Member States. EU neighbouring country/EU internal includes routes of countries that have become part of the EU to countries outside the EU. Extra EU includes routes of countries outside the EU.

Figure 18: Shares of routes operated in the Mediterranean region



Source: Elaboration of the authors from Shippax publications

Table 18: Number of ferries in the EU

Year	Baltic	North Sea	Medit.	Total EU	Total world	Baltic	North Sea	Medit.	Total EU
2006	194	115	392	**701**	**1 172**	28%	16%	56%	**100%**
2007	205	122	395	**722**	**1 193**	28%	17%	55%	**100%**
2008	203	123	385	**711**	**1 188**	29%	17%	54%	**100%**
2009	196	124	384	**704**	**1 184**	28%	18%	55%	**100%**
2010	208	122	367	**697**	**1 184**	30%	18%	53%	**100%**
2011	203	122	357	**682**	**1 164**	30%	18%	52%	**100%**
2012	206	121	344	**671**	**1 161**	31%	18%	51%	**100%**

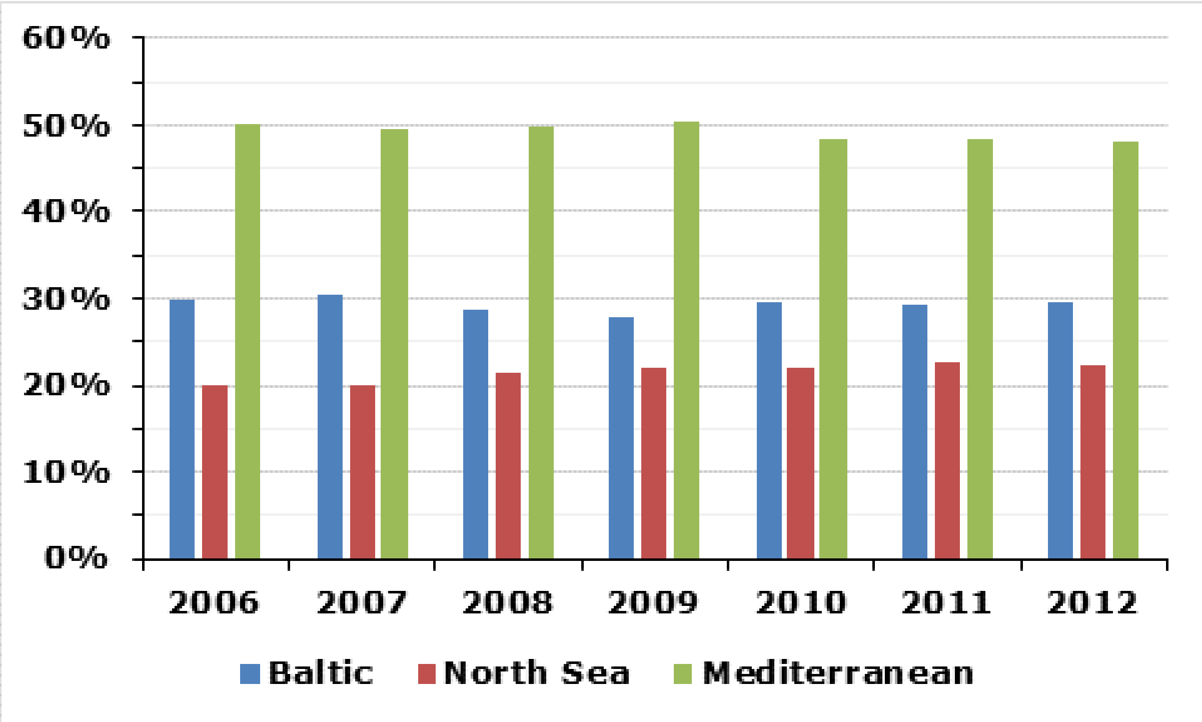
Source: Elaboration of the authors from Shippax publications

Table 19: Gross Tonnes (thousands) transported by ferries in the EU

Year	Baltic	North Sea	Medit.	Total EU	Total world	Baltic	North Sea	Medit.	Total EU
2006	2 922	1 959	4 882	**9 763**	**13 151**	30%	20%	50%	**100%**
2007	3 035	2 000	4 965	**10 000**	**13 587**	30%	20%	50%	**100%**
2008	2 953	2 194	5 094	**10 241**	**14 103**	29%	21%	50%	**100%**
2009	2 838	2 239	5 141	**10 218**	**14 167**	28%	22%	50%	**100%**
2010	2 993	2 242	4 925	**10 160**	**14 221**	29%	22%	48%	**100%**
2011	2 926	2 256	4 827	**10 009**	**14 050**	29%	23%	48%	**100%**
2012	2 909	2 201	4 717	**9 828**	**13 925**	30%	22%	48%	**100%**

Source: Elaboration of the authors from Shippax publications

Figure 19: Share of Gross Tonnes amongst EU regions



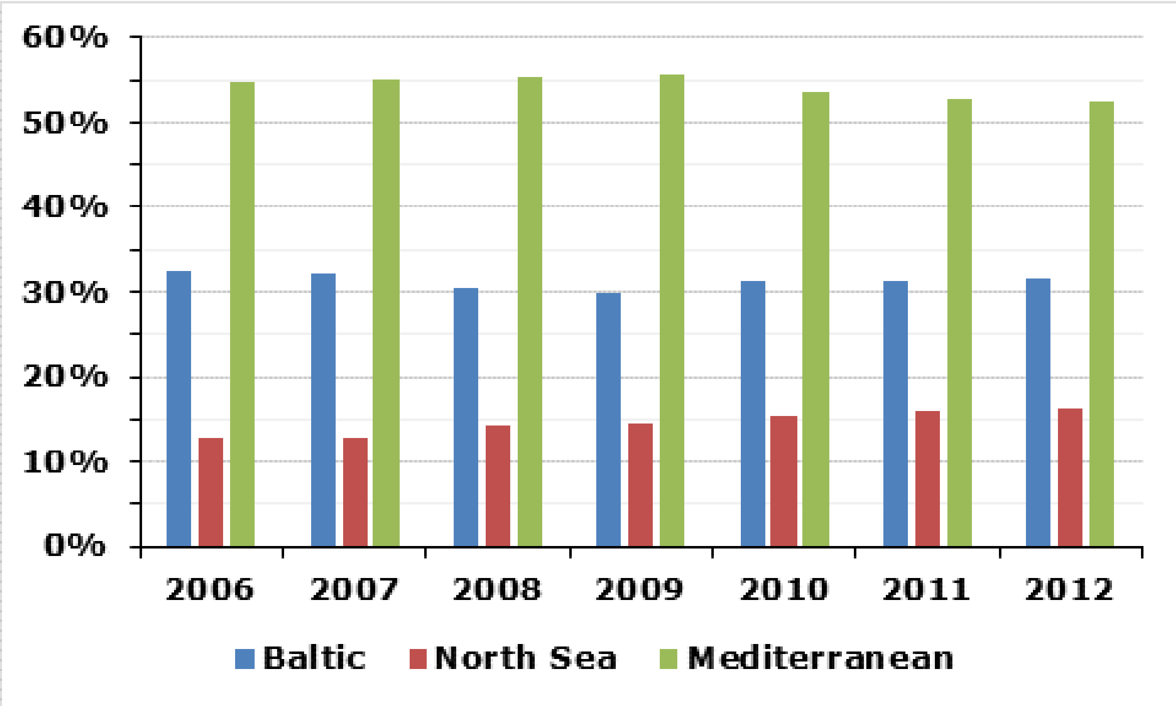
Source: Elaboration of the authors from Shippax publications

Table 20: Number of beds (thousands) in ferries in the EU

Year	Baltic	North Sea	Medit.	Total EU	Total world	Baltic	North Sea	Medit.	Total EU
2006	81	32	137	**250**	**311**	33%	13%	55%	100%
2007	82	33	140	**255**	**317**	32%	13%	55%	100%
2008	78	36	141	**255**	**329**	30%	14%	55%	100%
2009	76	37	140	**253**	**325**	30%	15%	56%	100%
2010	77	37	131	**246**	**316**	31%	15%	54%	100%
2011	76	39	128	**243**	**314**	31%	16%	53%	100%
2012	76	39	127	**242**	**312**	32%	16%	52%	100%

Source: Elaboration of the authors from Shippax publications

Figure 20: Share of number of beds amongst EU regions



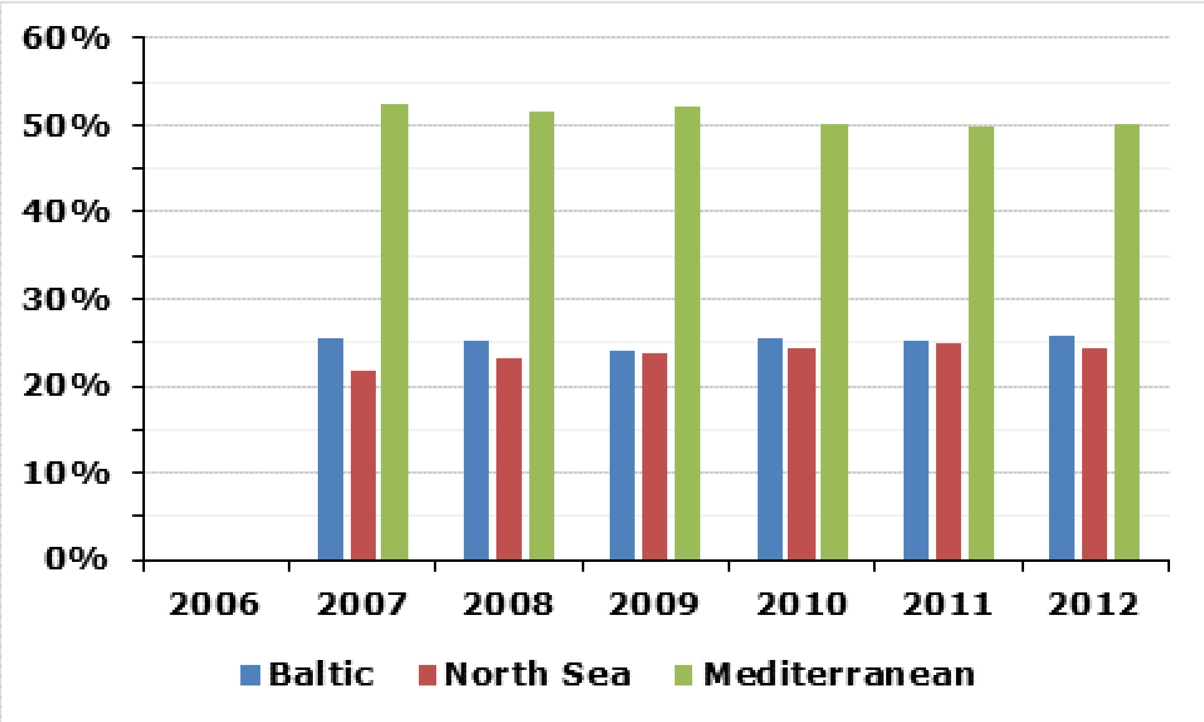
Source: Elaboration of the authors from Shippax publications

Table 21: Vehicles capacity (lanemetre) (thousands) of ferries in the EU

Year	Baltic	North Sea	Medit.	Total EU	Total world	Baltic	North Sea	Medit.	Total EU
2006	n. a.	n. a.	n. a.	n. a.	**779**	n. a.	n. a.	n. a.	n. a.
2007	150	128	308	**587**	**822**	26%	22%	53%	**100%**
2008	150	137	306	**593**	**853**	25%	23%	52%	**100%**
2009	141	140	307	**588**	**847**	24%	24%	52%	**100%**
2010	149	142	292	**583**	**853**	26%	24%	50%	**100%**
2011	146	143	286	**575**	**842**	25%	25%	50%	**100%**
2012	146	137	284	**567**	**836**	26%	24%	50%	**100%**

Source: Elaboration of the authors from Shippax publications

Figure 21: Share of vehicles capacity amongst EU regions



Source: Elaboration of the authors from Shippax publications

Table 22: Ferries fleet (ships)

Year	New ships			Sell and purchase			Chartering			Conversions			Scrapped		
	EU	Tot.	%	EU	Tot.	%	EU	Tot.	%	EU	Tot.	%	EU	Tot.	%
2006	16	18	89	41	61	67	17	18	94	n. a.	n. a.	n. a.	n. a.	23	n. a.
2007	22	28	79	40	60	67	25	25	100	n. a.	n. a.	n. a.	n. a.	21	n. a.
2008	21	35	60	38	61	62	16	16	100	n. a.	n. a.	n. a.	n. a.	20	n. a.
2009	14	17	82	18	31	58	22	22	100	n. a.	n. a.	n. a.	n. a.	12	n. a.
2010	18	23	78	24	35	69	33	33	100	n. a.	n. a.	n. a.	n. a.	29	n. a.
2011	17	27	63	10	18	56	36	40	90	10	13	77	n. a.	30	n. a.
2012	11	22	50	24	32	75	38	41	93	7	8	88	11	17	65
2013	7	11	64	22	28	79	34	36	94	5	5	100	15	21	71
2014	10	17	59	17	22	77	30	32	94	6	6	100	7	10	70

Source: Elaboration of the authors from Shippax publications

Table 23: Investments financed under TEN-T

Year	Project	Description	State of progress	Total cost	EU contribution
2008	High Quality Rail and Intermodal Nordic Corridor Königslinie (TEN-T Priority Project 21 Motorways of the Sea)	The objective of this project was to **upgrade the existing rail ferry** link between the ports of Trelleborg (Sweden) and Sassnitz (Germany) in order to increase the share of rail and intermodal transport on the Swedish-German corridor in particular and the Sweden-Central Europe/Italy corridor. The achievements the project included **adaptation of berths** in the port of Trellborg (additional roadside ramps, wider breakwater). **Corridor involved**: Swedish-German corridor in particular and the Sweden-Central Europe/Italy corridor.	This project has been completed.	€50 349 000	€10 200 000 (20.26% for works and studies).
2010	Motorway of the Sea Rostock-Gedser (TEN-T Priority Project 21 Motorways of the Sea)	The project was part of a global project, covering infrastructure initiatives on the transport axis Copenhagen-Berlin: extension of railway Rostock-Berlin, upgrading of European road E55 into the port of Rostock, **introduction of new ferries**. This transport axis has seen a growing demand. The ferries were operating at capacity limits and reached the end of their technical lifetime. They have been replaced by new ferries (2012), which **doubled capacity and improved operational reliability, environmental performance and service costs**. Corridors involved: Copenhagen-Berlin and Berlin-Verona/Milano-Bologna-Napoli-Messina-Palermo.	This project has been completed.	€111 797 328	€22 359 466 (20% for work and studies).
2010	LNG infrastructure of filling stations and deployment in ships (TEN-T Priority Project 21 Motorways of the Sea)	The project consisted **of feasibility studies on LNG filling station infrastructure** as well as a full scale pilot action. The project aimed at harvesting positive environmental and climate effects, The pilot project modified the design of two new build vessels to a LNG propulsion system, This was the first time that a Ro-Pax vessel of 1,350 lane metre (for trucks) was built with LNG propulsion.	This project has been completed,	€26 789 000	€9 569 500 (35.72% for work and studies).

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Year	Project	Description	State of progress	Total cost	EU contribution
2011	LNG in Baltic Sea Ports (TEN-T Priority Project 21 Motorways of the Sea)	The aim of the proposed action was to develop a **harmonised approach towards LNG bunker filling infrastructure in the Baltic Sea region**. By sharing knowledge between 7 Baltic partner ports (Aarhus, Helsingborg, Helsinki, Malmö-Copenhagen, Tallinn, Turku, Stockholm). The project contributed to the implementation of the Baltic Sea Strategy.	This project has been completed.	€3 394 040	€1 697 020 (50% for studies).
2012	Flexible LNG bunkering value chain in the Spanish Mediterranean Coast (TEN-T Greening Transport)	The project consisted of studies to address both maritime fleet and port facilities transition simultaneously, **reducing the time-to-market of the LNG Bunkering Service in the Spanish Mediterranean ports**. To meet the objective, a study conducted to analyse the technical, operative, economic and legal aspects of LNG bunkering vessel operations enabling medium term deployment (2015-2020).	This project has been completed.	€2 088 000	€1 044 000 (50% for studies).
2012	Kvarken Multimodal Link - Midway Alignment of the Bothnian Corridor (TEN-T Priority Project 21 Motorways of the Sea)	This **MoS project** looked at upgrading the transport link between northern Sweden and western Finland, including land and waterborne transport systems. Infrastructure investments made in both countries improved port logistics, rail connections and port intermodality. Works: **start-up aid for a temporary ferry, including the necessary upgrading and adjustments** made and planned for this temporary solution. The upgrading and adjustments have been used as examples during the analyses and concept development. Studies: which include an analysis of traffic management and organizational aspects of the transport link, as well as the development of a transport concept to meet the needs and provide a good foundation as input for the **detailed design or procurement of a ferry.**	This project has been completed.	€20 574 000	€6 129 000 (50% for studies, 30% for start-up aid and 20% for works).

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Year	Project	Description	State of progress	Total cost	EU contribution
2012	LNG hub in the northwestern Iberian Peninsula (TEN-T Greening Transport)	The objective of the project was **to develop a hub for LNG as fuel for the Port of Ferrol** in the northwest of Iberian Peninsula. It focused on the design of the necessary facilities, infrastructure and procedures in order to supply LNG as fuel along the entire port logistics chain: from the port services to ships navigating on the Atlantic corridor, which belongs to **the MoS Western Europe, Corridor involved: Atlantic corridor**.	This project has been completed.	€1 204 000	€602 000 (50% for studies).
2012	LNG Masterplan for Rhine-Main-Danube (TEN-T Priority Project 18 Waterway axis Rhine/Meuse-Main-Danube)	The project objective was to prepare and to launch the **full-scale deployment of LNG**. The Masterplan built on the results and lessons learned from pilot deployments of LNG vessels and terminals in a set of 13 pilots. The pilot deployments was performed by barge and terminal operators, logistics service providers as well as shipyards together with their commercial partners and suppliers. All pilots covered parts of an entire LNG supply chain from the LNG import terminal to the end client, Corridor involved: Rhine/Meuse-Main-Danube.	This project has been completed.	€33 967 845	€16 983 922.5 (50% for studies).
2012	LNG Rotterdam Gothenburg (TEN-T Priority Project 21 Motorways of the Sea)	The project created break bulk infrastructure for **small-scale LNG supply in the Ports of Rotterdam and Gothenburg**. The facilities in Rotterdam distribute LNG in the Gas Access To Europe terminal in smaller quantities. From this new break bulk facility other LNG infrastructure facilities can be supplied with LNG, like smaller terminals in other ports or fuelling infrastructure for ships. The facility in Gothenburg will be the first satellite terminal to be supplied from the Rotterdam break bulk facility. It serves as a proof of concept as well as a means to **serve the Scandinavian LNG bunkering market**.	This project has been completed.	€171 360 000	€34 272 000 (20% for works).

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Year	Project	Description	State of progress	Total cost	EU contribution
2013	LNG uptake in the UK: a real-life trial with the first small scale bunkering infrastructure in Teesport and innovative LNG vessels (TEN-T Greening Transport)	The project aimed to realise a breakthrough in the application of **LNG for short sea shipping** through a dedicated LNG supply and demand chain **in the UK**. It deployed a LNG bunkering facility in the port of Teesport and carry out a real-life trial in two vessels (ethylene carriers) propelled with an innovative LNG fuel system.	This project has been completed.	€8 604 024	€4 302 012 Euro (50% for studies).
2013	Channel LNG (TEN-T Priority Project 21 Motorways of the Sea)	The main objective of the Global Project was to enable a **gradual but rapid transition towards the viable supply of LNG for a fleet of vessels operating in the ECA and within EU**, (i) Installation of small scale equipment for LNG bunkering in the Zeebrugge terminal (Belgium) to break down large quantities of LNG into smaller ones, (ii) Equipment of three ferry berths with automatic quick release mooring hooks, two at the Port of Portsmouth (UK) and one in the Port of Caen/Ouistreham (France), (iii) Establishment of an optimal logistic chain to LNG in order to deliver LNG to ports and ships remote from the main European gas import terminals and therefore **encourage the rapid growth in the number of vessels using LNG**.	This project has been completed.	€26 646 180	€5 329 236 Euro (50% for studies and 20% for works).
2013	Deployment of next generation scrubber technology for clean and sustainable short sea shipping in the North Sea ECA (TEN-T Priority Project 21 Motorways of the Sea)	This study was a pilot action aiming to overcome technical and operational barriers related to the **introduction of hybrid scrubber technology**, (i) Study of unique prototyped hybrid scrubber system that will be installed on a ferry (P&O Ferries) operating on a strategic transport route between the UK and the EU mainland (Hull-Rotterdam), (ii) Port impact study on the new technology's impact on the environment, including SO_x, NO_x, CO_2, and particle emissions in order to facilitate the uptake of the technology in the EU.	This project has been completed.	€10 270 000	€5 135 000 (50% for studies).

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Year	Project	Description	State of progress	Total cost	EU contribution
2013	Innovative LNG-powered hopper barge deployed under real-life conditions in the ports of Bremen and Bremerhaven (TEN-T Greening Transport)	The pilot study featured technical design and **construction of a LNG propulsion system** for a new hopper barge in the ports of Bremen and Bremerhaven, Germany. The activities included permissions to operate in inland waterways of the port's area, the construction of the LNG related components of the hopper barge and testing the barge under real life conditions. The project's findings and solutions could be **replicable on all types of inland navigation vessels.**	This project has been completed.	€3 307 500	1 653 750 Euro (50% for studies).
2013	LNG Bunkering Infrastructure Solution and Pilot actions for ships operating on the Motorway of the Baltic Sea (TEN-T Priority Project 21 Motorways of the Sea)	The aim of the Global Project was implementing **three pilot actions for LNG, methanol and the use of scrubbers**. These pilots looked at meeting the sulphur legislation in 2015 in the ECA and support the development of a competitive and environmentally sustainable shipping sector in the Baltic Sea. The Action was composed of works and studies. The works aimed at the implementation of an LNG bunker supply infrastructure for the use of LNG at the Port of Brofjorden (Sweden). The studies aimed at the deployment of new LNG technologies in full scale Pilot Actions in vessels in the Baltic Sea and in the North Sea.	This project has been completed.	€74 557 500	€23 103 000 (50% for studies and 20% for works).
2013	LNG in Baltic Sea Ports II (TEN-T Priority Project 21 Motorways of the Sea)	The project aimed to minimise maritime transport pollution in the Baltic region by supporting the **widespread use of LNG**. It built on and extended the "LNG in the Baltic Sea Ports" project (2011), The extension included roll-out of the network to four new Baltic ports (Trelleborg, Sundsvall, Rostock and Klaipeda). The second phase consisted of construction and launching of LNG bunker terminals within the Baltic Sea region.	This project has been completed.	€1 664 646	€832 323 (50% for studies).

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Year	Project	Description	State of progress	Total cost	EU contribution
2013	Pilot deployment of emissions reduction technologies on general cargo vessels on North Sea and Baltic **MoS corridors** (TEN-T Greening Transport)	The project installed and **test the latest scrubber technology** that uses sea water instead of fresh water in an open loop to reduce the sulphur emissions on maritime transport in compliance with new EU Regulations. The **latest scrubber technology** was tried out on three different types of cargo ships, which represented the most common general cargo vessels in the water trade routes of the North and Baltic Seas.	This project has been completed.	€9 058 218	€4 529 109 (50% for studies).
2013	Pilot Implementation of a LNG-Propulsion System on a MoS Test Track in the Environmental Model Region 'Wadden Sea' (TEN-T Priority Project 21 **Motorways of the Sea**)	The objective of this MoS project was to deliver the pilot development and testing of the **innovative methodology for LNG retrofitting**. One of the vessels operating the Borkum service has been converted to LNG by retrofitting its propulsion system in an innovative manner.	This project has been completed.	€6 140 000	€3 070 000 (50% for studies).
2014	Sweden-Poland Sustainable Sea-Hinterland Services "Sustainable Swinoujscie-Trelleborg MoS" (integrate TEN-T Core Network as bridge between the Baltic-Adriatic and the Scandinavian-Mediterranean Core Network Corridors),	The Swinoujscie **ferry terminal reconstruct two berths into a larger berth**, construct new intermodal handling tracks and reconstruct old rail tracks. The Port of Trelleborg prepare for the next step in the extension and development of the port by conducting studies/planning. The port makes the final OPS investment in berth 5. The ferry operator Unity Line invests in two new vessels and increase in capacity by 55%. Improve and integrate as a part of the TEN-T Core Network a sea bridge between the Baltic-Adriatic and the Scandinavian-Mediterranean Core Network Corridors.	This project is ongoing (end date, December 2019).	€6 221 500	€2 739 200 (44.03% recommended EU support).

Source: INEA website (TEN-T)

Table 24: Investments financed under CEF

Year	Project	Description	State of progress	Total cost	EU contribution
2014	CLEANPORT - Alternative Fuels and Solutions for Port's Cold-Ironing	The project aims to overcome the barriers for harmonization and standardization of the supply of alternative fuels (LNG and natural gas) in maritime ports, (i) **Installation of a dedicated auxiliary natural gas engine on the ferry Abel Matute to generate electricity**, (ii) Small scale LNG bunkering facility (truck to ship), (iii) Natural gas bunkering facility both located in the core port of Barcelona.	This project is ongoing (end date, September 2017).	€6 349 058	€3 174 529 (50%).
2014	Environmental compliance and service upgrade of the North Sea MoS Cuxhaven-Immingham	The project's objective is to **upgrade the MoS link** in accordance with the international environmental Regulations and increase the efficiency, capacity and quality of the sea link and the ports and terminal operations. The core element of the action is **installation and deployment of an effective ship emission abatement solution (hybrid wet-scrubber system) on the Ro-Ro vessel "Britannia Seaways"** deployed on maritime link.	This project is ongoing (end date, December 2016).	€5 255 520	€1 576 656 (30%).
2014	Environmental compliance and upgrade of the North Sea MoS Felixstowe-Vlaardingen	The peoject's objective is to **upgrade the MoS link** in accordance with the international environmental Regulations as well as to increase the quality, efficiency and safety of the ports and terminal operations. **The core element of the action is the installation and deployment of emission abatement technology (hybrid wet-scrubber) on "Suecia Seaways" mid-size Ro-Ro vessel**.	This project is ongoing (end date, December 2016).	€4 340 000	€1 302 000 (30%).

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Year	Project	Description	State of progress	Total cost	EU contribution
2014	HEKLA – Helsingborg & Klaipeda LNG Infrastructure Facility Deployment	The project is the second phase of the Global Project, aiming at **developing a LNG network within the Baltic Sea region so as to create a viable and alternative fuel source for vessels**. This wider **benefit MoS** Action encompasses physical investments into an LNG bunkering infrastructure in the Helsingborg and Klaipeda ports, which are part of the Core Network of Maritime ports located on the Scandinavian-Mediterranean and North-Baltic Sea Core Network Corridors respectively.	This project is ongoing (end date, December 2017).	€28 711 788	€10 195 241 (35.31%).
2014	LNG Technologies and Innovation for Maritime Transport (GAINN 4 Ship Innovation)	The proposal aims to **retrofit a high-speed craft (HSC) Ro-Pax vessel so that it will be fuelled by a mix of 75% LNG and 25% diesel**. The prototype will be the first case in the world of a retrofitted HSC Ro-Pax vessel that maintains all the features needed in the liner service where the ship is deployed whilst increasing service quality. The project will support the **definition of environmental indicators for LNG retrofitted vessels**, the definition of bunkering technical solutions, the control of methane emission release to the atmosphere for the LNG retrofitted vessels and the selection of shipyards where the LNG prototype vessel will be retrofitted.	This project is ongoing (end date, December 2018).	€15 025 564	€7 512 782 (50%).
2014	Motorway of the Sea Rostock-Gedser - Part 2	The project will cover the environmental compliance and energy efficiency related conversions of the **two new building Ro-Pax ships** "MS Berlin" (Danish flag) and "MS Copenhagen" (German flag), as well as the required adjustment and improvement works in the TEN-T ports of Rostock (Germany) and Gedser (Denmark). The two new Ro-Pax ships "MS Berlin" and "MS Copenhagen will be **equipped with hybrid-propulsion** as the best-possible combination of running on marine fuel and providing energy from batteries.	This project is ongoing (end date, December 2017).	€21 105 000	€6 331 500 (30%).

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Year	Project	Description	State of progress	Total cost	EU contribution
2014	Nordic Maritime Hub - Linking Northern Denmark to Core Network Corridors and Motorways of the Sea	The objective of the project is to support the development of the port of Frederikshavn by (i) improving rail hinterland connections, (ii) establishing LNG bunkering services to supply ships with LNG, (iii) building a facility for bunkering biofuels to vessels (iv) **installing facilities for shore side power supply to be used by ferry services**.	This project is ongoing (end date, August 2018).	€14 520 700	€2 904 140 (20%).
2014	Nordic Maritime Hub - Linking Northern Denmark to Core Network Corridors and Motorways of the Sea	The investments at the port will (i) improve and upgrade the maritime link between port of Frederikshavn and the port of Gothenburg, (ii) facilitate traffic flows in the Baltic Sea Region through the **availability of alternative fuels and shore-side power supply facilities**, (iii) facilitate the integration of inland and maritime transport modes on the core network.	This project is ongoing (end date, July 2017).	€19 461 500	€3 892 300 (20%).
2014	Pilot LNG-powered multipurpose Ro-Ro ship	The project, a study including a pilot deployment, relates to the **very first built LNG powered Ro-Ro multipurpose ship** to be in operation in Northern European EU waters and ports, mainly Netherlands, Belgium, Germany, Denmark and the UK, for both inland and marine navigation. The project will lay the required foundation for deployment of a larger scale and a suitable market roll out of this innovative and efficient and flexible marine vessel.	This project is ongoing (end date, December 2017).	€7 480 000	€3 740 000 (50%).

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Year	Project	Description	State of progress	Total cost	EU contribution
2014	ReaLNG: Turning LNG as marine fuel into reality in the North Sea-Baltic region	This project aims to ensure deployment of LNG in the ECA, by **providing a bunkering vessel and LNG-related infrastructure in the port of Rotterdam and Port of Lubeck**. This is a horizontal wider benefits action, under Motorways of the Sea.	This project is ongoing (end date, June 2017).	€40 065 856	€13 082 775 (50% for studies and 30% for works).
2014	Scrubbers: Closing the loop	**Closed loop scrubbers** will be installed on two ships sailing on the short sea shipping routes between Harwich (UK)-Rotterdam/Hoek van Holland terminal (NL), to upgrade an important maritime link on the TEN-T core network. Furthermore, the **two scrubbers will be fitted with a measuring device for continuous follow-up of cleaning system efficiency**. The proposed Action will also develop chemical and waste management guidelines for scrubber use.	This project is ongoing (end date, December 2017).	€24 555 500	€7 740 650 (50% for studies and 30% for works).
2014	Study and deployment of integrated gas & water cleaning system and biofuel-MGO blend for the upgrade of the Atlantic corridor	The project contributes by demonstrating and validating two new emission reducing techniques in an operational environment and subsequently study and disseminate results, The first technique comprises of a new, **composite scrubber that will be deployed on a large passenger ferry ("Mont St Michel")**.	This project is ongoing (end date, June 2017).	€6 585 000	€3 187 500 (50% for studies and 30% for works).

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Year	Project	Description	State of progress	Total cost	EU contribution
2014	Sustainable LNG Operations for Ports and Shipping - Innovative Pilot Actions (GAINN4MOS)	Amongst the objectives set, the project prove that bunkering barges, tugboats, general cargo and **pax or Ro-Pax types of vessels can be successfully retrofitted for them to use LNG as marine fuel and that financial feasibility** analyses for their operating companies after the indicators obtained in real life pilots are taken into account confirm the convenience of this choice to external sea carriers.	This project is ongoing (end date, September 2019).	€41 314 934	€19 191 067 (50% for studies and 30% for works).
2014	Sweden-Poland Sustainable Sea-Hinterland Services "Sustainable Swinoujscie-Trelleborg MoS"	The ports of Trelleborg and Swinoujscie are both important European transfer nodes. Investments will be made into developments and relocation within and towards the port of Trelleborg, **alleviating the existing congestion through the city center and into a new onshore power connection in berth 5**. It follows a previously TEN-T financed Action no, 2013-EU-21004-P.	This project is ongoing (end date, September 2019).	€5 357 500	€2 480 000 (50% for studies and 30% for works).
2014	Sweden-Poland Sustainable Sea-Hinterland Services "Sustainable Swinoujscie-Trelleborg MoS"	The Swinoujscie ferry terminal will reconstruct two berths into a larger berth. The Port of Trelleborg will prepare for the next step in the extension and development of the port by conducting studies/planning. **The ferry operator Unity Line will invest in two new vessels and increase in capacity by 55%**.	This project is ongoing (end date, December 2019).	€6 221 500	€2 739 200 (44.03%).

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Year	Project	Description	State of progress	Total cost	EU contribution
2014	The Northern ScanMed Ports - Sustainable Maritime Links	The overall objective of the project is to improve **energy-efficiency** in port operations and shipping, provide onshore power and reception of ship waste and waste water. These port services include onshore power supply, **reception facilities for sewage and scrubber waste**.	This project is ongoing (end date, December 2016).	€8 100 000	€2 650 000 (50% for studies and 30% for works).
2014	Twin–Port 2	The project aims at fostering greater cross-border cooperation between Finland and Estonia through developing and upgrading the MoS link between the ports of Helsinki and Tallinn, In addition, environmental and efficiency solution investments for a **new generation Ro-Pax ferry will be co-financed which will operate on this link**. These investments will significantly advance the Global Project of removing port bottlenecks, optimise port operations and **further increase Ro-Pax capacity by commissioning a new generation LNG Ro-Pax vessel**.	This project is ongoing (end date, December 2018).	€97 600 000	€29 300 000 (50% for studies and 30% for works).
2014	Upgrading and sustaining the competitive Baltic MoS link Germany-Finland (Ro-Ro multiple ports loop)	The project has two objectives (i) increase the productivity and capacity of the MoS link and service related terminal operations, (ii) reduce the environmental impact of the ship operations. To achieve these aims the maritime **operator will upgrade three existing very modern and large freight Ro-Ro ships** deployed on the maritime link – namely "Finnbreeze", "Finnsea" and "Finnsky", In addition, **energy efficiency measures will be installed on the same vessels** for optimizing bunker consumption and minimizing the emission of green-house gases from ship operations	This project is ongoing (end date, December 2016).	€18 038 510	€5 411 553 (30%).

(continues on the next page)

Year	Project	Description	State of progress	Total cost	EU contribution
2014	Upgrading and sustaining the competitive core Baltic MoS link Helsinki-Lübeck	The project include the design and construction of an embarkation facility in the Port of Helsinki-Vuosaari, as well as the improvements in the terminal operation of Lübeck-Travemünde. It will also include the installation of **open-loop hybrid ready wet scrubber systems and new blades and rudder systems on board of the four very large Ro-Pax ships named "Nordlink", "Finnstar", "Finnmaid" and "Finnlady".**	This project is ongoing (end date, December 2016).	€25 939 350	€7 781 805 (30%).
2014	Zero Emission Ferries - a green link across the Öresund	The projecy will (i) upgrade environmentally a very busy maritime link, connecting the comprehensive TEN-T network ports of Helsingör (Denmark) and Helsingborg (Sweden), (ii) deploy ship fitting with the required power provision and charging installations in the ports/ ferry terminals will be realized. **Two Ro-Pax ships are converted from marine gasoil to plug-in all electric powered operation using exclusively batteries.**	This project is ongoing (end date, December 2017).	€26 300 000	€13 150 000 (50%).

Source: INEA website (CEF)

ANNEX II: RELATED TO SECTION 3

Table 25: Most dramatic events involving ferries in the EU over the last 30 years

Year	Ship	Cause	Casualties	Lessons learned
1987	Herald of Free Enterprise (Belgium)	The accident occurred because the bow door was left open when the ship left port allowing water to enter and flood the car deck.	193	The MSC adopted the first package of amendments to the SOLAS in October 1988 and entered into force in April 1990 (i.e., the "SOLAS 90" standard)[81]. • New Regulation requiring indicators on the navigating bridge for all doors and monitoring to detect water leakage. • New Regulation requiring monitoring of special category and Ro-Ro spaces to detect undue movement of vehicles in adverse weather, fire, the presence of water or unauthorized access by passengers whilst the ship is underway. • Provision of supplementary emergency lighting for Ro-Ro passenger ships. • Introduction of "SOLAS 90" standard, relating to the stability of passenger ships in damaged condition. • Further amendments regarding: locking cargo loading doors, verification of changes in lightweight displacement and the longitudinal centre of gravity, power-operated sliding doors, subdivision and damage stability of cargo ships, safe stowage and securing of cargoes and fire safety.
1991	Moby Prince (Italy)	Collision with the oil tanker Agip Abruzzo outside the port of Livorno, sparking an extensive fire.	140 (65 crew members and 75 passengers)	Investigations and trials were not conclusive regarding the hypotheses considered as cause of the accident (fog, human error, rudder malfunction). Rescue operations were slow and chaotic, and it was later proved that problems with the rescue constituted one of the major causes of death.
1994	Estonia (between Estonia and Sweden)	Severe storm in the Baltic Sea. The official report indicated that the locks on the bow door had failed from the strain of the waves and the door had separated from the rest of the vessel.	850	The impact of the Estonia incident was to accelerate a comprehensive review of all aspects of Ro-Ro ferry safety, including search and rescue requirements. The IMO assembly adopted five resolutions directly related to the safety of Ro-Ro passenger ships, as follows. • Safety culture in and around passenger ships. • Strengthening and securing locking arrangements of shell doors. • Surveys and inspections. • Navigational guidance and information scheme for Ro-Ro ferry operations. • Recommendations on a decision-support system for masters on passenger ships. The SOLAS conference on Ro-Ro safety adopted a series of Regulations to ensure stability with regard to both new and existing Ro-Ro passenger ships.

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[81] The work to develop the SOLAS 90 standard begun following the accident of the ferry "European Gateway". In 1982, the ship capsized onto her starboard side following a collision with the Speedlink Vanguard (2.5 miles off Harwich) and settled on a sandbank, in relatively shallow water. Five lives were lost.

Year	Ship	Cause	Casualties	Lessons learned
1999	Superfast 3 (off the west coast of Greece)	The fire broke out from a truck.	14 passengers	The ferry caught fire on its route from Patras (Greece) to Ancona (Italy). The fire broke out in a freezer trailer, most likely from the electrical system. The vessel's vehicle deck drenching system along with the crew extinguished the fire.
1999	Sleipner (Norway)	On November 26, the Norwegian catamaran ferry hit a reef in the Bomla fjord in rough sea and sunk.	16 deaths out of 88 persons on board	The ferry should have not been allowed to sail under such conditions and the life rafts were not ready for use. The ship entered into service few months before, at the beginning of August.
2000	Express Samina (off the Greek island of Paros)	The ferry run aground on rocks that were clearly visible and market with beacons. The ferry broke apart and sunk in 45 minutes.	80 deaths out of 534 persons on board	Express Samina was one of the oldest car ferries in the Greek fleet (a year away from compulsory retirement). Her 1960s design - with the comparative lack of exit facilities - made hard to escape from inside the vessel in a rapid sinking, as the only exits for deck-class passengers were at the stern. Other doors were kept locked to prevent deck-class passengers going into higher ticket price areas. It lacked also of a modern bulkhead, mandatory in the design of ferries' car decks and essential to prevent them sinking quickly once water gets onto the flat surface. The captain and the officers were said to be watching a football game, instead of being on the bridge. The captain was arrested.
2014	Norman Atlantic (between Greece and Italy)	The ferry caught fire on the car deck.	13 deaths, including two rescue operators of Albanian tugboats	Ferry operator non-compliant with safety rules; the state-controlled inspection carried out nine days earlier identified six safety-related defects on the ship. Serious security failure, since 80 persons on board were not in the passengers list and a proportion of these were illegal immigrants.

Source: Elaboration of the authors from IMO (2016a) and websites

Table 26: Incidents related to ferries in non-EU developed countries (1996-2016)

Region	Number of accidents		Cause										Casualties					
			Human error		Mech. failure		Fire		Weather		Unkn.		Deaths		Injured		Missing	
	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%
Asia	2	40	2	100	0	-	0	-	0	0	0	0	302	96	93	72	0	-
America	2	40	0	0	0	-	0	-	1	50	1	100	14	4	37	28	0	-
Pacific	1	20	0	0	0	-	0	-	1	50	0	0	0	0	0	0	0	-
Total	**5**	**100**	**2**	**100**	**0**	**-**	**0**	**-**	**2**	**100**	**1**	**100**	**316**	**100**	**130**	**100**	**0**	**-**

Source: Elaboration of the authors from EuroTest (2014) and Shippax publications

Table 27: Incidents related to ferries in non-EU developing countries (1996-2016)

Region	Number of accidents		Cause										Casualties					
			Human error		Mech. failure		Fire		Weather		Unkn.		Deaths		Injured		Missing	
	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%	Val.	%
Africa	7	15	1	8	0	0	2	15	3	25	1	20	2 505	62	0	0	169	14
Asia	36	78	10	77	2	67	11	85	9	75	4	80	1 466	36	201	100	978	82
America	2	4	2	15	0	0	0	0	0	0	0	0	18	0	0	0	50	4
Pacific	1	2	0	0	1	33	0	0	0	0	0	0	74	2	0	0	0	0
Total	**46**	**100**	**13**	**100**	**3**	**100**	**13**	**100**	**12**	**100**	**5**	**100**	**4 063**	**100**	**201**	**100**	**1 197**	**100**

Source: Elaboration of the authors from EuroTest (2014) and Shippax publications

ANNEX III: RELATED TO SECTION 6

Table 28: Cases of ferry services in urban areas

Location	Service provided	Users	Transport demand	Integration with PT
La Navette Maritime, Marseille (France)[82]	Shuttle service connecting two ports of the city, in about 40 minutes (Vieux Port- Pointe Rouge). Boats capacity 100 seats.	Commuters and tourists.	Studies estimated 700 users per day.	Bus network and integrated ticketing (Transpass Métropole).
Water tram Gdynia, Sopot and Gdansk (Poland)[83]	Three water trams connecting Gdansk and Sopot accommodate 140 passengers and two catamarans from Gdynia have a capacity of 450 seats. Seasonal service.	Inhabitants of the three cities and tourists.	n. a.	No integrated ticketing.
Solar water tram, Bydgoszcz (Poland)[84]	Vessel carrying up to 30 passengers. Seasonal service operated within Bydgoszcz waterways system. Part of the old town renewal project.	Inhabitants of the city and tourists.	n. a.	No integrated ticketing.
Waterbus service, Loch Lomond (UK)[85]	Service along the banks of Scottish Loch Lomond. Improve local accessibility and reduce road use. Seasonal service.	Inhabitants of the community and tourists.	Tested over six-week period, it attracted more than 5,000 passengers.	n. a.
Tejo river crossing, Lisbon (Portugal)	Integral component of city's PT network. Three terminals operate: Terreiro do Paço, Cais do Sodré and in Belém district. Alternative to Ponte Abril (suspension bridge).	Commuters (southern districts of the city) and tourists.	13.1 million passengers and 25.9 thousand vehicles in 2014 (downward trend).	Tram and metro networks and integrated ticketing.

(continues on the next page)

82 Moore Levene (2014).
83 Beim (2014).
84 Christiaens (2014).
85 Eltis project (2015) and Eltis project (2015).

Location	Service provided	Users	Transport demand	Integration with PT
Djurgården ferry, Stockholm (Sweden)	Service provided between Slussen, Djurgården and Skeppsholmen.	Commuters, archipelago inhabitants and tourists.	4 million passengers and 7 000 tonnes of goods each year.	Metro and bus network integration. Ticketing integration in Stockholm PT.
Gotenburg archipelago (Sweden)	Routes Älvsnabbare and Älvsnabben operate in city's harbour. To southern islands the ferry operates from terminal Saltholmen. To northern islands the ferry operates from Lilla Varholmen.	Pedestrians, cyclists and vehicles.	n. a.	Ferries integrated in Gothenburg PT.
Woolwich ferry, London (UK)	Ferry link South-North Woolwich.	Pedestrians, cyclists, vans and lorries across Thames river.	n. a.	Part of London PT network. Free of charge.
River Thames Clippers, London (UK)	Five river bus routes operated from 19 piers between Putney and Woolwich.	Commuters and tourists.	3.3 million passengers in 2013 and 3.1 million in 2009.	Part of London PT network. Free of charge.

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Location	Service provided	Users	Transport demand	Integration with PT
Amsterdam (the Netherlands)	Three ferries operate from the Central Station to Buiksloterweg, IJplein and NDSM Wharf. A number of routes cross the North Sea canal.	Pedestrians, cyclists and mopeds.	n. a.	Part of Amsterdam PT network.
Waterbus Drechtsteden-Rotterdam (the Netherlands)[86]	Waterbus system (8 services) links Dordrecht with the adjacent towns and Rotterdam.	Commuters and tourists.	1.54 million passengers 2014, 1.42 million in 2013 and 1.67 million in 2009.	Integrated ticketing with OV Chipcard of Rotterdam PT, for discounted fares.
Aqualiner Rotterdam City-Heijplaat (the Netherlands)	Public fast ferry between central Rotterdam and RDM campus.	Forensic/students, 50% and tourists/leisure (50%).	60 965 passengers in 2009, 137 000 in 2013 and 158 000 passengers in 2014.	Integrated ticketing with OV Chipcard of Rotterdam PT, for discounted fares.
Venice ferries network (Italy)	Urban PT in Venice's canals network and lagoon.	Commuters and tourists.	115.4 million passengers in 2011, 118.1 million in 2012 and 122.5 million in 2013.	Integrated ticketing with bus and tram networks and people mover (season ticket).
Gulf of Naples (Italy)	Network of routes between Naples, adjacent towns (Sorrento and Pozzuoli) and the islands of the gulf (Capri, Ischia and Procida). Private operators provide services under concession regimes.	Inhabitants, commuters and tourists.	2.40 million passengers in 2010, 2.28 million in 2013 and 2.28 million in 2014.	No.

Source: Elaboration of the authors from operators' websites, references in footnote and Shippax publications

[86] Iriarte (2014).

Table 29: Cases of ferry services on a regional scale

Location	Main services provided
Greece	It is the largest EU domestic market, with 7 regions, 114 inhabited islands (Baird and Wilmsmeier 2011) and 34.1 million passengers (Shippax, 2015). All ferry operators are privately owned and the government subsidises services that are otherwise not provided in the market. Surcharges applied to market services cross-subsidise routes economically not viable (Chlomoudis et al., 2007; Baird and Wilmsmeier, 2011; Gratsos, 2014).
Denmark	Until 2005, the government operated many domestic regional services and most of the routes were both owned and run by local authorities. After 2005, many ferry companies have been split into two: one public entity, often owned at municipal level, owns the ferry and berth facilities, and another company runs the service. The government, in accordance with "net cost" contracts, grants the subsidies (Baird and Wilmsmeier, 2011).
Italy	A public body provides transport services on the widest Northern lakes (i.e., Como, Maggiore and Garda); they are an important alternative to ensure mobility of inhabitants (8.14 million passengers, Shippax 2015) living on shores of regions where the road network is not reliable (Ercoli S. et al., 2014).
Germany	Crossing of rivers Elbe and Weser.
France/Switzerland	Border crossing of Lac Léman.
Germany/Switzerland	Border crossing of Lake Constance.

Source: Elaboration of the authors

Table 30: Cases of ferry services on a national scale

Location	Main services provided
France	The services between Corsica and the mainland are subsidised on the principle of territorial continuity. However, the subsidies granted to the public company SNCM were declared illegal by the EU due to a breach of competition rules (CISCo, 2013; Hirst, 2014; Spurrier 2016).
Spain	The responsibility for subsidising inter-island ferries lies with the region (Hernández Luis 2004 and La Gomera, 2013), while the responsibility for services between the Balearics and the mainland lies with the national authorities (Malachy Walsh et al., 2004).
Italy	A long privatisation process involved the formerly state-owned incumbent Tirrenia (Shippax 2013). The services between Sardinia and mainland are still being subsidised (in form of PSO and special rates for Sardinian residents), but today the owner is a private company (CIN) and competitors say that services can be provided in the market. Privatisation would also be needed for regional operators providing services to minor islands (i.e., Caremar, Toremar and Saremar, all subsidised).
Sweden	The major subsidised ferry service connects the island of Gotland in the Baltic Sea with the Swedish mainland; the service is tendered by Swedish National Public Transport Agency (Baird and Wilmsmeier, 2011).

Source: Elaboration of the authors

Table 31: Cases of ferry services in competition with infrastructures and services

Case	Description
Channel Tunnel	The tunnel opened in 1994 to link the UK with mainland Europe. Ferries actively engaged in competition by introducing weeklong shifts, lowering prices, staggering their pricing to spread demand throughout the day and investing in bigger ships to get more room for freight. A fire in the tunnel in 2008 helped the ferries to maintain the market share for two years (The Economist, 2014). In 2012, for the first time, more passengers travelled internationally via the Channel Tunnel than used international short sea shipping, and in 2013 ferries accounted for 1.7 million more international journeys than the Channel Tunnel (DfT, 2014) (see Table 33**Error! Reference source not found.**). Trends observed between 2000 and 2014 show that the Channel Tunnel has been serving the majority of passengers' traffic crossing the Dover Strait[87] (see Figure 22), while ferries rely on road hauliers and bus traffic (see Figure 24 and Figure 25). For the first time, in 2014, the number of cars that used the Channel Tunnel is higher than that crossing on ferries (see Figure 23).
Øserund link	The link opened in 2000 between South West Sweden and East Denmark. It is nested in the wider Øresund-Kattegat-Skagerrak cross-border area of the Baltic region. When opened, the traffic crossing the strait leapt by 43%. Over the period 2001-2007, traffic increase has been gradual (10% annually) for both road and rail modes (Ørestat, 2012) and after the economic crisis it has reached standstill and has been decreasing until its rebound in 2014 (A/S Øserund, 2015). The Øserund link accommodates two types of traffic, namely regional traffic (both train and car commuters) between Copenhagen and Malmö and international traffic between the European continent and Sweden and Norway. There is no competition for regional traffic, while international travellers have several options. The most important ferry service is Helsingör-Helsingborg (2 NM, 20 minutes, north of the fixed link). Over the last 20 years, ferry traffic increased until 2000 and decreased after that (Ørestat, 2012, Nauwelaers et al. 2013, and Shippax publications) (see Table 33). Ferries carry a high proportion of leisure and holiday travellers (Ørestat, 2012) and in 2013, when they became competitive on prices, Denmark and Swedish governments reacted by lowering tolls (CHP, 2013) (see Table 33 and Figure 26 to Figure 29).

(continues on the next page)

[87] Passenger crossings on ferries have been eroded by 1.82 million units over the period considered, due in part to competition by low-cost airline carriers.

Case	Description
Competition with aviation between Sardinia and Italy's mainland	Flights between Rome Fiumicino and Milano Linate with Sardinia's airports (i.e., Alghero, Cagliari and Olbia) are operated under PSO, for purposes of territorial continuity, with special rates for Sardinian residents. According to figures of the Italian Ministry of Transport (MIT), the market of low-cost airline carriers amounts to 46% of the total Italian domestic sector. With respect to connections, the flight Bergamo-Cagliari and return rank in the top ten, given that Bergamo airport is a hub of one of the leading low-cost airline carriers in Europe (CNIT, 2015). The PSO connection Rome Fiumicino-Cagliari follows immediately after. Sardinia's three airports report a remarkable increase of passenger traffic. Over the period 2003-2014, figures show +57% (ISTAT, 2016), while the loss suffered by the passenger ferry market amounts to 35% (CNIT, 2015). Besides, figures on cars show a reduction of 26%, while trucks and buses have not reduced significantly (-3%).

Source: Elaboration of the authors

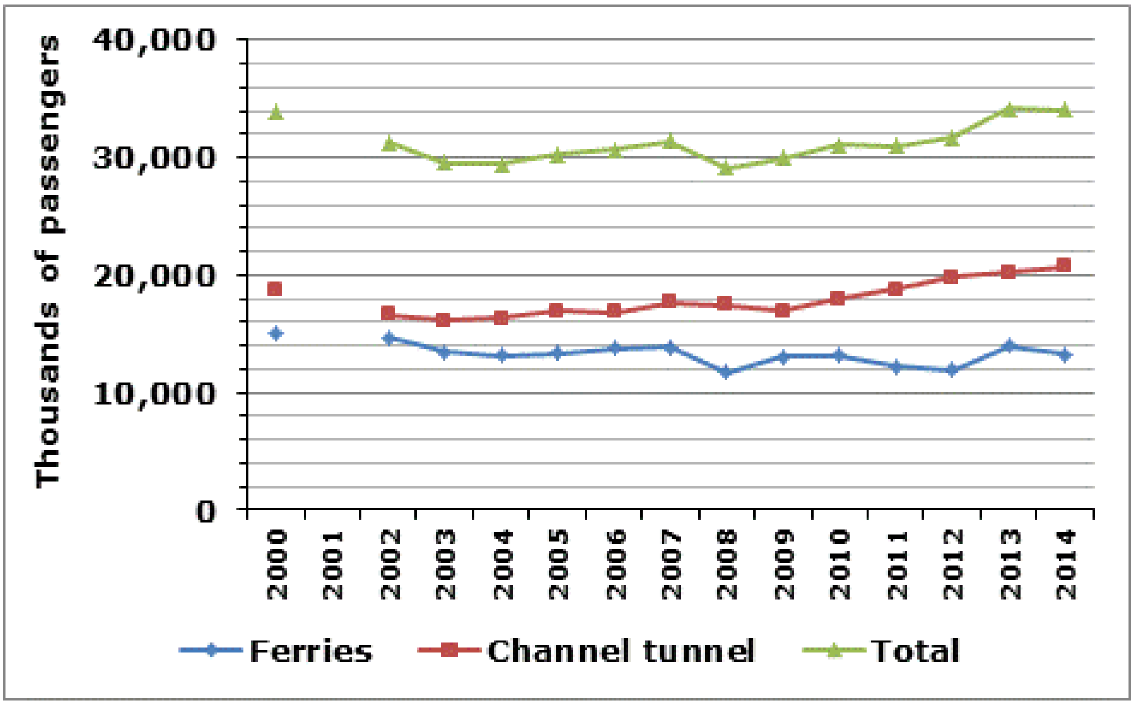
Table 32: Ferry traffic crossing the Dover Strait (thousands)

Year	Total traffic[88]			
	Passengers	Cars	Buses	Trailers
2000	33 906	4 740	229	2 493
2001	n. a.	n. a.	n. a.	n. a.
2002	31 274	5 175	221	2 909
2003	29 538	4 515	198	3 104
2004	29 416	4 245	190	3 299
2005	30 266	4 554	182	3 380
2006	30 649	4 669	173	3 663
2007	31 433	4 981	171	3 822
2008	29 105	4 070	153	3 035
2009	29 983	4 776	136	3 107
2010	31 106	4 965	141	3 209
2011	31 029	4 936	140	3 462
2012	31 692	5 400	137	3 418
2013	34 154	5 269	144	3 896
2014	34 051	5 030	160	3 863

Source: Elaboration of the authors from Shippax publications

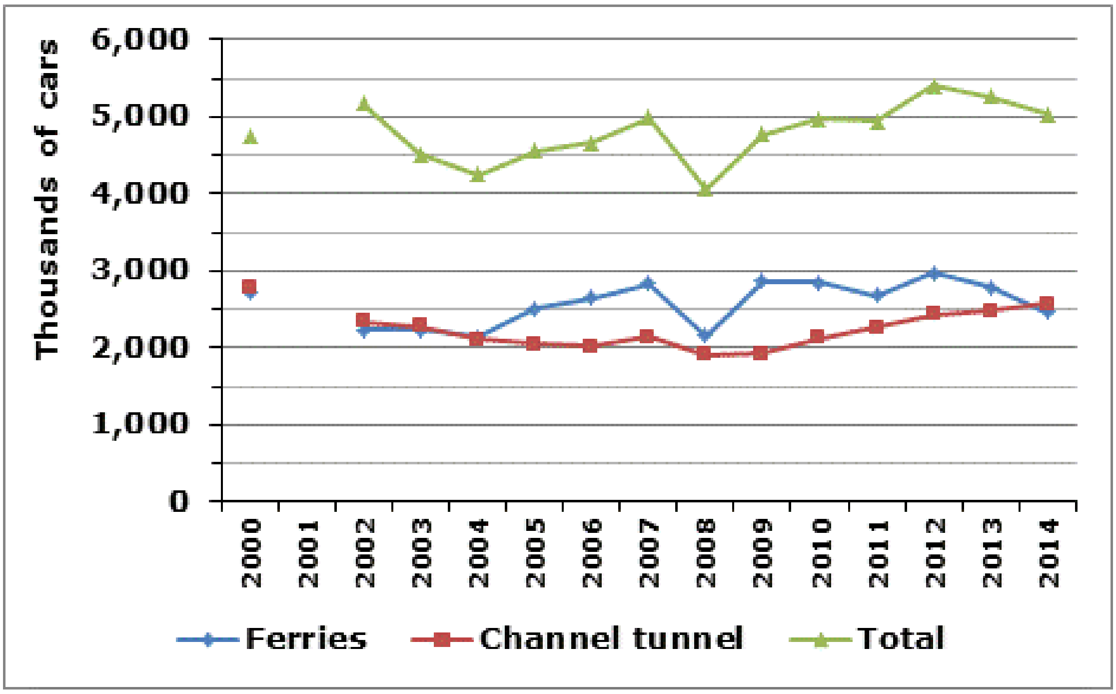
[88] Traffic of Eurotunnel and routes Calais-Dover, Dunkerque-Dover and Boulogne-Dover.

Figure 22: Passengers crossing the Dover Strait



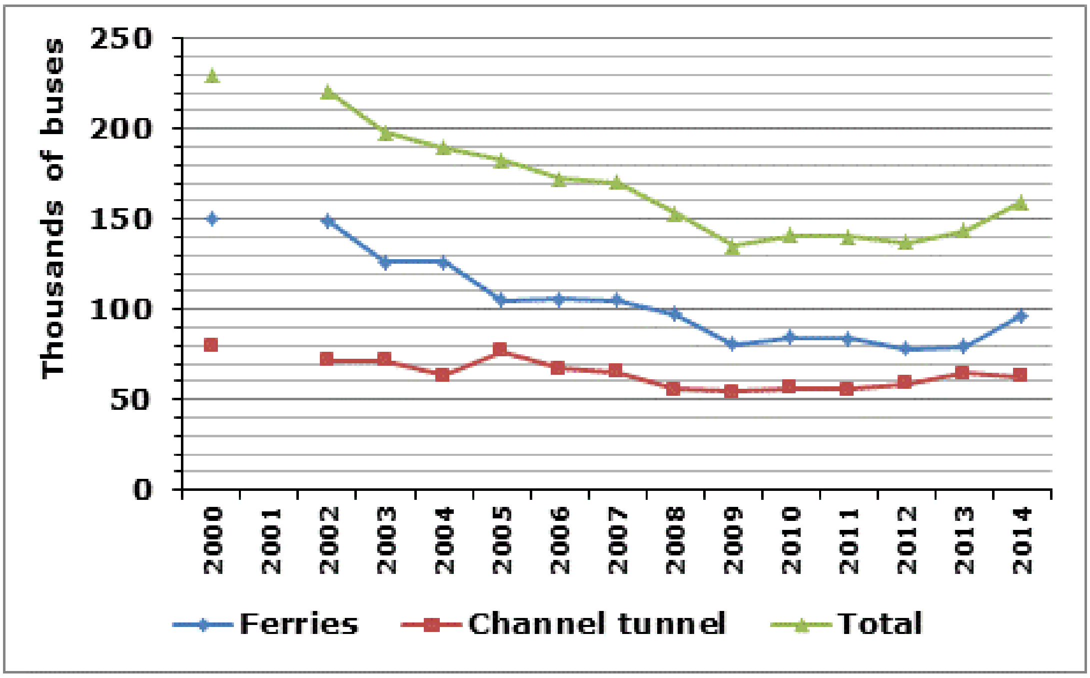
Source: Elaboration of the authors from Shippax publications

Figure 23: Cars crossing the Dover Strait



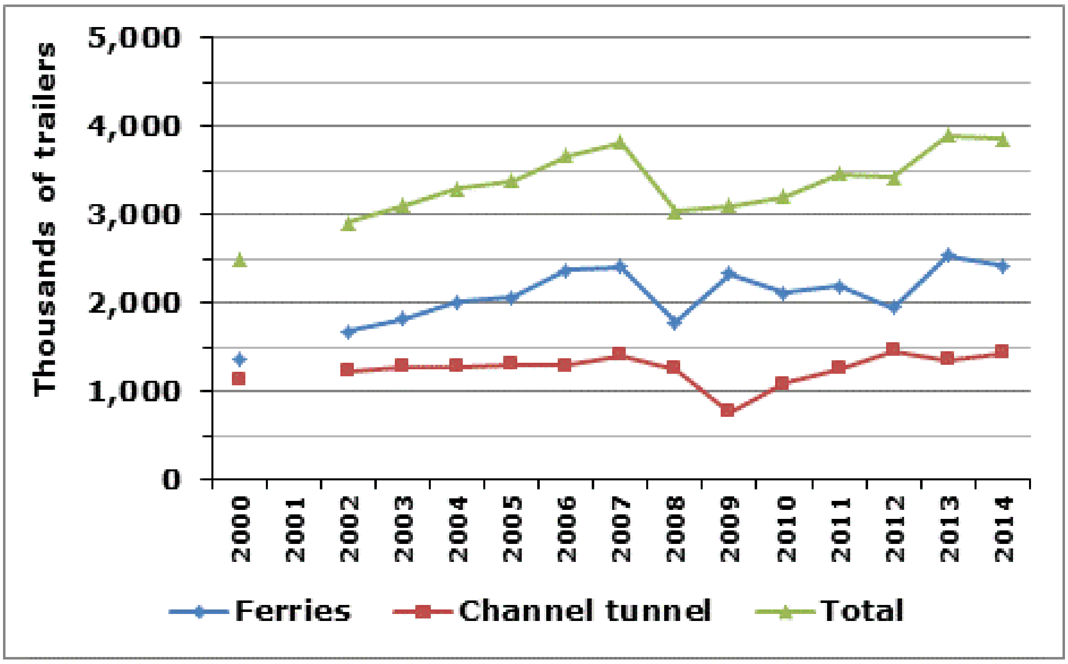
Source: Elaboration of the authors from Shippax publications

Figure 24: Buses crossing the Dover Strait



Source: Elaboration of the authors from Shippax publications

Figure 25: Trailers crossing the Dover Strait



Source: Elaboration of the authors from Shippax publications

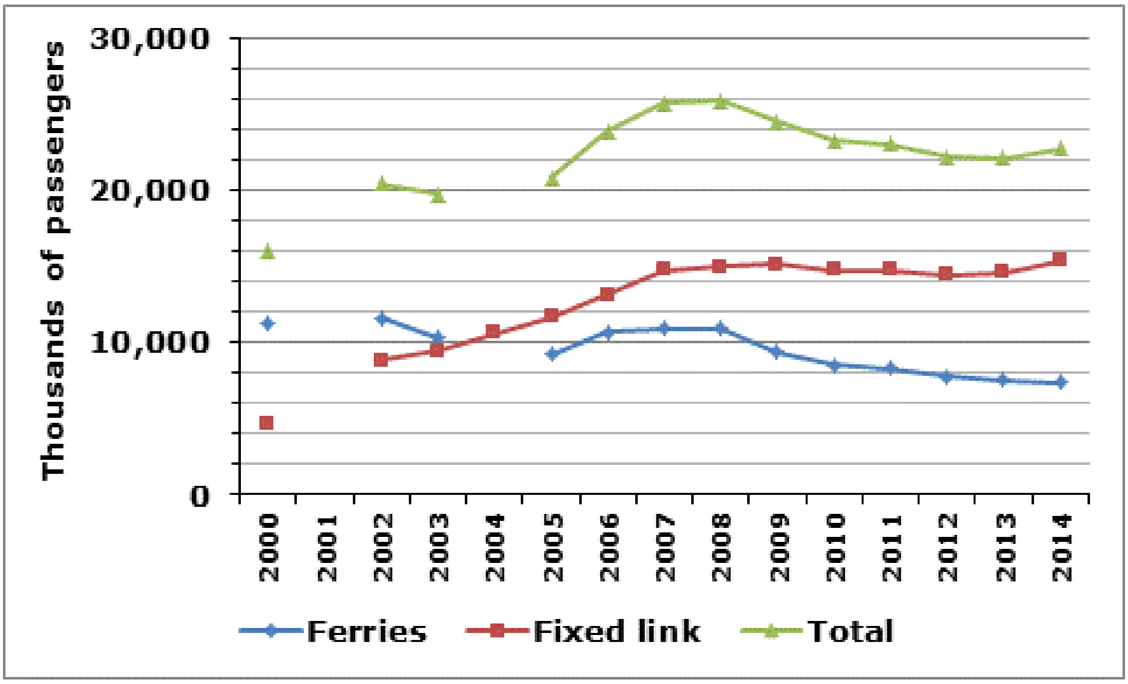
Table 33: Ferry traffic crossing the Øresund (thousands)

Year	Total traffic[89]			
	Passengers	Cars	Buses	Trailers
2000	15 971	3 196	63	409
2001	n. a.	n. a.	n. a.	n. a.
2002	20 457	5 137	77	562
2003	19 805	5 564	77	571
2004	n. a.	n. a.	n. a.	n. a.
2005	20 886	6 060	80	544
2006	23 927	6 763	76	595
2007	25 772	8 374	83	746
2008	25 889	8 668	71	741
2009	24 545	8 632	64	646
2010	23 318	8 454	67	687
2011	23 106	8 211	66	722
2012	22 197	7 868	62	722
2013	22 165	7 673	63	755
2014	22 788	7 830	70	792

Source: Elaboration of the authors from Shippax publications

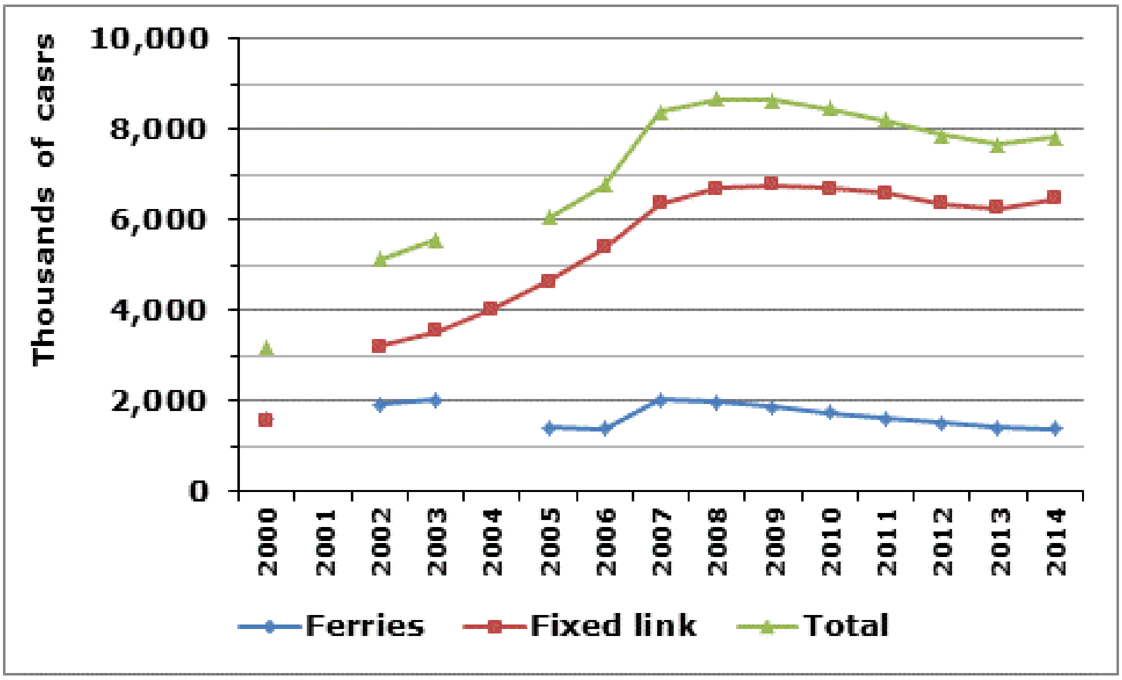
[89] Traffic of fixed link and ferry route Helsingör-Helsinborg.

Figure 26: Passengers crossing the Øresund



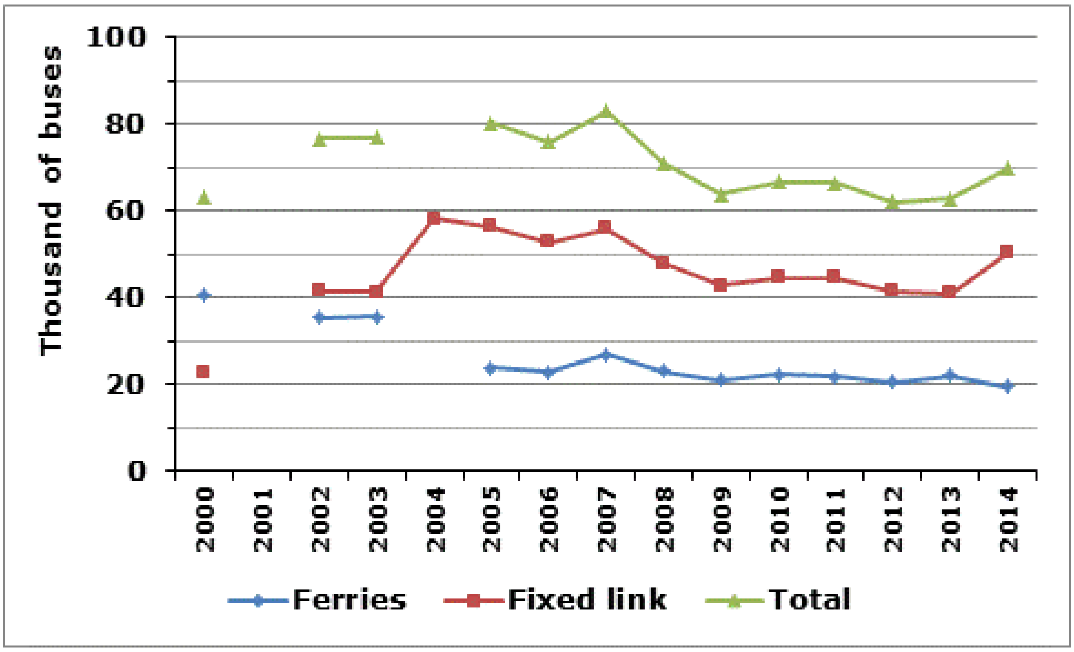
Source: Elaboration of the authors from Shippax publications

Figure 27: Cars crossing the Øresund



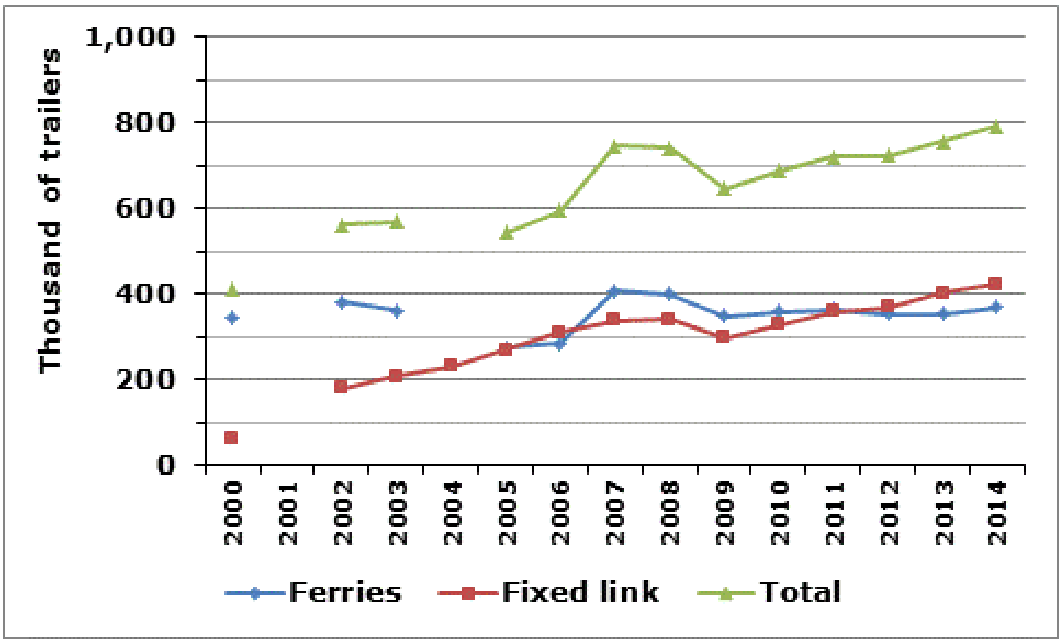
Source: Elaboration of the authors from Shippax publications

Figure 28: Buses crossing the Øresund



Source: Elaboration of the authors from Shippax publications

Figure 29: Trailers crossing the Øresund



Source: Elaboration of the authors from Shippax publications

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CAT: QA-02-16-176-EN-N (pdf)

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PHOTO CREDIT: iStock International Inc., Photodisk, Phovoir

ISBN 978-92-823-8807-5 (paper)
ISBN 978-92-823-8806-8 (pdf)

doi:10.2861/65075 (paper)
doi:10.2861/657769 (pdf)

Publications Office