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Risks related to maritime transportation of crude oil and liquefied natural gas in the Baltic Sea

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Abstract

Growing traffic density is believed to increase the wide range of maritime risks in the Baltic Sea. Any accidents involving oil and LNG spills may potentially have devastating impact on the vulnerable environment of the Baltic Sea.

The present study aimed to discover the risks related to the maritime transportation of oil and LNG in the Baltic Sea and examine the regulations and requirements for the maritime safety in the area.

Qualitative method was used to achieve the objective. A simple statistical analysis was used to compare the indexes of different periods to explain the nature of revealed changes. An interview was conducted to explore the issues related to LNG and oil seaborne transportation with closer consideration of the Baltic Sea area.

The results of the thesis showed that notwithstanding the traffic growth, risks pertaining to the maritime transportation of oil and LNG are effectively assessed, managed, minimized or even eliminated with the help of different instruments considered in the paper.

Human factor plays vital role in maritime accidents. Paying special attention to the navigation conditions of the Baltic Sea, shipping in the area is constantly under monitoring safety measures are reviewed, improved and consequently implemented. In the future, for the efficient prevention of and reaction to maritime accidents and incidents, close cooperation of the Baltic States, port authorities, shipowners and crew is essential.

Keywords
emissions, environment, accident, Baltic Sea, crude oil, LNG, maritime transportation, risk assessment, tanker

CONTENTS

ABBREVIATIONS

AIS – Automatic Identification System

BWM Convention – International Convention for the Control and Management of Ships' Ballast Water and Sediments

CO_2 – Carbon dioxide

COLREG – IMO International Regulations for Preventing Collisions at Sea

COW – Crude oil washing

ECA – Emission Control Areas

EU – European Union

GT – Gross tonnage

HELCOM – Baltic Marine Environment protection commission

IMO – International Maritime Organization

ISGOTT – International Safety Guide for Oil Tankers and Terminals

ISM Code - International Safety Management Code

LNG – Liquefied natural gas

LOT – Load on top

MARPOL 73/78 – International Convention for the Prevention of pollution from ships

NECA – Nitrogen Emission Control Area

NO_x – Nitrogen oxides

OCIMF – Oil Companies International Marine Forum

ppm – parts per million

PSSA – Particularly Sensitive Sea Area

RMRS – Russian Maritime Register of Shipping

SBT – Segregated Ballast tanks

SECA – Sulphur Emission Control Area

SIRE – OCIMF Ship Inspection Report system

SOLAS – International Convention of Safety of Life at Sea

SO_x – Sulphur oxides

ULCC - Ultra Large Crude Carrier

VLCC - Very Large Crude Carrier

1 INTRODUCTION

As a means of moving goods from production point to end consumers, maritime shipping has become widely spread all around the world due to the possibility of moving great amounts of cargo for considerably long distances. Among general world fleet, tonnage has grown from 793,771 thousand tons in 2000 to 1,862,241.771 thousand tons in 2017, and oil tanking capacity has grown as well: from 284,684 in 2000 to 535,864 in 2017. (Merchant fleet by flag of registration and by type of ship, annual, 1980-2018). Growing oil carrier tonnage directly leads to increase of ship accidents and incidents, such as oil spill from Amoco Cadiz crude oil tanker in 1978 or Exxon Valdez crude oil tanker in 1989, having terrifying consequences for people and environment. After such accidents, it became obvious that in order to save people, seas, oceans and their flora and fauna, it is of great need to develop and strictly follow the rules with respect to pollution from ships. This was the reason for implementing manuals and conventions such as The International Convention for the Prevention of pollution from ships (MARPOL 73/78), International Safety Guide for Oil Tankers and Terminals (ISGOTT) and International Convention of Safety of Life at Sea (SOLAS). The aforementioned regulations are applied to oil and liquefied natural gas (LNG) carriers, terminal processes of cargo transshipments and oil spills by providing preventive and corrective measures which were investigated in the thesis. The main focus of the study is on the maritime safety of the Baltic Sea area.

The author’s experience in oil shipping gained while working for the Port of Primorsk served as a useful supplement to the survey.

The main objectives of this study were the collection of the latest seaborne transportation data, including oil and LNG cargo, prognoses of infrastructure development and assessment of maritime risks associated with oil and LNG shipping within the Baltic Sea region. The study also aims to determine the extent to which an LNG terminal development is able to affect the traffic density and harmful environmental impact on the examined area.

For the purpose of achieving the main objectives, the study seeks to address the following questions:

- Which ports of the Baltic Sea are involved in crude oil and LNG transshipment?
- What are the most sensitive areas in the Baltic Sea for oil and LNG transportation and transhipment?
- What are the risks related to transportation of oil and LNG through the Baltic Sea?
- How does the international trading and transhipment of oil and LNG influence the local environment?
- What are the trends in the development of the regional oil and LNG trade in the Baltic Sea?
- How the existing maritime safety governance system contributes to maritime safety of the Baltic Sea?
- What can serve as the reason for accidents?
- How can the maritime safety level be improved in the Baltic Sea?

Based on the personal experience and existing data collection and analysis pertaining to the topic, the author used qualitative method as a basic principle of study. A simple statistical analysis was used to compare the indexes such as maritime accidents, emissions, traffic density of different periods to explain the nature of revealed changes.

The theoretical framework includes International Maritime Organization manuals, publications, articles, newsletters and guidelines of Helsinki Commission connected to the topic of the survey. Also, an interview with Maxim Tokarev was conducted as part of the thesis. Tokarev has wide knowledge of maritime safety as he was a seafarer for around 15 years. For the time being, Mr. M.Tokarev represents Primorsk Oil Terminal in Oil Companies International Marine Forum (OCIMF). The interview questions are included in the survey (Appendix 3). The empirical material obtained from the interview is compared to the research literature, and sequential outcome is presented.

The findings generated in the study can be of interest to all the parties involved in oil and LNG transportation and trading. This study offers some important insights to the present state and trends of the oil and LNG shipping and maritime safety within the Baltic Sea area.

Chapter 2 introduces the topic of the Baltic Sea shipping and special characteristics. A consideration of the features of the Baltic Sea in depth is essential to understand the motives of the emphasis made on the safe and clean shipping in the area. After the introduction of the Baltic Sea peculiarities in Chapter 2.1, information about the major shipping routes, traffic intensity and requirements for winter navigation is presented in Chapters 2.2 and 2.3 respectively.

In Chapters 3 and 4, major Finnish and Russian oil and LNG ports in terms of its' share in the Baltic Sea maritime traffic and cargo turnover will be measured and analyzed. An analysis of LNG port and facilities development and its contribution to trade and shipping in the Baltic Sea is made. There are numerous challenges for shipping in the Baltic Sea that could cause vessels accidents, incidents and contamination of waters, which are revealed, assessed and described in Chapter 6.

The paper concludes with the presentation of the results and a short summary.

2 MARITIME TRANSPORTATION IN THE BALTIC SEA AREA

The following chapter provides an overview of the geographical features of the Baltic Sea, major oil ports and maritime traffic and the winter navigation restrictions applied to ships calling Russian and Finnish ports.

2.1 General information about the Baltic Sea

The Baltic Sea is a large, densely navigated brackish water area. Its semi-closed disposition and low salinity are challenging for aquatic nature. On the one hand, the salinity of the Baltic Sea is insufficiently low for a vast majority of marine species, and, on the other hand, is excessively high for species inhabiting in freshwater (Maritime activities in the Baltic Sea, 2018, p. 80). Despite this difference, marine and freshwater life forms exist together making the Baltic Sea environment unique and highly sensitive.

The shallowness of the Baltic Sea - its average depth is around 50 meters, while in the Gulf of Finland the mean depth is 38 meters (Baltic Sea clean shipping, 2017, p. 3) – presents difficulties and restrictions for large vessels approaching the shore area or entering the Baltic Sea through Danish waters. The maximum depth throughout the route there is only 17 meters (Danish Maritime Authority, 2019, p. 33) that is scarcely enough for Ultra Large Crude Carriers (ULCC) or Very Large Crude Carriers (VLCC), or Supertankers which have a draught of 35 and up to 20 meters respectively.

The Baltic Sea covers an area of approximately 420,000 km^2 which is surrounded by nine coastal countries – Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden and Russian Federation (State of the Baltic Sea, 2018, p. 12). Major navigating areas are the entrance to the Baltic Sea between Sweden (Gothenburg) and Denmark (Skagen) and, as marked in Figure 1, The Baltic Proper, The Gulf of Riga, The Gulf of Finland and The Gulf of Bothnia (Baltic Sea clean shipping guide, 2017, p.3).

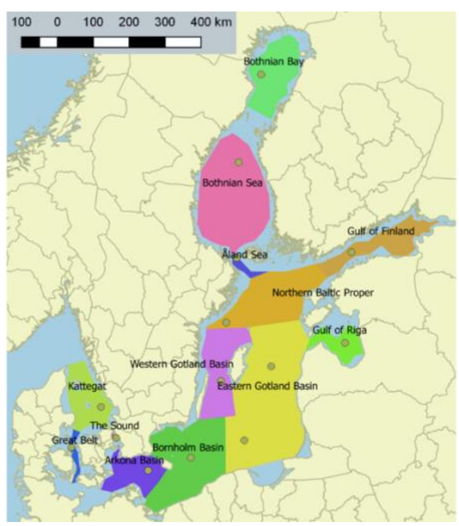


Figure 1. Map showing the marine areas and the basins of the Baltic Sea (Viktorsson, L., 2018)

Due to narrow straits linking the Baltic Sea with the Atlantic ocean, the whole cycle of water renewal takes approximately 30 years (State of the Baltic Sea, 2018, p. 12). This fact should always be borne in mind, especially in view of dense traffic in this region, as notwithstanding the amount of contamination, polluted waters will stay within the Baltic Sea for many years, which greatly endangers the environment.

2.2 Maritime traffic in the Baltic Sea

Nowadays, the least environmentally harmful fuel alternative to traditional oil fuel is liquefied natural gas, referred to as LNG, which consists of methane and has a significantly low amount of sulphur oxides and nitrogen oxygens in comparison to traditional oil fuels (Albrecht J., 2015, p.12). The gas is removed from CO_2 and H_2S, cooling down to -162 °C and becoming 600 times less in volume. It has no odour and poses no health hazards, with the exception of ignition cases. In order to be loaded on the ship, gas should be liquefied on the liquefication plant, and upon delivery to the port of destination, it should be pumped to regasification plant for further delivery. (Liquefied Natural gas, Shell). LNG is an important energy source in Europe, which is imported from Russia through the Baltic Sea among other trade routes.

The largest share of 46% of the traffic intensity in the Baltic Sea in 2016 was had by passenger ships although the total number of vessels was considerably low comparing to total number of ships navigating in the Baltic Sea area – 425 out of 7,889 (State of the Baltic Sea, 2018, p. 24, 32-33). The findings can be justified by constant ferry connection between European Union countries. The following five ports were mostly visited by cruise ships: Copenhagen, Helsinki, Stockholm, St. Petersburg and Tallinn (Cruise Baltic Market review, 2018).

Less than one third, or 22%, of the port visits was made by ships transporting goods (dry bulk cargo, container or tanker ships). Among these cargo carriers, 1,734 tanker vessels transported oil between more than 50 ports in and outside the Baltic Sea region in 2016. For the purpose of the present study, both oil and gas carriers are considered as a tanker ship. The most densely navigated areas by vessels - the Gulf of Finland, The Gulf of Riga, Arkona Basin – did not change through the years as shown in Figure 2. (Maritime activities in the Baltic Sea, 2018, p.31).

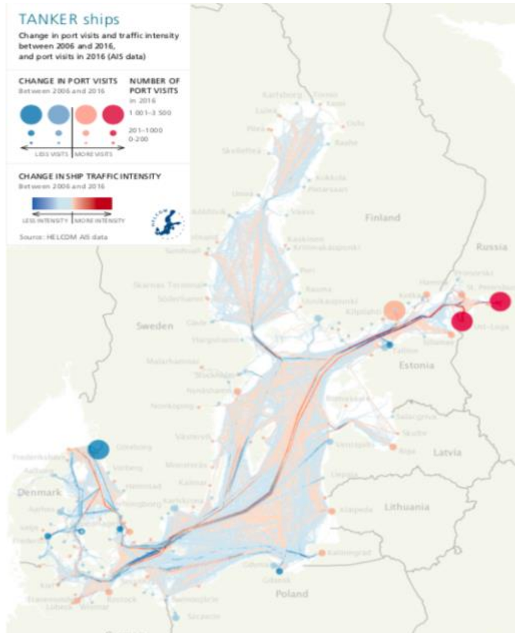


Figure 2. Change in port visits and traffic intensity between 2006 and 2016, and port visits in 2016 (AIS data) (Maritime activities in the Baltic Sea, 2018, p.31)

The most frequently visited ports were Skagen in Denmark, Gothenburg in Sweden, Klipilahti in Finland and Primorsk, Vysotsk and Ust-Luga in Russia. (State of the Baltic Sea, 2018, p. 30-31). The port of Skagen, being located in the North of Denmark, attracts more than 60,000 ships passing in and out of the Baltic Sea annually for bunkering and supply operations (Port of Skagen profile, 2016, p. 18). The port of Gothenburg, the largest port of Scandinavia, has both oil and LNG bunkering terminals. The major advantage, along with strategic location of the west of Sweden, is that the port is ice-free the whole year round (The port of Gothenburg website).

The ports of Ust-Luga, Primorsk and Vysotsk have been the largest exporters of crude and product oil in the Gulf of Finland. However, due to growing tension in the political sphere between Europe and Russia and growing independence from Russian fuel, export is steadily decreasing: Ust-Luga handled 59.9 million tons of petroleum cargo in 2018, which is less than in 2017. The situation is similar to the Port of Primorsk: 57.6 million tons in 2017 against 53.5 million tons in 2018 as depicted in Figure 6. (Gruzooborot morskih portov Rossii za yanvar'-dekabr'

2017, 2018). The detailed examination of the cargo turnover of Russian ports is provided in Chapter 3.

The present state of LNG facilities and transportation in the Baltic Sea region is lacking of proper infrastructure. LNG terminal development and its influence on maritime traffic is closely considered in Chapters 4 and 5 of the present study.

2.3 Winter navigation

It is becoming severe for ships to travel in the narrow, densely navigated passages of the sensitive areas of the Baltic Sea in winter due to subzero temperatures, ice-covered waters, and darkness. In addition to the aforementioned factors, strong winds and downfalls multiply the risks of delays, ships' failures or even accidents along the way. From the author's experience, due to subzero temperatures and thick ice which cannot be broken by icebreakers, vessels could be prompted to deviate to other ports for cargo operations. In the Gulf of Finland, icebreakers assistance during winter navigation is compulsory and rendered in the Russian ports of Primorsk, Ust-Luga, Vysotsk, Vyborg and St. Petersburg.

Throughout the winter, a large area of the Baltic Sea is covered with ice, which is challenging for navigation. Based on The Baltic Marine Environment protection commission, abbreviated as HELCOM, Recommendation 25/7, adequate ice strengthening is especially vital for ships navigating in the Baltic Sea during winter season. (Recommendation 25/7, 2016, p.4). The Baltic Marine Environment protection commission activities are examined in Chapter 3.

Winter navigation restrictions established by HELCOM were considered in accordance with vessels ice classes of the Finnish-Swedish Ice Class Rules and Russian Maritime Register of Shipping (RMRS) Rules (see Appendix 2) and ice thickness:

- When ice is 10–15 cm, and, if the weather forecast predicts continuing low temperature, at least ice class **Category II or Ice 1** (or equivalent) should be required for ships entering the ports of a Contracting Party;

- When ice is 15–30 cm, and if the weather forecast predicts continuing low temperature, at least ice class **IC or Ice 2** (or equivalent) should be required for ships entering the ports of a Contracting Party;
- When ice is 30–50 cm, a minimum ice class IB or Ice 3 or equivalent should be required for ships entering the ports of a Contracting Party.
- If ice thickness is more than 50 cm, a minimum ice class **IA or Arc 4** (or equivalent) should be required for ships entering the ports of a Contracting Party. (Recommendation 25/7, 2016, p.4).

Finnish-Swedish Ice Class rules were developed in cooperation between the Finnish Transport Safety Agency, Swedish Transport agency and classification societies. Ships of ice class IA and IA Super in accordance with these rules are intended for year-round operations in the Baltic Area. In contrast to an ice class IA, the aministrations do not impose navigation restrictions on an IA Super vessel type calling the Baltic ports. For IA ice class ships, a few size restrictions could be applied. For ships having an ice class IB or IC, access to ports of Finland and Sweden may be limited for a part of the year. Ships belonging to ice classes II and III do not have ice strengthening. In Finland, fairway dues are dependent on the ice class of the vessel, and for this reason ice class categories II and III are used. (Recommendation 25/7, 2016, p.4).

The administrations of Finnish and Swedish ports provide icebreaker assistance to ships bound for ports in these countries in the winter navigation season. Depending on the ice conditions, restrictions for ships are enforced or lifted. (Guidelines for the application of the Finnish-Swedish Ice Class Rules, 2011, p.4).

The winter traffic restrictions mentioned above for vessels calling at the Finnish ports are announced by the Finnish Transport Infrastructure Agency on an annual basis. These restrictions come into force five days after being published (Finnish transport agency, 2019). Information on ice thickness and the latest restrictions imposed in this respect by the ports of the Baltic Sea region is gathered and published by Finnish Meteorological Institute. Charts and data are updated every day depending on ice formation. For the time of writing the paper, the north part of the Gulf of Finland was covered with ice, and the whole territory of Bothnian Bay was covered with compact ice that is illustrated in the chart compiled by Finnish Meteorological Institute (Appendix 1/1).

The time frames and restrictions for ships entering Russian ports during winter navigation period are announced annually by the harbor masters' official decree depending on ice conditions. For instance, at the port of Primorsk icebreaker assistance period in 2019 began on the 22nd of February, provided the ice in the port was 10-15 cm thick, and since then it was prohibited for vessels without ice-class to approach the ports, even with icebreaker assistance (Rasporyazhenie kapitana porta Primorsk, 2019).

In accordance with the Baltic Sea Icebreaking Report (Baltic Icebreaking management, 2018, p.4), the first traffic restrictions in 2018 were imposed by Finnish ports of Kotka, Hamina and Loviisa on the 27th of January and were lifted on the 22nd of April. Maximum ice extent was reached on the 5th of March, 2018. It is notable that restrictions were not imposed on Swedish ports during winter season 2017-2018 (Baltic Icebreaking management, 2018, p.15). The data of Appendix ½ reveals that in 2018-2019 winter season some Swedish port restricted entrance for vessels depending on the deadweight and ice-class. The ports of Germany, Poland, Latvia and Lithuania imposed no restrictions.

3 ENVIRONMENTAL REGULATIONS IN THE BALTIC SEA AREA

This chapter follows on from the previous chapters which outlined the unique environment of the Baltic Sea.

Nowadays, the Baltic Sea is increasingly affected by the intense shipping that contributes to water pollution and land contamination (Baltic LINes, 2016). In order to cope with the issue through the international cooperation, the Convention on the Protection of the Marine Environment of the Baltic Sea area, or the Helsinki Convention, was established in 1974. Having entered into force in 1980, the Convention was revised in 1992. In 2000, updated Convention entered into force. The prevention of pollution from ships, land and offshore exploration and exploitation is the primary mission of the Convention. For the purpose of the Convention, Denmark, Estonia, the European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden agreed either individually or jointly to take sufficient preventive or reactive measures. In order to control and monitor the fulfillment of the Helsinki Convention, the Helsinki Commission, also known as HELCOM, was established in 1974. The intergovernmental organization comprises countries of the Baltic Sea region which participate in Helsinki Convention. Entering the Baltic Sea area, ships should comply with anti-pollution regulations and recommendations of the Helsinki Convention which include mandatory delivery of wastes generated by the ship, prohibited incineration of such wastes on the territorial waters of the Baltic Sea states and incineration of any other wastes. (Helsinki Convention, 1992).

The primary convention that covers both accidental and operational pollution of marine environment from ships is The International Convention for the Prevention of Pollution from Ships, abbreviated as MARPOL, which was adopted in 1973 by International Maritime Organization (IMO). The MARPOL convention was edited several times by adopting new protocols in 1978 and 1997. The convention consists of six chapters-Annexes, devoted to different marine pollutants such as noxious liquid substances and oil. (MARPOL 73/78). MARPOL 73/78 is the principal shipping law source under which the Baltic Sea was recognized as one of the special areas and specific shipping and navigation rules are prescribed. In addition to the status of a special navigating area, the Baltic Sea was also appointed by IMO as a Particularly Sensitive Sea Area (PSSA), meaning that special attention should be paid to the local environment and the regulations of the safe navigation. (Particularly sensitive areas). As follows from MARPOL Annex l and Helsinki Convention Annex lV, any discharge of oil or oily mixtures into the Baltic Sea is prohibited. Only if the oil content is less than 15 parts per million (ppm), discharge could be permitted within the special area. It is worth to mention that Denmark has completely prohibited any oil discharge in its territorial waters. (Baltic Sea clean shipping guide, 2017, p.5).

Furthermore, other conventions such as International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) govern shipping in terms of environmental impact. Ballas water management is crucial for the safe navigation of the vessel, maintaing her maneuverability and stability. However, the exchange of ballast compromises ecology due to inappropriate mixing of marine species contained in the ship's ballast and hosting waters. Thus, the BWM Convention prescribes regional recommendations for the ballast water exchange and obligatory requirements for ships to carry onboard the Ballast Water Record Book and to implement the Ballast Water and Sediments Management Plan. The problem of invasive species emerging from ballast waters is of paramount importance for the Baltic Sea in view of its sensitive environment. That was the reason for HELCOM to conclude that ballast water exchange is not recommended within the Baltic Sea area. (IMO BWM Convention, 2004).

Following the tendency of the obligatory reduction of emissions and pollution from ships, the International Maritime Organization has announced a distinct intention to enforce 0.5% sulphur content limitation instead of presently existing 3.5% on the in the bunker fuel for ships navigating outside the Emission Control Areas (ECA). The limitation will enter into force in 2020 upon the implementation of the amended MARPOL Annex VI. In accordance with the current version of Annex VI, the Baltic Sea is an ECA where limitation is set on 0.1%. (MARPOL 73/78, 2017, p. 286). Stringent limitations on the sulphur content make shipping companies switch from high to low sulphur fuel, especially in the Baltic Sea, which will affect the oil and petroleum product demand along with the LNG. Liquefied natural gas, as an eco-friendly fuel, has a competitive advantage over traditional fuels with its compliance to the IMO requirements. Consequently, terminal development and the construction of LNG liquefication and regasification plants is inevitable for the sustainable development of the European States and Russia.

4 MAJOR OIL AND LNG PORTS IN THE BALTIC SEA REGION

4.1 Finland

The following chapter introduces an analysis of the current state and future development of oil and LNG ports in Finland.

Data collected from Eurostat revealed that Finland is a net importer of oil and petroleum products although oil and oil products are also being exported from Finland. The nature of the ratio lays in Finland's engagement only in the refinery of oil, not in the exploration. Oil products produced in Finland are destined to the domestic market as well as to export. (Elonen P. et all, 2014). There are two oil refineries in Finland located at the ports of Porvoo and Naantali (Who we are, Neste).

In accordance with the Finnish customs data (Finnish international trade, 2018), import flows of oil and petroleum products come from:

- Russia – 54% of total import from the country,
- Sweden – 16.2% of total import from Sweden,
- Germany – 0.5%,
- the United States – 0.9%,
- the Netherlands – 4.4% of total import,

which proves dependence on Russian energy recourses, which could be a reason for growing demand on Russian LNG in the future.

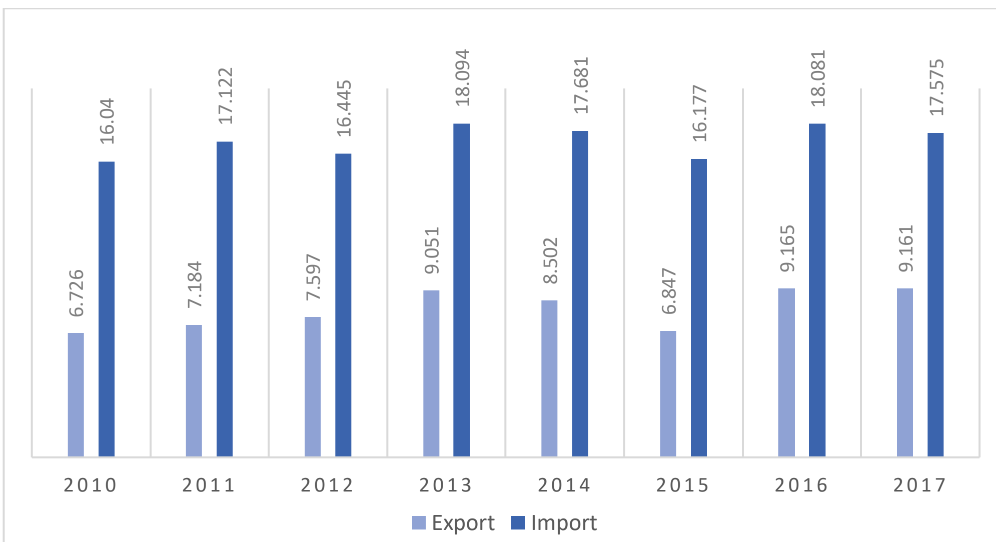


Figure 3. Statistics on oil and petroleum products import and export, million tons (Eurostat, 2019)

Major export routes of oil and petroleum products lead to the United States, the Netherlands and Sweden. It is worth to mention that Russian Federation was the third major trade partner of Finland after Germany and Sweden in terms of import in 2018. (Finnish international trade, 2018).

According to the Eurostat data (Gas import annual data, 2019), Finland did not import LNG from Russia or any other country in 2016. However, at the end of 2016, the construction of the LNG liquefication plant in Pori was accomplished and commenced its operation. Several studies have identified the lack of the infrastructure and technical uncertainties as key reasons for a low level of LNG sea transportation in the future (Arnaud S, 2017).

Russia is regarded as the major supplier of the crude oil and natural gas to Europe. In accordance with the Eurostat report (Energy production and import, 2019), in 2016, the share of Russia in European crude oil import was 31.9% and in Natural Gas import 39.9%, although dependence on Russian resources is slightly diminishing year by year (Figure 4). Future plans on terminal development in Finland and Russia are considered further.

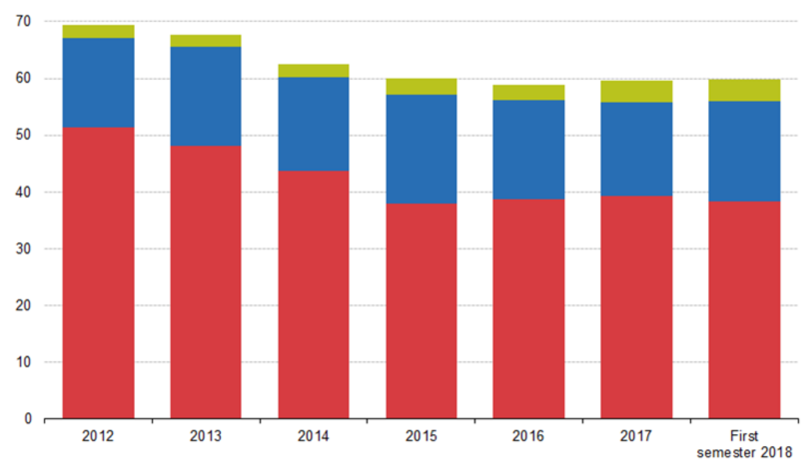


Figure 4. Share on energy products in total EU-28 imports from Russia, 2012-first semester 2018, % of total in value (Eurostat, 2019)

4.1.1 Hamina

The port of Hamina is mainly specialized in wood-processing industry although the port also handles general cargo, liquid and dry bulk and project shipments. Hamina Oil Terminal has two berths with a maximum draught of 9-10 meters (Terminal Facts, Oiltanking).

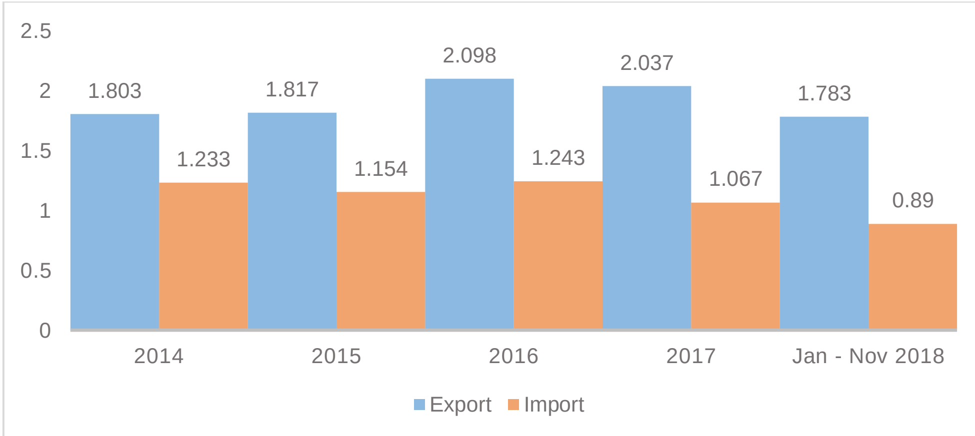


Figure 5. Statistics on oil import and export in the port of Hamina, million tons (Statistics, Port of HaminaKotka, 2014-2018)

For the time of writing the paper, a LNG import terminal was in the process of construction in the port of Hamina. The first phase of the project assumed the building of a 30,000 m^3 LNG storage tank, regasification plant, gas metering, bunkering and truck loading facilities and control systems. The second phase included the construction of additional tank capacity of 20,000 m^3 along with transshipment facilities. The project was planned to be fully executed by 2020.

The Hamina LNG terminal will allow to contribute not only to cleaner shipping by providing LNG bunker fuel, but also to increase the LNG supplies within the country (Hamina LNG Terminal).

4.1.2 Naantali

The Port of Naantali is situated near Turku, in the south-west of Finland. In terms of tonnage, the port is the fourth largest universal port in Finland. It offers a wide range of services such as handling of liquid and dry bulk, Ro-Ro cargo and serving the ferry flows. Deep fairways, up to 15.3 meters and the absence of heavy ice, allow Aframax tankers to enter the port regularly all year round. The short distance and regular ferry connection to Sweden makes the Port of Naantali a strategically important cargo hub between Finland and Scandinavian countries. Also, geographical advantage allows to connect the cargo flows between Europe and Russia owing to a road network and access to the Baltic Sea. In 2018, approximately 5.09 million tons of liquid bulk cargo was loaded to and unloaded from the port of Naantali, which is 37% more than in 2017. It is notable that circa 65% of the total cargo turnover (7.84 million tons) accounted for liquid bulk. Nearly 97% of the liquid bulk cargo (5,096 million tons) was transported to and from the oil refinery in Naantali owned by Neste. (Traffic, Port of Naantali). Naantali Refinery Plant produces diesel, solvents, bitumen and small-engine gasoline. (Naantali, Neste official website).

Transportation to and from the refinery plant in 2018 accounted for approximately 63% of the total transport volume in the port. The share of international transportation from refinery was 60% and domestic transportation only accounted for 40%. (Port of Naantali official website).

4.1.3 Porvoo

In terms of tonnage, the Porvoo Oil Terminal is the largest port in Finland and one of the largest in Scandinavia with the average of 1,250 ship calls and approximately 20-23-million-ton crude oil and petroleum product throughput per annum.

The refinery plant, located in the industrial area of Kilpilahti, allows to produce fuels and lubricants immediately upon reception of the crude oil. The storage capacity of the refinery’s underground and overground tanks is approximately 8 million m^3 for feedstock and products. (Who we are, Neste official website).

Nowadays, the primary raw material for the refinery plant is Russian Export Blend crude oil transported by tankers. According to a report by Neste, (Porvoo refinery process, Neste) approximately 40% of the products are intended for domestic market and the rest is exported to the Central Europe, Nordic countries and North America, transported mainly by the sea.

It is notable that the port of Kotka was one of the largest ports handling oil cargo up to 2002, when oil facilities were removed, and the shore was cleaned from contaminations. The reason for reconstruction was in the stricter regulations and closeness to the city. In addition, Kotka was gradually losing its importance as an oil terminal since the construction of a new oil refinery in Porvoo in 1970.

(Katariina seaside park, city of Kotka official website). This case could serve as an evidence of how port construction and terminal development affect trade routes

4.1.4 Terminal development

As was mentioned above, demand for liquefied natural gas is steadily growing due to low-carbon policies introduced by European countries and orientation to sustainable development.

At the beginning of Chapter 4, it was highlighted that in 2016 Finland did not import LNG. The first liquefied natural gas import terminal in Finland was launched in 2016 in the Port of Pori. The construction of the terminal contributed to the diversification of energy resource supplies. The storage capacity of the terminal is approximately 30,000 m^3, and it provides gas to industrial, heavy-duty land transport and shipping customers by pipelines, trucks and tanker vessels. (Skangas LNG import terminal, Hydrocarbons technology).

It is in the plans to build a new Manga LNG import terminal in the Port of Tornio, which would serve the region of the Bay of Bothnia along with maritime and heavy-duty transport in the Northern Finland, Northern Norway and Northern Sweden. The net volume of the storage capacity would be 50,000 m^3. The LNG is planned to be delivered mainly from Norway by a time-chartered supertanker with a capacity of 18,000 m^3. (Manga terminal in Tornio, Gasum). The third project is the construction of a LNG plant in the Port of Rauma. The planned storage capacity of the terminal is 10,000 m^3 (AGA aikoo rakentaa LNG-terminaalin Raumalle).

The combined operational capacity of the aforementioned terminals is provisionally approximately 450,000 tons. The development of the terminals will contribute to transfer from traditional fuel oil to natural gas and reduction of greenhouse emissions and decrease the dependence of Finland on Russian energy resources. Although LNG terminal development in the Baltic Sea region is in an infant stage, abovementioned projects will allow to widen the gas network in the nearest future.

4.2 Russia

The Russian Federation is a net oil exporting country, and consequently vast majority of ports, especially in the Baltic Sea region, are mostly dedicated for the export of oil and oil products. According to the estimates, in 2018, the Baltic Sea ports handled 136.5 million tons of crude oil and oil products, which demonstrates a steady reduction from 2016. (*Gruzooborot morskih portov Rossii za yanvar' – dekabr' 2017, 2018*).

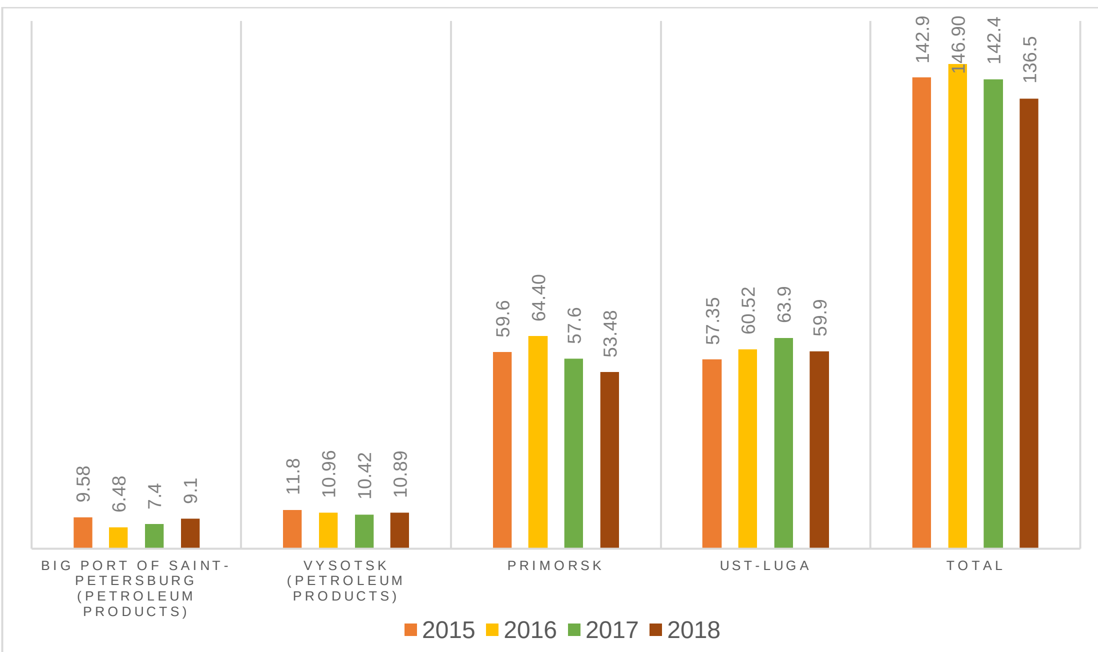


Figure 6. Throughput of the oil ports in the Baltic Sea, 2017. Million tons. (Assotsiatsiya morskih portov, 2016, 2017, 2018, 2019)

Ust-Luga was leading in the export as illustrated in Figure 6. The Port of Vysotsk and the Big Port of Saint-Petersburg handled only petroleum products and demonstrated growth in 2018 in comparison to 2017 by 4.51% and 22.93% respectively, although the throughput of the Big Port of Saint-Petersburg was considerably lower than in other examined ports.

In the following Chapter, the ports of Ust-Luga, Primosk and Vysotsk are considered in terms of ship traffic, cargo turnover and future development of the LNG terminals.

4.2.1 Ust-Luga

The Port of Ust-Luga, the universal port, is located in the Leningrad Oblast on the Luga River (Figure 7). It is the leading port in the Baltic Sea in terms of turnover, handling liquid and bulk cargo, general cargo, timber, coal, ore, fish and containers. The approach area to the port features the deepest fairways in the Baltic Sea and enables it to accept vessels of large capacity. The port capacities are sufficient for the cargo to be delivered directly, bypassing the transshipment through the Baltic States. In addition to other advantages, the Port of Ust-Luga has a railroad connection to the hinterland, which is a competitive advantage over other ports. (Morskoy port Ust-Luga, Administratsiya morksih portov Baltiiskogo morya).

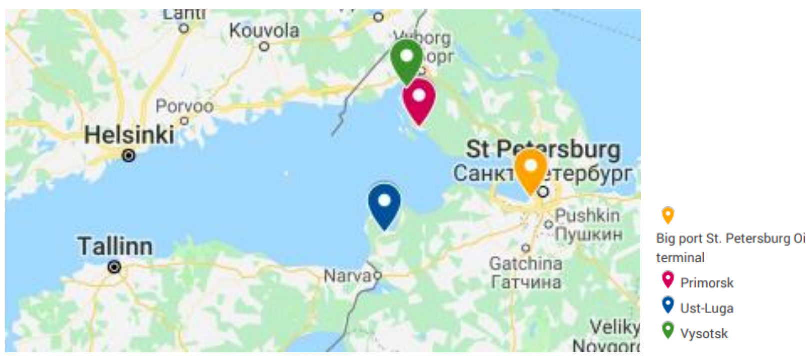


Figure 7. Location of Russian oil terminals in the Gulf of Finland

Due to the deep fairways and advantageous location, Ust-Luga was chosen as the point of construction for a new LNG liquification plant "Baltic LNG" with a production capacity of 10 million tons or 45 billion m^3 per year. Among potential consumers, the Baltic Sea region countries were considered such as Spain, Portugal, Latin America, India, and small-scale import terminals in the Baltic Sea region, which consequently led to the increase of the traffic through the Baltic Sea and endangers its sensitive environment. (Baltic LNG, Gazprom). It is worth to mention that Ust-Luga is planned to be the starting point of Nord Stream-2 pipeline for which Finland is one of the investing parties. (Economic benefits for the EU, 2017).

4.2.2 Primorsk

The Port of Primorsk is located in the Leningrad Region at the Gulf of Finland. The port has handles crude oil and petroleum products since 2001when the first tanker was loaded. The crude and light oil terminals of Primorsk are the largest in the North-West region of Russia with a throughput of 60 million tons and 15 million tons respectively. (Primorsk Oil Terminal).

The russian company Transneft, which owns the pipelines and quays in the Port of Primorsk, made decision to increase the share of petroleum products, especially diesel oil, by realizing the Sever-25 project. The project assumes an enlargement of desel oil type ‘Euro-5’ supplies from the refineries of Tatarstan to Primorsk and an increase of total turnover from 8.5 to 25 million tons. Excessive crude oil capacities were adapted for oil product storage and loading facilities. The construction was completed in 2018, but the first loading of diesel oil after improvements did not take place in 26 February 2019 (Transneft voshla v Primorsk s DT, 2019).

4.2.3 Vysotsk

The Port of Vysotsk, situated on the eastern shore of the Vyborg Bay, northwest of Saint-Petersburg, is the largest port in the North-West region of Russia. The port has coil, oil and two LNG production and loading terminals. The port handling capacity of oil product terminal is approximately 12 million tons per year. The terminal has three quays with a maximum draught of 13.2 meters. (Administration of Baltic Sea ports).
The first LNG liquefication and loading plant was under construction for the time of writing the thesis. The project capacity of the terminal is approximately 2 million tons, which will enable to load vessels of capacity up to 170,000 m^3. The second LNG transshipment and bunkering terminal of considerably smaller scale – 0.66 million tons per year – was planned to commence operations in April 2019.

Finland and countries of the Baltic Sea region were considered to be the key sales markets for the LNG delivered from the terminal. (NOVATEK set to launch LNG plant in Vysotsk in February 2019, 2019). In comparison to Baltic LNG plant in Ust-Luga, the aforementioned facilities will affect considerably less the traffic in the Baltic Sea due to the smaller capacity.

As depicted in Figure 1 and Figure 6, Primorsk, Ust-Luga and Vysotsk are the three major ports exporting oil and petroleum products shipped through the Baltic Sea to European countries. The development of LNG export terminals in Russia and LNG import plants in Finland and Europe will have direct influence on the traffic density in the Baltic Sea, which might be the cause of accidents and incidents such as oil spills, contaminations and collisions.

5 RISKS OF OIL AND LNG TRANSPORTATION IN THE BALTIC SEA

Despite the high level of the ship's crew's competency and good condition of the vessel, a certain maritime risks exist related to the navigation within the sensitive and demanding conditions of the Baltic Sea. This requires proper assistance from various authorities in the case of emergency. (Viertola, J, 2013, p. 12).

The following chapter aims to distinguish the typology of maritime risks which are feasible while navigating in the Baltic Sea and introduces regulatory instruments for the risk assessment, maintenance of the safe navigation and minimization of any possible risks. The empirical material obtained from the interview is compared to the research literature and appropriate conclusion is presented.

5.1 Maritime safety and risks

The remarkable increase of maritime transport in general and oil and fuels transport in particular present challenges for maritime safety in the Baltic Sea.

The term 'maritime safety' includes safety of life, property and environment during the operational activities of vessels. There are two groups of factors affecting the maritime safety: internal and external. Internal factors include the level of crew competency and the ship's condition. External factors comprise updates of navigational charts, depth of the fairways, ice conditions, piloting and icebreaker assistance and availability of the timely notifications on weather conditions. In other words, external factors are other than the vessel or the crew. (Viertola, J, 2013, p. 17).

Tokarev states that the major factor that turns maritime risks into the real events is the human element, which is, however, preceded by the chain of conditions caused either by internal or external factors. The HELCOM study reveals that the human element is indeed one of the major factors in maritime accidents along with unawareness of the situation and engine failures (Maritime activities in the Baltic Sea, 2018, p. 102). Even if nowadays new technologies are implemented onboard vessels to ease the crew's workload, the workload is still high, which directly influences on the crew performance and may be the reason of a human error.

There is a wide range of descriptions used to define accidents, incidents and near misses. Throughout this paper, the term 'accident' will refer to the event resulting in injury to people or damage to vessel or any other equipment.

Near miss is an unsafe event that could have resulted in loss that was fortunately prevented. The term 'loss' includes adverse events such as the human injuries, environmental damage, delay of the vessel's arrival and negative impact on the company's reputation. (Guidance on near-miss reporting, 2008, p.1).

Marine incident means an event, or events caused directly by the vessel's operations that endangered, or would endanger the ship's safety, people or the environment. An incident does not include the deliberate acts of negligence or omissions. (Resolution MSC.225(84), 2008, p.7).

In view of the traffic density, nature of sensitive environment and close location of the coastline, the consequences of the accidents, especially oil spills, in the Baltic Sea are considered disastrous. The main aim of the maritime safety is the prevention of the accidents and incidents occurring and minimization of its' harmful consequences. (Viertola, J, 2013, p. 17).

5.2 Maritime accidents

International attention to the maritime accidents increased sharply after the ill-famed Titanic accident in 1912. In response to the event, IMO adopted the first version of the International Convention for the Safety of Life at Sea (SOLAS) in 1914, which was amended and commonly referred to as SOLAS, 1974. The Convention specifies the safety requirements for the construction, operation, safety measures and equipment of ships. (IMO, SOLAS, 1974).

SOLAS 1974 and MARPOL 73/78 requirements are of paramount importance especially for oil and LNG transportation in the Baltic Sea area. Tankers represent vast majority, or 22% of the total fleet operating in the Baltic Sea (Report on shipping accidents in the Baltic Sea, 2018, p. 5). The HELCOM report affirms that the number of accidents in the Baltic Sea is unstable and unpredictable, which is illustrated in Figure 8, although seasonal changes in accident reporting are distinct. According to the HELCOM report, from January to March, when ice season is well underway, ship accidents reach their peak index. From May to August accidental events occur considerably rare. (Maritime activities in the Baltic Sea, 2018, p. 104).

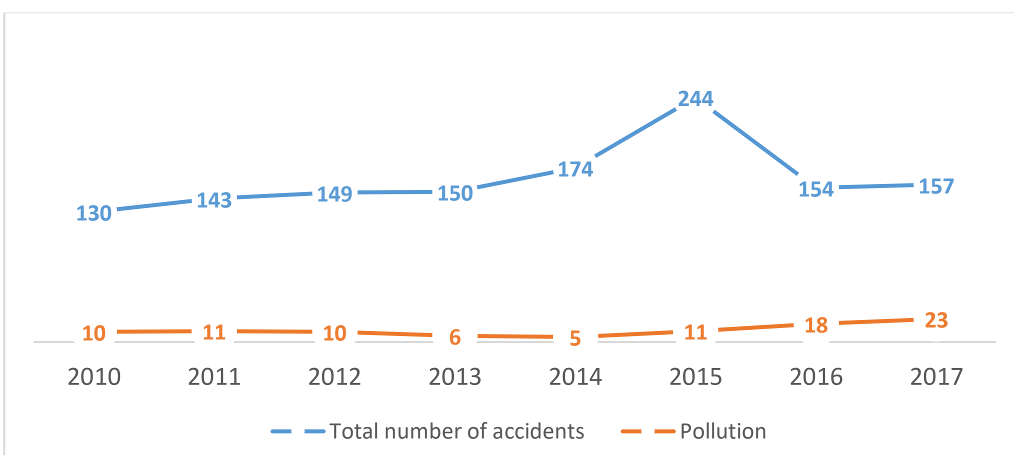


Figure 8. Number of reported accidents in the Baltic Sea 2010-2017 (Report on shipping accidents in the Baltic Sea, 2018, p. 10)

Collisions, along with engine failures, were the most common types of accidents in 2014-2017. As the major factors of collisions were indicated vessels violations of the IMO International Regulations for Preventing Collisions at Sea (COLREG) and poor interconnection between vessels (Maritime activities in the Baltic Sea, 2018, p. 105), which proves the statement that the human element at sea is the primary factor.

From 2011 to 2015, tankers were the third most common type of vessels involved in maritime accidents in the Baltic Sea. The number of tanker accidents was 170 out of total of 1,520 accidents occurring within the mentioned period. It is noteworthy that product tankers were involved in accidents more often compared to crude oil tankers, which correlates with statistics showing that small-size vessels of 1,501 – 6,000 gross tonnage were mostly engaged in maritime accidents in the Baltic Sea. The safety culture of the vessel operators is growing due to the implementation of internal safety procedures, compliance with international regulations and vetting inspections for tankers aimed to ensure the safety of transportation. (Maritime activities in the Baltic Sea, 2018, p. 107).

In the Port of Primorsk, for instance, tanker operators are obliged to conduct the vetting inspection for tankers calling the port, especially during winter navigation period, or to have valid vetting inspection carried out prior to the port entrance. Tokarev states that the OCIMF SIRE inspections along with proper risk assessment management is an efficient procedure to guarantee safe operation of the vessel not only in the open sea, but also alongside the terminal. OCIMF is an abbreviation for Oil Companies International Marine Forum formed in 1970 in response to growing concern on the marine pollution after Torrey Canyon incident in 1970. OCIMF obtained a consultative status at the IMO, which allows to represent the viewpoint of 110 oil companies at the IMO meetings. The Ship Inspection Report Program (SIRE) is a tanker risk assessment instrument which helps to indicate violations onboard, technical inconsistence of the vessel and incompliance with the procedures. Also, the SIRE vetting inspections reveal sub-standard vessels, which helps to reduce the risk of possible accidents or incidents. (OCIMF official website). Even if the safety of navigation is one of the most critical concerns for the vessel operators, maritime accidents are still feasible and even growing, which is illustrated by Figure 8 (Maritime activities in the Baltic Sea, 2018, p. 102).

LNG is a liquid that poses no health hazards as was mentioned in Chapter 2.2, and evaporates from the water surface in a short time span. However, the critical consequences of the LNG spill should not be underestimated. Methane that evaporates from the water surface is a greenhouse gas (Albrecht, J. 2015, p. 13). Collision incidents, which happen quite often in the Baltic Sea, can lead to the deformation of LNG tanks and consequential gas release (Galierikova A. et al., 2017). If a large amount of LNG is transported, ignition onboard can lead to explosion and flash fires. Until the beginning of 2019, no major LNG accidents were recorded. However, with the use of LNG as a fuel, it is possible that the number of accidents will increase significantly. (Albrecht, J. 2015, p. 13).

5.3 Accidents with pollution

For the purpose of protecting the environment of the Baltic Sea, any ship entering its waters should be in compliance with the Helsinki Convention anti-pollution regulations.

As depicted in Figure 8, the number of oil pollution accidents is constantly increasing. The growing number is causing concerns in view of development of stringent regulations and safety monitoring procedures and remarkable increase in the traffic in the Baltic Sea. The risk of oil spills is high in the open sea areas, en route to the Baltic ports, as can be seen from Figure 9.

A major reason for oil spills is a collision of the vessels, especially at the intersections of the main trade routes. Statistics proves that accidents are more likely to occur either in the port area or in the open sea rather than near the coastline. Between 2014 and 2017, 255 accidents occurred in the port areas and 212 in the open sea, and for the remainig 133 events were not specified in terms of area (Report on shipping accidents in the Baltic Sea, 2018, p. 10). Oil collection in the coastal areas is a very expensive action in comparison to other sea areas. For instance, an oil leak of 5,000 tons can cost up to hundreds of millions of euro. (Viertola, J. 2013).

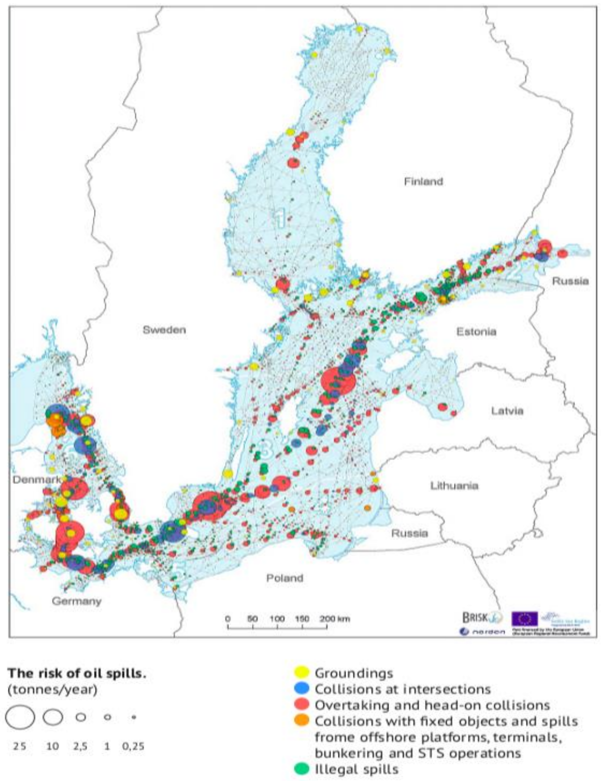


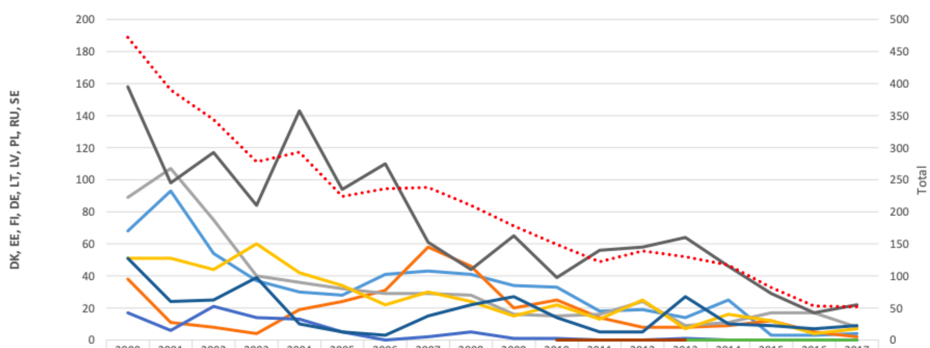
Figure 9. The risk of oil spills (Risks of Oil and Chemical Pollution in the Baltic Sea, p. 13)

The aforementioned data analysis reveals the problem of vessels' preparedness for port operations, insufficient measures taken by the ports in terms of maintenance and control and inconsistence with the regulations. Nevertheless, proper measures by the ships' and ports' management are essential for maritime safety. As follows from the interview with Tokarev, special attention should be paid to vessels managed by companies that scarce resources for comprehensive vessel and equipment maintenance, procurement, staff training and fulfillment of safety requirements and inspections.

In addition to collisions, oil can be released into the waters of the Baltic Sea after tank cleaning, from machinery spaces and in ballast waters, which are commonly referred to as operational discharge of oil. As was mentioned in Chapter 3, any discharge of oil and oily mixtures is prohibited in the PSSA and ECA area of the Baltic Sea. However, discharges from machinery spaces can legally take placeif the oil content does not exceed 15 ppm. Segregated ballast tanks (SBT) have contributed to the considerable decrease of oil content in the ballast waters and ,therefore, the share of oily mixtures discharged overboard. Nowadays, given sea area is most likely contaminated by an unauthorized discharge of waters after tank cleaning, resulting in violation of MARPOL requirements. However, there are several factors that reduce operational oil discharge into the sea. The first factor is the method of tank cleansing. The implementation of the crude oil washing (COW) and load-on-top (LOT) methods reduced significantly the accidents of oil discharges. The second factor is the reception facilities in the ports of the Baltic Sea. Major ports are obliged to provide reception facilities for the oily substances from tankers for comprehensive disposal is free of charge (commonly known as the no-special-fee system). The costs should be covered by the general harbor or environmental fees. (Honkanen, M. et al., 2012, p. 33).

The master and the vessel’s crew should be thoroughly proficient in the fulfillment of the prescribed procedures. Also, it is the charterer’s responsibility to include in the Charter Party the clause elaborating on the policy of pollution prevention compliance. In terms of safety and pollution prevention procedures, the shipowner is responsible for ensuring the compliance with International Safety Management Code (ISM Code). (Clean Seas Guide, 2012, p. 5).

According to the HELCOM data (Figure 10), the number of illegal oil discharges is constantly decreasing, despite the growing density of shipping in the area.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	68	93	54	37	30	28	41	43	41	34	33	18	19	14	25	3	3	4
Estonia	38	11	8	4	19	24	31	58	46	20	25	14	8	8	9	12	5	2
Finland	89	107	75	40	36	32	29	29	28	16	15	16	24	9	11	17	17	8
Germany	51	51	44	60	42	34	22	30	24	15	22	13	25	7	16	12	4	7
Latvia	17	6	21	14	13	5	0	2	5	1	1	0	0	1	0	0	0	0
Lithuania											0	0	0	0	0	0	0	0
Poland	51	24	25	39	10	5	3	15	22	27	14	5	5	27	10	9	7	9
Russia						2					0	0	0	0				
Sweden	158	98	117	84	143	94	110	61	44	65	39	56	58	64	46	29	17	22
Total	472	390	344	278	293	224	236	238	210	178	149	122	139	130	117	82	53	52

Figure 10. The number of oil spills per HELCOM country, 2000-2017 (Annual report on discharges, 2018, p. 10)

The statistics show that the pressure on the environment is also decreasing, although it is still high. The size of oil spills nowadays has a tendency to decline – the majority of spills are smaller than $1m^3$ and less than 100 liters (Illegal discharges of oil in the Baltic Sea, 2012).

The allocation of operational oil spills in 2018 (Figure 11) was the same as of risks of oil spills depicted in Figure 8.

In order to reduce the harmful impact of oil and other spill types, the procedure of the Baltic Sea incidents reporting was agreed internationally. The master or any other responsible person in charge of the vessel involved in an incident should report in the shortest possible time span all the particulars of the event to the nearest coastal state. In the event of oil pollution, the oil pollution emergency plan should be followed. (Baltic Sea clean Shipping, 2017, p. 21).

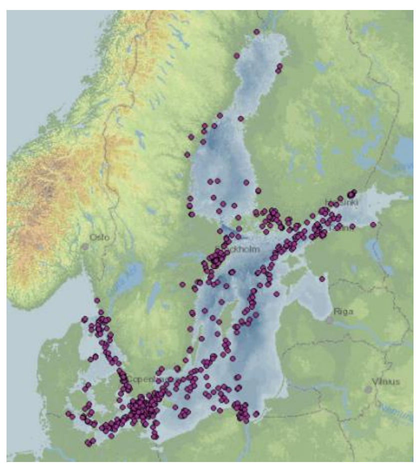


Figure 11. Operational oil spills from ships 2018 data (HELCOM AIS)

As was considered in the previous Chapters, oil and LNG terminal development in the Baltic Sea is well underway, and therefore, traffic is expected to grow in the nearest future, and the number of accidents will grow, in a likelihood, consequently. The transportation of the dangerous goods such as oil and LNG through the sensitive Baltic Sea requires special training, skills and competency.

5.4 Discharge of sewage, garbage, dumping and fuel oil quality

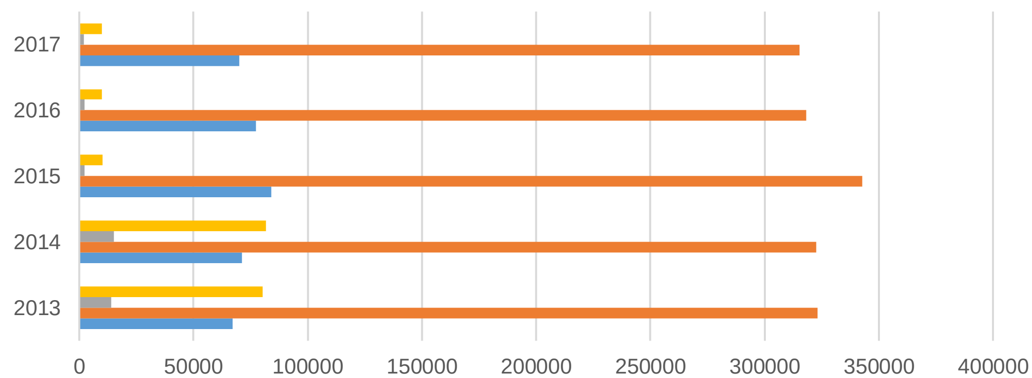
Sewage is defined by the MARPOL 73/78 Convention as a drainage from toilets, medical premises and from spaces containing animals or other waste waters when mixed with the aforementioned sources of drainage (MARPOL 73/78, 2017, p. 231). The sewage discharge is prohibited within 12 nautical miles from the closest land. If the sewage has been disinfected and refined by the approved equipment and in accordance with an approved sewage treatment plan, it can be discharged if the nearest land is not less than 3 nautical miles from the vessel, and if she proceeds at the speed not exceeding 4 knots. The sewage discharge to the sea is hazardous for health, and visible pollution can be observed. The sewage discharge into the sea area is regulated by the Annex lV of the MARPOL 73/78 Convention titled ‘Regulations for the Prevention of Pollution by Sewage from Ships’. According to the latest version of the Annex lV, entered into force in 2005, the Baltic Sea is the only area designated as a Special Area for sewage discharge. These requirements are applied for ships engaged in international shipping, of 400 gross tonnage and more or certified for the carriage of more than 15 persons. (IMO, Prevention of Pollution by Sewage from Ships).

The garbage discharge into the Baltic Sea is prohibited in accordance with MARPOL Annex V, as the Baltic Sea has been designated as Annex V special area since 1989. As an exception, food wastes generated during the ongoing operation of a ship can be discharged, but not less than 12 nautical miles from the shore. (MARPOL 73/78, 2017, p. 256). An appropriate and comprehensive garbage reception facilities in the Baltic Sea ports should be provided in accordance with the MARPOL Annex V (MARPOL 73/78, 2017, p. 257). The MARPOL 73/78 and Helsinki Convention comprise the requirement on keeping onboard the vessel the Oil, Garbage and Cargo Record Book where all operations should be described in details (Clean Seas Guide, 2012, p. 11).

Dumping means any discharge of wastes and other matters from ship into the sea. These actions are strictly prohibited in the Baltic Sea by the IMO London Convention and the Helsinki Convention (Baltic Sea clean Shipping, 2017, p. 9). It is worth to mention that Russia, Latvia, Lithuania, Poland have not ratified the

1996 London Protocol of the IMO London Convention (Maritime activities in the Baltic Sea, 2018, p. 91).

In accordance with Annex VI ‘Regulations for Prevention of Air Pollution from Ships’ of the MARPOL Convention, the Baltic Sea is recognized as a SO_x emission control area (SECA). As was mentioned in Chapter 3, the sulphur content of the fuel oil for ships navigating in the Baltic Sea should not exceed 0,1%. (MARPOL 73/78, 2017, p. 286). Sulphur oxides (SO_x) have negative effect on the human health and pollute the Baltic Sea with nutrients (Maritime activities in the Baltic Sea, 2018, p. 38). As shown in Figure 12, SO_x emission indexes were significantly lower in 2015-2017 compared to those in 2013-2014.



	2013	2014	2015	2016	2017
Total Sox	80200	81845	10269	9779	10042
Tanker Sox	14000	15146	2248	2196	2050
Total Nox	323200	322529	342846	318286	315395
Tanker NOx	67000	71128	84157	77378	70174

Total Sox Tanker Sox Total Nox Tanker NOx

Figure 12. SO_x and NO_x emissions in the Baltic Sea from tankers and in total from all vessel types, tons (Emissions from the Baltic Sea, 2014, 2015, 2016, 2017, 2018)

Since 2016, the Baltic Sea has been designated as NO_x emission control area (NECA). Nitrogen disposition from tanker vessels and from all vessel types, as can be seen from Figure 12, has been reducing constantly from 2015.

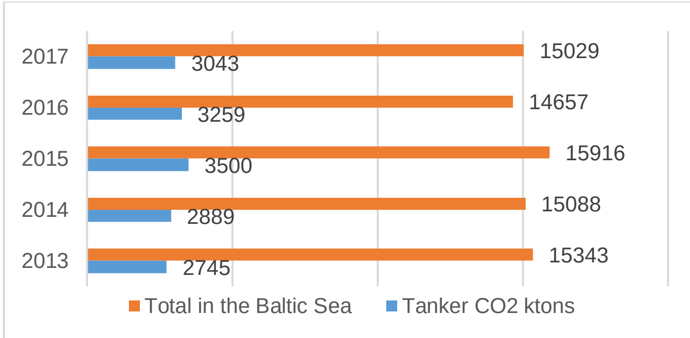


Figure 13. Carbon dioxide emissions from all vessels type and tankers 2015 – 2017, ktons (Emissions from the Baltic Sea, 2014, 2015, 2016, 2017, 2018)

Carbon dioxide emissions from ships are stable on the average of 15.000 ktons per annum although the emissions from tanker vessels navigating in the Baltic Sea have been reducing gradually from 2015 (Figure 13).

The aforementioned findings and figures show that threats to environment and human health resulting from ships' operations still existt although the risks are under constant monitoring and managed by international organizations, governments and vessel operators.

CONCLUSION

The study was conducted to provide insight into the latest seaborne transportation data, including oil and LNG cargo, to show the trends of infrastructure development and assess maritime risks associated with oil and LNG shipping within the Baltic Sea area. The study examined the special features of the Baltic Sea, traffic density in the area and related LNG and oil maritime transportation risks based on a literature survey and an interview with a specialist. The objectives were reached by means of thoroughly addressing the research questions.

The literature reviewed in the study was mostly based on the IMO MARPOL 73/78 Convention, IMO guidances and manuals, OCIMF and HELCOM publications related to the topic, which can be considered as reliable and valid sources of information. Eurostat and UNCTAD data was used to gather statistical data for a comparative analysis.

The literature review revealed that the topic of environmental and operational challenges for ships' navigation in the Baltic Sea is thoroughly examined although it is mainly focused on crude oil carriers. As for gas carriers, studies are still scarce, owing to the infant stage of the LNG projects and infrastructure in the Baltic Sea. Upon commencement of the operation of the LNG liquefication plants in Ust-Luga and Vysotsk, and the LNG regasification plants in Hamina, it is possible that the amount of the researches about the LNG transportation via the Baltic Sea will consequently increase.

The study has proved that generally the current safety situation in the Baltic Sea is quite positive in comparison to the previous years, although threats such as illegal sewage and garbage discharges, oil spills, dumping and air pollution from ships still exist. Nowadays, maritime safety is regulated and monitored to great extent by the efforts of such organizations as IMO, OCIMF, HELCOM and conventions and guidance such as ISGOTT, MARPOL, SOLAS, ISM Code. These instruments are efficient in providing maritime safety in the Baltic Sea.

Efficiency is proven by statistics data analysis which revealed that oil spills accidents have reduced remarkably in the last ten years along a decrease in NO_x and SO_x emissions. The total emissions of NO_x from tanker vessels decreased from 84.157 tons in 2015 to 70.174 tons in 2017. In 2015, when navigation in the Baltic Sea reached its peak indexes, SO_x emissions rapidly fell in comparison to 2014 due to new IMO regulations entered into force. For instance, in 2014, the total SO_x emissions were counted at 81.845 ktons, whereas in 2015 the figure was 10.269 ktons that is nearly eight times less. Carbon dioxide emissions remained on the average level, however, it is expected that CO_2 emissions from ships in the Baltic Sea will significantly decrease when new IMO sulphur regulations will enter into force in 2020. The hazards arising from the accidents, incidents, oil spills and discharge of garbage and sewage involving oil and LNG tankers remain one of the major threats to human health and environment in the Baltic Sea. Based on the study results, the number of oil spills is decreasing annually, although the total number of pollution related accidents have been increasing since 2015.

The port development in Finland and Russia will directly influence the vessel traffic due to possibility for bunkering vessels with LNG fuel in Ust-Luga, Vysotsk and Hamina, and trend of growing international LNG trade and shipping.

One of the results generated in the study, based on the interview with a maritime expert and a literature review, showed that one of the most effective ways to support safe and secure shipping in the sensitive area of the Baltic Sea were cooperation between the Baltic States' governments, shipping companies and port authorities as well as valid OCIMF SIRE inspections for oil tankers. Sharing information is of paramount importance for the improvement and maintenance of maritime safety.

Even if the study was limited to the Russian and Finnish port development, the traffic density was examined for the whole area of the Baltic Sea. Two vessel types were exclusively considered in the study in terms of related risks, although some regulations can be applicable for other cargo vessel types. Terminal regulations were considered in terms of winter navigation and oil tanker inspections. The present study could be beneficial and valuable for the policy makers due to analysis of the latest available data.

It would be recommended for future studies to examine and analyze the LNG and oil terminal regulations based on ISGOTT and other documents and guidances that are of great importance in view of growing LNG trade and constantly high demand for hydrocarbons in general. In addition, LNG terminal development in other Baltic States can be proposed as a topic for future studies.

Although there are several areas of concern in terms of maritime transportation of oil and LNG in the Baltic Sea, the results of the study provide support for the statement that the risks related to the maritime transportation of crude oil are closely monitored, properly addressed and their reoccurrence is minimized. LNG transportation through the Baltic Sea could serve as a topic for a future research and risk assessment.

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Figure 10. The number of oil spills per HELCOM country, 2000-2017 (Annual report on discharges, 2018, p. 10). [Online]. Available at: https://portal.helcom.fi/meetings/MARITIME%2018-2018-503/MeetingDocuments/8-1%20HELCOM%20Annual%20report%20on%20discharges%20observed%20during%20aerial%20surveillance%20in%20the%20Baltic%20Sea%202017.pdf
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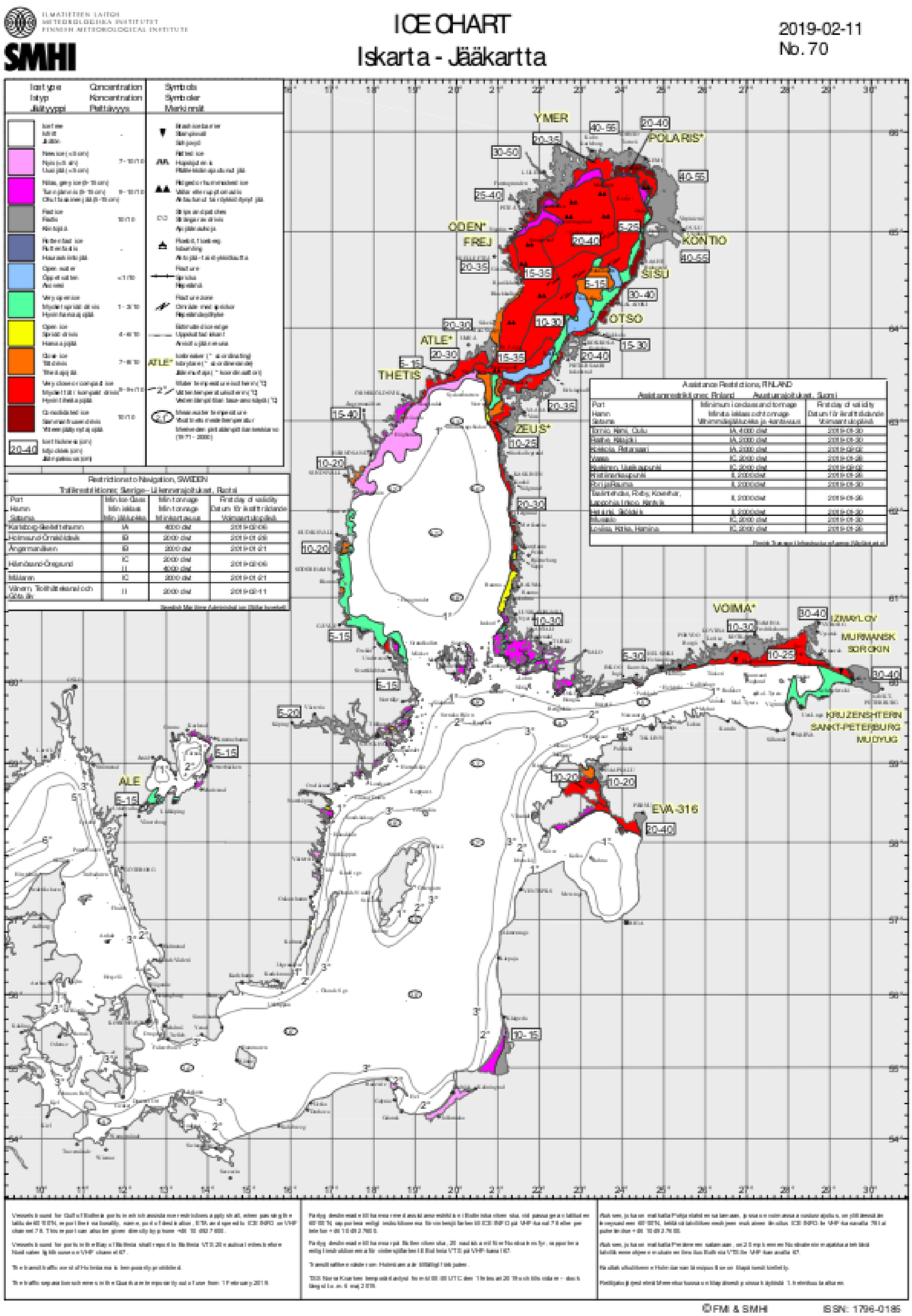
Figure 11. Operational oil spills from ships 2018 data (HELCOM AIS).

Figure 12. SO_x and NO_x emissions in the Baltic Sea from tankers and in total from all vessel types (Emissions from the Baltic Sea, 2014, 2015, 2016, 2017, 2018).

Figure 13. Carbon dioxide emissions from all vessels type and tankers 2015 – 2017 (Emissions from the Baltic Sea, 2014, 2015, 2016, 2017, 2018).

APPENDIX 1/1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ICE CHART
Iskarta - Jääkartta
2019-02-11
No. 70
Restrictions to Navigation, SWEDEN
Assistance Restrictions, FINLAND
YMER
POLARIS*
ODEN*
FREJ
KONTIO
SISU
OTSO
ATLE*
THETIS
ZEUS*
VOIMA*
IZMAYLOV
MURMANSK
SOROKIN
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SANKT-PETERBURG
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ALE
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APPENDIX 1/2

FINLAND – FINLAND – SUOMI

Port Hamn Satama	Minimum ice class and tonnage Minsta isklass och tonnage Vähimmäisjääluokka ja -kantavuus	First day of validity Datum för ikraftträdande Voimaantulopäivä
Tornio, Kemi, Oulu	IA, 4000 dwt	30.1.2019
Raahe, Kalajoki	IA, 2000 dwt	30.1.2019
Kokkola, Pietarsaari	IA, 2000 dwt	2.2.2019
Vaasa	IC, 2000 dwt	28.1.2019
Kaskinen, Uusikaupunki	IC, 2000 dwt	2.2.2019
Kristiinankaupunki	II, 2000 dwt	26.1.2019
Pori, Rauma	II, 2000 dwt	30.1.2019
Taalintehdas, Förby, Koverhar, Lappohja, Inkoo, Kantvik	II, 2000 dwt	26.1.2019
Helsinki, Sköldvik	II, 2000 dwt	30.1.2019
Loviisa	IC, 2000 dwt	26.1.2019
Mussalo	IC, 2000 dwt	30.1.2019
Kotka, Hamina	IC, 2000 dwt	26.1.2019
Saimaan kanava on suljettu liikenteeltä tammikuun 1. päivänä 2019. Saima kanal är stängd för trafik den 1 januari 2019. The Saimaa Canal was closed for traffic 1st of January 2019.		

SWEDEN – SVERIGE – RUOTSI

Port Hamn Satama	Minimum ice class and tonnage Minsta isklass och tonnage Vähimmäisjääluokka ja -kantavuus	First day of validity Datum för ikraftträdande Voimaantulopäivä
Karlsborg, Luleå, Haraholmen, Skelleftehamn	IA, 4000 dwt	6.2.2019
Holmsund, Rundvik, Husum, Örnsköldsvik	IB, 2000 dwt	6.2.2019
Ångermanälven	IB, 2000 dwt	21.1.2019
Härnösand, Söråker, Sundsvall, Stocka, Hudiksvall, Iggesund, Söderhamn, Orrskär, Norrsundet, Gävle, Skutskär, Öregrund	IC, 2000 dwt II, 4000 dwt	31.1.2019
Mälaren	IC, 2000 dwt	21.1.2019
Vänern, Göta älv, Trolhätte kanal	II, 2000 dwt	11.2.2019

DENMARK – DANMARK – TANSKA

RUSSIA – RYSSLAND – VENÄJÄ

Port Hamn Satama	Restriction Restriktion Rajoitus	First day of validity Datum för ikraftträdande Voimaantulopäivä
Vyborg	Without ice class. Ice class "Ice1" only with icebreaker.	6.2.2019
Vysotsk	Without ice class. Ice class "Ice1" only with icebreaker.	8.2.2019
Primorsk	Small crafts, barge towed by tug. Without ice class only with icebreaker.	25.1.2019
Saint-Petersburg	Small crafts, barge towed by tug. Without ice class only with icebreaker.	25.1.2019
Ust'-Luga	Small crafts.	1.12.2018
Primorsk	**Without ice class. Ice class "Ice1" only with icebreaker.**	**22.2.2019**
Ust´-Luga	**Barge towed by tug. Without ice class only with icebreaker.**	**14.2.2019**

ESTONIA – ESTLAND – VIRO

Port Hamn Satama	Min engine power Minimimaskineffekt Vähimmäiskoneteho	Ice class Isklass Jääluokka	First day of validity Datum för ikraftträdande Voimaantulopäivä
Pärnu	1600 kW	1C (Lloyd´s)	19.1.2019

LATVIA – LETTLAND – LATVIA

Port Hamn Satama	Restriction Restriktion Rajoitus	First day of validity Datum för ikraftträdande Voimaantulopäivä

LITHUANIA – LITAUEN – LIETTUA

Port Hamn Satama	Restriction Restriktion Rajoitus	First day of validity Datum för ikraftträdande Voimaantulopäivä

POLAND – POLEN – PUOLA

Port Hamn Satama	Min. engine power Min. maskineffekt Vähimmäiskoneteho	Ice class Isklass Jääluokka	First day of validity Datum för ikraftträdande Voimaantulopäivä

GERMANY – TYSKLAND – SAKSA

Port Hamn Satama	Min. engine power Min. maskineffekt Vähimmäiskoneteho	Ice class Isklass Jääluokka	First day of validity Datum för ikraftträdande Voimaantulopäivä

APPENDIX 2

Classification Society	Ice Class				
Finnish-Swedish Ice Class Rules	**IA Super**	**IA**	**IB**	**IC**	**Category II**
Russian Maritime Register of Shipping (Rules 1995)	UL	L1	L2	L3	L4
Russian Maritime Register of Shipping (Rules 1999)	LU5	LU4	LU3	LU2	LU1
Russian Maritime Register of Shipping (Rules 2008)	Arc 5	Arc 4	Ice 3	Ice 2	Ice 1
American Bureau of Shipping	Ice Class I AA	Ice Class I A	Ice Class I B	Ice Class I C	D0
Bureau Veritas	ICE CLASS IA SUPER	ICE CLASS IA	ICE CLASS IB	ICE CLASS IC	ID
CASPPR, 1972	A	B	C	D	E
China Classification Society	Ice Class B1*	Ice Class B1	Ice Class B2	Ice Class B3	Ice Class B
Det Norske Veritas	ICE-1A*	ICE-1A	ICE-1B	ICE-1C	ICE-C
DNV GL	Ice(1A*)	Ice(1A)	Ice(1B)	Ice(1C)	-
Germanischer Lloyd	E4	E3	E2	E1	E
IACS Polar Rules	PC6	PC7	-	-	-

APPENDIX 3

INTERVIEW QUESTIONS

1. What impact will the Vysotsk and Ust-Luga LNG plant have on regional oil trade and shipping in the Baltic Sea region once it is launched?

2. Does the Port of Primorsk anticipate any hurdles in the future?

3. What are the current plans for modernization and improvement of oil terminals in the Port of Primorsk?

4. In your opinion, what is the future of Oil and LNG for the next 10-20 years?

5. Judging by your own experience, what were the major reasons of oil spills/ships accidents alongside the POT terminal and offshore?
6. Would you agree with the statement that nowadays there are still shipping companies and/or its personnel, who in the pursue of high revenues neglect simple safety rules and regulations, which could have considerable consequences?

7. What is, to your mind, the best tool for enhancement of safe and clean tanker shipping in the Baltic Sea in general and in the Gulf of Finland in particular?