HELCOM MARITIME ASSESSMENT 2018

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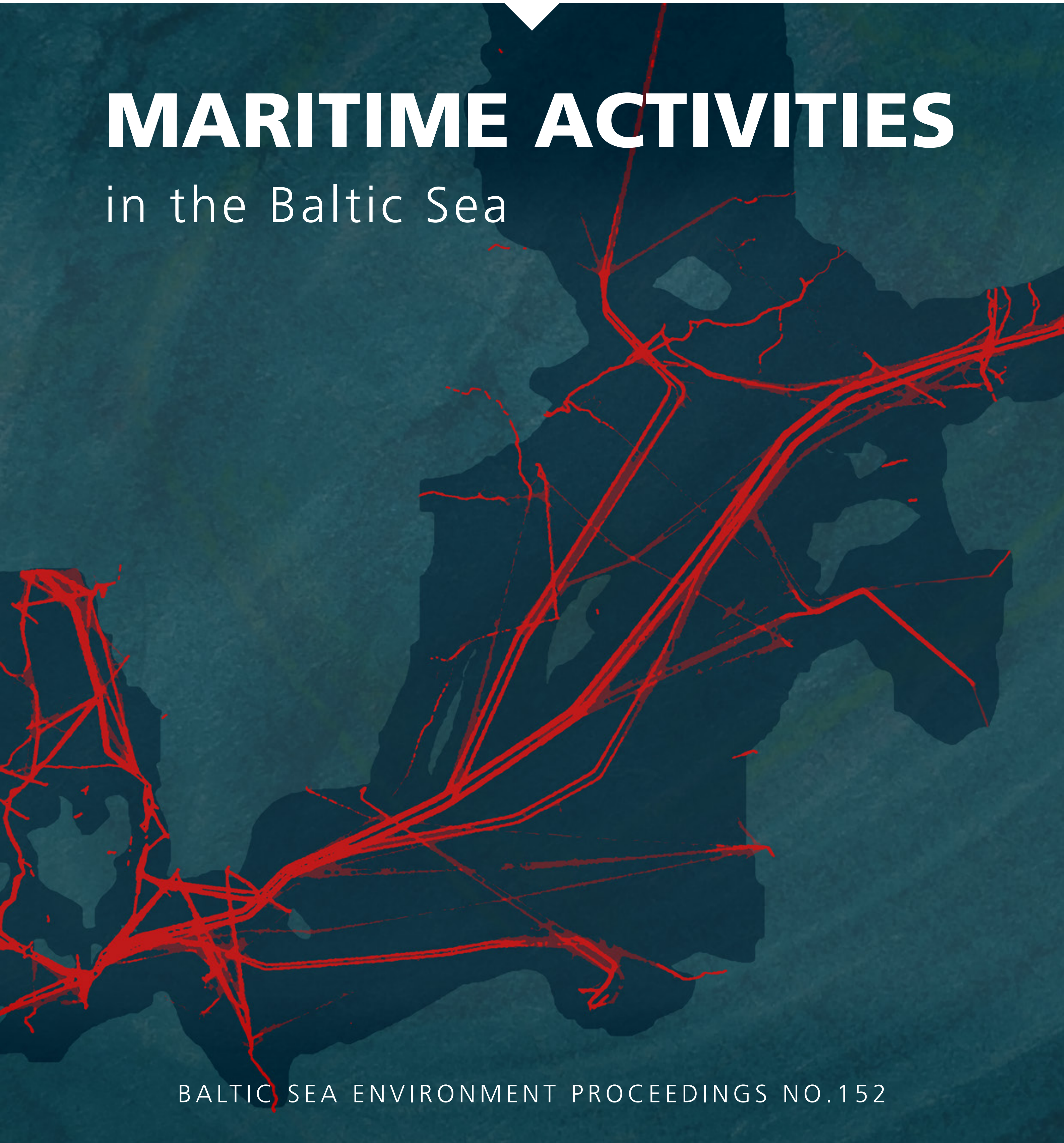
MARITIME ACTIVITIES

in the Baltic Sea



BALTIC SEA ENVIRONMENT PROCEEDINGS NO.152

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in the Baltic Sea

Helsinki Commission
Baltic Marine Environment Protection Commission

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PREFACE

This publication fulfills the commitment to comprehensively assess the status, environmental risks and opportunities of maritime activities in the Baltic Sea region within HELCOM, to which the coastal countries and the EU agreed as part of the 2013 HELCOM Ministerial Declaration (Copenhagen).

It is intended to support the update of the "State of the Baltic Sea -Holistic Assessment" as well as to benefit the work of the relevant HELCOM Working Groups. This includes HELCOM Maritime, Response and Fish but also others.

Addressing sea based pollution sources is a key area of HELCOM work but due to its operational and technical nature it has not been in the focus of assessment activities until recently. The first HELCOM Assessment of Maritime Activities was published in 2010 as BSEP No. 123 as a response to the implementation of the Ecosystem Approach, and the 2007 Baltic Sea Action Plan (BSAP).

The main part of the effort behind this publication has been focusing on providing an overview of human activities on the Baltic Sea by compiling, and presenting in an understandable way, the latest information and long-term trends available for a number topics. In addition, each chapter concludes with a segment of "Future Perspectives" which provides some identified issues for further consideration within HELCOM and elsewhere.

In addition to this traditional publication, a large number of GIS datasets generated in the process, particularly AIS based maps on maritime activities, are released simultaneously for the general public via the HELCOM Map and Data Service (MADS). These might be interesting and useful for various purposes including research. Also the code used in producing these datasets is made available for the same purpose via the GitHub platform.

The publication has been drafted as a collective process where drafts of text and illustrations, provided by the Secretariat, have been commented and amended by the Contracting Parties and Observers via a number of consultation rounds during spring-autumn 2017. The outline of the report, including chapter headings, was similarly consulted with Maritime, Response and Fish working groups during 2015–2016.

We wish you will enjoy this publication as a guide for your explorations in the world of Baltic Sea maritime activities.

Bon Voyage !

BRIEF CONTENTS

VISUAL CONTENTS

BALTIC MARINE ENVIRONMENT PROTECTION COMMISSION
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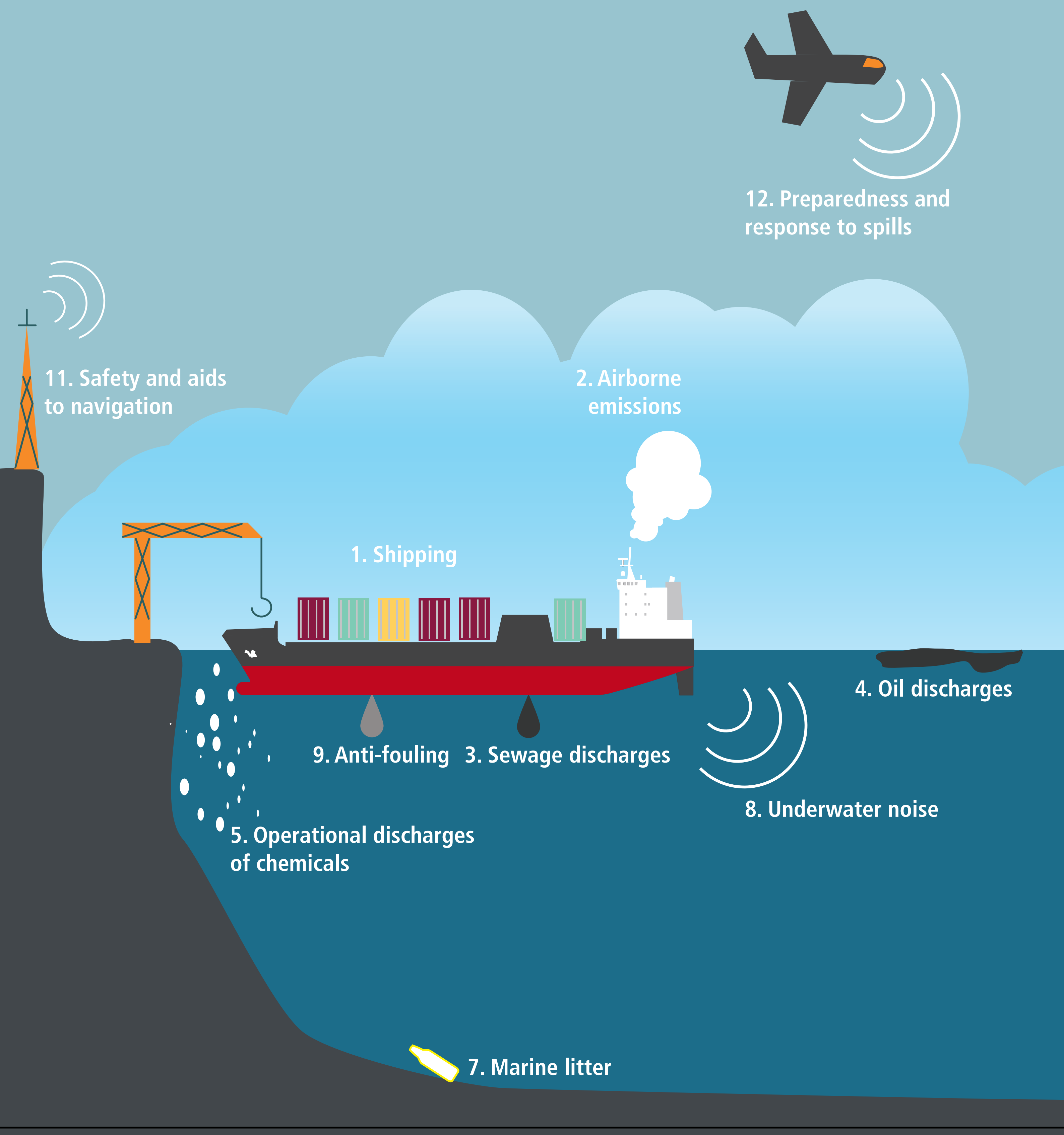

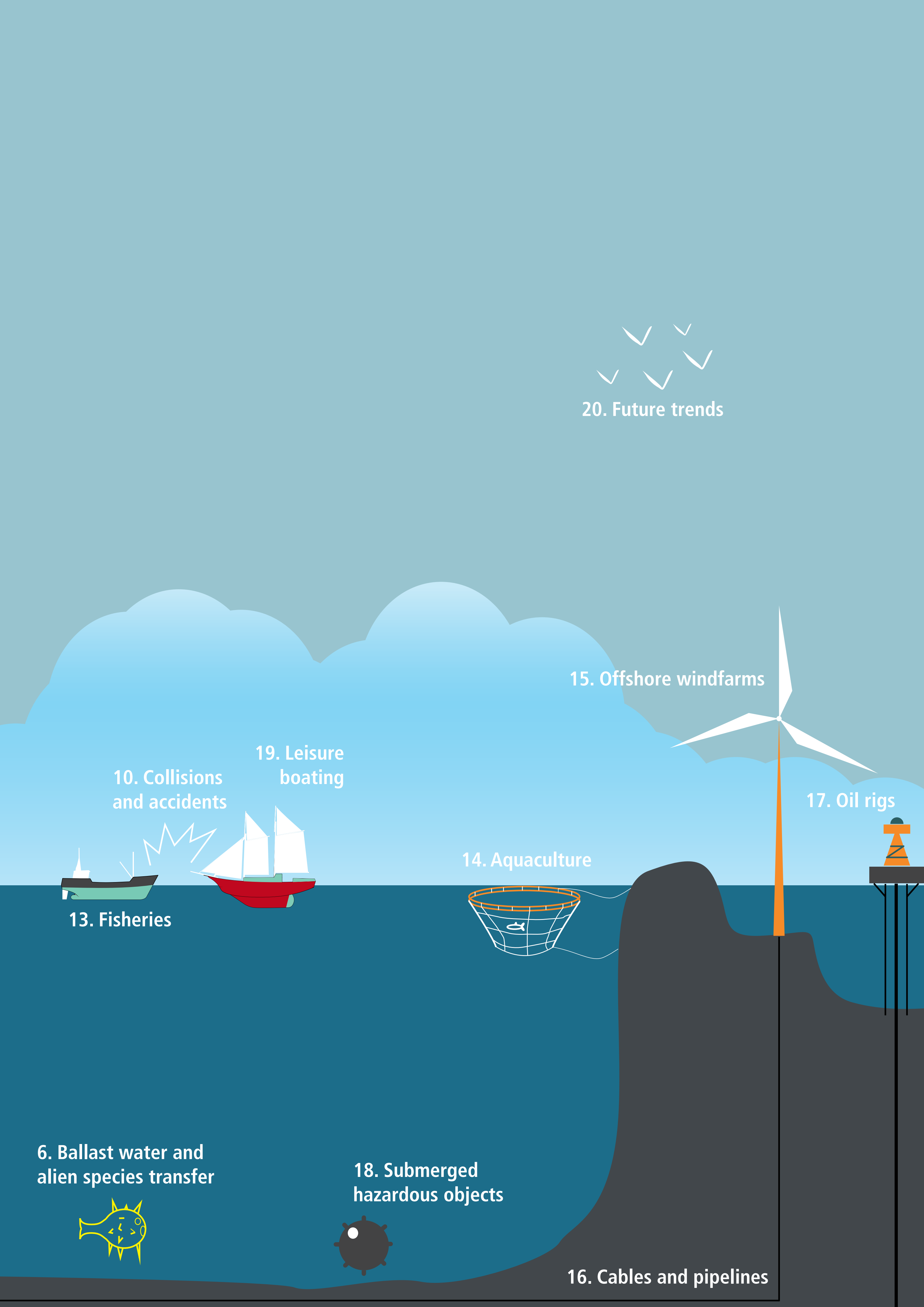
20. Future trends
15. Offshore windfarms
19. Leisure boating
10. Collisions and accidents
17. Oil rigs
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13. Fisheries
6. Ballast water and alien species transfer
18. Submerged hazardous objects
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CONTENTS

INTRODUCTION

Humans have used the Baltic Sea for a very long time — especially as a transportation route and source of food. Today the surface and seabed of the Baltic is the scene for much more diverse and intensive human activities. These include the traditional uses, maritime transportation and fisheries for example, but also more recent developments such as aquaculture, oil and gas exploitation, offshore wind, cables and pipelines as well as leisure activities including boating. Many of these activities are taking place all the time, even now as you read these lines.

Activities at sea are important for the way of life in modern human society in many ways — but also exert pressure on the sensitive Baltic Sea marine environment. This pressure is combined with the pollution from land — but also the dirty remnants of wars and old waste handling practices at sea in the form of submerged hazards such as dumped munitions and polluting wrecks.

Perhaps surprisingly, human activities at sea have been much less studied than the status of the Baltic Sea marine environment, which has been assessed to a considerable detail over the last century. There are especially few attempts to provide an overview of the various major human activities on the Baltic Sea in a single publication.

This HELCOM Maritime Assessment 2018 aims to fill that gap by presenting to the reader the main maritime activities in the Baltic Sea as well as the main environmental issues related to these activities.

Besides being a compilation of the available regional knowledge on specific activities, the publication aims to enable the HELCOM Contracting Parties (Denmark, Estonia, European Union, Finland, Germany, Latvia, Lithuania, Poland, Russian Federation and Sweden) to demonstrate achieved results of past cooperation around maritime activities and the Baltic Sea marine environment.

As can be seen in this publication, the countries around the Baltic Sea are, and have been, quite good in making efforts to minimise the pressure of many human activities at sea by inventing and applying more sustainable technologies and practices.

However, with increasing activities and new demands on use of the sea space, including the expansion of wind power, aquaculture and maritime traffic, it is essential to continue this productive Baltic Sea track record and ensure the sustainability of maritime activities in to the future.

For this, new technological innovations and also, perhaps even more importantly, new future oriented and thematically wide ways of addressing maritime activities in the Baltic Sea are needed. The presented material is hopefully useful in opening up such wider perspectives for the reader. Naturally, it also provides material for planning future HELCOM work in the field of maritime activities, which continues to evolve and re-invent itself.

Overview of the contents

A large part of this publication focuses on maritime transportation and ship movements in general. This is partly a result of the fact that this is arguably the most common maritime activity in the Baltic Sea region. In order to provide a starting point, Chapter 1 describes the general patterns of ship traffic in the Baltic Sea during the period 2006–2016.

Preventing and mitigating operational pollution from ships, described in Chapters 2-10, has been the task of the HELCOM Maritime Working Group since the 1970s. Even if focus is on developments during the last ten years, these chapters document also the significant progress made within the region in this field during the last few decades. Significant developments in environmentally friendly shipping have been achieved by an innovative form of regional maritime cooperation, closely linked with the global discussions at the International Maritime Organization (IMO). In these processes, industry and civil society participants have had an increasingly important role, in addition to the coastal states and the EU. The Baltic Sea coastal countries are at the global forefront in addressing operational ship pollution, particularly in exhaust emissions and sewage. With these topics the regional HELCOM cooperation has demonstrated its capacity to maintain focus and achieve results requiring decades of persistent efforts. New issues are added to the work programmes as they are detected.

Also, in the fields of response capacity to spills (Chapter 12) and preventing such spills by measures in the field of safety of navigation (Chapters 10 and 11), the Baltic Sea has reached a high level and continues to be a global pioneer in many issues. This can be demonstrated by the regional developments in fields such as shoreline spill response, oiled wildlife response, risk assessments, re-surveys, routeing measures, as well as the emerging field of e-navigation.

The environmental effects of fishing and aquaculture presented in Chapters 13 & 14 are two examples of maritime activities where HELCOM work has intensified with the implementation of the ecosystem-based approach, in line with global calls for a more holistic approach to regional seas governance.

Due to various reasons, the remaining described activities are currently less of a focus in regional discussions. Offshore wind power developments (Chapter 14) and underwater pipelines and cables (Chapter 15) are examples of topics which have caught the attention of the Contracting Parties fairly recently, in the wake of intensifying development interests in these fields. In the remaining covered issues of offshore oil and gas (Chapter 17), submerged hazardous objects (Chapter 18) and leisure boating (Chapter 19) there is a long track record of regional work which continues to take new forms.

The last Chapter (20) presents a number of future scenarios around maritime traffic in the Baltic Sea.

Data sources

The main source and inspiration of the presented material is the regular regional cooperation within HELCOM working groups. National data submissions to HELCOM are used as a key source but, as regular data collection is not carried out for many of the topics presented, other available sources have also been used.

However, a particular feature of this publication, especially visible in the case of the maritime traffic related chapters, is the extensive use of the regional HELCOM Automatic Identification System (AIS) ship movement data. This unique, long-term dataset on ship movements in the Baltic Sea region, covering the period since 2005, has been generated by the regional AIS network and overseen by the HELCOM AIS Expert Working Group. This dataset has been central in many of the policy processes described in Chapters 1-11 but is also potentially useful in many other issues.

Methodologies used for the maps based on AIS data, presented in different chapters, are provided as Annex 1 (ship movements) & Annex 2 (fishing activities). Annex 3 provides a timeline of the history of HELCOM work in the field of environmental regulation of maritime transportation, safety of navigation, preparedness and response to spills and fisheries and the environment. A list of the Chairs of the HELCOM Maritime, Response and Fish working groups is also included. List of references, glossary and overview of IMO convention ratifications can be found in the end.

Note on limited coverage of EU legislation and some sea based activities

For eight of the nine coastal countries around the Baltic, EU legislation is an important source of law for many of the themes addressed in this publication, often superseding international agreements in practical applications. However, due to the limited resources available for this study it was simply not possible to cover correctly the vast number of relevant EU legislation (with a few exceptions) in this overview and the focus has been on international agreements including the 1992 Helsinki Convention.

Due to the large number of topics covered it was clear that the format had to be concise and for this reason involved subjective decisions on what to present and what not. Most of the human activities on the Baltic Sea should be covered with material contained in this report. However, some relevant topics such as sand/gravel extraction, fairway dredging and military activities are not addressed due to various reasons.

If resources are made available these omissions will naturally be rectified in possible future updates of this report.

We are the ships without homes,
forever moving.

Section I
TRAFFIC STATISTICS

01. SHIP TRAFFIC IN THE BALTIC SEA 2006–2016

Introduction

This chapter provides an overview of the traffic of larger vessels (hereafter "ships") registered by the International Maritime Organization (IMO) and operating in the Baltic Sea (Figure. 1.1). The focus is on cargo, tanker, passenger and container ships, which account for 80% of the traffic of such IMO ships. Where no other reference are given the maps and figures presented are based on raw HELCOM AIS (Automated Identification System) data from 2006 to 2016, processed and drawn by the editorial team at the HELCOM Secretariat.

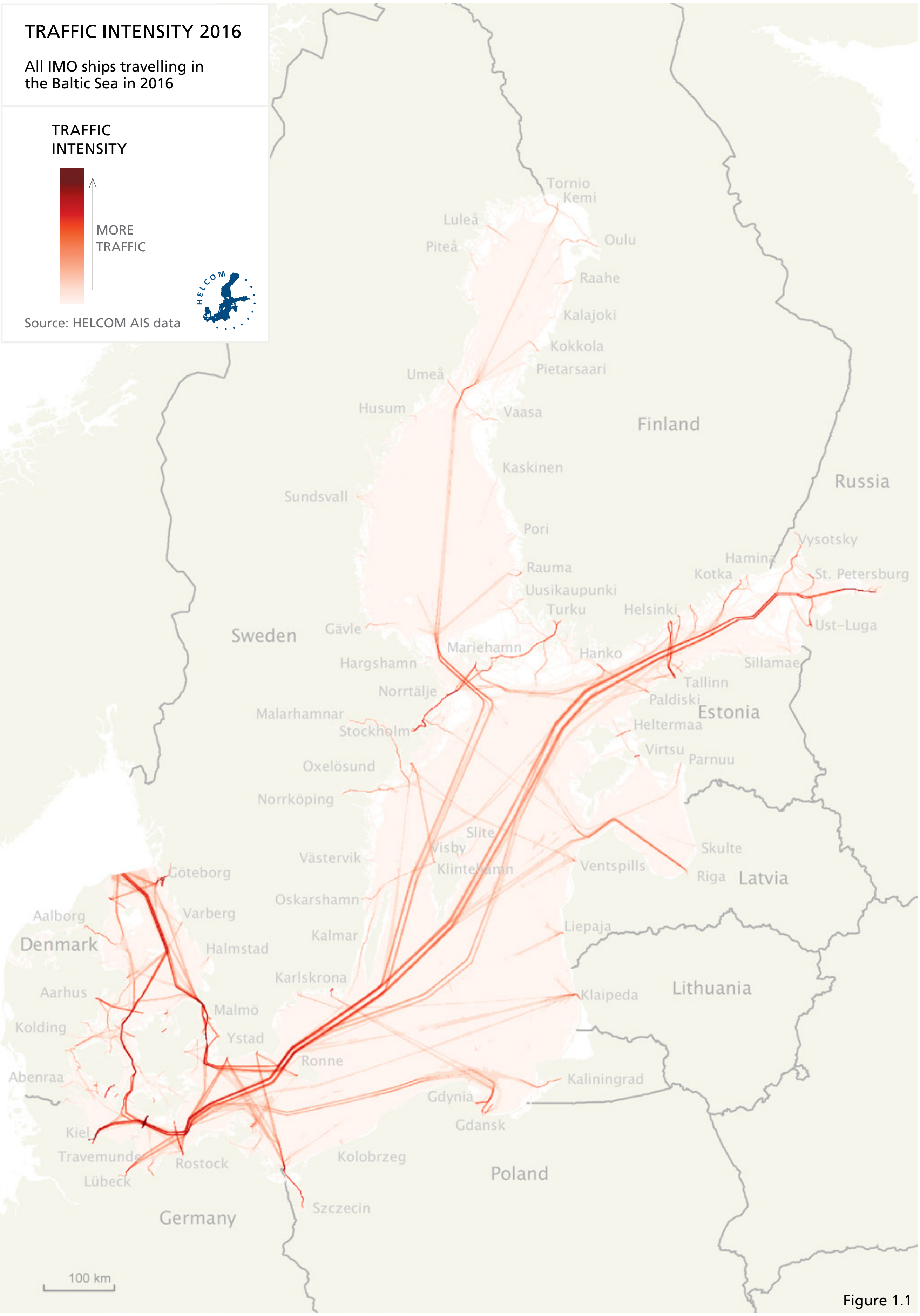
In this publication we use the ship categories in Table 1.1. The following pages include short descriptions and examples of the main categories of ships sailing the Baltic Sea in 2016, including illustrations, average length and gross tonnage of typical ships.

Table 1.1

SHIP TYPES WITH AIS DEVICE

VESSEL GROSS SHIP TYPE AIS	VESSEL DETAIL SHIP TYPE AIS
Cargo ship	General cargo, bulk cargo or other cargo ship
Tanker ship	Chemical tanker, crude oil tanker, gas tanker, oil product tanker or other tanker
Passenger ship	Cruise ship, ferry, ro-ro passenger ship or other passenger ship
Fishing vessel	Fishing vessel
Service ship	Service ship
Container ship	Container ship
Ro-ro cargo ship	Vehicle carrier or ro-ro cargo ship
Other ship	Tug, dredger or other ship

Limitations: IMO ships, including tanker ships over 150 gross tonnage, passenger ships certified for more than 12 passengers, other ships over 400 gross tonnage, as well as fishing vessels


TRAFFIC INTENSITY 2016
All IMO ships travelling in the Baltic Sea in 2016
TRAFFIC INTENSITY
MORE TRAFFIC
Source: HELCOM AIS data
HELCOM
Tornio
Kemi
Luleå
Piteå
Oulu
Raahe
Kalajoki
Kokkola
Pietarsaari
Umeå
Husum
Vaasa
Finland
Kaskinen
Russia
Sundsvall
Pori
Vysotsky
Rauma
Hamina
Kotka
St. Petersburg
Uusikaupunki
Turku
Helsinki
Gävle
Ust-Luga
Sweden
Mariehamn
Hanko
Hargshamn
Sillamae
Norrtälje
Tallinn
Paldiski
Malarhamnar
Estonia
Stockholm
Heltermaa
Virtsu
Parnuu
Oxelösund
Norrköping
Slite
Visby
Skulte
Västervik
Klintehamn
Ventspills
Riga
Latvia
Göteborg
Oskarshamn
Aalborg
Varberg
Liepaja
Kalmar
Denmark
Halmstad
Karlskrona
Lithuania
Klaipeda
Aarhus
Malmö
Kolding
Ystad
Ronne
Abenraa
Kaliningrad
Gdynia
Gdansk
Kiel
Travemunde
Kolobrzeg
Rostock
Poland
Lübeck
Szczecin
Germany
100 km
Figure 1.1

GROSS TONNAGE (GT) EXPLAINED
Gross tonnage converted into internal volume of a ship

Gross Tons	Volume (m³)
24	100
260	1 000
2 800	10 000
30 000	100 000
320 000	1 000 000

Table 1.2.

Ship categories

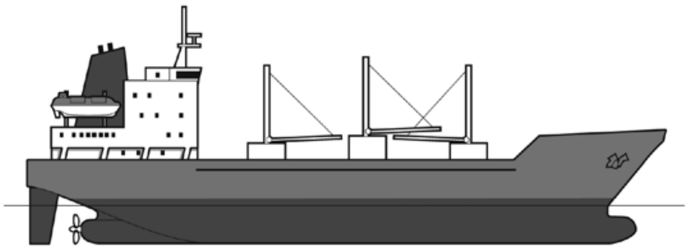
For better overview of the main categories of ships sailing the Baltic Sea mentioned in Table 1.1 you can find below short descriptions of the ship types based on HELCOM AIS data from 2016. The illustrations show a ship with average length in each ship category. Only IMO ships are included.

Please note that there are several ways to measure the size of a ship. Here we have chosen length and gross tonnage (GT) and give their minimum, maximum and average values for each ship category in 2016. Gross tonnage is actually measuring the ship's internal volume. It is a non-linear measurement and, for ease of understanding, Table 1.2 gross tonnage is converted into cubic meters.

CARGO

Cargo ships move cargo, goods or material from one port to another. Cargo ships can be divided into three sub-categories: general, bulk and other cargo. Cargo ships are the most numerous ships in the Baltic Sea.

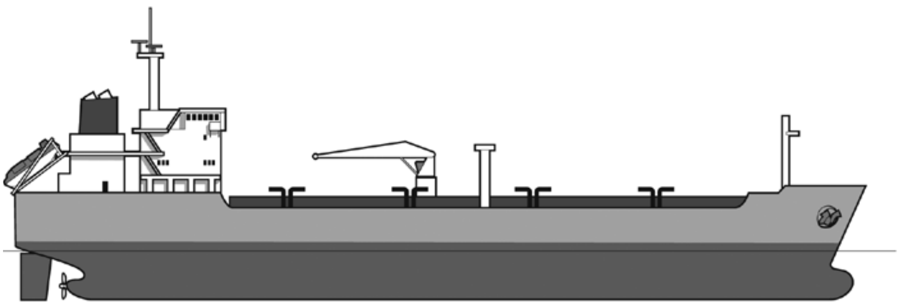
LENGTH: average 134 meters
(min 22 – max 292 m)
GROSS TONNAGE: average 6990 GT
(min 104 GT – max 94 200 GT)



TANKER

Tanker ships are transporting liquid or gases in bulk. There are different sub-categories such as chemical tanker (carrying hazardous substances), crude oil tanker, gas tanker, oil product tanker and other types of tanker. These ships have nearly always a double hull to protect the cargo in case of collision or groundings.

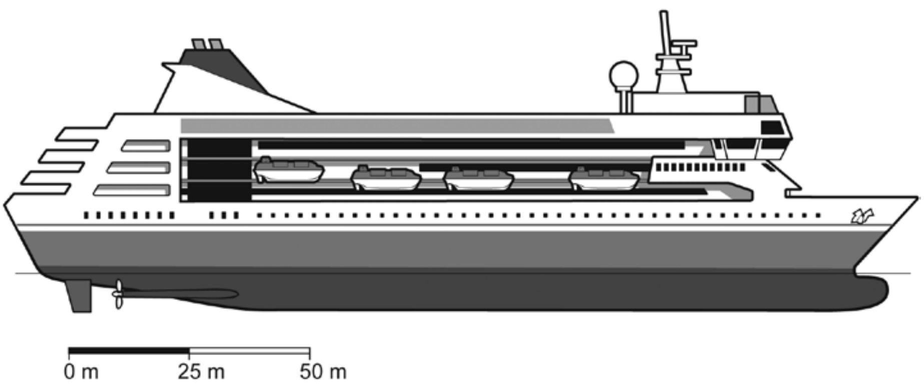
LENGTH: average 164 meters
(min 25 – max 333 m)
GROSS TONNAGE: average 25 500 GT
(min 107 – max 162 000 GT)



PASSENGER

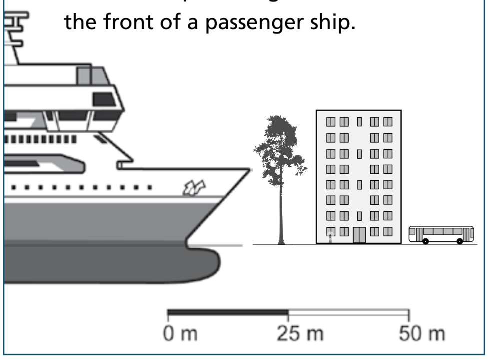
IMO Passenger ships are registered to transport more than 12 passengers. Passenger ships can be ferries that operate day to day or overnight moving passengers and vehicles, RoPax (roll-on/roll-off passenger) that transport also freight vehicles, and cruise ships operating from May to October -mostly coming from outside the Baltic Sea region.

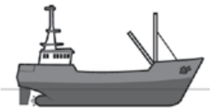
LENGTH: average 110 meters
(min 20 – max 330 m)
GROSS TONNAGE: average 17 300 GT
(min 101 – max 14 700 GT)



SCALE

All the ships on the page are shown in the same scale.
A pine tree, an 8 story high flat building and a city bus look quite small when placed right beside of the front of a passenger ship.





FISHING

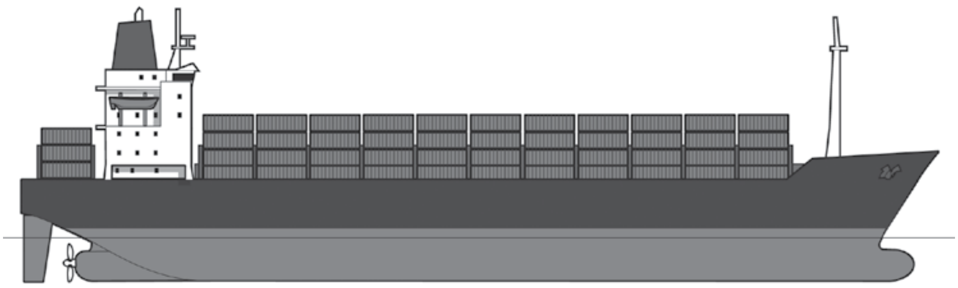
Fishing vessels are smaller than the other categories but the interior volume is always more than 100 GT.
The largest ones are trawlers.

LENGTH: average 33 meters
GROSS TONNAGE: average 993 GT
(min 102 – max 7 770 GT)

SERVICE

Service ships are mostly supporting diving activities, research or the maintenance of structures at sea such as windfarms, underwater cables and oil rigs.

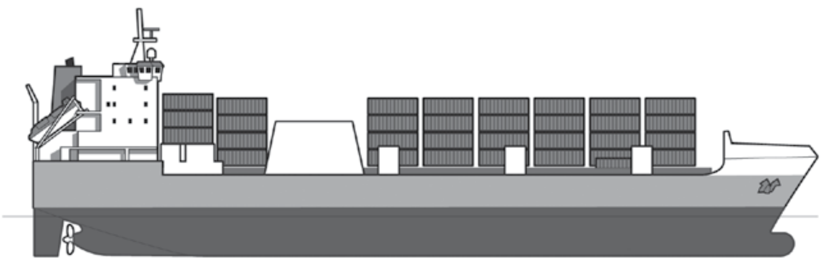
LENGTH: average 59 meters
GROSS TONNAGE: average 2 920 GT
(min 100 – max 25 500 GT)



CONTAINER

Container ships carry their entire load in truck-size intermodal containers. They are known to be the biggest ships operating in the Baltic Sea Region.

LENGTH: average 190 meters
(min 95 – max 399 m)
GROSS TONNAGE: average 36 100 GT
(min 3 820 – max 195 000 GT)



RO-RO CARGO

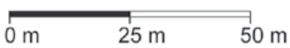
Ro-ro cargo (roll-on/roll-off) are ships designed to transport wheeled cargo such as cars, trucks, semi-trailer trucks, trailers, and railroad cars, that are driven on and off the ship on their own wheels or using a platform vehicle. Ro-ro cargo can be divided into vehicle carrier, specialized to carry vehicles, or general ro-ro cargo.

LENGTH: average 173 meters
(min 63 – max 262 m)
GROSS TONNAGE: average 36 600 GT
(min 957 – max 74 300 GT)

OTHER

This category includes smaller vessels such as dredgers, tugs (ships supporting other vessels), yachts and other less common types of vessels. The largest sailing ships (usually sail training vessels) are IMO ships and are included in this category, but not the small leisure sailing boats.

LENGTH: average 47 meters
(min 13 – max 269 m)
GROSS TONNAGE: average 1 740 GT
(min 35 – max 42 500 GT)



Overview of ship traffic in the Baltic Sea

Port visits

NUMBER OF VISITS PER SHIP TYPE IN 2015
Total 295 498 visits (HELCOM AIS data)

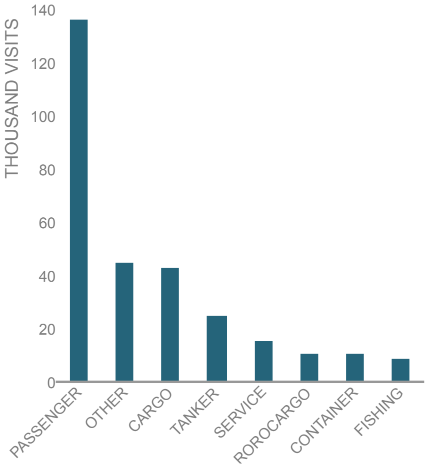


Figure 1.2.

There were over 295 000 visits to the ports of the Baltic Sea region in 2015, defined as entering and exiting a port with at least 10 minutes spent inside in the port (Figure 1.2).

Almost half (46%) of the port visits were passenger ships, largely due to the frequent ferry connections between cities in the region. Due to this fact, passenger traffic dominates the general overview of port visits.

Many visits are also a result of traffic in the category "Other" – which includes smaller vessels which do many short operations, returning to port in between. A pilot boat or a tug, a ship that manoeuvres bigger vessels by pushing or towing them, is an example of a boat included in this category.

Less than one third of the port visits were done by ships transporting goods (cargo, container or tanker ships).

The overall traffic patterns between different ports are illustrated with a chord diagram (Figure 1.3). It shows the 50 ports with most (more than 1000) visits in the Baltic and the width of the circle segment is proportional to the number of visits, or entering and exiting the Baltic Sea, in 2016. This includes also the following four pathways for entering and exiting the Baltic Sea: 1) Skagen area (Kattegat), 2) Kiel Canal: a 100 km waterway which

Figure 1.3.

INTERACTION BETWEEN PORTS IN, AND ENTRANCES TO, THE BALTIC SEA
Traffic from all ship types in 2015: 50 biggest ports,
minimum of 1000 trips between the locations (HELCOM AIS data)

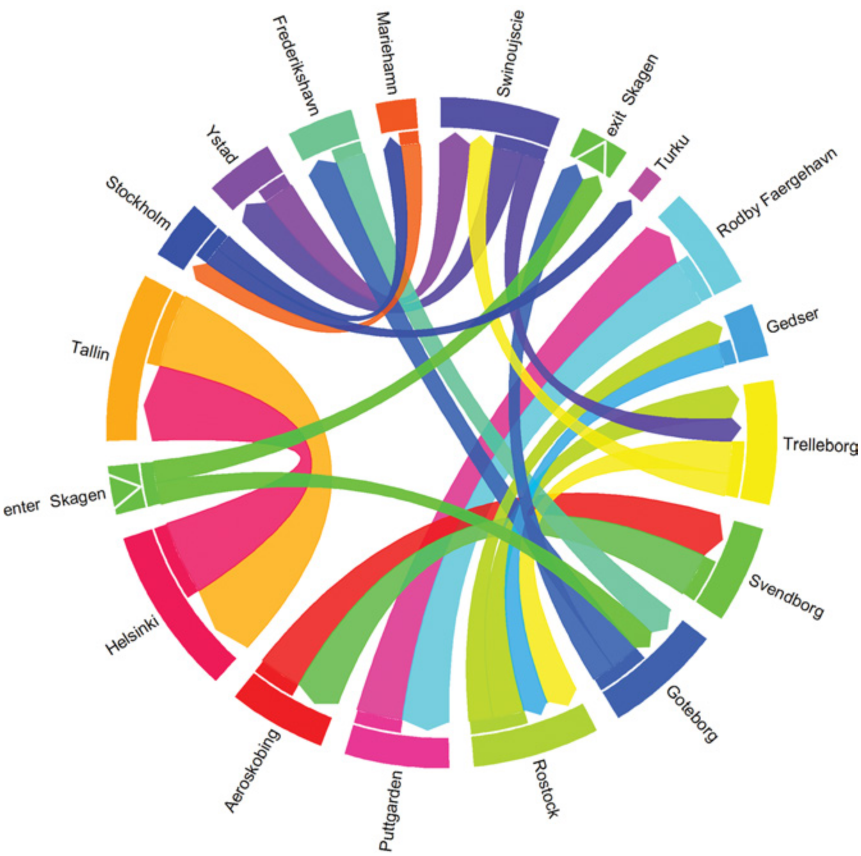
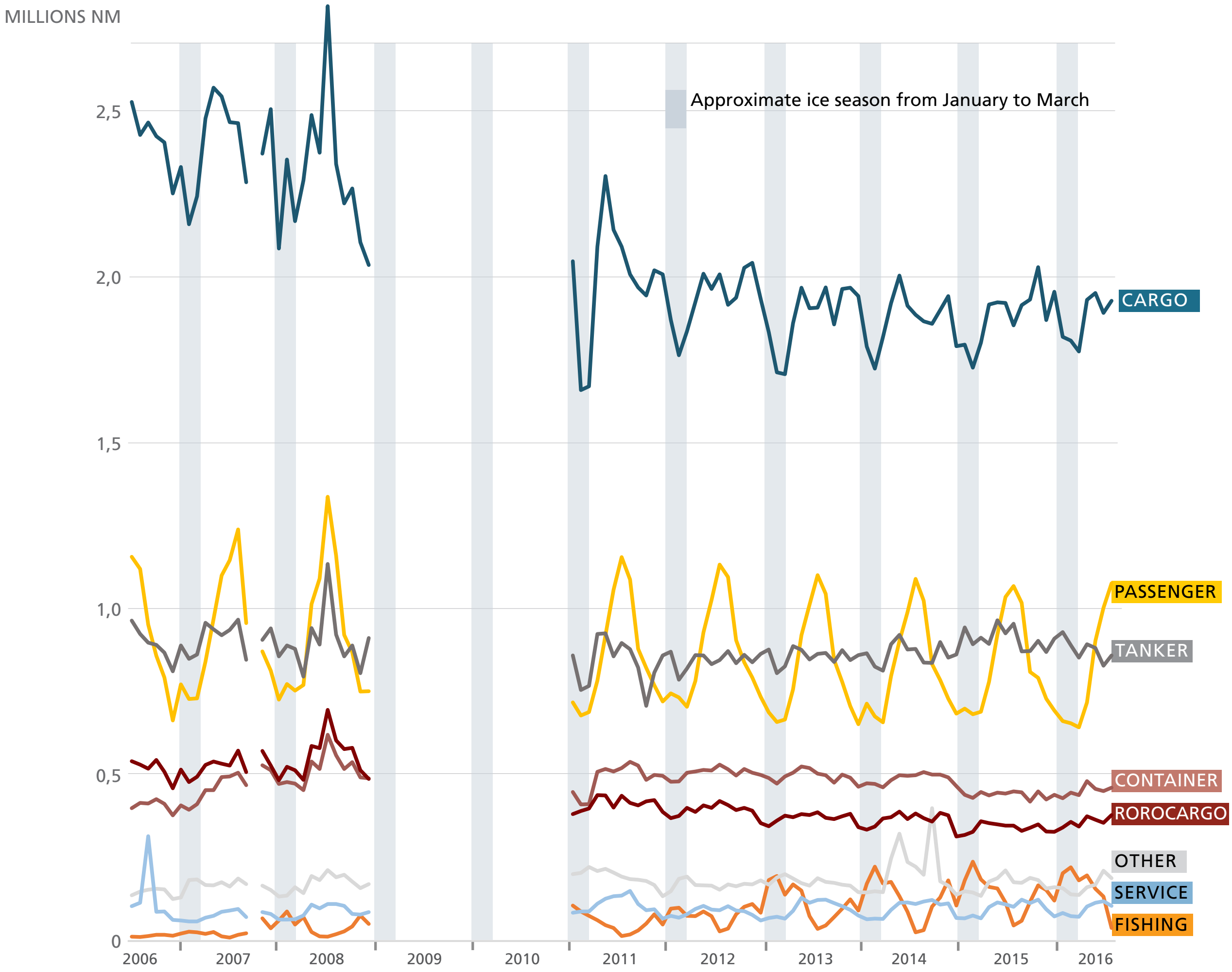


Figure 1.4.

DISTANCE SAILED IN THE BALTIC SEA PER IMO SHIP TYPE
Monthly figures from July 2006 to July 2016



Source: HELCOM AIS data
The data gap of 2009 and 2010 is due to missing AIS data from the Kiel channel entrance for these years.
Data from 2006–2008 is uneven in quality which should be considered when interpreting the results.

links the North Sea with the Baltic Sea used to save time and avoid storm-prone seas, 3) Mouth of Neva River: river in north western Russia flowing from Lake Ladoga and 4) Lappeenranta: a Finnish city close to the Saimaa Canal which connects Saimaa Lake to the Gulf of Finland.

Please keep in mind that Figure 1.3 is presenting the number of port visits of IMO-registered vessels only, not tonnage transported or other measure, and, due to the proportion of passenger traffic of overall visits, it is heavily influenced by passenger traffic. For traffic overviews of cargo, tanker and container vessels, please see next pages for further information.

Distances sailed

The overall distances sailed seems to be rather stable in all ship types since 2006. Most of the nautical miles (NM) sailed in the Baltic Sea are done by ships in the cargo ship category. Both container and tanker ships have slightly decreased the distance sailed over the recent years (Figure 1.4).

Some seasonal variation is visible, particularly for passenger traffic which is more intense during summer. Fishing vessels, on the contrary, seem to increase their activity during winter. From approximately January to March the sea freezes in some parts of the Baltic Sea, which presents challenges to marine traffic. In some cases, ships have to deviate routes as there can be solid ice that cannot be broken by icebreakers.

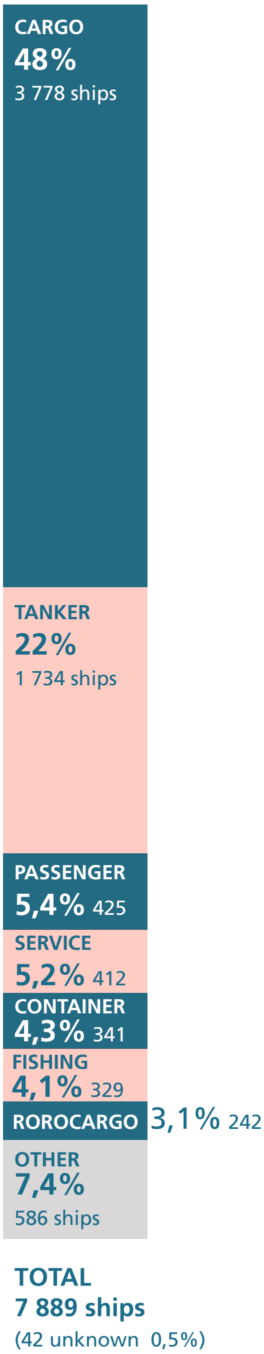
Number of ships

More than half (68%) of the IMO -registered ships travelling the Baltic Sea are in the category "cargo"- general cargo ships (Figure 1.5). Even if individual ships travel in and out of the Baltic Sea, around 1500 IMO ships are present in the region at any any given time.

AIS has been obligatory for ships larger than 300 GT on international voyages since early 2005. The number of ships in the AIS dataset seem to be increasing in all ship types from 2006 but for some ship types this can be due to the fact that more ships carry AIS transmitters. The technology has become more affordable and due to its usefulness in collision avoidance it is also attractive for those ships that are not formally obliged by IMO to carry an AIS device. The numbers of tugs and other smaller vessels not required to carry AIS, included in the category "Other ", have particularly increased in recent years (Figure 1.6).

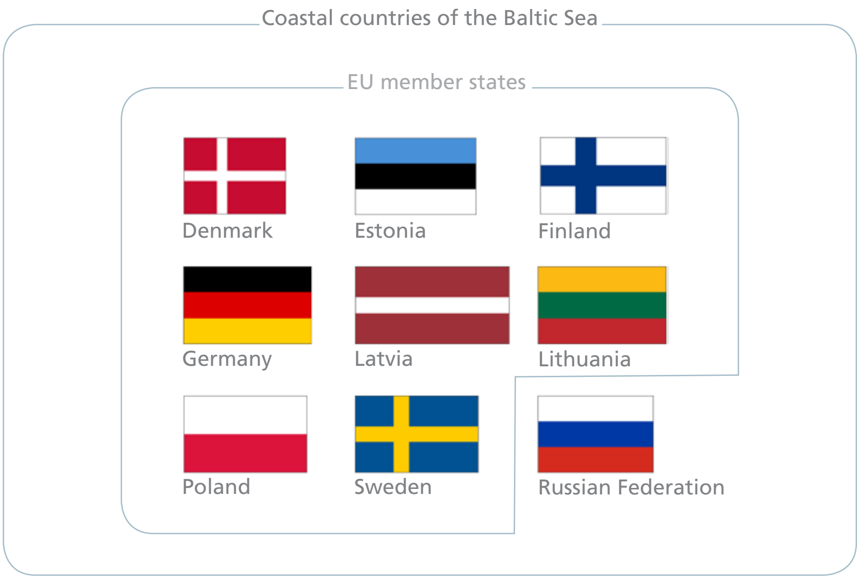
Figure 1.5.

IMO SHIPS OPERATING IN THE BALTIC SEA IN 2015 BY TYPE
Source: HELCOM AIS data



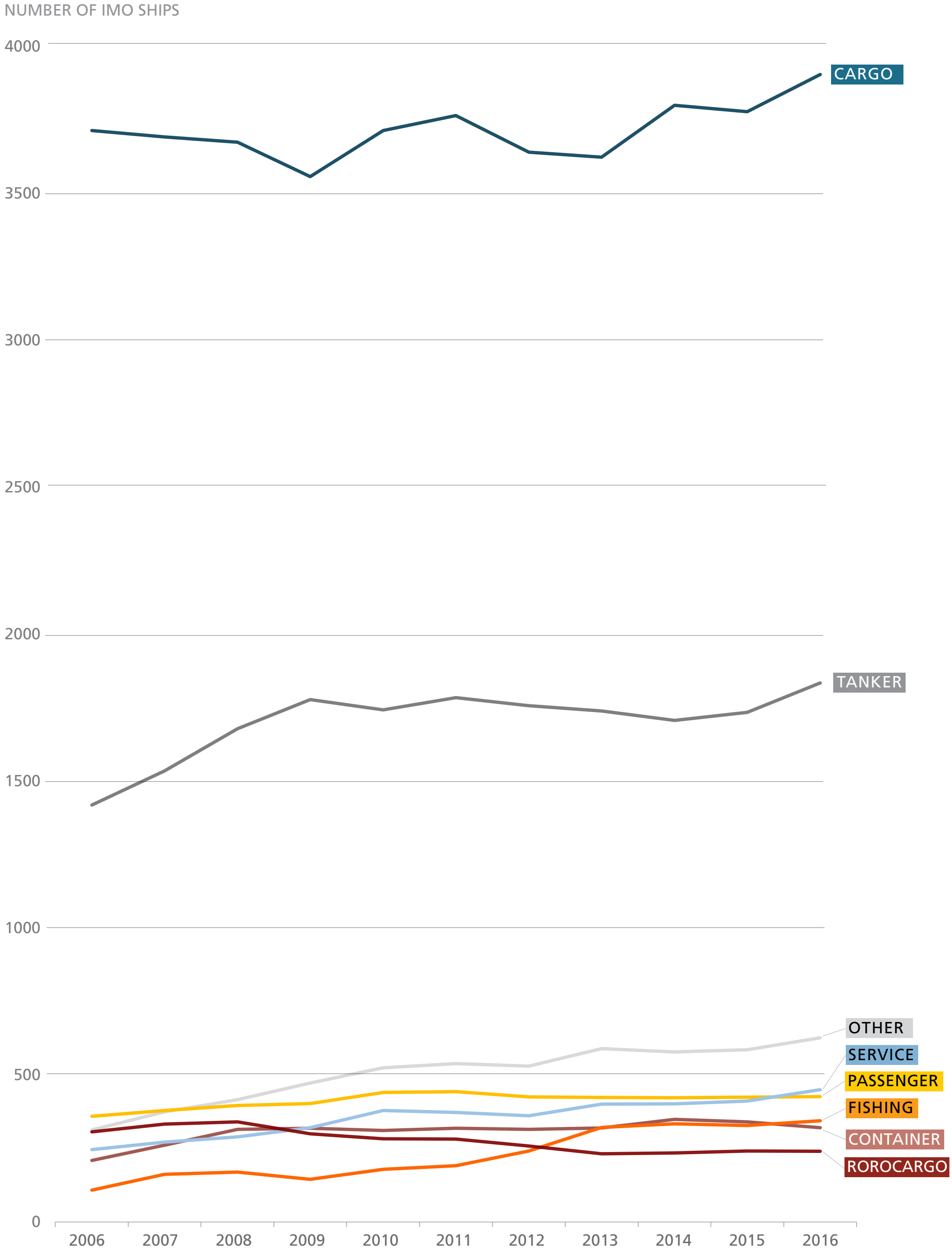
Flags

In 2016, only 25% of the ships in the Baltic Sea flew a flag belonging to Baltic Sea countries. This is a normal practice called 'flagging out': registering a merchant ship in a sovereign state different from that of the ship's owners and flying that state civil ensign on the ship. Ships are usually flagged out to reduce taxes, operating costs or to avoid regulations in the owner's country (Figure 1.7).



CARGO AND TANKER ARE THE MOST COMMON SHIP TYPES IN THE BALTIC SEA
Number of IMO ships in the Baltic Sea in 2006–2016 per ship type

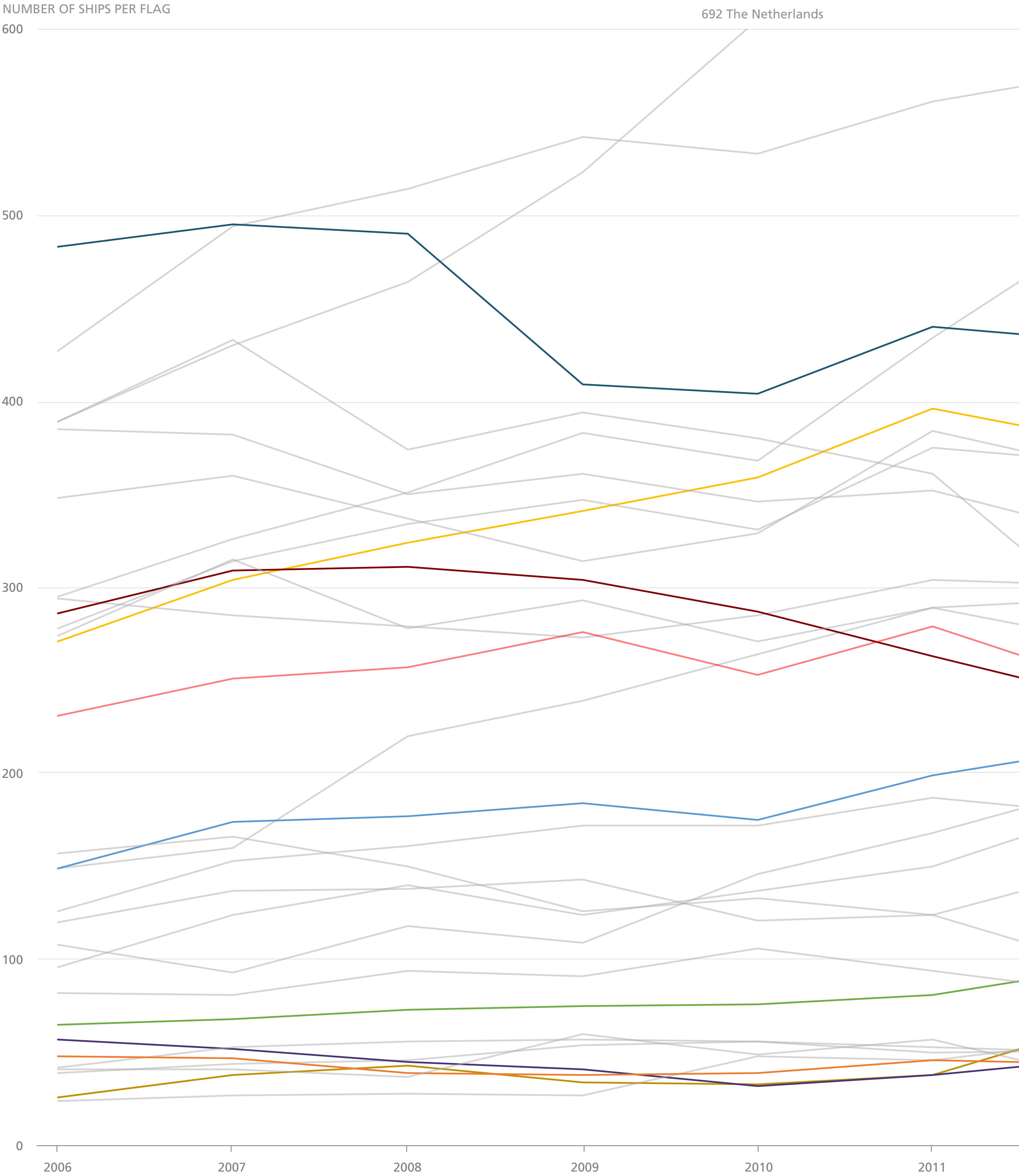
Figure 1.6.

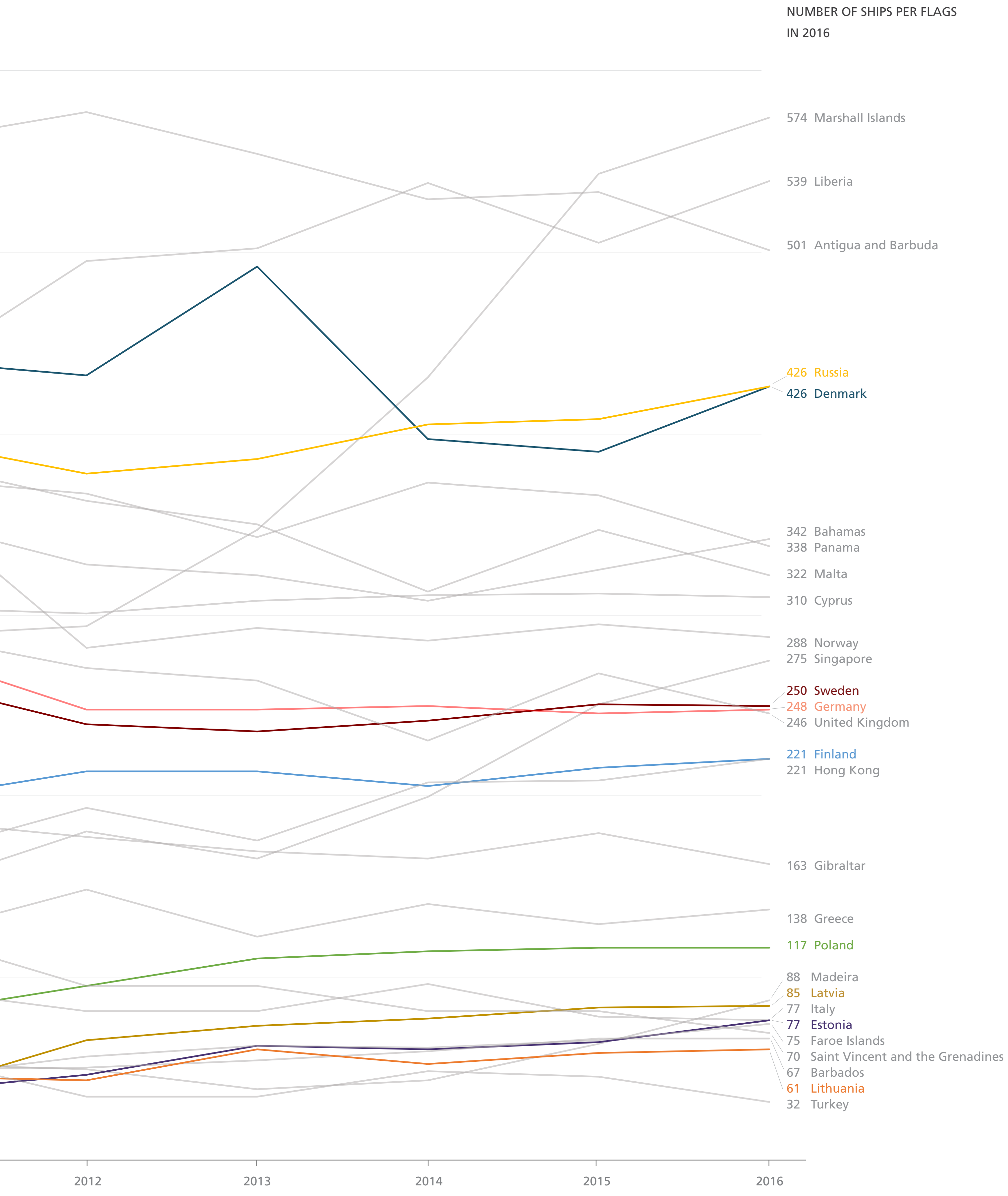


Source: HELCOM AIS data

Figure 1.7.

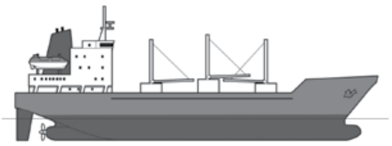
NUMBER OF SHIPS SAILING IN THE BALTIC SEA IN 2006–2016 BY FLAG
Top 30 IMO ship flags, yearly values
Source: HELCOM AIS data




NUMBER OF SHIPS PER FLAGS
IN 2016
574 Marshall Islands
539 Liberia
501 Antigua and Barbuda
426 Russia
426 Denmark
342 Bahamas
338 Panama
322 Malta
310 Cyprus
288 Norway
275 Singapore
250 Sweden
248 Germany
246 United Kingdom
221 Finland
221 Hong Kong
163 Gibraltar
138 Greece
117 Poland
88 Madeira
85 Latvia
77 Italy
77 Estonia
75 Faroe Islands
70 Saint Vincent and the Grenadines
67 Barbados
61 Lithuania
32 Turkey
2012
2013
2014
2015
2016

Ship types

The following pages present a detailed overview of the four major ship types that sail the most in the Baltic Sea: general cargo, passenger, tanker and container ships.



STATISTICS of CARGO ships in 2015

NUMBER OF SHIPS: 3 778 ships
48% OTHER SHIPS

DISTANCE SAILED: 21,9 million NM
39% OTHER SHIPS

TIME AT SEA: 2,9 million hours
34% OTHER SHIPS

NUMBER OF PORT VISITS: 43 163 visits
15% OTHER SHIPS

Figure 1.8.

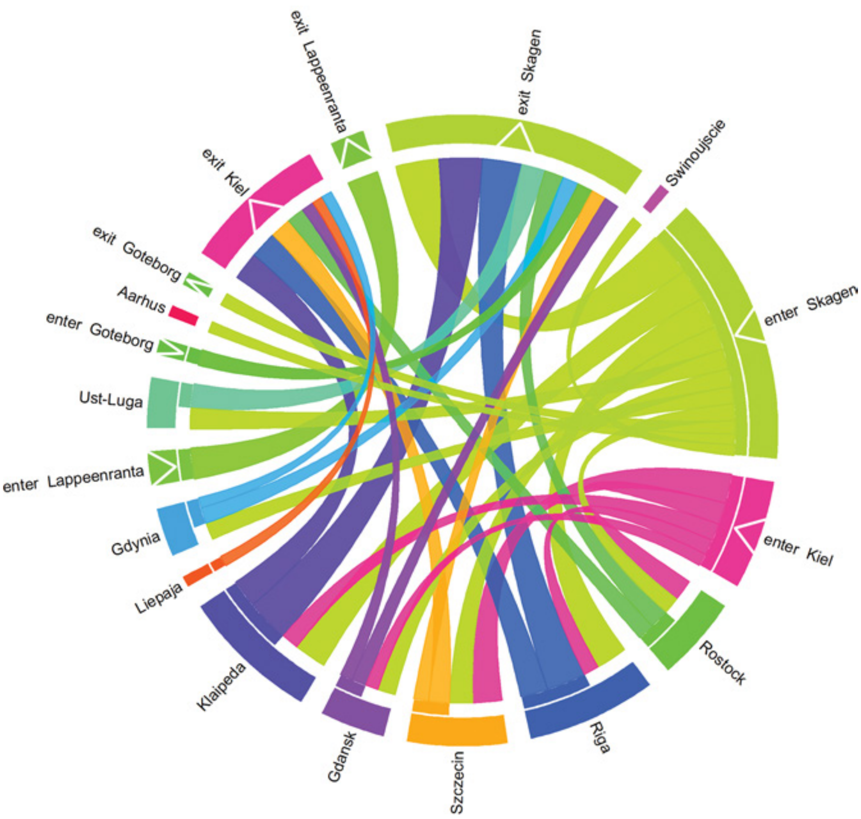
General CARGO ships

Cargo ships, including general cargo and bulk cargo, are the most numerous ships in the Baltic Sea – almost every second IMO ship is a cargo ship. These spend totally around 3 million hours and sail nearly 22 million nautical miles on the surface of the Baltic Sea every year. That is over one third of the time and distance IMO ships sail in total in the Baltic Sea (Fig 1.8).

Figure 1.9 shows the traffic of general cargo ships between the 50 biggest general cargo ports with more than 1000 cargo ship visits in the Baltic, including entrances and exit routes. Cargo ship visits decreased in most of the ports between 2006 and 2016 (Figure 1.10). A significant share of general cargo traffic between the larger Baltic Sea ports is to or from a port outside the Baltic. This is why port visits in this category account for only 15% of all visits, despite the large number of cargo ships.

Most of the cargo ships enter through Skagen and go to the main hubs of general cargo traffic (Klaipeda, Riga but also ports such as Szczecin, Rostock and Gdansk) . Many cargo ships enter also through Kiel Canal (Figure 1.9). If all traffic is considered (also smaller general cargo ports, not shown in Figure 1.9), 72% of general cargo ship trips are inside the Baltic Sea and 28% are to or from outside the Baltic.

Figure 1.9. INTERACTION BETWEEN PORTS (ARRIVALS AND DEPARTURES) IN THE BALTIC SEA
Cargo ship traffic in 2015: 50 biggest ports, minimum of 150 trips



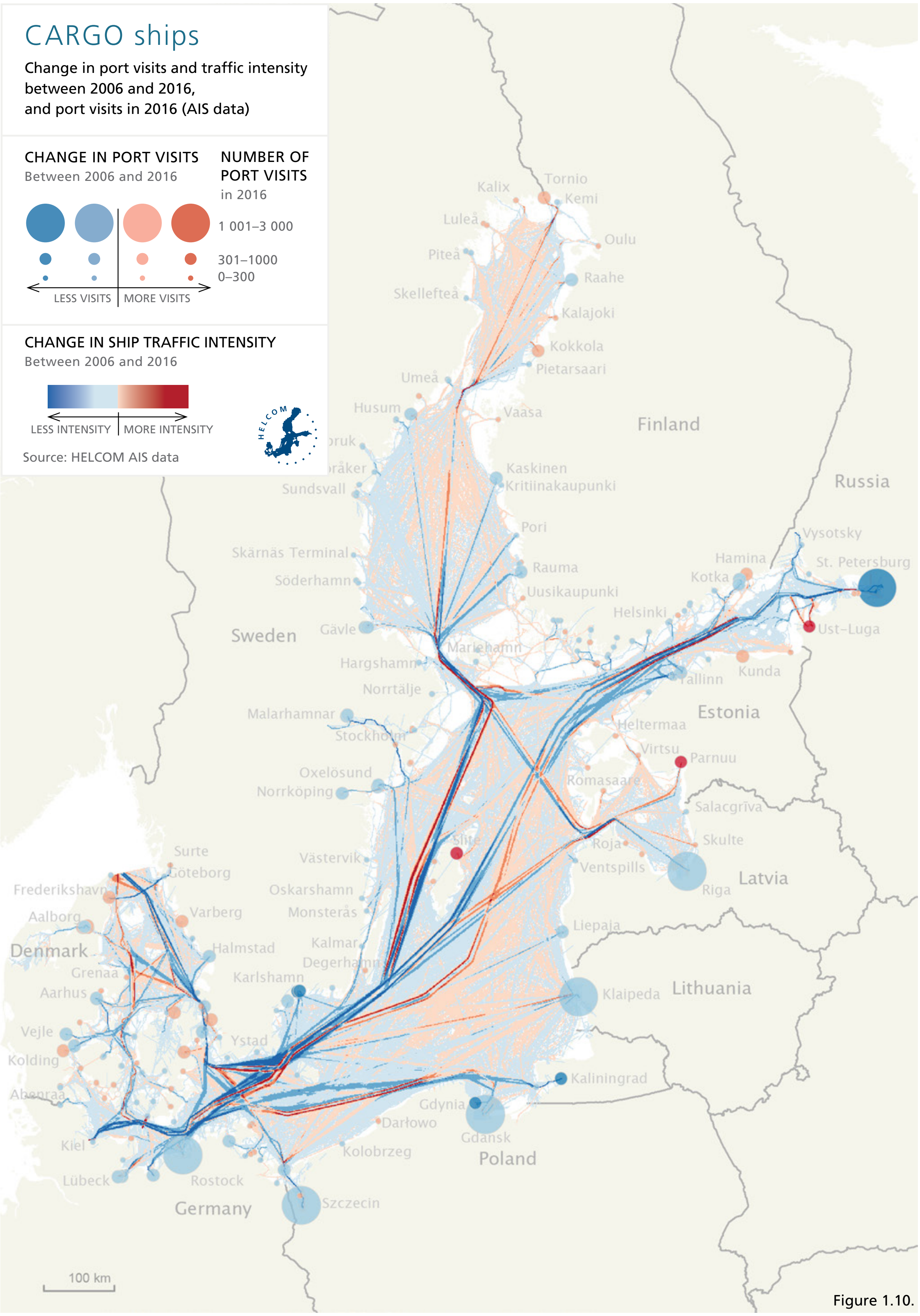

CARGO ships
Change in port visits and traffic intensity between 2006 and 2016, and port visits in 2016 (AIS data)
CHANGE IN PORT VISITS
Between 2006 and 2016
NUMBER OF PORT VISITS
in 2016
1 001–3 000
301–1000
0–300
LESS VISITS
MORE VISITS
CHANGE IN SHIP TRAFFIC INTENSITY
Between 2006 and 2016
LESS INTENSITY
MORE INTENSITY
Source: HELCOM AIS data
HELCOM
Tornio
Kalix
Kemi
Luleå
Oulu
Piteå
Raahe
Skellefteå
Kalajoki
Kokkola
Pietarsaari
Umeå
Husum
Vaasa
Finland
Kaskinen
Kristiinakaupunki
Sundsvall
Russia
Pori
Vysotsky
Skärnäs Terminal
Rauma
Hamina
St. Petersburg
Söderhamn
Kotka
Uusikaupunki
Helsinki
Ust-Luga
Sweden
Gävle
Mariehamn
Hargshamn
Kunda
Tallinn
Norrtälje
Estonia
Malarhamnar
Heltermaa
Stockholm
Virtsu
Parnuu
Oxelösund
Romasaare
Norrköping
Salacgrīva
Skulte
Slite
Roja
Surte
Västervik
Ventspills
Latvia
Göteborg
Riga
Frederikshavn
Oskarshamn
Varberg
Monsterås
Aalborg
Liepaja
Denmark
Halmstad
Kalmar
Grenaa
Degerhamn
Karlshamn
Aarhus
Klaipeda
Lithuania
Vejle
Ystad
Kolding
Aabenraa
Kaliningrad
Gdynia
Darłowo
Gdansk
Kiel
Kolobrzeg
Poland
Lübeck
Rostock
Szczecin
Germany
100 km

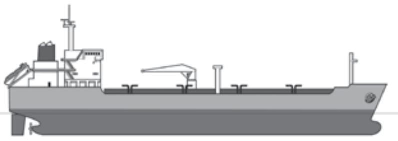
Figure 1.10.

TANKER ships

Tanker ships transport liquid or gas in bulk and are relatively common, as every fifth IMO ship in the Baltic Sea is a tanker. They spend almost 1,5 million hours and sail over 10 million nautical miles in the Baltic Sea every year. That is nearly one fifth of the time and distance IMO ships sail in the Baltic Sea in total.

Figure 1.14 shows the traffic of tanker ships between the 50 biggest ports in terms of tanker traffic, with more than 100 tanker visits in the Baltic, as well as entrances and exit routes. Tanker traffic between the larger ports in the Baltic Sea are to or from a port outside the region, between Skagen and Gothenburg, Ust-Luga, Primorsk, Kilpilahti and other main tanker ports.

If all traffic is considered (also smaller ports, not shown in Figure 1.14 are also considered), 77% of tanker vessel trips are within the Baltic Sea and 23% are to or from outside the Baltic.



STATISTICS of TANKER ships in 2015

NUMBER OF SHIPS: 1 734 ships

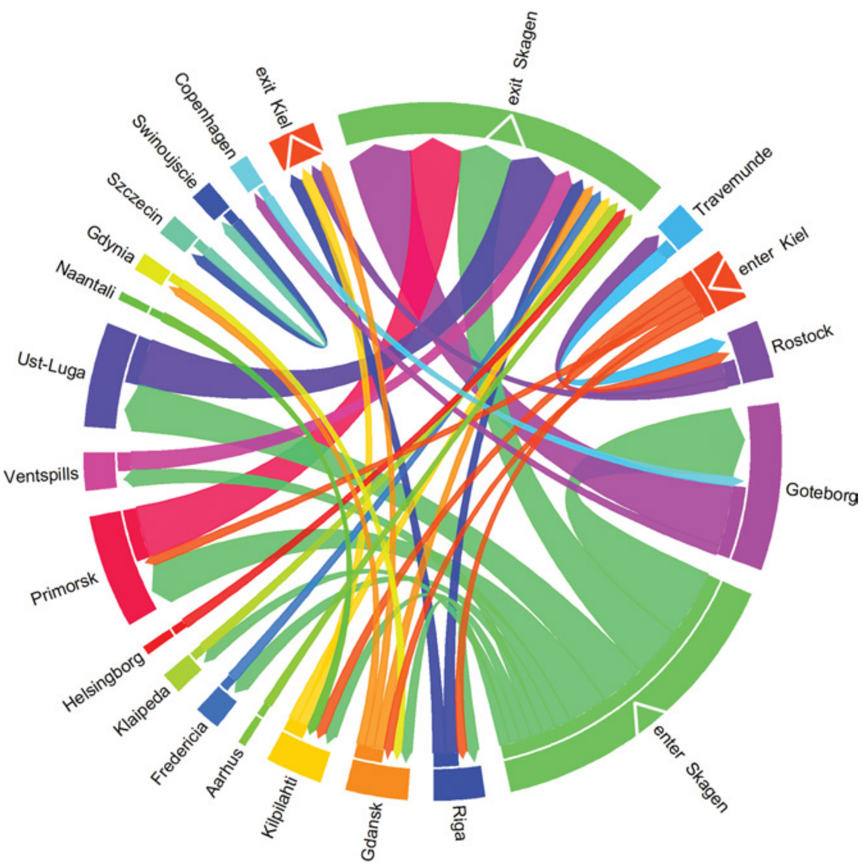
DISTANCE SAILED: 10,6 million NM

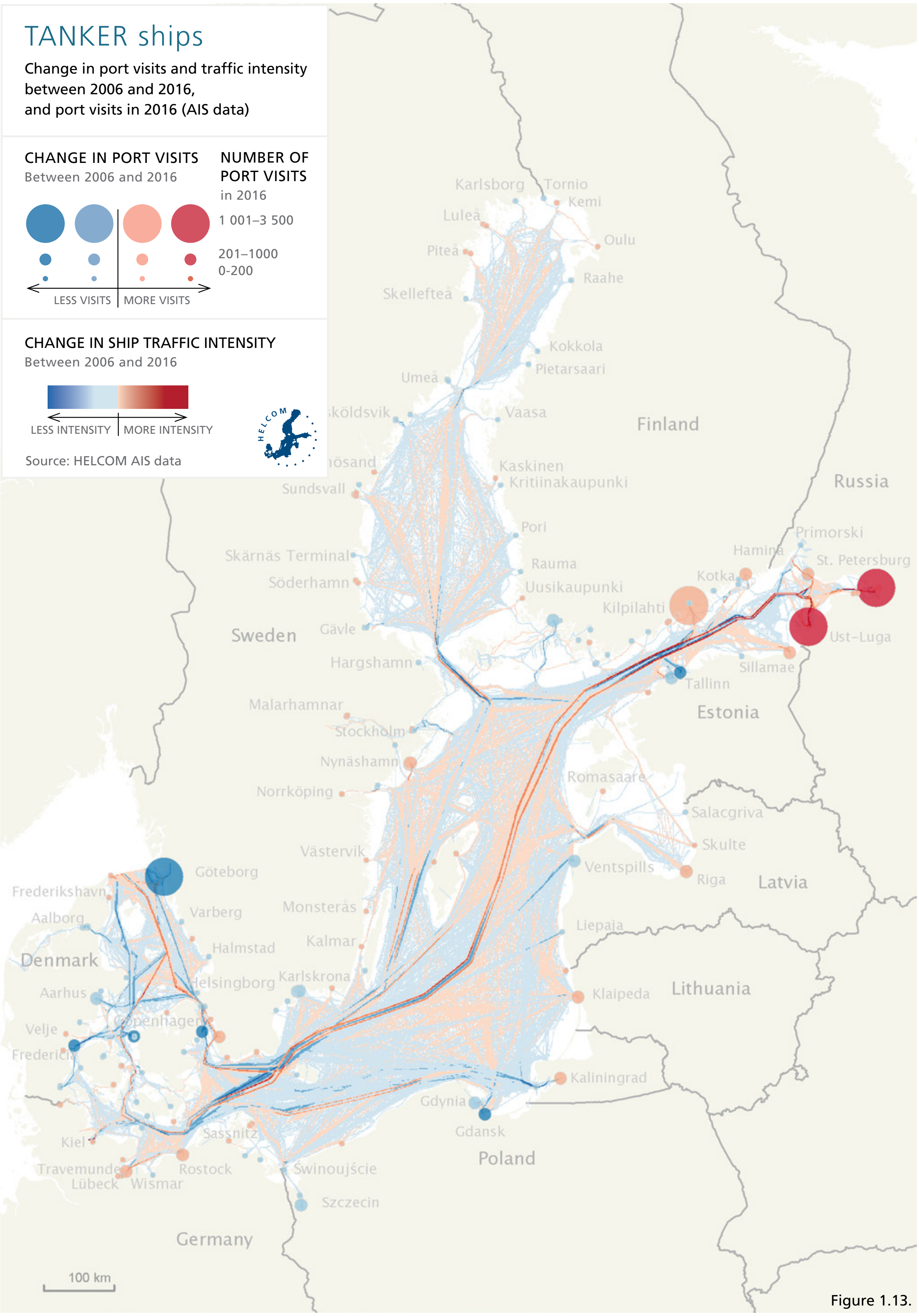
TIME AT SEA: 1,5 million hours

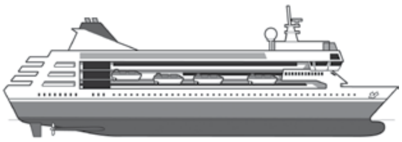
NUMBER OF PORT VISITS: 25 131 visits

Figure 1.11.

Figure 1.12. INTERACTION BETWEEN PORTS (ARRIVALS AND DEPARTURES) IN THE BALTIC SEA
Tanker ship traffic in 2015: 50 biggest ports, minimum of 100 trips




TANKER ships
Change in port visits and traffic intensity between 2006 and 2016, and port visits in 2016 (AIS data)
CHANGE IN PORT VISITS
Between 2006 and 2016
LESS VISITS
MORE VISITS
NUMBER OF PORT VISITS
in 2016
1 001–3 500
201–1000
0-200
CHANGE IN SHIP TRAFFIC INTENSITY
Between 2006 and 2016
LESS INTENSITY
MORE INTENSITY
Source: HELCOM AIS data
HELCOM
Karlsborg
Tornio
Kemi
Luleå
Oulu
Piteå
Raahe
Skellefteå
Kokkola
Pietarsaari
Umeå
Vaasa
Finland
Kaskinen
Kritiinakaupunki
Russia
Sundsvall
Pori
Primorski
Skärnäs Terminal
Hamina
St. Petersburg
Rauma
Kotka
Söderhamn
Uusikaupunki
Kilpilahti
Sweden
Gävle
Ust-Luga
Hargshamn
Sillamae
Tallinn
Malarhamnar
Estonia
Stockholm
Nynäshamn
Romasaare
Norrköping
Salacgriva
Västervik
Skulte
Göteborg
Ventspills
Riga
Latvia
Frederikshavn
Aalborg
Varberg
Monsterås
Liepaja
Kalmar
Halmstad
Denmark
Karlskrona
Klaipeda
Lithuania
Aarhus
Velje
Kaliningrad
Gdynia
Gdansk
Sassnitz
Kiel
Poland
Travemunde
Rostock
Świnoujście
Lübeck
Wismar
Szczecin
Germany
100 km
Figure 1.13.



STATISTICS of PASSENGER ships in 2015

NUMBER OF SHIPS: 425 ships

5,4% OTHER SHIPS

DISTANCE SAILED: 9,7 million NM

17% OTHER SHIPS

TIME AT SEA: 1,4 million hours

16% OTHER SHIPS

NUMBER OF PORT VISITS: 136 219 visits

46% OTHER SHIPS

Figure 1.14.

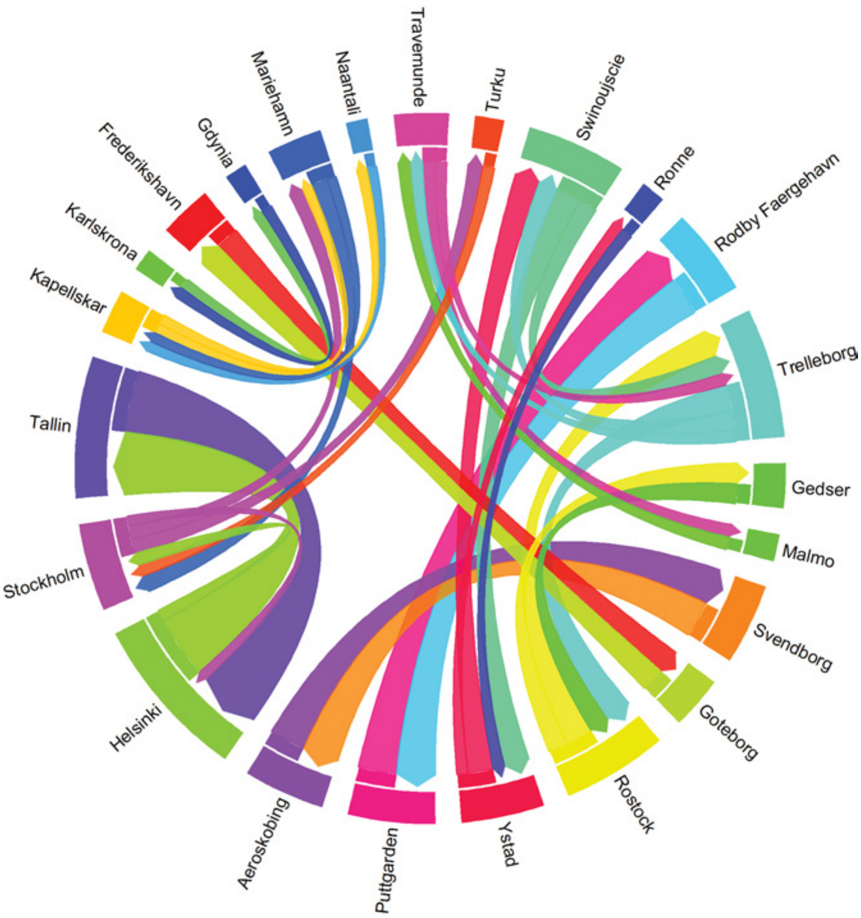
PASSENGER ships

Only 6% of the IMO ships in the Baltic Sea are passenger ships (Figure 1.16). However, due to the fact that ferries make so many trips, sometimes several per day, they spend almost 1,4 million hours and sail nearly 10 million nautical miles in the Baltic Sea every year. That is nearly one fifth of the time and distance IMO ships sail in total.

Figure 1.17 shows the traffic of passenger ships between the 50 main ports in the Baltic in terms of passenger traffic, with more than 500 passenger ship visits, as well as entrances and exit routes. The busiest passenger ports in the region include ferry ports such as Helsinki and Tallinn.

Most of the passenger traffic is the result of ferries and therefore inside the Baltic Sea. During summer time, cruise ships (passenger ships without fixed routes) increase overall passenger traffic.

Figure 1.15. INTERACTION BETWEEN PORTS (ARRIVALS AND DEPARTURES) IN THE BALTIC SEA
Passenger ship traffic in 2015: 50 biggest ports, minimum of 500 trips



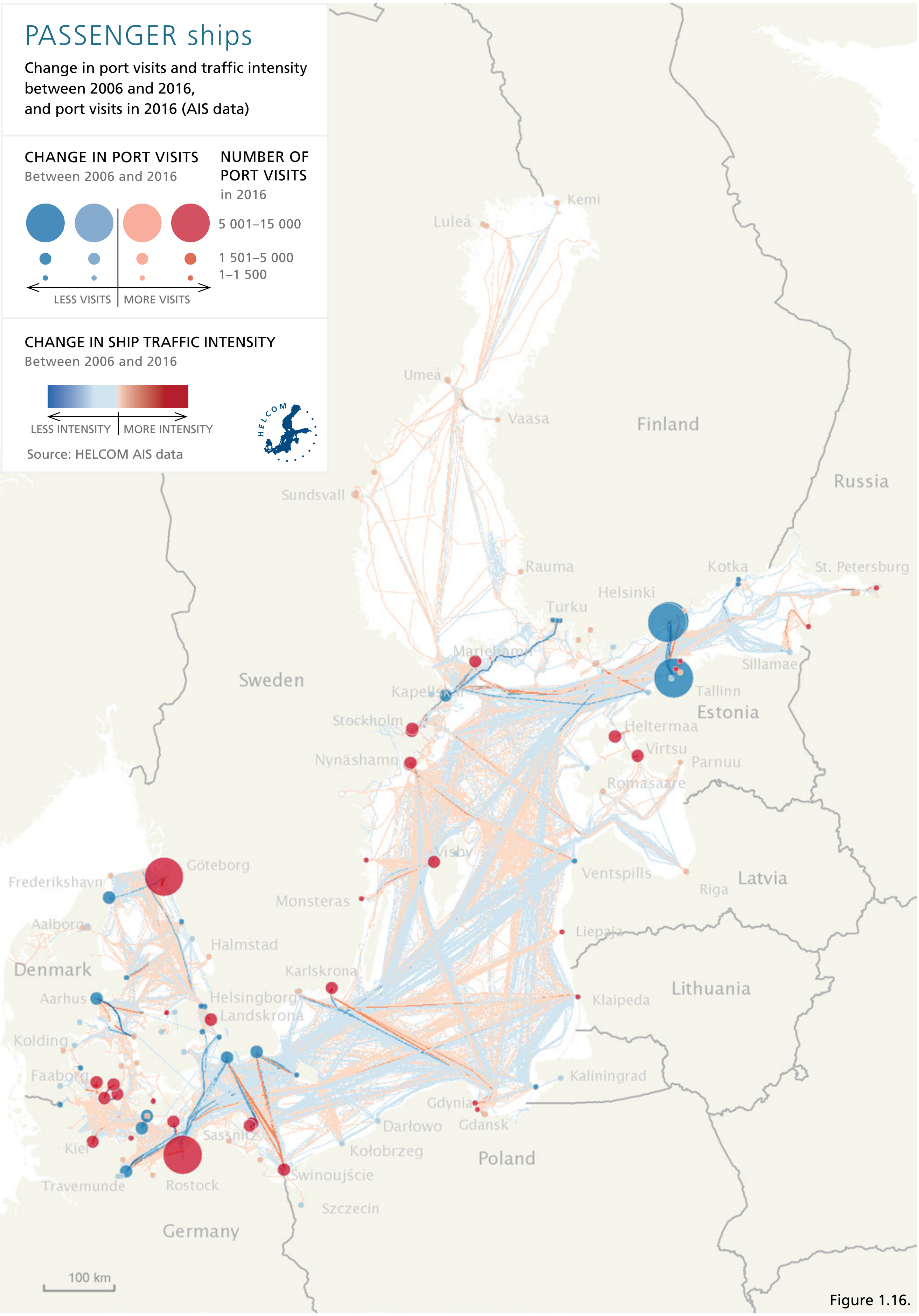

PASSENGER ships
Change in port visits and traffic intensity between 2006 and 2016, and port visits in 2016 (AIS data)
CHANGE IN PORT VISITS
Between 2006 and 2016
NUMBER OF PORT VISITS
in 2016
5 001–15 000
1 501–5 000
1–1 500
LESS VISITS
MORE VISITS
CHANGE IN SHIP TRAFFIC INTENSITY
Between 2006 and 2016
LESS INTENSITY
MORE INTENSITY
Source: HELCOM AIS data
HELCOM
Kemi
Luleå
Umeå
Vaasa
Finland
Russia
Sundsvall
Rauma
Kotka
St. Petersburg
Helsinki
Turku
Mariehamn
Sillamae
Sweden
Kapellskär
Tallinn
Estonia
Stockholm
Heltermaa
Virtsu
Nynäshamn
Parnuu
Romasaare
Visby
Göteborg
Frederikshavn
Ventspills
Riga
Latvia
Monsteras
Aalborg
Liepaja
Halmstad
Denmark
Karlskrona
Lithuania
Aarhus
Helsingborg
Klaipeda
Landskrona
Kolding
Faaborg
Kaliningrad
Gdynia
Darłowo
Gdansk
Sassnitz
Kiel
Kołobrzeg
Poland
Travemunde
Rostock
Swinoujście
Szczecin
Germany
100 km

Figure 1.16.

CONTAINER ships

Many of the biggest ships operating in the Baltic Sea region are container vessels which carry various containerized goods, often over great distances. Partly due to their size these are relatively few in number and do fewer visits than many other vessel types (Figure 1.19).
The 13 largest container ports in 2015, that have over 300 container vessel visits are St. Petersburg, Gothenburg, Vuosaari, Gdynia, Aarhus, Kotka, Klaipeda, Helsingborg, Riga, Gdansk, Copenhagen, Tallinn and Muuga (Figure 1.21). Many Baltic Sea ports have seen a rapid growth in container traffic over the last decade (Figure 1.21).

As with other types of ships transporting goods, the larger ports have a major share of traffic to or from outside the Baltic. In proportion, smaller ports have much more intra-Baltic container traffic (Figure 1.20).

STATISTICS of CONTAINER ships in 2015

NUMBER OF SHIPS: 341 ships

4,3% OTHER SHIPS

DISTANCE SAILED: 5,4 million NM

9% OTHER SHIPS

TIME AT SEA: 424 000 hours

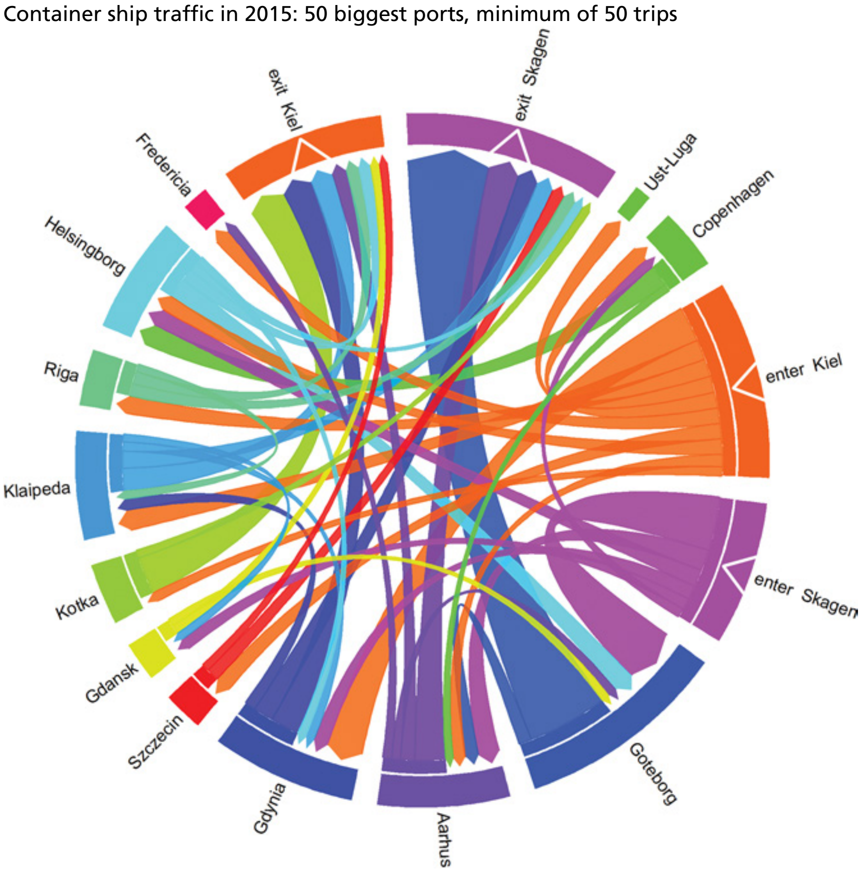
5% OTHER SHIPS

NUMBER OF PORT VISITS: 6 828 visits

4% OTHER SHIPS

Figure 1.17.

Figure 1.18. INTERACTION BETWEEN PORTS (ARRIVALS AND DEPARTURES) IN THE BALTIC SEA
Container ship traffic in 2015: 50 biggest ports, minimum of 50 trips



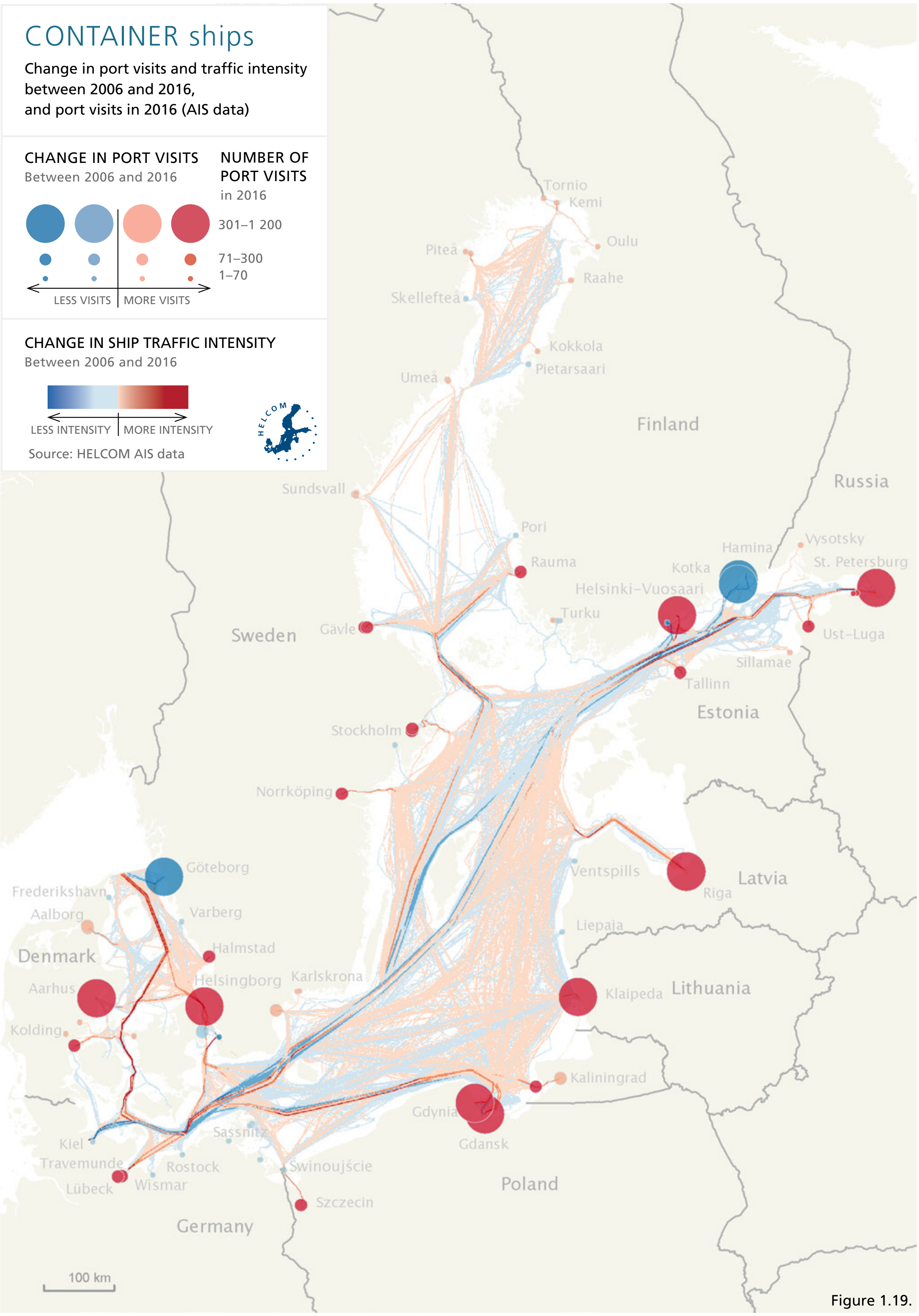

CONTAINER ships
Change in port visits and traffic intensity between 2006 and 2016, and port visits in 2016 (AIS data)
CHANGE IN PORT VISITS
Between 2006 and 2016
NUMBER OF PORT VISITS
in 2016
301–1 200
71–300
1–70
LESS VISITS
MORE VISITS
CHANGE IN SHIP TRAFFIC INTENSITY
Between 2006 and 2016
LESS INTENSITY
MORE INTENSITY
Source: HELCOM AIS data
HELCOM
Tornio
Kemi
Oulu
Piteå
Raahe
Skellefteå
Kokkola
Pietarsaari
Umeå
Finland
Russia
Sundsvall
Pori
Rauma
Hamina
Vysotsky
St. Petersburg
Kotka
Helsinki–Vuosaari
Turku
Gävle
Sweden
Ust-Luga
Sillamae
Tallinn
Estonia
Stockholm
Norrköping
Göteborg
Ventspills
Latvia
Riga
Frederikshavn
Aalborg
Varberg
Liepaja
Halmstad
Denmark
Helsingborg
Karlskrona
Klaipeda
Lithuania
Aarhus
Kolding
Kaliningrad
Gdynia
Sassnitz
Gdansk
Kiel
Travemunde
Rostock
Swinoujście
Lübeck
Wismar
Poland
Szczecin
Germany
100 km

Figure 1.19.

You can't control the wind,
but you can adjust the sails.

Section II
ENVIRONMENT AND SHIPPING

02. SHIPS' EMISSIONS TO AIR IN THE BALTIC SEA

Introduction

Emissions to air, mainly exhaust gases and particulate matter, is a central form of pollution from ships in the Baltic Sea region. Exhaust gases and particulate matter (PM) from ships have increasingly become an issue of public interest as sources on land have become increasingly regulated and emissions have been documented to have both environmental and human health effects (Brandt *et al*. 2013; Corbett *et al*. 2007; Jonson *et al*. 2015; Liu *et al*. 2016; Raudsepp *et al*. 2013). The use of fossil fuels also directly contributes to climate change through the increase of greenhouse gases in the atmosphere.

Even if exhaust gas and PM are the main form of aerial pollution from ships, other airborne pollution exists such as waste incineration smoke, volatile organic compounds (VOC) from liquid cargo handling and ozone depleting substances from cooling devices.

Since the 1970s, ships equipped with an internal combustion engine burning diesel or fuel oil have dominated the world fleet, including ships operating in the Baltic Sea. Even if other fuel alternatives such as Liquefied Natural Gas (LNG) are emerging, the overwhelming majority of ships today use diesel oil or heavy fuel oil due to operating simplicity, robustness, fuel economy and fuel infrastructure.

Exhaust emissions from these marine combustion engines are comprised of largely harmless elemental nitrogen (N_2, ca. 3/4), oxygen (O_2, ca. 1/10) and water vapour (ca. 1/20), but also carbon dioxide (CO_2, ca. 1/20) and smaller amounts of carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), hydrocarbons, and smoke (including particulates) which are related to various environmental and human health concerns.

The main focus of the work in the Baltic Sea region so far has been to reduce exhaust gas emissions of SOx, which cause negative human health effects and acidification of the environment (mainly on land), and NOx during the 2000s, which contribute to negative human health effects, nutrient pollution of the Baltic Sea and similar fertilization effects on land. Even if exhaust gas emissions from ships (e.g. CO_2 and PM "black carbon") contribute to climate change, measures to address these types of ship pollution are negotiated globally and have not been considered in regional discussions.

As a response to the public and scientific concern, relatively drastic regulatory decisions have been taken in recent decades to reduce airborne emissions from ships in the region. The Baltic Sea was the first SOx Emission Control Area in the world, established in May 2005, and as a consequence fuel sulphur content has been reduced by distinct steps. This stepwise reduction of maximum allowable sulphur content, including the early reduction of sulphur content for ships at berth in an EU port, has led to dramatic decreases of SOx emissions from ships in the Baltic Sea.

Reduction of exhaust gas pollution can be achieved by exhaust gas cleaning and/or cleaner fuels (e.g. higher grade oil distillates, biofuel, LNG, methane). Emissions can also be reduced by new propulsion technologies such as fuel cells (hydrogen fuel source), auxiliary wind devices and operational efficiency including "slow steaming" (to a lesser extent) – or a combination of such measures. When in port, properly equipped ships can also use the onshore power supply ("cold ironing") to avoid using their engines and thus comply with the requirements.

As existing ships have to comply with the requirements to reduce SOx emissions, ship owners have usually chosen to either comply by using fuel oil with very low sulphur content or to retrofit an exhaust gas cleaning system ("scrubber") targeted to the required SOx reduction level.

Reducing NOx emissions is perhaps a more complicated matter from the ship owner point of view, because using higher grade fuel alone does not reduce NOx emissions. NOx emission reductions to the required ("Tier III") level may require the installation of new equipment such as a catalysator, exhaust gas recirculation system or a completely new engine/fuel type.

Even if ships can reduce both SOx and NOx emissions by introducing completely new fuel types (such as biofuels or LNG), such technology is very costly to install on existing vessels and is more frequently taken into use on new builds. Because of this, international regulation of the NOx emissions from shipping only covers new ships built after the entry into force date of the regulation (2021 for the Baltic Sea NECA).

This delay in fleet renewal causes a practical time lag of 20–30 years before new ship technologies are mainstream and when the full benefits of NOx emission reduction from ships can be expected.

Estimations of pollution load from ship exhaust gases

By using AIS data and ship data models (Jalkanen *et al*. 2009, 2012; Johansson *et al*. 2013), the Finnish Meteorological Institute (FMI) has estimated the monthly emissions of certain exhaust gas pollutants from ships operating in the Baltic Sea between 2006–2015 (see Figure 2.1). Besides illustrating the developments over time, these available time series of NOx, SOx, CO_2 and PM2.5 (particulate matter) emissions can be used to estimate the contribution of exhaust gases from Baltic Sea shipping to the pollution ending up in the Baltic Sea, mainly via direct deposition to the sea surface.

Besides emissions from shipping in the Baltic Sea, a large share of the emissions from shipping in the North Sea and North East Atlantic ends up in the Baltic Sea due to the prevailing westerly winds.

Less information is available on the emissions of other ship sources, including incineration.

SOx – Sulphur oxides

When it comes to emissions from Baltic Sea shipping (Figure 2.1), SOx emissions have dropped drastically during the period 2006–2015 due to the implementation of new regulations (Figure 2.1). Currently, SOx emissions from exhaust gases of Baltic Sea shipping are approximately 10 kt annually, while in 2005 emissions were around 14 times higher, at approximately 140 kt annually.

NOx – Nitrogen oxides

From 2005–2015, the annual emissions of NOx (N and O) from Baltic Sea ships have been relatively stable, around 320–360 kt per year (Figure 2.1).

Of these total annual emissions, approximately 19 kt of reduced nitrogen ends up in the Baltic Sea as direct deposition to the sea surface (Jonson *et al*. 2015). This can be compared with the 115 kt total atmospheric deposition of nitrogen to the sea from all sources.

Around 40 kt of reduced nitrogen is deposited on land in the drainage area of the Baltic Sea. As nitrogen-related processes on land and inland waters is very complex, it is difficult to estimate how much, if any, of this 40 kt ends up in the Baltic Sea. A share of NOx emissions within the region is carried outside the Baltic Sea drainage area by wind.

In 2016 the Baltic Sea was designated as a NOx emission control area (NECA) in parallel to a similar designation for the North Sea and the regulation will enter into force for new ships on 1 January 2021. According to recent estimates by the European Monitoring and Evaluation Programme (EMEP 2016), compared to a non-NECA scenario, the reduction in annual total nitrogen deposition to the Baltic Sea region achieved by these regulations will be approximately 22 kt by the 2030s – as a combined effect of the Baltic Sea and North Sea NECAs (Jonson *et al*. 2015).

Out of this total anticipated reduction in NOx deposition, 7 kt is estimated to be reduced from direct deposition to the surface of the Baltic Sea and the remaining 15 kt is estimated to be reduced from deposition to land in the drainage area of the Baltic Sea (EMEP 2016). However, as the NECA regulations target only new ships, a lengthy two-decade long period of fleet renewal is needed before the regulation will cause this effect.

PM2.5 – Particulate matter 2.5

Particulate matter (PM) is a generic term for a broad class of chemically and physically diverse substances. It can be principally characterized as discrete particles that exist in the condensed (liquid or solid) phase spanning several orders of magnitude in size. PM2.5 refers to one size class of relatively fine particles, less than or equal to 2.5 micrometers in aerodynamic diameter, which also indicates the level of other PM size classes. Sulphur in fuel contributes to particle formation because sulphuric acid is one of the key constituents to PM mass. The SOx regulations have reduced the annual emissions of PM2.5 from ships in the Baltic Sea by 50% over the last ten years to 10 kt. Nitrogen also contributes to PM formation, even if nitrate is not a direct combustion product but formed in the atmospheric processes.

TRANSPORT WORK AND EMISSIONS FROM BALTIC SEA SHIPPING DURING 2006–2015

Monthly values Source: Johansson & Jalkanen, HELCOM Baltic Sea Environment Fact Sheet 2016

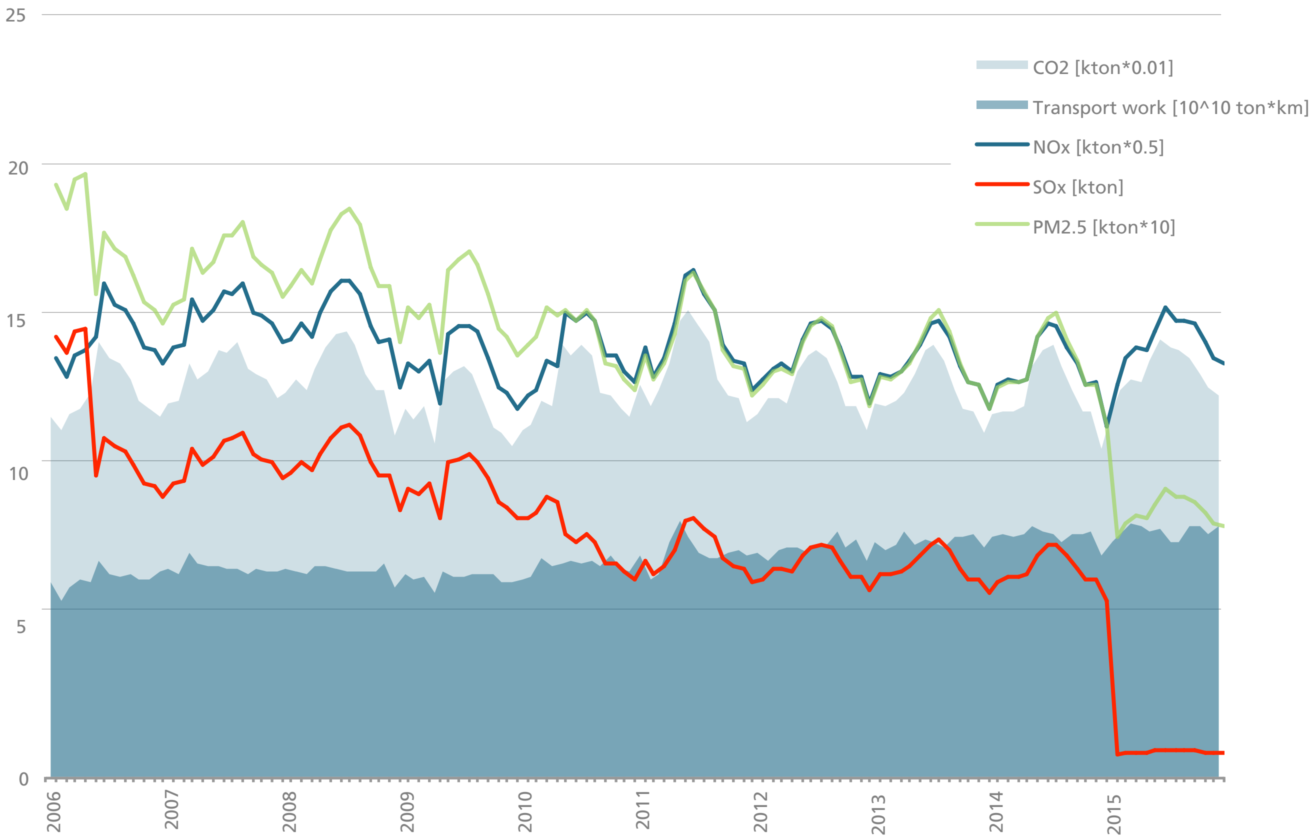


Figure 2.1.

The foreseen measures for NOx emission reduction will decrease the atmospheric concentrations of particulate matter.

Particulate matter, including PM2.5, is related to human health as it causes damage to the respiratory system and has been characterized as carcinogenic by WHO. Additionally, black carbon from particulate matter on snow and ice reduces the backscatter of light energy to the atmosphere, and therefore, negatively contributes to global climate change.

CO_2 – Carbon dioxide

During the last ten years, CO_2 emissions from Baltic Sea shipping have remained relatively stable at 15 000 kt annually while the maritime transport of goods has increased 23% during the same period. Indirectly, it can thus be argued that shipping has become more climate friendly per transported unit. Traffic in the Baltic Sea is responsible for about 2% of the global shipping GHG emissions (Johansson & Jalkanen 2016, IMO 2015).

Ships exhaust gases compared to other sources of airborne pollution

Based on emission figures from all transport modes reported by member countries to the CLRTAP convention, the developments in exhaust gas emissions from ships can be compared with other forms of transport and sources. Even if these figures include ship activity on the North Sea side

SOx AND NOx EMISSIONS of TRANSPORT 1990–2014 IN BALTIC COUNTRIES (excluding Russia)
% change between years 1990 and 2014, Source: CLRTAP 2016

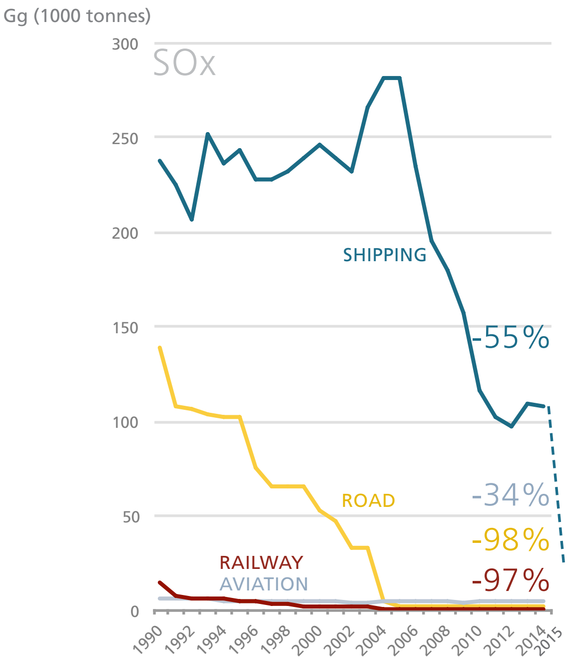


Figure 2.2.

for Denmark and Germany, and are thus not directly comparable with the emission estimates from FMI, they still provide a way to study the relative development between transport modes over longer time periods.

SOx sources

The main source of SOx emissions in Europe is energy production (burning coal and oil), responsible for 75% of total emissions (UNECE 2016). Mainly due to EU regulations requiring sulphur free fuels in land based transportation, maritime transport is currently the only transport sector with a significant level of SOx emissions in the Baltic Sea region. This general picture can be illustrated by data reported by the Baltic Sea coastal countries to the Convention from Long Range Transboundary Air Pollution (CLRTAP) (Figure 2.2). Please note that the emissions in Figure 2.2 are not based on the same ship-by-ship modelling data as Figure 2.1 and include also emissions from ship traffic in the North Sea for Germany and Denmark. For this reason, the emissions depicted in Figure 2.2 are higher than those for the Baltic Sea only (Figure 2.1).

NOx sources

The most important source sectors for atmospheric NOx emissions are the fossil fuel combustion in road transport, energy production and shipping (UNECE 2016). Agriculture is the most significant source for ammonia (NH3) emissions.

In 2014, around 7% of NOx emissions in Europe came from non-land transportation, mainly shipping (UNECE 2016). Even if land transportation – mainly personal cars and trucks – is responsible for a much larger share (40% in 2014), the introduction of catalytic converters during the 1990s have reduced emissions to less than half during the period 1990–2014. During the same period, ship emissions have remained relatively stable (320–360 kt during 2006–2015), while NOx emissions from air transportation are small but have nearly doubled since 1990.

Regulation of emissions to air from ships in the Baltic Sea

1992 Helsinki Convention and HELCOM Recommendations

The 1992 Helsinki Convention Annex IV does not currently list MARPOL Annex VI among the IMO regulations it is urging its Contracting Parties to comply with. However, airborne emissions from ships have been considered over three decades within the HELCOM MARITIME group. This group was used to develop and negotiate regional submissions of proposals to IMO for both the SOx (submitted 1995 and agreed 1997) and NOx (submitted 2016 and agreed 2017) emission control areas in the Baltic Sea.

In addition to MARPOL requirements, the 1992 Helsinki Convention prohibits incineration of wastes deriving from the normal operation of the ship in the territorial seas of the Baltic Sea States (Annex IV, Regulation 7).

MARPOL Annex VI General provisions

Annex VI of the MARPOL Convention sets the general framework for exhaust gas emissions and other airborne pollution from all ships, fixed or floating platforms (drilling rigs), floating craft and submersibles. Besides NOx and SOx, it also covers reception facilities of relevant wastes (e.g. SOx scrubber waste), shipboard incineration, ozone depleting substances (ODS), volatile organic compounds (VOC) and fuel oil quality and availability.

With regards to NOx, Annex VI is based on three emission reduction levels of NOx emissions (Tier I, II and III) each of which also become stricter over time. The compliance of ships with MARPOL Annex VI tiers is documented in the International Air Pollution Prevention (IAPP) Certificate carried by each ship. NOx regulation applies to new ships only.

Tier I and II apply worldwide. The strictest tier, Tier III, is to be applied within specific “Emission Control Areas”, i.e. “NECAs”. Currently this covers the North American and the United States Caribbean waters, while the Baltic Sea and North Sea will be covered from 1 January 2021 (Figure 2.3).

The Annex was the result of lengthy negotiations during the 1990s, adopted in 1997 and entered into force 19 May 2005 after the necessary ratifications. A revision of the Annex was initiated in 2006 and adopted in 2008. Its provisions do not apply when suffering damage to ship or equipment, when saving life at sea or when securing safety of the ship.

If a certified incineration plant is available, Annex VI allows burning wastes generated from normal ship operation. However, as an exception it prohibits burning of certain products including contaminated packaging materials and polychlorinated biphenyls.

MARPOL Annex VI SECA Baltic Sea

The Baltic Sea was designated as a MARPOL Annex VI SOx Emission Control Area (“SECA”) in 1997 (entered into force 19 May 2005, in effect a year later

EMISSION CONTROL AREAS (IMO MARPOL ANNEX VI)

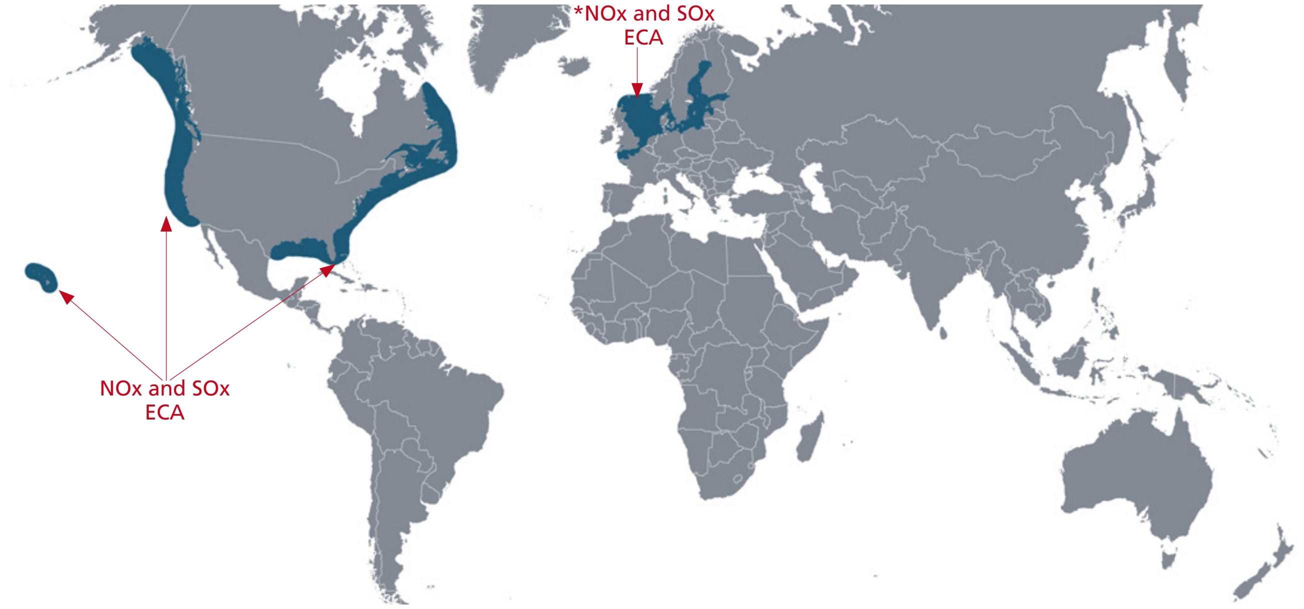


Figure 2.3. Existing MARPOL Emission Control Areas include:
Baltic Sea (SOx adopted 1997 / entered into force 2005; NOx new ships built 2021 or after)
North Sea (SOx 2005/2006 ; NOx new ships built 2021 or after)
North American ECA, including most of US and Canadian coast (NOx and SOx 2010/2012)
US Caribbean ECA, including Puerto Rico and the US Virgin Islands (NOx and SOx 2011/2014)
*NOx ECA entering into force 2021

SULPHUR LIMITS IN FUEL OIL

Limits globally and within SOx Emission Control Areas (SECAs)
From 2000 to 2025

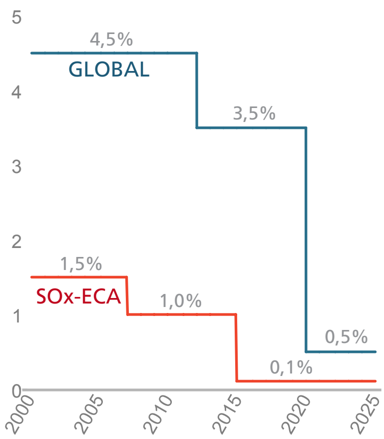


Figure 2.4.

from 19 May 2006) and the emission limits were tightened by an amendment in October 2008 which entered into force 1 July 2010. The last revision included a schedule with further tightening of the emission limits, to 0.1% within SECAs in 2015 and globally to 0.5 % in 2020 (Figure 2.4).

The valid requirement in the Baltic Sea SECA, from January 2015, is that all ships navigating in its waters use fuel oil with a sulphur content not exceeding 0.1% m/m. In order to prove compliance, a bunker delivery note accompanied by a representative sample of the delivered fuel oil shall be kept on board the ship for port state control inspection.

Alternatively, in the Baltic Sea area and other SECAs, the ship may use an exhaust gas cleaning system and/or any other technical abatement method. This must reduce the total emission of sulphur oxides from ships at the same level of efficiency as with fuel containing 0.1% m/m of sulphur.

New exhaust gas cleaning systems must be approved in accordance with resolution MEPC 259(68), 2015 Guidelines for Exhaust Gas Cleaning Systems.

The discharge of scrubber wash waters is not allowed in German rivers and ports. In most of the other countries ports can set their own rules but have not yet done so (by 2015).

Most ports can receive residues from exhaust gas cleaning systems by using waste handling service trucks.

MARPOL Annex VI NECA Baltic Sea

NECA regulations, including measures to limit NOx emissions via exhaust gases of ships sailing in the Baltic or North Seas to Tier III level, were submitted to the IMO in July 2016, approved by the IMO MEPC in October 2016 and resulting in final amendments to MARPOL Annex VI in July 2017. These foreseen NECA regulations target new ships built in or after 2021 and do not address existing ships.

New ships, built in 2021 or later, sailing in the Baltic Sea NECAs have to meet the stricter Tier III standards of MARPOL Annex VI, in comparison to the Tier II standard applied globally outside of NECAs. This corresponds to approximately an 80% reduction in NOx emissions compared to current levels and can be achieved by adopting new technologies, such as those explained below.

Technology answers for reduction needs

NOx reducing technology for ships

Currently, the main technologies to meet the Tier III NOx emission standards are Selective Catalytic Reduction (SCR), Exhaust Gas Recirculation (EGR) and the use of alternative fuels such as liquefied natural gas (LNG).

In addition, internal engine modifications and various ‘wet methods’ (using evaporation of water to reduce NOx emissions by local cooling inside the combustion chamber) are available but do not meet Tier III and therefore, are not discussed further here.

Selective Catalytic Reduction (SCR)

Selective Catalytic Reduction (SCR) is currently the leading exhaust gas after-treatment technology and has a NOx abatement capability of more than 80%. The SCR concept involves injecting urea-water solution into the exhaust gas stream in combination with a catalyst unit in the exhaust channel.

The SCR unit consumes a urea-water solution (40%) which has to be stored on board. Urea tank size depends on the engine size, how often the engine is used, and how often the ship can load urea. Modern vessels (offshore vessels, RoPax, fishing vessels) equipped with SCR typically have a total urea capacity of 30–100 m^3 distributed between 1 to 2 tanks.

SCR has a long history in land-based applications and has been in use aboard ships for nearly 15 years. It is thus a well-known exhaust gas after-treatment system which may be integrated with the engine or installed as an “add-on” system which does not interfere with the basic engine design. The process requires a certain minimum engine exhaust gas temperature level, which makes SCR to perform sub-optimally under low engine load conditions (like port manoeuvres). For the same reason, NOx reduction may not be as effective during low engine load conditions compared with higher loads.

Exhaust Gas Recirculation (EGR)

Exhaust Gas Recirculation (EGR) relies on a part of the exhaust gases being filtered, cooled and rerouted back to the engine charge air. Since the specific heat capacities of the principal exhaust components are higher than air, the process results in a reduced combustion temperature and thereby less NOx formation. Also, as a secondary effect, a reduction of oxygen in the chamber means that there is less material available to combine with nitrogen to form NOx. The system results in bleed-off water which has to be managed. Bleed-off water can be stored in a tank or released to the sea after cleaning.

SOx reducing technology for ships

Fuel oil with low level of sulphur

One of the reasons for the high level of SOx emissions from ships is that heavy fuel oil (also called residual oil) used on board is essentially a waste product of refineries where cleaner fuels have been produced, i.e. by removing sulphur and other unwanted components. The most commonly used method to comply with SOx provisions of Annex VI of MARPOL is simply switch to using low sulphur fuel oil.

From highest to lowest residual oil content, the traditionally classified marine fuels are Heavy Fuel Oil (HFO), Marine Fuel Oil (MFO), Intermediate Fuel Oil (IFO), as well as Marine Diesel Oil (MDO) and the pure distillate Marine Gas Oil (MGO). The currently valid ISO 8217-2012 standard for marine fuels specifies instead four different distillate grades (DM, i.e. DMA, DMB, DBX and DMZ) and a number of residual grades (RM).

Even if distillates such as low sulphur MGO can be used to comply with SECA, new types of residuals called ultra-low-sulphur fuel oils (ULSFO) are also starting to be available in response to the 0.1% SECA limit.

Exhaust Gas SOx Scrubber Technology

In general, “scrubbers” refer to a diverse group of pollution control devices (in this case exhaust gas cleaning systems) that use a liquid to wash unwanted pollutants from a gas stream, including exhaust gases. These can be used on board ships to clean exhaust gases from SOx by washing it with a liquid shower in a dedicated chamber before release to air. Water blended with caustic soda (NaOH) as a reagent is commonly used as scrubbing liquid in closed loop systems which reduces the SOx content by 95%.

The scrubbing water, including the Sulphur from SOx, is then sent to water treatment to clean the discharge water and to store the waste as a condensed liquid lotion or solid paste. The system has to be continuously supplied with new reagent. The waste product has to be stored on board and disposed of at port. Closed loop systems produce a bleed-off stream which may be stored in a tank or released to the sea after cleaning.

While marine scrubber systems cover a large diversity of different technological solutions, the two main types are closed loop and open loop scrubbers. Closed loop scrubbers recirculate most of the wash water inside the system while open loop scrubbers release the water to the sea after the cleaning process. The release of scrubber water from open loop systems to coastal waters has been a controversial issue in some Baltic Sea countries due to concerns for the effect of the scrubber wash water on the marine environment.

Exhaust gas cleaning systems using a dry cleaning medium have been tested but are not widely applied.

Alternative fuels

LNG fuelled ships

The use of alternative fuels, such as liquefied natural gas (LNG) in lean-burn diesel engines, offers another method to reduce SOx and NOx emissions. LNG is mostly cryogenic methane gas which is liquefied to reduce the volume of fuel onboard ships. It can be produced both from fossil and renewable sources, which makes it a well-suited energy source for marine traffic. Existing marine engines can be modified to use LNG and for many years, LNG carriers have been using boil-off gas in their steam power plants. LNG does not contain Sulphur and lean-burn diesel engines have shown to be capable of 80–90% NOx reductions compared to using fuel oil, and therefore comply with Tier III.

Dual fuel marine diesel engines have become available which can operate on fuel oil, LNG, or a combination of both. The NOx reduction potential using LNG in dual fuel engines depends on the amount of pilot fuel injected to start the combustion process (diesel process) and the cycle mode (2-stroke/4-stroke). When operating on natural gas, peak cylinder temperatures are reduced (compared to diesel operation) through the use of a lean-burn Otto-cycle combustion process. These lower peak cylinder temperatures restrict the formation of NOx.

The use of LNG has been observed to lead to the release of unburnt methane into the atmosphere ('methane slip'), which counteracts the climate benefits of LNG as marine fuel. However, such methane emissions have been reduced with recent technological developments and can even be eliminated altogether with solutions such as high-pressure Gas Injection Dual Fuel (HPDF) gas engines (Stenersen & Thonstad 2017).

The use of reformulated gas-to-liquid-fuels, however rare so far, produces substantially less NOx emissions in a manner comparable to Dimethyl Ether (DME) with no need for a pressurized fuel system.

Availability of LNG for ships is also important to enable the use and development of LNG propulsion technology on board ships. According to the EU Directive 2014/94/EU on the deployment of alternative fuels infrastructure, a core network of refueling points for LNG at maritime TEN-T ports should be available at least by the end of 2025. Refueling points for LNG include, inter alia, LNG terminals, tanks, mobile containers, bunker vessels and barges.

Currently, LNG terminals are operational in the port of Stockholm in Sweden and in the port of Swinoujscie in Poland. Also, a LNG bunkering station in the port of Szczecin-Swinoujscie in Poland is under consideration. In Finland, LNG bunkering is already possible in Pori (Gasum 2016) and there are plans to build LNG bunkering stations in three additional ports: Tornio Röyttä (2018), Rauma and Hamina. Major suppliers have also ordered bunker vessels. If there will be demand for a LNG fuel supply to ships, LNG terminals could be constructed also in Russian Baltic Sea ports.

Methanol fuelled ships

Methanol is an alcohol which is today usually produced in large scale with the Fischer-Tropsch process from natural gas (70%) or coal (30%). However, methanol can be produced from almost any biological material.

As it is a liquid in standard atmospheric conditions, methanol has a big practical advantage over LNG – which has to be carried in pressurized containers. Marine engine models running on methanol are available, exclusively or in dual fuel engines as an alternative to fuel oil. As distribution infrastructure for methanol as a marine fuel has the same challenges as for LNG, operation using methanol has become especially attractive for specialized methanol carriers which operate in SECA areas because they already carry their fuel on board.

Electric motors

Electric motors, using large storage batteries which are charged from power grid in port, have been used in Norway for main propulsion since 2015 (Siemens 2015). Depending on the source of energy production, this may reduce the environmental and carbon footprints of shipping. Other more pioneering approaches generate the electricity on board from the fusion of hydrogen and oxygen to water, i.e. using a fuel cell.

Wind-assisted propulsion for ships

Wind is a potential source of energy for ship propulsion, which results in no pollution and is completely free. Several attempts have been made over the last decades to re-introduce wind power as a serious source of ship propulsion for commercial traffic using innovative devices which enable automatic operation, including kites, fixed sails or so called Flettner rotors.

Some of these devices have been experimented in the Baltic Sea, even though it is generally considered too small with wind patterns, too irregular to harness the full potential of wind propulsion. None of the experiments have resulted in full mainstreaming so far but these experiments have demonstrated that wind devices can be used to reduce emissions and fuel costs.

The most promising approach currently is to install Flettner rotors on board existing ships. These devices use spinning/rotating cylinder shaped devices on the deck which tap to the physical phenomenon called the Magnus effect for propulsion. Some electric power is needed to rotate the cylinder but this is greatly exceeded by the propulsion energy gained.

Shore-to-ship power

Shore-to-ship power or “Cold ironing” is increasing in popularity but further mainstreaming requires coordinated action between ports and the ships calling them regularly. There is strong potential as using onshore power has benefits to ship-owners and is a business case for ports. A relevant milestone for the implementation of this technology has been the approval of the ‘ad-hoc’ international standard for shore-to-ship power connections (IEC/ISO/IEEE 8000-5).

Future perspectives

Enforcement challenges of air pollution from ships

As compliance with the stricter emission standards of MARPOL Annex VI emission control areas involves relatively high costs, enforcement has to ensure that non-compliant operators do not gain an economic advantage over law-abiding ones. The economic gains of using a non-compliant fuel during a single voyage from the North Atlantic across the North Sea/Baltic Sea emission control areas and back can be roughly 100 000 euro.

Enforcement of the sulphur content of fuel oil is traditionally done by bunker delivery notes, documenting the quality of oil provided by the seller, as well as spot checks of fuel used as part of port state control or dedicated sulphur control. However, these approaches have their weaknesses because high sulphur fuel can be purchased for use outside the SECA or in combination with exhaust gas cleaning technologies. Existence of high sulphur fuel inside fuel tanks cannot be used as grounds for violation of sulphur rules. For this reason, monitoring of the SO_2 concentration of exhaust gases by remote sensing from airplanes or fixed devices has also been tested in the Baltic Sea to investigate whether the emission levels of sulphur requirements are actually met during voyage. Technology for monitoring Tier III NOx compliance will have to be developed further and due to inherent challenges it may remain even more indicative nature than SOx monitoring.

Even if the compliance monitoring challenges are to be solved, the fines for infringements need to be a greater deterrent than the potential economic gains through non-compliance. Already in 1998, HELCOM adopted Recommendation 19/14 in order to harmonise administrative fines for non-compliance of environmental regulations concerning ships.

Incentives to implement green ship technology and alternative fuels

Various economic incentives can be used in order to apply green ship technology voluntarily, in advance of regulatory requirements. This includes traditional public sector financial support to green investments as well as innovative tools such as the combination of a NOx tax and a related fund in Norway.

In order to accelerate the application of green technologies and alternative fuels, HELCOM has launched a public-private partnership (GREEN TEAM) that aims to assist the emerging "green shift" within Baltic Sea shipping. This partnership is in cooperation with other similar initiatives in the region and beyond.

Green steaming reduces anchoring time and emissions

The goal of green steaming is to enable ships to reduce their speed to arrive just-in-time rather than anchor and wait. In August 2014, the Swedish consultancy SSPA conducted a one-month study collecting AIS-data of the ships in the Kattegat region (a part of the Baltic Sea between Sweden and Denmark). During this period approximately every fifth tanker or cargo vessel sailing for the port of Gothenburg anchored outside the harbour waiting time for berthing. In order to reduce anchoring time, SSPA's analysis of the collected data indicates potential energy and emissions savings of 34% for vessels approaching at their slowest safe speed. Across all commercial vessels entering the Port of Gothenburg in August 2014, the emissions and fuel savings were 4.1%. Since less than half of the anchoring time was eliminated in the analysis, there is strong potential for green steaming to have an even greater environmental impact. Reduced speed also leads to reduction of noise emissions. The implementation of such just-in-time sailing requires mainstreaming of e-navigation services which are ongoing in projects such as Sea Traffic Management (STM) (see "Future Perspectives" under Chapter 11).

03. SHIPS' SEWAGE IN THE BALTIC SEA

Introduction

Because most commercial ships often have small crews, sewage from ships is a topic which is particularly linked to passenger ship traffic. Passenger ship traffic in the Baltic Sea (see Chapter 1) includes ferries (including RoPax), particularly international ferries on fixed routes, as well as the recently booming activity of international cruise ships. In addition, a multitude of smaller national ferry lines operate within national waters of the Baltic Sea coastal states. Passenger traffic at sea is important to the whole region for connecting cities and countries whose citizens are increasingly interested in travel.

Due to the small crews of cargo ships, the environmental impact of sewage discharges to the marine ecosystem has traditionally been considered as negligible and therefore, until recently, sewage discharges have been allowed in international waters around the world. In national waters, discharges are usually allowed following a certain minimum level of treatment.

However, because modern passenger ships operating in the Baltic Sea are large both in size and number of people on board, sewage handling and discharges from these passenger ships has been identified as an environmental issue of regional concern. In 2014, cruise ships had a median capacity of ca 1900 people including staff and passengers (HELCOM 2005).

While sanitary concerns have traditionally been the focus of sewage management, sewage from passenger ships is primarily a source of nutrients for the marine environment (mainly Phosphorus and Nitrogen). Nutrients are important as they further intensify the over-fertilization, or eutrophication, of the Baltic Sea. Eutrophication, with massive algal blooms as one of the most visible signs, is currently recognised by the Coastal States as one of the main marine environmental impacts in the region.

Even if it is recognised that sewage from passenger ships is not the biggest source of nutrients in the Baltic Sea, it is not insignificant either. With over 7.15 million person days spent annually on cruise ships in the Baltic Sea 2014 and approximately over 40 million ferry passengers annually on international journeys (HELCOM 2015), proper sewage disposal is critical and fortunately manageable measure in the overall effort to protect the health of the Baltic Sea marine environment.

Estimated pollution load from ships sewage discharges

Toilet sewage is the main source of nutrients in ship sewage, but other sources of nutrients in waste water exist on board passenger ships, such as ground food waste, which could be covered to further reduce the nutrient load.

A study on nutrient loads from ships commissioned by Finland for the purposes of HELCOM Maritime in 2009 (Hänninen & Sassi 2009) estimated the nutrient content of human toilet waste to be 15 g/person/day of nitrogen and 5 g/person/day of phosphorus. Hänninen and Sassi (2009) referred to another study from the same period, commissioned by the cruise ship industry, which claimed figures of 12 g nitrogen/person/day and 3 g phosphorus/person/day (Hänninen & Sassi 2009).

The annual number of person days spent on cruise ships in the Baltic Sea can be estimated using AIS data and ship details about passengers and crew numbers. The estimated 7.15 million person days in 2014 (HELCOM 2015) is comparable to a town with approximately 20,000 year round inhabitants.

Based on the estimations of the nutrient content of daily toilet sewage per person (thus excluding other potential sources of nutrients) and person days on board cruise ships operating in the Baltic Sea, the total annual nutrient content of toilet sewage from cruise ships can be roughly estimated at 86–107 tonnes of nitrogen and 30–36 tonnes of phosphorus, depending on the figures used for nutrient content of daily toilet sewage per person.

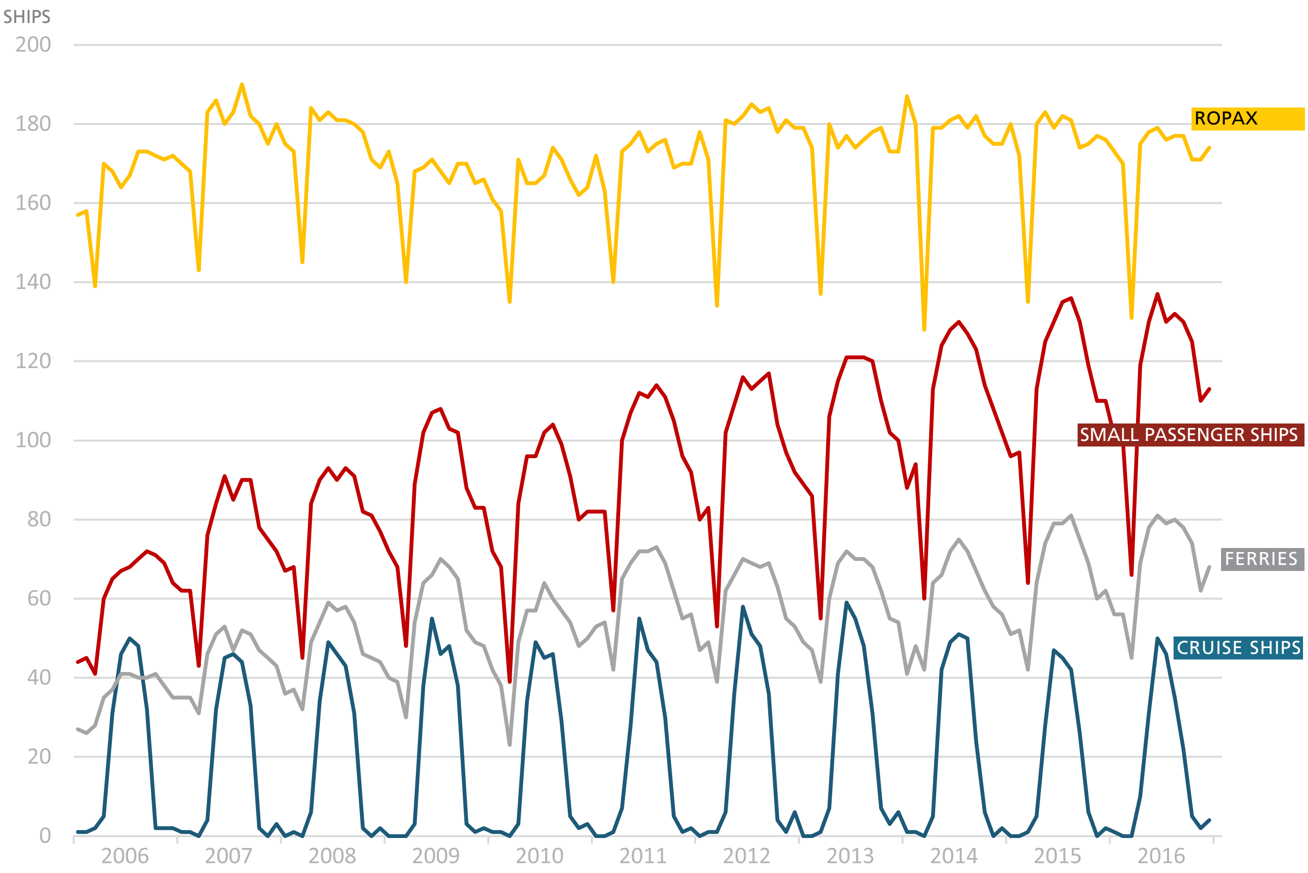
In addition, sewage is produced by the 40 million passengers on board international ferries as well as the uncalculated number of voyages by smaller ferries and leisure boats. Many international ferries have their own fixed berths and sewage port reception facilities and discharge most, or all, of their sewage at these facilities. There is a substantial variation of the number of passenger ships operating through the seasons. Figure 3.1 shows the amount of passenger ships travelling at sea since 2016 (monthly values) based on AIS data.

In comparison, Helsinki's main Viikinmäki waste water treatment facility processes the sewage from around 800 000 residents and the region's industry waste water. Approximately 89% of the nitrogen (discharge of 1.7 g/person/day) and 97% of the phosphorus (discharge of 0.1 g/person/day) is removed during treatment, with a total N load of 479 tonnes/year and a total P load of 24 tonnes/year (Hänninen & Sassi 2009).

Sewage discharges to the Baltic Sea (without nutrient removal) are allowed for existing passenger ships until 2021. Further, it can be assumed that discharged sewage currently contains the majority of original nutrient content because existing cruise ship sewage treatment is not specifically targeting nutrients.

However, some sewage is already being delivered to ports in the Baltic Sea area on a voluntary basis, but there is currently no available estimations of these amounts. Because of this, it is difficult to estimate the share of the above total potential nutrient load which is not discharged to the sea.

NUMBER OF PASSENGER SHIPS TRAVELLING IN THE BALTIC SEA 2006–2016
Monthly values



Source: HELCOM AIS data

Figure 3.1.

Characteristics of passenger ship sewage

According to the MARPOL definition, the term sewage covers all wastewater from toilets and urinals, as well as drainage (via wash basins, wash tubs and scuppers) from medical premises, drainage from spaces containing living animals, or other wastewater when mixed with sewage.

This means that, in contrast to household sewage on land, sewage from ships only covers black water (faecal and urinal waste, including mixtures) according to MARPOL definition. In practice, however, it might also include grey water (generated from activities such as laundering, dishwashing, bathing and food stuffs), and even mixtures of cooking oil and other substances. Sewage sludge and other bio-residues from on board treatment fall under the MARPOL definition of ship-generated waste, not sewage.

The specific composition of sewage varies due to several factors, for example the ship type, number of passengers, length of the voyage and use of on-board wastewater treatment systems. Nevertheless, recent studies (Anon. 2015a, 2015b) have shown that, despite the concerns, wastewater from passenger ships usually does not differ dramatically from normal household sewage. However, in case of very effective water saving vacuum systems for example, the concentrations can be much higher on board ships.

Mixing black water with grey water, which greatly increases the volume of sewage generated, is commonly carried out on board new ships as this mixing is needed to ensure the functioning of advanced treatment systems.

Regulation of sewage discharges from passenger ships in the Baltic Sea

Sewage from ships has been a standing topic in regional cooperation in the Baltic Sea, likely due to its nature as a source of pollution which is easily understandable for everyone.

1992 Helsinki Convention and HELCOM Recommendations

The Helsinki Convention addresses the issue of sewage from passenger ships in its Annex IV on sea based pollution mainly by requesting the Contracting Parties to implement existing MARPOL requirements (MARPOL Annex IV).

Based on the Convention, HELCOM has also given Recommendations on the sewage treatment systems and their capacity calculations on board passenger ships (Rec. 11/10). Also, HELCOM has recommended to apply a 'No Special Fee' (NSF) system related to port reception of ship generated wastes, including sewage (Rec. 26/1), which means that the usage fee of facilities should be borne regardless of use.

MARPOL Annex IV

Sewage is defined by MARPOL Annex IV as:

- Drainage and other wastes from any form of toilets and urinals;
- Drainage from medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs, and scuppers located in such premises;
- Drainage from spaces containing living animals; or
- Other wastewater mixed with drainage.

According to Regulation 9 of MARPOL Annex IV, every ship certified to carry more than 15 persons or of size above 400 GT shall be equipped with one of the following:

- A sewage treatment plant;
- A sewage comminuting and disinfecting system for the temporary storage of sewage when the ship is less than 3 nautical miles from the nearest land; or
- A holding tank of sufficient capacity for the retention of all sewage, having regard to the operation of the ship, the number of persons on board and other relevant factors.

According to the provisions of MARPOL Annex IV the discharge of untreated sewage from ships is prohibited closer than 12 nautical miles from the nearest land. This is not necessary if the ship is operating a type approved sewage treatment plant or sewage has been comminuted and disinfected using an approved system and the distance from the nearest land is longer than 3 nautical miles. When discharging from a sewage holding tank, the discharge must be at a moderate rate and the ship must be proceeding en-route at a minimum speed of 4 knots.

The Baltic Sea as a special area under MARPOL Annex IV

In general, global rules on ship sewage, such as the IMO MARPOL Convention Annex IV targeting sewage, have typically addressed sanitary concerns of sewage – but not the nutrient content of sewage. At the same time, the Baltic coastal countries have applied increasingly stringent nutrient limits to sewage discharges from land. The considerable investments on sewage treatment on land have turned the public opinion against the international maritime rules allowing sewage discharges from ships at sea.

In a recent major development, after over four decades of work in addressing sewage from passenger ships as a pollution source, the IMO declared the Baltic Sea as a special area for sewage in 2011.

This decision was based on a joint application by the Baltic Sea countries and the dates for entry into effect were decided by IMO in 2016. The Baltic Sea was the first in the world to receive status as a special area for sewage and have this status enforced by the International Maritime Organization (IMO).

The special area regulations will be applied on or after 1 June 2021 for existing IMO-registered passenger ships. For new passenger ships, the regulations come into effect on or after 1 June 2019. For direct passages between St. Petersburg and the North Sea, there is an extension until 1 June 2023.

When the special area regulations are in effect, passenger ships certified for more than 12 passengers will be limited to discharging sewage into port reception facilities or alternatively at sea only after treatment with advanced on-board sewage treatment plants able to reduce nutrient input into the sea.

Sewage delivery to port

Port reception facilities in the Baltic Sea region

Ensuring availability of port reception facilities (PRFs), including those for sewage, is a big task for the Baltic Sea coastal countries and their ports. The development to the current level is the result of persistent work over several decades. As an example for the long-term nature of this work, the first HELCOM Recommendation (1/1) adopted in 1980 called to ensure the use of the port reception facilities, including for sewage, in the Baltic Sea ports.

During the 1990s the HELCOM's Baltic Sea Strategy on port reception facilities ("Baltic Strategy") introduced a round of concrete improvements of sewage reception facilities in Baltic Sea ports, especially in Estonia, Latvia, Lithuania, Poland and Russia. The preparation and implementation of MARPOL Annex IV Special Area after 2007 introduced a second round of investments in sewage port reception facilities in the Baltic Sea.

By 2016 IMO received notice from coastal countries that adequate port reception facilities were available or will be available by the entry into effect of the Baltic Sea Special Area regulations.

Sewage port reception facilities can be divided into two main types:
1) Fixed facilities serving the vessel with a sewage discharge hose connected to a sewer pipe leading to a land-based treatment facility. These fixed links may have very high levels of reception capacity, up to several hundred cubic metres per hour.

MOST OF THE VISITS HAVE SMALL SEWAGE DISCHARGE NEEDS

Estimated sewage discharge needs for all cruise ship visits (total 1866) to Baltic Sea ports in 2014

For discharge need in $m^3 h^{-1}$ multiply values in figure by preferred estimate of sewage generation for person day in m^3, in the range of 0,1 (vacuum systems) to 0,17 $m^3 person^{-1} day^{-1}$.

Source: HELCOM 2015

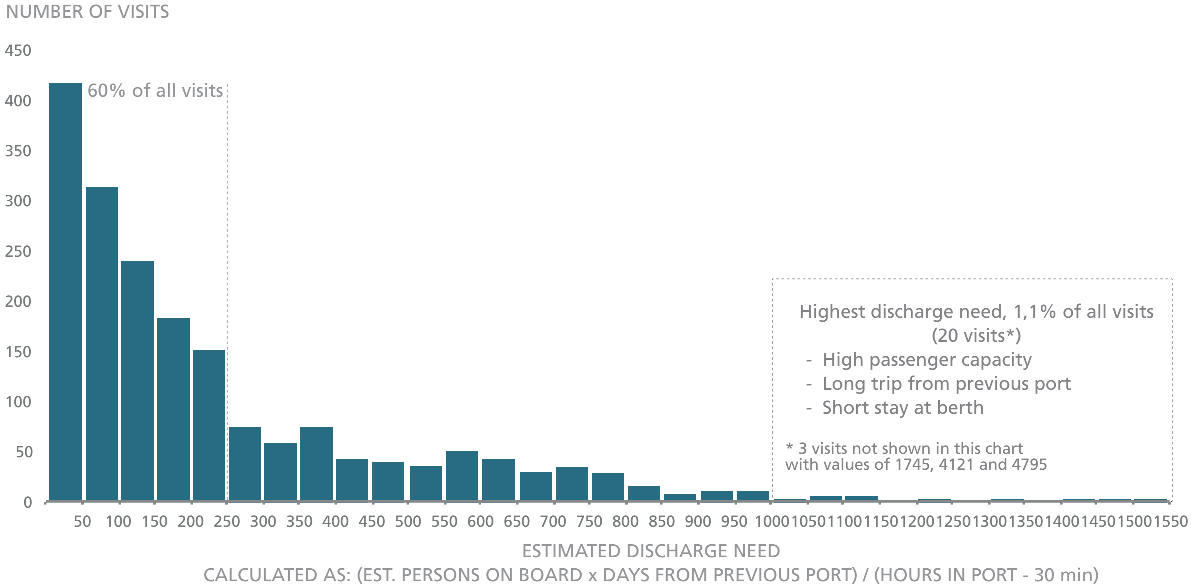


Figure 3.2.

2) Mobile facilities which is a sewage tank on a truck or barge. These have the advantage of mobility but tend to have small total capacity ranging from approx. tens (trucks) to hundreds (barges) of cubic metres, which then has to be emptied to a sewage collecting point before it can be filled again from the ship.

Use of port reception facilities for sewage

Even if bigger passenger ships seem relatively similar, cruise vessels and international ferries are different from each other in terms of sewage handling needs in ports. While ferry companies have usually their own port facilities or other arrangements, including better control over possibilities to discharge sewage on land, cruise ships have irregular routes and must rely on the facilities provided by the frequented ports.

Likely due to image concerns and as a result of their better possibilities to solve sewage handling problems themselves, many ferry companies operating fixed routes in the Baltic Sea have informed that they deliver all sewage to port reception facilities or discharge after treating with sewage treatment facilities meeting the stringent Baltic Sea special area requirements (IMO MEPC Res. 227(64)) (WWF 2015). However, deviations from this general rule may exist as information on sewage treatment practices of all ferry lines operating in the Baltic Sea is not available (WWF 2015).

Cruise ships are fully dependant on the facilities provided by the frequented ports. Ships carry an average of 1500 passengers and crew, while every tenth vessel holds more than 4000, and typical port stopovers last only about 8–10 hours, so high reception capacity (volume capacity per time unit) is needed for timely sewage discharge of these ships. (Figure 3.3.).

Two-thirds of cruise ship port calls are made in either St. Petersburg, Copenhagen, Tallinn, Helsinki, or Stockholm, which have very advanced fixed sewage port reception facilities (hose connection), but smaller ports are also commonly visited (HELCOM 2014) which may have difficulties to cope with the discharge needs.

Onboard treatment

Sewage can be treated to a high degree by special on-board treatments plants (Figure 3.4). The capacity of such facilities is very much depending on the device and on how it is operated.

When the Special Area under MARPOL Annex IV takes effect, passenger ships in the Baltic Sea will only be allowed to discharge sewage that is processed through an advanced onboard sewage treatment plant. These are required to reduce nitrogen and phosphorous concentrations to specified levels – 20 mg/L of total nitrogen (or at least 70% reduction) and 1 mg/l of total phosphorous (or at least 80% reduction)

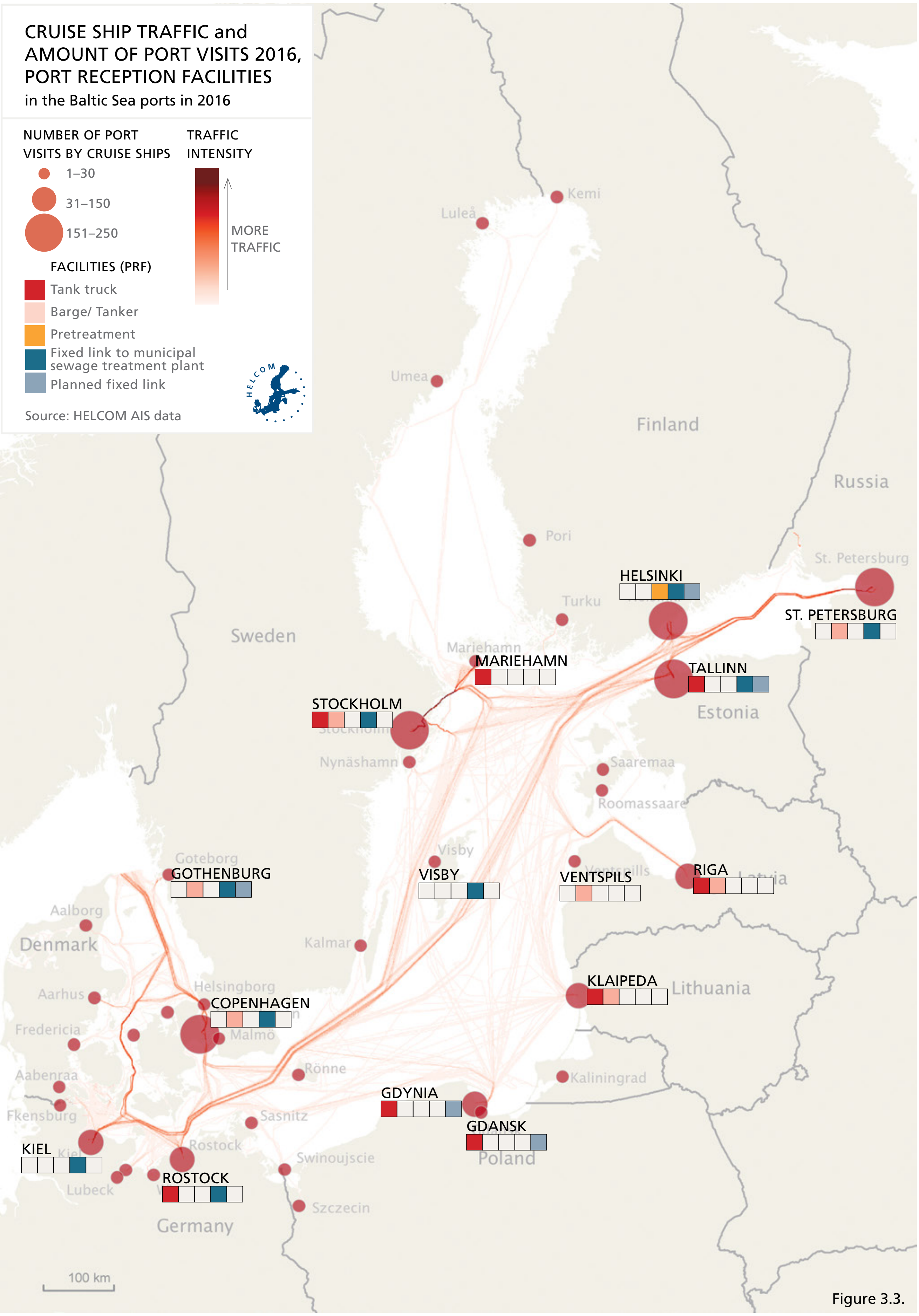
For comparison with treatment requirements on land, HELCOM Recommendation 28E/5 sets reduction targets of 30% for total nitrogen and 80% for total phosphorus for cities with 2,000–10,000 inhabitants which are situated on the Baltic Sea coastline or in the catchment area.

Advanced onboard treatment plants complying with the Special Area regulations of MARPOL Annex IV are type approved by national administrations, taking into account the standards and test methods developed by IMO – see resolution MEPC.227 (64). There has been a rapid increase of approved on-board treatment plants since 2015. By April 2017 the IMO GISIS system listed 52 different Advanced Wastewater Treatment System (AWTS) models from 5 manufacturers (Aco Marine, Evac, MARTIN Membrane Systems, Rochem Technical Services and Scanship) which are approved to fulfil the requirements of Passenger Ships & Ferries operating in MARPOL Annex IV Special Areas (including the Baltic Sea) (Tables 3.1 and 3.2)

Future perspectives

The coastal countries and the industry are currently preparing for the entry into force of the MARPOL Annex IV Special Area. As part of this work, coastal countries and NGOs/organisations with port and passenger shipping interests continue their collective efforts to further improve availability of adequate sewage port reception facilities across the Baltic Sea area.

In order to optimise the sewage port reception facilities to serve the vessels typically using them, as well as to ensure a justifiable level of investment, there is still some work to do to consider both supply and demand of PRFs. In addition, the enforcement of the Special Area provides its own challenges. This section takes up some issues which have emerged during regional discussions on sewage PRFs.


CRUISE SHIP TRAFFIC and AMOUNT OF PORT VISITS 2016, PORT RECEPTION FACILITIES
in the Baltic Sea ports in 2016
NUMBER OF PORT VISITS BY CRUISE SHIPS
1–30
31–150
151–250
TRAFFIC INTENSITY
MORE TRAFFIC
FACILITIES (PRF)
Tank truck
Barge/ Tanker
Pretreatment
Fixed link to municipal sewage treatment plant
Planned fixed link
Source: HELCOM AIS data
Finland
Russia
Sweden
Estonia
Denmark
Lithuania
Poland
Germany
Kemi
Luleå
Umea
Pori
Turku
St. Petersburg
HELSINKI
ST. PETERSBURG
Mariehamn
MARIEHAMN
TALLINN
STOCKHOLM
Nynäshamn
Saaremaa
Roomassaare
Visby
VISBY
GOTHENBURG
Goteborg
VENTSPILS
RIGA
Aalborg
Kalmar
KLAIPEDA
Aarhus
Helsingborg
COPENHAGEN
Fredericia
Malmo
Rönne
Aabenraa
Kaliningrad
GDYNIA
Fkensburg
Sasnitz
GDANSK
KIEL
Rostock
Swinoujscie
ROSTOCK
Lubeck
Szczecin
100 km
Figure 3.3.

The possibilities of advanced route planning to optimise port reception capacity

Port reception facilities are typically costly and as this cost has to be borne by ports, so far without any direct benefit, upgrades have typically been implemented slowly except in the biggest cruise ports. Eight of the nine coastal countries are EU members and the currently ongoing updates of the PRF Directive might speed up the developments by regulatory requirements.

Estimating the appropriate level of investment and capacity of a given sewage port reception facility in a Baltic Sea port is a complicated task. Several variables play a decisive role, including the number and size of ships usually visiting, distance from and facilities at the previous port, length of stopover as well as vessel design (e.g. whether vacuum or gravity toilets are used and whether grey water from showers and black water from toilets have separate systems or not).

Even if larger ports can be expected to be able to receive very high volumes of sewage over short periods of time the picture becomes much less clear with smaller ports, especially very small ports with only a handful of visits annually. The smallest ports should be able to justify a lower level of investment to, and capacity of, their sewage PRFs.

As the distances between Baltic Sea ports are usually reasonable, the sewage discharge needs at a given port are drastically reduced if the facilities provided at the previous port of call enabled full or partial discharge. Therefore, including the planning of sewage discharges into the overall route planning of vessels has great potential to reduce the unforeseen sewage discharge burden when visiting small ports with low numbers of annual visits.

Separation between grey water and black water to reduce sewage volumes

In terms of volume, the bulk of the sewage volume produced on board a passenger ship is not black water from toilets but originates from showers and similar washing facilities with low levels of nutrient content. However, if mixed with black water all of this grey water volume has to be dealt with in the same way as unmixed black water. This is naturally translated to a high capacity demand to port reception facilities.

The effect of this mixing to the estimations of sewage volumes can be clearly seen by comparing the black water sewage volumes in vessels with and without a vacuum toilet system. In vessels with a vacuum toilet system the sewage volume generated by a single person on board has been estimated to be 0,1$m^3 person^{-1} day^{-1}$ (Hänninen & Sassi 2009). However, cruise vessels produce usually significantly higher volumes such as 0,175 $m^3 person^{-1} day^{-1}$ (HELCOM 2015).

It is clear that, even with a certain degree of mixing, the volume of sewage produced and the discharge capacity required from sewage PRFs could be drastically reduced by separating the piping and retention tanks for black water and at least certain types of low-nutrient grey water. However, naturally these kinds of solutions are difficult if not impossible to retrofit and consequently mainly engineered to, and constructed on, new vessels.

ON-BOARD TREATMENT: SEWAGE FROM PASSENGER SHIPS

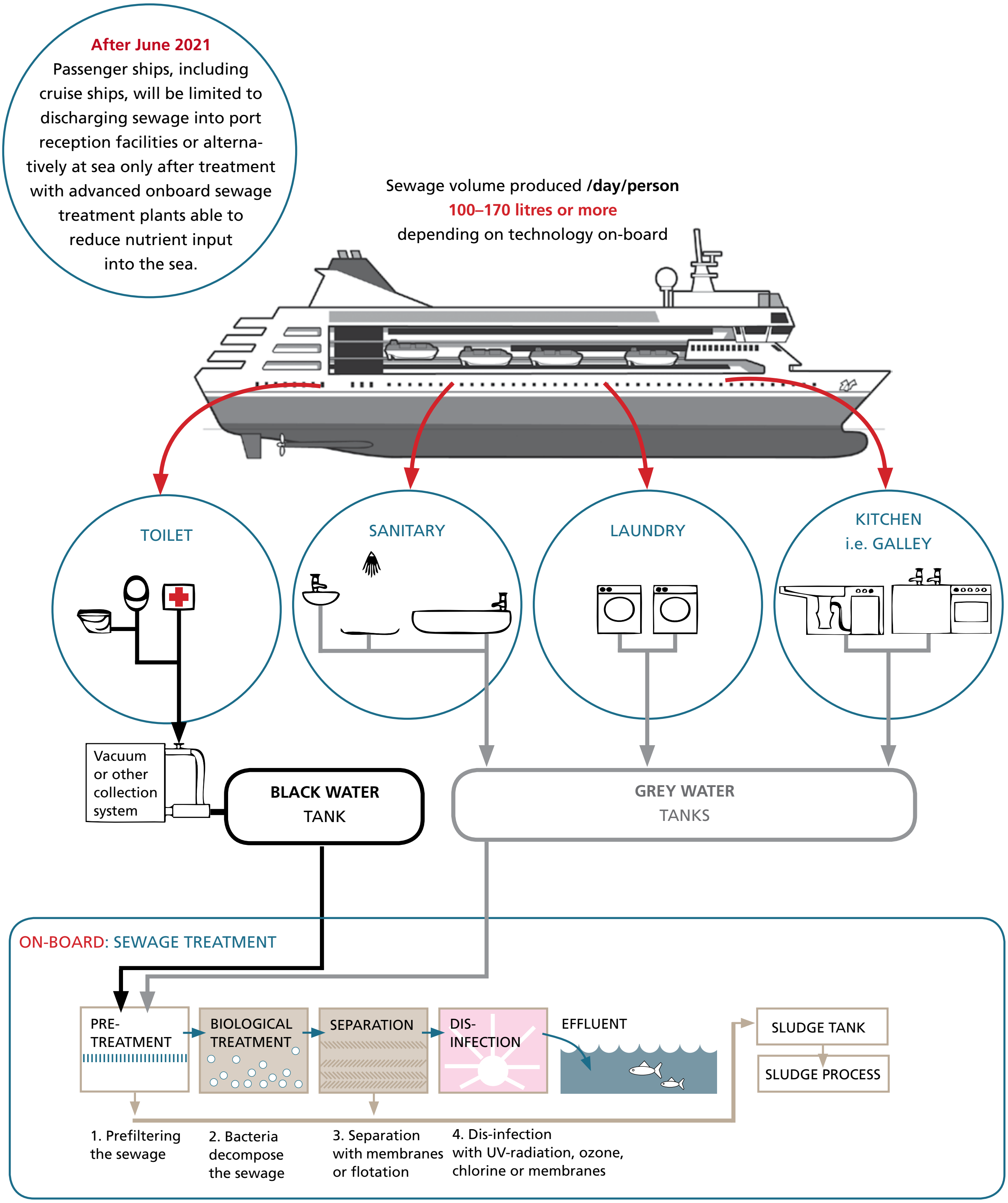


Figure 3.4.

COMPARISON OF EFFLUENT STANDARDS

Table. 3.1.

NEW TREATMENT STANDARD FOR SHIPS TO DISCHARGE TREATED EFFLUENT INTO THE BALTIC SEA

Effluent standards during test for type approval (10 days performance test), *there is no specific type approval for the Alaska GP standard*

		IMO - International Maritime Organization				USCG - United States Cost Guard			
Treatment standard		***Helcom Std*** **MEPC.227 (64) Incl. sect. 4.2**	**MEPC.227 (64) Excl. sect. 4.2**	**MEPC.159 (55)**	**MEPC.2 (VI)**	***Alaska Std*** **GP 2013 DB0004 (<6kn)**	***Alaska Std***	**MSD Type II**	**MSD Type I**
Enforcement date		from 2019/21	**2016**	**2010, until 2016**	**1976, until 2010**	**from 2015/19**	**2001**	**1975**	**1975**
BOD5	mg/l	25	25	25	50	30	30	-	-
COD	mg/l	125	125	125	-	-	-	-	-
TSS	mg/l	35	35	35	100**	30	30	150	-***
Coliforms	cfu/100 ml	100	100	100	250	14	20	200	1000
res. Chlorine	mg/l	0,5	0,5	0,5	-	0,01	0,01	-	-
PH		6,0 - 8,5	6,0 - 8,5	6,0 - 8,5	-	6,0 - 8,5	6,0 - 9,0	-	-
Nitrogen, total	mgN/l	20* (or 70 % reduction)	-	-	-	-	-	-	-
Phosphorus, total	mgP/l	1,0* (or 80 % reduction)	-	-	-	-	-	-	-
Ammonia	mgN/l	-	-	-	-	78	?	-	-
Dis. Copper	µ/l	-	-	-	-	77	?	-	-
Enforcement and compliance monitoring		No	No	No	No	Yes	Yes	?	?

BOD5 – Biochemical Oxygen Demand, measure the amount of organic compounds in water
COD – Chemical Oxygen Demand, measure the amount of organic compounds in water
TSS – Total Suspended Solids

MEPC – Marine Environment Protection Committee
MSD – Marine Sanitation Devices (3 types)
(Type III MSDs store wastes and do not treat them)

* for passenger ships operating in special areas
** 100 mg/l when tested onboard, 50 mg/l when tested ashore
*** no visible floating solids

Table. 3.2.

DIFFERENT TREATMENT STANDARDS DEMAND DIFFERENT WATER QUALITY FROM THE EFFLUENT

	TREATMENT STANDARD							
To be removed from the sewage	IMO 2019/21 *Helcom*	IMO 2016	IMO 2010	IMO 1976	USCG 2015/19 *Alaska*	USCG 2001 *Alaska*	USCG 1975 Type II	USCG 1975 Type I
BOD5	High	High	High	Moderate	High	High	No	No
COD	High	High	High	No	No	No	No	No
TSS	High	High	High	Moderate	High	High	Moderate	Low
Chlorine	Moderate	Moderate	Moderate	No	High	High	No	No
Nutrients: N, P	High	No	No	No	Low	No	No	No
Pathogens	High	High	High	Moderate	Extremely	Extremely	Moderate	Low

Extremely	Removed from the effluent in **extremely high** level
High	Removed from the effluent in **high** level
Moderate	Removed from the effluent in **moderate** level
Low	Removed from the effluent in **low** level
No	The standard does not require

Performance of installed on-board treatment

The current provisions of MARPOL Annex IV regarding on-board treatment are based on the notion of type approval, and not actual performance or operation. In other words, there are no sanctions for a sub-optimally operating facility if it has been type approved and operated according to the instructions.

Closer follow-up of the operation of onboard facilities has been suggested as a way to ensure that treated sewage actually meets the standards set by type approval. Alaska is currently the only area of the world where such operational performance requirement of on-board sewage treatment exists. In the MARPOL system there is no adequate enforcement of proper working, and maintenance, of onboard sewage treatment plants (IMO 2017).

Surveillance and enforcement

Even if untreated discharges of sewage to the sea will not be allowed after 1 June 2021 (except for direct passages between St. Petersburg and the North Sea, for which there is an extension until 1 June 2023) the enforcement of this regulation is challenging as sewage discharges are difficult to see from satellites or airplanes. New technology, or alternatively a requirement to keep a sewage record book, would be needed to limit deliberate infringements.

04. OPERATIONAL OIL DISCHARGES FROM SHIPS

Introduction

Operational oil spills refer to various smaller spills that are not the result of ship accidents but, instead, result from discharges of small amounts of oil, or more usually unfiltered oily water. Such spills are usually the result of activities like cleaning of tanks or engine rooms at sea. These spills can be in fully deliberate or may be accidental in the sense that they result from unintentional, incorrect procedures. Even small amounts of oil can have a negative impact on the marine environment; seabirds for instance are very sensitive to oil.

The Baltic Sea was among the first sea areas in the world (adopted 1973, in force 1983 alongside the Mediterranean Sea, Black Sea, Red Sea and the Gulfs Area) to be declared as a special area for oil according to the MARPOL Convention Annex I.

This status means that oil and other petroleum products can be legally discharged to the sea only at very low concentrations, not visible to the naked eye (less than 15 ppm). This is achieved by passing all water discharged from engine rooms, cargo holds and other comparable spaces through a bilge separator/oil filter system. Thus, a non-accidental visible slick always implies an illegal oil spill in the Baltic Sea.

This long history means firstly that port reception of oil is, according to the 'no-special-fee' approach, covered by the obligatory environmental fee in practically every port in the Baltic Sea. Thanks to this, it is difficult to find any reason for the remaining intentional operational oil spills as there is no direct economic gain in discharging oil at sea (except perhaps time pressure). It is therefore likely that these spills are (at least partly) the result of action by uninformed mariners from other sea areas who are simply not aware of the rules and practices in the Baltic Sea.

Another consequence of the long history of work against operational oil spills is that there is a low tolerance of port and coastal states to even smaller spills. Combined with the very effective satellite and airplane surveillance in the Baltic Sea these factors have together led to the very small number of operational oil spills in the region compared with some other European sea areas (Kachel 2008). Continuous 24/7 satellite image coverage has further removed the concerns that a high number of undetected spills would take place during times and in areas not under aircraft surveillance.

However, even with modern surveillance equipment and high degree of satellite coverage, prosecuting of the operators of polluting vessels is still challenging. The situation has started to improve only recently as several information sources can be used by the public prosecutors to build convincing cases.

The significant reduction in operational oil spills in the Baltic Sea, which can be observed in the official HELCOM aerial surveillance data time series covering the period 1989-2016 is one of the often forgotten success stories of clean shipping in the Baltic Sea.

Figure 4.1.

LESS OIL DISCHARGES AND SMALLER AMOUNT OF SPILLED OIL

Number of observed spills and amount of oil detected in the Baltic Sea 1989–2015

Source: HELCOM Aerial surveillance data

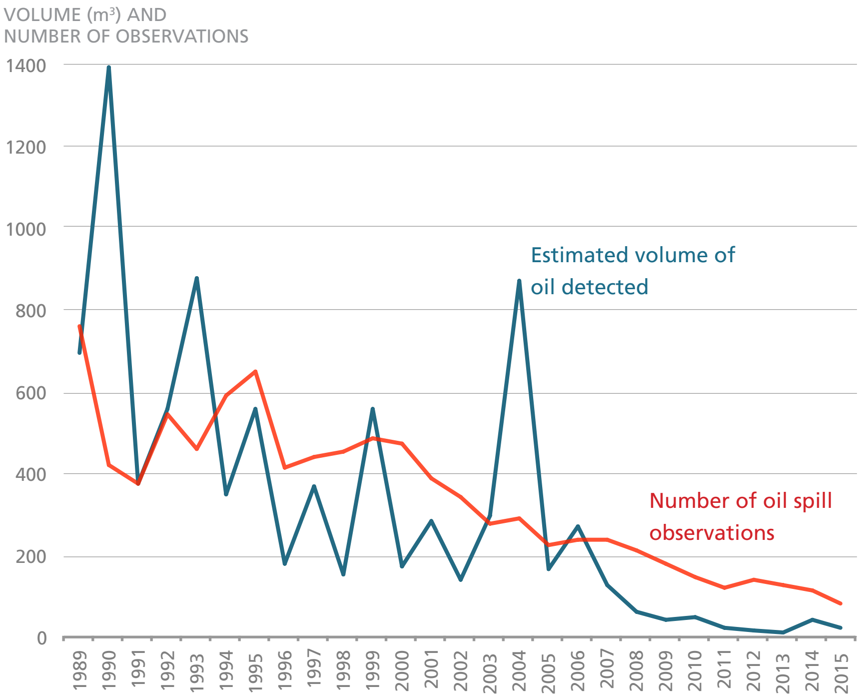
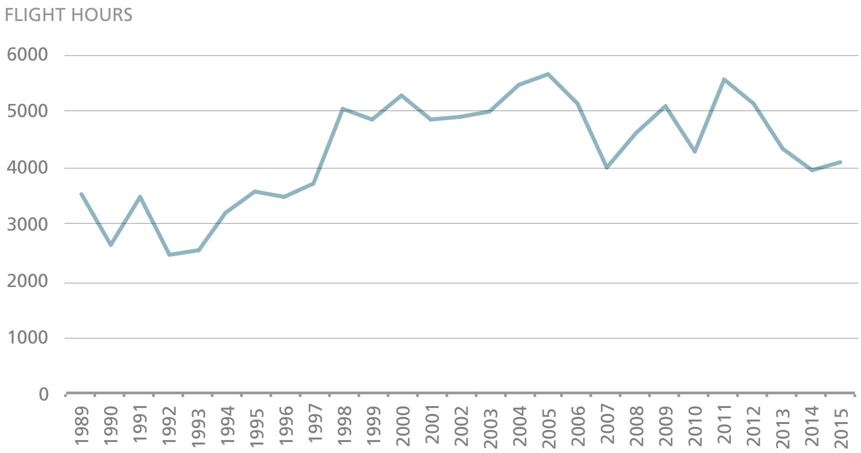


Figure 4.2.

THOUSANDS OF FLIGHT HOURS USED FOR OIL DETECTING

Flight hours HELCOM countries spent for oil observations in the Baltic Sea 1989–2015

Source: HELCOM Aerial surveillance data



Operational oil discharges in the Baltic Sea

Cooperation on aerial surveillance in the Baltic Sea was established already in the 1980s, which has enabled an unusually long time series of observed operational oil spills. The data shows the clearly decreasing trend in the number of illegal discharges of oil during the last ten years with the same level of surveillance in flight hours and even supported by intensified satellite observations since 2007.

The total estimated annual volume of oil spills observed in 2009–2015 has been in the order of 20 m^3 while during the 1990s the volumes were a magnitude higher and annual total estimated volume was below 200 m^3 only during two years. The operational spills have thus decreased by more than 90% since the early 1990s. Also, the number of spills has dropped significantly during the same period from the around 400–600 observed spills during the early 1990s to the 80 spills in 2015 (see Figures 4.1, 4.2 and 4.3 and HELCOM 2017).

Regulation related to operational oil discharges in the Baltic Sea

MARPOL Annex I targeting oil pollution defines oil as petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products. Subject to the provisions below any discharge of oil or oily mixtures into the Baltic Sea area is prohibited based on MARPOL and its Annex I as well as the 1992 Helsinki Convention.

1992 Helsinki Convention and HELCOM

Based on the Helsinki Convention and HELCOM Recommendation 19/10 the MARPOL Annex I Special Area requirements for oil separator arrangements, described below, apply also to ships of less than 400 gross tons, flying the flag of a Baltic Sea State.

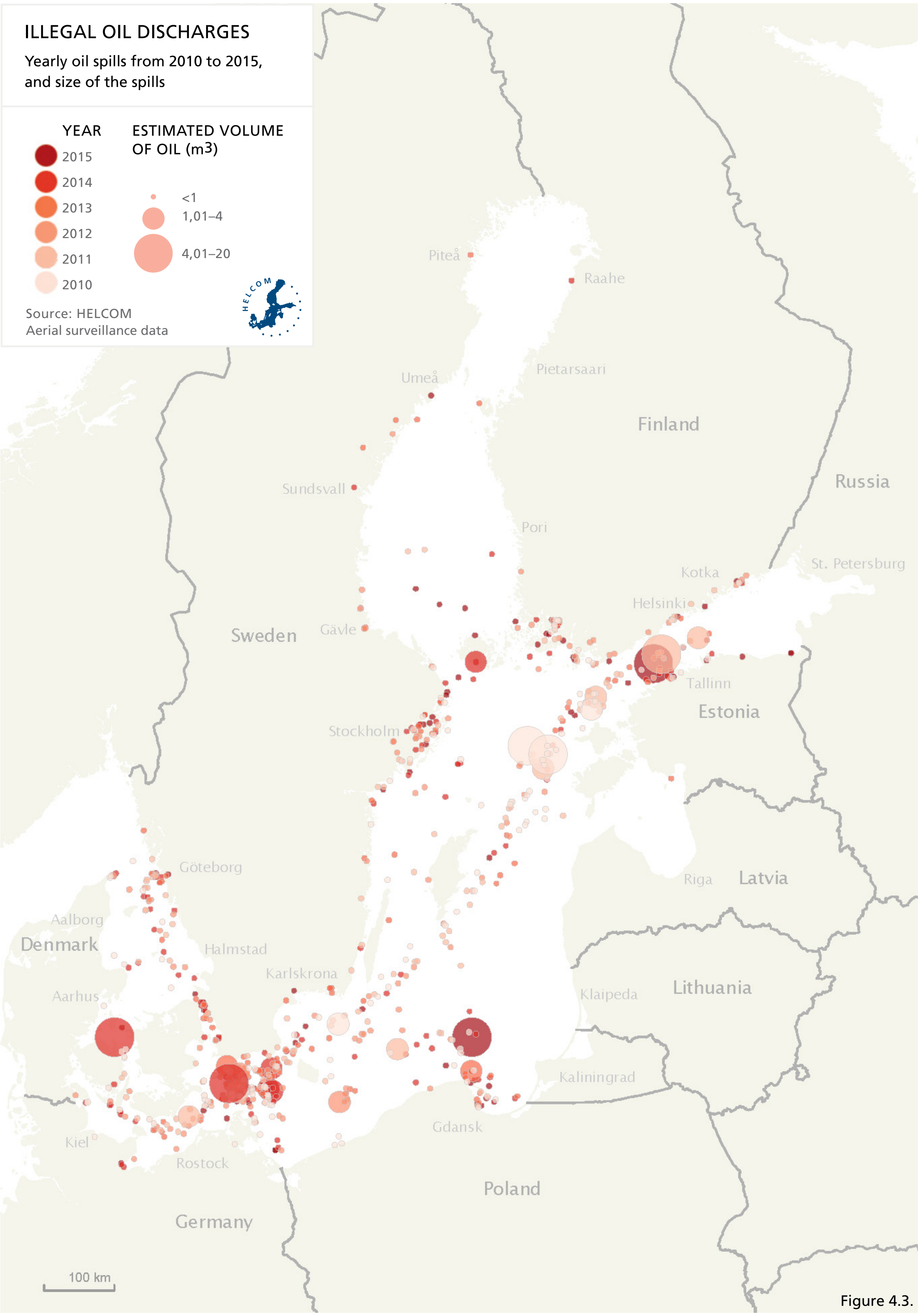
In addition, national regulations are in place in the Baltic Sea region. Finland has prohibited the use of bilge water separators in its inland waterways and in the territorial waters, within the area 4 nautical miles from the nearest land, and Denmark has a total ban on the discharge of oil in territorial waters.

MARPOL

The Baltic Sea was designated as a MARPOL Annex I Special Area in 1973 (in effect from 2 October 1983). Based on this a discharge can be permitted only if the oil content in the effluent does not exceed 15 parts per million (ppm).

In summary, MARPOL Annex I requires that, for ships of 400 gross tons and above, the oil filtering equipment must be provided with arrangements that ensure that any discharge of oil or oily mixtures is automatically stopped when the oil content in the effluent exceeds 15 parts per million. The permitted concentration 15 ppm is so low that it is not possible to see it with bare eyes.

The regulations apply not only to discharges from the cargo tanks of oil tankers but equally to discharges from the machinery spaces of any ship.


ILLEGAL OIL DISCHARGES
Yearly oil spills from 2010 to 2015, and size of the spills
YEAR
2015
2014
2013
2012
2011
2010
ESTIMATED VOLUME OF OIL (m3)
<1
1,01–4
4,01–20
Source: HELCOM
Aerial surveillance data
HELCOM
Piteå
Raahe
Umeå
Pietarsaari
Finland
Russia
Sundsvall
Pori
Kotka
St. Petersburg
Helsinki
Gävle
Sweden
Tallinn
Estonia
Stockholm
Göteborg
Riga
Latvia
Aalborg
Denmark
Halmstad
Karlskrona
Lithuania
Klaipeda
Aarhus
Kaliningrad
Gdansk
Kiel
Rostock
Poland
Germany
100 km
Figure 4.3.

Port reception of oil waste

All ports in the Baltic Sea are equipped with reception facilities for other residues and oily mixtures from all ships. As a general rule a "no-special-fee" system is applied in Baltic Sea ports to oily wastes from machinery spaces, in order to avoid incentives for illegal disposal, see HELCOM Recommendation 28E/10.

Oil loading terminals and repair ports are provided with reception facilities to receive and treat all the dirty ballast and tank washing water from oil tankers. The consignor in the loading port is responsible for reception arrangements for cargo-related wastes covered by MARPOL Annex I (oil residues from cargo tanks).

Aerial surveillance to detect operational oil discharges

Cooperation on surveillance within the Helsinki Convention is carried out in accordance with Annex VII (Regulations 1, 3, 4, 10) to the Helsinki Convention and HELCOM Recommendation 34E/4 and was established already during the 1980s.

The purpose of aerial surveillance is to detect spills of oil and other harmful substances, which can threaten the marine environment of the Baltic Sea area. These spills caused by accident or made in contravention of international Conventions will be registered and, if possible, sampled from both the sea surface and on board the suspected offender.

The aerial surveillance is complemented by satellite surveillance to enable bigger area coverage and to optimize the effectiveness of flights.

Within the framework of the Helsinki Convention a very close cooperation on airborne surveillance has been established. The cooperation aims at a high level of surveillance achieved by regular National Flights, special coordinated surveillance flights such as Coordinated Extended Pollution Control Operation (CEPCO) Flights, standardization of reporting formats and exchange of information to Contracting Parties as well as working together in improving existing systems and procedures.

All coastal states are committed to fly - as a minimum - twice per week over regular traffic zones including approaches to major sea ports as well as in regions with regular offshore activities. Other regions with sporadic traffic and fishing activities should be covered once per week.

Experienced observers and pilots are involved contributing to reliable detections, classifications and quantification of observed pollution, their frequencies and geographical distributions.

According to the HELCOM Response Manual the following equipment can be considered as standard for surveillance aircraft operating in the Baltic Sea and are used regularly: video/photo cameras, SLAR radar, IR-UV sensor, EO/IR sensor, AIS (Automatic Identification System) receiver, Maritime VHF with DSC, satellite positioning system (GPS or similar).

This standard equipment has overcome the limitations in identifying offenders visually during flights in darkness or poor visibility. Flights are for this reason regularly flown in darkness (according to the aviation definition) and the share of such flights is according to the HELCOM Response Manual recommended to be 15–25% on average.

The following equipment can be considered voluntary but is available on board some surveillance aircraft in the region: Microwave, laser fluorosensor, voice recording, satellite telecommunication, HF radio with DSC.

The HELCOM Informal Working Group on Aerial Surveillance (IWGAS) works to implement the aerial surveillance cooperation and commitments. The HELCOM Secretariat compiles annually data on illegal discharges observed in the Baltic Sea area during national and joint co-ordinated aerial surveillance activities.

Satellite surveillance to detect operational oil discharges

Satellite observations support regularly the efforts of the Baltic Sea states in their surveillance work. Satellite surveillance in the Baltic Sea has intensified since 2007 by the CleanSeaNet satellite surveillance service provided by the European Maritime Safety Agency (EMSA).

The coastal countries receive in near real time early warnings of potential oil spills based on satellite data from EMSA. This allows the countries to do spot checks by aircraft very soon after detection, which increases the likelihood of catching polluters red-handed. In around 60% of cases aircraft can reach slicks in time to be checked. Typical false positive detections are caused by natural phenomenon like waves.

Enforcement and prosecution of operational oil discharges

The purpose of regional aerial surveillance is to detect spills of oil and other harmful substances and thus prevent violations of the existing regulations on prevention of pollution from ships. To enable this, surveillance activities aim always to establish the identity of a polluter. The coastal countries also make efforts to sample spills from both the sea surface and on board suspected offenders to enable prosecution. However, even today in a majority of cases of detected discharges polluters remain unknown.

The identification of ships suspected of illegally discharging oil into the sea is further facilitated by tools such as the HELCOM SeaTrackWeb (STW) oil drift forecasting system as well as EMSA tools linked to the CleanSeaNet service. This tool, in combination with AIS data, is used for backtracking and forecasting simulation of detected oil spills, and matching the ship tracks with oil spill backtracking trajectory. STW, enriched with AIS, have also been integrated with satellite information to increase the likelihood that polluters will be identified.

05. OPERATIONAL DISCHARGES OF CHEMICALS

Introduction

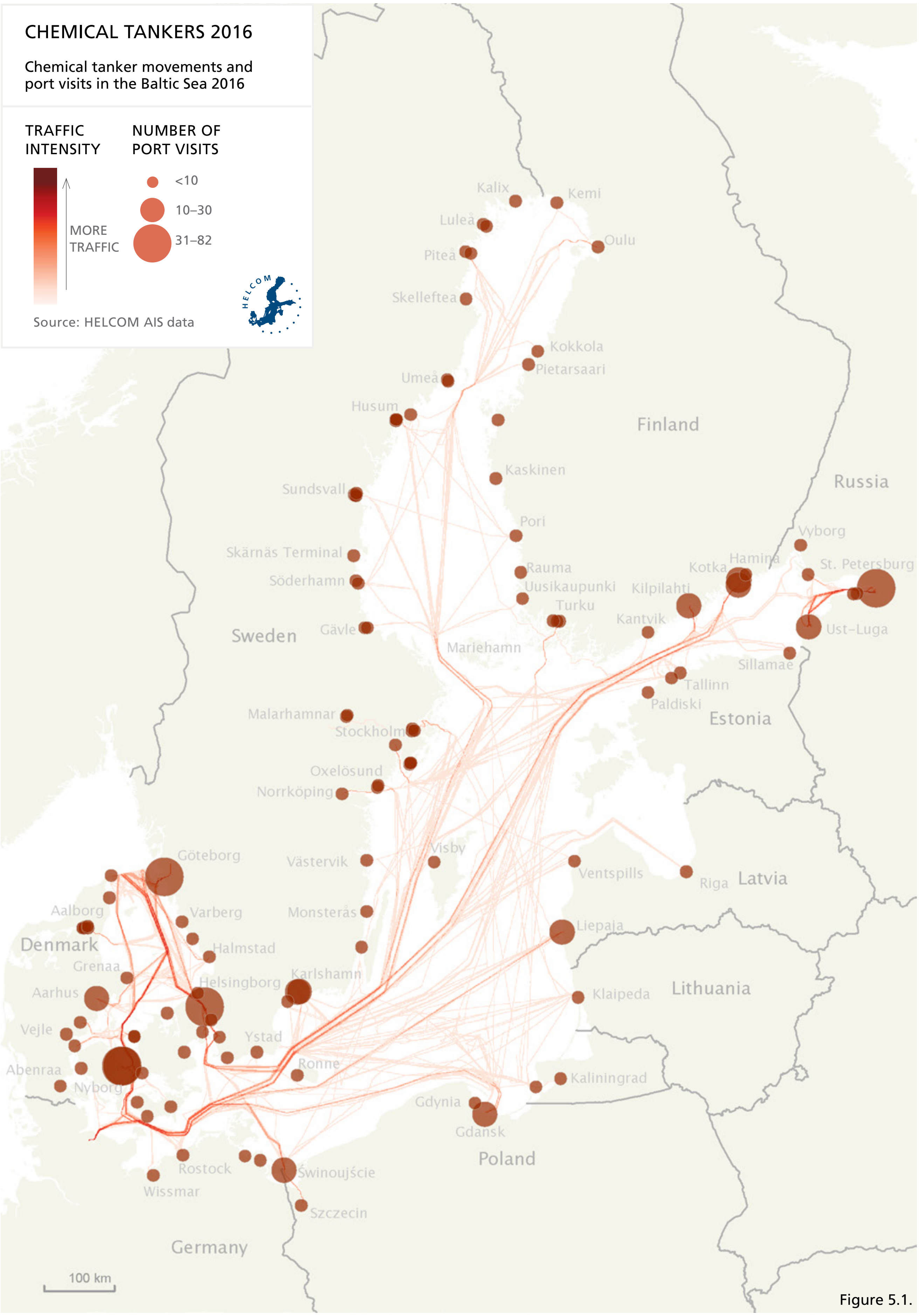
Our highly technological societies use large numbers of different potentially hazardous substances other than oil and oil products. Many of these are transported by sea in the Baltic Sea, some in high, but mostly in smaller quantities. The vessels carrying these chemicals are rarely specialised in a single substance but transport instead a large number of different chemicals based on customer needs (Hänninen & Rytkönen 2006; Posti & Häkkinen 2012).

As the carried chemicals are not necessarily identical, tanks have to be washed between such operations to ensure purity of the next cargo (McGeorge 1995). Due to this fact tank washing, and a series of flushing rounds to empty even traces of the contents, is an essential feature of chemical tanker operations (Kunichkin 2006).

As chemicals are commonly relatively expensive per volume unit, operators have usually their own economic self-interest in emptying the tanks to the highest degree practically possible before washing. However, some of the substance will remain in the tanks even after a prewash procedure and only a high number of repeated washing/flushing will reduce all traces of the carried chemicals (McGeorge 1995; Kunichkin 2006).

However, as time in port and the use of port reception facilities have economic consequences to the terminal or the ship operators, there are practical and economic limits to the level of washing which is required to be carried out in port. The flushing commonly continues at sea and for this reason some effluents of this tank washing, or more commonly water from secondary flushing after washing, is usually discharged to the sea. This water usually includes at least some traces of the carried chemical (Honkanen *et al* 2012).

The toxicity or harmfulness of the carried substance determines the level of tank cleaning required before such operational discharges to the sea from tanker vessels carrying chemicals. As there exist thousands of chemical substances carried by sea, substances have, for this purpose, been grouped according to harmfulness, and thus, the level of required tank cleaning before any discharges to the sea.


CHEMICAL TANKERS 2016
Chemical tanker movements and port visits in the Baltic Sea 2016
TRAFFIC INTENSITY
MORE TRAFFIC
NUMBER OF PORT VISITS
<10
10–30
31–82
Source: HELCOM AIS data
HELCOM
Kalix
Kemi
Luleå
Oulu
Piteå
Skellefteå
Kokkola
Pietarsaari
Umeå
Husum
Finland
Russia
Kaskinen
Sundsvall
Pori
Skärnäs Terminal
Söderhamn
Rauma
Uusikaupunki
Turku
Kotka
Hamina
St. Petersburg
Vyborg
Kilpilahti
Kantvik
Ust-Luga
Sweden
Gävle
Mariehamn
Sillamäe
Tallinn
Paldiski
Estonia
Malarhamnar
Stockholm
Oxelösund
Norrköping
Göteborg
Västervik
Visby
Ventspills
Riga
Latvia
Aalborg
Varberg
Monsterås
Liepaja
Denmark
Halmstad
Grenaa
Karlshamn
Aarhus
Helsingborg
Klaipeda
Lithuania
Vejle
Ystad
Abenraa
Nyborg
Ronne
Kaliningrad
Gdynia
Gdansk
Poland
Rostock
Swinoujście
Wissmar
Szczecin
Germany
100 km
Figure 5.1.

The level of such operational discharges of chemicals is based on grouping, essentially a form of risk assessment based on the properties of the substance. It is clear that due to the number of substances involved some possible environmental effects might have been overlooked in the classification. This is usually a challenging issue to study further as the discharges are done offshore while the ship is moving and as the volumes released are usually relatively small (Honkanen *et al.* 2012).

One example of a class of substances which seem to warrant a review of the existing tank washing requirements are high-viscosity, solidifying and persistent floating products in the least toxic substance group (category Z, minor hazard). These include for example paraffin wax. Although these substances are not toxic in the traditional sense of the word they have very low solubility in water, float on the surface after discharge and eventually end up on shore (Dahlmann *et al.* 1994; Camphuysen *et al.* 1999). Furthermore, these substances might be mistaken by seabirds or other marine animals as food.

Over the last ten years, relatively large amounts of paraffin wax and similar products, which most likely originate from tank washing/flushing, have been found on the beaches of the Baltic and North Sea countries and needed to be cleaned. This has triggered an ongoing process to review the classification, and tighten the discharge requirements of these substances at IMO level.

Discharges of Hazardous and Noxious Substances (HNS) cargo residues in the Baltic Sea

Figure 5.1 shows ports visited by chemical tankers as well as their traffic density in the Baltic Sea based on AIS (Automatic Identification System) data.

The amount of a chemical that may legally be released into the sea per cargo tank is 75–300 litres depending on the ship's construction year (Appendix 4 to MARPOL Annex II). When chemical remnants are washed away with water, the total quantity of slop generated per tank in the main washing procedure may vary from 10 m^3 to hundreds of cubic meters per tank (HELCOM 1993). A ship has typically 10–60 cargo tanks (Hänninen & Rytkönen 2006).

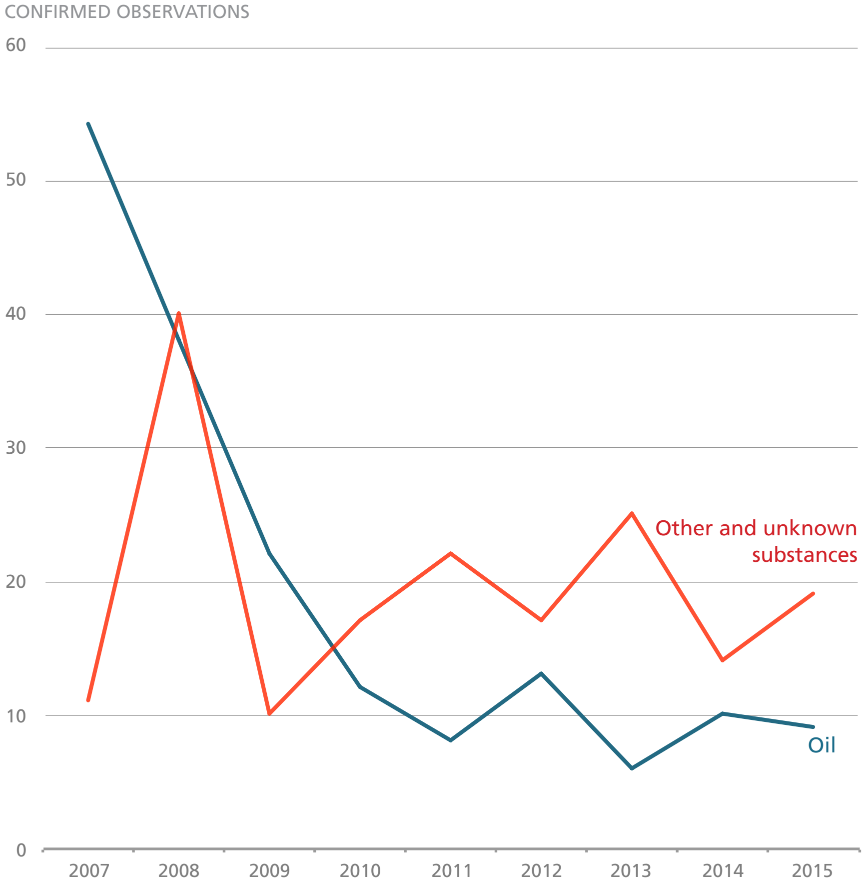
During the recent decades the aerial surveillance contacts of the Baltic Sea coastal countries have reported orally at HELCOM meetings on a number of confirmed detections of "other substances" or "unknowns" in the Baltic Sea. This indicates observations of substances other than oil, or other targets which are not natural phenomena, but which could not be identified more precisely with the available sensors or the naked eye (Figure 5.2).

As such other substances have not been a cause of concern previously, they have not been systematically covered in the aerial surveillance data collection in the Baltic Sea before 2016. Nevertheless, such observations have been included since 2007 in the EMSA satellite detections sent to those coastal countries which are also EU countries in near real time and who have made efforts to check them within three hours of satellite detection. Even if the absolute number of detections varies a lot between years, after 2010 there has been a higher number of confirmed observations including

LESS OIL DISCHARGES BUT MORE OTHER SUBSTANCES?

Number of other and unknown substances and oil detected in the Baltic Sea 2007–2015

Figure 5.2.



Source: HELCOM 2017, Satellite detections confirmed by aerial surveillance

"other substances" or "unknowns" (Figure 5.2).

Even if the aerial observations data does not give a clear picture, there has been an increasing number of incidents where floating paraffin wax and similar chemical products have been observed on beaches in Germany and Denmark, both on the coast of the Baltic Sea and the North Sea, as well as in Lithuania and Poland.

According to MARPOL Annex II, most paraffin is classified as a code "Z" substance, and thus, of minor hazard to the environment, for which pre-washing at a port reception facility is not required.

According to data from Germany, a number of these pollution incidents have involved large quantities of paraffin products which are according to official reports most likely from cargo residue discharged at sea by tankers (Table 5.1). In this kind of cases beaches must be closed to the public and expensive cleaning operation must be carried out.

The damages in the Baltic Sea have been limited to economical costs of clean-up. However, on the coast of South-West England, incidents with a polyisobutylene (or polyisobutene, PIB) killed a large number of seabirds in 2013 (Aldred 2013). PIB is an oil additive often used to improve the performance of lubricating oil and in products ranging from adhesives to sealants and chewing gum. This specific product was rapidly reclassified by the IMO

Table 5.1. "Z" SUBSTANCE POLLUTION INCIDENTS IN GERMANY 2007–2014

RESPONCE OPERATION START/STOP	NAME OF AREA	COASTLINE AFFECTED	VOLUME OF WASTE
27.04.2014 / 30.04.2014	Rügen / Tromper Wiek	10 km	32,5 m³
21.02.2012 / 27.02.2012	Fischland-Darß & Hiddensee	25 km+25 km	11 t
02.06.2010 / 04.06.2010	Usedom	10 km	64 t
21.05.2010 / 23.05.2010	Rügen, north side	30 km	100 m³
18.05.2007 / 19.05.2007	Dierhagen / Darß	10 km	150 m³

Sources: HELCOM meeting reports

during the course of 2013, and any discharging without prewashing the tanks is now prohibited.

Regulation related to HNS

1992 Helsinki Convention

Within HELCOM, and 1992 Helsinki Convention, HNS is mainly dealt with under the general provisions related to pollution from ships.

MARPOL & International Bulk Chemical (IBC) Code

MARPOL Annex II (Noxious liquid substances in bulk) originally entered into force on April 6, 1987 to protect the environment by controlling operational pollution and reducing accidental pollution resulting from groundings and collisions from vessels carrying Hazardous and Noxious Substances (HNS) in bulk. Annex II substances can be any bulk liquid that does not meet the definition for oil as defined in MARPOL Annex I. These substances might include, inter alia: petrochemicals, solvents, waxes, lube oil additives, vegetable oils and animal fats.

In 2004 MARPOL Annex II and the related IBC Code, were thoroughly revised (in effect January 1, 2007). These revisions changed significantly carriage requirements for HNS in bulk. The aim was to make the regulations easier to use via a new categorization, and to take into account new knowledge about the effects of some chemical products on the marine environment. Even if the Baltic Sea was a special area under the old MARPOL Annex II, this was lifted with the revision and the same MARPOL Annex II rules apply as elsewhere.

MARPOL Annex II and the IMO International Bulk Chemical (IBC) Code divide substances to Categories X (major hazard/very harmful), Y (hazard/harmful), Z (minor hazard/minor harm) and OS (considered not harmful, not subject to any requirements of MARPOL Annex II). Examples of OS products carried in bulk are clay slurry, molasses, and apple juice. Specific stripping and discharge requirements for the different substance categories are summarised in Table 5.2 below.

The carriage and discharge into the sea of noxious liquid substances, which have not been categorized to these categories, or provisionally assessed/evaluated, is prohibited. This prohibition applies also to non-categorized substances contained in ballast water, tank washings, or other residues or mixtures.

According to MARPOL Annex II every ship certified to carry substances of Category X, Y or Z shall have on board a Procedures and Arrangements (P&A) Manual approved by the Flag State administration.

Tanks having contained IBC Code Category X substances must be prewashed and the resultant tank washings must be delivered to a reception facility before a ship leaves the port of unloading. The concentration of the substance in the effluent to the facility must be at or below 0.1% by weight and after this the tank must be fully emptied to the facility.

Tanks having contained IBC Code Category Y or Z substances must be pre-washed if unloading of cargo has not been carried out in accordance with the P&A Manual and the resultant tank washings must be delivered to a reception facility before a ship leaves the port of unloading. The exception is high-viscosity or solidifying substances in IBC Code Category Y for which specific pre-wash procedures (Appendix 6 of MARPOL Annex II) must be applied and the residue must be discharged to a reception facility at the port of unloading until the tank is empty.

Table 5.2.

STRIPPING AND DISCHARGE REQUIREMENTS FOR NOXIOUS LIQUID SUBSTANCES CARRIED IN BULK
Laid in revised MARPOL Annex and IBC code

CATEGORY	BCH SHIPS: constructed before 1 July 1986	BCH SHIPS: constructed on or after 1 July 1986 but before 1 January 2007	NEW SHIPS: keel laid down after 1 January 2007	OTHER THAN CHEMICAL TANKERS: keel laid down before 1 January 2007
X major hazard / very harmful	strip 300 + 50 L tolerance prewash max 1,0 % 12 mile 25 m depth 7 knots, en route	strip 100 + 50 L tolerance prewash max 1,0 % 12 mile 25 m depth 7 knots, en route	strip 75 L prewash max 1,0 % 12 mile 25 m depth 7 knots, en route	carriage prohibited
Y - high viscosity / solidifying substance hazard / harmful	strip 300 + 50 L tolerance prewash 12 mile 25 m depth 7 knots, en route	strip 100 + 50 L tolerance prewash 12 mile 25 m depth 7 knots, en route	strip 75 L prewash 12 mile 25 m depth 7 knots, en route	carriage prohibited
Y hazard / harmful	strip 300 + 50 L tolerance 12 mile 25 m depth 7 knots, en route	strip 100 + 50 L tolerance 12 mile 25 m depth 7 knots, en route	strip 75 L 12 mile 25 m depth 7 knots, en route	carriage prohibited
Z minor hazard/ minor harm	strip 900 + 50 L tolerance 12 mile 25 m depth 7 knots, en route	strip 300 + 50 L tolerance 12 mile 25 m depth 7 knots, en route	strip 75 L 12 mile 25 m depth 7 knots, en route	strip to max extent 12 mile 25 m depth 7 knots, en route
OS not harmful	no limitations	no limitations	no limitations	no limitations

Source: Modified from INTERTANKO 2006

The eventual discharge of any residues of substances in Categories X, Y or Z into the sea, remaining after the tank washing and discharge specified above, must be done below the waterline while proceeding en route at a sufficient speed (7kn for self-propulsion) at minimum 12 NM distance from the nearest land and in water depth of at least 25 m.

Pre-washing – an efficient measure for chemicals carried in liquid bulk

Based on modelling, when pre-washing has been carried out properly, the subsequent tank washings released to the sea seem to represent only a very minor and local risk for the marine environment even when involving substances of the most toxic cargo category X (Honkanen et al 2012). It can be thus considered an effective measure, even if this should be verified by measurements in the sea around a real discharge.

Future perspectives

Amendments to MARPOL Annex II related to the discharge of cargo residues and tank washings of high-viscosity, solidifying and persistent floating products

Even if technically allowed under the 2007 revisions of MARPOL Annex II, the frequency and volumes of incidents of high-viscosity, solidifying and persistent floating products washing up on the coasts of the Baltic Sea countries run intuitively against the meaning and purpose of MARPOL.

Even if some commentators have raised the idea to re-introduce special areas under MARPOL Annex II, currently tightened discharge and pre-wash requirements for all high-viscosity, solidifying and persistent floating products (regardless whether classified as category X, Y or Z substance) have been the focus of global discussions. This includes proposals to change the temperature at which "high-viscosity" is determined to e.g. 20°C compared to current "at discharge temperature" as well as to change the "en route" definition to ban the practice of circumventing the regulation by going out from port to discharge at sea, and returning to the same port for loading.

As in many other MARPOL regulations port reception facilities are a critical link as proper pre-wash implementation is completely depending on the availability of adequate reception facilities.

As around 150 products in the IBC Code are classified as "floaters" alone, and as some of these are carried in high volumes, this would in itself be a major commitment and will likely take a long time to negotiate with the industry.

Aerial surveillance and new sensors for HNS substances

Observations of hazardous noxious substances (HNS) discharges are a challenge today as the number of different substances is large and as adequate sensor systems are not available, as sensors have been heavily focusing on oil. Due to the number of different substances carried by chemical tankers, a single sensor approach, covering all possible substances, is naturally not possible. Instead, any future instruments will target some main characteristics of some substance groups of interest.

For this purpose X, Y and Z substances should be studied in depth to identify which of those substances are floaters (and so can be measured by a sensor from an aircraft) and the likelihood of their release. Also the practices of MARPOL Annex II discharges, as well as routes and typical cargoes should be studied more to develop HNS aerial surveillance as well as the related technology further.

Airborne hyperspectral cameras have been studied as a possible future tool to enable detection of HNS discharges. In addition, Microwave Radio Meter and Laser-Fluorosensors have also been identified as promising technologies for aerial surveillance of HNS.

06. SHIPS' BALLAST WATER IN THE BALTIC SEA

Introduction

All ships are designed for a certain cargo load range. For this reason weight (ballast) needs to be taken on board after unloading of cargo in order to reduce stress on the hull, provide stability as well as to optimise propulsion and manoeuvrability.

While stones or other heavy items were used for this purpose during the age of sail ships, modern vessels use water pumped into dedicated ballast water tanks. Most of ballast water is taken or discharged at the place of cargo handling, which in most cases means a port.

As ports are often situated in estuaries, and as ship movements mobilize sediment to the water column, this water commonly contains a relatively high concentration of suspended matter as well as organisms, whether as eggs/cysts, larvae or full-grown individuals, from bacteria to small fish.

As the ship may travel a long distance before it loads new cargo, and consequently discharges its ballast water, it may happen that the organisms contained in the ballast water tanks are released alive to a new environment where they may thrive but where they are non-indigenous. Even if ballast water would be exchanged along the voyage, the complex internal structure of a ballast tank allows many locations for sediments and organisms to become trapped and accumulate over several voyages.

Due to the large volumes of ballast water transported around the world, species introductions via this mechanism are common. As some of the introduced species become invasive in their new environments, species introduction and spread may pose substantial threats to marine biodiversity but also economy and health.

Consequently, the introduction of invasive species via ships' ballast water has been identified as a major threat to the world's oceans and to biodiversity globally (McNeely *et al*. 2001).

The characteristics of the Baltic Sea as a relatively young brackish water sea with intense maritime traffic makes it prone to entrance and settlement of non-native species present in ships' ballast water. By 2016, 80 non-native species of the total of more than 130 observations, have been documented to settle permanently in the Baltic as a result of ship-vector introductions (ballast water but also hull fouling) (Ojaveer et al. 2017). Over time, the central introduction pathways of non-indigenous species, both in terms of primary introductions and secondary spread from nearby areas, have been shipping, then stocking and natural spread (Ojaveer et al. 2017).

Ballast water and invasive species introductions in the Baltic Sea

Ballast water is assumed to be one of the main pathways of non-indigenous species introductions to the Baltic Sea marine environment (HELCOM 2017, Ojaveer et al. 2017).

Ballast water transport and discharge in the Baltic Sea

Bulk cargo ships and tankers are the ship types which carry the largest amount of ballast water. Even if no quantitative estimations are available on the volumes one can use the movement patterns of these ship types as a kind of "proxy" to illustrate the movement of ballast water to, from and within the Baltic Sea (Figure 6.1).

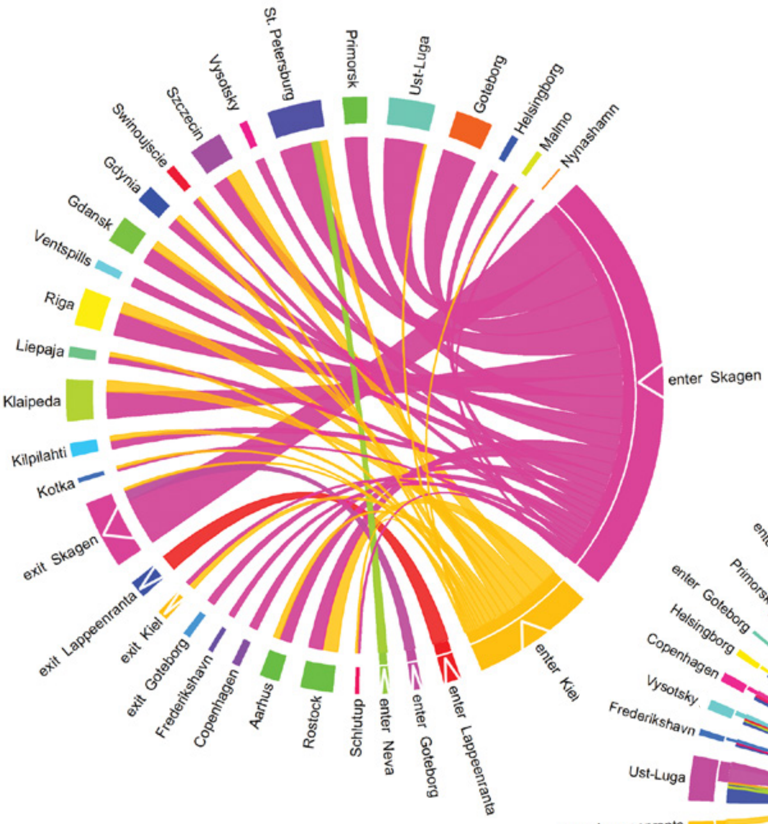


Figure 6.1. Movements of ships (cargo ships and tankers, based on AIS data) from outside the Baltic Sea (on the left) and also between larger Baltic Sea ports in terms of trips (on the right). The figure is only showing when there are more than 50 trips from outside the Baltic Sea to a certain port or between two ports.

Alien species introductions to the Baltic Sea via ships

In order to have an overview of species introductions over time, a comprehensive list of non-indigenous (NIS), cryptogenic (CS) and harmful native species introductions in the Baltic Sea has been compiled and updated by HELCOM since 2008. Lately updates have been carried out as part of the work to develop a HELCOM core indicator for non-indigenous species (HELCOM 2017).

Based on this data the development of alien species introductions over time is presented in Figures 6.2 and 6.3.

Regulation related to Ballast water and invasive species in the Baltic Sea

The 1992 Helsinki Convention

Invasive species are not explicitly mentioned in the 1992 Convention but the issue falls under the provisions on biodiversity (Art. 15) and those on pollution from ships (Art. 8).

In order to address this threat to the biodiversity of the Baltic Sea, the coastal countries have early on co-operated within HELCOM for a harmonized implementation of the 2004 Ballast Water Management Convention (BWMC) of the International Maritime Organisation (IMO) in the Baltic Sea area. This kind of regional work is foreseen in Article 13 of the IMO BWMC.

Besides monitoring of new species these actions have included regional measures such as recommendations regarding ballast water exchange, definitions of target species and regional procedures for estimating the risk of introductions by ship voyages.

As a first milestone the Contracting Parties to the Helsinki Convention agreed in 2007 upon a roadmap in order to structure the joint efforts towards ratification of the BWMC. A new roadmap was adopted in 2016 after most of the actions in the original document had been completed.

The 2004 IMO Ballast Water Management Convention (BWMC)

In order to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens (HAOPs) through the control and management of ships' ballast water and sediments, the BWMC was adopted by the IMO in 2004, providing the international regulation framework to face this global marine biodiversity threat.

It aims to reach its goal through the treatment, control and management of ships' ballast water and sediments. The detailed provisions require ships in international traffic to manage their ballast water and sediments (Regulation B-3) to certain standards specified in the Convention (Regulation D-2), documented in an international ballast water management certificate. Further, the ships are required to keep a ballast water management plan as well as a ballast water record book, which document uptake and release of ballast water.

The IMO BWMC entered into force on 8 September 2017. However, there is a phase-in period after the entry into force to enable existing ships to implement their ballast water and sediment management plan and to retrofit a ballast water treatment system. During this period there is also

NUMBER OF NIS AND CS INTRODUCTIONS IN THE BALTIC SEA
Number of species per decade from prior to 1840 to 2016

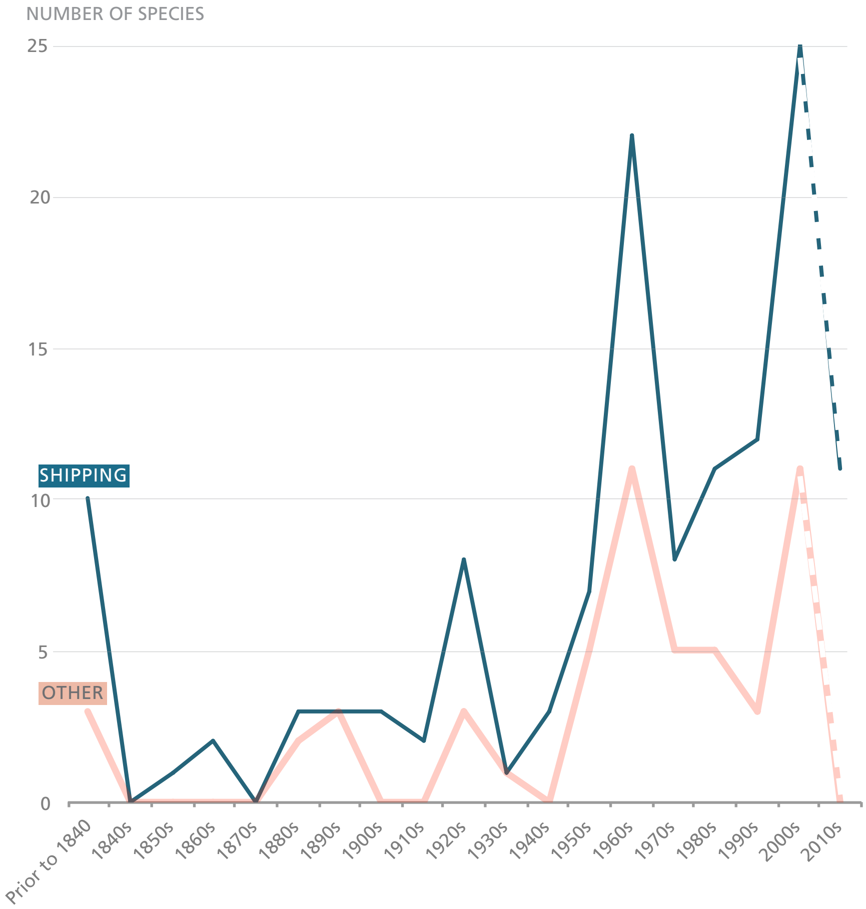
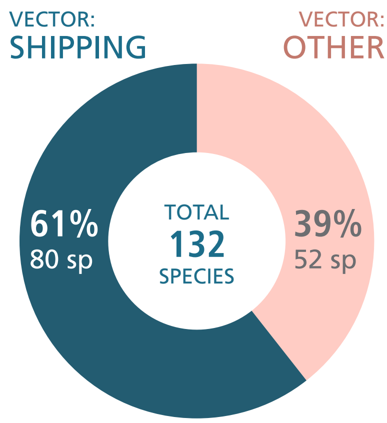


Figure 6.2
Source: HELCOM 2017



CUMULATIVE NUMBER OF NON-INDIGENOUS SPECIES IN THE BALTIC SEA
Number of species per decade from prior to 1840 to 2016

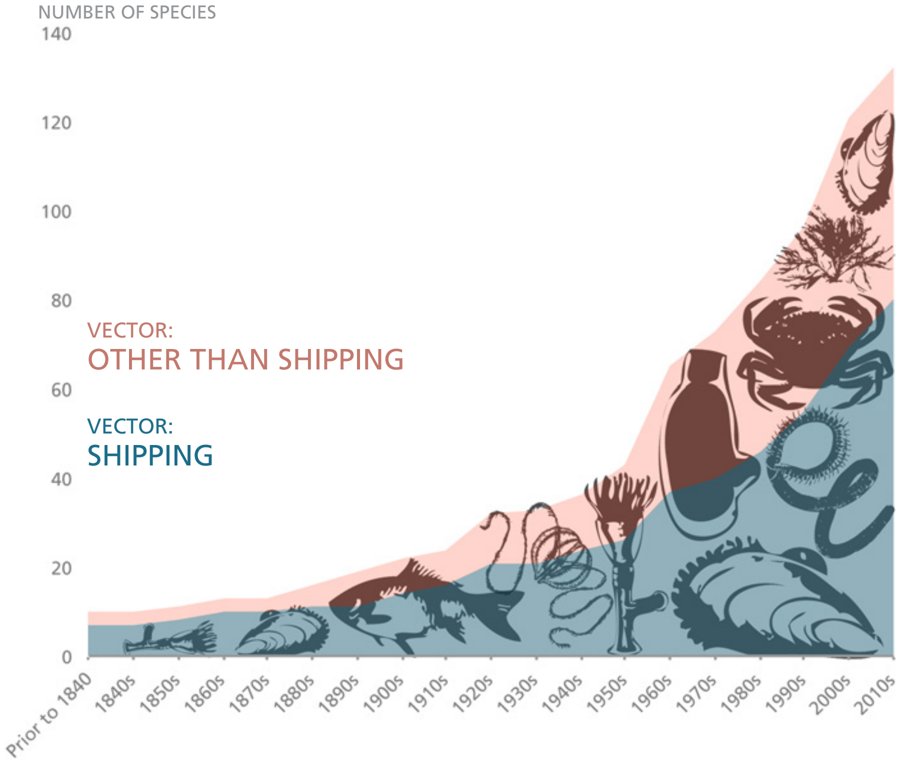


Figure 6.3.
Source: HELCOM 2017

the option to exchange ballast water in the open sea under certain conditions of depth and distance from the shore (Regulation D-1). However, as no such areas have been identified in the Baltic Sea, ballast water exchange is not permitted within the region.

The BWMC has been organized in five sections (General provisions, Management and control requirements for ships, Special requirements in certain areas, Standards for ballast water management and Survey and certification requirements for ballast water management) with technical standards and requirements for the control and management of ships' ballast water and sediments.

Due to the challenges in implementing this complex Convention which involves aspects of marine biodiversity, engineering and socio-economic trade-offs, the IMO, through its Marine Environment Protection Committee (MEPC), has developed a permanently updated set of 15 technical Guidelines with the aim of helping stakeholders on the implementation of the Convention.

Even if IMO Guidelines reflect a consensus at IMO level, and are thus highly authoritative, they sometimes lack all the details needed for harmonised implementation in a specific region like the Baltic Sea. Such details can, and have been, provided through HELCOM regional co-operation.

Ballast water treatment

According to the BWMC, ballast water has to be managed in order to fulfil the D-2 Standard that allows it to be discharged into the sea. In most cases, a treatment of the ballast water will be needed to reach the standard.

The Convention does not provide specific requirements regarding treatment methods. However, treatment systems have to be type approved following the IMO Guidelines (G8), and moreover, technologies that make use of active substances should be also approved by the MEPC of IMO (according to the IMO Guidelines G9).

For that purpose, there are different methods of treatment and a variety of IMO type -approved and available commercial solutions for installation on board. Most systems commercially available comprise two stages of treatment with a physical solids-liquid separation, followed by disinfection.

Regional ballast water exchange recommendations

The IMO Guidelines G6 provide specific depth and distance from the shore requirements for ballast water exchange (BWE). Ballast water can only be discharged at least 200 nautical miles from the nearest land and in water at least 200 meters in depth, and if it is not possible – as far as from the nearest land but at least 50 nautical miles from the nearest land and in water at least 200 meters in depth (Regulation B-4).

These depth and distance from the shore requirements cannot be met anywhere in the Baltic Sea. For such cases, according to the Convention, special areas for BWE could be designated following the IMO Guidelines (G14). However, HELCOM has concluded that most of the alien species in the Baltic Sea have a wide tolerance in salinity, so therefore, it was agreed that BWE was not a suitable option within the Baltic Sea.

Instead, effective cooperation on ballast water exchange between Helsinki Convention in the Baltic Sea, the OSPAR Convention for the North-

East Atlantic and the Barcelona Convention in the Mediterranean Sea took place. Three voluntary interim guidelines have been agreed upon indicating where ballast water is to be exchanged in the combined sea area covering the Baltic Sea, the North-East Atlantic and the Mediterranean Sea, depending on the route of the ship.

These regional Ballast Water Exchange Guidelines can be summarised as follows:

- General Guidance on the Voluntary Interim Application of the D-1 Ballast Water Exchange Standard in the North-East Atlantic : jointly adopted by HELCOM and OSPAR countries and applicable from 1 April 2008. According to them, vessels transiting the Atlantic or entering the North-East Atlantic from routes passing the West African Coast are requested to conduct, until entry into force on a voluntary basis, BWE before arriving at the OSPAR area or passing through the OSPAR area and heading to the Baltic Sea.
- Similarly, HELCOM and OSPAR countries agreed that vessels leaving the Baltic and transiting through the OSPAR maritime area to other destinations will be requested, starting from January 2010, to discharge their ballast water until the vessel is 200 NM off the coast of North-West Europe in waters deeper than 200 m, with the aim of avoiding BWE within HELCOM and OSPAR areas. This agreement adopted the form of General Guidance of voluntary application. Additionally, a Joint Notice to Shipping Industry and the Instructions to Surveyors on both Guidelines was developed for their use by HELCOM and OSPAR countries.
- General Guidance on the voluntary Interim Application of the D-1 Ballast Water Exchange Standard by Vessels operating between the Mediterranean Sea and the North-East Atlantic and/or the Baltic Sea, applicable since 1 October 2012, recommends that vessels should exchange ballast water from all their ballast tanks at least 200 NM from the nearest land in water at least 200m deep, as soon as they enter or leave the North-East Atlantic, depending on the direction of their route, but outside the Mediterranean Sea.

All these guidance documents have an voluntary, interim character and they will no longer apply when a ship is in a position to apply the D-2 Standard of the BWMC, or latest when the Convention comes into force and a ship has to apply the D-2 Standard.

Exemptions based on harmonized robust risk assessment

Under certain low risk conditions the BWMC Regulation A-4 enables parties to grant exemptions to any requirements to apply regulation B-3, on ballast water management for ships, or regulation C-1, on measures additional to those in Section B of the Convention. The IMO Guidelines for risk assessment under regulation A-4 of the BWM Convention (G7) outline the general framework for these exemptions.

In order to ensure a transparent and harmonised implementation of exemptions in the Baltic Sea and North-East Atlantic, HELCOM and the OSPAR Commission agreed together on more comprehensive and detailed joint harmonised procedure on A-4 exemptions in October 2013: the “HELCOM-

OSPAR Joint Harmonized Procedure for BWMC A-4 exemptions (JHP)". The agreed procedure is based on and fully in line with the G7 IMO Guidelines and specifies concrete procedural steps for granting BWMC A-4 exemptions in the combined HELCOM and OSPAR marine area.

After consultation of the affected coastal state, port surveys of alien species and physical parameters in the ports concerned should be carried out according to the port survey protocol described in the JHP, or results of surveys carried out by others (according to the JHP) can be accessed to. This information should cover each stopover port on the route for which the exemption is applied.

Through operational tests the agreed methodology has been optimised to ensure reliable and comparable results with minimal costs. As a feature introduced to further ease the burden and costs involved the port surveys carried out according to the JHP are regarded as valid for re-use during a period of maximum of five years.

As a second step the applicant should submit the port survey data to a joint regional HELCOM-OSPAR database (www.jointbwmexemptions.org), established with the joint procedure, and run an online risk assessment on the data.

The risk assessment is based on matching the lists of species found in the stopover ports, a risk assessment algorithm and list of target species included in the joint procedure and the tolerances of target species to environmental parameters. The adopted approach is thus a combination of the species-specific and environmental matching risk assessment mentioned in IMO G7.

Finally, the applicant should attach the results of the risk assessment to an application fulfilling other national requirements and submit for the consideration of port states. The administrations will then carry out an overall evaluation of the available data and information and grant or deny an exemption.

The BWM Convention opens additionally for "exceptions" of ballast water management for voyages involving ballast water uptake and release in the so called "same location" (see A-3 of the BWM Convention), but does not provide an exact definition of the extent of such locations. This issue has also been considered in regional discussions, but without any regionally harmonized conclusions so far.

Future perspectives

DNA barcoding to cut costs of alien species monitoring

Monitoring the presence of alien species is a challenging task. Besides sampling it needs taxonomic expert knowledge for reliable species identification.

Modern DNA barcoding technologies have enabled the identification of species from larvae and other traces found in the water. This offers an opportunity for the identification of the presence of species from e.g. water samples. However, this approach is based on DNA libraries, which are not always available for rare species. The field is progressing rapidly and, based on preliminary trials, the approach seems to have particular advantages in monitoring of plankton species. Co-operation of HELCOM member states will increase the opportunity for the future routine implementation of the methods.

Reception facilities for ballast water sediments in ports

The provision of adequate reception facilities for sediments in ports and terminals where cleaning and repair of ballast tanks occurs based on the IMO Guidelines G1 is included in the previously mentioned HELCOM's roadmap.

Ballast water free ship designs

Ballast water free designs are emerging with various technical solutions to avoid intake of ballast water altogether by innovative ship design.

07. MARINE LITTER FROM SHIP BASED SOURCES

Introduction

Marine litter is defined as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (UNEP 2009). Also in the Baltic Sea marine litter is increasingly identified as an important type of marine pollution.

While marine litter is found in all the seas of the world, questions on amounts and pathways are still uncertain (Veiga *et al.* 2016). Even though it is commonly concluded that land based sources predominate in the region (e.g. Arcadis 2013), accidental or deliberate discharges of galley or cargo waste from commercial ships, fishing vessels and gear as well as recreational boating remains one source of marine litter.

Deliberate disposal of such waste to the sea, whether from normal operation from a ship or waste created on land, is called "dumping" and has been illegal in the Baltic already since 1980s (London Convention , MARPOL Annex V) and the rules have been further tightened during the last decade. In order to minimize incentives for dumping, port reception facilities for Annex V waste in Baltic Sea ports were among the early focus areas of HELCOM work.

Even if regulations are thus in place determining any trends in the level of compliance is a challenge for this type of waste. Much of the dumped material sinks, and the floating fraction is usually relatively small in size and thus difficult to spot at sea. Usually the floating fraction becomes visible only when accumulating on the shore, but at that point practically impossible to link to the source. Eventual infringements are thus largely depending on first hand reports from crew even if port state control inspections may also, in some cases, observe deviations in protocols.

Over half of the marine litter in the Baltic Sea is believed to consist of plastic materials in line with the worldwide predominance of plastics amongst the marine litter (from 60% to 80%) (Gregory & Ryan 1997). Ultimately this is based on the rapid increase in the use of plastic for consumer goods and packaging since the early 20th century. The global plastic production continues to increase, increasing from 230 to 322 million tons during the period 2005–2015.

Plastic litter provides a particular challenge as most types of plastics are not bio-degradable in the traditional sense of the word. Instead they weather over time due to exposure to UV-light, oxygen, elevated temperatures and mechanical stress to smaller and smaller pieces, eventually reaching microscopic dimensions (UNEP 2015). Due to its presence everywhere, this resulting microplastic waste has been observed to enter food webs as it is ingested by various microscopic and larger organisms (Hollman *et al*., 2013). Also larger pieces of marine litter deteriorate habitat quality and can cause direct harm to animals when they become entangled or ingest the litter.

Marine litter from ship sources in the Baltic Sea

Once litter is introduced in the marine environment it can be transported long distances by water currents. It may sink and accumulate on the seafloor far away from its original source. Recent reviews indicate that the density of macro-scale (>2 cm) litter items is higher on the seafloor than floating on the sea surface (Galgani *et al.* 2015), suggesting that a large part of the total amount of litter in the marine environment is deposited on the seafloor. An example is abandoned, lost or otherwise discarded fishing gear (ALDFG) which continue to fish after being lost. The catching efficiency of lost gillnets amounts to approximately 20% of the initial catch rates after three months, and around 6% after 27 months (WWF Poland 2011).

As reliable aerial or satellite surveillance of litter at sea is still in its infancy, beach litter monitoring and Baltic International Trawl Surveys (BITS) (ICES 2014) are currently the main potential sources of information to follow the amounts of marine litter in the Baltic Sea.

Updated data for the Baltic Sea region is currently available covering with the time period either 2012–2016 or 2014–2016 for eight countries, and gives a snapshot on the spatial distribution of marine beach litter along the coastline in the basins of the Baltic Sea (Figure 7.1).

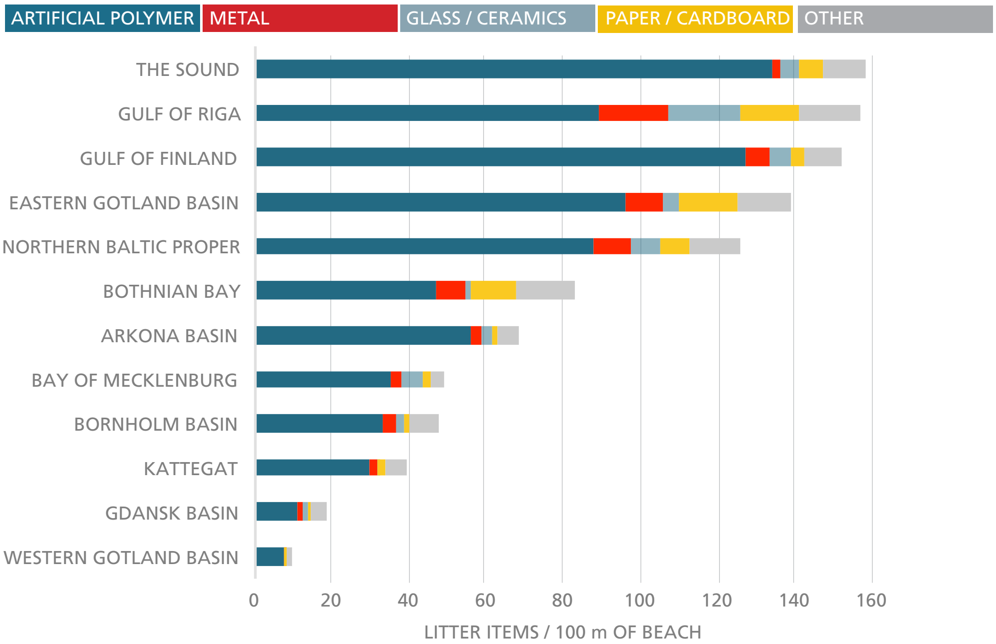
Plastic is clearly the most common litter material, followed by paper, processed wood, metal and ceramics (Figure 7.2). The amounts of litter items on the beach are highest during spring for most types of litter materials for the Baltic Sea, although there are differences between countries. Most of the litter items are found in the western Baltic Sea and in the northern Baltic Proper, while wooden litter items are recorded mostly in the central and northern Baltic Sea. The spatial differences are influenced by local human activities but also by the level of beach cleaning. In addition, the shape of the coastline and the direction of water currents appear to play an important role in determining where litter is accumulated.

The available data is not yet sufficient to evaluate the trend in beach litter over time for all basins. It is anticipated that the longest available data series will be used for further analysis and baseline determination.

If observations from the Baltic Sea (Table 7.1) are compared with those from the OSPAR area, beach litter amounts seems to be much lower in the Baltic. This might reflect regional measures, such as the Baltic Sea No Special Fee system for port reception (HELCOM Rec. 28E/10), which seem to have been effective in reducing releases of oily wastes from ships (see Chapter 4).

ARTIFICIAL POLYMERS - THE MOST COMMON TYPE OF MARINE LITTER ON BEACHES OF THE BALTIC SEA

Marine litter found from different areas of the Baltic Sea, Source: HELCOM 2017



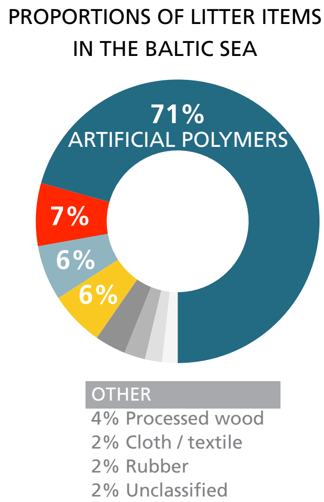


Figure 7.1. An indication of marine litter items on the beach in different basins of the Baltic Sea, using available data from Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden for the years 2012 to 2016. The spatial differences are influenced by local human activities but also by the level of beach cleaning, the shape of the coastline and the water currents. Because the period for litter monitoring and the number of the monitoring sites varies between countries, all data have been recalculated and presented as the average number of litter items per 100 m of the beach. The litter is divided into eight regionally agreed litter categories

Figure 7.2. Proportions of litter items in the eight regionally agreed litter categories, based on the average number of litter items per 100 meter beach in the Baltic Sea.

However, beach litter observations alone do not necessarily mean less littering or, for sea based sources, better compliance with MARPOL Annex V, London Convention or other regulations in the Baltic Sea. The lower amounts of beach litter may be a result of the near absence of currents in the Baltic Sea — and more litter may be deposited on the seabed instead.

In addition to beach litter, also data on litter on the seafloor is being collected and this has been further catalysed by the on-going development of a HELCOM indicator on litter on the seafloor. Data collection occurs systematically since 2015 as part of the Baltic International Trawl Survey, coordinated by the International Council for Exploration of the Sea (ICES), with the understanding that seafloor litter can be measured alongside fish, using trawling surveys. Unfortunately, trawl survey covers only sea areas from the northern Baltic Proper and southward. Very shallow waters (shallower than 10m or 20m depending on the area) are not covered (ICES 2014).

Table 7.1

AMOUNTS OF LITTER IN THE BALTIC SEA AND IN THE NORTH EAST ATLANTIC

	BALTIC SEA	NORTH EAST ATLANTIC
Location	Amount	Amount
Beach litter	75,5 items/100 m in rural beaches 87,5 items/100 m in peri-urban beaches 236,6 items/100 m in urban beaches (1	542 items/100 m (3 712 items/100 m, average(4
Litter on the seafloor	44-208 items/km² (2	0-101 items/km² (5 1-193 items/km² (6

Sources: 1) MARLIN 2013, 2) Ocean Conservancy/ICC 2002–2006,
3) OSPAR 2007, 2009, 4) OSPAR 2010, 5) Galgani *et al.* 2000, 6) UNEP 2009 for the North Sea

Regulations

1992 Helsinki Convention and Recommendations

Besides generally urging to comply with MARPOL Annex V, the 1992 Helsinki Convention Annex V includes Regulation 6 on Mandatory discharge of all wastes to a port reception facility. It requires that before leaving port ships shall discharge all ship-generated wastes, which are not allowed to be discharged into the sea in the Baltic Sea area in accordance with MARPOL and the 1992 Helsinki Convention, to a port reception facility. In addition the same Regulation requires that all cargo residues shall be discharged to a port reception facility in accordance with MARPOL.

The HELCOM No Special Fee Recommendation (HELCOM Rec. 28E/10) applies to garbage as well as litter caught in fishing nets, in addition to oily wastes from machinery spaces and sewage disposal. According to the "no-special-fee" system, a fee covering the cost of reception, handling and final disposal of ship-generated wastes is levied on the ship irrespective of whether or not ship-generated wastes are actually delivered. The fee is included in the harbour fee or otherwise automatically charged from the ship. Some MARPOL Annex V waste is practically always included in the obligatory waste fee, even if there might be some port-specific limitations regarding amounts.

The Helsinki Convention prohibits also all incineration of ship-generated waste within the territorial seas of the Baltic Sea coastal countries.

Relevant for the general topic of dumping, in 2015 HELCOM adopted revised Guidelines for Management of Dredged Material at Sea for the purpose of regulating disposal of dredged materials at sea, which is allowed provided specific provisions are complied with.

Finally, HELCOM Recommendation 36/1 on the Regional Action Plan for Marine Litter contemplates regional actions to address shipping related waste (RS 1, RS 2 and RS 3), waste delivered in ports/marinas (RS 4) as well as fishing and aquaculture (RS 5 – RS 9) as well as remediation and removal measures (RS 10 - RS 12)

MARPOL Annex V and the Baltic Sea Special Area

MARPOL Annex V aims to prevent pollution from ship-generated waste, as waste generated on land and dumped at sea is covered by the London

Convention (see below). MARPOL Annex V was originally adopted in 1973, in effect in 1988, and was last amended in 2011 (entered into force 2013). MARPOL Annex V defines ship-generated waste as:

- Food waste;
- Cargo residues contained or not contained in wash water;
- Cleaning agents and additives contained or not contained in wash water;
- Animal carcasses; and
- All other waste including plastics, synthetic ropes, fishing gear, waste bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse.

According to the latest amendments discharge of all waste generated during the normal operation of the ship is prohibited at sea. The exceptions of the general provisions are food waste, cleaning agents and additives in cargo wash waters, cleaning agents and additives in deck wash waters, animal carcasses as well as certain types of cargo residues. Besides the Annex itself, IMO also revised guidelines for implementation which were adopted in 2012 (IMO 2012).

The Baltic Sea was designated as a MARPOL Annex V special area already in 1973 (in effect from 1 October 1989). Based on this status the discharge of Annex V waste from a ship in the Baltic Sea area is more restricted than the general provisions above. The only allowed discharges, if resulting from normal operation and discharged outside 12 NM, are the following: ground or comminuted food waste, cargo residues and cleaning agents in cargo hold wash waters as well as deck cleaning agents in deck wash waters.

In addition to these discharge prohibitions, MARPOL Annex V requires every ship of 400 GT or larger which are engaged in international voyages to carry a Garbage Record Book. All waste disposal or discharge events the ship is engaged in must be recorded in detail in this document. Further, every ship of 100 GT, and/or certified to carry more than 15 passengers, is required to have a garbage management plan which specifies procedures the crew must follow for compliance.

London Convention and Protocol

The "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972", the "London Convention" for short, has been in force since 1975 and aims to effective control of dumping of wastes and other matter to the marine environment. It includes a list of waste items for which dumping is not allowed or is restricted. In the Baltic Sea Denmark, Finland, Germany, Poland, Sweden and Russia have ratified the 1975 London Convention by end of 2017 (Estonia, Latvia and Lithuania have not ratified).

The Convention was supplemented by the London Protocol in 1996 which tightens the regulations of the original 1975 Convention by generally prohibiting all dumping except for a "reverse list" of possibly acceptable wastes as well as prohibiting at sea incineration of waste which is not ship generated. In the Baltic Sea area, the 1996 London Protocol has been ratified by Denmark, Finland Germany, Estonia and Sweden by end of 2017 (Latvia, Lithuania, Poland and Russia have not ratified).

Port Reception of MARPOL Annex V waste in the Baltic Sea

Port reception fees are important element in the work to minimize illegal discharges. Already during the 1990s the coastal countries developed and agreed within HELCOM that a 100% indirect fee, the "No Special Fee" (NSF), should be applied in the region in order to avoid incentives for illegal discharges. As ships have to always pay for waste handling, regardless if they actually need it, NSF removes a major reason for illegal dumping.

The existence of a regional practice in terms of fees as in the Baltic Sea is not available elsewhere in Europe. Even if there is some heterogeneity in actual implementation, which in many cases includes limits to the amounts of waste which is possible to deliver under the indirect fee, this measure has likely had a major role in promoting the use of port reception facilities for ship generated wastes, and reducing waste dumping, in the region.

Information on MARPOL Annex V waste reception facilities in ports of the Baltic Sea States can be found in the IMO Global Integrated Shipping Information System (GISIS) on http://gisis.imo.org/Public/. Detailed waste discharge procedures and arrangements for specific ports are described in waste management plans elaborated by the ports. As mentioned above some form of NSF is applied in nearly all ports in the Baltic Sea.

To ensure the use and efficiency of the port reception facilities, an information sheet must be forwarded to the next port of call 24 hours in advance of the intended use of a port reception facility or, if the voyage takes less than 24 hours, on departure from the previous port.

If the ship's next port of call is determined less than 24 hours before arrival thereto, the notification shall be submitted immediately upon determination of the next port of call. The sheet must include the following information: the capacity of the waste storage tanks/bins on board; the amounts of wastes delivered at the last port of call; and the estimated amounts of wastes to be delivered at the next port of call.

Enforcement and compliance

The major challenge when it comes to enforcement and prosecution of MARPOL Annex V violation is collecting sufficient evidence for an illegal discharge. Such evidence should clearly, beyond reasonable doubt, connect a specific ship to a detected discharge. This is less related to the legislation or implementation of MARPOL Annex V, but to the challenging nature of Annex V waste which makes dumping very difficult to detect compared to e.g. oil discharges for which effective aerial and satellite surveillance is in place.

Connecting a ship to waste incident is only possible if the discharge/violation is observed "red handed" by whistle-blowers on board, aircraft or passing vessels, documenting the incident by video or photos. The difficulty in gathering evidence at sea underlines the importance of port enforcement and to look into possible ways of taking away any financial incitement to discharge litter or garbage into the sea.

As the Baltic Sea NSF has largely addressed the financial incitement issue, enforcement measures in ports of call are practically the main available measure to improve compliance. These measures include using track ship waste delivery record to identify possible offenders, which would require ship-specific statistics of waste delivery, or more effective Port State Control inspections.

The difficulty of prosecuting discharges can be illustrated by the answers to a questionnaire circulated in 2013 by HELCOM Secretariat on Annex V related infringements and the resulting administrative fines. Only 10 cases of illegal dumping of ship generated waste were successfully prosecuted by the Baltic Sea countries during 2009–2016. During the same period around 200 violations related to administrative procedures (e.g. failures in keeping Garbage Record Book or having an updated Garbage Management Plan) and 74 other MARPOL V related cases ended up in fines for the ships.

The administrative fines issued in these cases were further low, usually in the order of 100–200 euros per case. However, in many countries such fines are followed by criminal sanctions which are usually considerably higher.

Future perspectives

Rewarding green practices by reduced port fees

A weak point of the NSF approach to port reception is that it does not reward for implementation of advanced on-board waste minimization and handling.

Fee reductions from advanced on-board waste minimization and handling by green shipping indices/certificates in relation to Annex V waste handling (e.g. implementation of ISO 21070) has been proposed as one way to promote good practices on board. However, the financing of such schemes remain a question mark.

Further, different sorting categories may be used on board compared to land. In some cases due to the different categories used, waste is not recycled on land but end up treated as mixed waste, even if sorted on board. This could be addressed by studying further the potential in developing a harmonized scheme of sorting to bridging the IMO practices and realities of onshore waste handing.

Improving statistics on ship-generated waste

The exact quantification of trends in waste delivery and thus, the efficiency of measures like the NSF, is difficult due to the lack of statistics. This is due to the fact that waste handling in Baltic Sea ports, and also ports Europe wide, is carried out by different forms of co-operation between port authorities and waste handling companies and also involving differences within countries due to diverging municipal practices. Due to the involvement of various private actors waste statistics are simply not available regionally in the Baltic Sea, or commonly even nationally.

Improving waste statistics, both on waste produced on board ships and waste delivered to PRF facilities, is crucial to enable more advanced technical work on improving port reception facilities and their use. This should include statistics of not only big commercial ports but also on smaller fishing ports which tend to fall outside the national systems in place for larger ports.

Improving remote sensing of marine litter, especially plastics

Optical observations, Imaging spectroscopy, Synthetic Aperture Radar (SAR) and Raman spectroscopy (new technology able to find subsurface floaters) have all potential uses in remote sensing of marine litter, particularly plastic (NASA 2017). These tools can naturally be mounted on other vessels than satellites, including surveillance aircraft and ships, be mounted on the shore or even be used in handheld devices.

However, application of these methods to remote sensing of plastic marine litter would require work in calibrating/validating sensor signals, translating measurements to be comparable with in situ data, and efforts in correcting signal bias (NASA 2017).

1996 London Protocol ratifications in the Baltic Sea

Of the Baltic Sea countries Latvia, Lithuania, Poland, and the Russian Federation have not ratified the 1996 London Protocol.

Dredged material and plastics and marine litter

Additionally, the London Convention adopted in 2016 the recommendation to encourage action to combat marine litter (IMO 2016, para 9.31.1 and Annex 8) as well as encouraged Parties to take into account the issue of plastics and marine litter when applying the dredged material waste assessment guidance (IMO 2016, para 9.31.2).

08. UNDERWATER SOUND FROM SHIP BASED SOURCES

Introduction

Sound created under water spreads on average 4.5 times faster than in air and especially low frequency sounds can be heard over much greater distances. Human generated underwater noise can have both short and long-term negative consequences on marine life.

Underwater noise can be categorized into continuous noise, including e.g. noise from ship engines, and impulsive noise, e.g. underwater explosions, pile driving or seismic airguns used in oil and gas exploration as well as certain types of sonars.

Impulsive sound may scare off, and affect the behaviour of animals and can even cause temporary or permanent hearing loss. Human generated continuous sound may, for example, mask animals' communication and signals used for orientation and detection of prey.

Maritime traffic is one of the sources of continuous underwater noise. The recent mapping of continuous underwater noise in the Baltic Sea shows that ship traffic is the main source of noise for lower frequencies audible for marine animals. However, its impacts on the marine life in the Baltic Sea are unknown on the level of populations.

The primary sources of underwater noise in a ship are associated with propellers, hull form (minimizing wake), on-board machinery, and operational aspects (e.g. optimum speed for low noise levels). As many of the key parameters are difficult to influence on existing ships, the most efficient mitigation of underwater noise from ships seems to be attention during initial ship design. Additionally, speed reduction as well as temporal or geographical restrictions can also be effective means to mitigate noise from shipping (Weilgart 2007; Merchant *et al.* 2012).

Sound from shipping in the Baltic Sea

Soundscape maps for the Baltic Sea have been modelled based on hydrophone data in the frame of the recently completed project BIAS. Particularly the maps of the lower frequencies (63 and 125 Hz) highlight the role of ship traffic (Figure 8.1). These frequencies are within the audible range of some noise sensitive species, especially fish (Figure 8.2).

SOUNDSCAPE MAPS IN THE BALTIC SEA

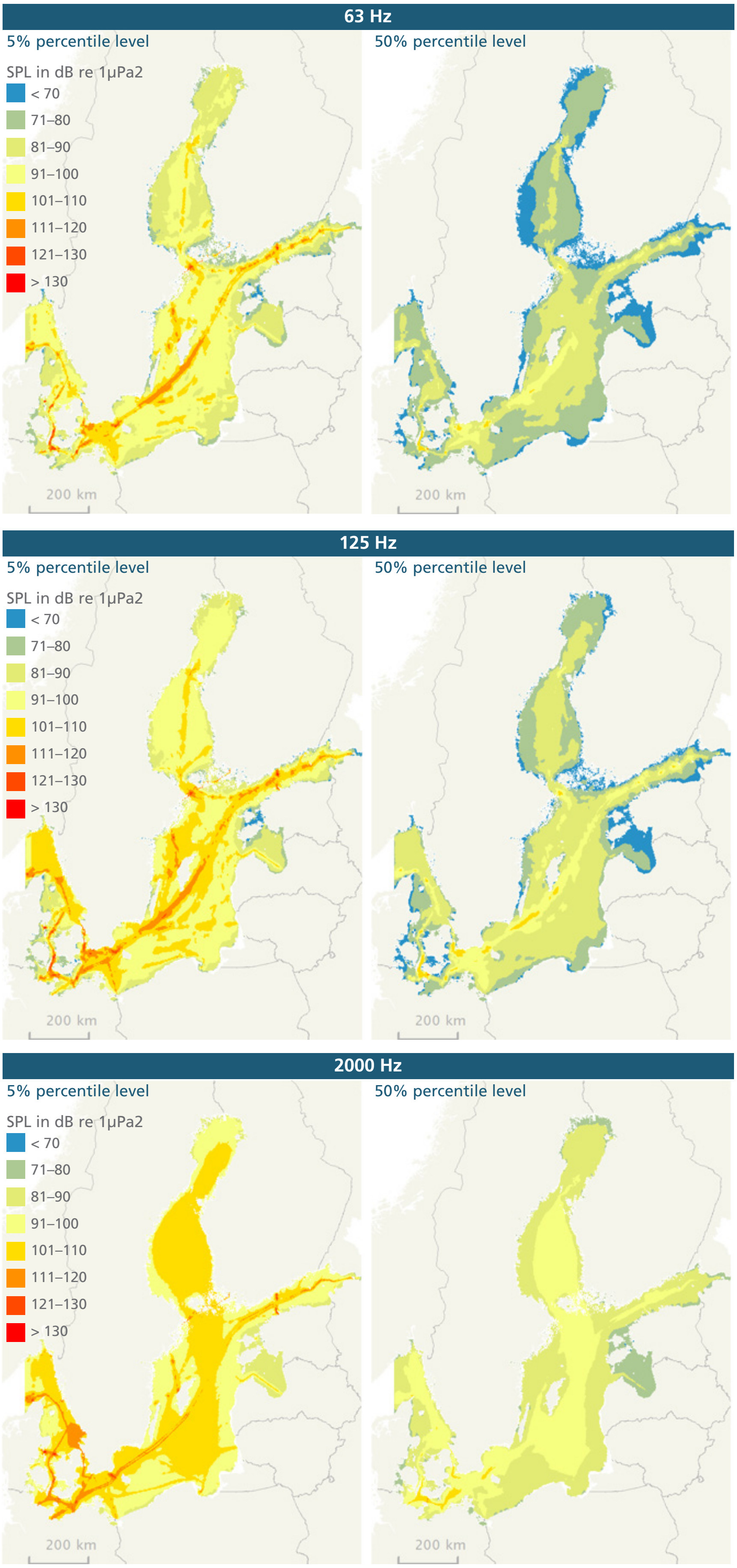


Figure 8.1. Soundscape maps in the Baltic Sea, showing sound pressure level (SPL) of underwater continuous sound at 1/3 octave frequency bands of 63 Hz, 125 Hz and 2000 Hz L05 (5% of the time) and L50 (50% of the time) exceedance levels for the depth layer from surface to the bottom (yearly average). Areas with high sound level overlap clearly with the location of major shipping routes. The sound produced from shipping is within a frequency interval that overlaps with the hearing range of several species. The results have been extracted with help of the soundscape planning tool of BIAS (2016).

Regulation related to underwater noise from ships in the Baltic Sea

Underwater noise, especially continuous noise from sources like ships, is a relatively new issue which is poorly, if at all, covered by the existing framework of international environmental law.

1992 Helsinki Convention

Noise is not covered explicitly in the Helsinki Convention but, in addition to general provisions, the definition of pollution to be reduced by the Contracting Parties includes "introduction of energy", which includes noise.

IMO Guidelines on reduction of noise from shipping

IMO adopted 2014 the non-mandatory guidance document "Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life" (IMO 2014) to advice designers, shipbuilders and ship operators. It remains the only dedicated IMO instrument on reducing noise from ships.

Ship design to reduce noise

The IMO guidelines list a number of design and operational measures which may be used to reduce noise from ships. For the purposes of illustration some of these are described below.

Design aspects: Propeller cavitation, hull design and machine vibrations

Much of the underwater noise from ships is caused by the physical phenomenon called propeller cavitation. Propeller cavitation is the formation and implosion of gas bubbles on the propeller blade due to the pressure differences created by propeller rotation and movement through water. The implosion of these bubbles create propeller noise (IMO 2014; Arveson & Venditis 2000).

Cavitation can be reduced under normal operating conditions through design, such as optimizing propeller load, ensuring as uniform water flow as possible into propellers (which can be influenced by hull design), and careful selection of the propeller characteristics such as: diameter, blade number, pitch, skew and sections. Minimizing fouling of propeller and underwater hull also help to reduce propeller cavitation and thus noise.

Actual noise level is largely determined by the difference between the design speed and actual speed (Wittekind & Schuster 2017). However, as propellers are usually designed for highest efficiency and not low noise emission, wake equalisation devices (including ducts) may have the highest potential in enabling both noise minimization and high efficiency (Wittekind & Schuster 2017).

Vibrations from diesel or LNG engines can be reduced by appropriate cushioning during installation of onboard machinery. Due to their nature electric engines have inherently lower vibration levels.

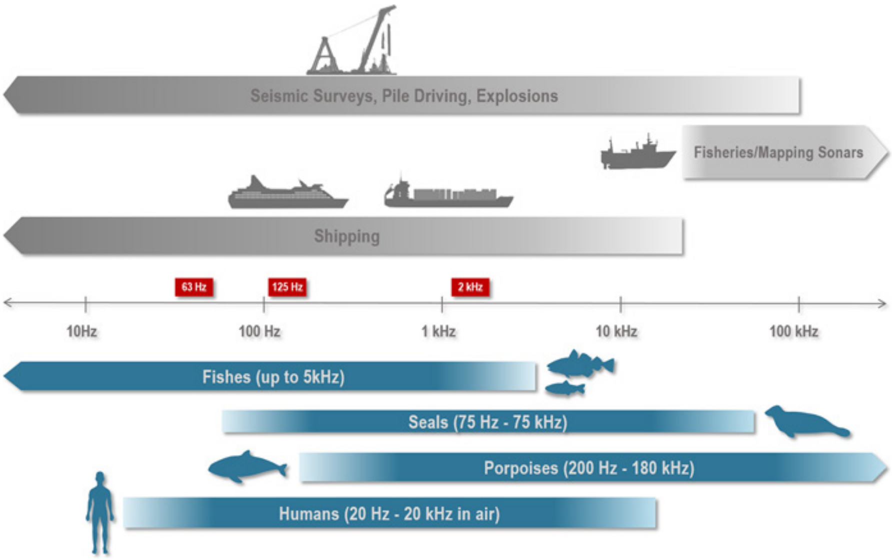


Figure 8.2. Auditory range of some marine species present in the Baltic Sea and sound frequencies generated by human activities. Human hearing is provided as a reference. After Scholik-Schlomer (2015) adjusted to Baltic Sea conditions. The red fields indicate the monitored frequency bands within BIAS.
Source: BIAS 2017

Operational aspects

When possible, the speed of the ship can be optimized for lower noise (depending on ship design). Further, in some cases known areas with highly sensitive species can be avoided by route selection.

Future perspectives

Studies on the effects of ship noise on marine life

The impacts of continuous noise from ships on the population levels of marine life in the Baltic Sea are relatively unknown. Further studies, following the study on noise sensitivity of animals in the Baltic Sea, recently conducted in HELCOM, could be used to document any concrete effects. Underwater Noise is a Descriptor (D11) under the European Union Marine Strategy Framework Directive (MSDF), and as part of the implementation process EU Members are currently developing indicators describing good environmental status in terms of noise.

Promoting use of IMO guidelines in ship design

The existing IMO guidelines as well as some other documents, such as the ICES CRR 209 noise specification for research vessels, include guidance on how to implement noise reducing designs. Voluntary incentives could be considered to promote the use of these available technologies.

09. ANTI-FOULING SYSTEMS

Introduction

Biofouling is the growth of marine and aquatic organisms on submerged surfaces. This includes vessel hulls where it increases drag, leading to a higher fuel consumption and higher CO_2 emissions. Biofouling may also reduce manoeuvrability and increase corrosion and may, like ballast water, result in transportation and introduction of invasive non-native species. Biofouling is also an issue in other maritime activities, including aquaculture.

As attached forms of marine life in the cold and brackish Baltic Sea are small, and relatively slow growing, biofouling is a much smaller issue here than in fully marine environments. However, as many ships in the region sail also outside the Baltic, they need to be prepared for more aggressive forms of biofouling.

Historically, various methods have been used for preventing biofouling on ship hulls, including copper and lead sheets, tar or lime (CaO). However, since the 1960s dedicated anti-fouling paints have been the most commonly used method to prevent biofouling.

Anti-fouling paints include traditionally active substances, biocides, preventing settling and growth. These active substances may be an environmental hazard on their own right, especially in docks and other areas where such paints are frequently removed or applied.

Tributyltin tin (TBT) paints introduced on the market in the 1960s, proved to be very efficient. However, by the 1980s it was discovered that TBT accumulates in food webs and causes widespread malformations and imposex (feminisation of males) of marine fauna also outside main shipping areas, and TBT was successively banned from anti-fouling paints. Globally TBT was addressed by the 2001 IMO AFS Convention (in force 17 September 2008).

After the ban of TBT most anti-fouling paints used today include copper (Cu2O, CuSCN or metallic copper) as the active ingredient, with various biocides sometimes used as “boosters”, some of which have been banned nationally. Even if the use of copper in anti-fouling paints is considered less problematic for the environment than TBT, it is still a pollutant. The use of copper in anti-fouling paints is today the main source of diffuse copper input to the marine environment.

Especially in the Baltic Sea, where biofouling is relatively light, the available, and emerging, alternatives to copper paints, such as foul-release paints, bio-mimicing surfaces and in water hull cleaning, as well as optimizing copper content could be explored further to reduce load of copper from anti-fouling paints.

In absence of major technological breakthroughs, balancing between the environmental and economic gains of anti-fouling (significant reduction in fuel use and thus CO_2 emissions, reducing non-native introductions) and the effects from release of copper as main active substance remains a challenge.

Anti-fouling systems and the marine environment of the Baltic Sea

TBT

As would be expected from the IMO and EU ban of TBT in anti-fouling paints, imposex effects are decreasing in the Kattegat and Belt Sea/Sound area between Sweden and Denmark, the only part of the Baltic Sea where imposex monitoring data is available (Figure 9.1, HELCOM 2017). Also current levels of TBT, and its breakdown products dibutyltin (DBT) and monobutyltin (MBT), as such are close to detection limits in pristine areas away from ship routes and harbours with historic contaminations. However, sediments are still a source for TBT in harbours and shipping lanes, which can be re-suspended during storms.

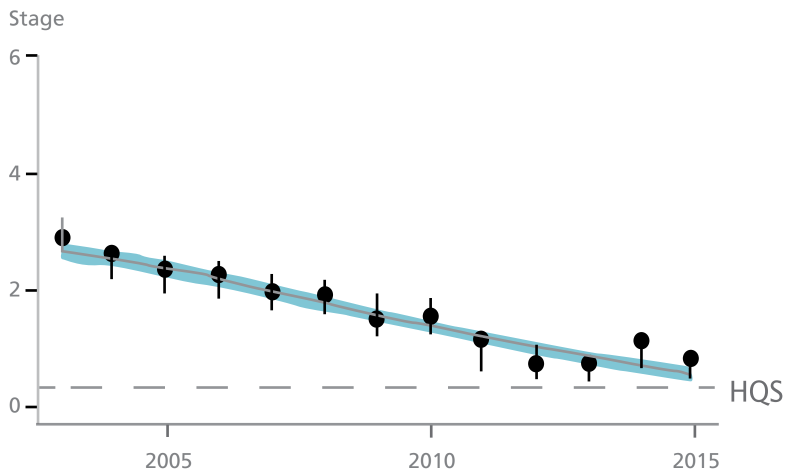
Copper

Copper, currently the most widely used active substance in anti-fouling systems, is not assessed in detail in recent HELCOM assessments or indicators, and consequently an updated regional synthesis of copper in the Baltic Sea marine environment is not available to assess the potential effect of anti-fouling paints with copper as active substance or trends in the marine environment.

IMPOSEX DECREASING AMONG MARINE GASTROPODS IN ÖRESUND 2003–2015

Figure 9.1.

Imposex (Vas deference Sequence index, “VDSI”) among marine gastropods in Öresund area
HQS=High Quality Standard, EU regulation 782/2003 on TBT was adopted in 2003



Source: HELCOM 2017

However, according to a 2010 HELCOM thematic assessment on hazardous substances, sediment concentrations of copper (along with arsenic, cadmium, chromium, cobalt, nickel and zinc) increased from 2003 to 2008 in almost all of the 17 Swedish frequently sampled stations covered by the review (HELCOM 2010).

Regulation

2001 International Convention on the Control of Harmful Anti-fouling Systems on Ships (the AFS-Convention).

The 2001 IMO AFS Convention entered into force on 17 September 2008, according to which ships are not allowed to use organotin compounds which act as biocides in their anti-fouling systems. The Convention applies to ships flying the flag of a Party to the Convention, as well as ships not entitled to fly their flag but which operate under their authority and to all ships that enter a port, shipyard or offshore terminal of a Party. All the coastal countries of the Baltic Sea have ratified the AFS Convention.

To support the implementation, IMO has adopted several sets of guidelines, namely the "Guidelines for Survey and Certification of Anti-fouling Systems on Ships" (Resolution MEPC.102(48)), "Guidelines for brief sampling of anti-fouling systems on ships" (Resolution MEPC.104(49)) and the "Guidelines for Inspection of Anti-fouling Systems on Ships" (Resolution MEPC.105(49)).

Guidance is also available for hull cleaning activities including "Guidance on best management practices for removal of anti-fouling coatings from ships, including TBT hull paints" (Circular AFS.3/Circ.3 of 22 July 2009) and relevant sections of the 2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (MEPC.207(62)).

According to the Article 11 of the AFS-Convention, a ship may be inspected for the purpose of determining whether the ship is in compliance with the Convention. Such "initial" inspection covers verification of valid certificates required by the Convention and/or a brief sampling of the ship's anti-fouling system according to Resolution MEPC.104(49).

If there are clear grounds to believe that the ship is in violation of the Convention, a thorough inspection may be carried out taking into account the IMO Resolution MEPC.105(49) on Guidelines for inspection of anti-fouling systems on ships.

EU regulations (applicable for ships and ports of EU Member States)

Two EC Regulations, transposing the IMO AFS Convention to EU law, bind the EU member states: EU Regulation (EC) No. 782/2003 on the prohibition of organotin compounds on ships and Regulation 536/2008, giving effect to Article 7 of the EC Regulation 782/2003.

After a phase in period the EC regulations did not allow from 1 January 2008 any ships with an organotin-based anti-fouling system to enter any EU port or offshore terminal and any ship flying the flag of an EU Member State to bear organotin compounds acting as biocides in its anti-fouling systems.

Future perspectives

Hull biofouling and invasive species

Invasive aquatic species are introduced to new environments by ships through ballast water, but also hull fouling constitutes a major vector of introductions. As a global response IMO adopted the 2011 Guidelines to provide guidance on addressing transfer of non-indigenous species via hull fouling, and as a follow up document the 2013 Guidance for the future review of the 2011 Guidelines. In the Baltic introductions via hull fouling is a less studied topic than introductions via Ballast water.

More information on the role of hull fouling as a vector of non-native species introductions could enable a more comprehensive regional approach on invasive species. The EU Interreg BSR project COMPLETE (2017-2020) will address these questions.

Optimizing copper content of anti-fouling paints

Recent studies (e.g. Lagerström *et al.* 2017) point out that the concentration of copper may be further optimized, as some studies show that maximum effect can be achieved in the Baltic Sea with lower concentrations than included in many commercial products.

In-water hull cleaning

Further, new fast methods and services using divers, robots and technological tools like ultrasonic cleaning have emerged for hull cleaning in water, avoiding costly dry-docking. Some of the approaches use filtering and storing the effluents to ensure environmental sustainability. When regularly used these methods enable cleaner hulls, and lower fuel consumption, with less use of anti-fouling paints. Another experimental approach is to drop anti-fouling paint altogether, and use simply a hard hull surface in combination with frequent hard brushing.

As mechanical cleaning releases nearly always also some anti-fouling paint, copper and non-indigenous species to the water, some ports have restricted this kind of “wet brushing”. Basic information for regional recommendations on in-water hull cleaning activities will be explored within the COMPLETE project (2017–2020) mentioned above.

Foul release paints and bio-mimicking surfaces

Acknowledging the problems in the widespread use of copper, new types of non-toxic anti-fouling paints and surface coatings are emerging as alternative. The traditional approach to this problem with “foul release paints” uses silicone and fluoropolymers to create a smooth, slippery underwater hull surface which prevents, or weakens, attachment of biofouling organisms. However, currently available products require frequent application - and high operating speeds - to be effective. In addition, sheltered parts of the hull will need other solutions.

Other more recent proposals involve creating a micro-, or nano-texture for the hull itself to produce a similar effect, mimicking natural materials like shark skin or lotus leaf.

Technological breakthroughs are needed to successfully mainstream such approaches which can be enabled by technological research funding.

You think safety is expensive?
Try an accident.

Section III

SAFETY OF NAVIGATION

10. MARITIME ACCIDENTS IN THE BALTIC SEA

Introduction

High level of traffic in combination with regional peculiarities such as narrow passages, wintertime darkness and ice makes the Baltic Sea a challenging area for navigation. Even if safety of navigation is one of the key concern for mariners and ship owners, maritime accidents happen and the Baltic Sea is no exception in this respect.

Statistics on the occurrence of accidents is useful to identify areas where further safety measures could be considered and thus reduce the risk of i.e. environmental damage. For this purpose HELCOM has since the 1990s collected a regional dataset on accidents, which is based on reporting by the coastal countries. This has been published in various forms, until recently as annual HELCOM accident reports.

Accident statistics is a challenging material to use as its quality depends fully on the level of reporting by companies and, in the case of HELCOM, countries. As reporting practices, persons and databases change over time it is not easy to create a reliable overview of accident occurrence over time in a region like the Baltic Sea, especially if minor accidents are included in the dataset. Nevertheless, by comparing different data sources one can improve the quality of accident data.

For the purposes of this chapter an improved time series of HELCOM accident data for the period 2011–2015 was created by double checking accidents reported to HELCOM with the coastal countries as well as by consulting other available accident databases (EMSA, Lloyds List Intelligence). The dataset covers tankers over 150 GT and other vessels over 400 GT.

The resulting dataset includes in total 1520 reported maritime accidents occurred in the Baltic Sea area during the period 2011–2015, with a fairly stable rate of 300 accidents per year. Around 4 % of these accidents led to loss of life, serious injuries or environmental damages.

While trends might look stable, and acceptable from the regulatory point of view, it is in the nature of accidents that they are sometimes difficult to predict, especially very serious accidents. Regarding geographic distribution it should also be kept in mind that it is not self-evident to assume that future accidents will follow past patterns.

Accidents are generally related to factors such as poor situation aware-

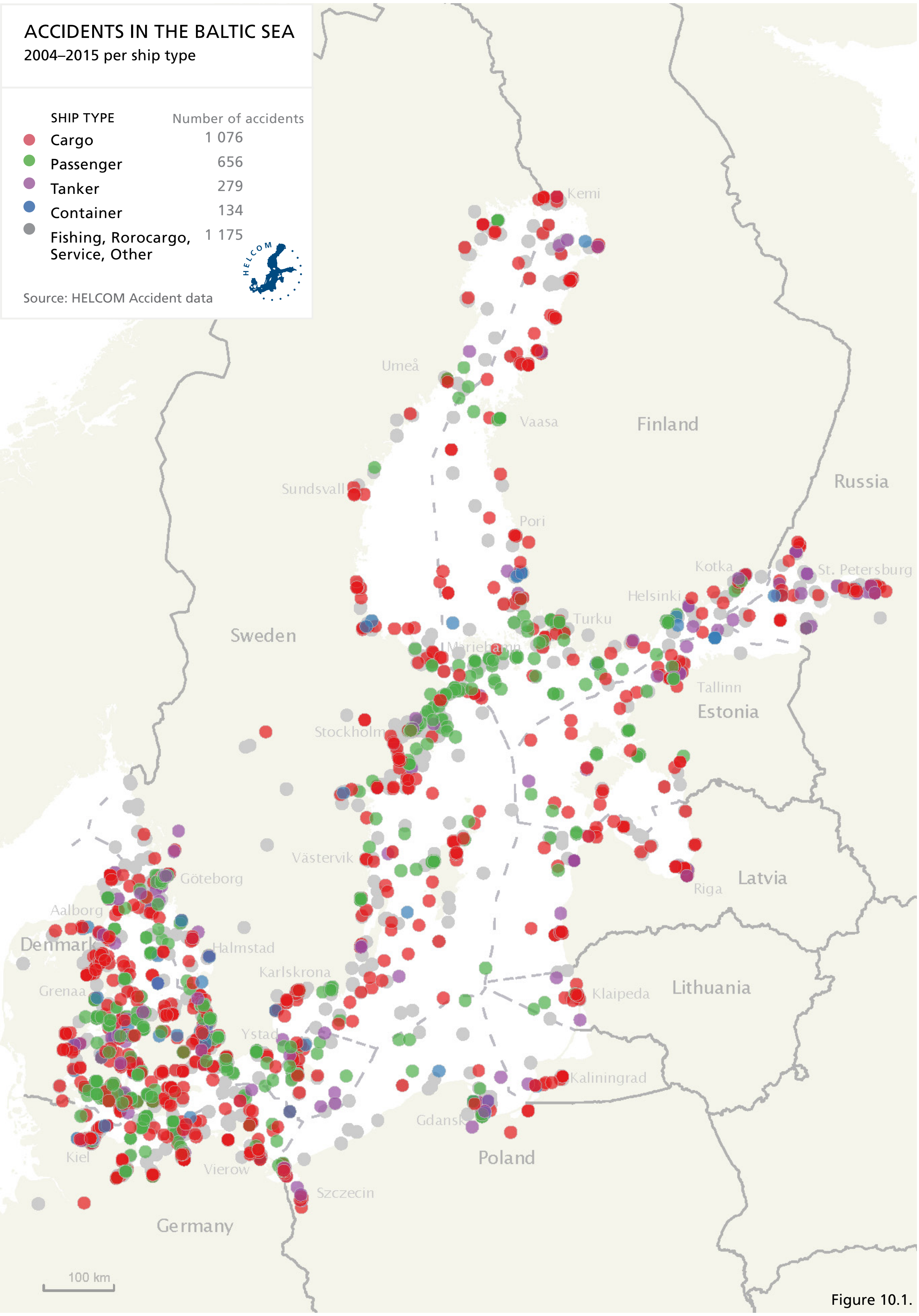

ACCIDENTS IN THE BALTIC SEA
2004–2015 per ship type
SHIP TYPE
Number of accidents
Cargo 1 076
Passenger 656
Tanker 279
Container 134
Fishing, Rorocargo, Service, Other 1 175
Source: HELCOM Accident data
HELCOM
Kemi
Umeå
Vaasa
Finland
Russia
Sundsvall
Pori
Kotka
St. Petersburg
Helsinki
Turku
Sweden
Mariehamn
Tallinn
Estonia
Stockholm
Västervik
Latvia
Göteborg
Riga
Aalborg
Denmark
Halmstad
Karlskrona
Lithuania
Klaipeda
Grenaa
Ystad
Kaliningrad
Gdansk
Kiel
Vierow
Poland
Szczecin
Germany
100 km

Figure 10.1.

ness, engine failures and vast operating areas, but one unpredictable “Black Swan” type of event can change commonly held views on accidents.

Maritime accidents in the Baltic Sea

Accidents in the Baltic Sea 2011–2015

According to the revised HELCOM accident statistics (HELCOM 2016), 1520 reported maritime accidents occurred in the Baltic Sea area during the period 2011–2015, at a fairly stable level of 300 accidents per year without major drops or increases. Slightly more than 4 % of those accidents led to loss of life, serious injuries or environmental damages.

Spatial distribution

As expected these reported accidents cluster around highly trafficked sections of the Baltic Sea, particularly the southwest waters of Denmark, Germany and Swedish west coast (Figure 10.1).

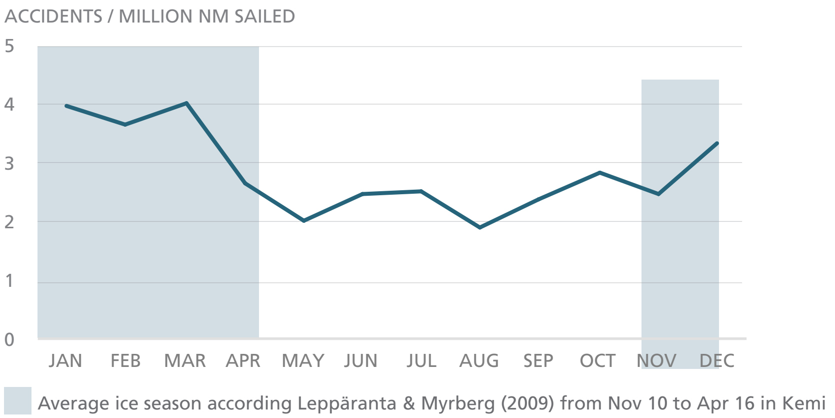
Seasonal distribution

When the maritime accidents of the review period are broken down by month, a clear increase in the accident frequency can be identified from November to March. Ice, darkness and strong winds make navigation more challenging during the winter months. Beyond weather conditions, a contributing factor may be the drop in compliance with international regulations during wintertime, observed in Port State Control statistics from the northern Baltic Sea (Figure 10.2).

Accident types

Figure 10.3 presents the frequency of different accident types in the Baltic Sea during the period 2011–2015. The most common type of maritime accident in the Baltic Sea has been for many years grounding or stranding of a vessel. During the period from 2011 to 2015 groundings accounted for 21 % of the total number of accidents.

Figure 10.2. SEASONAL DISTRIBUTION OF ACCIDENTS IN THE BALTIC SEA
Monthly average of years 2011– 2015

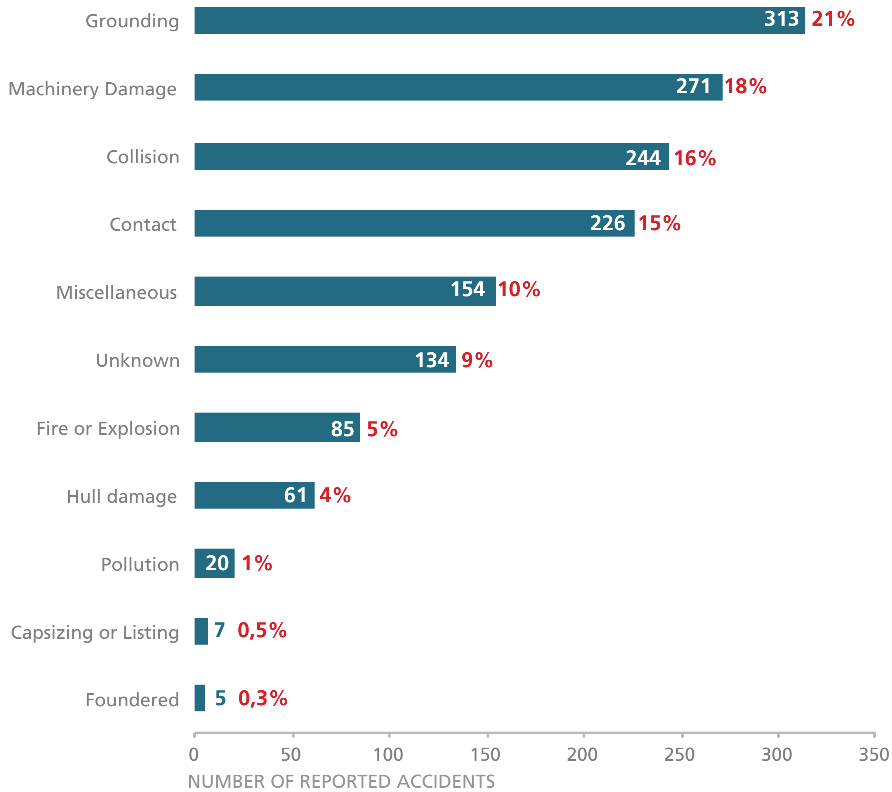


Source: HELCOM Accident data

GROUNDING IS THE MOST COMMON ACCIDENT TYPE OCCURING IN THE BALTIC SEA

Figure 10.3.

Rate of reported accidents from 2011 to 2015 per accident types, total 1520 accidents



Source: HELCOM Accident data

Two of the 313 groundings caused also some degree of environmental damages. In this five years period, the number of groundings has been decreasing slightly. Typical contributing factors to these accidents were loss of manoeuvrability of ship and inadequate situation awareness including anticipation.

Engine failures were the second most common type of maritime accident from 2011 to 2015 (Figure 10.3), which accounted for 18 % of the total number of accidents. Two of these 271 events led to environmental damages. During the review period, the number of engine failures has been increasing slightly. Based on earlier findings, common reasons for these accidents are malfunctions of engine automation or electricity supply, poorly planned maintenance and lack of technical redundancy.

Collisions were the third most common type of maritime accident during the review period (Figure 10.3). They accounted for 16 % of the total number of accidents. None of the 244 reported events caused any environmental damages. The number of collisions has been decreasing clearly during the five years period. Typical contributing factors to these accidents were violations of the IMO International Regulations for Preventing Collisions at Sea (COLREGs) rules (see Chapter 11) and poor availability of information between vessels.

Other noteworthy type of maritime accident are fires and explosions. Such accidents have received a lot of attention in Europe due to recent increase in the number of ship fires aboard ro-ro passenger vessels, many with fatal consequences. In the Baltic Sea there were 85 fires or explosions during the review period, which accounted for 5 % of the total number of accidents. The number of this type of accident has been decreasing slightly in the five years period. Based on earlier findings, most of the ship fires originate in engine rooms, followed by cargo areas and accommodations.

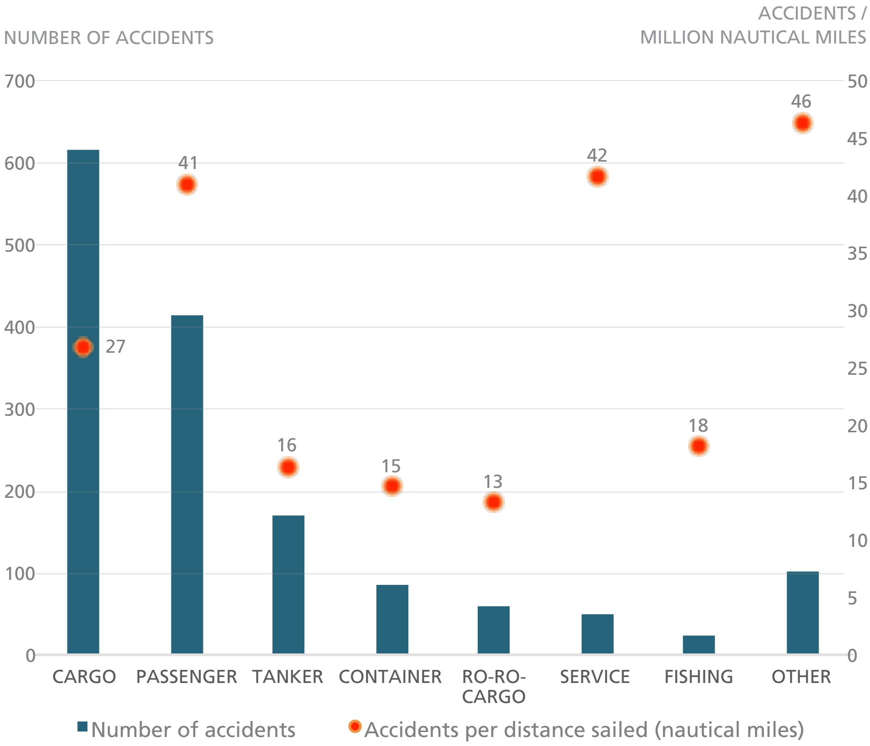
Ship types

Perhaps due to their large numbers (Chapter 1), cargo ships have been the most common type of vessels included in accidents in the Baltic Sea. From 2011 to 2015 the number of maritime accidents occurred to this vessel type was 616 (Figure 10.4), which accounted for 42 % of the total number of accidents. The accident frequency of cargo ships is 27 accidents per million nautical miles sailed (Figure 10.4).

Most of the cargo vessel accidents were groundings (Figure 10.5). Typical size of the accident vessel was from 1 500 to 6 000 GT (Figure 10.6). When the cargo ships accidents are broken down by year, no significant changes are evident. The main reason behind the quite high number of accidents occurred to this ship type could be found in the safety culture of the shipping companies, as many of them still need plenty of further development.

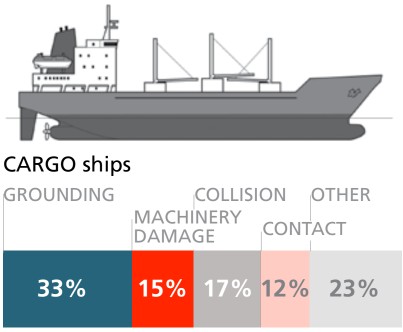
The second highest number of maritime accidents involved passenger vessels. During the review period the number of accidents occurred to this ship type was 413, which accounted for 28 % of the total number of accidents (Figure 10.4). The accident frequency of passenger ships is 41 accidents per million nautical miles sailed, which is clearly above the average. Consequently, changes in the passenger ships' traffic volumes may have

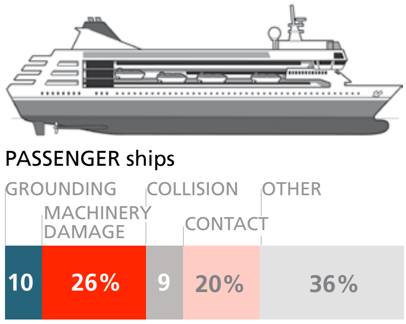
Figure 10.4. NUMBER OF ACCIDENTS PER SHIP TYPE from 2011 to 2015
Number of accidents and accidents per distance sailed

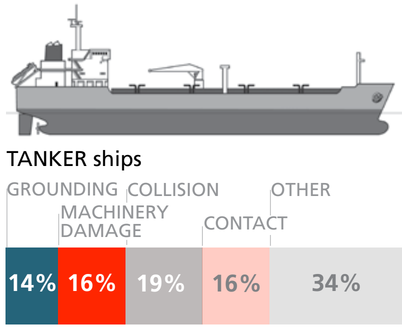


Source: HELCOM Accident data

ACCIDENT TYPES IN THE BALTIC SEA 2011–2015





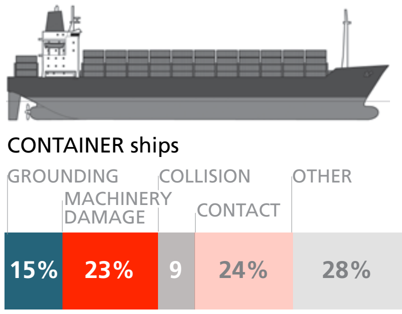


a greater impact on the future accident numbers in the Baltic Sea than changes in many other ship types. Most of the passenger ship accidents were machinery damages or contacts with fixed objects (Figure 10.5), and the typical size of the accident vessel was from 15 000 to 40 000 GT (Figure 10.6).

From 2011 to 2015 the number of passenger vessel accidents has been increasing slightly. A breakdown of this vessel category reveals that accident ships were mainly ro-ro passenger vessels where the safety culture of these shipping companies is usually considered to be more developed.

Tankers were the third most common type of accident vessels during the review period. From 2011 to 2015 the number of accidents occurred to this vessel type was 170, which accounted for 12 % of the total number of accidents. The accident frequency of this ship type is 16 accidents per million nautical miles sailed, which is below the average. Most of the tanker vessel accidents were collisions with other ships. Typical size of the ship involved in an accident was from 1 500 to 6 000 gross tonnage. When the tanker vessel accidents are broken down by year, no significant changes are evident.

Most of the accident vessels in the tanker category were product tankers. The safety culture of the relevant shipping companies operating product tankers is considered to be above average and the tanker industry has developed its own vetting process to ensure the safety on these transportations. However, the statistics show that improvement is still needed.



Source: HELCOM Accident data

Figure 10.5.

Figure 10.6. MARITIME ACCCIDENTS IN THE BALTIC SEA 2011–2015 BY SHIP TYPE AND SIZE

CARGO SHIPS

SIZE, Gross Tonnage	NUMBER OF ACCIDENTS, Total 616
40 001–200 000	22
15 001–40 000	60
6 001–15 000	73
1 501–6 000	401
300–1 500	60

PASSENGER SHIPS

SIZE, Gross Tonnage	NUMBER OF ACCIDENTS, Total 413
40 001–200 000	61
15 001–40 000	158
6 001–15 000	61
1 501–6 000	54
300–1 500	79

TANKER SHIPS

SIZE, Gross Tonnage	NUMBER OF ACCIDENTS, Total 170
40 001–200 000	8
15 001–40 000	22
6 001–15 000	44
1 501–6 000	78
300–1 500	18

Source: HELCOM Accident data

11. MEASURES TO IMPROVE SAFETY OF NAVIGATION IN THE BALTIC SEA

Introduction

Even if safety culture on board ships is perhaps the key factor in ensuring safety of navigation in the Baltic Sea, accidents and accidental spills can be reduced by various safety measures by the coastal states.

As there is a close relationship between safety of navigation and prevention of accidental spills from ships this has been an important part of HELCOM work since the very beginning. As in other ship related matters international bodies working with safety of navigation, IMO but also IALA and IHO, are the fora where the regulations are adopted. However, regional co-operation has an important role to support this global work.

The early HELCOM work on safety of navigation in the 1970s concentrated on the use of pilotage services in the Baltic Sea area and developing a position reporting system for ships. The Declaration on the Safety of Navigation and Emergency Capacity in the Baltic Sea area (HELCOM Copenhagen Declaration), adopted September 2001 in Copenhagen by Ministers of Transport of the Baltic Sea region (HELCOM 2001), has provided an important long-term regional road map for the coastal countries in the field of safety of navigation.

More recently the work in this field has, besides collection and analysis of accident data (described in Chapter 10), focused on improving nautical charts in the Baltic Sea through hydrographic re-surveys (in co-operation with IHO Baltic Sea Hydrographic Commission, or BSHC), providing a regional platform for regional consultations on new IMO routing measures, Recommendations on ice navigation including ships ice classes, co-operation on AIS data exchange as well as following up the rapidly developing field of e-navigation.

Regulations

The International Convention for the Safety of Life at Sea (SOLAS 1974)

The SOLAS Convention is the central international agreement, which was first adopted in 1914 (following the Titanic accident), and revised/renewed in 1929, 1948, 1960 and 1974. The current convention in force, known as SOLAS 1974, covers various aspects of ship safety, including construction, fire protection, life-saving appliances, radio communications, safety of navigation, the carriage of cargoes and safety measures for high speed craft. The SOLAS Chapter V is the dedicated section on safety of navigation and covers a wide number of issues. As examples, Chapter V regulation 10 (SOLAS V/10) provides that IMO is the only competent organisation to establish ships' routeing measures and regulation 19 (SOLAS V/19) makes the carriage of AIS mandatory for certain types of ships.

Other IMO instruments

As safety at sea is the core of IMO mandate, there is a large number of instruments beyond SOLAS 1974 related to this issue. It does not make sense to attempt covering them comprehensively in this report and the reader is instructed to consult the IMO webpage. Nevertheless, it could be mentioned that the Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREGs) provides the "rules of the road" at sea – obligations concerning manoeuvres and the necessary signals and lights and the Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW 1978) provides minimum requirements of seafarers in terms of education and training.

1992 Helsinki Convention and HELCOM work

As for other maritime traffic related issues HELCOM provides a platform which the Contracting Parties can use for regional consultations on safety of navigation measures to be proposed at, and decided by, IMO.

A large part of the 1992 Helsinki Convention Annex IV on ship-based pollution is devoted to regional cooperation to improve safety of navigation in the Baltic Sea region by Re-surveys and ENC, cooperation on AIS, common procedure of accident investigations and places of refuge.

The shallow Baltic Sea requires also special caution when calculating ships' Under Keel Clearance (UKC). For this purpose the national administrations have worked within HELCOM to develop basic Baltic specific information on determination of a ship's minimum under keel clearance (UKC) to provide safe navigation through sea areas with restricted available depth of water and thus enhancing the safety of navigation and protection of the marine environment. The material is available in the HELCOM Clean Shipping Guide (HELCOM, 2016) for the Baltic Sea.

Improved Nautical Charts and Re-Surveys in the Baltic Sea

The availability of reliable nautical charts is a key enabling factor in improving safety of navigation (SOLAS V/4). As with maps on land the openly available nautical charts in the Baltic Sea region were during a long period based on the major historical hydrographic survey campaigns carried out by the coastal states during the expansion period of maritime traffic from mid-1800s to the First World War. The production of more reliable nautical charts (paper as well as electronic), is in most cases only possible through a considerable investment in new re-surveys in the field using modern technology.

The work of the hydrographers of the Baltic Sea region and particularly IHO Baltic Sea Hydrographic Commission (BSHC) during the last three decades in carrying out the needed re-surveys has been one instrumental factor in delivering safer navigation in, and thus prevention of accidental pollution of, the Baltic Sea.

A major leap forward in this work was taken as an immediate reaction to the Baltic Carrier accident in 2001. Ministers of Transport of the Baltic Sea region agreed, in the 2001 HELCOM Ministerial Meeting in Copenhagen on safety of navigation, to develop a scheme for systematic re-surveying of major shipping routes and ports and to start implementation by 2003.

The national hydrographic offices of the region followed up the decision and developed by 2002 the regional Harmonized Hydrographic Re-Survey Plan, based on estimations of the main routes used by the ships, and started implementation by 2003. Besides identifying areas used by ships the plan divided the areas according to their level of traffic to Categories I (highest priority), II and III.

In July 2005 the Baltic Sea coastal countries launched the, still operational, regional HELCOM AIS network for monitoring maritime traffic in the Baltic Sea, another fruit of the 2001 Copenhagen Declaration. The synoptic and historical AIS information, showing the actual sailed routes of ships in the entire region, made it clear that that there were high priority areas for surveys outside the original scheme.

This new information led to extension and revision of the plan in 2010 and 2013, to cover more areas used for navigation.

Between 2001 and 2016, nearly 200 000 km^2 of seabed, more than the combined surface area of Estonia, Latvia and Lithuania, have been re-surveyed by national hydrographic agencies in the Baltic Sea in order to implement the regional re-survey scheme (Figure 11.1). Surveys of nearly all Category I areas have been completed and also a significant number of Category II areas.

Ships routeing measures

As elsewhere the safety of navigation in the Baltic Sea took a leap forward with the 1960 revision of the Safety of Life at Sea Convention (SOLAS1960), which explicitly referred to ships' routeing measures for safety of navigation, a topic later expanded in the SOLAS revision of 1974.

In the Baltic Sea, these developments were followed closely and a number of routeing measures to prevent accidents in the Gulf of Finland and Northern Baltic Proper were adopted by the Inter-Governmental Maritime Consultative Organization (IMCO) (present International Maritime Organization IMO) already in 1968 (IMCO 1968), only a year after the world's first traffic separation scheme in Dover Straits.

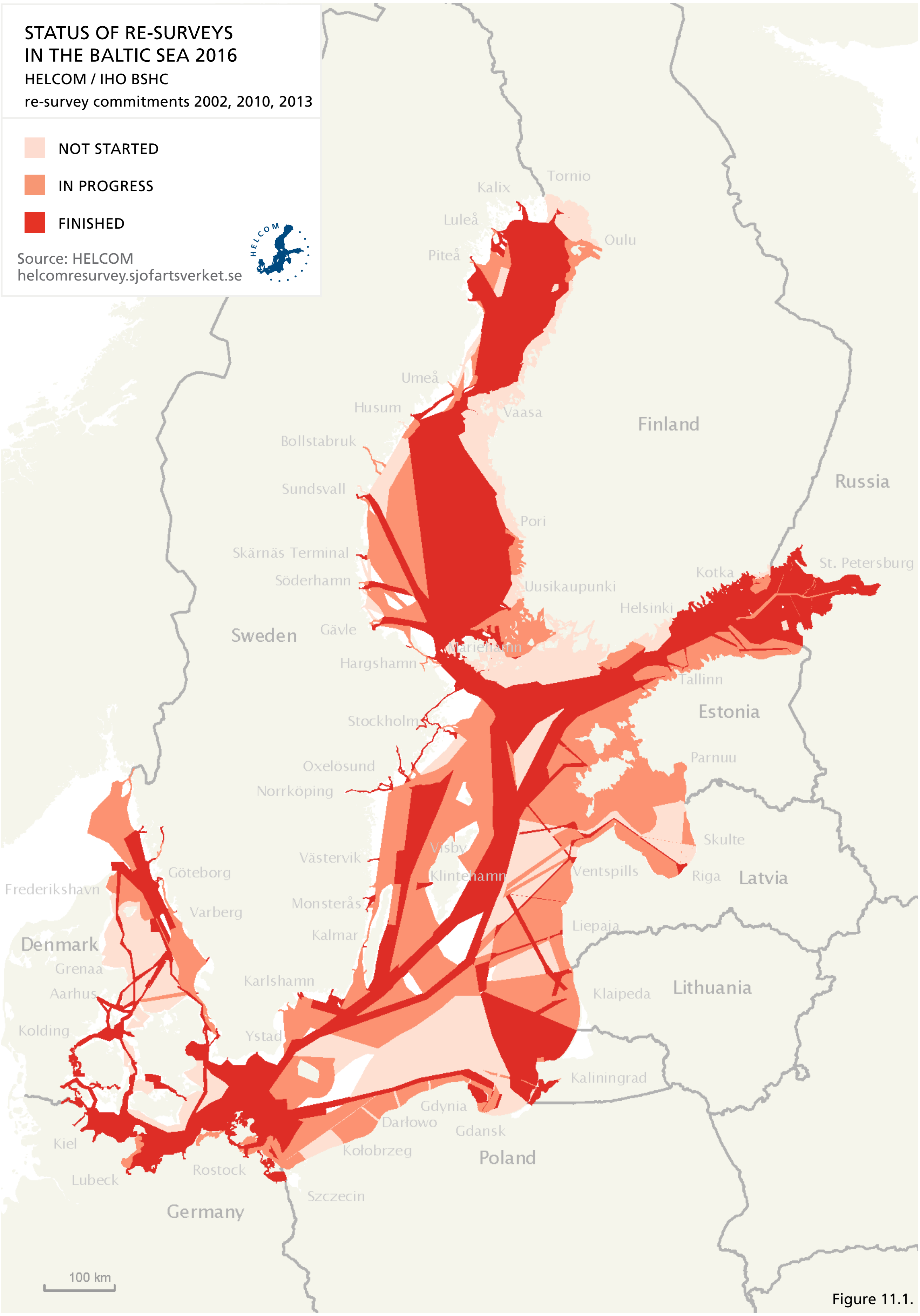

STATUS OF RE-SURVEYS
IN THE BALTIC SEA 2016
HELCOM / IHO BSHC
re-survey commitments 2002, 2010, 2013
NOT STARTED
IN PROGRESS
FINISHED
Source: HELCOM
helcomresurvey.sjofartsverket.se
HELCOM
Tornio
Kalix
Luleå
Oulu
Piteå
Umeå
Husum
Vaasa
Finland
Bollstabruk
Sundsvall
Russia
Pori
Skärnäs Terminal
Söderhamn
Uusikaupunki
Kotka
St. Petersburg
Helsinki
Gävle
Sweden
Mariehamn
Hargshamn
Tallinn
Estonia
Stockholm
Parnuu
Oxelösund
Norrköping
Visby
Skulte
Västervik
Klintehamn
Ventspills
Riga
Latvia
Göteborg
Frederikshavn
Varberg
Monsterås
Liepaja
Kalmar
Denmark
Grenaa
Aarhus
Karlshamn
Klaipeda
Lithuania
Kolding
Ystad
Kaliningrad
Gdynia
Darłowo
Gdansk
Kiel
Kołobrzeg
Poland
Rostock
Lubeck
Szczecin
Germany
100 km

Figure 11.1.

Measures in the Baltic Sea adopted in 1968 include ‘Off Kalbådagrund Lighthouse’, ‘Off Hogland (Gogland) Island’, ‘Off Porkkala Lighthouse’, ‘Off Hankoniemi Peninsula’, ‘Off Kopu Peninsula’, ‘Off Gotland Island’ and ‘Off Öland island’ (IMCO 1968).

These and other such routeing measures were initially voluntary, but later established as recommendations (IMCO 1971) and also defined in greater detail (IMCO 1973). In strict legal sense the majority of IMO routeing measures are only recommendatory, even if navigation in them becomes de facto mandatory via rule 10 of COLREG. During 1980s, IMO decisions allowed also routeing measures based on environmental justifications.

By 2016 the Baltic Sea States had established (mainly via IMO) a large number of routeing measures in the Baltic Sea area. These include ship routeing systems such as 25 Traffic Separation Schemes (TSS), seven other spatial measures (such as two-way routes), six deep-water routes, four mandatory Ship Reporting Systems (SRS) – SOUNDREP, BELTREP, GOFREP and GDANREP – as well as two areas to be avoided (ATBAs). In addition, Vessel Traffic Service (VTS) all over the Baltic Sea provides services to mariners and follow the implementation of routeing measures.

HELCOM Clean Shipping Guide (HELCOM 2016) includes a list of valid routeing measures in the Baltic Sea by 2016.

AIS

The International Automatic Identification System (AIS) carriage requirements are applied in the Baltic Sea. SOLAS Chapter V regulation 19 requires that AIS equipment onboard all ships of 300 GT and upwards engaged on international voyages, cargo ships of 500 GT and upwards not engaged on international voyages (by 2008) and all passenger ships irrespective of size. The requirement became effective for all ships by 31 December 2004. Ships fitted with AIS shall maintain AIS in operation at all times.

Some Aids to Navigation (AtoNs) in the region are installed with AIS transponders. In addition, some coastal states use “Virtual AtoNs”, or AtoNs without a physical presence and visible only via AIS-enrichened chart systems. Virtual AtoNs are commonly used in dynamic situations, for example when temporary dangers occur or in heavy ice conditions when preferred routes are sometimes marked out electronically. Some countries in the Baltic Sea, like Sweden and the Russian Federation, provide also weather data via AIS which can be received by some AIS equipment models.

The Baltic Sea area is covered by a dense network of national AIS base stations (Figure 11.2) which, if combined, enable coverage of the entire region in normal operating conditions. Since the 1st of July 2005 the national AIS networks in the Baltic Sea area are linked together as HELCOM AIS, which gives to all coastal countries a real time picture of traffic situation in the entire region.

This globally pioneering regional HELCOM AIS network between the nine maritime administrations, was launched as one direct result of commitments at the HELCOM Ministerial Meeting of 2001 and continues to be developed and maintained by a dedicated HELCOM Group (HELCOM AIS EWG). In 2017 hosting of the central server was moved from Denmark to Norway.

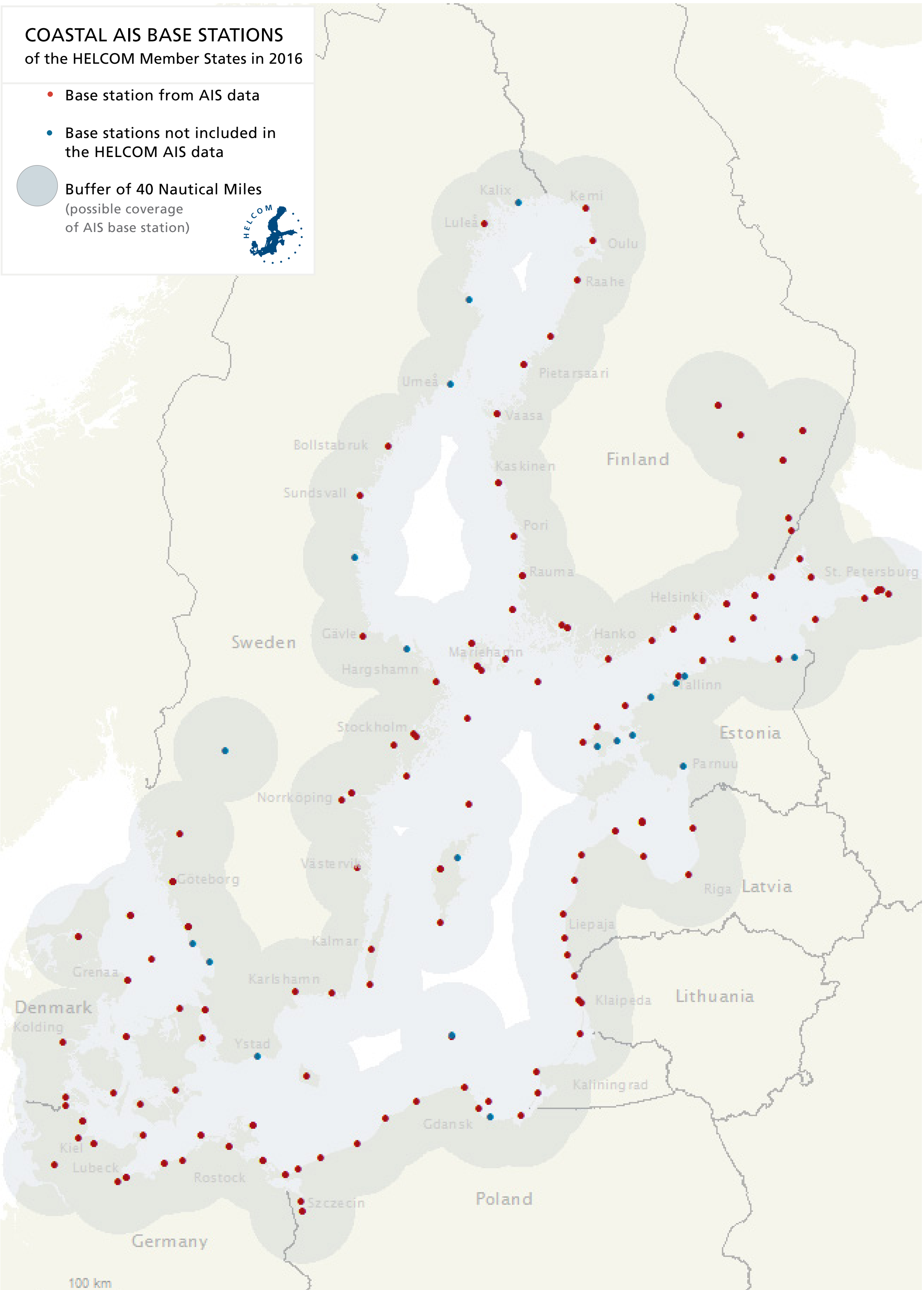

COASTAL AIS BASE STATIONS
of the HELCOM Member States in 2016
Base station from AIS data
Base stations not included in the HELCOM AIS data
Buffer of 40 Nautical Miles
(possible coverage of AIS base station)
HELCOM
Kalix
Kemi
Luleå
Oulu
Raahe
Umeå
Pietarsaari
Vaasa
Bollstabruk
Finland
Kaskinen
Sundsvall
Pori
Rauma
St. Petersburg
Helsinki
Gävle
Hanko
Sweden
Mariehamn
Hargshamn
Tallinn
Stockholm
Estonia
Parnuu
Norrkoping
Västervik
Göteborg
Riga
Latvia
Liepaja
Kalmar
Grenaa
Karlshamn
Klaipeda
Lithuania
Denmark
Kolding
Ystad
Kaliningrad
Gdansk
Kiel
Lubeck
Rostock
Szczecin
Poland
Germany
100 km

Figure 11.2.

As mentioned earlier, the synoptic and historical AIS information, showing the density of traffic and the actual sailed routes of ships in the entire region, has during the last ten years highlighted the need for new high priority areas for bathymetric re-surveys, new charts (especially ENCs) as well as other safety of navigation measures such as IMO routeing.

Access to the regional AIS data generated by the system is also available to a wide range of actors either automatically, or in some cases after an explicit consultation. The recent surge of maritime developments in the form of wind-power farms, pipelines and cables have increased the interest in this information for planning purposes.

Ice navigation

During winter months ice is a major navigational challenge in the Baltic Sea region. During winter a large part of the Baltic Sea area is covered with ice and the largest ice extent is observed during February-March.

Based on HELCOM Recommendation 25/7 adequate ice strengthening is needed for ships sailing in the Baltic Sea during ice season depending on the thickness of level ice.

Below restriction categories according to ice classes of the Finnish-Swedish Ice Class Rules (Baltic Ice Classes) and Russian Maritime Register of Shipping Rules 2008 (see Table 11.1 of ice class comparisons):

- In ice thickness in the range of 10–15 cm, and if the weather forecast predicts continuing low temperature, a minimum ice class Category II or Ice 1 or equivalent should be required for ships entering the ports of a Contracting Party.
- In ice thickness in the range of 15–30 cm, and if the weather forecast predicts continuing low temperature, a minimum ice class IC or Ice 2 or equivalent should be required for ships entering the ports of a Contracting Party.
- In ice thickness in the range of 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 exceeds 50 cm, a minimum ice class IA or Arc 4 or equivalent should be required for ships entering the ports of a Contracting Party.

If in force, these requirements will be announced to the mariners as traffic restrictions which can be lightened and finally removed after the melting period of ice has started in spring and the strength of the level ice fields has started to decrease.

Information on ice conditions, traffic restrictions, ice breakers and other issues relevant to mariners navigating in the Baltic Sea during winter time can be obtained from the website www.baltice.org.

Additional information about ice conditions in the Baltic Sea countries, including contact information of the national ice services can be obtained from the common website of the national ice services of the Baltic Sea States www.bsis-ice.de.

Table 11.1. ICE CLASS COMPARISONS IN HELCOM RECOMMENDATION 25/7 (last revision 2016)

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	-	-	-
Korean Register of Shipping	IA Super	IA	IB	IC	ID
Lloyd's Register of Shipping	Ice Class 1AS FS (+) Ice Class 1AS FS	Ice Class 1A FS (+) Ice Class 1A FS	Ice Class 1B FS (+) Ice Class 1B FS	Ice Class 1C FS (+) Ice Class 1C FS	Ice Class 1D Ice Class 1E
Nippon Kaiji Kyokai	NS* (Class IA Super Ice Strengthening) NS (Class IA Super Ice Strengthening)	NS* (Class IA Ice Strengthening) NS (Class IA Ice Strengthening)	NS* (Class IB Ice Strengthening) NS (Class IB Ice Strengthening)	NS* (Class IC Ice Strengthening) NS (Class IC Ice Strengthening)	NS* (Class ID Ice Strengthening) NS (Class ID Ice Strengthening)
Polski Rejestr Statków	L1A	L1	L2	L3	L4
Registro Italiano Navale	ICE CLASS IA SUPER	ICE CLASS IA	ICE CLASS IB	ICE CLASS IC	ID

Pilotage requirements

Pilotage is traditionally considered as an efficient way to reduce the risk of accidents in specific high risk areas. For this purpose certified Baltic Deep Sea Pilots are available in all Baltic Sea coastal states and ships' masters are recommended through IMO Resolution A. 1081(28) to use their services.

Pilotage recommendations in the Danish straits were among the early topics of HELCOM work on safety of navigation and already considered during the 1970s. Based on the 2002 IMO Recommendation on Navigation through the Entrances to the Baltic Sea, pilotage is required on the following legs:

The Sound

When passing through the designated areas of the Sound, the following ships should use the pilotage services established by the Governments of Denmark and Sweden:

– loaded oil tankers with a draught of 7 m or more
– loaded chemical tankers and gas carriers irrespective of size
– ships carrying a shipment of irradiated nuclear fuel or INF-cargoes

Route – T

When passing through the Route-T, the following ships should use the pilotage services established by the coastal States:

– ships with a draught of 11 m or more
– ships carrying nuclear fuel or irrespective of size or draught

Future perspectives

Open tools for risk assessments

A risk assessment means systematically identifying, evaluating and analysing risks. By getting a full picture of risks, accidents can be better prevented and their consequences minimized with optimized risk reduction measures. These are regularly carried out in the coastal country administrations. However, they can also be carried out for an entire region such as the Baltic Sea in order to support joint regional planning and work.

The HELCOM BRISK/BRISK-RU projects 2009–2012 carried out the first regional risk assessment of ship accidents and related spills in the entire Baltic Sea region.

A challenge is that results of such risk assessments are typically valid for a limited period as the traffic patterns change. The lack of regular risk assessments with a common methodology has caused difficulties in following how the risks of accidents, and pollution, develop over time and thus, monitoring the cost efficiency of implemented policy measures.

New approaches are greatly needed to address these issues and use the full potential of risk assessments. The HELCOM led OpenRisk project 2017–2018 will take the first step in developing a toolbox of joint and open methods enabling frequent assessments of spill risks from maritime accidents and to optimize response preparedness.

The expected main end users are national authorities and regional organizations working on spill prevention, preparedness and response, or their consultants. As such, the project focusses on risks related to spills from ship accidents.

The challenge of improving safety culture of operators

The measures described above, as well as ensuring compliance with international safety regulations, are efficient measures which the coastal countries can take to improve safety of navigation in the Baltic Sea. However, shipping is most of all a business and it is shipping companies, not states, which have the decisive role in the maritime industry.

Safety culture of shipping companies and their associated partners is a particularly crucial feature to improve safety at sea. Safety culture is an inherent part of the operation of the organization and must be based on high levels of information sharing and trust between management and the work force.

e-navigation and Sea Traffic Management

The digitalisation of the maritime sector, generally “e-navigation”, allows better information sharing and operational improvements based on a common situational awareness. One example is Sea Traffic Management (STM), a concept conceived and defined during a series of recent large EU-funded projects (MONALISA, STM) led by the Swedish Maritime Administration. STM aims to enable a higher level of safety in the region by common situational awareness, including digital exchange of route information between ships and between ships and shore. The ongoing trials on board 300 vessels and in 13 ports in two large-scale test beds, one in the Nordic including the

Baltic Sea, and the other in the Mediterranean will demonstrate the benefits of the approach by the end of 2018.

STM will be realised through four strategic enablers:

- Voyage Management services will provide support to individual ships both in the planning process and during a voyage, including route planning, route exchange, and route optimisation services.
- Flow Management services will support both onshore organisations and ships in optimising overall traffic flow through areas of dense traffic and areas with particular navigational challenges.
- Port Collaborative Decision Making, Port CDM, services will increase the efficiency of port calls for all stakeholders through improved information sharing, situational awareness, optimised processes, and collaborative decision making during port calls.
- System Wide Information Management, SeaSWIM, will facilitate data sharing using a common information environment and struc ture (e.g. the Maritime Cloud). This ensures interoperability of STM and other services.

12. PREPAREDNESS AND RESPONSE CAPACITY IN THE BALTIC SEA

Introduction

Only few of the around 300 maritime accidents which take place yearly in the Baltic Sea result in an oil spill, and mostly these are small releases with only local impact and importance. Nevertheless time to time larger spills take place in Baltic Sea, requiring some sort of international response action to avoid damage to the environment. With the current frequency of traffic and size of modern ships, including tankers, it is not unthinkable that a major spill could happen again.

In order to prepare for major pollution incidents, the coastal countries of the Baltic Sea and the EU (European Maritime Safety Agency, EMSA) maintain and develop a high level of preparedness and response capacity in the region. This includes naturally acquiring and maintaining the needed equipment including specialized spill response vessels and surveillance aircraft - but also agreed regional procedures, which are trained in joint annual operational exercises.

Due to the sensitivity of the Baltic Sea, dispersants – chemical products, which dissolve oil slicks to minuscule droplets - are not considered a primary response measure for oil spills. Instead, the focus is on ensuring sufficient mechanical recovery capacity at sea (sweeping arms, skimmers and brushes), as well as booms, to be able to jointly collect or stop large spills before they reach the shore.

In addition to such capacity at sea, the countries have recently also developed joint response co-operation on the shore. This is necessary as in some cases it might not be possible to stop a larger spill from reaching the shore. In such cases international response from the shore may be necessary, involving beach booms, trucks, smaller vessels and volunteers. It may also include preparedness in handling large amounts of oiled wildlife, which might include threatened species.

Even if oil remains to be in focus of the response activities and co-operation due to the large volumes carried in the Baltic Sea, the region is also prepared to respond to spills of hazardous chemicals. For this purpose

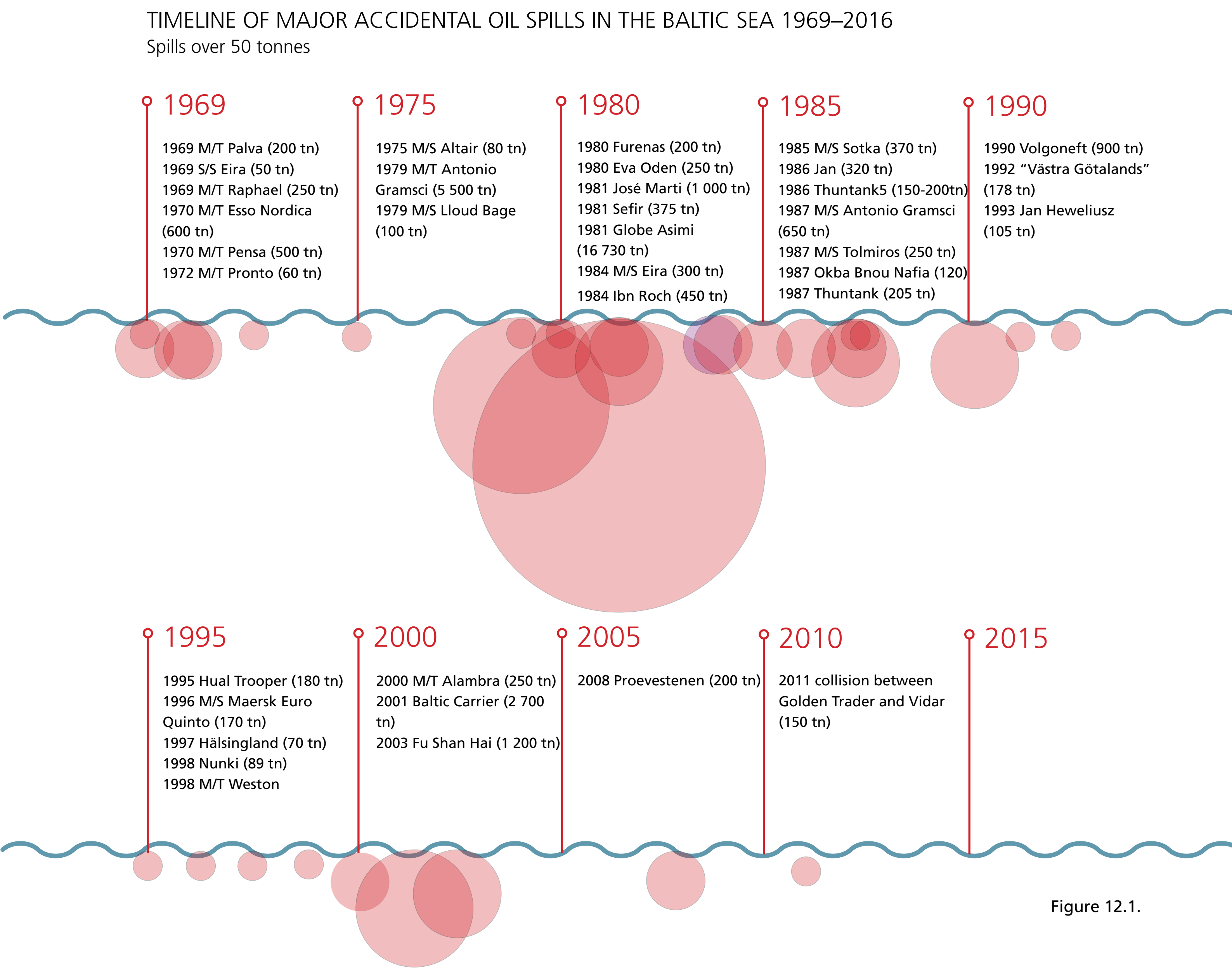


Figure 12.1.

a number of advanced "safe platform" vessels for chemical response have been introduced recently.

Timeline of accidental spills in the Baltic Sea

The largest spills recorded in the Baltic Sea took place during the late 1970s and early 1980s. This is not surprising as during that time oil shipments increased rapidly but current safety measures, technology and perhaps also awareness were not in place. The Globe Asimi accident of 1981, with 16 730 tonnes of oil spilt to the Baltic Sea in the vicinity of Klaipeda (Lithuania), keeps the questionable record of the biggest spill in the history of the Baltic Sea.

After a number of relatively quiet years during the 1980s and 1990s, the Baltic Carrier (2001, 2 700 t) and Fu Shan Hai (2003, 1 200 t) incidents awakened the region again to the threat from large spills (Figure 12.1 and Figure

12.2). As a result a number of new safety of navigation measures were agreed for the region including also a revision of the relevant sections of the 1992 Helsinki Convention. No spills over 1000 tonnes have taken place in the Baltic Sea since the 2003 Fu Shan Hai incident.

Volume of oil carried in the Baltic Sea

The volume of liquid bulk including oil handled in bigger Baltic Sea ports increased rapidly during the period 2000-2008 but then levelled off (Figure 12.3). In 2013, a total of 315 million tonnes of liquid bulk cargo were handled in 116 Baltic Ports (Baltic Port List 2014).

More than 40 % of this volume consists of traffic which crosses the entire Baltic Sea area - to and from Russian (Primorsk, Ust-Luga, St. Petersburg and Vysotsk), Finnish (Kilpilahti) and Estonian (Muuga) ports in the Gulf of Finland. In Figure 12.4 are shown the biggest ten oil terminals in the Baltic Sea in 2013.

Regulations

1992 Helsinki Convention

The Helsinki Convention of 1992 and the specific Articles 13, 14 and Annex VII target ensuring preparedness and response to pollution incidents in the Baltic Sea. A large number of HELCOM Recommendations have also been agreed.

According to Regulation 4, Annex VII of the Helsinki Convention and HELCOM Recommendation 2/7 concerning the Delimitation of Response Regions for Combatting Marine Pollution, the Contracting Parties are obliged, *inter alia*, to agree bilaterally or multilaterally on those regions of the Baltic Sea in which they will conduct aerial surveillance activities and take action for combatting and salvage activities. As a principle the response regions should coincide with the boundaries of the Exclusive Economic Zones, where applicable.

Sub-regional agreements and cooperation

In addition to the provisions of the 1992 Helsinki Convention, which cover the whole Baltic Sea, nine sub-regional response agreements have been agreed in the Baltic Sea according to the agreed three tiered approach to response (national-sub regional –Baltic wide) and Regulation 4 of the 1992 Helsinki Convention Annex VII.

These include currently the pollution preparedness and response agreements between Estonia and Finland (1993), Finland and Russia (1989), Sweden-Denmark-Germany (2002), Latvia and Lithuania (2001), Latvia and Sweden (2002), Latvia and Estonia (2014), Poland and Germany (2001), Lithuania and Russia (2009), Poland and Russia (2010). In addition, sub - regional agreements for Sweden-Estonia-Latvia as well as between Estonia and Russia are currently being negotiated.

These sub-regional agreements enable closer practical co-operation between neighbouring countries, including detailed response planning and targeted exercises.

LOCATION OF MAJOR ACCIDENTAL OIL SPILLS IN THE BALTIC SEA 1969–2016
Spills over 50 tonnes

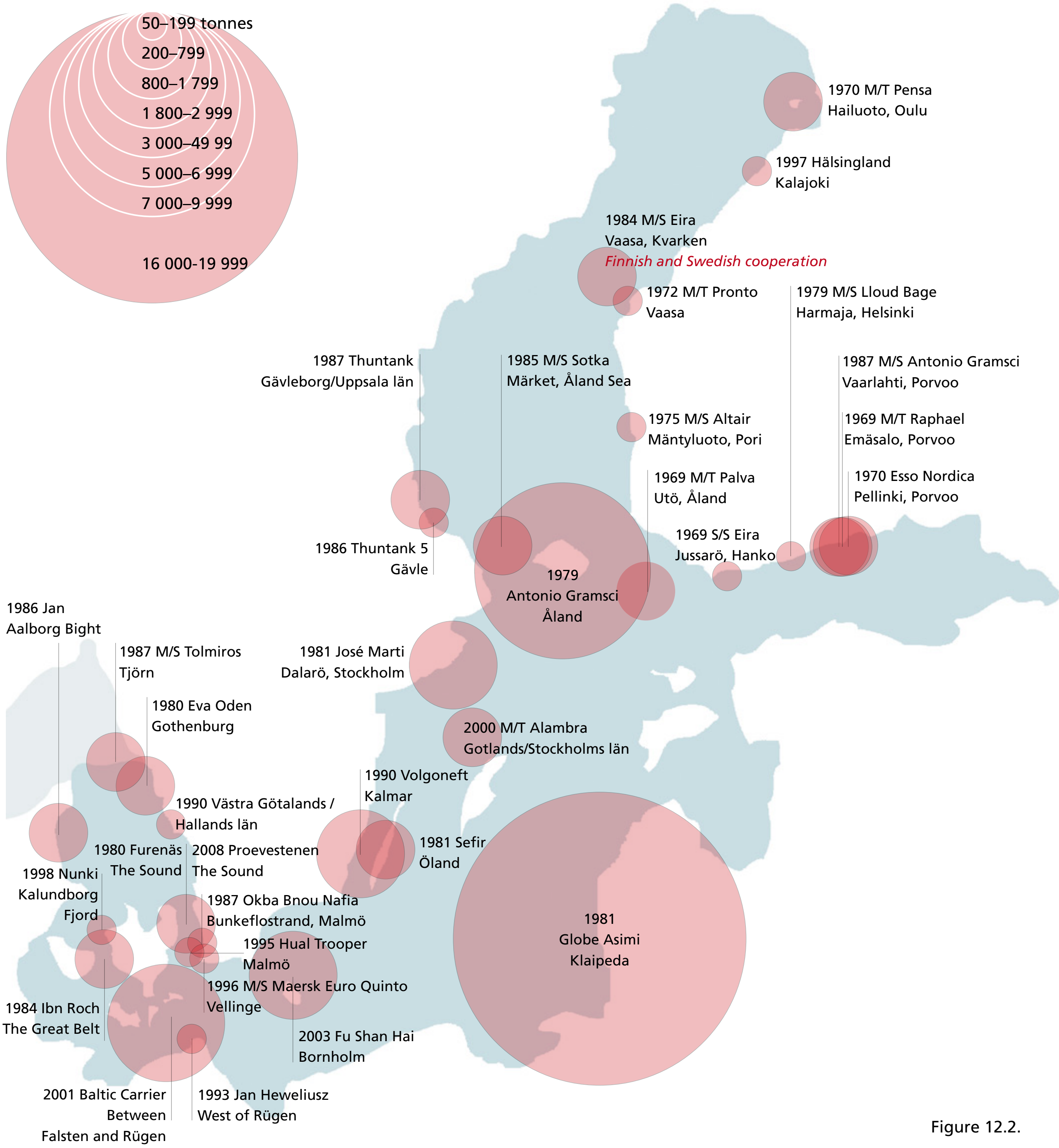


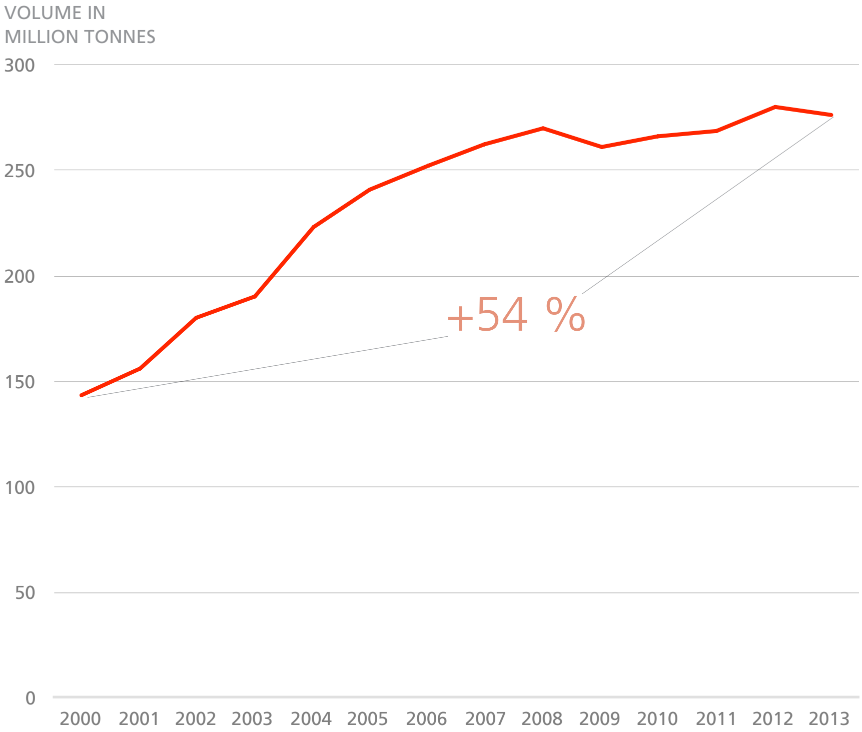
Figure 12.2.

Figure 12.3.

INCREASING AMOUNT OF OIL HANDLED IN THE BALTIC SEA

Oil handling in 18 larger ports in the Baltic Sea representing 88 % of total volume handled

Source: HELCOM data and Baltic Port Lists 2008–2014



Other regional agreements related to pollution preparedness and response in the Baltic Sea

The 1971 Copenhagen Agreement on response co-operation between the Nordic countries is applied in the Baltic within the Exclusive Economic Zones (EEZs) of Denmark, Sweden and Finland.

The 2013 Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic is applied in the Bothnian Bay north of 63°30’00”N.

In addition, EU regulations are applied in those Baltic States which are also EU Members.

IMO Agreements

The global framework for international co-operation in combatting major incidents or threats of marine pollution is provided by the 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC). In addition, liability issues and the arrangements to cover the costs caused by major oil spills are addressed in a number of dedicated global agreements.

Baltic Sea standard operating procedures (HELCOM Response Manual)

The HELCOM response manual, which is essentially an extension of the Annex VII of the 1992 Convention, summarises technical details and the

TOP 10 BIGGEST OIL TERMINALS IN THE BALTIC SEA IN 2013

Oil handling in ten largest terminals in the Baltic Sea Ports 2000–2013

Source: HELCOM data and Baltic Port Lists 2008–2014

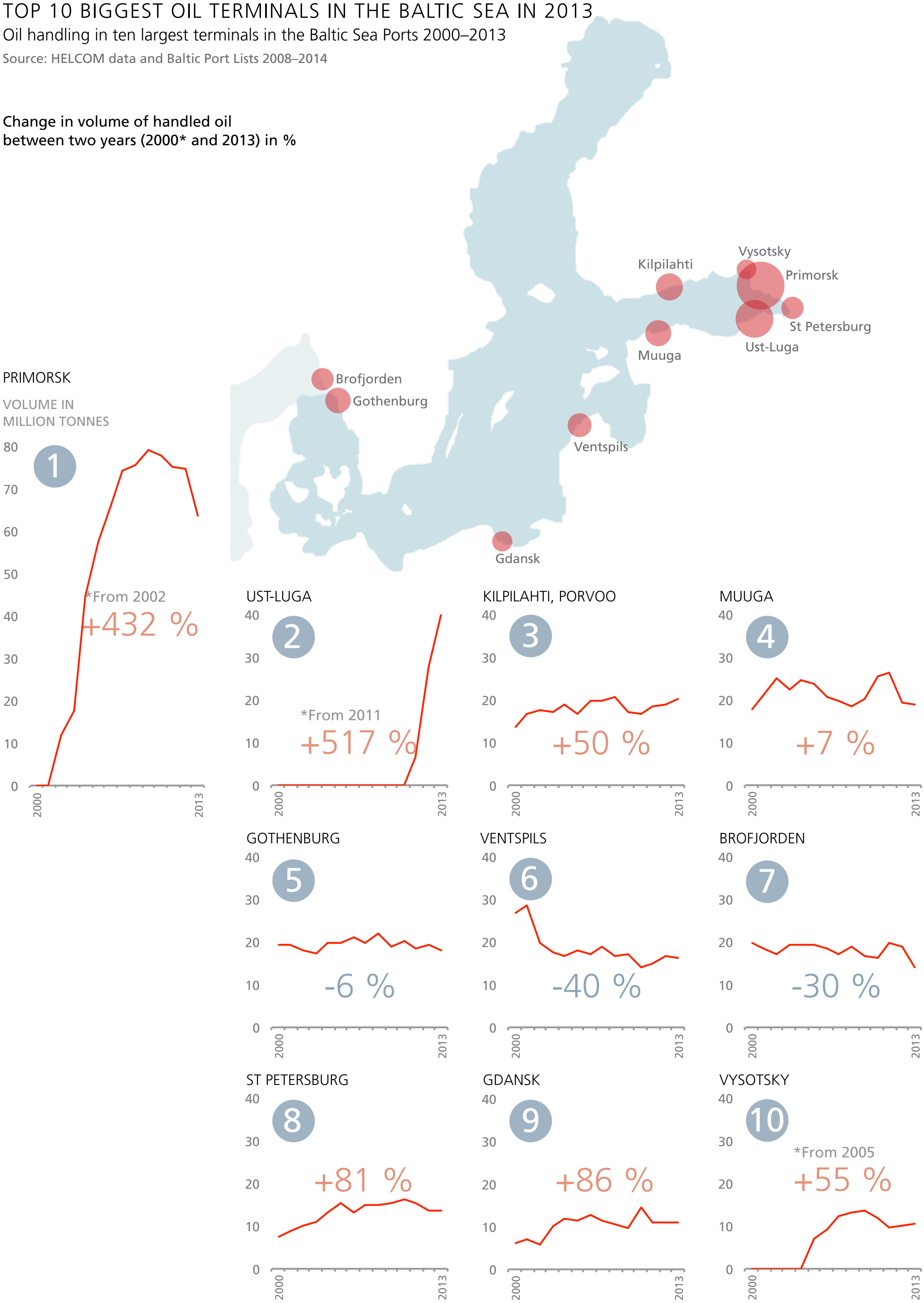


Figure 12.4.

agreed procedures and practices in Baltic co-operation on response issues. It is under constant updating by the Response Working Group and available online (helcom.fi). It includes besides the main text all the valid HELCOM Recommendations relevant for pollution preparedness and response.

The response manual was originally created based on early work during the late 1970s when a series of Recommendations dealing with regional warning-, reporting-, communication- and command systems related to regional response operations were adopted by the Commission in 1980 and 1981, and later compiled in a targeted HELCOM Manual on Co-operation in Combatting Marine Pollution adopted in 1983. Later entire new sections, e.g. on aerial surveillance and sub-regional co-operation, were added.

A separate Volume II of the manual, focusing on response to accidents at sea involving spills of hazardous substances and loss of packaged dangerous goods, was adopted in 1990 to make the region better prepared also for this type of pollution incidents. The last addition is the volume III on response on the shore, adopted in 2013 and revised in 2017.

Response activities in the Baltic Sea

Response vessel fleet in the Baltic Sea

The Baltic Sea fleet consisted of 85 response vessels as reported to HELCOM in 2016 (HELCOM 2016a) (Table 12.1., Figure 12.5.), including specially designed response vessels as well as navy and other vessels with national tasks in oil spill response. In total these vessels have a recovery capacity of 9144 m^3 oil per hour, carry 27.7 km of booms to stop and contain oil slicks and have a total capacity to store 19742 m^3 of collected oil and oily water. In addition storage capacity ashore is made available. However, it should be noted that usually only a share of this capacity is available for international response operations as certain capacity needs to be retained in the home country to preserve a minimum response capacity; and due to overhauls, maintenance, technological updates, and participation in international exercises outside the Baltic.

All coastal countries have at least one response vessel and also EMSA has

Table 12.1. RESPONSE CAPACITY OF THE BALTIC SEA COASTAL STATES AND EU (EMSA vessel)*

Contracting Party	Number of vessels	Recovery capacity (m3/h)	Boom length (m)	Storage capacity (m3)
DENMARK	24	270	7 560	751
EU (EMSA)	1	900	500	2 880
ESTONIA	3	480	800	413
FINLAND	18	1 444	6 200	5 913
GERMANY	7	2 400	1 800	2 845
LATVIA	4	280	1 800	444
LITHUANIA	2	300	650	328
POLAND	5	540	1 340	610
RUSSIA	8	770	1 250	440
SWEDEN	13	1 760	5 800	5108
Total Baltic Sea	85	9 144	27 700	19 732

*As reported to HELCOM in 2016 (HELCOM 2016a)

RECOVERY CAPACITY OF, AND AVAILABLE BOOMS IN, RESPONSE VESSELS BY COASTAL COUNTRIES

Source: As reported to HELCOM in 2016 (HELCOM 2016a)

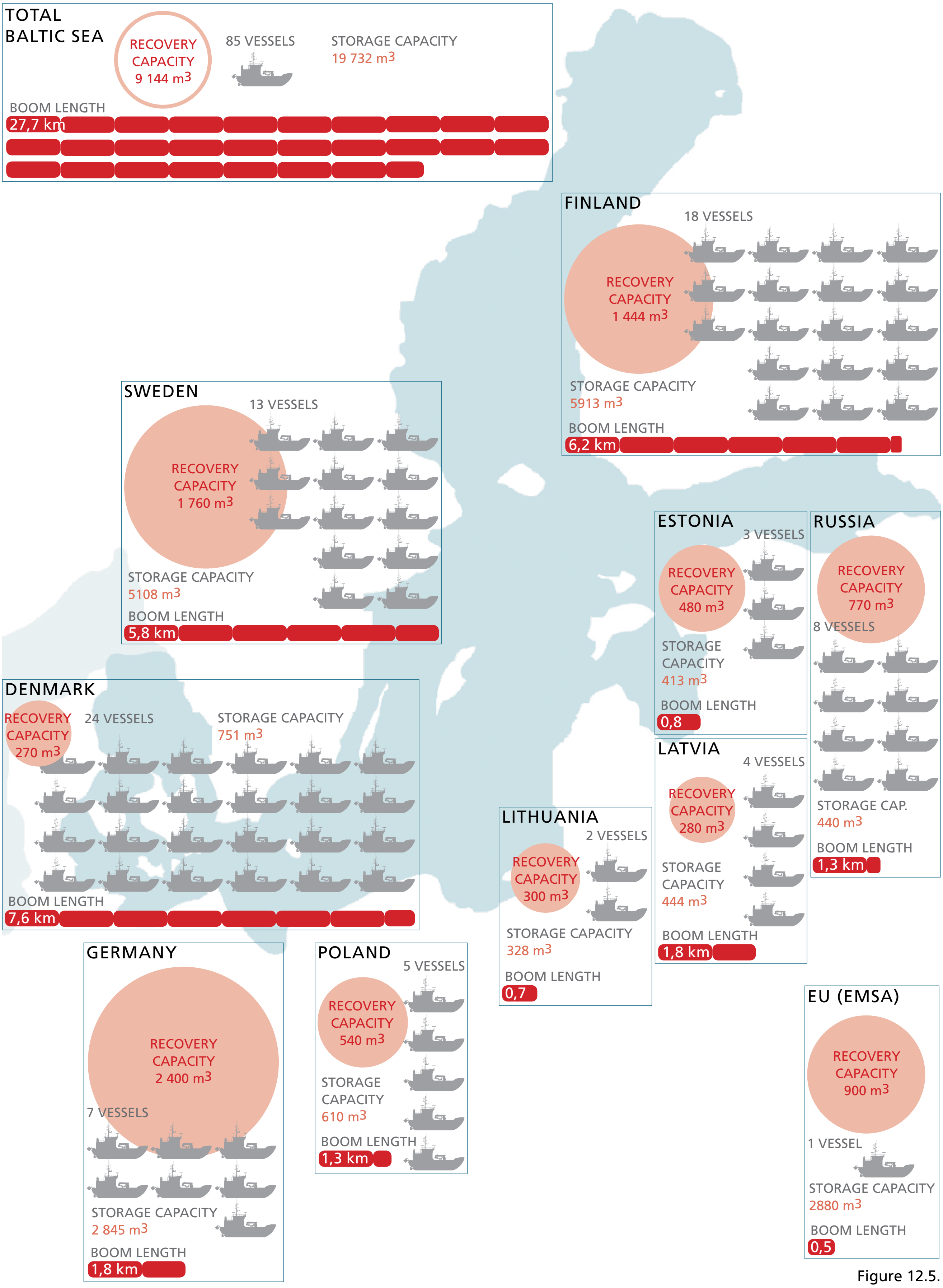


Figure 12.5.

a response vessel in the southern Baltic Sea. The national fleets of Germany, Sweden and Finland have largest recovery and storage capacities, more than half of the total capacity, with many specialised vessels.

Response aircraft fleet in the Baltic Sea

In addition to response vessels the coastal countries of the Baltic Sea have 35 surveillance aircraft (19 airplanes and 16 helicopters) which have an important role in response operations, observing slick movements and enabling situational awareness. These aircraft are in regular use and i.e. provide the surveillance data on operational pollution described in Chapters 4 & 5.

Exercises

In order to ensure an effective joint response in practice the HELCOM Contracting Parties carry out joint response exercises regularly. These exercises range from table top or "paper" exercises to operational exercises. BALEX DELTA operational exercises are the most famous of the HELCOM response exercises, which since the late 1980s have gathered the coastal states response fleets annually to the same port. The general objective of the BALEX DELTA exercises is to ensure that every Contracting Party is able to lead a major response operation.

Baltic focus on mechanical recovery of oil & dispersants

Due to the sensitivity of the Baltic Sea, the coastal countries concluded in 1978 that in oil combatting operations in the Baltic Sea, the use of dispersants should be limited as far as possible, that sinking agents should not be used at all in the Baltic Sea area, that synthetic or natural absorbents could be used in certain cases, and that mechanical means for oil pollution combatting are preferable (HELCOM1978).

This agreement to focus on mechanical recovery and avoid dispersant and sinking agent use in the region is still valid today and included in Annex VII of the 1992 Helsinki Convention as Regulation 7 on Response Measures.

Response to chemical spills

Already in 1990, the coastal countries adopted a dedicated volume of the HELCOM Response Manual to address the potential risks from accidents involving hazardous chemicals, comprehensively revised in 2002. Today, new knowledge is available and as chemical transportations in the region, both in bulk and in packaged form, have increased during later years there are aims for another revision.

Fourteen response vessels, five in Finland (Merikarhu, Tursas, Uisko, Louhi & Turva), two in Germany (Scharhörn & Arkona) and seven in Sweden (KVB001 Poseidon, KBV002 Triton, KBV003 Amfitrite, 031, 032, 033 & 034) have been reported to be equipped to be able to participate in response operations involving spills of hazardous chemicals, even if many of these only to a limited degree (HELCOM 2016a).

Risk assessments & dimensioning adequate response capacity

Maintaining response preparedness and the needed equipment is expensive and it is important to dimension the capacity according to the foreseen risks of spills. This includes in some countries the identification of "target spills" or "spill objective", or a spill of certain size which will form the basis for national preparedness planning (Table 12.2.).

Such targets are supported by national risk assessments which cover, besides dimensioning capacity itself, also its optimal placement along the coastline.

Table 12.2.

NATIONAL TARGETS FOR SPILL RESPONSE CAPACITY IN THE BALTIC SEA

Country	Response target/objective
DENMARK	capacity to respond to a spill of 5000 t within three days
ESTONIA	10 000 t
FINLAND	30 000 t (Gulf of Finland) /20 000 t (Archipelago Sea)/ 5000 t (Gulf of Bothnia) within three days
GERMANY	15 000 t
LATVIA	No fixed value
LITHUANIA	NA
POLAND	No fixed value
RUSSIA	NA
SWEDEN	10 000 t (National resources only)

Source: HELCOM 2016b

Drift modelling

The Seatrack Web (STW) oil drift calculation system is the official HELCOM drift model/forecasting and hindcasting system which is used for calculating the fate of oil spills. It is developed and hosted by the Swedish Meteorological and Hydrographic Institute (SMHI) in co-operation with other regional institutes and available online for national authorities and certain research organisations.

STW has an important role in the response co-operation in the Baltic Sea region and is since the 1990s used by all Baltic Sea coastal states - in some cases in parallel with national systems. Several versions have been developed since the 1990s, the recent one being a completely overhauled version, with new web interface and enhanced model algorithms, released in 2014.

The STW system is able to make forecasts of how a cloud of particles (e.g. oil) will be moving and behaving on the sea surface. In case an oil spill is detected, the system is used to predict where the oil will be after some hours. This enables combatting units to be able to plan where to be positioned to make the most use of their oil recovery equipment. On shore, cleaning units can plan where to move their units so they can protect the shorelines most probable of being affected by the oil.

If it is an illegal spill it is of interest to identify the polluter. STW combines modelling run in a backtracking mode with the HELCOM AIS data in order to identify which ships have passed the track of the oil spill. This information is used to find possible polluters for further investigations.

Places of refuge

Based on the explicit requirements of the 1992 Helsinki Convention, the coastal countries and the EU agreed in 2010 on a mutual plan for places of refuge in the Baltic Sea area (HELCOM Recommendation 31E/5). It calls the countries to define places of refuge in their jurisdiction and make them operational within sub-regional co-operation arrangements (see under Regulations within this chapter).

The main responsibility to grant a place of refuge (PoR) to a polluting ship in distress is with the country in which the response operation started. However, in some cases this is not possible and a PoR in another coastal country would help to limit pollution or safety of life. The recommendation provides guidance for these cases when the country of origin requests another country to grant a PoR. Financial reasons are explicitly defined as not a sufficient justification for such requests.

Future perspectives

Alternative fuels and spills

Besides positive contribution to reducing ship emissions, some alternative fuels such as Liquified Natural Gas (LNG) have the added benefit that they reduce the risk of oil spills as no bunker is carried on board. However, accident situations may naturally result in different types of hazards including the risk of human life loss.

However, some new types of synthethic fuels, developed as a response to the SECA regulations (see Chapter 2) have very different properties, if released to water, compared to traditional products, and might not be compatible with existing response equipment.

The sea is a source of food,
of energy, of FUN!

Section IV

OTHER MARITIME ISSUES

13. FISHING ACTIVITY IN THE BALTIC SEA

Introduction

Fishing activities in the Baltic Sea can be divided roughly to two main types: commercial and recreational fishing. Recreational fishing refers to fisheries as a leisure activity and takes place mainly in the coastal areas of the Baltic Sea. Commercial fishing includes mainly activities of vessels registered in national fishery vessel registers (Figure 13.1.).

Overall, the mechanization of commercial fishing between the 1950s–70s profoundly changed, and centralized, the industry resulting in the general long-terms trend towards fewer fishermen working in larger vessels catching more fish (Figure 13.2). On one hand, the bigger and more effective trawlers, tankers and gear have ensured large catches. On the other hand, suction pumps, sorting machines, refrigeration units and filleting machines have eased handling and transportation of bulk catch.

Fisheries in the Baltic Sea land annually in the order of 7–800 000 tonnes of fish (ICES, 2017, Lassen, 2011). The target species include herring (*Clupea harengus*), sprat (*Sprattus sprattus*), cod (*Gadus morhua*), European flounder (*Platichthys flesus*), salmon (*Salmo salar*) and sea trout (*Salmo trutta*) and a number of coastal species, e.g. vendace (*Coregonus albula*), pike (*Esox lucius*), perch (*Perca fluviatilis*), pike perch (*Sander lucioperca*) and garfish (*Belone belone*) (in the southern Baltic only). In the western parts of the Baltic Sea and Kattegat there are fisheries targeting other flatfishes, as well as Norwegian lobster and prawn. Eel (*Anguilla anguilla*) fishery has diminished during the last 30 years (Lassen 2011).

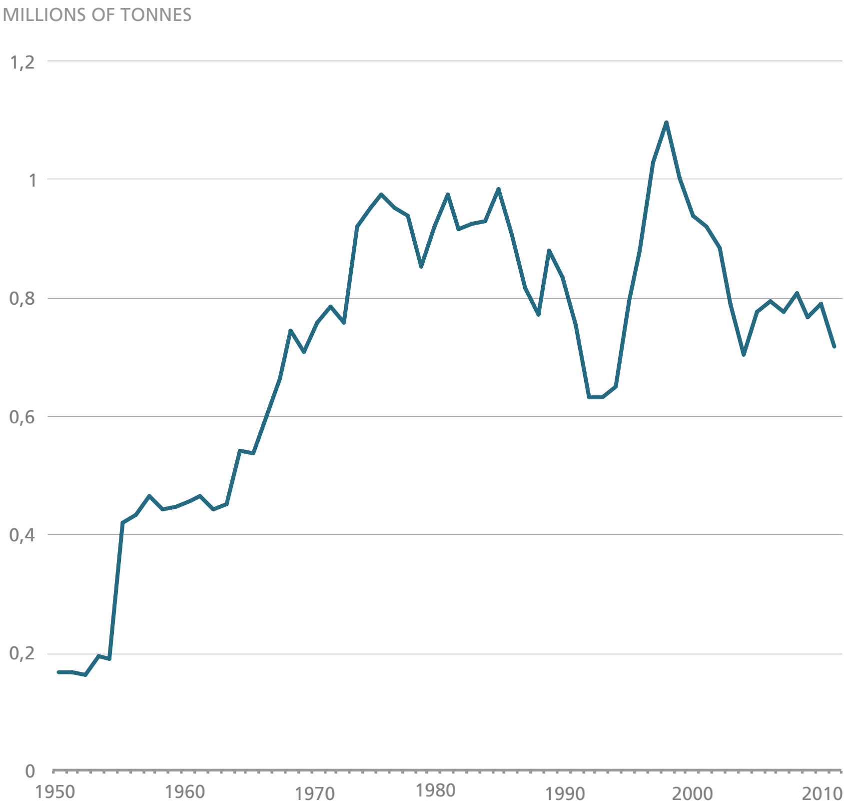
In terms of volume the main species targeted by commercial fishing in the Baltic Sea include, in decreasing importance, Atlantic herring and sprat (midwater trawls) as well as cod (demersal trawls). These three species constitute together about 95% (ICES, 2017) and that of herring and sprat alone nearly 90% of the commercial catch in terms of volume (STECF, 2017).

Even if fishing uses boats and ships, and in this way a pollution source similar to shipping (see first chapters), the main environmental impact of fishing activity is the direct effects it has on the biodiversity of the Baltic Sea. Fisheries impact naturally the targeted fish stocks, but depending on the gears used, may also have an effect on the sea bed and its fauna and

TOTAL CATCH OF COMMERCIAL FISHERIES 1950–2010

In the Baltic Sea (excluding the Kattegat area) in millions of tonnes, Source: ICES

Figure 13.1.



flora (bottom trawling) or other species including marine mammals and sea birds (incidental bycatch). Also derelict gears (e.g. "ghost nets") are a fisheries related environmental issue. These may cause mortality of fish and other fauna in the Baltic Sea for a long period after they have been lost at sea.

Fishing activities in the Baltic Sea

Based on the latest available figures the total commercial fisheries fleet of EU Member Countries operating in the Baltic Sea, excluding Kattegat, consisted in 2015 of around 6192 registered vessels, 9% of which were large scale (LSF) vessels, while 91% were small scale (SSF) vessels (STECF 2017). In addition to EU vessels, an unquantified number of Russian vessels operate in the Baltic Sea.

Commercial fishing activities, particularly that of larger vessels (>12m), are relatively well known as they are closely monitored by various data collection activities, for EU members as part of the Common Fisheries Policy implementation. Inversely, the activities of smaller coastal vessels, very much like leisure boats, in the Baltic Sea remain to be described in their full spatial complexity.

Large scale fishing vessels

In 2015 there were around 557 EU flagged industrial vessels in the large scale fishing (LSF) vessel category operating in the Baltic Sea (STECF, 2017). These LSF vessels operating in the Baltic Sea used as main gear either demersal ("bottom") trawls, targeting mainly species such as cod (*Gadus morhua*) as well as various flatfish species, or alternatively midwater trawls, targeting mainly herring and sprat. While cod is caught mainly for human consumption, herring and sprat are mostly caught to produce fish meal and fish oil for animal feed (including aquaculture) (Lassen, 2011). LSF vessels landed 91% of the total catch in terms of volume, 60% in weight and 40% in landing value (STECF, 2017).

In 2015 the largest vessel segment of the LSF category operating 80% or more in the Baltic (24-40m) included 14 Lithuanian demersal trawlers and 148 midwater trawlers (49 Latvian, 26 Estonian, 41 Polish, 23 Finnish and 9 Lithuanian) (STECF, 2017).

The fishing activities of larger vessels (usually >12 m) are monitored closely by their flag states, using mandatory procedures like obligatory landing as well as technologies like Vessel Monitoring System (VMS) and fisheries control cameras installed on deck.

Figures 13.3. illustrates the main target species in the Baltic Sea: cod, herring, sprat and flatfish as well as which gears are used to catch them.

Small scale fishing vessels

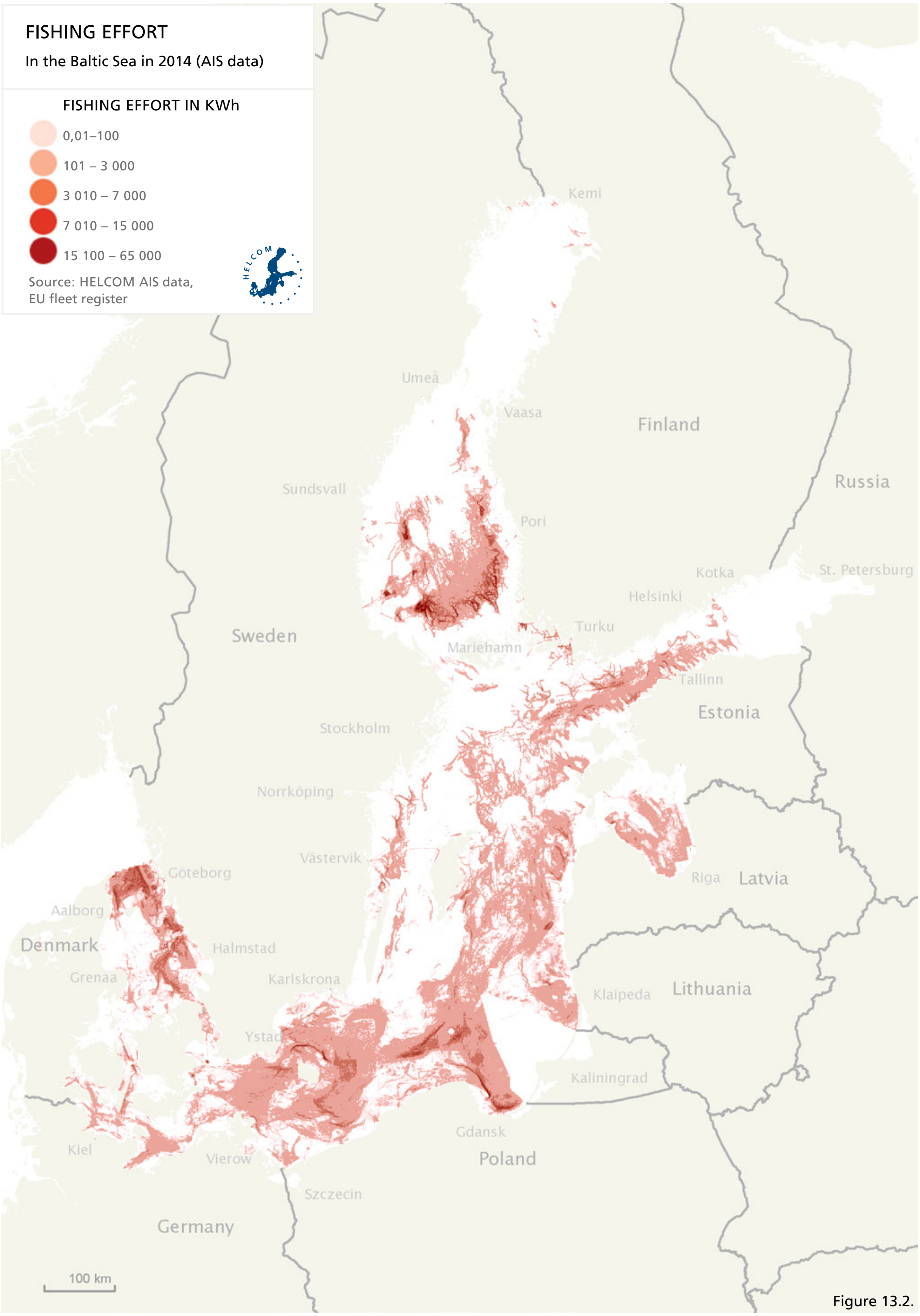
In terms of numbers the main part of the EU fishing fleet operating in the Baltic Sea consists of around 5635 smaller SSF fishing vessels (STECF, 2017). For European Maritime and Fisheries Fund (EMFF) purposes SSF vessels have been defined as having an overall length of less than 12 m and not using towed fishing gear.

These vessels use commonly different types of gears than the larger vessels. Usually various static or passive gear (FAO, 2016a), e.g. set gillnets and longlines as well as fixed traps, without a defined main gear (categorized as "PGP" or polyvalent passive gears) are used to target a wider variety of species (STECF 2016). Smaller vessels employ more fishermen per landed fish (STECF 2017) and tend to focus on catching higher value species for human consumption (IFREMER, 2007).

Mapping commercial fisheries activities by AIS

It is possible to map commercial fishing effort using the VMS data (ICES 2016; Bergström & Fredriksson 2012). However, also AIS data is becoming a viable basis for such mapping. AIS is compulsory for all EU fishing vessels with a length more than 15 meters since 2014 (EU Dir 2011/15/EU), but is also used on a voluntary basis by many smaller fishing vessels.

Following the methodology developed by Natale *et al.* (2015), the fishing effort in the Baltic Sea during 2015 was mapped for this report using the HELCOM AIS data covering the entire Baltic Sea and a database of fishing vessels. These maps, presented in Figures 13.1 and 13.4, show the resulting maps, presenting fishing effort for each of the main fishing gears based on AIS data. The complete methodology behind the maps is available as Appendix 2. Please note that due to the lack of a vessel registry, fishing vessels from Russia are not covered in these maps.


FISHING EFFORT
In the Baltic Sea in 2014 (AIS data)
FISHING EFFORT IN KWh
0,01–100
101 – 3 000
3 010 – 7 000
7 010 – 15 000
15 100 – 65 000
Source: HELCOM AIS data, EU fleet register
HELCOM
Kemi
Umeå
Vaasa
Finland
Russia
Sundsvall
Pori
Kotka
St. Petersburg
Helsinki
Turku
Sweden
Mariehamn
Tallinn
Estonia
Stockholm
Norrköping
Västervik
Riga
Latvia
Göteborg
Aalborg
Denmark
Halmstad
Grenaa
Karlskrona
Klaipeda
Lithuania
Ystad
Kalingrad
Gdansk
Kiel
Vierow
Poland
Szczecin
Germany
100 km
Figure 13.2.

Recreational fishing

Recreational fisheries refers to fishing during leisure time and target an even larger variety of species, but also species such as cod which are targeted by commercial fisheries. The species targeted by recreational fisheries vary depending on local circumstances. As an example, in Sweden and Finland recreational catches are mostly perch (*Perca fluviatilis*), pike (*Esox lucius*), pikeperch (*Sander lucioperca*) but also roach (*Rutilus*) (HELCOM 2017a).

Also sea trout and salmon are attractive species for recreational fishing in the region, even if most of the activity takes place in estuarine and riverine areas. River restoration activities provide a way to recover lost spawning grounds of such migratory species, and ensure sustainable growth of such recreational fishing.

As recreational fisheries have, at least until recently, been less regulated than commercial fisheries, and not under the same reporting obligations, it is more difficult to get quantitative information on its definitive extent and impact on a Baltic-wide scale. However, some recerational catches of salmon and German data on receational catches of western Baltic cod are included in ICES assessments (ICES 2017).

Even if there are no obligations some surveys on the catches of recreational fishing are carried out every year in Denmark and Sweden, and every two years in Finland. For the other Baltic Sea countries, there is no regular assessment of recreational catches but the number of fishing licenses are monitored in Poland, Estonia and Germany. In Estonia, recreational catch data is available for some specific area such as rivers where salmons are spawning (HELCOM 2017a).

Based on the available information recreational fishing may equal commercial catches of certain commercially fished stocks (HELCOM, 2017a). Further, recreational catches exceed commercial catches for non-internationally assessed species such as the perch, the pike and the sea trout in Finland and Sweden. However, in many areas including for example Denmark overall, recreational catches are clearly smaller than commercial catches (Lassen 2011).

Recreational fishing is a coastal activity which likely peaks in densely populated areas. Even if angling is perhaps the most common type of recreational gear also passive gears such as gill nets and fyke nets are allowed for recreational fishermen in many Baltic Sea countries. However, in Germany, these passive gears are allowed only for former commercial fishermen and they are completely forbidden in Poland and Russia. In Poland only angling and spearfishing is allowed for recreational fishermen.

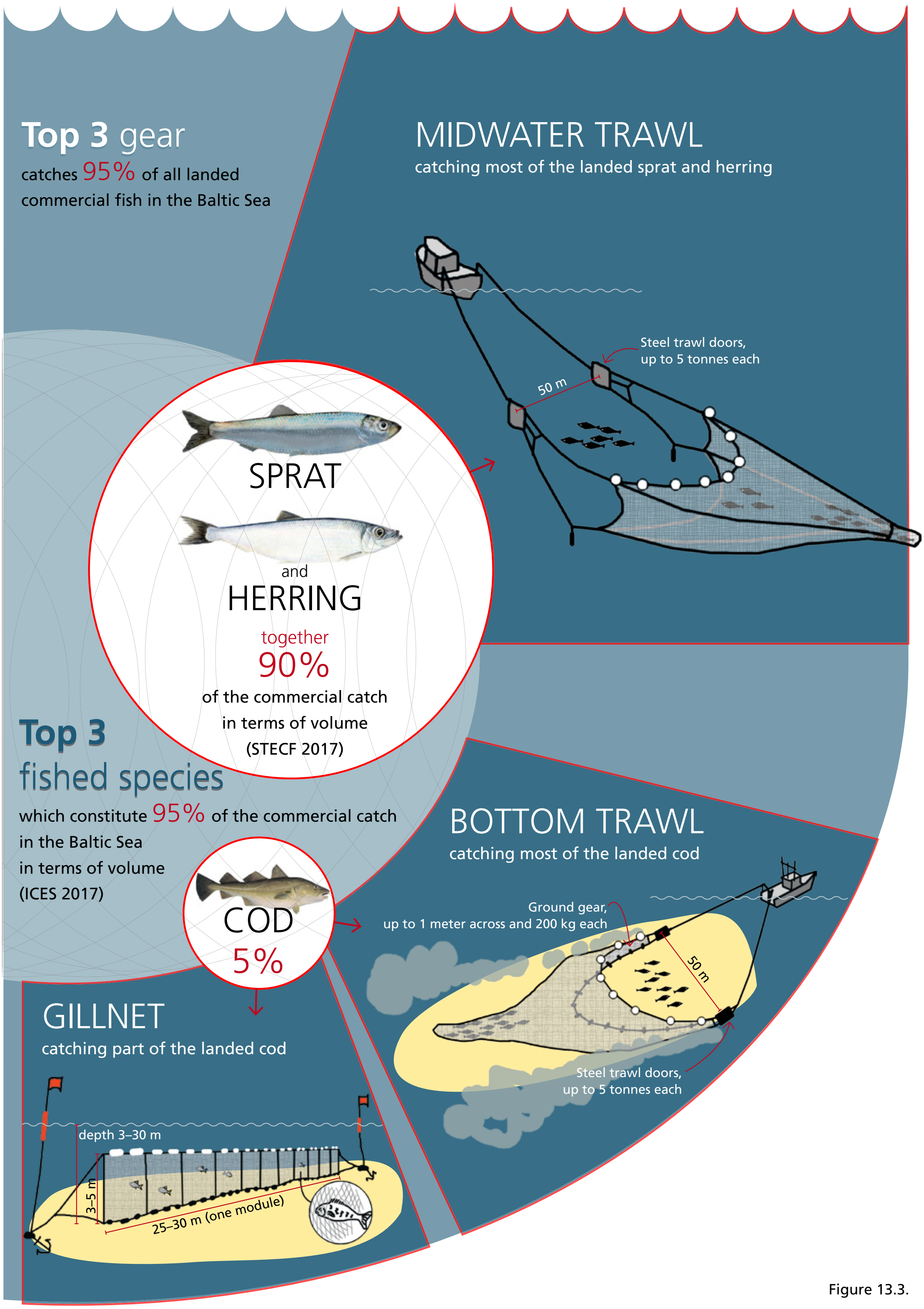
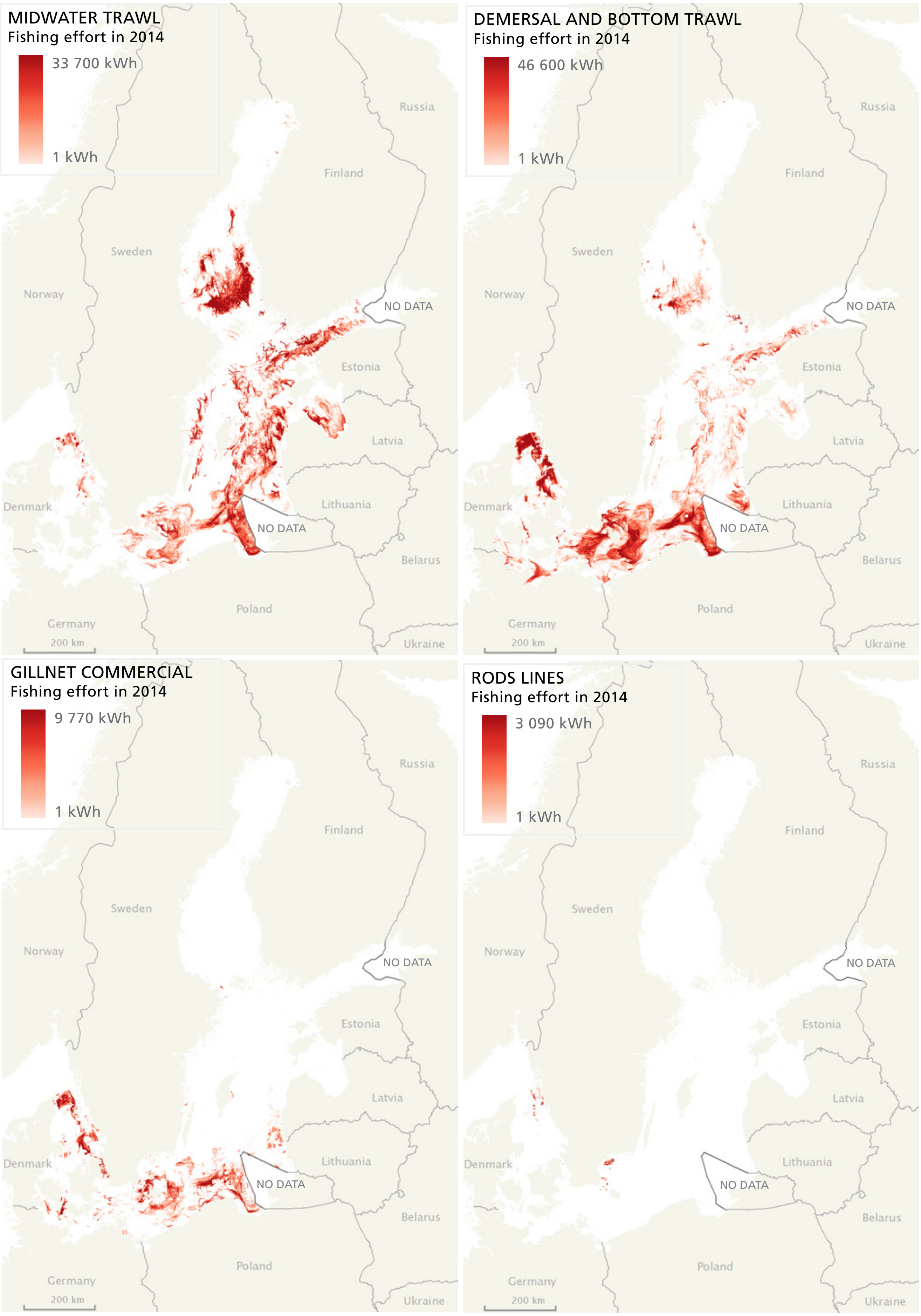
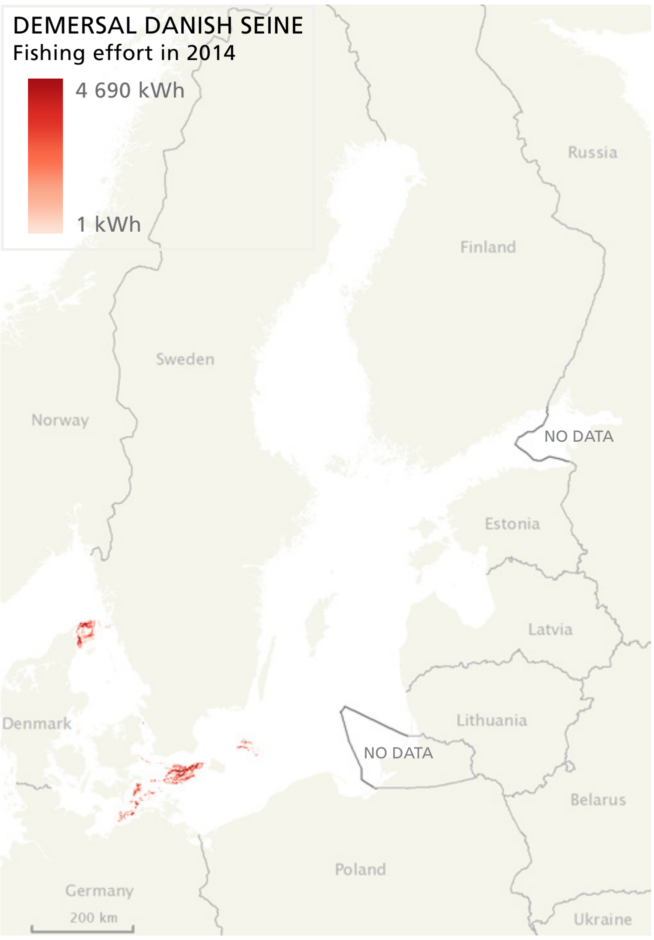

Top 3 gear
catches 95% of all landed commercial fish in the Baltic Sea
MIDWATER TRAWL
catching most of the landed sprat and herring
Steel trawl doors, up to 5 tonnes each
50 m
SPRAT
and
HERRING
together
90%
of the commercial catch
in terms of volume
(STECF 2017)
Top 3
fished species
which constitute 95% of the commercial catch
in the Baltic Sea
in terms of volume
(ICES 2017)
COD
5%
BOTTOM TRAWL
catching most of the landed cod
Ground gear, up to 1 meter across and 200 kg each
50 m
Steel trawl doors, up to 5 tonnes each
GILLNET
catching part of the landed cod
depth 3–30 m
3–5 m
25–30 m (one module)

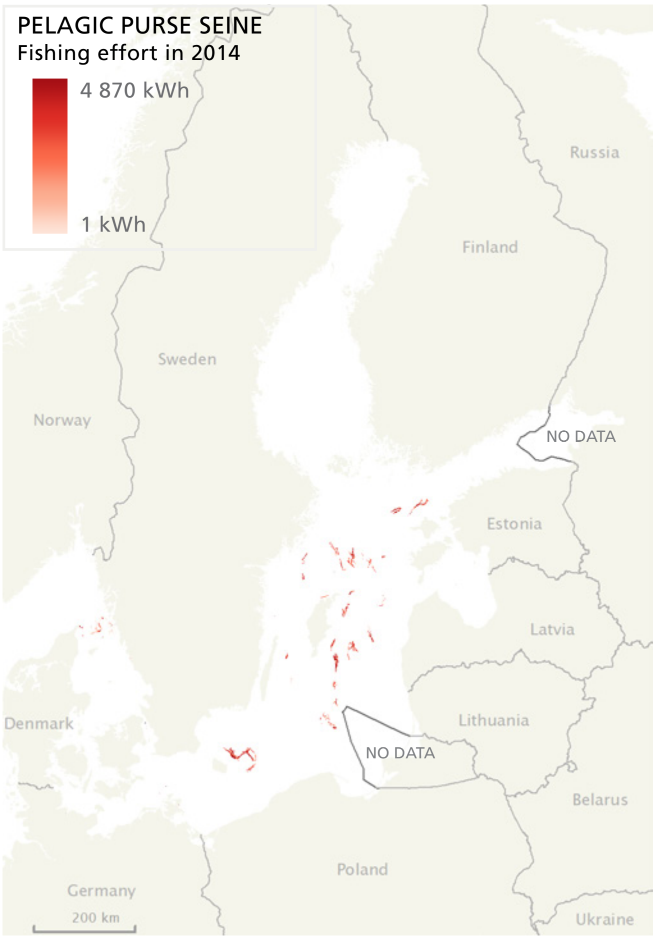
Figure 13.3.

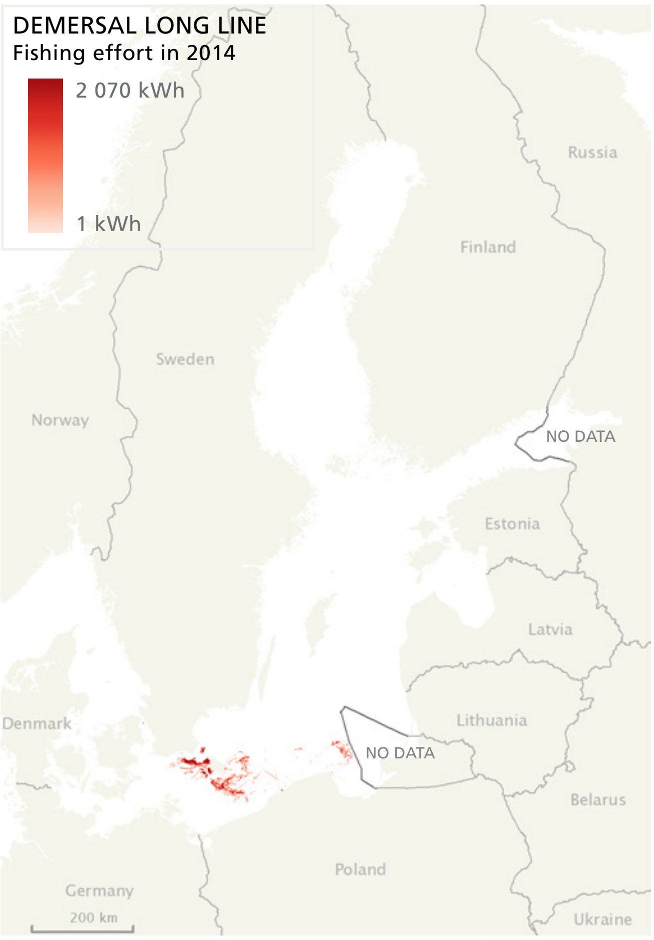
Figure 13.4. COMMERCIAL FISHING EFFORT WITH DIFFERENT GEARS IN THE BALTIC SEA

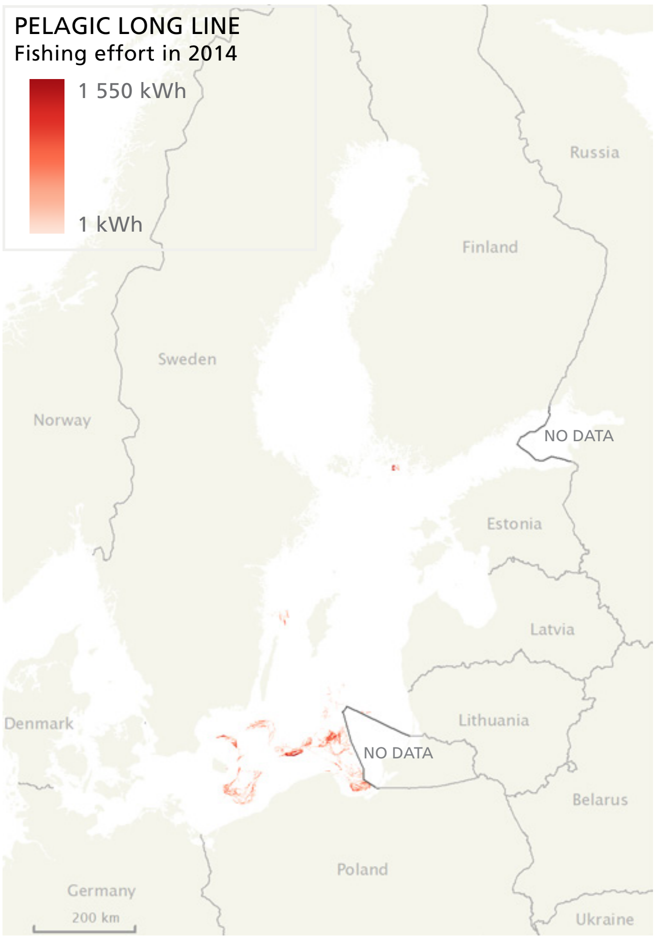
Source: HELCOM AIS data, EU fleet register




DEMERSAL DANISH SEINE
Fishing effort in 2014
4 690 kWh
1 kWh
Russia
Finland
Sweden
Norway
NO DATA
Estonia
Latvia
Denmark
Lithuania
NO DATA
Belarus
Poland
Germany
200 km
Ukraine


PELAGIC PURSE SEINE
Fishing effort in 2014
4 870 kWh
1 kWh
Russia
Finland
Sweden
Norway
NO DATA
Estonia
Latvia
Denmark
Lithuania
NO DATA
Belarus
Poland
Germany
200 km
Ukraine


DEMERSAL LONG LINE
Fishing effort in 2014
2 070 kWh
1 kWh
Russia
Finland
Sweden
Norway
NO DATA
Estonia
Latvia
Denmark
Lithuania
NO DATA
Belarus
Poland
Germany
200 km
Ukraine


PELAGIC LONG LINE
Fishing effort in 2014
1 550 kWh
1 kWh
Russia
Finland
Sweden
Norway
NO DATA
Estonia
Latvia
Denmark
Lithuania
NO DATA
Belarus
Poland
Germany
200 km
Ukraine

Environmental impacts of fisheries

Target species removals

Impacts of overfishing include depleted fish stocks and reduced biomass. Since fisheries is typically focused on specific species and larger fish, it may also cause structural changes to populations and the food web. Such changes in overall species composition, and a decreased size and age structure of populations, have been seen both in the Baltic and adjacent areas (Cardinale et *al.* 2009; Eero *et al.* 2008; Svedäng & Hornborg 2014). Overfishing, and the associated changes at population and ecosystem level, affect long-term fishing opportunities and food provision, since the changes in population or food web structure make the depleted stocks less productive and more vulnerable to environmental pressures (Berkeley *et al.* 2004; Stige *et al.* 2017).

Sea-bed disturbance by active bottom contact gears

Bottom contacting fishing gear causes surface abrasion. During bottom-trawling it may also reach deeper down into the sediment, causing subsurface abrasion to the seabed.

The substrate that is swept by bottom trawling is affected by temporary disturbance, and bottom dwelling species are removed from the habitat or relocated (Dayton *et al.* 1995). The impact is particularly strong on slow growing sessile species which may be eradicated. Since the same areas are typically swept repeatedly, and due to high density of trawling in some areas, the possibility to recover may also be low for more resilient organisms, and a change in species composition may be seen (Kaiser *et al*. 2006; Olsgaard *et al.* 2008).

In addition, the activity may mobilise sediments into the water, which may be transported to other areas and cause smothering on hard substrates, or may release hazardous substances that have been previously buried in the seabed (Jones1992; Wikström *et al.* 2016).

Incidental by-catch

In addition to the targeted species and size classes of fish, unselective fishing imposes mortality on smaller sized fish and non-target species of fish, but also on mammals and birds, which are caught as incidental by-catch. The unwanted catch of fish has been mostly discarded in the past, and has been monitored and included in stock assessments for cod and some flatfishes. By 2017, there is a discard ban in place for plaice, cod, sprat, herring and salmon. In coming years, the effects of these measures are to be evaluated.

Ghost nets

Abandoned, lost, or discarded, fishing gear is termed 'ghost nets' and pose a threat to marine life since they continue fishing not only fish, but also birds and marine mammals and can be considered as posing an especially large risk to marine life. Experiments have shown that the catching efficiecy of lost gillnets amounts to approximately 20 % of the initial catch rates after three months, and around 6 % after 27 months (WWF Poland 2011).

Fishing regulations in the Baltic Sea

EU Fisheries Policy in the Baltic Sea

The regional fisheries commission, International Baltic Sea Fisheries Commission (IBSFC), established with the 1973 Gdansk Convention (Anon. 1973) was discontinued on the 31st of December 2005.

Today the overall regional fisheries management regime in the Baltic Sea, including spatial measures, is in the global context somewhat special, as the European Union (EU) member countries in the region have, according to the EU treaty, delegated powers in fisheries matters to the EU. EU member countries in the region have, nevertheless, the task and certain freedom to implement the EU level decisions EU Common Fisheries Policy (CFP) and may impose stricter requirements to their own fleets.

Within the ongoing regionalization of the CFP, the high level group of the regional co-operation body, BALTFISH, established by a memorandum of understanding in 2013 (Anon. 2013), prepares and pre-consults regional proposals on fisheries measures to be considered and adopted by the EU Agriculture and Fisheries Council.

The needed CFP data collection activities in the Baltic Sea are coordinated in a dedicated group (Regional Coordination Group, RCG) consisting of Baltic Sea coastal countries which are members of the EU. Implementation of the data collection is based on the EU multiannual programme on data collection (EU-MAP) but implemented by the EU member countries based on national data collection programmes.

Another EU body, the Baltic Sea Advisory Council (BSAC) provides stakeholder advice on management of fisheries in the Baltic Sea.

EU-Russia co-operation

In 2009, the EU and the Russian Federation concluded a new agreement on fisheries and living marine resources of the Baltic Sea (Anon. 2009a), establishing the Joint Baltic Sea Fisheries Committee, a bilateral fisheries body in order to fill the gap left by the closure of the IBSFC in 2005.

ICES

Authorative scientific advice on the status of fisheries stocks is provided by the International Council for the Exploration of the Seas (ICES 1964).

1992 Helsinki Convention & HELCOM

Based on the 1992 Helsinki Convention as well as later HELCOM decisions, including the 2007 Baltic Sea Action Plan (BSAP), the HELCOM group on ecosystem based sustainable fisheries (HELCOM FISH), originally established in 2008, involves environmental and fisheries authorities of all Baltic Sea states and the EU as well as interest groups for regional negotiations on fisheries –environment issues. HELCOM FISH is currently the only regional intergovernmental body which includes all coastal countries (EU countries and Russia) on an equal footing in fisheries related negotiations beyond science.

Future perspectives

Enhanced co-operation between fisheries and environmental organisations

As a part of global developments towards a more coherent marine governance there is a need for enhanced cooperation and collaboration at the regional level in the fisheries and environment theme, supported by continuous exchange of information and lessons learned, exploring of shared objectives, and addressing issues of common interest (SOI 2016).

Besides the HELCOM FISH group, providing a joint platform for both fisheries and environment authorities to reduce the environmental impact of fisheries, there is also a need for closer co-operation between the regional bodies focusing on fisheries management (BALTFISH and EU-Russia agreement as well as BSAC) as well as regional marine environment management work carried out mainly within HELCOM. First steps for this enhanced cooperation has been taken during 2016-2017 but this work needs to be intensified in order to help the coastal countries and the EU to achieve regionally coherent policies related to the Baltic Sea marine environment and its resources.

Improved information on incidental catches of birds and mammals in the Baltic Sea

The monitoring of incidental by-catches of birds and mammals in the Baltic Sea is currently rudimental and little facts are available, or available compiled region wide, on the actual levels of these catches to enable considering further measures. Besides some small scale national initiatives, the only species covered by the existing regular data collection in the EU framework is harbour porpoise (*Phocoena phocoena*) which is not observed in the entire Baltic Sea area. The ongoing work around the new EU fisheries policy data collection might enable more information to emerge in the future but this would need additional resources. Close co-operation between the authorities working with marine environment and fisheries is needed to optimise incidental bycatch data collection across sectoral boundaries.

Promoting the development and use of alternative fishing gears and devices

Initiatives in the Baltic Sea region have recently tested a number of alternative gears, both passive (e.g. fish pots as well as fixed and automatized longlines,) and active (e.g. trawls with escape windows) as well as related equipment, such as sound (“pingers”) and visible light devices, in order to reduce incidental bycatch (HELCOM 2017c). If developed further and deployed commercially, these could provide a means to reduce the incidental bycatches and at the same time allow for commercial fisheries operations.

Assessing and addressing ghost nets

The numbers of derelict gears lying on the seabed have been studied in recent initiatives in some parts of the Baltic Sea. A regional synthesis of the information could help in considering regional measures. Further, the concrete impacts of derelict gears are currently less known.

All coastal countries in the world adopted the Code of Conduct for Responsible Fisheries (FAO 1995). Unfortunately at the moment there are no global standards on marking fishing gear. FAO is working on the finalisation of the draft guidelines on marking of fishing gear. After Technical Consultation in February 2018, the International Guidelines will be submitted for adoption by the FAO Committee on Fisheries (COFI 33) in July 2018.

River restoration best practices

Rivers are the paths which migratory fish like salmon and sea trout take upstream to their spawning grounds. Thus, the river and stream conditions directly influence the status of several migratory fish populations, which spend part of their life in the sea.

During the last centuries, many streams and waters in the region have been subjected to intensive modifications such as straightening and dredging of streams for log driving, water level control, hydro-power developments as well as decreased water quality. In many cases such river and stream modifications have collapsed the natural fish production capacity.

The changes in energy production, timber transportation and how we spend our leisure time have created interest to restore river and stream environments and their fish populations. To follow up public interest, several municipalities in the coastal countries of the Baltic Sea have recently implemented river restoration activities.

River and stream restoration ranges from smaller interventions, such as adding gravel and riverside vegetation, to complete reconstruction of physical features, including natural meandering and removal of dams. As a fringe benefit, river restoration includes also often increased attention also to the water quality and thus, reduction of riverine pollution to the Baltic Sea.

As restoration activities are costly there is a need to intensify sharing of best practices in order to restore degraded riverine habitats in the coastal countries. An example of recent work is the regional workshop on river restoration organised in Denmark in May 2017 (HELCOM 2017d) as well as the RETROUT project, funded by Interreg and implemented during 2017–2020.

14. AQUACULTURE IN THE BALTIC SEA

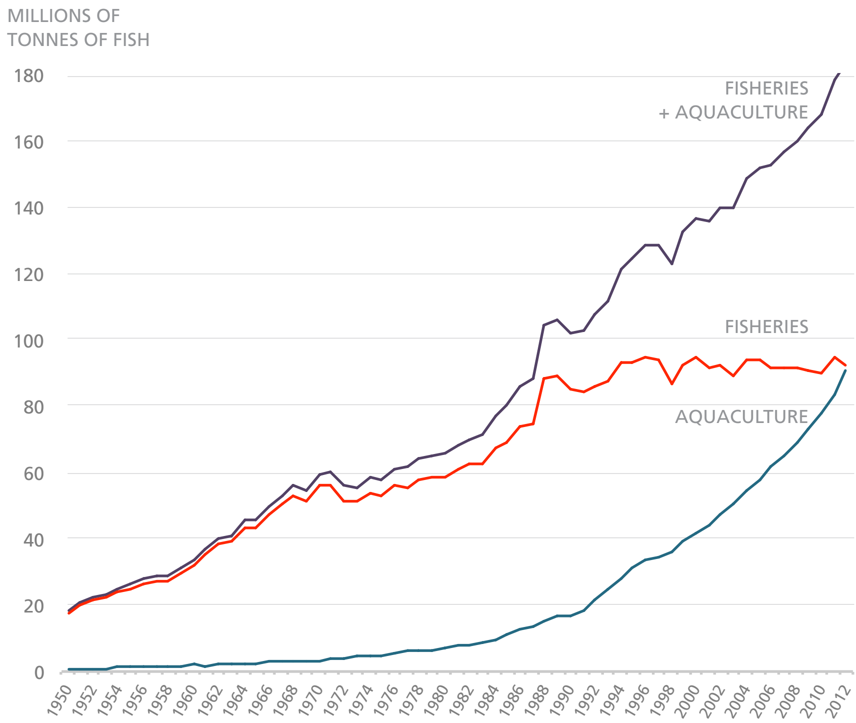
Introduction

Aquaculture is the controlled production of aquatic organisms whether at sea, in estuaries or inland. As an activity, aquaculture provides today half of all fish for human consumption worldwide (FAO 2017) and has had a vigorous global growth during recent decades (Figure 14.1).

Many Baltic Sea coastal countries such as Denmark, Germany and Poland, have a long history with inland aquaculture of rainbow trout, but also other species such as common carp.

Figure 14.1. GLOBAL VOLUMES OF AQUACULTURE AND FISHERIES

Total weight of catch by fisheries and production by aquaculture 1950–2012



Source: FAO FISHSTAT-J 2017

In the Baltic Sea itself aquaculture developed mainly after the second world war and today consists of farming of fish, mainly rainbow trout, and smaller volumes of mussels.

After a rapid period of growth, environmental concerns during the 1990s led to a stagnation of production volumes in the Baltic Sea. During last few years some coastal countries, particularly Denmark and Finland, have taken steps to increase national aquaculture production in the Baltic Sea and the volumes show growing trends.

Aquaculture in the Baltic Sea

There are 332 aquaculture sites in the Baltic Sea that were reported to HELCOM (HOLAS II project) (Figure 14.2). In terms of volume practically all (>90%) aquaculture production for human consumption in Baltic Sea waters is cultivation of rainbow trout (*Oncorhynchus mykiss*, a salmonid fish native to the north American west coast first bred in captivity in California during the late 19th century). A main requirement of rainbow trout rearing is the availability of good quality, well-aerated water, which is available at sea.

The production of rainbow trout in the Baltic Sea increased rapidly during the 1970s/1980s, reached a peak during the 1990s and stagnated or even decreased during the first decade of the 2000s (Figure 14.3). Today, the Baltic Sea aquaculture industry is again in an expansive phase and total production in the Baltic Sea coastal countries reached an all-time high of 29 000 tonnes annual production in 2013 (FAO 2016).

Rainbow trout production takes place in net pens, open systems in free interaction with the surrounding marine environment, mainly along the SW coasts of Finland, Belt Sea and Kattegat in Denmark as well as the Swedish coast of the Gulf of Bothnia. Smaller amounts of whitefish (Finland) and mussels (Denmark and Sweden) are also reared in the Baltic Sea (Table 14.1).

The sea cages, also called sea pens or net pens, used in sea trout aquaculture consist of a flotation, usually a round ring, on the surface from which a net bag is hanging. These are fixed to the seabed with anchor and rode, and/or to the shore, but are commonly movable to enable sorting by size and butchering.

In more advanced facilities the feeding of the fish is taken care of by computer controlled systems. These optimise the amount of feed according to parameters like the temperature of the water and use means such as pressurised air to distribute the right amount of feed to the pens.

Fish feed consists mainly of processed fish, in the form of fish meal and fish oil, but includes also vitamins, minerals and colour additives. The feed may also include vegetable oils and other products such as soya, wheat- and maize gluten or crushed sunflower (Heldbo 2013).

Environmental effects of aquaculture in the Baltic Sea

As feeding of fish cannot be done fish by fish there is always a share of the feed which is not eaten and ends up as waste. Further, the fraction consumed by the fish is only partly metabolized as fish growth while the remainder is excreted by the fish.

Table 14.1.

AQUACULTURE PRODUCTION IN THE BALTIC SEA COUNTRIES

COUNTRY	Baltic Sea	Inland
Estonia	(no production)	rainbow trout, freshwater fishes (incl. carp) and eel
Denmark	Rainbow trout (ca. 12 000 t/yr), mussels (minor)	rainbow trout, salmon, oysters, eel, other freshwater fishes
Germany	Rainbow trout (ca. 20 t/yr)	common carp, Salvenilus, rainbow trout, other freshwater fishes
Finland	Rainbow trout (ca. 12 000 t/yr), Whitefish (ca. 600 t/yr)	rainbow trout, whitefish, other freshwater fishes
Latvia	(no production)	common carp, rainbow trout, other freshwater fishes
Lithuania	(no production)	common carp, rainbow trout, other freshwater fishes
Poland	(no production)	common carp, rainbow trout, other freshwater fishes
Russian Federation (Baltic Sea catchment)	(no production)	common carp, rainbow trout
Sweden	Rainbow trout (ca. 2 000 t/yr), mussels (ca. 1 500 t/yr)	rainbow trout, Salvenilus, european eel

Source: FAO 2017; Aquafima 2014

Due to the open cage systems utilized in rainbow trout aquaculture production in the Baltic Sea this waste results in inputs of nitrogen, phosphorus and organic matter to the Baltic Sea. The 158 aquaculture sites reported by coastal countries for the purposes of the HELCOM Pollution Load Compilation aquaculture had total load of 901 tonnes total nitrogen and 96 tonnes total phosphorus to the Baltic Sea (HELCOM 2017).

Heldbo has estimated nutrient losses from farmed fish as 41 tonnes nitrogen and 8 tonnes phosphorus per thousand tonnes produced fish (Heldbo 2013, Table 36 on page 197). Asmala and Saikku have estimated that during the period 2004–2007 548 tonnes nitrogen and 80 tonnes phosphorus ended up annually to the Baltic Sea from Finnish rainbow aquaculture units (Asmala & Saikku, 2010). During this period the Finnish annual rainbow trout production was in the order of 10 thousand tonnes. From this a load of 55 tonnes nitrogen and 8 tonnes phosphorus per thousand tonne produced fish can be inferred for Finland. Assuming that production systems are more or less similar in the Baltic Sea region these figures would indicate that with the 2015 production level of ca. 26 thousand tonnes, rainbow trout aquaculture in the Baltic Sea would result in annual direct loads to the Baltic in the order of 1000–1500 tonnes nitrogen and 200 tonnes phosphorus.

Besides nutrients, other environmental pressures from sea based aquaculture include emissions of traces of medical substances, copper from antifouling paints used at the facility, escapes of non-native reared fish as well as contagion of wild fish with diseases carried by cultured species. The two latter, escapes of reared species to the wild as well as spread of diseases are commonly highlighted as environmental issues.

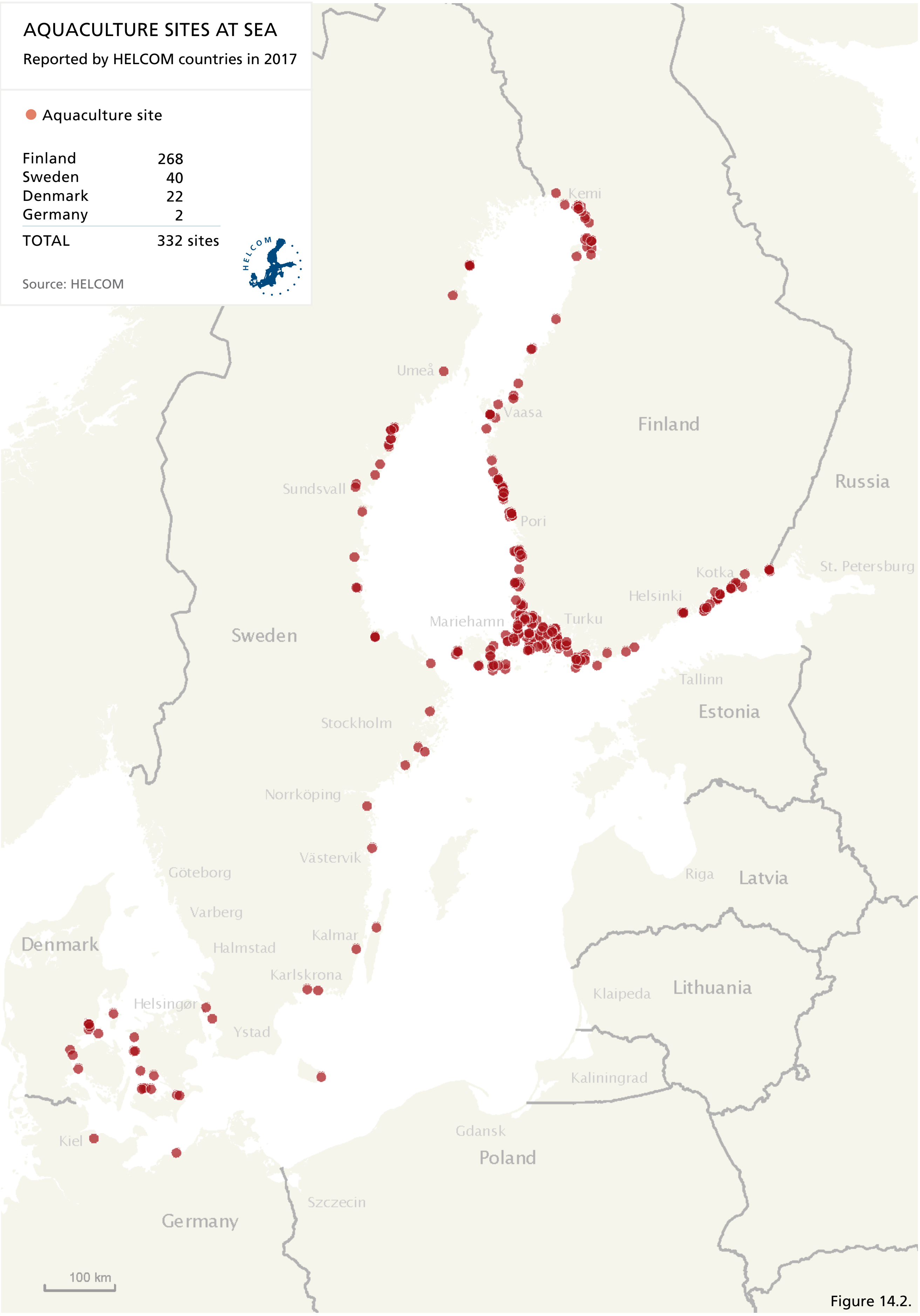

AQUACULTURE SITES AT SEA
Reported by HELCOM countries in 2017
Aquaculture site
Finland 268
Sweden 40
Denmark 22
Germany 2
TOTAL 332 sites
Source: HELCOM
HELCOM
Kemi
Umeå
Vaasa
Finland
Russia
Sundsvall
Pori
Kotka
St. Petersburg
Helsinki
Mariehamn
Turku
Sweden
Tallinn
Estonia
Stockholm
Norrköping
Västervik
Göteborg
Riga
Latvia
Varberg
Kalmar
Denmark
Halmstad
Karlskrona
Lithuania
Klaipeda
Helsingør
Ystad
Kalinigrad
Gdansk
Poland
Kiel
Szczecin
Germany
100 km

Figure 14.2.

Overall, environmental concerns have been responded to by the industry, which has improved its environmental record during the last decades. This has also been recognised by certification bodies such as Aquaculture Stewardship Council (ASC) and WWF "green list" which has been awarded to some rainbow trout producers in the Baltic Sea region.

Environmental regulation of aquaculture

1992 Helsinki Convention and HELCOM Recommendations

Aquaculture at sea is not explicitly addressed in the 1992 Helsinki Convention and the commitment to reduce pollution from aquaculture is covered by the general provisions of the Article 3 Fundamental principles and obligations. However, more specific commitments have been agreed in the form of HELCOM Recommendations.

Aquaculture inland is addressed more directly. Regulation 2 (Specific requirements) of Annex III "Criteria and measures concerning the prevention of pollution from land-based sources" specifies that pollution from fish-farming shall be prevented and eliminated by promoting and implementing Best Environmental Practice and Best Available Technology.

The 1992 Helsinki Convention Annex II "Criteria for the use of Best Environmental Practice and Best Available Technology" includes general characteristics of BAT and BEP to be applied in the Contracting Parties in relation to the Baltic Sea.

HELCOM Recommendation 25/4 "Measures aimed at the reduction of discharges from marine fish farming" includes more specific regional BAT and BEP for marine fish farming and as part of these, e.g. recommend that nutrient discharges from marine aquaculture facilities should not exceed the annual averages of 7g tot-P and 50g tot-N per 1kg produced fish.

HELCOM Recommendation 37/3 "Sustainable aquaculture in the Baltic Sea region" recommends that the Governments of the Contracting Parties to the Helsinki Convention jointly develop by 2018 Best Available Technology (BAT) and Best Environmental Practice (BEP) descriptions for sustainable and environmentally friendly aquaculture in the Baltic Sea region and apply them based on a number of principles.

As a source of nutrient pollution aquaculture is an activity contributing to the achievement of the Maximum Allowable Inputs (MAI) as well as Country Allocated Reduction Targets (CART) for Phosphorus and Nitrogen, agreed by the Contracting Parties in 2007 and 2013.

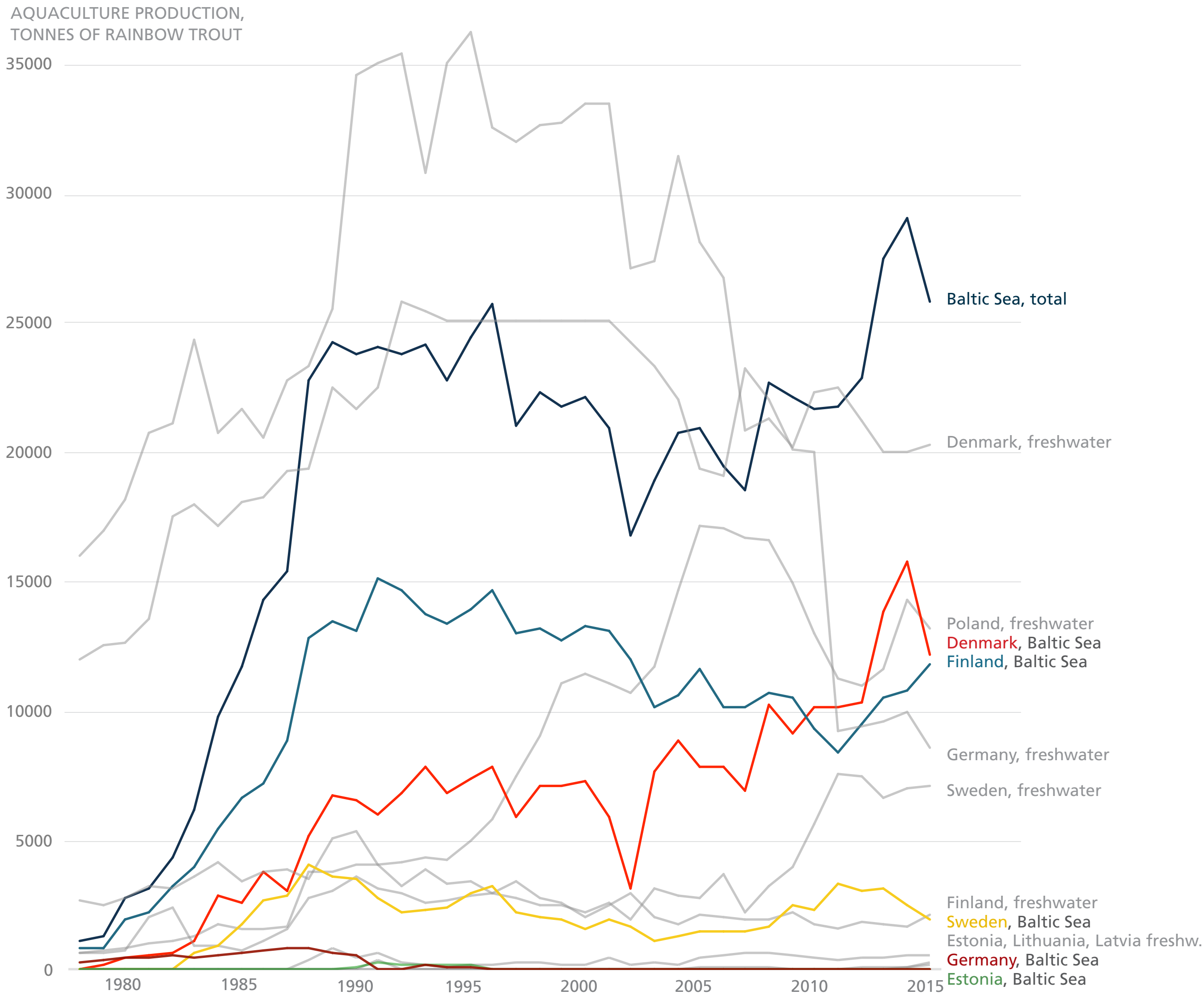
National legislation

As the aquaculture facilities constructed so far have been relatively small scale they do not fall under international EIA or SEA procedures. The central legislation concerning aquaculture is thus mainly national regulations concerning environmental permits for aquaculture facilities and in some cases EIA.

For EU countries a wide variety of EU legislation is naturally highly relevant for aquaculture.

RAINBOW TROUT AQUACULTURE PRODUCTION IN THE BALTIC SEA COUNTRIES 1978–2015

Aquaculture in the Baltic Sea and in freshwater sites, production in tonnes



Source: FAO 2017

Figure 14.3.

Future perspectives

Nutrient mass balance equilibrium: fish feed from local raw materials

The use of locally sourced fish meal has also been put forward as a way to reduce nutrient pollution of enclosed, or semi-enclosed, systems like the Baltic Sea with material from the outside. Using local fish as fish feed material would avoid this, and instead re-circulate local biomass.

Integrated multi-trophic aquaculture (mussels and fish)

Recent research shows that commercial farming of mussels in the Baltic Sea region may be viable even in low salinity environments. The mussels will remain small in size but may, nevertheless, provide an alternative biomass feedstock for fish meal, or even in other sectors such as biogas production.

In some areas of the Baltic Sea, fish farming combined with mussel farming may also offer a way to compensate for nutrient emissions from fish aquaculture - by binding nutrients via the filter feeding of mussels.

Inland farming including re-circulation systems

Terrestrial re-circulation aquaculture systems (RAS) offer good opportunities to control pollution compared to open net pen systems at sea which use the pollution assimilative capacity of the surrounding aquatic environment. However, these RAS systems are technology intensive and have today relatively high capital expenditure costs.

Improving fish feed digestibility and selective breeding

There are ongoing research activities around the world to reduce nutrient pollution from aquaculture by improving the digestibility of fish feeds, as well as to improve the uptake of feed by selective breeding of cultivated species.

15. OFFSHORE WINDFARMS IN THE BALTIC SEA REGION

Introduction

Wind power and other offshore renewables, such as wave power, are part of the solution in the ongoing global move away from coal, oil, gas and nuclear power to more sustainable forms of energy production, mainly in order to reduce CO_2 emissions and reduce global climate change.

The first offshore windfarm in the world, the Danish Vindeby, was constructed in 1991 in the western end of the Baltic Sea. However, it is especially during the last ten years that interest in offshore wind energy in the Baltic Sea has taken off.

The nameplate production capacity of offshore wind in the Baltic Sea has more than tripled during the last five years, from 0,6 to 1,7 GW. This Baltic boom is partly a result of lack of space in the North Sea, but also a realisation that the Baltic Sea provides somewhat lower but more stable winds and enables lower construction costs due to, e.g. shallower depths and closer distances to the shore.

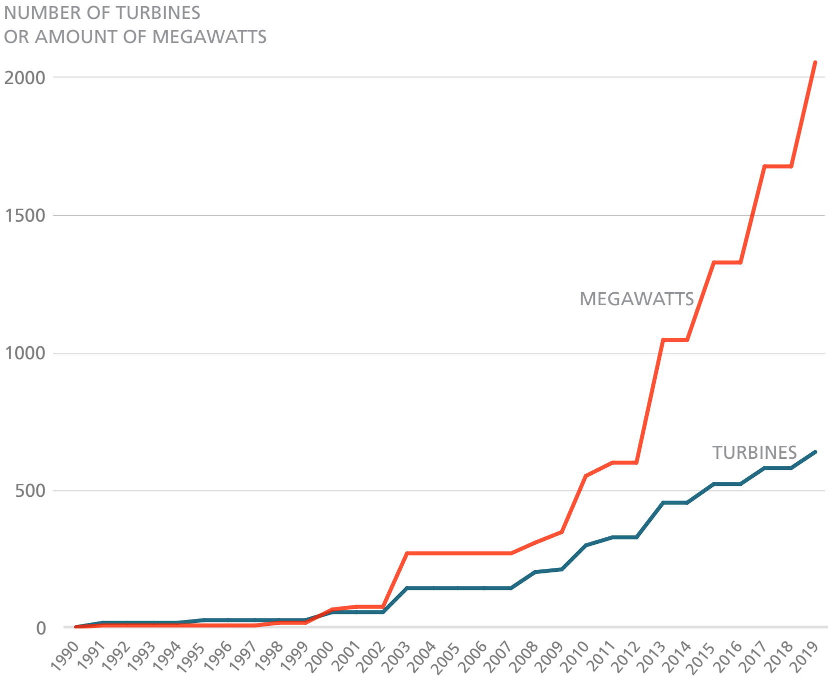
Besides increase in capacity, another trend is that while the first projects are characterised by smaller near-shore farms with smaller size turbines, the latest developments are larger, located further offshore and with much larger and effective turbines.

The main environmental concerns related to offshore wind are usually underwater noise during construction phase, pile driving or demolitions, and operational effects to birds (as well as bats nearshore). While underwater noise during construction phase can to some extent be mitigated by solutions such as bubble curtains, little studies are available on the region-scale operational effects of wind power farms to birds and their migration routes.

Even if offshore wind is out of sight from coastal homeowners, it occupies sea surface and infringes potentially with other maritime activities such as shipping or fisheries and is often planned to shallow banks, which have high biodiversity values. It is thus globally and in the region an activity which is perhaps the main underlying factor behind the development of Maritime Spatial Planning, overall planning of space at sea.

Also wave power technology solutions have emerged during last years

Figure 15.1. OFFSHORE WIND POWER PRODUCTION IS INCREASING RAPIDLY
Offshore wind power in the Baltic Sea 1990–2019 (incl. construction started 2017)



Source: EWEA

and it is not unforeseeable that also this form of renewable offshore energy production will be installed on a commercial scale during the coming years.

Offshore wind power in the Baltic

Despite the quick developments offshore, the bulk of wind power developments today take place on dry land. As an example 10 923 MW were installed onshore compared to 1 567 MW offshore in EU in 2016 (EWEA, 2016). However, this ratio is changing as cost-efficiency of offshore developments is improving.

By the end of 2017 there will be a total of 578 offshore turbines divided to 17 offshore windfarms (solitary turbines excluded) in the Baltic Sea. In total these will be generating a nominal total of 1,7 GW of power by the end of the year 2017. The recent developments have been fast and the capacity has nearly tripled from 598 MW to 1669 MW during the period 2012–2017 (Figure 15.1).

Denmark and Sweden were the first countries to develop offshore windfarms in the region during the 1990s, but Germany has quickly established itself as a major offshore wind country in the region since 2011. 95% of the existing capacity is located in the south-west of the Baltic Sea region in the territorial waters of Denmark, Sweden and Germany (Figure 15.2). There are currently many active planned projects in Poland but also in Finland as well as Denmark, Sweden and Germany (Figure 15.3).

Two offshore wind farms have been decommissioned so far in the region: Yttre Stengrund (Sweden) built 2001 and dismantled 2015, as well as Vindeby (Denmark) built 1991 and dismantled in 2017.

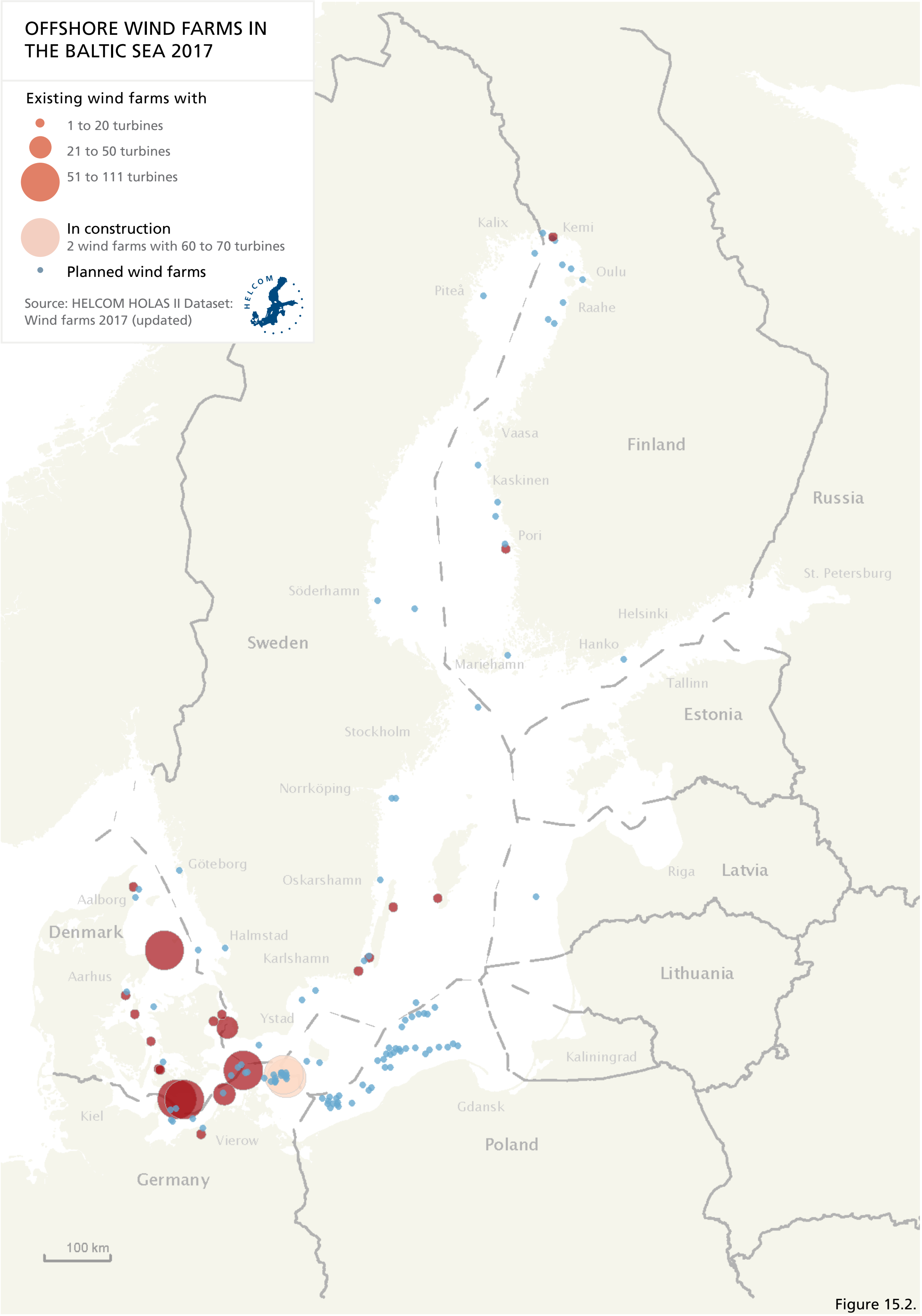
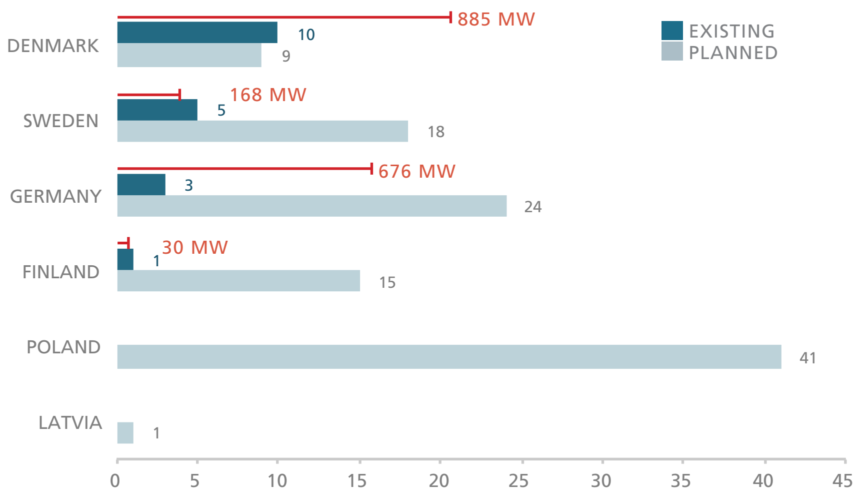

OFFSHORE WIND FARMS IN THE BALTIC SEA 2017
Existing wind farms with
1 to 20 turbines
21 to 50 turbines
51 to 111 turbines
In construction
2 wind farms with 60 to 70 turbines
Planned wind farms
Source: HELCOM HOLAS II Dataset: Wind farms 2017 (updated)
HELCOM
Kalix
Kemi
Oulu
Piteå
Raahe
Vaasa
Finland
Kaskinen
Russia
Pori
St. Petersburg
Söderhamn
Helsinki
Sweden
Hanko
Mariehamn
Tallinn
Estonia
Stockholm
Norrköping
Göteborg
Oskarshamn
Riga
Latvia
Aalborg
Denmark
Halmstad
Karlshamn
Lithuania
Aarhus
Ystad
Kaliningrad
Kiel
Gdansk
Vierow
Poland
Germany
100 km
Figure 15.2.

Figure 15.3. OVER 100 NEW OFFSHORE WIND FARMS ARE PLANNED IN THE BALTIC SEA
Number of existing (20) and planned (108) offshore wind farms and production capacity (total 1 762 Megawatts) per country



Source: EWEA

Seven of the farms have 48 or more turbines, the largest being the Anholt farm in Denmark with 111 units (400 MW). At the time of writing two farms are being constructed in German waters, the Wikinger farm (350 MW, 70 turbines) to be operational by 2017, and Arkona (385 MW, 60 turbines) currently under construction and to be operational by 2019 (Table 15.1).

Table 15.1. OFFSHORE WIND FARMS IN THE BALTIC SEA

Operation	Name	MW	Turbines	Depth (min, m)	Distance from shore (km)	Country
1991–2017	Vindeby	4,95	11	2	1,8	Denmark
1995–	Tunø Knob	5	10	3	6	Denmark
1998–	Bockstigen	2,75	5	5	4	Sweden
2000–	Middelgrunden	40	20	3	4,7	Denmark
2000–	Utgrunden	11	7	6	4	Sweden
2001–2015	Yttre Stengrund	10	5	6	2	Sweden
2003–	Nysted (Rødsand I)	166	72	6	11	Denmark
2003–	Samsø	23	10	10	4	Denmark
2003–	Frederikshavn	7,6	3	1	0,3	Denmark
2008–	Lillgrund	110	48	4	9	Sweden
2008–	Kemi Ajos I + II	30	10	1	3	Finland
2009–	Sprogø	21	7	6	10	Denmark
2009–	Avedøre Holme	11	3	2	0,5	Denmark
2010–	Rødsand II	207	90	6	9	Denmark
2011–	EnBW Baltic 1	48,3	21	16	16	Germany
2013–	Anholt	400	111	15	20	Denmark
2013-	Karehamn	48	16	21	5	Sweden
2015–	EnBW Baltic 2	288	80	23	32	Germany
2017–	EnBW Wikinger	350	70	36	35	Germany
(2019–)	Arkona	385	60	21	35	Germany

Some smaller wind farms, which are only in test use, operating with one turbine, not included. The construction of the Wikinger project will be completed by end of 2017 and the Arkona project started construction phase in 2017 and will be completed by 2019. Source: EWEA

While the early offshore windfarms in the Baltic Sea were built in shallow waters less than 10 m depth and less than 6 km from the coast the recent developments have been in somewhat deeper waters, more than 15 m and further from the shore, up to 35 km.

The turbines have also grown in size. The turbines of the ongoing Arkona project are at 177 m max height, three times the size of those of the first windfarm (Vindeby, dismantled in 2017) at 52,5 m (Figure 15.4).

Offshore windfarm and the Baltic Sea marine environment

As a renewable form of energy wind power is, in the long run, a way to reduce the dependency in fossil fuels and CO_2 emissions worldwide. Nevertheless, as with all human activity, there are environmental effects in constructing and operating windfarms which should be minimised with good planning but cannot be entirely avoided.

The main environmental concerns related to offshore wind are usually underwater noise during construction phase, pile driving or demolitions, and operational effects to wildlife, mainly birds.

Beyond construction activities windfarms are usually assessed to have no or minor negative effects to underwater life (marine pelagic, demersal and benthic species) (Bergström *et al.* 2012; Hoffmann *et al.* 2002).

Noise from pile driving and other underwater construction work

The construction phase effects are commonly due to noise from installing a solid turbine base, or foundation on the seafloor. Even if other types of solutions exist, including floating turbines, today most of the offshore wind turbines in the Baltic Sea use a solid foundation.

Solid foundations of wind power turbines require activities such as pile driving and demolitions which create high level of impulsive noise which has shown to have direct harmful effects to marine fauna, especially marine mammals such as porpoises but also fish (see Chapter 8).

As an example of regulatory developments related to this type of environmental effects the German government has set a mandatory 160-decibel limit on the sound levels allowed in windfarm construction, measured at a distance of 750 meters (half a nautical mile) from the pile or source of noise.

Construction phase underwater noise can be reduced by using technical mitigation solutions such as bubble curtains during the operations.

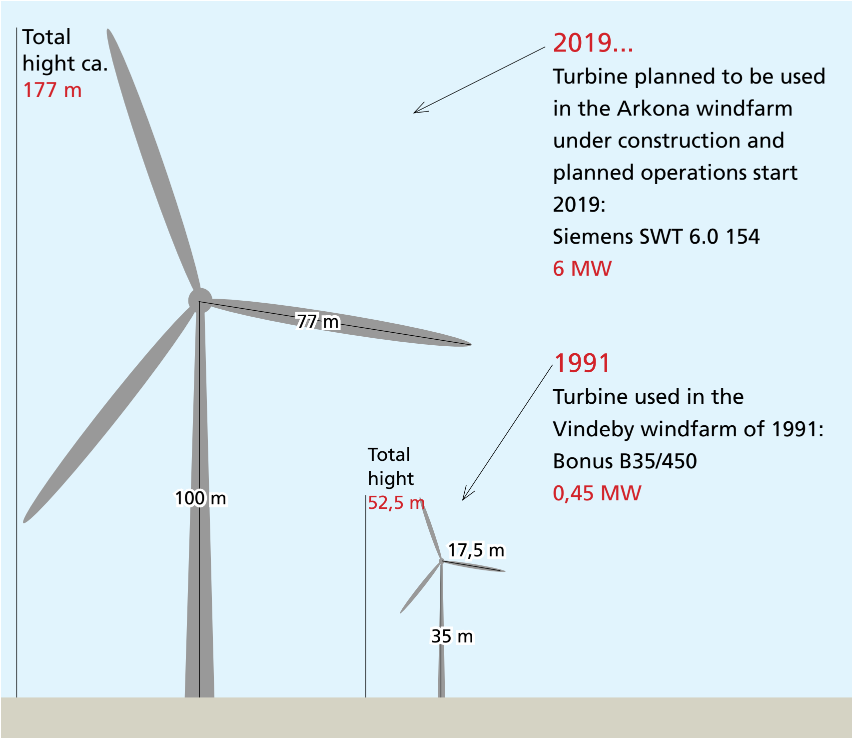
Regulations

1992 Helsinki Convention and HELCOM Recommendations

Beyond the general provisions to minimise harm the 1992 Helsinki Convention Article 7 covers Environmental Impact Assessment (EIA) even if the more specific provisions and procedures of the 1991 UNECE Convention are commonly used instead (see below).

HELCOM Recommendation 17/3 (1996) on Information and Consultation with Regard to Construction of New Installations Affecting the Baltic Sea, recommends the countries to inform the Helsinki Commission about new installations including offshore wind power.

Figure 15.4. SIZE OF WIND TURBINES HAS INCREASED IN THE BALTIC SEA
Increase in size of wind turbines in the Baltic Sea 1991–2019



Source: EWEA, Bonus and Siemens

HELCOM Recommendation 24/10 (2003) on implementation of integrated marine and coastal management of human activities in the Baltic Sea Area calls the Contracting Parties to develop Maritime Spatial Planning (MSP).

HELCOM Recommendation 34E/1 (2013) on safeguarding important bird habitats and migration routes in the Baltic Sea was adopted in 2013 to enhance the research and monitoring of important bird species to map migration routes and staging areas such as wintering, feeding, moulting and resting grounds.

1991 UNECE Convention on transboundary EIA and its 2003 SEA protocol

Even if wind power developments are usually not considered to warrant transboundary EIA (national EIAs are naturally carried out) based on the 1991 Espoo Convention, or the UNECE Convention on Environmental Impact Assessment in a Transboundary Context (UNECE, 1991), offshore wind power farms are in some countries, such as Germany, included in the explicit maritime spatial plans, which is in turn warrant a SEA according to the SEA protocol of the Convention.

Future perspectives

Future developments of offshore wind farming in the Baltic Sea Region

A regional study from 2012 estimated that 40 GW of offshore wind capacity is possible in the Baltic Sea, when taking into account estimates on known environmental and, other constraints (BASREC, 2011). This would indicate more than twenty –fold increase from the existing capacity of 1,7 GW in the long run.

Even if the realization of such scenarios is always debatable, it is very likely that the rapid growth of wind power capacity will continue well into the 2020s as a number of large projects have been approved or are in final phases of approval.

More than a hundred new projects were in some form of preparation by 2015 (EWEA, 2015) (Figure 15.2.). These are not covered in detail as many of them might not be constructed due to business reasons despite formal approvals. Nevertheless, they can be used to illustrate the relative level of interest on offshore wind in the region.

The main number of these new developments are taking place in the waters of Denmark, Finland, Germany and Sweden but also Poland, Estonia and Latvia have active offshore wind projects. The EEZ of Poland is one of the new hotspots of new developments as there are currently more than 70 submitted applications for the installation of new windfarms. There are also a large number of proposed projects in Finland. Offshore wind projects have been proposed also in Lithuania and Russia, but according to the latest data these are no longer active.

Floating windfarm installations

Floating turbines moored to the seabed offer an alternative to solid foundations and enable installation in deeper waters, even if the ice conditions in the Baltic Sea provide some challenges. A pilot facility will be installed in 2017 in German waters to test the feasibility of the approach.

Wave power in the Baltic Sea

Wave power is another strongly emerging form of offshore renewable energy in addition to wind power. Based on rapid technological developments recently the first commercial wave power farms are in the process of being constructed in Europe. Even if these initial developments are mainly focused in the waviest corners of Europe (Portugal, Scotland), also Baltic wave power plants might become a reality with maturing technology and falling costs.

Region-scale effects of windfarms to bird populations

The main environmental concerns related to the operation of windfarms are Baltic Sea-wide effects to birds, as windfarm avoidance might induce population level changes due to changing flight patterns including migration routes.

Even if studies focusing on single projects are available as part of the Environmental Impact Assessments (EIAs), no studies are available on the region-scale operational effects of wind power farms to birds and their migration routes. More research would be needed to enable evidence based planning on this point.

16. UNDERWATER CABLES AND PIPELINES

Introduction

A number of underwater pipelines and cables cross large distances under the surface of the Baltic Sea to connect the telecommunication and energy networks of the coastal countries with each other and the rest of the world.

Even if underwater cables and pipelines seem to be relatively harmless to the Baltic Sea marine environment during operation, the installation of this type of infrastructure may have environmental effects and is for this reason covered by international requirements to carry out international impact studies. They will also limit activities like fisheries and anchoring in the areas where they have been laid.

There has been public concern on the environmental effects from installation and operation of both power cables (Andrulewicz *et al.* 2003) and pipelines but the evidence for any environmental effects beyond seabed disturbance during the construction phase is fragmentary.

Underwater cables in the Baltic Sea

Telecommunication and energy transmission are the two main uses of underwater cables. A large number of underwater cables have been laid on the seabed of the Baltic Sea, even if the available information compiled by HELCOM in 2017 is likely incomplete (Figure 16.1). The status classification follows the format of European Wind Energy Association and International Hydrographic Organization (IHO) used in electronic nautical charts.

Even if cables may be buried they can be damaged as result of human activities, especially anchoring and fish trawling and for this reason commonly shown in nautical charts.

Telecommunication cables

Even if the Baltic Sea region is geographically somewhat of a periphery, at least from the central European perspective, it is well connected to the rest of the world by telecommunication networks.

Underwater cables carry over 99% or modern international telecommunication traffic, and provide the regional backbone of internet. Important

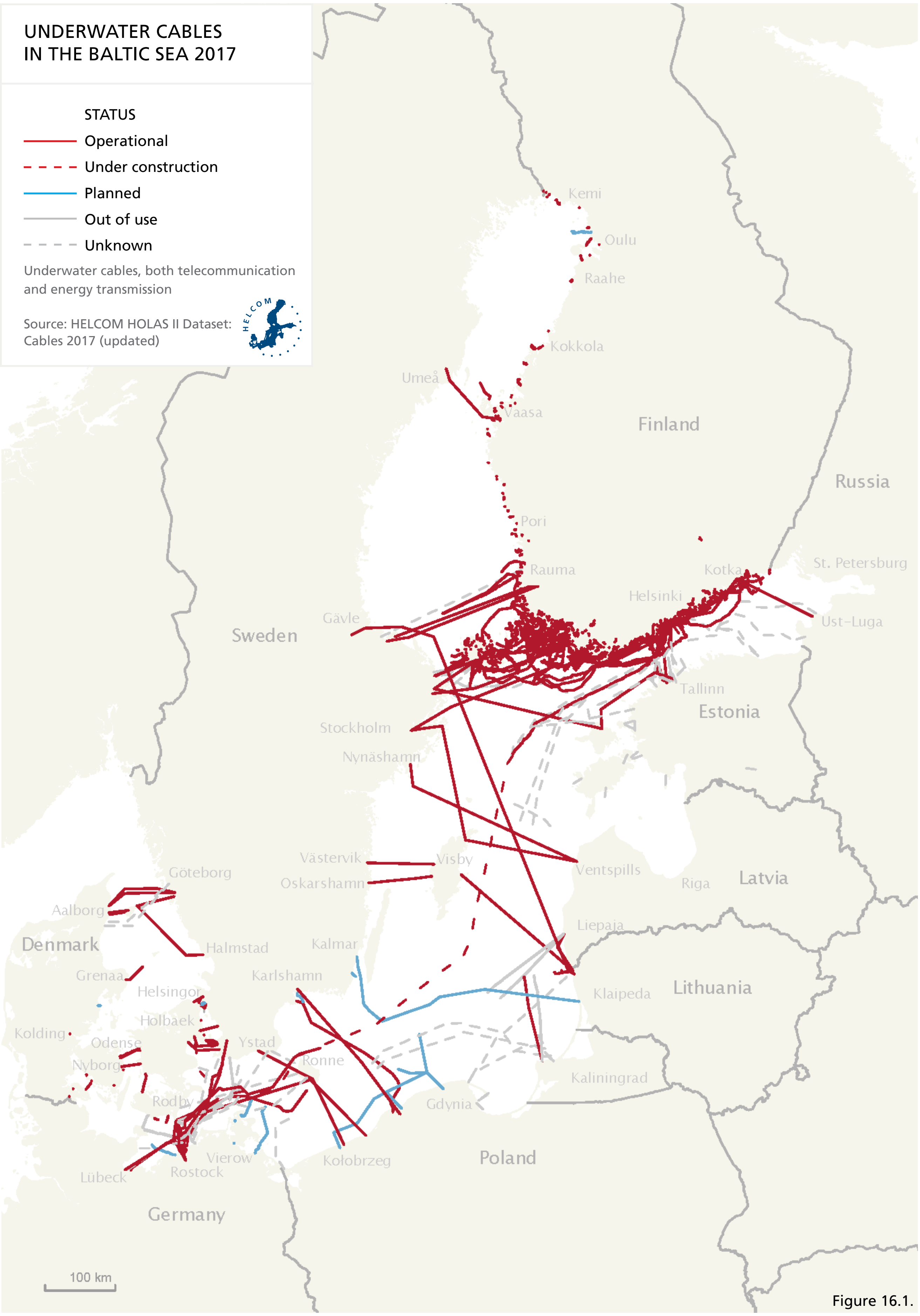
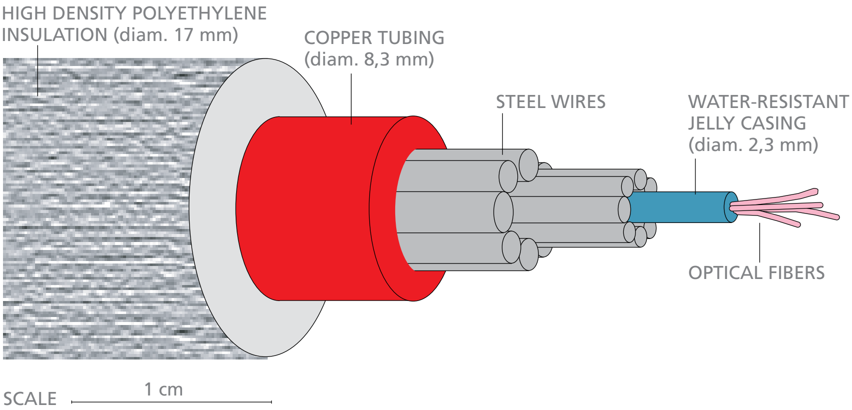

UNDERWATER CABLES
IN THE BALTIC SEA 2017
STATUS
Operational
Under construction
Planned
Out of use
Unknown
Underwater cables, both telecommunication and energy transmission
Source: HELCOM HOLAS II Dataset: Cables 2017 (updated)
HELCOM
Kemi
Oulu
Raahe
Kokkola
Umeå
Vaasa
Finland
Russia
Pori
Rauma
Kotka
St. Petersburg
Helsinki
Ust-Luga
Gävle
Sweden
Tallinn
Estonia
Stockholm
Nynäshamn
Västervik
Visby
Göteborg
Oskarshamn
Ventspills
Riga
Latvia
Aalborg
Liepaja
Denmark
Halmstad
Kalmar
Grenaa
Karlshamn
Klaipeda
Lithuania
Helsingor
Kolding
Holbaek
Odense
Ystad
Nyborg
Ronne
Kaliningrad
Rodby
Gdynia
Vierow
Kolobrzeg
Poland
Lübeck
Rostock
Germany
100 km

Figure 16.1.

Figure 16.2. DIMENSIONS AND COMPONENTS OF A SUBMARINE TELECOMMUNICATION CABLE



Redrawn from Quartz, 2015.

internet, and thus telecommunication cable, nodes for the region are Stockholm, base of Telia Carrier, and Bonn, base of Deutche Telecom, two of the sixteen internet service providers (ISP) in the world who have the highest (Tier 1) status.

Usually, modern telecommunication cables are small, typically 17–20 mm diameter without protective armour. Armoured fibre-optic cables may reach 50 mm diameter (Figure 16.2).

Even if modern underwater cables, based on advanced fibre optics, are a relatively new development they can be regarded as an evolution of underwater telegraph cables laid during the mid 1800s in the Baltic Sea. Examples of such early underwater cables in the region include, for example, telegraph cables between Helsingborg (Sweden) and Helsingör (Denmark) laid in 1855 and between Grisslinge (Sweden) and Uusikaupunki (Finland) laid in 1869, the latter providing a connection between Europe and the Far East via Russia.

Energy transmission cables

Energy transmission between countries and offshore installations is another common use of underwater cables for their high reliability, security and cost-effectiveness.

Power cable diameters are up to 300 mm depending on the current capacity and the amount of armour protection (ICPC 2011a; 2011b).

Underwater pipelines in the Baltic Sea

A number of underwater pipelines for transporting energy products such as gas between countries have been installed on the Baltic Sea seabed (Figure 17.1 in next chapter).

The Nord Stream pipeline, which started operating 2011 and is used for transporting natural gas across the Baltic Sea from Russia to Germany, is with its 1220 km one of the longest underwater pipelines of the world.

The two oil and gas production fields in the Baltic Sea, the Polish B3 and B8, as well as the Russian D6 fields, use pipelines to transport oil and gas within the fields as well as from the fields to the mainland.

Regulations

1992 Helsinki Convention and HELCOM Recommendations

Even if the 1992 Helsinki Convention Article 7 covers Environmental Impact Assessment (EIA), the more specific provisions and procedures of the 1991 UNECE Convention are commonly used instead (see below).

According to HELCOM Recommendation 17/3 the countries planning installation of cables and pipelines should inform the Helsinki Commission, as well as non-HELCOM countries that could be affected.

1991 UNECE Convention on transboundary EIA and its 2003 SEA protocol

The 1991 United Nations Economic Commission for Europe (UNECE) Convention on Environmental Impact Assessment in a Transboundary Context, or the Espoo Convention, and its SEA protocol from 2003 aim to ensure the sustainability of large scale infrastructure developments such as international pipelines and cables. All coastal countries except the Russian Federation have ratified the UNECE Espoo Convention.

Those HELCOM countries which are Espoo Convention Contracting Parties have discussed maritime and land-based projects as well as maritime spatial planning within the Espoo Convention main treaty bodies but also within regional Baltic Sea co-operation seminars.

International Conventions

The installation and operation of submarine cables and pipelines are regulated and protected by a number of international treaties including:

- 1982: United Nations Convention on Law of the Sea (UNCLOS)
- 1958: The Geneva Conventions of the Continental Shelf and High Seas
- 1884: The International Convention for the Protection of Submarine Cables

Future trends

Planned pipelines

A second Nordstream gas pipeline project, running along the first one, is currently in an advanced planning phase. Other international pipeline projects in the Baltic Sea area include two new gas pipelines between Germany and Sweden and between Denmark and Poland.

17. OFFSHORE OIL AND GAS IN THE BALTIC SEA

Introduction

Offshore oil and gas exploration is not a large scale activity in the Baltic Sea. The activities are likely increasing as there are plans to exploit a number of other fields in both Polish and Russian waters of the Baltic Sea.

There are currently three exploited oil and gas fields in the region. Two of the existing fields, called B-3 and B-8, lie in the Polish Exclusive Economic Zone (EEZ) north of the Gdansk region. The third, Kravtsovskoye (D-6), lies in Russian waters west from Kaliningrad (Figure 16.3). The production rigs on D-6 and B-3 are connected to coast with pipelines, gas in the case of B-3 and oil and gas for D6. The B-8 operation is not connected to the shore but with B-3 (crude oil pipeline).

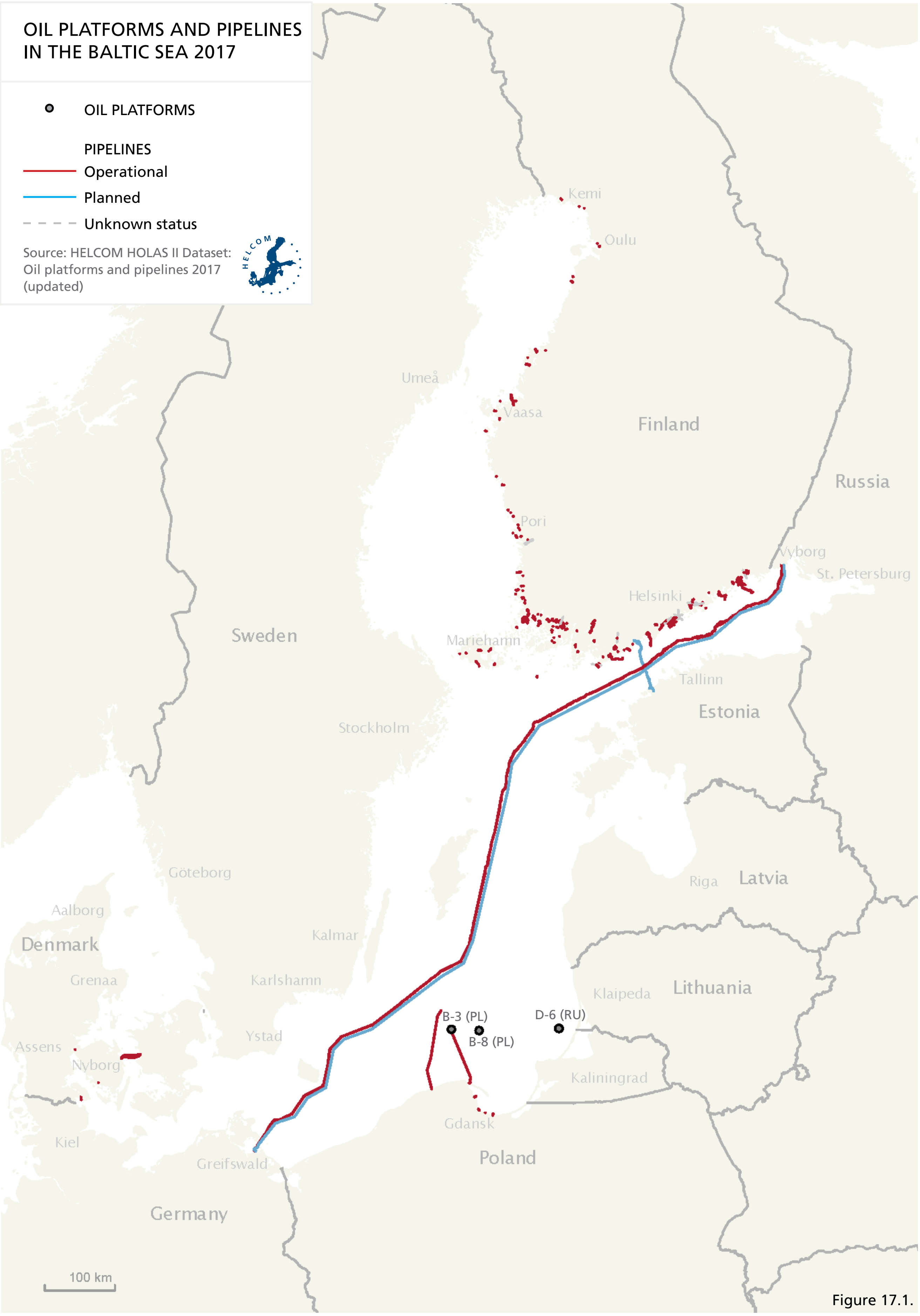
Offshore oil and gas platforms in the Baltic Sea

B-3 & B-8 (Poland)

The B-3 field is situated about 80 km north town of Rozewie, in the vicinity of the Hel Peninsula. The B-3 field hosts the "Baltic Beta" platform which is a production facility for both oil, shipped via a tanker to the refinery in Gdansk, as well as gas, which is transported by a pipeline to the heat and power plant of Władysławowo on the Polish coast. The operations commenced in 1992 and the extraction licence is valid until 2026.

B-8 is a newly developed oil field which is estimated to contain 3.5 million tonnes of recoverable crude oil. Operations on the "Petrobaltic" rig on B-8 commenced in 2015 with a licence valid until 2031 and produce 250 000 tonnes annually.

The B-8 field is situated 35 km from B-3 and the two are connected with an underwater pipeline which carries crude oil from the operations in B-8 to the production platform on B-3. There are also two unexploited gas deposits, B-4 and B-6, in the Polish EEZ for which the company Lotos holds licenses (valid until 2032).


OIL PLATFORMS AND PIPELINES IN THE BALTIC SEA 2017
OIL PLATFORMS
PIPELINES
Operational
Planned
Unknown status
Source: HELCOM HOLAS II Dataset: Oil platforms and pipelines 2017 (updated)
Kemi
Oulu
Umeå
Vaasa
Finland
Russia
Pori
Vyborg
St. Petersburg
Helsinki
Mariehamn
Sweden
Tallinn
Estonia
Stockholm
Göteborg
Riga
Latvia
Aalborg
Denmark
Kalmar
Grenaa
Karlshamn
Lithuania
Klaipeda
B-3 (PL)
D-6 (RU)
B-8 (PL)
Ystad
Assens
Nyborg
Kaliningrad
Gdansk
Kiel
Greifswald
Poland
Germany
100 km
Figure 17.1.

D-6 (Russia)

The Kravtsovskoye (D-6) oil field lies 22,5 km west from the coast of Kaliningrad region and is estimated to contain 9,1 million tonnes of recoverable crude oil. Extraction began in 2004 and today two rigs are in place on the D-6 field, both operated by Lukoil. The field produces in the order of 600 000 tonnes of crude oil annually.

Produced oil and associated gas is transported by a 47-kilometre underwater pipeline to the Romanovo oil-gathering unit on the shore. Produced crude oil is exported through the Izhevsky oil terminal.

Offshore oil and the environment

There are environmental impacts related to all stages of oil and gas activities, including initial exploration, production and final decommissioning: oil discharges from routine operations, the use and discharge of chemicals, accidental spills, drill cuttings, atmospheric emissions, low level naturally occurring radioactive material, noise, and to some extent the placement of installations and pipelines on the sea bed (OSPAR 2009).

In addition, tanker traffic, oil pipelines and possibly even wells may be potential sources of larger oil spills.

Regulations

1992 Helsinki Convention and HELCOM Recommendations

Article 12 “Exploration and exploitation of the seabed and its subsoil” of the 1992 Helsinki Convention states that each Contracting Party shall take all measures in order to prevent pollution of the marine environment of the Baltic Sea Area resulting from exploration or exploitation of its part of the seabed and the subsoil as well as ensure that adequate preparedness is maintained for immediate response actions against pollution incidents caused by such activities. Annex VI “Prevention of pollution from offshore activities” of the Helsinki Convention further describes procedures and measures for the Contracting Parties to avoid pollution.

HELCOM Recommendation 18/2, adopted in 1997, is a dedicated instrument on offshore activities. It recommends that marine protected areas are excluded from exploration and exploitation activities and that an environmental assessment should be conducted in the area of offshore activity before granting a permission.

HELCOM Recommendation 19/17 on Measures in order to combat pollution from offshore units, adopted in 1998, recommends that each offshore unit has a Pollution Emergency Plan and requests the Governments to exchange information on offshore activities, discharges and contingency measures.

Zero-discharge principle

There is a zero-discharge principle in place for discharges of process water (containing oil), solid wastes and specific production chemicals included in "black" and "red" lists, from offshore platforms in the Baltic Sea. This approach was adopted by the HELCOM 2010 Ministerial Meeting. However, results on any monitoring carried out to implement this principle are not reported regularly to HELCOM.

Future perspectives

New fields entering production

In Russia, Lukoil reported an oil discovery at its D-33 block in 2015, with recoverable oil reserves estimated at 21.2 million tonnes, making it the first mid-sized field of the Baltic Sea. Also four other fields in the Russian EEZ off Kaliningrad (D-41, D-29, D-6 and D-2) have production plans. If realised the combined peak aggregate output of oil fields in the Russian waters of the Baltic Sea 2.15 million tonness per year would be attained by 2027.

In Poland, Lotos has plans to exploit the two unexploited gas deposits, B-4 and B-6, with estimated aggregate reserves of 4000 million m^3, and presumed annual output of 250 million m^3.

Other fields

In Sweden exploration drilling since the 1990s has produced minimal results and several companies have let their permits lapse. Svenska Petroleum in 2009 was denied test drilling in the Baltic Sea.

Latvia has an offshore field, the E-6-1 block belonging to Balin Energy, discovered already in 1984 but its assumed reserves of 2-3 million tonnes might prove uneconomic to exploit. Lithuania has so far taken no steps to assess its hydrocarbon potential.

In Denmark licences for exploration and production of hydrocarbons are awarded according to two different procedures, depending on where in Denmark the area is located. Licensing rounds are held for the most attractive area in the North Sea, which is situated west of 6° 15′ eastern longitude. In the rest of Denmark, including the Baltic Sea, licences are granted according to a national "open door" procedure.

18. SUBMERGED HAZARDOUS OBJECTS IN THE BALTIC SEA

Introduction

A large but unquantified amount of dumped hazardous waste, warfare material as well as potentially polluting wrecks lie on the Baltic Sea seabed. These have ended up where they lie as a result of an accident, in the case of wrecks, naval warfare or as a result of wilful dumping. In many cases these objects are a potential or actual hazard to the marine environment but also to humans.

The location of certain types of objects, such as mines, chemical munitions and wrecks, are relatively well known. However, even in these cases there are large uncertainties around the amounts or types of submerged hazardous objects in the Baltic Sea, or their state of corrosion.

Even if technological means are available to actively remove and dispose these objects or the pollutants they contain, such operations are expensive and include always a risk of worsening the situation by spreading the contaminants in the surrounding sea area.

However, depending on the situation and with increasing knowledge, active removal has been considered as a viable option (HELCOM 2013). For example, proactive removal of oil from wrecks has potential for cost-effectiveness as this can be planned in advance and can be carried out relatively safely using modern technology.

Systematic mapping and assessment of submerged hazardous objects would need more resources and likely also new, cost efficient underwater technology.

Submerged hazardous objects in the Baltic Sea

Submerged warfare materials

Especially after the Second World War there was a pressing need for an economic and efficient way of disposing the enormous quantities of unnecessary warfare material. The solution was commonly to dump it to the sea, including the Baltic Sea.

Dumped warfare material in the Baltic Sea emerged as an issue during the 1980s as it was identified as a danger to the general public, especially for fishermen. Even today, the possibility of people encountering warfare materials on the seashore and working in the marine environment of the southern and western Baltic Sea is common. One to two hundred cases, involving several hundred objects, are reported annually in German waters alone. The increasing number of large-scale offshore construction projects (Chapter 15) make such encounters more likely than before.

Types of submerged warfare materials

Warfare material on the seabed of the Baltic Sea can be divided into two major categories, items containing either explosives, incendiary agents or chemical warfare agents and items which do not contain these.

Items of the first type have been either dumped or released on purpose- Dumping of explosives was usually done without fuses, or other important parts of the detonation chain, and classified as discarded military material (DMM). During military operations explosive items have been released on purpose, and are for this reason fused, and are classified as unexploded ordnance (UXO) if remaining on the seabed.

When the problem of pollution by underwater munitions is discussed, a general distinction between conventional and chemical munitions is also often made based on the type of payload it contains. Conventional munitions are filled with explosives or incendiary agents only, while chemical munitions contain chemical warfare agents (CWA) and many times also explosives or propellants as booster charge.

Chemical munitions is perhaps the type of warfare material, which has received the highest level of attention during the last decades (HELCOM 2013).

Location and amount of submerged warfare materials

Around 40 000 tonnes of chemical munitions were dumped from ships within, or en-route to, designated dumping areas (Figure 18.1.), e.g. close to Bornholm Basin, Gotland Deep, Gdansk Deep, Flensburg Fjord and Little Belt (HELCOM 2013). It is estimated that these chemical munitions contained, during dumping, some 15 000 tonnes of chemical warfare agents (HELCOM, 2013).

All kinds of munitions may also occur outside the designated dumping areas, as munitions are known to have been thrown overboard while ships were on their way in order to save time. As some munitions were dumped in wooden cases these have also drifted outside the area where they were actually dumped. Bottom trawling is another main cause for displacement of chemical and conventional munitions.

HELCOM maintained until recently an annual record on the reported incidents related to chemical munitions caught by fishermen, according to which there has been an overall decrease in the annual number of reported incidents over the last decades. This may reflect a decreased fishing effort and changes in fishing practices (e. g., switches from bottom trawl to pelagic trawl in areas of anoxic bottom conditions) as well as gaps in national reports.

In addition to chemical munitions, a high number of mines have been laid to the Baltic Sea during the last wars. In the Baltic Sea approximately

180 000 mines were laid in 2 200 mine fields between 1848 and 1945. Of these 35 000 to 50 000 mines have been swept and removed. It is estimated that 35 000 mines may remain in the Gulf of Finland alone.

Figure 18.1 presents a combined map of (a) former munition dumping grounds (conventional and chemical munitions) according to the current knowledge and published in official sea charts, by HELCOM BSEP 142 and as result of archival ongoing work of HELCOM SUBMERGED (blue areas) and (b) a risk index representing the present risk to encounter a sea-mine on the seabed of the described area (rose to dark red, darker colour means higher risk).

Finally, an unquantified but large amount of conventional ammunition (small and large calibre ammunition rounds) and other military material was dumped after the war to the Baltic Sea, mostly within the German Territorial Sea (12 NM) but also elsewhere. In addition, an unknown number of unexploded ordnance (UXO) from artillery and bombs lie on the seabed along the Baltic Sea coast and offshore. A total of around 300 000 tonnes of conventional munitions have been estimated to lie in German marine waters alone (Böttcher *et al.* 2011).

Environmental effects of dumped warfare materials

Particularly dumped chemical weapons, but also conventional munitions, contain large amounts of substances, some of which may cause a hazard to the environment or the marine environment. The 2013 HELCOM report dedicated to dumped chemical munitions describes 15 different substances or compounds used in chemical munitions.

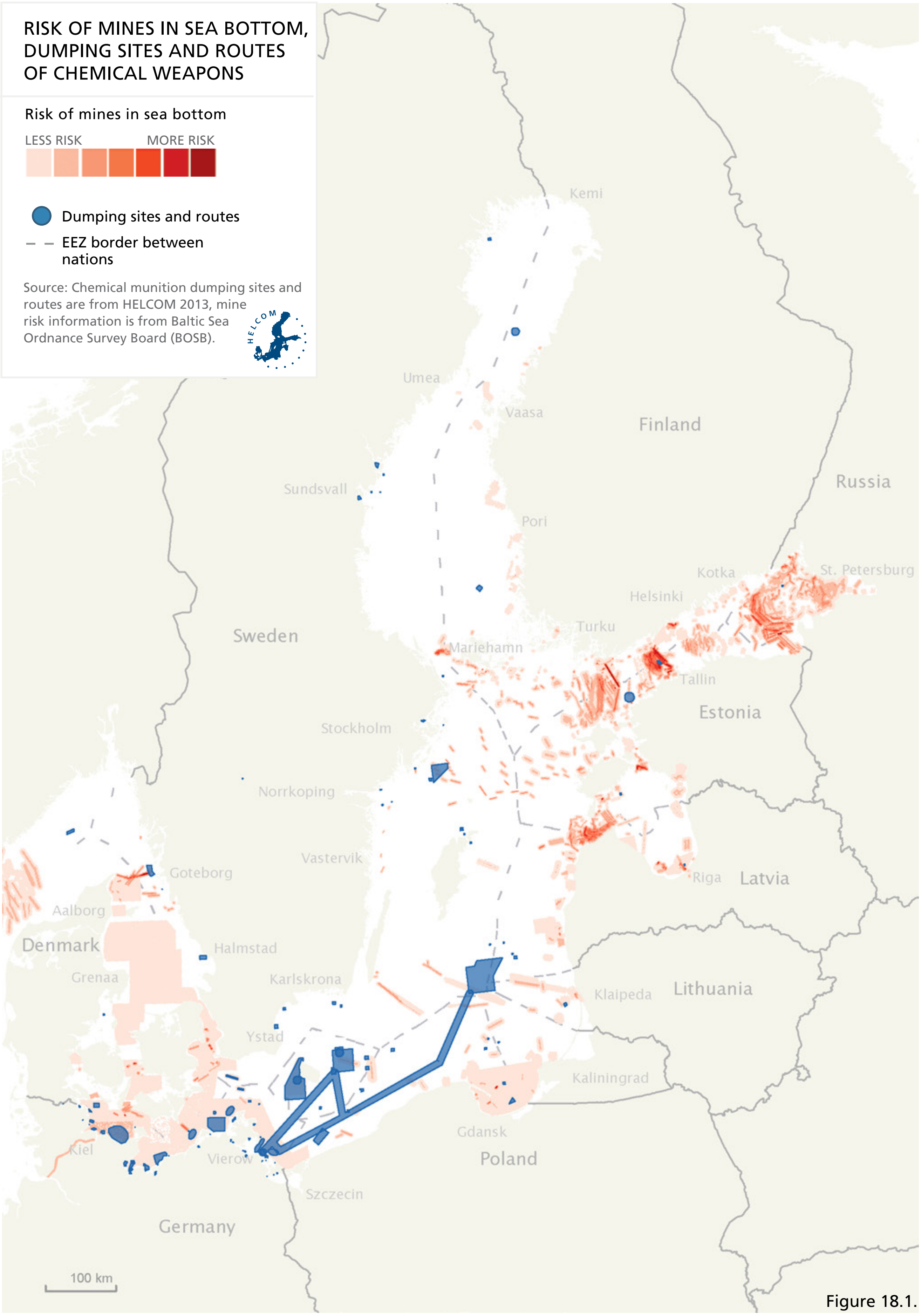
According to the historical information available, sulphur mustard is the most abundant chemical warfare agent in the dumped munitions. This chemical agent poses a present risk to humans who come into contact with it, and to organisms within its immediate vicinity, taking into account both short- and long-term effects.

According to existing knowledge, chemicals originating from chemical warfare materials can contaminate the nearby area but also spread from the disposal sites of the containers due to natural and anthropogenic processes. However, so far no chemical warfare agent parent compounds or degradation products have been detected in the water column in measurable quantities. However, these can be found in sediments of the dumpsites.

Recent findings of traces of chemical warfare agents Clark 1 and Clark 2 in Norwegian lobster (*Nephrops norvegicus*) in the area of Måseskär on the Swedish West Coast show that some compounds find their way into the marine food web (OSPAR 2017 §3.24). The environmental impact of chemical warfare agent mixtures has not either been thoroughly assessed by e.g. ecotoxicological means.

Smaller pieces of White Phosphorous used in the fuse of incendiary munitions washes ashore and appears like amber but causes severe burns and is highly toxic. In certain areas in the southern and western Baltic Sea (Germany, Poland and Latvia), there are reports every year that beach visitors have been in contact with White Phosphorus.

Conventional munitions contain also a number of toxic substances including heavy metals, trinitrotoluène (TNT) and hexa-nitro-di-phenyamin. The amounts of these conventional munition substances in the Baltic Sea marine environment has been estimated to be one order of magnitude


RISK OF MINES IN SEA BOTTOM, DUMPING SITES AND ROUTES OF CHEMICAL WEAPONS
Risk of mines in sea bottom
LESS RISK
MORE RISK
Dumping sites and routes
EEZ border between nations
Source: Chemical munition dumping sites and routes are from HELCOM 2013, mine risk information is from Baltic Sea Ordnance Survey Board (BOSB).
HELCOM
Kemi
Umea
Vaasa
Finland
Russia
Sundsvall
Pori
Kotka
St. Petersburg
Helsinki
Turku
Sweden
Mariehamn
Tallin
Estonia
Stockholm
Norrkoping
Vastervik
Goteborg
Riga
Latvia
Aalborg
Denmark
Halmstad
Grenaa
Karlskrona
Klaipeda
Lithuania
Ystad
Kalingrad
Kiel
Vierow
Gdansk
Poland
Szczecin
Germany
100 km
Figure 18.1.

larger than those of CWA substances. Effects of toxic and carcinogenic constituents of these conventional explosive materials to the marine environment are poorly understood and currently subject to several research projects in the Baltic Sea.

Polluting wrecks

A relatively large number of potentially polluting wrecks lie on the Baltic Sea seabed, containing oil or other environmentally harmful substances either as cargo or, more commonly, as fuel. However, there is currently no available Baltic Sea –wide dataset or register of polluting wrecks which would enable a full regional overview. Figure 18.2 presents the location and size of wrecks in the Baltic Sea based on the available data from Sweden, Poland and Estonia.

Sweden, Estonia and Finland have also completed dedicated studies classifying potentially polluting wrecks in their waters. In Sweden a comprehensive national register containing close to 17 000 underwater objects in Swedish waters was analysed in 2008. Of these 2 700 wrecks were selected as of interest having certain potential for environmental hazard using explicit criteria (wrecks 100 GT or larger, wrecked after the year 1900, used and had on board oil product or similar, carried environmentally hazardous cargo or from which leakage had been observed). 316 of the potential wrecks were confirmed as having of potential environmental hazard and further studies identified 31 wrecks as being of acute concern.

In Estonia out of total 705 identified wrecks 84 have been identified as having potential for risk of oil leakage, of which 14 have been confirmed as having a risk of oil leakage. In Finland 46 wrecks were identified in 1999 to potentially carry over 100 tons of oil, 13 of which were confirmed to carry this volume.

Environmental effects of polluting wrecks

Possible release of hazardous cargo or fuel from the large number of wrecks in the Baltic Sea has been recently highlighted as a potential issue of regional concern as sudden leakages may result in an emergency spill response operation similar to spills from maritime or coastal accidents.

In addition to fuel oil, the cargo of the ships must be considered as a relevant source of contamination, either way, if it was a tank vessel, loaded with fuel-oil or toxic industrial chemicals, a goods freighter, carrying dangerous goods in containers, or a former military ship, filled with munitions as supply for its own gunnery and sometimes in large quantities for logistical purposes. Wrecks also entangle fishing gear and thus contribute to the 'ghost fishing' phenomenon (c.f. Ch. 13).

Historic dumping of industrial and radioactive waste

Modern environmental legislation developed in the Baltic Sea countries only during the 1950s-60s and before this period the sea was a legal disposal site for waste, both solid and liquid. As a large part of this historic dumping was done by individual industrial facilities, municipalities and even private persons, much of this dumping is very poorly documented. Some of the dumped material might be hazardous and resist degradation over time and thus remain as an environmental hazard on the seabed.

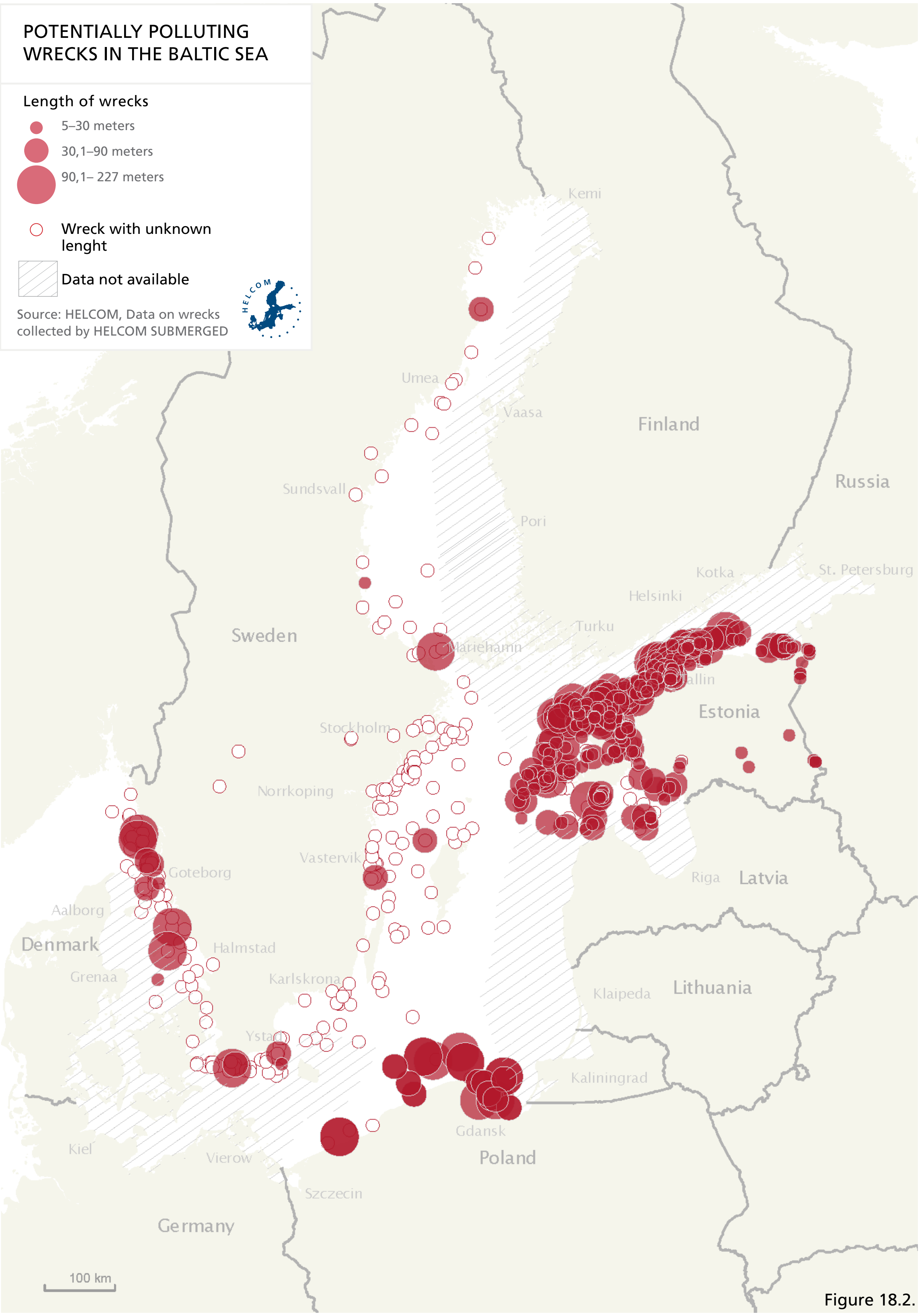

POTENTIALLY POLLUTING WRECKS IN THE BALTIC SEA
Length of wrecks
5–30 meters
30,1–90 meters
90,1– 227 meters
Wreck with unknown lenght
Data not available
Source: HELCOM, Data on wrecks collected by HELCOM SUBMERGED
HELCOM
Kemi
Umea
Vaasa
Finland
Russia
Sundsvall
Pori
Kotka
St. Petersburg
Helsinki
Turku
Sweden
Mariehamn
Tallin
Estonia
Stockholm
Norrkoping
Vastervik
Goteborg
Riga
Latvia
Aalborg
Denmark
Halmstad
Grenaa
Karlskrona
Klaipeda
Lithuania
Ystad
Kalinigrad
Gdansk
Kiel
Vierow
Poland
Szczecin
Germany
100 km

Figure 18.2.

Some dumping sites or hazardous waste have been identified accidentally during hydrographic soundings or when searching for mines or wrecks. In some cases, particularly regarding dumping of radioactive waste, dumping was carried out by national authorities and thus, more readily available.

For example, according to an overview on disposal of radioactive wastes at sea done by IAEA (IAEA 1999) on the request by the IMO London Convention, at least Sweden and Russia have carried out dumping of radioactive waste in the Baltic Sea mainly during the 1950–60s (IAEA 1999, page 48 Sweden, page 77 Russia) (Table 18.1.).

Table 18.1.
RADIOACTIVE WASTE DUMPED IN THE BALTIC SEA

Year	Country	Location	Amount	GBq	Ci
1959	Russia	65 44'N, 35 54'E	600 m^3	<10	0,02
1960	Russia	Near Gogland island	100 m^3	10	0,20
1959–61	Sweden	Landsort deep	*1) 43 m^3	14,8	0,4
(*two operations)			*2) 75 m^3 (230 containers, 64 t)		

Source: IAEA 1999

There are also identified examples of historic dumping of other types of industrial waste to the Baltic Sea. One example is the more than 20 000 barrels containing hazardous waste with estimated 10 tonnes of mercury, encapsulated in concrete, dumped during the 1950s and 60s in the Bothnian Sea outside Sundsvall (Åstön, Brämön and Sundvallsfjärden). Some thousands of the dumped barrels were observed during geological investigations in 2006 and more have been detected over time. The quicksilver-containing material in the barrels is catalysator mass from vinyl chloride, raw material for PVC production. However, this is likely just one of many cases as similar industrial activities producing hazardous waste took place in many areas around the Baltic Sea during the 1950s and 60s.

As the amounts, types and locations of historic dumping of industrial waste remain largely unknown, it is not possible to estimate the possible environmental hazards involved.

Regulations

1992 Helsinki Convention and Recommendations

The 1992 Helsinki Convention has a dedicated Article 11 and Annex V addressing dumping. According to Article 11 the Contracting Parties shall prohibit dumping in the Baltic Sea Area with the exception of dredged material, if the criteria specified in Annex V are met, as well as under specific circumstances when dumping is the only way to ensure safety of human life.

London Convention 1972 and Protocol 1996

See descriptions under Chapter 7 – Marine Litter.

Nairobi International Convention on the Removal of Wrecks 2007

The Nairobi International Convention on the Removal of Wrecks, 2007, provides a legal basis for states to remove, or have removed, shipwrecks that may have the potential to affect adversely the safety of lives, goods and property at sea, as well as the marine environment. It mainly addresses wrecks outside the territorial sea but has also an optional clause by which a Contracting Party may make it applicable in the territorial sea. It makes shipowners financially liable and require them to take out insurance or provide other financial security to cover the costs of wreck removal. It will also provide states with a right of direct action against insurers.

Basel Convention 1989

The 1989 Basel Convention restricts transboundary movements of hazardous waste, particularly from more to less developed countries.

Active removal of hazardous underwater objects

As mitigation/ active removal of hazardous underwater objects is generally expensive, and as such operations involve certain risks of worsening the situation by spreading hazardous substances to the marine environment, the default decision of many national authorities has been to leave the material on the seabed (HELCOM, 2013). The exception is mines which are systematically and regularly cleared in the region by national activities and the Baltic Ordnance Survey Board (BOSB), which is the regional co-operation structure on ordnance clearance in the Baltic Sea.

However, depending on the situation and with increasing knowledge, active removal has been considered as a viable option (HELCOM, 2013). For example, proactive removal of oil from wrecks has potential for cost-effectiveness as this can be planned in advance and can be carried out relatively safely using modern technology.

In view of the increasing utilization of the sea floor for economic purposes (e.g., offshore windfarms, sea cables, pipelines), the risk of encountering hazardous submerged objects is likely increasing in the Baltic Sea.

Future perspectives

Mapping historic dumping of hazardous industrial waste in the Baltic Sea

It is possible that more historic dumping sites of hazardous waste comparable to the few identified cases await detection on the Baltic Sea seabed. National overviews of such historic dumping are not available in the Baltic Sea and information on this topic is in general scarce. Historic dumping of hazardous waste could be mapped in future regional initiatives.

Mapping and classification of polluting wrecks in the Baltic Sea

There is currently no available Baltic Sea –wide dataset or register of potentially polluting wrecks. The ongoing HELCOM SUBMERGED initiative to create a regional dataset of potentially polluting wrecks would benefit from region-wide projects or similar studies.

Current illicit trafficking and dumping of waste in the Baltic Sea

Illegal trafficking of waste has been rising recently particularly between countries in North West and North East Europe (EUROPOL, 2013). Criminals are exploiting the high costs associated with legal waste management and are in this way making substantial profits from illegal trafficking and disposal activities, circumventing environmental legislation. According to EUROPOL criminals make use of a wide variety of improvised illegal dumping sites such as gravel and sand pits, abandoned industrial facilities, open-cast mines. Recent illegal dumping at sea has been documented in other parts of the world but so far not in the Baltic.

19. LEISURE BOATING IN THE BALTIC SEA

Introduction

Particularly in Sweden, Denmark and Finland but also in Germany leisure boating, particularly sailing, has a long history and strong traditions. Sweden, Denmark and Finland belong to the countries in the world with the highest per capita boat ownership. During recent years leisure boating has increased in popularity also in the other coastal countries. In the Baltic Sea boating takes place mainly along the coastline, with relatively few offshore voyages.

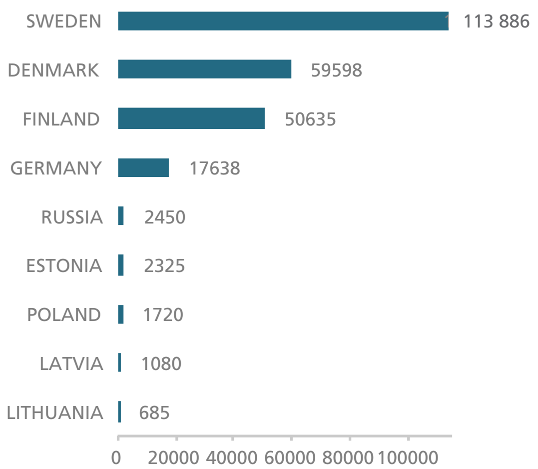
National registers and figures of boat ownership are available in many countries (e.g. Transportstyrelsen, 2016) but it is difficult to use them to identify the number of leisure boats actually used in the Baltic Sea. National summary figures and registers also include boats used in inland waters, which represents a significant share in countries like Sweden and Finland.

In a recent study (Johansson & Jalkanen, 2016) around 250 000 leisure boats were observed from satellite images within 3 000 leisure boat marinas along the Baltic Sea in 2016, most of them in Sweden, Denmark, Finland and Germany (Figures 19.1. & 19.2.). As the focus is on marinas these figures

Figure 19.1.

NUMBER OF LEISURE BOATS IN THE BALTIC SEA MARINAS

Counted from satellite images by country of marina



Source: Johansson & Jalkanen, 2016

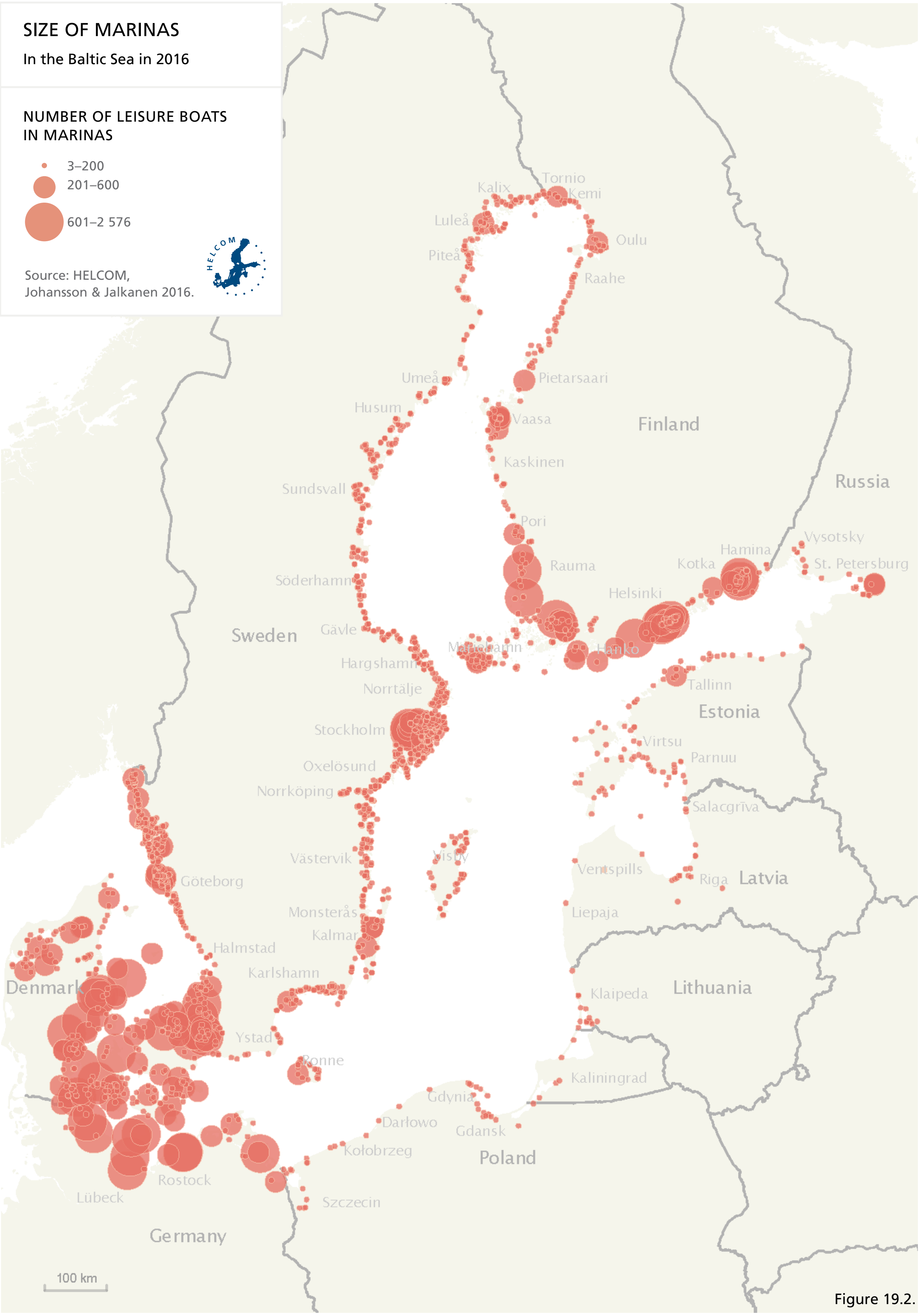
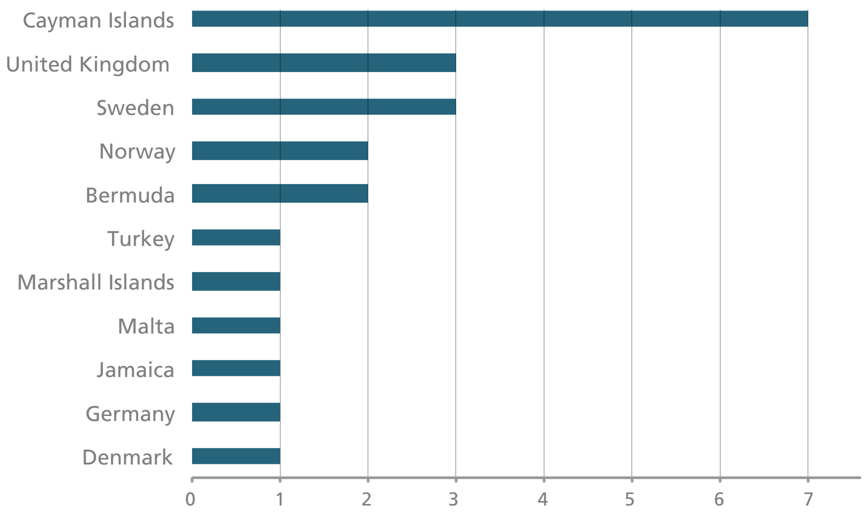

SIZE OF MARINAS
In the Baltic Sea in 2016
NUMBER OF LEISURE BOATS IN MARINAS
3–200
201–600
601–2 576
Source: HELCOM, Johansson & Jalkanen 2016.
HELCOM
Tornio
Kemi
Kalix
Luleå
Oulu
Piteå
Raahe
Umeå
Pietarsaari
Husum
Vaasa
Finland
Kaskinen
Sundsvall
Russia
Pori
Vysotsky
Hamina
St. Petersburg
Kotka
Rauma
Söderhamn
Helsinki
Sweden
Gävle
Hargshamn
Tallinn
Norrtälje
Estonia
Stockholm
Virtsu
Parnuu
Oxelösund
Norrköping
Salacgrīva
Västervik
Riga
Latvia
Göteborg
Liepaja
Monsterås
Kalmar
Halmstad
Karlshamn
Klaipeda
Lithuania
Ystad
Kaliningrad
Gdynia
Darłowo
Gdansk
Kołobrzeg
Poland
Rostock
Lübeck
Szczecin
Germany
100 km

Figure 19.2.

Figure 19.3.

NUMBER OF BIGGER LEISURE VESSELS SAILING IN THE BALTIC SEA IN 2016
Vessels over 100 GT, by flag of registration, total 23 vessels



do not account for all boats and thus, likely underestimate the number of leisure boats in the Baltic Sea (Johansson & Jalkanen, 2016).

A small number of very big leisure vessels, over 100 GT, are registered according to IMO regulations. In 2016, there were 23 of such bigger leisure vessels operating in the Baltic Sea, mostly flagged to countries outside the Baltic Sea region (Figure 19.3).

Environmental issues related to leisure boating

Leisure boats are potential sources of waste water, underwater noise, emissions of active substances in anti-fouling paints as well as exhaust gases (e.g. Johansson & Jalkanen, 2016).

However, due to the limited size of leisure boats they are usually considered as a minor pollution source. Inversely, leisure boating, particularly canoeing, rowing and sailing, likely contributes to environmental awareness as the persons engaged in these activities spend time at sea directly depending on the nature and its elements (Hasselström, 2008).

Boaters, facility owners and coastal municipalities have the shared responsibility to ensure that garbage and sewage from leisure boating is collected and disposed of properly.

Regulations

1992 Helsinki Convention and HELCOM Recommendations

While most IMO regulations address only larger vessels, certain discharge regulations apply to pleasure craft based on the Helsinki Convention 1992 (entered into force 17 January 2000).

As an example, small vessels built on or after 1 January 2000 and fitted with a toilet, should as a general rule, comply with the sewage discharge regulations of Annex IV to MARPOL (1992 Helsinki Convention Annex IV, Regulation 5) and be able to connect to sewage reception facility pipes (guidelines available in HELCOM Rec 22/1).

Small vessels built before 1 January 2000 can be exempted by the Baltic Sea countries from this obligation if the installation of toilet retention systems in these ships is technically difficult or the cost of installation is high compared to the value of the ship. Currently Finland and Sweden have national regulations in place on sewage discharge from small vessels under their flag. Dumping of waste to the sea is equally forbidden from leisure boats as it is from larger ships.

Future perspectives

Recycling end-of-life boats

Most boats in the Baltic Sea are made of glass fibre reinforced plastic materials (Transportstyrelsen, 2016). Fibre reinforced plastic is highly durable material but eventually these boats will reach the end of their useful life and need to be disposed of in an environmentally responsible manner. As regulation is starting to restrict the disposal of FRP to landfill, relatively costly recycling will become the only realistic option. Currently, there appears to be little incentive for innovation in green design and the development of new marine products that are more sustainable throughout their life-cycle and during scrapping and recycling.

Noise from leisure motorboats

Especially in coastal areas, recreational motor boating is one potentially important source of underwater noise. However, it is challenging to map this source as it is not covered by existing maritime surveillance such as AIS. Instead, alternative methods enabling the extraction of acoustic signatures of different types of boats could be applied. In parallel, a dialogue with the leisure boating community is needed to promote good boating behaviour (slow speed in sensitive areas, good engine maintenance and lower engine noise).

You cannot change the past,
but you can shape the future.

Section V

FUTURE TRENDS IN MARITIME TRAFFIC

20. FUTURE TRENDS IN MARITIME TRAFFIC

Introduction

This chapter focuses on future scenarios for maritime traffic in the Baltic Sea area. As a basis it includes a literature review on the scenario work done within the Baltic Sea region over the past few years. Also, it reports the results of a questionnaire study conducted based on the key factors for development identified through the literature review.

Previous scenario work in the Baltic Sea area

SHEBA project

The ongoing project Sustainable Shipping and Environment of the Baltic Sea region (SHEBA) has developed scenarios for shipping in the Baltic Sea for the years 2030 and 2040. The goal was to assess the impact of shipping on the Baltic Sea region environment and on ecosystem services (Fridell *et al.* 2016).

The SHEBA project has also made an extensive literature review and presents a table with the existing scenario work within the Baltic Sea area, methodology used and a short overview of the types of scenarios made. The scenario work reports that were considered the most relevant for the Baltic Sea shipping development are summarized below in the following chapters. The documents chosen for summaries fulfilled the following criteria:

1. document directly addressing shipping developments

OR

2. the geographical scale was limited on the Baltic Sea or Europe

WWF: Future Trends in the Baltic Sea

WWF Baltic Ecoregion Programme focused on making scenarios for the period until 2030 (WWF 2010). The scenarios were made separately for 15 different sectors covering most human uses of the marine areas across the Baltic Sea region and the goal was to find out if the future visions for different sectors and especially the related sea use would overlap. The chapters related to maritime transport handled shipping, ports and tourism and recreation. The report mentions shipping in the executive summary showing the most striking growth in human uses of the sea: the prediction was that the number of ships in the region would double within 20 years.

The WWF report predicts an increase from about 3000–5000 ships per month to more than 9000 ships every month (Figure 20.1). Furthermore, the prediction is that the size of ships will increase considerably over the study period.

The report makes a separate scenario for oil transports as the development and expansion of ports in the Gulf of Finland are considered to play an important role in the general growth of shipping numbers. According to the WWF scenario, the amount of oil shipped in the Baltic Sea would grow by 64% by 2030, from about 180 million tonnes to almost 300 million tonnes.

Assuming that the tanker ship size would grow and all the oil transports would be done with fully laden Aframax size class tankers with a draught of about 15 meters (maximum draught that can enter the Baltic Sea through Danish straits) and with a cargo carrying capacity of about 100 000 metric tons, transporting 300 million tons of oil would require minimum 3000 voyages per year, or about 8 tanker voyages per day. Transporting the current 180 million tons of oil would require about 1800 Aframax voyages per year, or five voyages per day.

The actual number of ships would, however, be much larger, as most crude oil and product tankers operating in the Baltic Sea area are smaller than Aframax size class (or cannot be fully laden to keep the draught at acceptable level), as currently rare ports in the Baltic Sea can receive ships up to 15 meters' draught.

The report mentions the sea use aspect of safe manoeuvring and recommends sufficient safety zones around the shipping areas. If the prediction of growing ship size is accurate, the importance of safety zones is even greater. This will be complicated in the many shallow and narrow areas of the Baltic Sea where the cargo ships and oil tankers are voyaging.

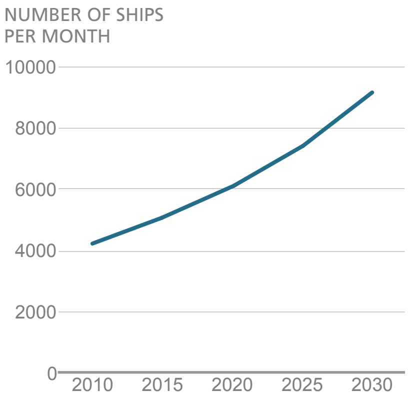
Ports are likewise predicted to grow and dredging of ports and entrances to ports is likely to become more common, to accommodate the larger ships.

Blue Growth study (European Commission)

The Blue Growth Study commissioned by the EU Commission in 2012 (Ecorys, Deltares, OceaniC development, 2012) includes shipping related scenarios with focus on short sea shipping. Identified trends included the increase in LNG especially for the Baltic Sea short sea shipping. The document includes also an impact scenario, predicting strong positive trend for market share, mild positive trend for employment and energy consumption and mild negative trend for aquatic life and natural habitats (especially due to lacking regulation for underwater noise), although the more stringent ECA regulations in the Baltic Sea is anticipated to reduce certain types of harmful emissions. The scenario also predicts possible fuel cost fluctuations due to the pressure on the refinery industry to deliver large amounts of low sulphur fuels (Ecorys, Deltares, OceaniC development, 2012).

The Blue growth study includes also a cluster report for cruise tourism and predicted increase in the size of ships due to more intense price compe-

INCREASE IN NUMBER OF SHIPS PER MONTH 2010–2030



Source: WWF 2010

Figure 20.1.

tition. The study mentions the Baltic Sea cruise tourism as one of the areas that may benefit from increasing fuel prices as the destination ports are close to each other. Improving port facilities and development of attractive destinations are among the main drivers for the industry. In the Baltic Sea, this is likely to benefit the ports where the large cruise ships can berth close to city centres. The trend of cargo ports moving away from city centres may create new opportunities for the cruise ships to take over the cargo infrastructure.

A third cluster report included in the Blue Growth Study is related to maritime surveillance, and predicts increase in security surveillance in Europe. The development is, however, dependent on possible adoption of a European system of data sharing, and the negotiations for such an agreement within Europe are predicted to take several years. Pilot projects in European basins (such as the Baltic Sea) are nevertheless likely.

Global Marine Trends 2030 (Lloyds register)

This report is more focused on the global phenomena driving shipping patterns: Population growth and aging population in developing countries, GDP growth, resources geography and environment. The report further focuses on the developments for global demand for oil, LNG, steel, coal and certain other raw materials and products, as well as global fleet and fleet ownership characteristics. Such developments are relevant for the Baltic Sea shipping, especially regarding the raw materials transport from the Baltic Russian ports, but the scale of these scenarios is rather wide and it is hard to identify specific trends to the Baltic region (Lloyd's Register, QinetiQ, University of Strathclyde, 2013).

Shipping 2020 (Det Norske Veritas)

The Shipping 2020 report does not address the Baltic Sea specifically but it has built four comprehensive scenarios for world economy, shipping, environmental regulations, fleet growth, fuel prices and technology and innovation that can be applied to the case of the Baltic Sea.

The scenarios extend only till 2020, but the last chapter also identifies trends and drivers beyond the scenario timeline. These drivers include for example, research on black carbon, hull-fouling and underwater noise from shipping. Furthermore, the chapter mentions certain innovations that are considered important for the future development of shipping. These include green fuels, low-energy ships, arctic transport, digitalization of navigation and development of electric engines and battery technology (Det Norske Veritas 2012).

HELCOM Maritime scenarios: Methodology

Future scenario on Baltic Sea shipping were developed for this Chapter using the Delphi method, developed in the 1950s–1960s to collect expert judgements on variety of topics (Linstone & Turoff 1975).

Key factors for the Delphi study were identified based on the key topics in the HELCOM Maritime Assessment. The identified key factors were assessed using the real time Delphi method (RT-Delphi), described in Gordon & Pease 2006. The Delphi method gives the stakeholders an opportunity to express their personal ideas and opinions freely, as the panel is anonymous.

RT-Delphi differs from the traditional Delphi in the number of questionnaire rounds. While the traditional Delphi is done in three or more rounds to reach consensus, RT-Delphi requires only one round. The goal is to develop new ideas concerning future developments but not necessarily reach consensus. The panellists receive a report of the answers of other participants immediately after answering.

The real time Delphi survey was conducted during the 16th meeting of the HELCOM MARITIME Working Group (6–8 September 2016 in Tallinn, Estonia). The participants were given an opportunity to answer the questionnaire before the meeting, and during the meeting there was a briefing on the research goals and using the Delfoi portal.

After the briefing the participants were given 10 minutes to answer the survey. They were also informed that they could continue answering to the survey until the end of the day, after which the survey would be closed.

Description of the Delphi-exercise

The questionnaire consisted of three groups of questions:

1. Increase in shipping - Where will it happen?

The first key factor to consider was the increase in shipping traffic. The general assumption of any scenario work in the past has been that shipping is increasing and will continue to increase. Therefore, the participants were not asked to evaluate whether shipping increases, but where the impacts of increasing shipping will be mostly seen.

2. Environmental impacts - What impact will these pressures have in the future?

Impacts of the identified key factors were evaluated based on two criteria:

Firstly, the participants were asked to evaluate the significance of the impact of different environmental issues of shipping to the state of the Baltic Sea marine environment by 2030.

Secondly, the participants were asked to evaluate the probability of these issues causing degradation to the state of the Baltic Sea marine environment by 2030.

3. Environmental actions - What impact will these actions have in the future?

Actions to respond to any negative impacts of the identified key factors were evaluated based on the same criteria as in the previous section: the significance, or importance of the actions and the probability of the actions being carried out successfully by 2030. The goal was to evaluate the actions that can be taken to mitigate or avoid environmental impacts of shipping.

The answers were given on a scale of four: Very significant/probable, significant/probable, somewhat significant/probable and not significant/probable. The results were analysed by giving points for each answer in the following way: answers placed in far ends of the scale (very significant/probable and not significant/probable) were given 2 points and the mid-scale answers were given one point. The points were then counted together for the more "positive" points (Very significant and significant) and more "negative" points (Somewhat significant and not significant). The classification to "Low", "Medium" and "High" was made by counting the percentage of positive/negative points. 0–33,3% was deemed as "low" 33,3–66,6 as "medium" and 66,6–100% as "high".

The identified key factors and the results

Increasing shipping

Existing predictions for the future of maritime transport in the Baltic Sea mention a strong increase in shipping traffic. The number of ships in the Baltic has even been estimated to double during the period 2010–2030 (WWF 2010). The increase has been anticipated to occur due to expanding oil terminals and subsequent oil transports, regional development and increase in cruise ship tourism in the Baltic Sea area (WWF - Future Trends in the Baltic Sea 2010).

The latest shipping growth scenario is done by the SHEBA project (Fridell *et al* 2016). Their project deliverable presented three scenarios called "Sustainability", "Business as Usual" and "Fragmentation". All of these scenarios include increase in shipping volume, even if somewhat more moderate compared to the doubling estimated by WWF.

In short, the sustainability scenario illustrates a Baltic Sea area where there is high concern for the environment, with policies that require use of abatement technologies and alternative fuels and support development of such environmental technology. Global economic growth is strong and population growth is low.

Business as usual is the current trend-scenario where the global economic growth is stable and global population growth will slowly begin decreasing by the end of the 21st century, dependency on fossil fuels is decreasing slowly and development of new clean shipping technologies is as today.

Fragmentation scenario illustrates a Baltic Sea where environmental goals are not reached, the abatement technologies and alternative fuels development is weak. Global economic growth is slowing down and there is strong increase in global population.

The participants evaluated which basins will be mostly affected by the increase of shipping in the Baltic sea. The results are presented in figure 20.3.

The Gulf of Finland (GoF) was considered most affected by the increase in cargo and tanker shipping. The participants clarified in their comments that the predicted impacts are mainly due to the traffic between the GoF ports (especially Primorsk and Vysotsk) and routes or ports within other basins or outside the Baltic Sea, and not the increase in shipping between the ports within the GoF. This also explains why the rest of the areas where biggest change in shipping numbers were predicted, are located along the main traffic route between the entrance to the Baltic Sea and the GoF. LNG-carrier transports were especially mentioned as a ship type that will increase in the Baltic Sea.

The cruise ship traffic growth was considered to affect mainly the ports which are already more established in the cruise business. The mentioned

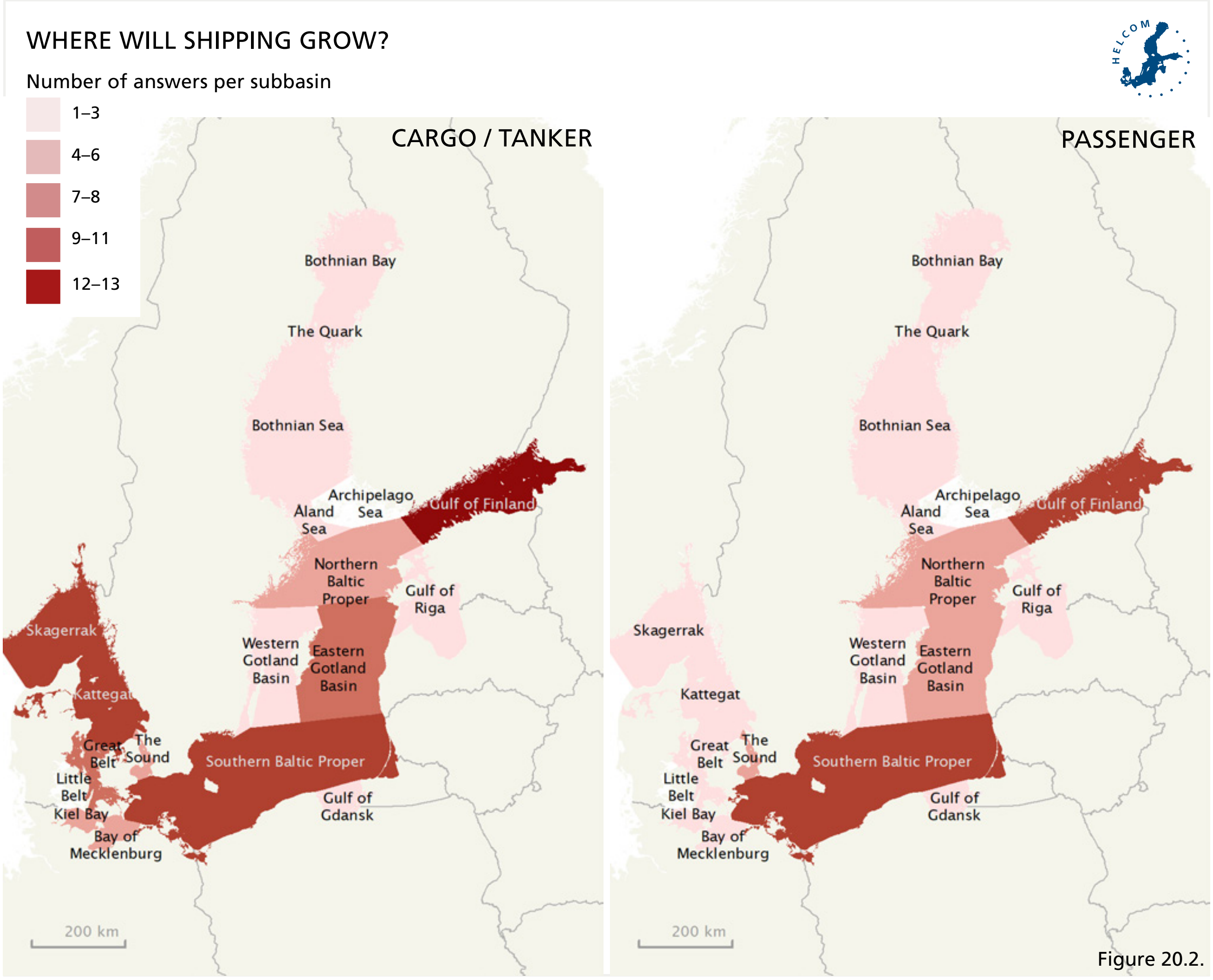


Figure 20.2.

ports and areas included the Gulf of Finland (St. Petersburg, Tallinn and Helsinki), Archipelago Sea, Stockholm and Copenhagen. Secondarily, there may be growth in newer destinations, e.g. in Bothnian Sea and Bay including The Quark area, although establishing tourism in new areas takes time due to change in habits of the consumers and necessary infrastructure and service development. Waste reception in ports was mentioned as one requirement for cruise ship tourism development. Regarding regular passenger traffic, two developments were mentioned. Firstly, the construction of a link between Fehmarn and Denmark may lead to less ship-based passenger traffic in the Baltic Sea. Secondly, a regular ferry line connection between Poland and Lithuania was mentioned as a possible future development for Baltic Ro-Ro and passenger traffic.

Figure 20.3.

RESULTS FROM HELCOM MARITIME 16 e-DELFI EXERCISE

Perspectives to environmental issues and actions in the Baltic Sea

	ENVIRONMENTAL IMPACT		ACTIONS	
Emissions	**Significance/ Severity for Baltic Environment**	**Probability of damage by 2030**	**Significance of actions**	**Probability of effective actions by 2030**
Anti-fouling paints	Low	Low	Low	Low/ medium
Chronic oil pollution	Medium	Low	Medium	Medium
Residual discharges	Medium	Low	Medium	Medium
Underwater noise	Medium	Medium	Low	Low
Airborne emissions	High	High	High	High
Marine litter	Medium	Low	Low	High
Large oil/chemical spill	High	Medium	High	Medium
Sewage	Medium	Low	High	High
Ballast water management	Medium	Medium	High	High
Airborne emissions actions				
Alternative fuels			High	High
SECA			High	High
NECA			High	High
Other				
E-navigation			Medium	Medium

Topics mentioned (to be incl. in 2nd round): Scrubbers (SECA), Changes in ice conditions and Climate change.

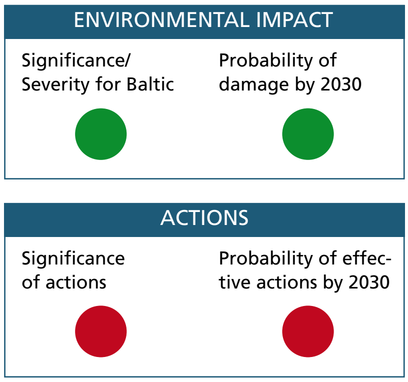
Notes: The answers were given on a scale of four: 1) Very significant/probable, 2) significant/probable, 3) somewhat significant/probable and 4) not significant/probable. The results were analyzed by giving points for each answer ina following way: answers placed in far ends of the scale (1 and 4) were given two points and the mid-scale answers were given one point. The points were then counted together for the more “positive” points (1 and 2) and more “negative” points (3 and 4). The classification to *Low*, *Medium* and *High* was made by counting the precentage of positive/negative points: 0–33,3% was deemed as *Low*, 33,3–66,6% as *Medium* and 66,6–100% as *High*.

Anti-Fouling paints

When the IMO Ballast Water Management Convention is enforced and the risk of species introductions from ballast water discharge is reduced, hull fouling will be the main vector for species introductions in the Baltic Sea and the issue will gain more attention.

The challenge is tackling invasive species with anti-fouling innovations that are effective but less harmful for the environment. There are two possible development straits. At least in the beginning there may be difficulties to reduce the harmfulness of the paints to the marine environment due to the pressure of reducing marine species invasions. A species invasion may have even more devastating effects on the Baltic marine ecosystem than the harmful effects from anti-fouling paints. On the other hand, more research and general attention to the issue may speed up the innovations process and finding new, less harmful solutions.

ANTI-FOULING PAINTS

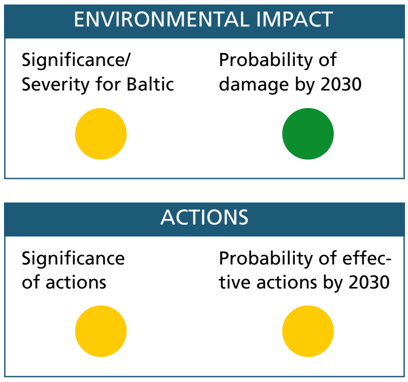


Chronic oil pollution & residual discharges

The issue of residual discharges can be addressed by improving the reception facilities for tank cleaning effluents. Positive developments are likely to be seen in the Baltic Sea area by 2030.

Member states and ports are working on this subject and are making progress, as shown during HELCOM PRF Cooperation Platform, and similar national events. With the implementation of IMO MARPOL Annex VI special area for sulphur (SECA), we may see an increase in scrubber emissions unless emission standards for the effluents will be enforced or scrubber water discharge is prohibited. Chronic oil pollution remains a significant environmental impact in the Baltic Sea due to its long-term effects on the environment.

CHRONIC OIL POLLUTION & RESIDUAL DISCHARGES

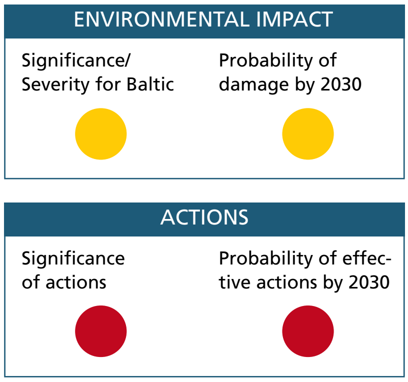


Underwater noise

Underwater noise does have an impact on the Baltic ecosystem albeit little is known of impacts on species on population level. Underwater noise has localized impacts in the Baltic Sea but it is not considered likely to cause severe damage to the Baltic Sea marine environment by 2030. The respondents see it unlikely that specific actions will be taken by 2030 to address the issue.

The results for underwater noise indicated that the probability of actions taken by 2030 to tackle the issue is low. The significance of such actions was also considered low. The issue with underwater noise may be partly solved with more silent alternative propulsion systems as they become more common. However, the cavitation noise from propellers is a major source for underwater noise and cannot be solved by reducing engine noise, but with propeller and design of the underwater hull.

UNDERWATER NOISE



AIRBORNE CO_2 EMISSIONS

ENVIRONMENTAL IMPACT	
Significance/ Severity for Baltic	Probability of damage by 2030

ACTIONS	
Significance of actions	Probability of effective actions by 2030

Airborne CO_2 emissions

Airborne emissions of CO_2 from shipping will have a strong negative impact on the Baltic Sea environment by 2030. It is very likely that we will continue seeing damage in the Baltic marine environment caused by CO_2 emissions for the next decades. However, using alternative fuels in the Baltic Sea area will have a significant impact on solving this matter and good development in this field will be seen by 2030.

LNG ships are considered as a likely ship type to increase in the Baltic Sea area. Hybrid diesel-electric with additional wind and solar propulsion are also mentioned. All electrical engine solutions are highly dependent on the development of battery technology. Currently the alternative propulsion systems are mainly pilot projects and unless there will be considerable political will to develop the systems, significant development will not be seen by 2030 and fossil fuels will be used in shipping as today.

SECA

ENVIRONMENTAL IMPACT	
Significance/ Severity for Baltic	Probability of damage by 2030

ACTIONS	
Significance of actions	Probability of effective actions by 2030

SECA

SO_x emissions will drop significantly, improving the state of the Baltic Sea and the air quality of surrounding countries. Increased use of alternative fuels by 2030 will also play a role in the SOx reduction. Retrofitted and newly built scrubbers will become more and more common and there will be somewhat significant effects to the state of the Baltic Sea caused by the scrubber emissions containing sulphuric acid and a number of other pollutants, unless the scrubber water discharge is prohibited.

Low-sulphur fuels and scrubbers are likely to reduce the SOx emissions at the first stage. The increase in LNG vessels and alternative propulsion systems may reduce the SOx emissions as they become more common in commercial shipping traffic.

NECA

ENVIRONMENTAL IMPACT	
Significance/ Severity for Baltic	Probability of damage by 2030

ACTIONS	
Significance of actions	Probability of effective actions by 2030

NECA

NECA Tier III regulations will be enforced by 2021 and new ships built after this date will have technology that reduces NOx emissions to Baltic Sea. There will still be significant NOx emissions by 2030 due to the slow fleet renewal rate but the emissions will start to decrease with new ships entering the Baltic Sea fleet.

Despite the designation of the Baltic Sea as a NECA, NOx emissions will still be significant in 2030 as the NECA will only affect new ships built on or after 2021. Ships in the future are likely to use more LNG as fuel source therefore complying with NECA. Hybrid diesel-electric engines with additional solar or wind propulsion, reducing diesel usage and therefore NOx emissions may also have an impact if the technology development continues.

The new ships fitted with fossil fuel engines must install abatement technology to comply with NECA Tier III.

Marine Litter

The issue of marine litter from ships will be effectively addressed by 2030. This will be done mainly by improving the reception facilities in ports. However, the actions will have limited significance for the Baltic Sea marine environment as main sources of plastic pollution are from land based sources.

Monitoring of transfer of waste within Baltic ports will help to control the volumes of waste and will facilitate better adjustment of port services as well as the proper management of waste within the ports.

Sewage discharge

The revised MARPOL Annex IV will enter fully into force by 2021 and both old and new passenger vessels are not allowed to discharge untreated black water in the Baltic Sea. Port reception facilities are an important factor in reducing sewage discharge by 2030. Sewage treatment facilities installed on board are also likely to play a role, although MARPOL Annex IV has no requirements for the operation of sewage treatment plants. There are no operational standards for the effluent quality. The treatment standards need to be enforced, as for example, done for cruise ships discharging in Alaskan waters and for the discharge of treated sewage on river cruise vessels in Europe. Such treatment standards should also cover grey water discharges.

Ballast water management

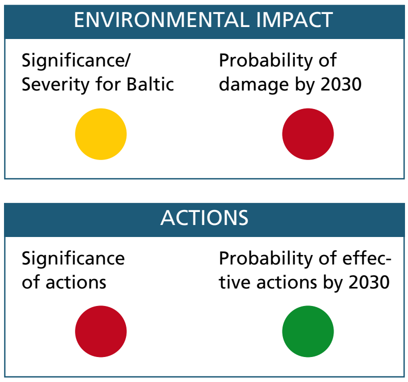
The IMO Ballast Water Management Convention (BWMC) entered in force in September 2017 and ships will comply with the new regulations according to a timetable set by IMO. The risk of new species introductions from ballast water will be reduced by 2030.

It will take some years before full impact can be reached due to ongoing work on the approval of treatment systems. Despite the BWMC, species introductions will continue to be an issue in the Baltic Sea due to hull fouling. However, invasive species introductions from hull fouling may have a significant impact on the Baltic marine environment.

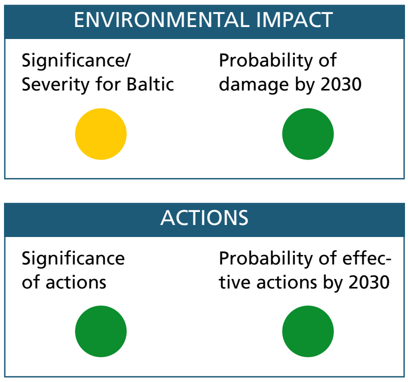
Large oil/chemical spill

The risk of a large oil or chemical spill in the Baltic Sea exists, the increasing traffic and especially the increase in oil and oil products traffic in the Gulf of Finland will add to the risk. Development of response facilities will continue and this will have a significant effect in limiting the negative environmental impacts in case an accident occurs. However, the risk of an accident can never be eliminated completely. Development of E-navigation has potential to prevent accidents to some extent.

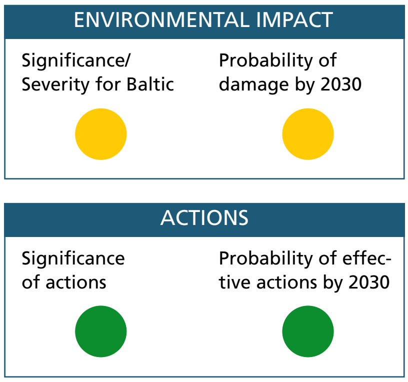
MARINE LITTER



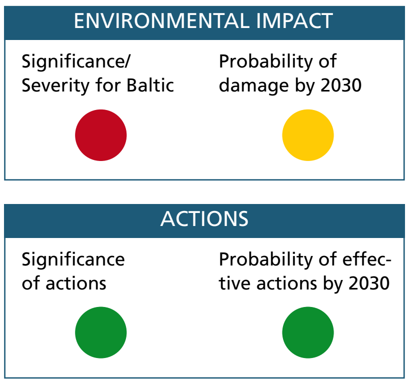
SEWAGE DISCHARGE



BALLAST WATER MANAGEMENT



LARGE OIL / CHEMICAL SPILL



Conclusions

Most likely trends

The consensus from the Delphi exercise was that regarding air emissions, there will be considerable substantial action by 2030, although it may not be sufficient to tackle the environmental damage caused by air emissions, at least by 2030. The reasons vary. Regarding the CO_2 emissions, the harmful effects to the Baltic environment cannot be fully prevented or stopped even if alternative fuels would be used more extensively by 2030. Seeing the full results from NECA will also take longer than 2030, due to the speed of fleet renewal, since the regulation will only be applied to newly built ships.

Among the very likely positive trends for the Baltic Sea environment are the enforcement of ban of sewage discharge (MARPOL Annex IV Special Area) and reduction of species introductions through ballast water management. Sewage discharge is seen as a relatively simple problem to solve with the ban of discharge and development of port facilities in the Baltic Sea area. Ballast water management is standing in force during 2017 and is likely to reduce species introductions effectively by 2030. By that time, discussion and challenges regarding invasive species introductions will shift towards possible regulation of hull fouling.

Least likely trends

The environmental issues that are least likely to be tackled by 2030 are the toxic effects from anti-fouling paints. The reason may be that the forbidding of TBT based paints has been considered a great success and the toxic effects from paints based on other active substances (mainly copper) are not considered as harmful. In addition, the pressure to reduce species introductions via hull fouling may make it difficult to consider less harmful, possibly less effective alternatives for current paints.

Underwater noise is not very likely to be thoroughly addressed by 2030, although it is included within the scope of work around the Marine Strategy Framework Directive. The reasons for this are probably the foreseen cost of measures and lack of scientific evidence on harmful effects of sound on population/species level. Also, any decisions on regulations regarding shipping noise are likely to take time way beyond 2030 to stand fully in force. It is not likely that any large scale single event in the Baltic Sea would speed up the process of managing the issue of underwater noise, as adverse environmental effects are mainly long-term. Sudden adverse impacts from powerful sonar systems could be such a factor, but such a noise source falls outside the scope of regular maritime transport in the Baltic Sea.

What do you learn,
when you learn by heart?

Section VI

ANNEXES

Annex I Methodology to create statistics and density maps from AIS data

The world's longest time series of AIS

This annex describes in detail the method to create the AIS-based ship traffic density maps and statistics presented in this publication, developed by the HELCOM Secretariat. The code used in executing the described method is available for download at the HELCOM GitHub repository, distributed under the Creative Commons licence.

The Automatic Identification System (AIS) is a tracking system used on ships, which was adapted to maritime use from aviation industry during the late 1990s. It provides information on surrounding traffic situation and supplements marine radar as a collision avoidance device. AIS devices are obligatory on-board all large vessels according to the IMO SOLAS Convention.

In 2001 the Ministers of Transport of the Baltic Sea region agreed to develop a network for sharing AIS information on ship movements among all the nine coastal countries. It was part of the HELCOM Copenhagen Declaration to "increase safety of navigation and gain environmental benefits".

In July 2005, the Baltic Sea coastal countries launched the regional HELCOM AIS network which provides all the countries with the same real-time view of maritime traffic in the entire Baltic Sea area.

This Baltic-wide HELCOM AIS dataset has over the years been used for several regional activities, for example improving navigation, emissions from or mapping underwater. This dataset remains the world's longest time series of AIS covering an entire region.

As AIS data is so called "Big Data" it requires specific techniques for data handling and processing which has limited its use. To overcome this barrier, the HELCOM Secretariat has since 2014 invested considerable time to develop capacity and methods enabling using this vast source of maritime data. This work was initiated by the work to develop an overview of cruise passenger traffic (HELCOM 2015) and was later further developed with part funding from EU projects (SCOPE and BALTIC LINes) in addition to in-house resources.

A method divided in three steps

The HELCOM method used to produce statistics and density maps from AIS data is divided in three parts which are described under dedicated chapters: 1) First, data is processed from raw data to a human-readable format and to be harmonized (Chapter 1. AIS data preparation). 2) Once the data is prepared in an appropriate format, it must be processed to produce statistics based on events (Chapter 2. Methods to produce statistics). 3) The resulting statistic dataset is the basis to make shipping density maps (Chapter 3. Method to produce density maps).

1. AIS data preparation

All AIS signals received by each country in the Baltic Sea since 2005 has been stored in a centralized HELCOM AIS database, until recently hosted by Denmark (Danish Maritime Administration) but was in 2016 migrated to Norway (Norwegian Coastal Administration). Taken as a whole this regional AIS dataset is so big (Figure 1) and complicated to handle that several preparatory steps are needed to make the data usable for creating maps or statistics. The whole process to prepare the AIS data is summarized in Figure 2.

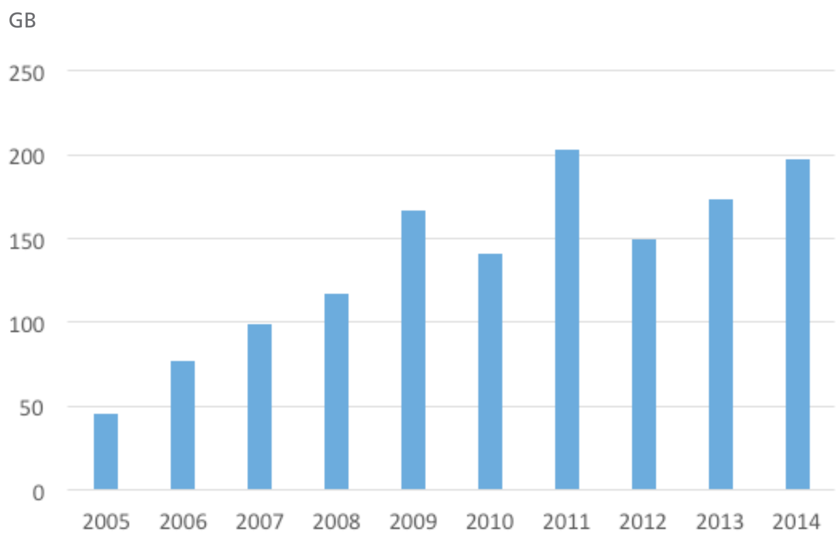


Figure 1. Size of HELCOM AIS data files according to year

Before starting: Hardware set up

Based on interviews with AIS data users we decided to work with the data on a dedicated server available by remote access with the following specifications: Intel Xeon E5-2630 0 @ 2,30GHz 10 cores with 48 GB RAM. This server allows several persons working at the same time.

The process consists or four parts:

1. First, raw data files are convereted into CSV files.
2. Second, data is cleaned from erroneous signals and duplicates
3. Third, data is sorted to monthly files
4. Finally, ship details are added or updated using a commercial database

Converting raw data

The AIS data for 2005-2016 was delivered by the HELCOM AIS data host in both decoded (human readable tables) and raw data (NMEA sentences), depending on the year. Raw NMEA data is not human readable and should be converted before working with it. The data contains all recorded AIS messages (position reports from ships, base stations reports, etc.) received from the national AIS base stations that are part of the HELCOM AIS network (Table 1).

The decoded AIS data in CSV files are human-readable tables containing several parameters (columns) such as the date and time when the signal was issued, the identification of the AIS message, the identification number of the AIS transmitter, etc.

The data for 2007, 2008, 2015 and 2016 were received in raw data divided into daily files. This data was in the globally standardized NMEA sentence format which is a set of data strings preceded by an encapsulated tag. These tags, in our case beginning with the characters "$PGHP" (proprietary format by the Gatehouse company in Denmark), contain the information related to the date and time when the signal was issued. The NMEA sentences contain the rest of information: the identification of the message issued, the identification of the AIS antenna, etc.

In order to be harmonized with the rest of the data the material in NMEA sentences had to be decoded to convert them to human-readable CSV files (see Figure 3 below). These monthly files were then decoded with a decoder called AIS2CSV, a free software available online developed in 2015 by DMA. The application decodes each NMEA sentences with its encapsulated tag and generates CSV files.

In order to make the process faster the daily raw data files were merged into monthly files. The output was monthly decoded files in CSV that were merged into a yearly file.

Table 1.
YEAR AND FORMAT THE DATA RECEIVED

Year	Format of AIS data received from DMA
2005	Yearly file (.CSV), decoded
2006	
2007	Daily AIS raw strings (.txt)
2008	
2009	
2010	
2011	Yearly file (.CSV), decoded
2012	
2013	
2014	
2007	Daily AIS raw strings (.txt)
2008	

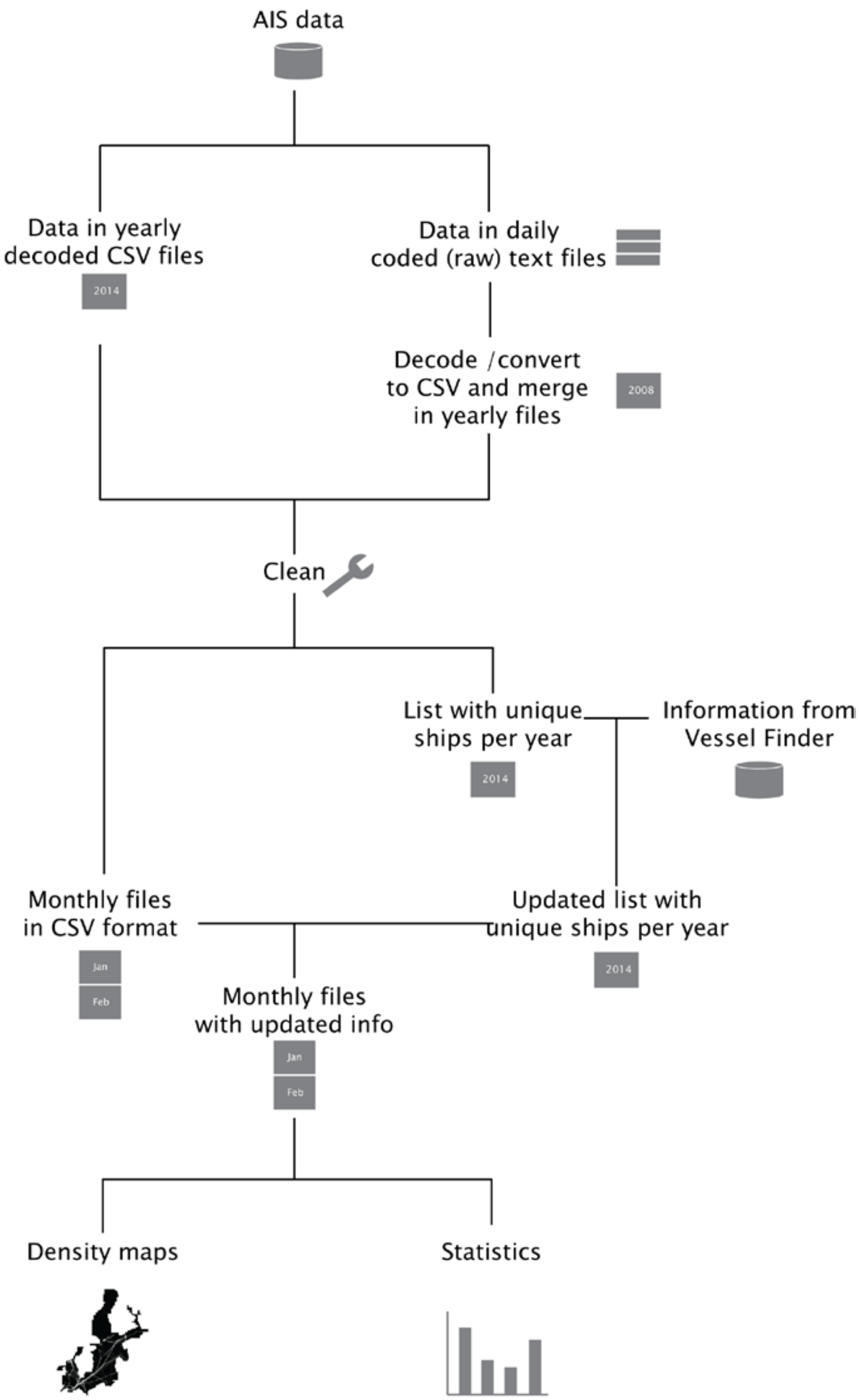
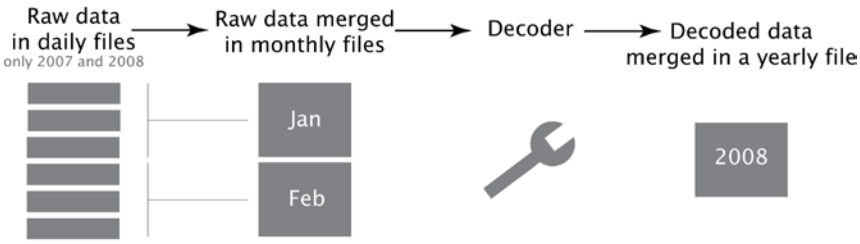


Figure 2. Overview flowchart of processing AIS data

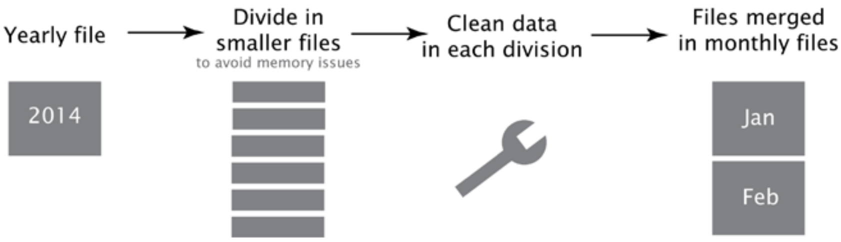
Figure 3. Raw data is merged in monthly files and decoded



Data cleaning

Once we had all years in yearly CSV file, the next step was to clean the data to produce monthly CSV files which will be used to create maps and statistics. The data cleaning is necessary to remove erroneous signals and duplicates (Figure 4).

Figure 4. Time to clean the data



The inputs of the preprocessing steps are yearly CSV files of AIS data containing all messages. The outputs are monthly CSV files that contain the positions of the ships in the Baltic Sea (position reports).

The data cleaning was done using R language with the RStudio interface, the same script was applied to the yearly files one by one.

The yearly file was divided in smaller files of 1 000 000 rows to avoid running out of memory. For each division, a process is going through each AIS signal to select the relevant data and to remove erroneous signals:

- Removal of the signals that are not from the selected year;
- Removal of the duplicated signals;
- Selection of AIS messages relevant for assessing shipping activities (1, 2, 3, 18 and 19);
- Removal of wrong MMSI signals. A list that can be updated (i.e. less or more than 9 digits or equal to 000000000, 111111111, 222222222, 333333333, 444444444, 555555555, 666666666, 777777777, 888888888, 999999999,123456789,0,12345, 1193046);
- Correction of wrong IMO numbers: each signal with an erroneous IMO number (not seven digits) is replaced with "NA";
- Add the Maritime Identification Digits (MID) and the flag of she ships for each signal. The MID is the three initial digits of the MMSI. This action is also removing MMSI numbers that do not have a MID (erroneous MMSI);

- Removal of special characters in all the division;
- Addition of two columns: one for the week number and one for the month;
- Selection of the signals within the planning area. A polygon was drawn manually around the planning area and only the signals within this polygon were kept;
- Removal of the signals with erroneous SOG (Speed Over Ground): negative values or more than 80 knots;
- Removal of the signals with erroneous COG (Course Over Ground): negative values or more than 360°;
- Selection of parameters to generate data products.

All key parameters were kept for all of the signals. This introduced a lot of redundancy but, because of the processing time to create the final files, we decided to avoid deleting information (Table 2).

Each division was saved as a CSV file. For each division, we created a file with the amount of signals kept after removing the erroneous signals — duplicated signals, wrong MMSI, etc. We call this file a report.

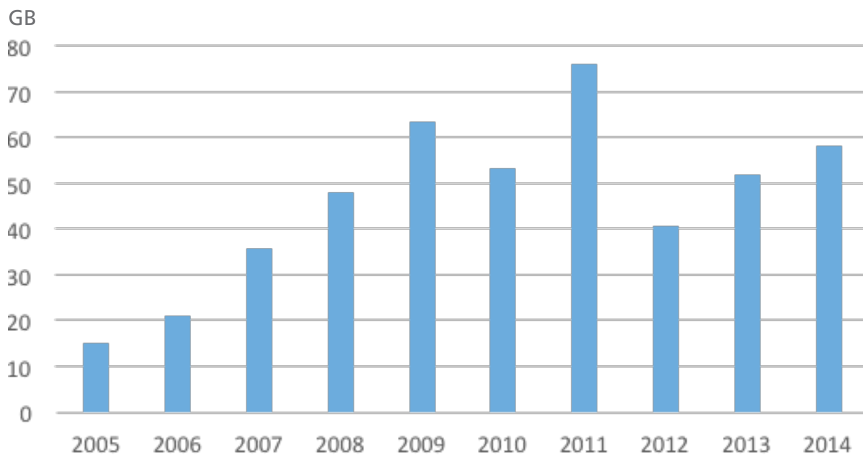
Table 2.
PARAMETERS IN THE PREPROCESSED AIS DATA

Parameters	Description
timestamp_pretty	time in format dd/mm/yyyy hh:mm:ss
timestamp	Unix time stamp (seconds since 01/01/1970 00:00:00)
msgid	The AIS message the signal was issued
targetType	AIS type A or B
mmsi	MMSI number of the ship
lat	Latitude in decimal format
	Longitude in decimal format
posacc	Position accuracy
SOG	Speed Over Ground in 0.1 knot
COG	Course Over Ground in 0.1°
shipType	Ship type of the vessel
dimBow	The dimension between the AIS transmitter and the bow of the ship in meters
draught	Draught of the ship in 0.1 meter
dimPort	The dimension between the AIS transmitter and the port side (left) of the boat in meters
dimStarboard	The dimension between the AIS transmitter and the starboard side (right) of the boat in meters
dimStern	The dimension between the AIS transmitter and the stern of the ship in meters
month	Month the signal was issued (between 1 and 12)
week	Week number the signal was issued
imo	IMO number of the ship
country	Flag of the ship

Figure 5.

THE SIZE OF EACH FILE AFTER CLEANING IS STILL HUGE

That is why we divided them in months for making statistics and maps



Sorting the selected AIS data by month

This final step of data handling goes through each division and creates a new CSV file for all the signals from a given month. The column "month" is used to sort the data into the final files. In total file sizes for a complete year ranged from about 15 GB to almost 80 GB (Figure 5).

Updating the ship information

Finally, we needed to update some information from each ship like dimensions or ship type. AIS signals include this data in the AIS Message 5. However, it is not reliable because it is not an obligatory.

We purchased a ship database from a data provider called Vessel Finder with up-to-date information of each ship. We did it as follows:

1) First, we made a ship list for each year
2) We removed the duplicate ships from the resulting list
3) Finally, we created a categorization of ship types

A ship list for each year

A ship list based on AIS data static information was generated for each year. The lists include all ships (IMO and non-IMO registered ships) and contain the following parameters:

- MMSI (Maritime Mobile Service Identity), a standardised series of 9 digits which uniquely identify ships or other transmitting stations
- IMO number
- Name of the ship
- Callsign
- Country
- Target type
- Ship type
- DimBow
- Draught
- DimPort
- DimStarboard
- DimStern

Removing duplicates from the ship list

The yearly lists of ships were merged to have a unique list of all ships that operated in the Baltic Sea during the studied period. The ship-related information was purchased from Vessel Finder. The IMO numbers were used to identify the ships and the following parameters were provided:

- IMO number
- Name
- Ship type
- Gross Tonnage
- Net Tonnage
- Length
- Width
- Draught

Each year ship lists were edited using the new information. When the information was available, the ship information from the AIS data (i.e. ship type) was replaced by the new information from the provider (only for IMO registered ships). When the information was not available from the provider, the original data (from AIS) was kept. At the end of this step, a total of 120 ship types were available in the ship list.

Making the ship types categories

Finally, two levels of ship type categories were created to use with full potential the 120 available ship types. The first level, the gross ship type, gives broad information about the ship. The second level, the detailed ship type, gives more precise information, for example about the type of cargo or tanker. The table below describes the gross and detailed:

Table 3.
SHIP TYPE CATEGORISATION USED TO UPDATE SHIP INFORMATION

Gross ship type categorisation	Detail ship type categorisation
Cargo	Bulk cargo
	General cargo
	Other cargo
Tanker	Chemical tanker
	Oil product tanker
	Gas tanker
	Crude oil tanker
	Other tanker
Container	Container
Passenger	Cruise
	Ferry
	ROPAX
Other	Dredger
	Other
	Tug
	Yacht
Fishing	Fishing
Service	Service
Roro Cargo	Vehicle carrier
	Roro Cargo

These ship types were chosen following the current work about emissions from shipping in the Baltic Sea done by the Finnish Meteorological Institute (cf. Information document 4-4 Emissions from Baltic Sea shipping in 2014 submitted by Finland for the HELCOM MARITIME 15-2015 meeting).

2. Methods to produce statistics

After the AIS data is cleaned and in CSV format, we want to prepare the files to create statistics and density maps for IMO registered ships.

To do this, we need to identify events occurring in four different areas that we created:

Table 4.

Event	Description	Area to identify the event
Exit	Ships exiting the Baltic Sea	Exiting area
Enter	Ships entering the Baltic Sea	Entering area
Trip	Ships going from port to port	Between ports
Stop	Ships stopping in a port	In ports

Statistics can be made based on these events (number of visits per ports, distance sailed, ships entering or exiting the Baltic Sea, etc.). Density maps can be produced using the information about the trips at sea: each trip will be assigned to a unique identification number that will be used to generate density maps.

The method outputs two files:

- A CSV file describing the ships' movements (events). This file is used to create statistics on how many visits per port, how many ships entering or exiting the Baltic, etc. There is one CSV file per year.
- A CSV file with a trip ID numbers. Each AIS signal is assigned a trip ID which identifies where the ship is going from port to port, from outside the Baltic Sea, etc. This file is used to produce density maps. There is one CSV file per month.

The exit and enter events

This first section will explain how to find ships exiting and entering the Baltic Sea. The output of this analysis are the exit and enter events table. It is a list describing which ships are leaving or entering the Baltic Sea, at what time and where.

Definition of inside, outside and exit areas

The very first step is to find the AIS signals from ships that could be leaving or entering the Baltic Sea. The signals are by definition the position reports from ships. The latitude and longitude are the two parameters used for this spatial analysis.

To start the process we defined five "exit areas", four "outside areas" and one "inside area". Figure 6 shows an example from the Kattegat exit area. The 5 "exit areas" are the borders between outside and inside the Baltic Sea where the ships have to go through to leave the Baltic Sea either towards the North Sea or to major lakes in the Baltic Sea region (Lakes Vänerm, Ladoga and Saimaa). These areas are between 2,4 and 16,6 km wide.

Figure 6. Location of outside and exit areas, example of the Kattegat Sea

Table 5.

Name of the exit area	Location
Skagen	Between the port of Skagen (Denmark) and the village of Kärna located 15 km north of Gothenburg (Sweden).
Goteborg	On the Göta Canal next to the city of Kungälv (Sweden). This location marks the entrance and exit to the Vänerm lake in central Sweden.
Kiel Canal	On the Kiel Canal on the Western side of the port of Kiel (Germany). This location marks a canal between the Baltic Sea and the North Sea.
Neva River	Along the Neva river, after the city of Saint-Petersburg (Russia). This location is used to assess the ships going to or coming from the lake Ladoga in Russia.
Lappenrenta	On the Saimaa Canal, between the Gulf of Finland the Saimaa lake.

We created a new column called "exit areas" in the table (position reports from ships). For each signal that is in one of the 5 polygons, the name of the exit area was added to this new column.
The "outside areas" are 4 polygons located next to each of the "exit areas".

Table 6.

Name of the outside area	Location
Skagen / Vänerm	The area of the North Sea (outside the Kattegat Sea towards the North Sea) and the Vänerm lake.
Kiel	The Kiel Canal.
Saimaa	The Saimaa lake
Neva River	The Neva River and the Ladoga lake

We added a new column to the table to identify the signals that are inside these "outside areas". The signals that are not in the "exit area" or in the "outside area" are assigned to be in the "inside area". They come from ships in ports or traveling in the Baltic Sea.

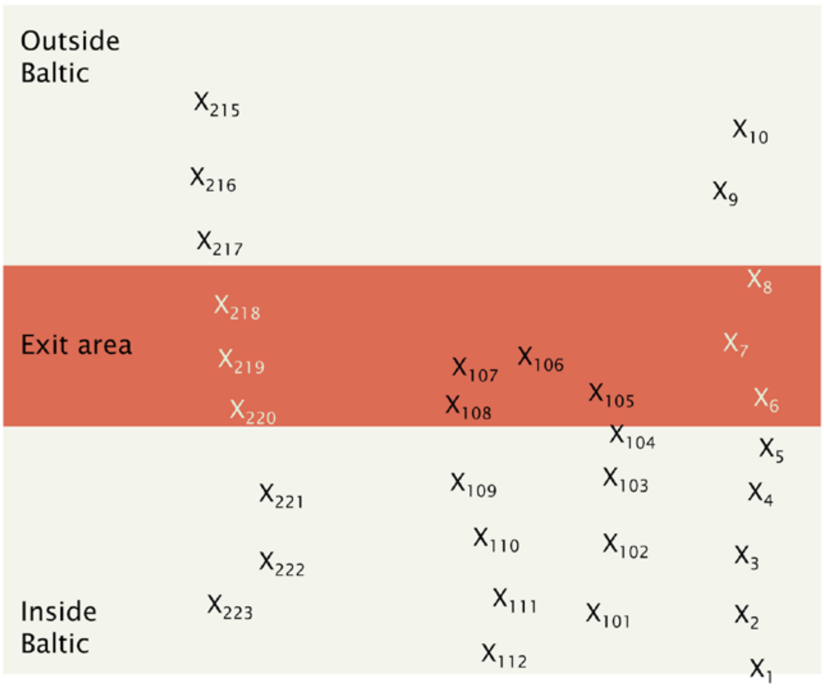
Identification of the sequences of signals in the exit areas of the Baltic Sea

After we have defined the areas, we must now find the location of each AIS signal: in an exit area, outside or in the Baltic Sea. We need to create sequences of signals entering or exiting the Baltic, then we need to find the direction of the ship.

A sequence is a group of signals from a ship describing a movement in the exit areas. It is identified by sorting the data by IMO number and by time. Each one has a unique identification number: the signals are gathered into groups of signals that match the same sequence.

In Figure 7, the points X6, X7 and X8 get an identification number for the same sequence. The points from X218 to X220 get another unique identification number for this other sequence. But the points from X105 to X108 do not have a sequence identification number. The ship is not leaving the Baltic Sea since there is no point in the outside area. This process is applied for all of the signals found in the exit areas.

Figure 7. generating the sequences in an exit area



Therefore, we give the sequence identification number to the ships following two kinds of paths:

1) inside area -> exit area -> outside Baltic

or

2) outside Baltic -> exit area -> inside area

No sequence identification number is added to the signals for ships that are returning to the same area (outside or inside) than they came from.

Now that we have identified the ships that are in the exit area we need to know which ones are actually exiting or entering. We do it thanks to the COG parameter.

Definition of the sequences entering or exiting the Baltic Sea

Each of the signals of AIS data have a parameter called "COG" (Course Over Ground) which represents the direction of the vessel from 0° to 360°. Following the COG of the signals within the 5 "exit areas", we could identify if the ships were entering or leaving the Baltic Sea.

For each signal in the exit area that has a sequence identification number, a new value with the direction of the boat was assigned: 0 for traveling north, 90 for traveling east, 180 for traveling south and 270 for traveling west. For example, if the boat is traveling between 90° and 270° in an exit area, the value 180 is added. This new column in the dataset is called COG2.

The next step was to identify all the sequences leaving or entering the Baltic Sea through the exit areas. A function available with the software R (under the package dplyr) was used to summarize the COG2 for each of the unique sequences and therefore the direction of the ships within the exiting area. The average of the COG2 (x?COG2) was computed for each of the unique sequences. We made these calculations of COG2 and x?COG2 to avoid some unexpected ship movements in the exit areas.

Finally, we selected the signals from ships going outside or inside the Baltic Sea for each exit area following the name of the location of these unique sequences:

Table 7.

Exit area	Value of x?COG2 for exiting the Baltic Sea	Value of x?COG2 for entering the Baltic Sea
Skagen	x?COG2 = 0 (north)	x?COG2 = 180 (south)
Goteborg	x?COG2 = 180	x?COG2 = 0
Kiel Canal	x?COG2 = 270 (west)	x?COG2 = 90 (east)
Neva River	x?COG2 = 90	x?COG2 = 180
Lappenrenta	x?COG2 = 0	x?COG2 = 180

After this step, we could know if the ships were exiting or entering the Baltic Sea for each exit area and for each sequence.

Creation of the exit/enter table

The next step was to create the exit and enter events table for each of the unique sequence identification number. An event is the information about the exits and enters of the Baltic Sea:

Table 8.

Parameters created for the exit and enter events	Definition
IMO number	IMO number of the ship
MMSI number	MMSI number of the ship
MinTime	Date and time of the first signal in the exit area
MaxTime	Date and time of the last signal in the exit area
Event	Exit or Enter
Location	the name of the exit area
Sequence number	The unique sequence of the exit or enter

After the events are identified, we could know the time of exiting or entering the Baltic Sea through the 5 exit areas for each ship. This new data was stored in a temporary file and was used during the last step of the analysis.

The trip and stop EVENTS

After the previous step we know which ships are entering and exiting the Baltic. In the next step we are going to explain how to find the stops and the trips inside the Baltic Sea.

The ports of the Baltic Sea

Before starting we need to create the ports. We created 339 polygons around ports in the 9 countries of the Baltic Sea by following these steps:

- We filtered some monthly AIS data keeping only the signals where the speed of the boat was equal to 0.
- We used Open Street Map, Google Maps as background images.
- Shipping lines produced with AIS data helped to see ship movements
- The publication Baltic Ports List of 2012 helped to identify ports.

Once the ports polygons were ready we wanted to check if the ships where inside or outside those areas. We plotted the AIS signals in R software and overlaid them on top of the ports polygons and the exit areas.

Preparation of the signals defining a stop in a port

To locate the ships that are stopped in a port we used the speed of the ship which is available as the parameter SOG (Speed Over Ground) for each position report.

In theory, just filtering those ships with SOG equals 0 (zero) would be enough. However, because of the accuracy of the AIS transmitter onboard the ships, it is possible that the SOG is not equal to 0 even when the ship is at berth in a port. To avoid this issue, the SOG of a ship at port with less than 0.5 knot was replaced by 0 knot.

When the speed was equal or higher than 0.5 knot, we kept the original SOG – the boat could be moving during the maneuver along the berth.

Producing the events stops in a port

The next step was to generate the stop events: a group of signals with a unique sequence identification number. Each signal that was qualified as a stop from the previous step would be assigned this number.

To find the stops as sequences we sorted the data by IMO number and by time. The table would show when a ship is at sea and coming into a port and is stopping (when the SOG value is equal to 0).

The sequence identification number is given to the ships following two kinds of paths:

1) at sea -> at stop

or

2) stop -> at sea

Finally, we created the following parameters by summarizing the information by each unique identification number:

Table 9.

Parameters created for the stops sequences	Definition
IMO number	IMO number of the ship
MMSI number	MMSI number of the ship
MinTime	Date and time of the first signal with SOG = 0
MaxTime	Date and time of the last signal with SOG = 0
Event	Stop
Location	the name of the port
Sequence number	The unique sequence of stop

Once we calculated the Mintime and Maxtime, it was possible to know the duration of the stops. Thereafter, we made a subset of the stops longer than 10 minutes, which was stored as a temporary file to be used later.

Producing the events trips at sea

After the stops at port were created we proceeded to calculate the trip of each trip at sea.

Naturally, all the signals outside the 339 port polygons and in the Baltic Sea were selected as trips.

To find the trips between two stops, between an enter and a stop and between a stop and an exit, we sorted the data by ship (IMO number) and by time

Figure 8 below shows three types of situations: the signals as trips between an exit area and a stop (situation 1), between two ports (situation 2) or between a port and an exit area (situation 3).

We assigned a unique sequence number, called the trip Id, to each movement between the locations.

Every signals of the same sequence will have assigned the same se-

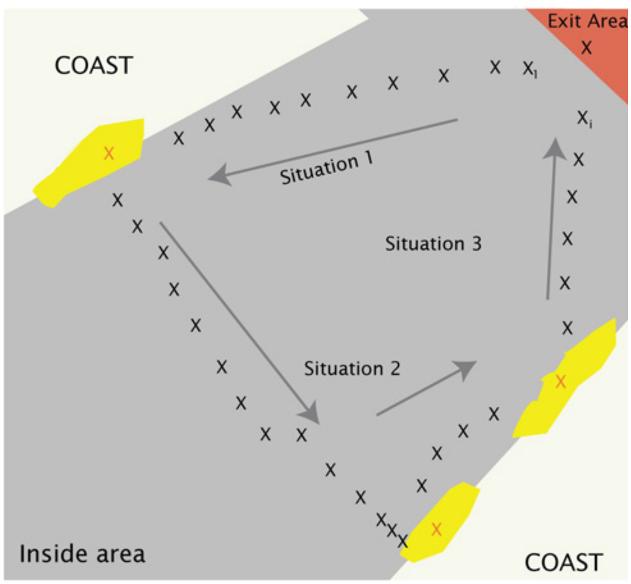
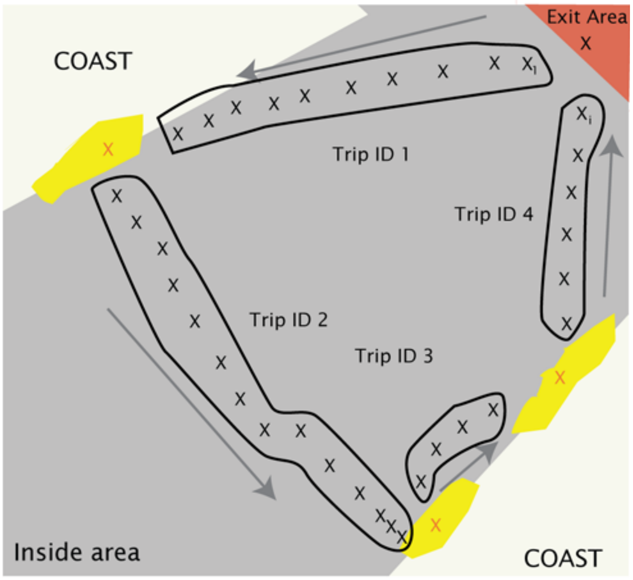


Figure 8. The 3 types of situations for the trips sequences

Figure 9. Assigning the trip ID value to the sequences at sea



x Signals form a ship
x_1 First signal of a trip sequence
x_i Signal of a trip sequence
x Signal defined as stops
Ship movement
Port

quence number, called trip ID (Figure 9). This is the input needed to produce lines and shipping density maps. The same process was applied to all of the ships.
These are all the parameters that we calculated:

Table 10.

Information collected for the trip sequences	Definition
IMO number	IMO number of the ship
MMSI number	MMSI number of the ship
MinTime	Date and time of the first signal of the trip
MaxTime	Date and time of the last signal of the trip
Distance sailed	Distance sailed
Event	Trip
Sequence number	The trip Id value

To calculate the duration of each trips we could use Mintime and Maxtime.

The distance sailed was calculated during the summarizing step—it is the cumulative distance between each signals of the same trip Id value. This table is saved as temporary file and will be used for the next step.

Outputs of the process

The outputs of the whole process are two CSV files.

- The first one is used to produce statistics of the events: they have to be harmonized to be relevant for further analysis.
- The second one is the file with the position reports from ships with a trip Id assigned to each AIS signal. These monthly files are used to produce shipping density maps.

Output to produce statistics

Three files per month:

- A table with the exit / enter sequences information
- A table with the stop sequences information
- A table with the trip sequences information

These three tables are merged and sorted by ship (IMO number) and time.

However, the files have to be harmonized: for the same ship, two stop sequences or visit sequences cannot be consecutive. If some of them are consecutive, they are merged together and the duration of the events and the distance sailed at sea are corrected.

The monthly files are finally merged as yearly files to generate statistics on a yearly basis.

Output to produce density maps

Monthly files with a trip ID assigned to each AIS position report with which we can produce density maps.

3. Methods to produce density maps

What is a shipping density map?

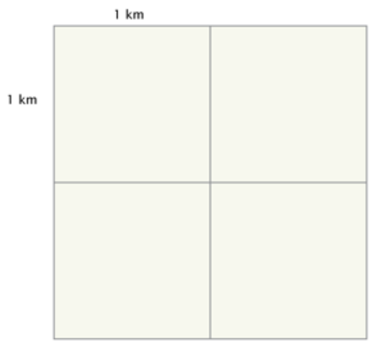
A shipping density map represents the intensity of shipping traffic in certain time period.

There is no standard definition or method to create shipping density maps. We have developed a method that answers a basic question: Assuming we have a grid of cells and the trips of ships from port to port, how many times do those trips cross each cell of the grid?

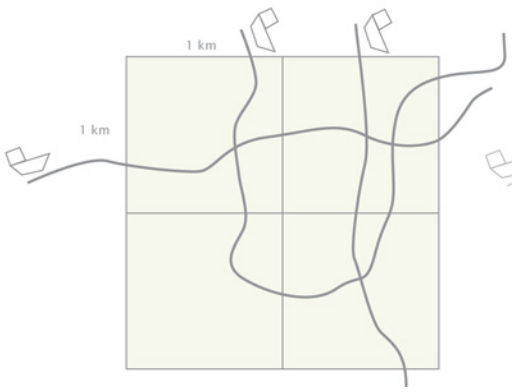
The process can be explained in four steps shown in Figure 10.

Figure 10.

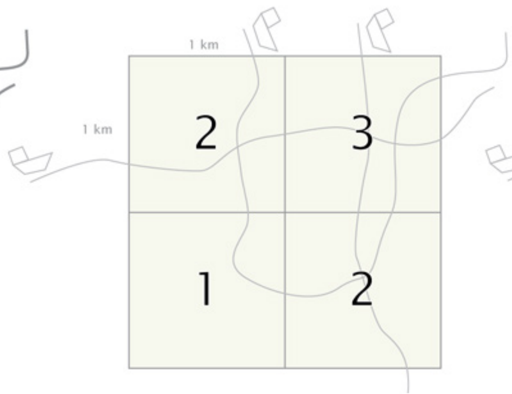
1 We need a grid with 1km*1km cells



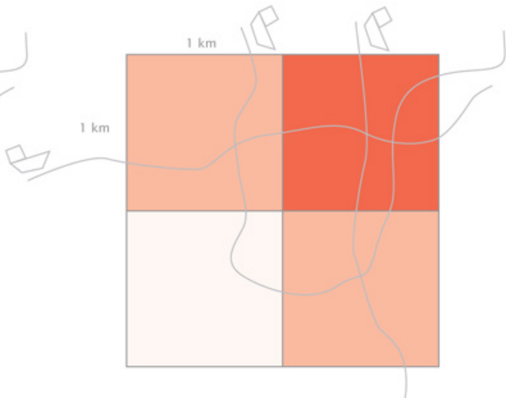
2 We overlap the trips of each ship onto the grid



3 We count how many lines are crossing each cell



4 We apply the style – darker color means more density



What we need before creating the density maps

Before we begin to produce shipping density maps we need:

- A GIS software
- Monthly CSV files with all the AIS signals
- A grid to overlap the lines and create the maps
- A ship list: a CSV file containing all ships per year

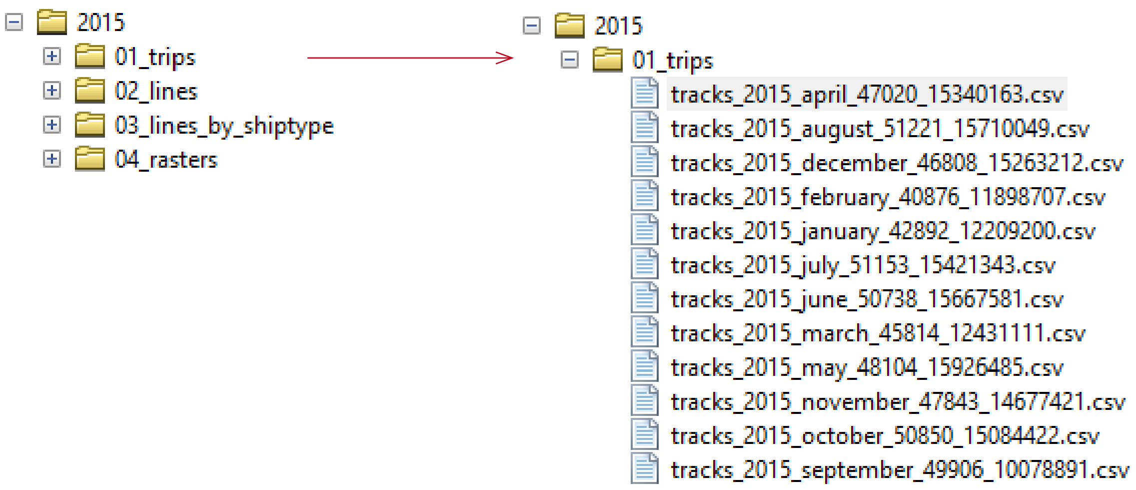
What software we need to create shipping density maps:

We used ArcGIS 10.4 for Desktop advanced license with Spatial Analyst for creating raster layers. All scripts were written in python scripting language version 2.7 using ArcPy, a Python ArcGIS scripting module.

Monthly csv files

We have to be sure we create beforehand the following folders under each year. O1_trips is created in a previous step (see 2. Methods to produce statistics). It contains a CSV file per month:

Figure 11.



Each monthly file contains the following columns:

date_time	timestamp	mmsi	lat	long	trip_id	visit	distance	new_trip_id
24.4.2015 14.2	1429874645	205114000	57,736862	10,843556	1	0	0	1
24.4.2015 14.2	1429874826	205114000	57,731323	10,85466	1	0	1	1
24.4.2015 14.3	1429875015	205114000	57,725517	10,866167	1	0	1	1
24.4.2015 14.3	1429875205	205114000	57,71953	10,877648	1	0	1	1
24.4.2015 14.3	1429875396	205114000	57,713375	10,889172	1	0	1	1
24.4.2015 14.3	1429875595	205114000	57,707054	10,900722	1	0	1	1
24.4.2015 14.4	1429875785	205114000	57,70108	10,911857	1	0	1	1
24.4.2015 14.4	1429875975	205114000	57,695354	10,922934	1	0	1	1

What grid do we need?

We need a grid, a shapefile with square cells, in order to put the lines on top. We then count how many of them are crossing each cell.

The grid file was downloaded from the European Environment Agency (EEA) and it is based on recommendations made at the 1st European Workshop on Reference Grids in 2003 and later from INSPIRE geographical grid systems. This standard grid was recommended to facilitate the management and analyses of spatial information for a variety of applications.

EEA offers a grid in shapefile format for each country in three scales: 1 km, 10 km and 100 km. We chose the 1 km grid to produce high resolution maps.

After we downloaded each Baltic Sea country we joined them all in one file. The resulting merged grid had more than four millions cells. We then delete the cells on land to save space and make the file easier to manage. The result was a file with about 400 000 cells.

Three steps for creating density maps

Once we have the monthly CSV files with the AIS signals, the folders and the grid we can start the process to create a density map.
We followed three steps to create density maps:

1. Create lines
2. Divide the lines in ship types (cargo, tanker, passenger…)
3. Make the density map overlapping lines onto the grid

There is a python script for each step. They all use python's multiprocessing module. This module allows us to submit multiple processes that can run independently from each other in order to make best use of our CPU cores. We used a machine with 10 cores.

The final result of processing one year is a density map in raster format (TIFF) per month and per ship type. That makes 96 maps. It takes about 40 hours to complete the process on average per year.

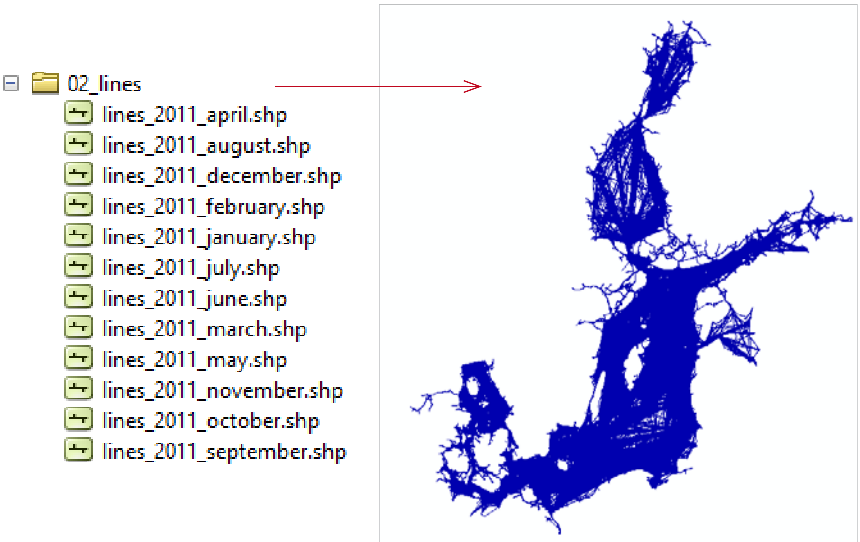
Create lines

NAME OF THE SCRIPT: TrackBuilderFromCSV_multiprocessing.py
PURPOSE: Creates lines representing trips of ships from port to port.
DURATION: three hours per year with multiprocessing.
PRECONDITIONS: Before creating lines we need:

- A year folder under which there are csv files containing all trips per month
- The file name of the monthly file must have the year and the month name in English
- The monthly csv file must have the following columns:
  - * MMSI
  - * Trip_id: Number of trips per MMSI (per ship)

HOW THE SCRIPT WORKS: This script reads each monthly csv file and converts coordinates to lines
OUTPUT: the output of this process is a folder with lines shapefiles for each month

Figure 12. Create lines



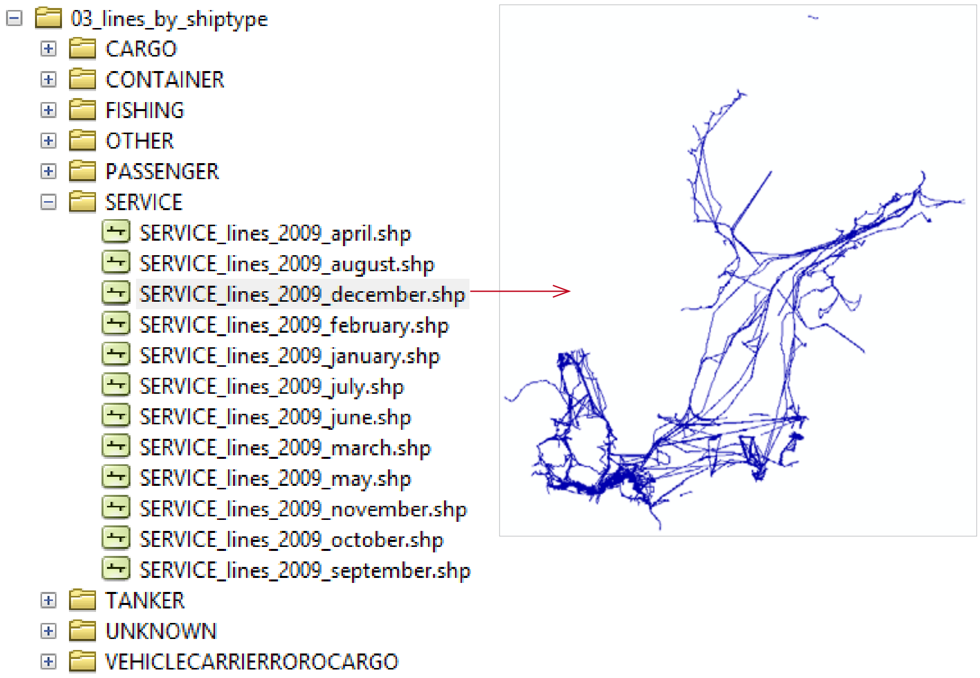
Divide lines by ship type

NAME OF THE SCRIPT: SplitTracksByShipType_multiprocessing.py
PURPOSE: Once we have the lines shapefiles we proceed to divide each file into different ship types
DURATION: two hours per year with multiprocessing.
PRECONDITIONS: Before splitting lines by ship type we need:

- A folder with monthly lines shapefiles
- The file name of the monthly file must have the year and the month in English
- A ship list: a csv file with unique number of ships per year created in a previous step (see A ship list for each year). This file must include at least the following fields:
  - * IMO number
  - * HELCOM_Gr: HELCOM Gross ship type – a wide classification of ship types
  - * HELCOM_De: HELCOM Detail ship type – a detail classification

HOW THE SCRIPT WORKS: This script divides the monthly line files into the HELCOM gross classification ship types (see Table 3 Ship type categorisation used to update ship information)
OUTPUT: a folder per ship type under which there are the monthly lines shapefiles

Figure 13. Devide lines by shiptype



Make the density map

NAME OF THE SCRIPT: CreateRastersYear_multiprocessing.py
PURPOSE: Create a density map by overlapping the lines onto a grid and counting the number of lines crossing each cell
DURATION: It depends on the ship type. We estimate an average of 5h per ship type. For cargo, the ship type with most signals, it takes about 10 hours. A ship type with less signals as service can take about 2h
PRECONDITIONS: Before creating the density map we need:

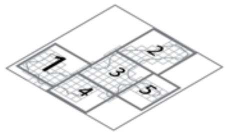
- A folder with monthly lines shapefiles divided in ship types
- The file name of the file must have the year and the month in English
- A grid shapefile (see What grid do we need?)

HOW THE SCRIPT WORKS: The process to create a map is divided into six steps, illustrated in the figure below. It uses python's multiprocessing module to run six months simultaneously:
OUTPUT: a folder, 04_rasters, with subfolders for each ship type. Under each subfolder there is a raster file in TIFF format for each month. There is also a yearly file (CARGO_2009_Year_Raster.tif) with the sum of all monthly raster files

Monthly lines file

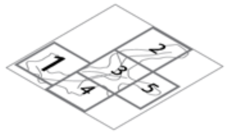
1 SELECT CELLS

We selected cells inside the Grid Division: in order to avoid running out of memory, we divided the Baltic Sea area into five large squares, which we called the "grid division". First, we had to select the 1km cells inside it.



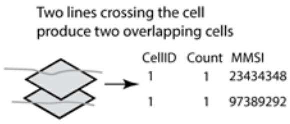
2 SELECT LINES

Then we selected the lines inside the first grid division.



3 SPATIAL JOIN

Once we had both 1km cells and lines selected in the first grid division, we applied a spatial join. The result was a 1km grid. If, for example, there were two lines crossing one cell, then two overlapping cells would be produced.

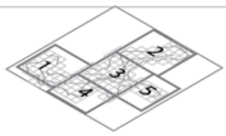


Then we checked if the spatial join in all grid divisions was ready.

NO YES

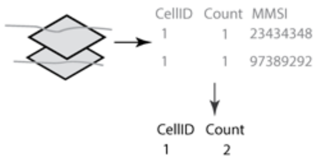
4 MERGE SPATIAL JOINS

When all spatial joins in all grid divisions were ready, then they could all be merged into one.



5 DISSOLVE

Then we summed up all the crossings in each cell with the "Dissolve" tool.



6 RASTER

Resulting from the actions of the "Dissolve" tool, a huge shapefile (about 80 MB) follows, which needs to be rastered to make it lighter and more practical to work with.

Then we check if all monthly files are ready.

NO YES

READY

Figure 14. Make the density map

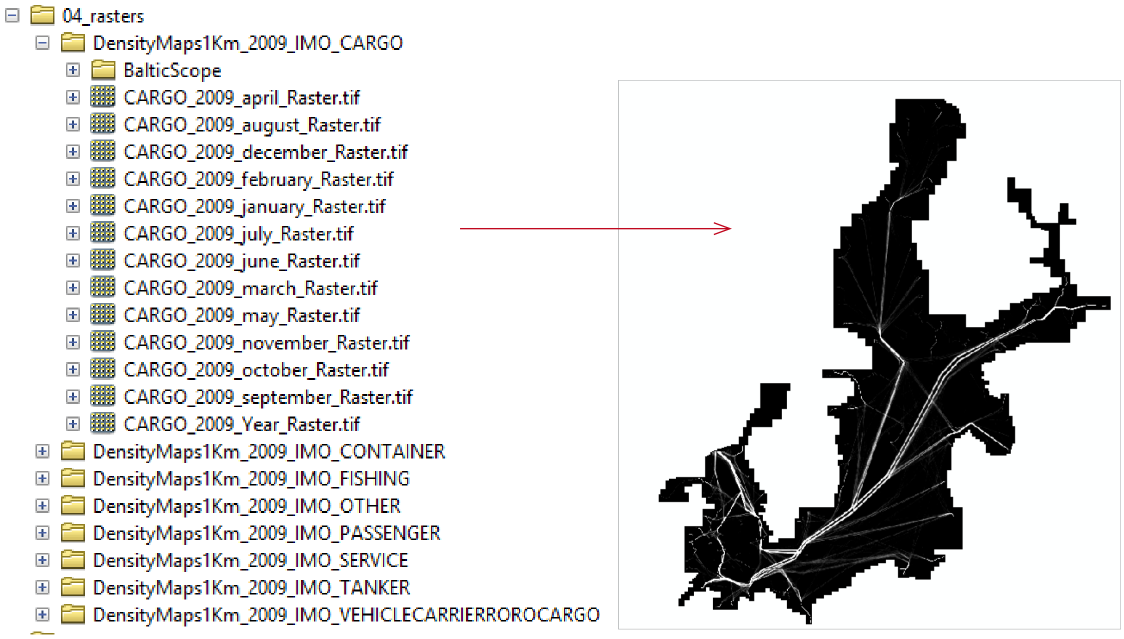


Figure 15. Make the density map

R software packages used to prepare and analyze AIS data

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Color gradiations used in the maps

Color gradations by Color Brewer 2.0 (http://colorbrewer2.org/)

Annex II Mapping fishing activities in the Baltic Sea using AIS data

Introduction

The original objective of this study was to produce an overall analysis of the fisheries activities in the Baltic Sea, presented in the form of GIS maps, figures and tables, and a description of the analyses performed. Original plans involved using a VMS dataset (vessel monitoring system used to track fishing vessels above 12 m length) from the year 2008 to 2012 for producing these maps. However, during the initial work with the VMS dataset the presence of non-fishing positions in the dataset were discovered. Since the dataset lacked information on vessel speed these steaming positions could not be corrected retrospectively. It was therefore decided that an AIS dataset with data from 2014 would be used instead, and that an evaluation of working with AIS (Automatic Identification System) data as a tool for fishery management should be included in the objectives.

The AIS system is an automatic tracking system used on ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data with other nearby ships and AIS base stations. The AIS has been progressively extended in the EU to medium-large size fishing vessels and has become compulsory since May 2014 for all fishing vessels of more than 15 meters of length (EU Dir 2011/15/EU). This makes the AIS system interesting as a tool for mapping of fishing activities.

Figure 1 illustrates the jurisdictional zones that affect fisheries in the Baltic Sea. The rules at sea is a subject to international law, notably to the United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS defines the conditions for States to extend sovereignty or jurisdiction over the oceans. In this regard, a coastal state has the possibility to claim different levels of access and rights at sea through declaration of different types of zones (Figure 1). Full sovereignty is exerted over territorial waters, which may be declared up to a maximum of 12 nautical miles (NM) from the coast baseline. Beyond the territorial water limits, a coastal state may also claim for exclusive economic zones (EEZs), to a maximum extent of 200 NM from the coast line. In both such zones, the rights for the exploitation of

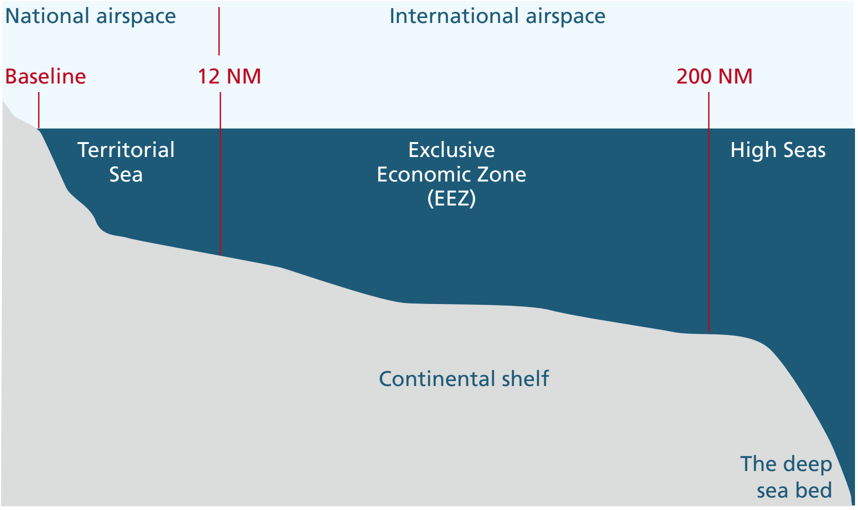

Figure 1. Sea delimitations based on international law (UNCLOS).

marine living resources (i.e. fishing) belong exclusively to the coastal state. However, some of the rights, i.e. the fishing, in both of these zones can be permitted to foreign vessels. In the absence of an EEZ claim, a coastal state may also exert sovereign rights over fishing only, by claiming an exclusive fishing zone. 'High seas' correspond to sea areas not subject to any claim by a coastal state. Access to fishing in the high seas is possible to vessels of any country (Weissenberger 2015).

The main aim of this study was to produce maps that describe the spatial distribution of the different fishing methods, hereafter referred to as fisheries, used within the Baltic Sea, and analyse their interaction with other types of maritime activities as well as the likely spatially relevant environmental effects. The secondary aim was to test the usability of AIS as a tool within the fishery management. In Natale *et al.* (2015) AIS data of Midwater trawl activities were tested and in this study we evaluated their method for different fisheries in the Baltic Sea.

Method

AIS and fleet list data extraction

The positions of the currently known fishing vessels operating in the Baltic Sea during the year 2014 were extracted from the HELCOM AIS data network (9 countries). A list of vessels identified to be fishing vessels was acquired from a ship information provider (www.vesselfinder.com) to cover all IMO (International Maritime Organization) vessels. The IMO number is a unique reference for ships and remains linked to the ship for its lifetime, regardless of a change in name, flag, or owner. If the ship information was not available with the provider (i.e. non-IMO ships), we used the ship information from the AIS data. This list included MMSI (Maritime Mobile Service Identifier, a unique number identifying ships at radio communication) and IMO numbers, dimensions, name, call sign and type of each vessel. Vessels in this list included a number of EU and non-EU countries. Next, all AIS equipped vessels of the Baltic Sea states identified as fishing vessels or unknown were checked against online information providers to identify AIS fishing vessels of the Baltic Sea states. Then information on VMS equipped vessels from the Baltic Sea EU countries was extracted from the EU fleet register and merged with the AIS list to create an exhaustive list of all relevant Baltic Sea fishing fleet (AIS and VMS merged). Thus, a table of all the Baltic Sea states fishing vessels was retrieved, including all the details of the AIS list plus the power of the vessels and their primary and secondary gear types (from the logbook, DCF level 4). Where gear types were not available, a visual (from online provider picture) estimation of the gear used (DCF level 3, rough estimate) was appended. In the AIS fishing fleet list, the fields relative to power and gear type were drawn from the Baltic Sea fleet list using the call sign as linkage between the lists. Information on gear type and power was still missing for a number of vessels from EU, non-Baltic, member states. This gap was filled using their call signs and the logbook information in the EU fleet register. For non-EU flag vessels (e.g. Russia, UK, Canada, USA etc.) a visual estimation of the gear was performed based on online archives of images (e.g. www.marinetraffic.com). Some vessels did not have available information on power in the EU fleet register (data gaps) or were from non-EU countries. For these vessels a power was estimated based on their lengths, using parameters from a power regression on the known power/length of 665 vessels (R-sq = 0.65). This operation also allowed to check and correct errors in the reported length of some vessels. The signals of the fishing vessels in the AIS fishing fleet list were extracted from the HELCOM AIS data for the year 2014 (following their MMSI number). Only the signals within the Baltic Sea (cf. Article 1 of the Helsinki Convention) were selected.

Data processing

The first step of the data handling was to exclude signals with a speed lower than 0.5 knots and thereby excluding signals from ports and other non-fishing positions. After that the time between sequent signals from a specific vessel were calculated as the variable "Fishing time". Fishing time above seven minutes were removed based on the assumption that the AIS-system had been turned off prior to the signal, and thus, the vessel had not been fishing. The limit was set to seven minutes based on the pattern of the fishing time variable in a histogram (Figure 1). Combined with information of engine power, the fishing time was used to calculate the effort in KWh.

The data were then divided into two separate datasets, one with information of primary gear type according to DCF level 4 (a detail level where for instance bottom trawls are separated into PTB - Bottom pair trawl, OTB - Bottom otter trawl, OTT - Multi-rig otter trawl and TBB - Beam trawl) and one dataset without information on primary gear type. The main analysis in this study was done on the dataset with detailed gear type information. The second dataset were mainly used to illustrate how much spatial information was lacking when using this method. In the dataset with detailed information on the gear type, all signals from gear types that only had one vessel or few signals in total were removed, see Figure 2. The gear types that were removed were DRB (Boat dredge, 1200 signals), GTR (Trammel net, 700 signals) and GND (Driftnet, forbidden method, 30 000 signals). All the bottom trawling gear types were merged together. Mid-water trawl gear types were merged together in the same way, as well as the rod and line -gear types.

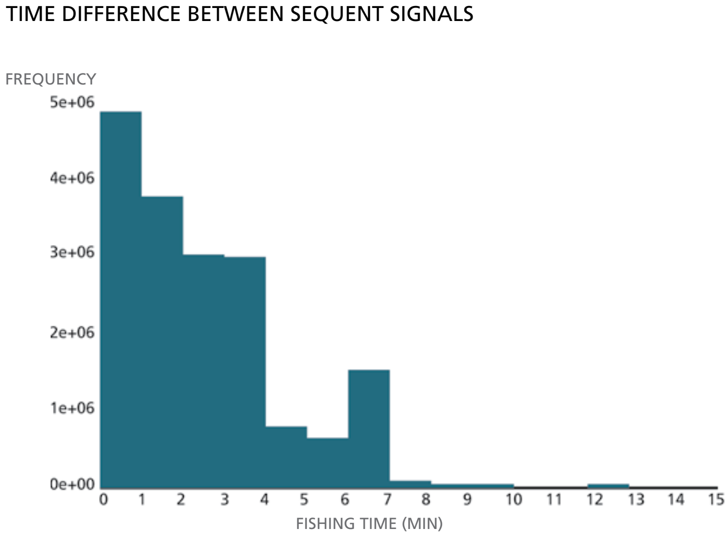

Figure 2. A histogram of every time difference between two sequent signals for every vessel. About 2 % of the signals had a difference exceeding seven minutes.

AIS-data does not provide any information about when a boat has been fishing or not. To retrieve this information from the data, a histogram for each gear type was made of vessel velocity at each signal, see Figure 3. The histograms generally consist of two Gaussian distributions, one at a lower speed where the boat was likely fishing and one at higher speeds representing steaming. According to Natale *et al.* (2015) an appropriate formula to calculate the speed limits for trawl fishing is μ ±1.5*Ó, where μ is the mean value and Ó is the standard deviation of the first Gaussian distribution. These limits gave a good fit for the mid-water trawl fishing but were not

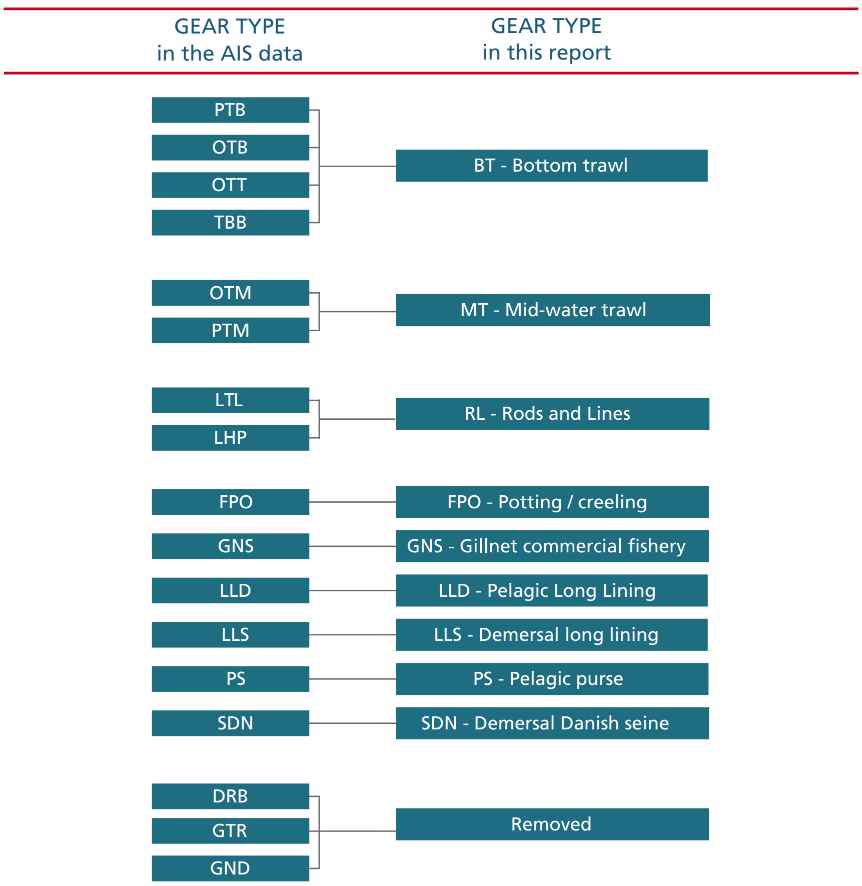

Figure 3. A complete list of gear types of Baltic Sea fishing vessels in 2014 and how they were treated in this report. All the bottom trawling gear types (PTB - Bottom pair trawl, OTB - Bottom otter trawl, OTT - Multi-rig otter trawl and TBB - Beam trawl) were merged together. Mid-water trawl gear types (OTM - Mid-water otter trawl and PTM - Pelagic pair trawl) were merged together in the same way, as well as rods and lines gear types (LTL - Trolling lines and LHP - Hand and Pole lines).

possible to use generally on all gear types. The Gaussian distribution of the speed profiles for each gear type was analysed in the statistical software R using the mixtools library and the function NormalmixEM2comp (Benaglia *et al.* 2009). After a visual check of the speed histograms, the interval 0.5 - 4.5 knots was defined as fishing for all of the fisheries.

To verify the quality of the velocity values in the AIS data, the values were compared with calculated velocity values based on the boat's difference in position and time between two consecutive signals. The methods did not differ significantly and the AIS data of velocity was considered to be useful.

Maps of the fishing effort per gear type and in total were produced in ArcGIS v. 10.3.1 by summarizing all the fishing efforts in 1*1 km squares. The maps were then supplemented with polygons displaying no fishing zones, cod fishing closures and the economic zone of Russia.

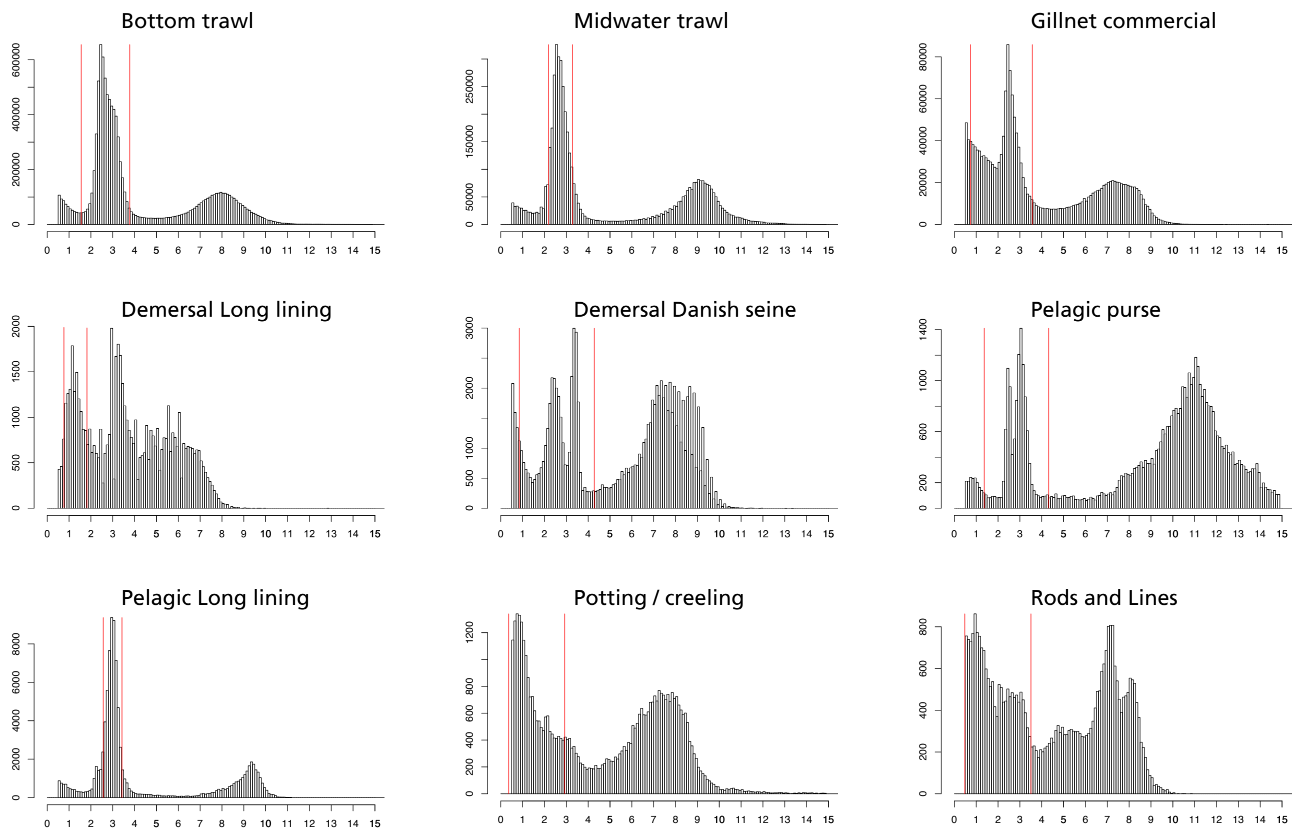

Figure 4. Histogram of the vessel's velocity at each signal for each gear type. The red marks shows 1.5 * SD from the mean of the first normal distribution in the R function normalmixEMcomp2.

Results and discussion

Maps of fishing activities

After applying the speed filter (0.5–4.5 knots) and excluding the minor gear types (DRB, GTR and GND) the dataset consisted of 998 vessels and approximately 13 000 000 AIS signals. For 236 of the vessels included in the dataset, corresponding to 24% of the fleet, detailed information on gear type was not available. The AIS signals from these vessels made up approximately 10% of the total filtered dataset.

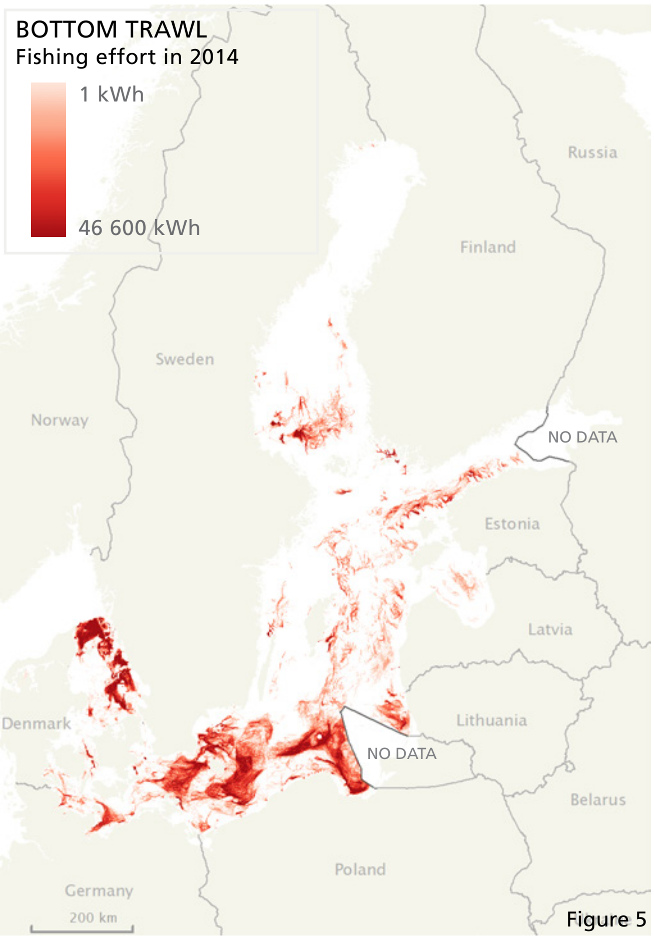

Figure 5

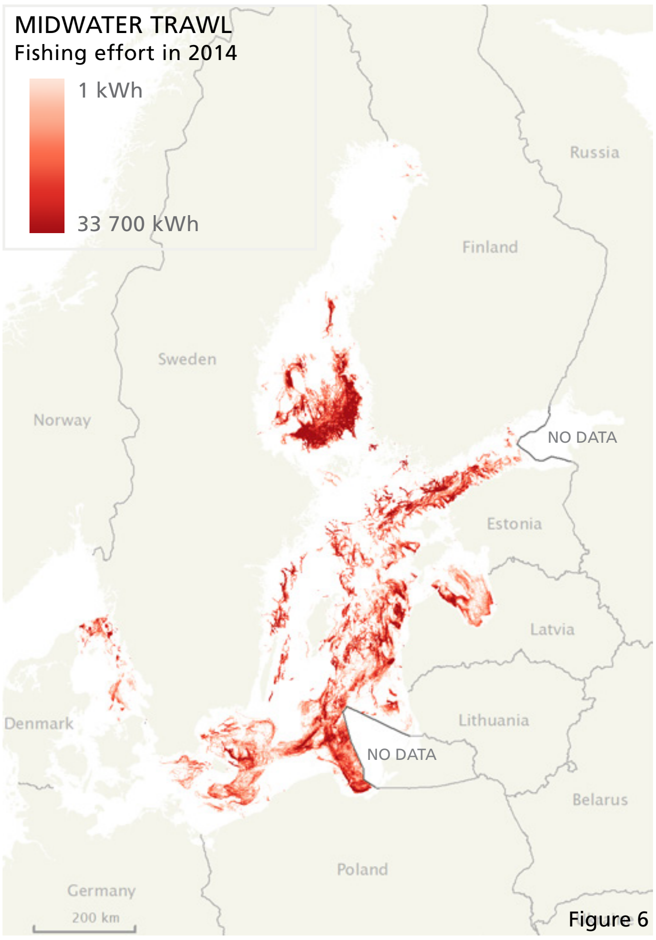

Figure 6

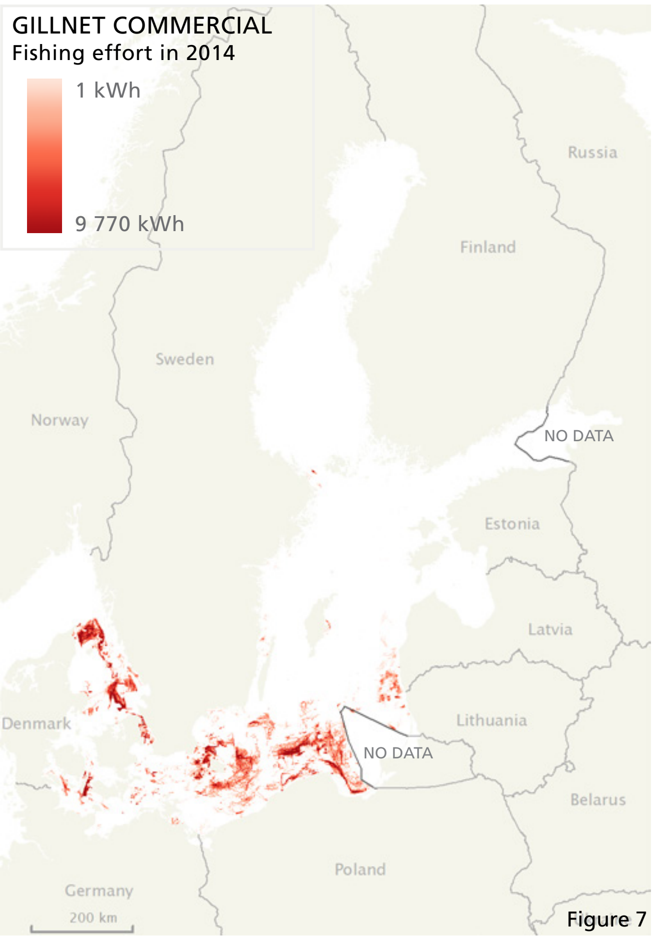

Figure 7

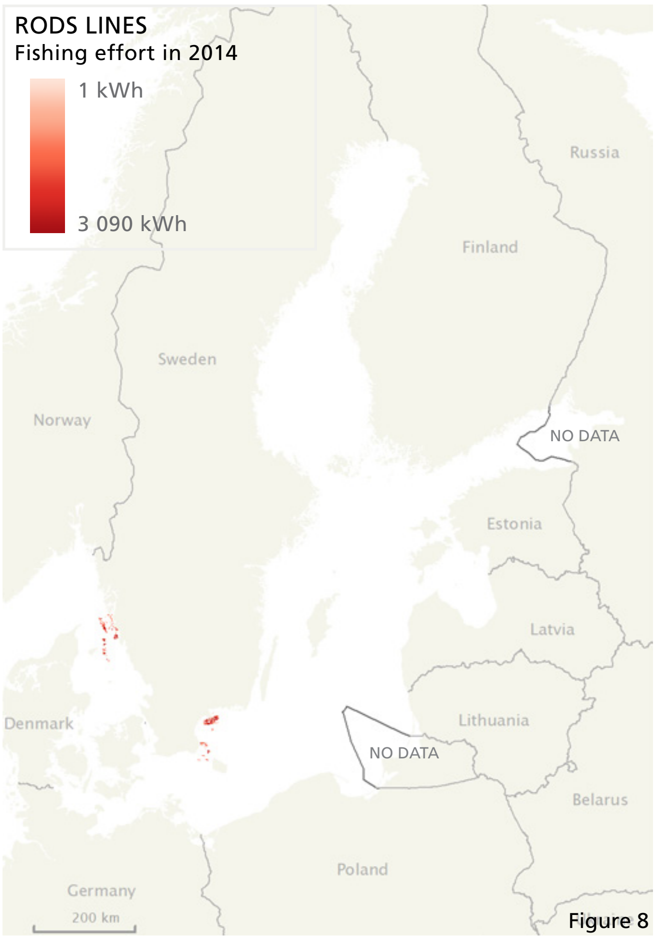

Figure 8

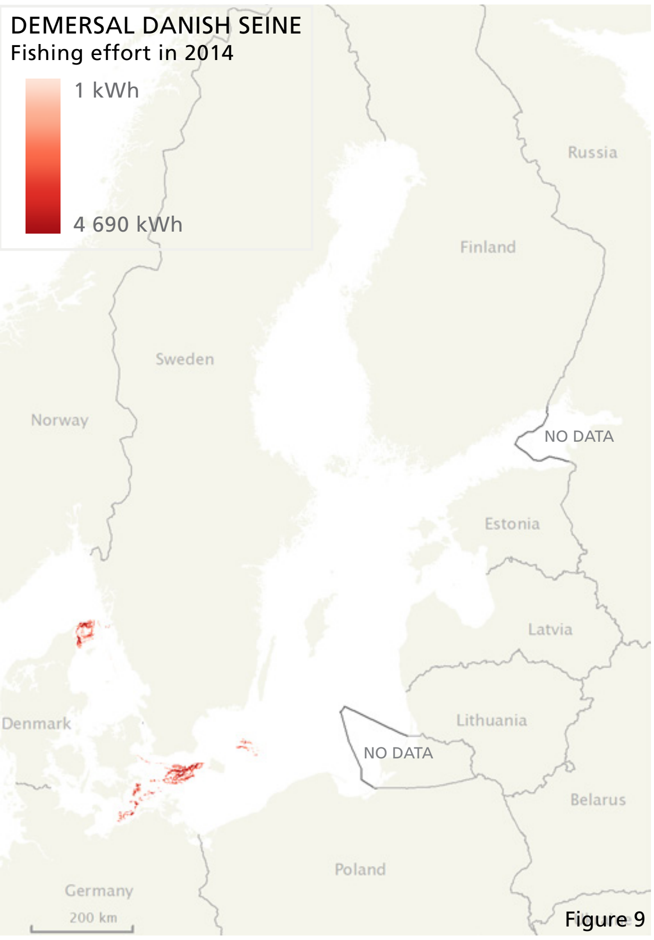

Figure 9

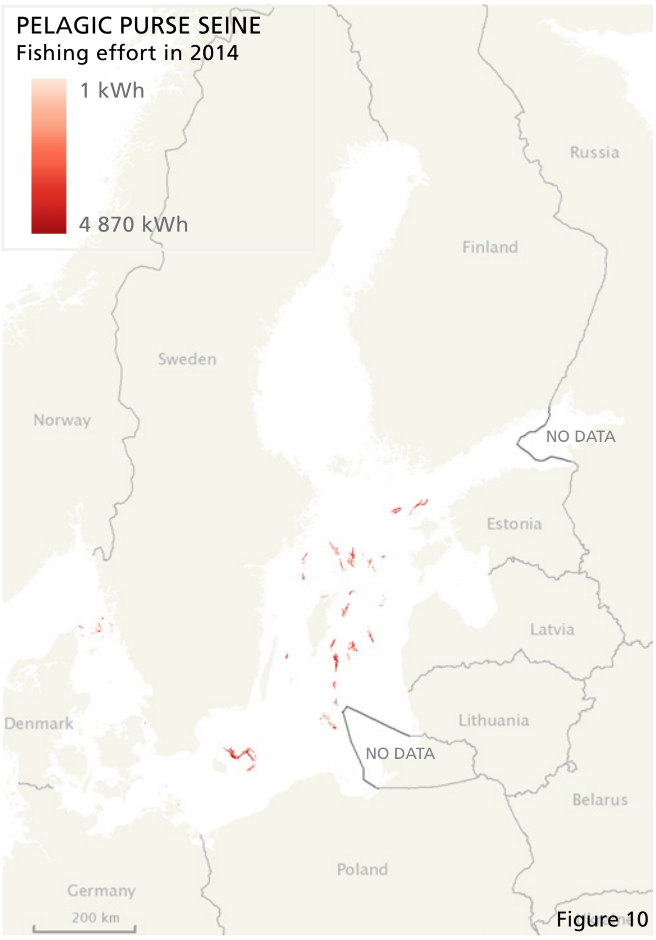

Figure 10

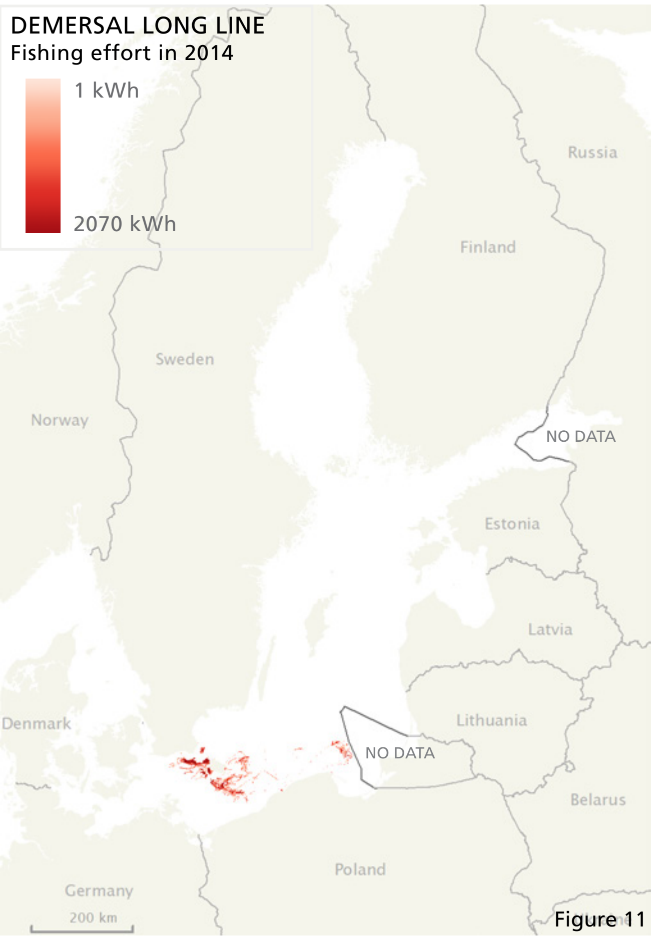

Figure 11

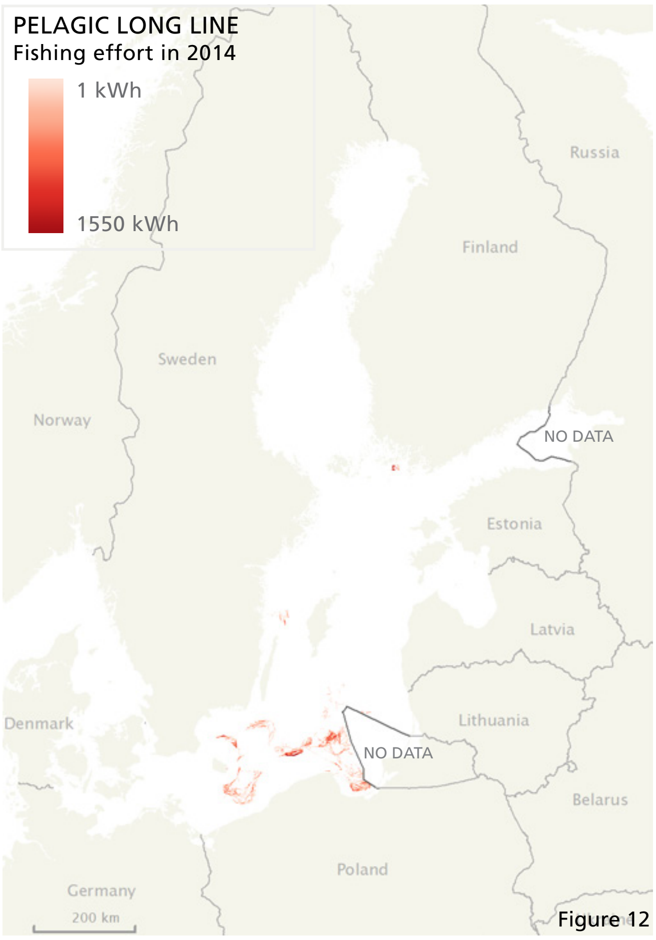

Figure 12

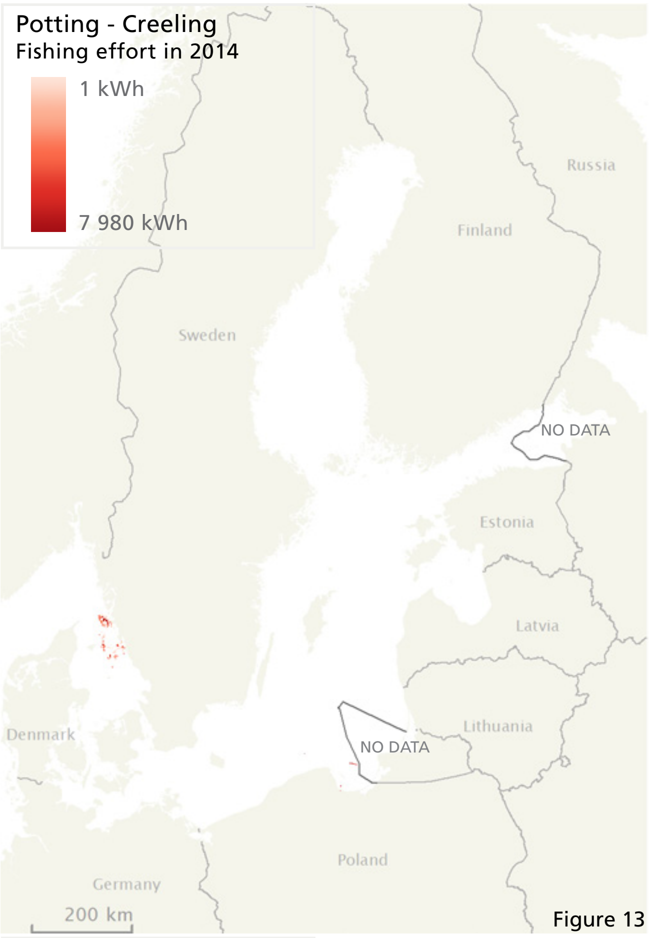

Figure 13

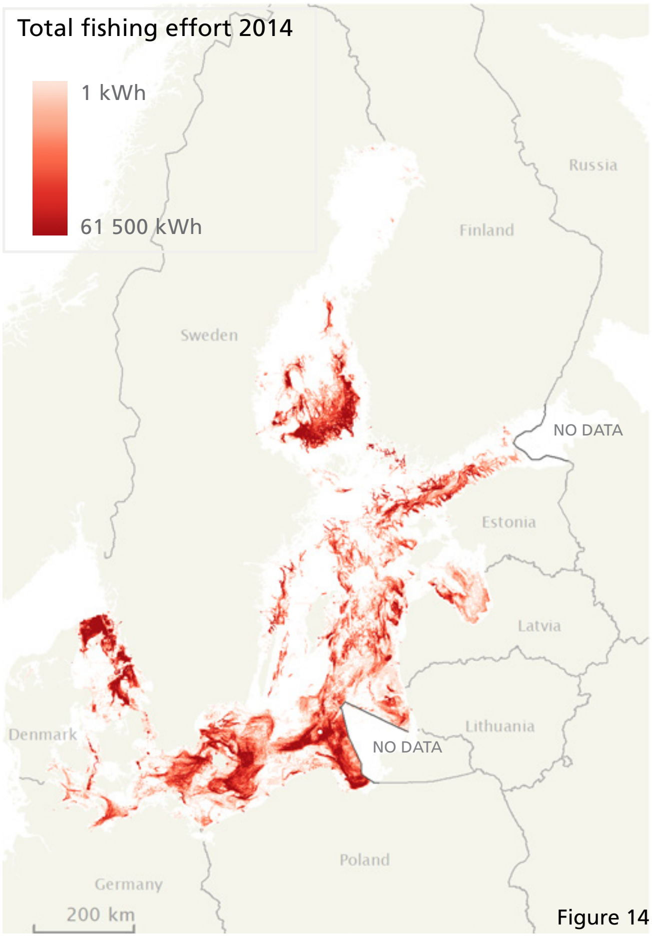

Figure 14

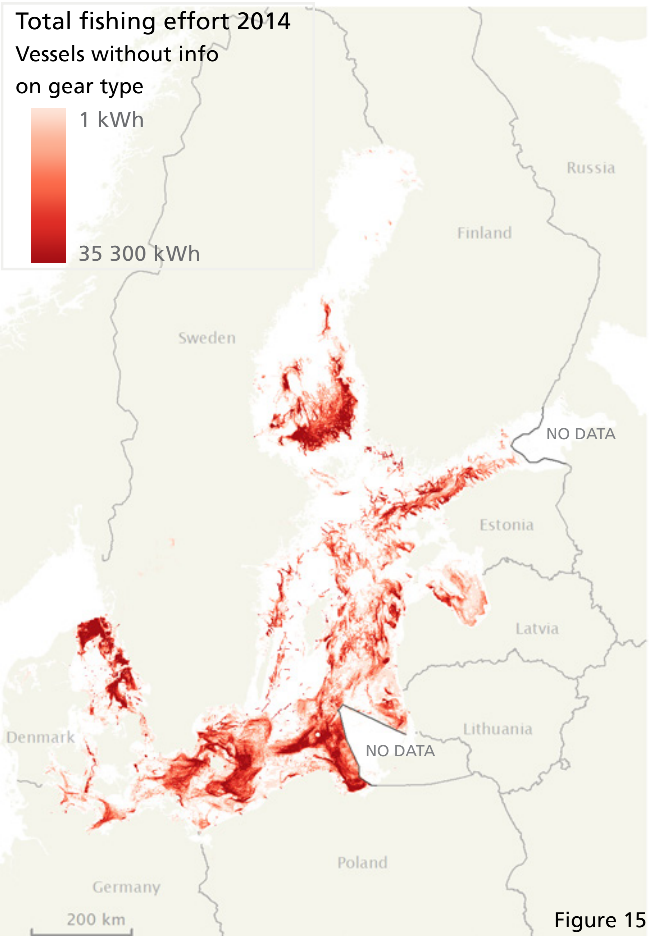

Figure 15

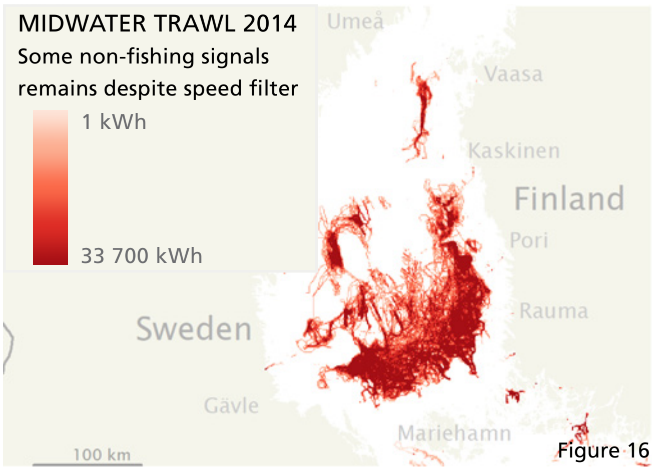

Figure 16

Figure 16. Illustration of the fact that non-fishing signals near harbours remains in the dataset despite the speed filter, illustrated by Midwater trawl fishery in the Bothnian Sea.

The major gear types in the dataset were bottom trawl, mid-water trawl and gillnet that together made up 99% of the total number of signals. In Table 1 the effort for each gear type is presented. In Figure 5-13 the resulting maps describing the fisheries are presented. Bottom trawl (Figure 5), Midwater trawl (Figure 6) and gillnet (Figure 7) were the most extensive fisheries in terms of number of signals in the dataset. They were also the fisheries that had the largest spatial distribution, where bottom trawl and mid-water trawl occurred throughout the whole study area and gillnet covered the major part of the Baltic Proper and Kattegat. The magnitude of the other fisheries were less extensive.

Table 1. NUMBER OF VESSELS, GENERATED NUMBER OF AIS SIGNALS DEFINED AS FISHING, AND FISHING TIME PER FISHERY

Fisheries	No. Vessels	No. Signals	Fishing time (h)
Bottom trawl	442	7 245 487	267 428
Midwater trawl	150	3 056 234	132 051
Rods and lines	7	18 349	813
Potting/creeling	11	21 776	1 078
Gillnet	114	1 211 670	48 605
Pelagic long line	3	10 478	2 709
Demersal long line	4	36 911	1 828
Pelagic purse seine	5	13 709	559
Demersal Danish seine	14	42 875	1 299
Tot DCF Level 4	762	11 657 489	456 370
Tot DCF Level 3	236	1 343 475	55 859

Figure 14 illustrates the total fishing effort made by all fisheries included in the analysis, and Figure 15 shows the fishing effort made from vessels without detailed information on gear type. Approximately 10 % of the total number of signals defined as fishing lacked detailed (from the logbook, DCF level 4) information of gear type. The general picture is that the extra data follow the same spatial pattern as the rest of the data, suggesting that the loss of these vessels from the detailed dataset did not distort the fishing patterns observed. Almost no fishing was detected within the Russian EEZ areas despite the fact that 31 Russian fishing vessels were included in the analysis.

The main parts of the method used in this report were first developed and tested by Natale *et al.* (2015). In their study, only Mid-water trawl data were used. Here we show that their algorithm for separating fishing activity from steaming worked well also on mid-water trawl data from the Baltic. However, the speed interval determined by the algorithm for other fisheries did not match the data as well as for the Mid-water trawl (figure 4). Therefore, after a visual check of the speed histograms, the interval 0.5-4.5 knots were defined as fishing for all different fishing methods studied. This interval worked fairly well, but there wasstill some evidence of steaming vessels and signals close to ports left in the dataset (figure 16). This could most likely be improved by setting the upper and lower speed limit for each gear type separately. For passive fisheries we might lose signals when applying the lower speed limit to the filter since vessels often stand still when hauling.

AIS and VMS comparison

Both VMS and AIS have their advantages and disadvantages. VMS offers a satellite based communication system with bi-directional guaranteed communications where every signal is transmitted and received, but at a cost. The costs per signal are shared between the user or fisherman and the authorities wishing to monitor them. AIS is primarily intended as a situational awareness tool and as means to exchange pertinent navigation information in near real-time and is used by ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations and satellites without a cost per message. Therefore, AIS is a more economical solution but since it is an open system there is no guarantee of message reception.

An advantage of AIS compared to VMS is the spatial resolution. The VMS system sends out a signal every one to two hours, while the AIS messages transmission rates range from 2 seconds to 3 minutes depending on speed or rate of turn. The high spatial resolution makes AIS an interesting tool for fishery management and science, for instance when comparing fishing with other activities or protected areas at sea. However, one aspect to consider is that there are areas with low AIS signal coverage. This is something to keep in mind if using AIS as a management tool as it can be difficult to determine if the absence of activity in an area is a true absence or a result of weak AIS signal strength. In this analysis there were no indications of week signals affecting the results. By using AIS instead of VMS data we get spatial information on non-EU fishing vessels. However, the down side is that we lose some detailed information on gear type for EU-vessels. Another important aspect to consider when comparing AIS with VMS is that AIS is compulsory for fishing vessels of more than 15 meters while the corresponding length for VMS is 12 meters. Thus, we lose some information on smaller vessels when working with AIS data compared to VMS. A common problem for both system is that they do not cover vessels smaller than 12 meters and thus, we lack information on a significant part of the fishery based near the coast.

Applications of AIS

Figure 17 illustrates an example of an overlay analysis between total fishing effort and protected Natura 2000 areas in the Baltic Sea. We only show an illustrating example since many of the protected areas are small and therefore it is difficult to illustrate the whole study area in one map. The analysis showed that during 2014 fishing had occurred in 179 of 1053 areas. Figure 17 indicates that fishing can be quite extensive within Natura 2000 areas. In Figure 17 the total fishing effort was used, but this analysis can be made separately for each fishery. This makes it possible to make fishery specific analysis, e.g. bottom trawl versus habitat destruction and bycatch estimations made by gillnet and so on.

Figure 17. An example from the southern Baltic sea illustrating the overlap between fisheries and protected Natura 2000 areas.

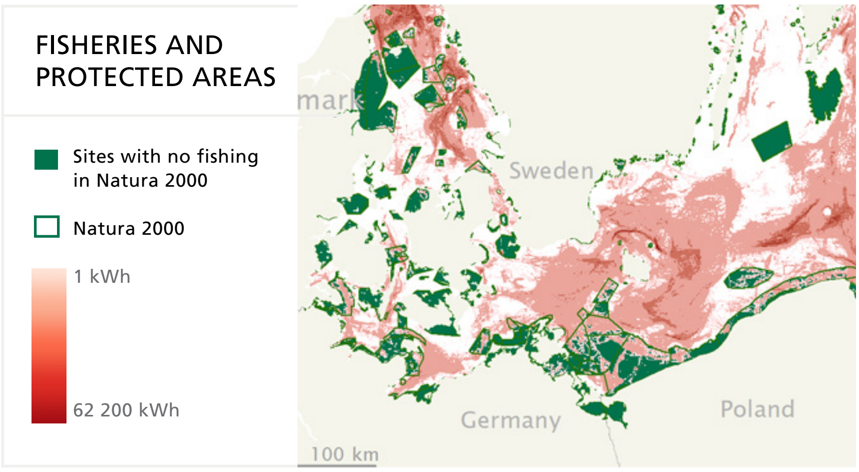

Figure 18 illustrates the overlap between shipping routes and fishing areas, to identify areas with a potential conflict of interests. Both shipping routes and important fishing areas are here defined as 20 % of the raster cells with the highest values in the study area. An area with both heavy traffic and a lot of fishing activity is for example the area west of Gothenburg, on the border area between Skagerrak and Kattegat. Also, northwest and north of Bornholm there are two smaller areas with a lot of fishing that overlaps areas with high traffic frequency areas. Also, in the inlet to the Gulf of Finland and in the southern parts of the Bothnian Sea there are areas where shipping routes overlap with important fishing areas.

Figure 18. The areas with highest fishing effort in relation to areas with the highest frequency of traffic, based on the number of vessels passing per month. The traffic data is from 2011 representing all shipping traffic that particular year.

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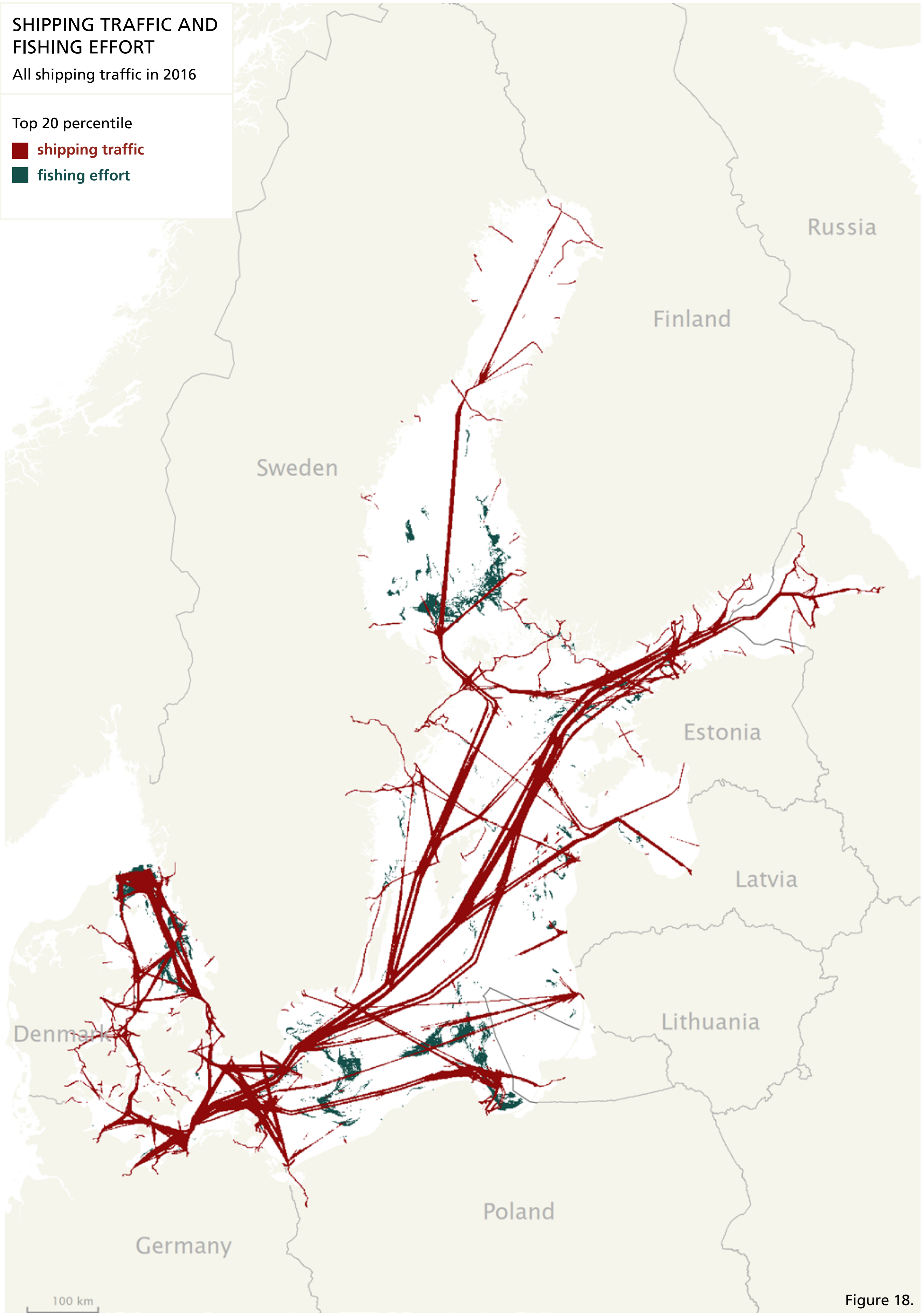
SHIPPING TRAFFIC AND FISHING EFFORT
All shipping traffic in 2016
Top 20 percentile
shipping traffic
fishing effort
Russia
Finland
Sweden
Estonia
Latvia
Lithuania
Denmark
Poland
Germany
100 km

Figure 18.

Annex III TIMELINE of HELCOM work

on clean shipping, response to spills and sustainable fisheries

OVERALL

1974

Signing of the 1974 Helsinki Convention. HELCOM Interim Commission starts work

MARITIME

Early 1970's and onward

Baltic Sea coastal states coordinate positions during "Baltic Club" meetings at IMO MEPC, later called Baltic Maritime Co-ordinating Meetings (BMCMs)

MARITIME

1976

First Meeting of the HELCOM Maritime working group

RESPONSE

1977

First meeting of HELCOM working group on pollution preparedness and response

MARITIME

1979

HELCOM booklet on port reception facilities for oily residues, sewage and garbage

1979

IMO approves a Danish-Swedish proposal on pilots in the Sound Area following consensus at HELCOM

1974 1975 1976 1977 1978 1979

OVERALL
1980
1974 Helsinki Convention enters into force. HELCOM established and replaces Interim Commission

MARITIME
1980 &1981
Several HELCOM Recommendations adopted on PRFs for oily residues, sewage and garbage as well as on safety including the BAREP Baltic Sea ship position reporting system

FISHERIES
1981 and onwards
Baltic Sea Fish and Fisheries covered in HELCOM regular assessment reports on the state of the Baltic Sea

MARITIME
1981
HELCOM Publication on the Helsinki Convention for mariners transiting in the Baltic Sea Area

RESPONSE
1980 &1981
HELCOM adopts Recommendations on regional warning-, reporting-, communication- and command systems on spills at sea

MARITIME
1982
Environmental issues around pleasure craft considered as a new issue

MARITIME
1983
Joint statement by the HELCOM countries at IMO MEPC 22 on implementation of MARPOL provisions on hazardous and noxious substances carried in bulk in the Baltic Sea

1983
New routeing measures in the Danish straits approved by IMO Maritime Safety Committee following consensus at HELCOM

RESPONSE
1983
HELCOM Manual on Co-operation in Combatting Marine Pollution compiled from Recommendations and other material

MARITIME
1984
HELCOM Study on ship casualties in the Baltic Sea 1979-1981 published

1980 — 1981 — 1982 — 1983 — 1984

MARITIME* CHAIR
1980
Per Eriksson,
National Administration of Shipping and Navigation, Sweden

MARITIME / RESPONSE
Professional Secretary
1980
Fleming Otzen,
Denmark

*and its predecessor groups SEA/CC/EGC
*and its predecessor groups SEA/MC

RESPONSE* CHAIR
1982
Gerd Haussmann,
Board of Navigation and Maritime Affairs, German Democratic Republic

RESPONSE* CHAIR
1983
Ingomar Joerss,
Ministry of Transport, Federal Republic of Germany

MARITIME* CHAIR
1983
Seppo Hildén,
Finnish Board of Navigation, Finland

RESPONSE* CHAIR
1984
Jerzy W. Doerffer,
Technical University of Gdansk, Poland

MARITIME

1985

HELCOM Recommendation on cooperation in investigating violations of environmental regulations for ships including dumping (HELCOM Rec. 6/11)

RESPONSE

Mid-1980's

First joint annual alarm and operational exercises (e.g. HELCOM BALEX DELTA)

MARITIME

1986

Seminar on pollution caused by noxious liquid substances carried in bulk by ships

1986

All HELCOM countries have ratified the MARPOL Convention. MARPOL related IMO decisions do not need to be transposed to HELCOM Recommendations

1986

HELCOM establishes sub-group on port reception facilities.

1986

HELCOM publishes first "Clean Seas Guide –the Baltic Sea Area, a MARPOL special area"

MARITIME

1987

Air pollution (esp. quality of fuel oil), IMO PSSAs and winter traffic safety included as new items to the HELCOM Maritime group work plan (MC 13)

1987

New sub-group on PRF established, later called MC REFAC.

MARITIME

1988

Proposal developed within the HELCOM Maritime group on 15 ppm as maximum oil content in bilge water discharges submitted by Germany to IMO MEPC 29

1988

Proposal on the application of MARPOL Annex IV (sewage) by the Baltic Sea countries developed within the HELCOM Maritime roup submitted by Germany to IMO MEPC 29

1988

Proposal aiming at reduction of air pollution from ships developed within the HELCOM Maritime group submitted by Sweden to IMO MEPC 29

1988

HECOM considers restrictions on the use of antifouling paints containing TBT in the Baltic Sea

MARITIME

1988/89

HELCOM establishes a sub-group on reduction of air pollution from ships (MC AIR)

RESPONSE

Late 1980's

Joint HELCOM annual airborne surveillance starts regular work (e.g. HELCOM CEPCOs)

1985 1986 1987 1988 1989

MARITIME / RESPONSE

Professional Secretariy

1988

Lars G. Thorell,
Sweden

MARITIME* CHAIR

1988

Peter Ehlers,
Federal Maritime and Hydrographic Agency,
Germany

RESPONSE* CHAIR

1988

Sven Uhler,
Swedish Customs HQ,
Sweden

*and its predecessor groups SEA/CC/EGC

*and its predecessor groups SEA/MC

1990

MARITIME

1990
HELCOM seminar on Baltic PSSAs

1990
HELCOM compiles data on air pollution from ships

1990
Measures to reduce Sulphur emissions and improve quality of marine fuel oils

1990–
HELCOM establishes a sub-group to discuss safe tanker construction to avoid spills

1990
Data compilation on control measures and investigations of violations

RESPONSE

1990
HELCOM adopts Manual on response to accidents at sea involving spills of hazardous substances and dangerous goods (presently vol. 2)

RESPONSE* CHAIR

1990
Oleg N. Khalimonov, Marine Pollution Control and Salvage Administration (MPCSA), USSR

MARITIME / RESPONSE

Professional Secretary

1990
Adam Kowalewski, Poland

1991

OVERALL

1990–1994
Revised 1992 Helsinki Convention negotiated and adopted. Contracting Parties increase in number as newly independent states (Estonia, Latvia, Lithuania), EU, Russia and unified Germany are included as Contracting Parties. Industry and NGO participation via observer arrangements established

RESPONSE

Early 1990's
HELCOM SeaTrackWeb oil drift forecast tool in operation.

Early 1990's
Operational BALEX DELTA exercises and aerial surveillance become regular part of the work

1992

MARITIME

1992
HELCOM Seminar on Port Reception Facilities

1992
Co-operation established with the recently formed Paris MoU

FISHERIES

1992
Sustainable use becomes part of the amended 1992 Helsinki Convention
–New Article 15 on Nature Conservation and Biodiversity covers measures to ensure the sustainable use of natural resources within the Baltic Sea Area
–New Annex II includes promoting and implementing Best Environmental Practice (BEP) and Best Available Technology (BAT) for fish farming on land
–Strengthened mutual cooperation with other organisations, including IBSFC, is enabled by the new arrangements for HELCOM observer organisations

1993

MARITIME

1993
HELCOM Maritime group drafts joint Baltic Sea States submission to IMO MEPC on the concept of "special area" under draft annex of MARPOL 73/78 on air pollution from ships (submitted to IMO MEPC in 1994)

1993
HELCOM meeting on investigation of violations of anti-pollution regulations and evidence

1993
HELCOM study on environmental hazards of packaged dangerous goods

RESPONSE* CHAIR

1993
Olli Pahkala, Ministry of the Environment, Finland

1994

MARITIME

1994
HELCOM Maritime group drafts Baltic Sea Strategy on improved PRFs.

1994–95
HELCOM and IMO visit former USSR ports to map needed PRF investments.

1994
HELCOM releases study on discharges of sewage from passenger ships in the Baltic Sea.

1994
Work within IMO for more stringent requirements on transport of HNS (packaged and bulk) in the Baltic Sea.

1994
HELCOM considers harmful marine organisms carried in ballast waters for the first time

FISHERIES

1994
HELCOM Recommendation to reduce discharges from marine fish farming by BAT and BEP

1994
System of coastal and marine Baltic Sea Protected Areas (BSPA) (HELCOM Rec.15/5) covers aquaculture and harmful fishing practices to be considered in management plans

MARITIME

1995

Two new HELCOM Recommendations concerning strengthening the cooperation in investigation of violations of anti-pollution regulations

1995

HELCOM approves Baltic Strategy for PRFs for Ship-generated Wastes and its follow-up, including the "no special fee" principle, enforcement and a 37.5 million USD IMO programme.

1995

HELCOM considers IMO Ballast Water Working Group work program and plans related work.

1995

The HELCOM countries provide information on the proposed Baltic SECA to IMO MEPC 39.

MARITIME

1996–

Joint work to mobilize funds for upgrading PRFs in post-soviet states by IMO, HELCOM, Nordic Investment Bank (NIB) and World Bank.

RESPONSE

1996

Major revision of the Manuals on Co-operation in Combatting Marine Pollution

MARITIME

1997

IMO MEPC 39 agrees to submission by the Baltic Sea States at IMO to designate the Baltic Sea as a "Special Area" for Sulphur Oxide emissions (SECA) under the new Annex to MARPOL on air pollution.

FISHERIES

1998

HELCOM Recommendation on management measures to improve wild salmon populations in the Baltic Sea area (Rec. 19/2)

FISHERIES

1999

HELCOM & IBSFC joint publication on the status of Baltic salmon rivers

1995 1996 1997 1998 1999

RESPONSE CHAIR

1998

Thomas Fagö, Swedish Coastguard, Sweden

MARITIME / RESPONSE Professional Secretary

1998

Anne Christine Brusendorff, Denmark

MARITIME CHAIR

1998

Jorma Kämäräinen, Finnish Maritime Administration, Finland

*and its predecessor groups SEA/CC/EGC

*and its predecessor groups SEA/MC

OVERALL
2000
The amended 1992 Convention enters into force as treaty law after all coastal countries and the EU have ratified it as part of their legislation.

MARITIME
2000
HELCOM adopts Baltic Legal Manual on prosecution of violations of anti-pollution regulations in the Baltic Sea Area and Guidelines for ensuring successful convictions.

RESPONSE
2000
HELCOM legal manual on information on anti-pollution regulations at sea and the prosecution of violations thereof in the Baltic Sea Area

MARITIME
2001
Baltic Carrier accident catalyses regional work on safety of navigation.
2001
Environment and Transport Ministers adopt the HELCOM Copenhagen Declaration to improve safety of navigation in the Baltic Sea including 1992 Helsinki Convention amendments.

RESPONSE
2001
HELCOM risk assessment and traffic overview for enhanced response capacity.
2001–2002
Major revision of the Manuals on Co-operation in Combatting Marine Pollution

MARITIME
2002
First Meeting of the HELCOM AIS EWG on a regional network for sharing AIS information on ship movements in the Baltic Sea.

FISHERIES
2003
HELCOM Recommendation on implementation of integrated marine and coastal management of human activities in the Baltic Sea Area (HELCOM Rec. 24/10).

OVERALL
2003
Joint HELCOM-OSPAR Ministerial Meeting launching the Ecosystem Approach concept

MARITIME
2003
HELCOM Maritime establishes sub group on transit routeing (group later renamed to group of experts on safety of navigation or HELCOM SAFE NAV)

MARITIME
2004
HELCOM Maritime Accident Response Information System (MARIS)

2000 2001 2002 2003 2004

MARITIME CHAIR
2000
Thomas Fagö,
Swedish Coastguard,
Sweden

MARITIME CHAIR
2003
Ingelore Hering,
Federal Maritime and
Hydrographic Agency,
Germany

MARITIME / RESPONSE
Professional Secretary
2003
Tadas Navickas,
Lithuania

MARITIME

2005

The Baltic Sea Area PSSA established by IMO Resolution MEPC.136(53) based on submission by eight coastal countries (DK, EE, FI, DE, LV, LT, PL and SE).

2005

Workshop on "Ballast water introductions of alien species into the Baltic Sea" leads to a series of HELCOM projects on BWM (HELCOM ALIENS 1,2 & 3).

2005

HELCOM considers further measures on air pollution from ships including stricter IMO rules as well as regional work on economic incentives.

2005

HELCOM AIS network for the Baltic region in operation

FISHERIES

2006

HELCOM Assessment of Coastal Fish in the Baltic Sea.

OVERALL

2007

HELCOM Baltic Sea Action Plan adopted at a Ministerial Meeting in Cracow, Poland

MARITIME

2007

Agreement to develop proposal to IMO on the Baltic Sea as a MARPOL Annex IV special area on sewage from passenger ships.

2007–2010

Decisions to carry out cost benefit analyses and to designate the Baltic Sea as a NOx emission control area (NECA) under IMO MARPOL

FISHERIES

2007, 2013

HELCOM Red list of threatened and declining species of lampreys and fishes of the Baltic Sea.

MARITIME

2008

HELCOM launches an online Transit Guide for the Baltic Sea hosted by Denmark

2008, 2009 & 2012

Joint HELCOM-OSPAR and HELCOM-OSPAR-REMPEC voluntary guidance on ballast water exchange circulated as IMO Circulars

FISHERIES

2008

HELCOM establishes Fish/Env Forum to gather environmental and fisheries authorities of the coastal countries and the EU to address fisheries and environment issues.

RESPONSE

2009

HELCOM BRISK and BRISK –RU projects approved and start working on a comprehensive risk assessment covering the whole Baltic Sea

FISHERIES

2009

Biodiversity in the Baltic Sea (HELCOM BSEP 116) covers Fish and Fisheries as dedicated chapters.

2005 — 2006 — 2007 — 2008 — 2009

MARITIME / RESPONSE

Professional Secretary

2006

Monika Stankiewicz, Poland

ESTABLISHMENT of the FISH Group

FISH Professional Secretary, 2008

Mikhail Durkin, Russia

FISH* CHAIR

2008

Markku Aro, Ministry of Agriculture and Forestry, Finland & Katarzyna Kaminska, Ministry of Agriculture, Poland

RESPONSE CHAIR

2009

Peter Soeberg Poulsen, Admiral Danish Fleet HQ, Denmark

MARITIME CHAIR

2009

Lolan Eriksson, Ministry of Transport and Communications, Finland

*and its predecessor group Fish Env Forum

OVERALL
2010
HELCOM Ministerial Meeting in Moscow

OVERALL
2013
HELCOM Ministerial Meeting in Copenhagen

MARITIME
2010
HELCOM completes and submits to IMO a proposal to enable and designate a MARPOL Annex IV special area on sewage from passenger ships in the Baltic Sea.
2010
HELCOM Cooperation Platform on PRFs launched to address remaining issues with sewage reception.

MARITIME
2011
IMO amends the MARPOL Convention Annex IV, and designates the Baltic Sea as a special area for sewage.

MARITIME
2012
HELCOM and OSPAR establish joint Task Group on regional aspects of Ballast Water Convention implementation, especially exemptions (Reg. A-4).

MARITIME
2013
HELCOM and OSPAR adopt Joint Harmonised Procedure on Ballast Water Convention exemptions in the Baltic and North East Atlantic drafted within joint Task Group.

MARITIME
2014 onwards
HELCOM establishes a sub-group on green technology and alternative fuels for shipping.

RESPONSE
2010
Oiled wildlife response Recommendation and Response Manual amendment

FISHERIES
2011
HELCOM assessment of salmon and sea trout populations and habitats in rivers flowing to the Baltic Sea.

RESPONSE
2012
Shoreline response Recommendation

RESPONSE
2013
HELCOM adopts an amendment of the 1992 Helsinki Convention and a related Manual on response on the shore.

FISHERIES
2014
HELCOM establishes HELCOM Fish Working Group, replacing the HELCOM Fish/Env Forum.

2010 2011 2012 2013 2014

RESPONSE CHAIR
2011
Bernt Stedt,
Swedish Coastguard,
Sweden

MARITIME / RESPONSE
Professional Secretary
2012
Hermanni Backer (Johnsen),
Finland

FISH
Professional Secretary
2014
Dmitry Frank-Kamenetsky,
Russia

MARITIME CHAIR
2014
Anna Petersson,
Swedish Transport Agency, Sweden

FISH* CHAIR
2010
Markku Aro,
Ministry of Agriculture and Forestry, Finland
& Anders Alm,
Ministry of the Environment, Sweden

FISH* CHAIR
2011
Markku Aro,
Ministry of Agriculture and Forestry, Finland
& Christian Pusch,
Federal Agency for Nature Conservation, Germany

FISH* CHAIR
2012
Katarzyna Kaminska,
Ministry of Agriculture and Rural Development, Poland
& Christian Pusch,
Federal Agency for Nature Conservation, Germany

FISH* CHAIR
2013
Markku Aro,
Ministry of Agriculture and Forestry, Finland
& Katarzyna Kaminska,
Ministry of Agriculture, Poland

FISH* CHAIR
2014
Christian Pusch,
Federal Agency for Nature Conservation, Germany
Marcin Rucinski,
Ministry of Agriculture and Rural Development, Poland

MARITIME

2016

HELCOM countries inform IMO that adequate sewage PRFs are available. IMO declares that the sewage special area be enforced by 2021, with an extension until 2023 for certain routes.

2016

The global tonnage ratification criteria of the IMO Ballast Water Management Convention fulfilled with the ratification of Finland 8.9.2016.

2016

HELCOM countries submit NECA application to IMO in parallel with a similar proposal from the North Sea countries. IMO approves the proposals for circulation and final decision by MEPC 71 in 2017.

FISHERIES

2016

HELCOM adopts new Recommendation on aquaculture BAT and BEP in the Baltic Sea region

MARITIME

2017

HELCOM Maritime group receives the 2017 Baltic Sea Fund prize for its work on the Special Areas MARPOL Annex IV and VI (NECA)

2017

The IMO Ballast Water Management Convention entered into force on 8.9.2017

RESPONSE

2017

HELCOM adopts a revised Manual on response on the shore

2017

OPENRISK project starts, aiming to develop open and transparent spill risk assessment methodology, led by HELCOM

FISHERIES

2017

HELCOM workshop on eel and the Baltic Sea

2017

RETROUT project starts
Joint worskhop on river restoration

2015

2016

2017

RESPONSE CHAIR

2015

Heli Haapasaari, Finnish Environment Institute, Finland

FISH

Professional Secretary

2015

Hermanni Backer (Johnsen), Finland

RESPONSE

2016

HELCOM publishes overview of national approaches to Oiled Wildlife Response

FISH CHAIR

2017

Marianne Goffeng Raakil, Ministry of Enterprise and Innovation, Sweden

Annex IV
GLOSSARY

A

AIS (Automatic Identification System): A Radio based transmitter-receiver device used on board ships which sends and receives standardised messages with information on vessel characteristics, as well as on its location, course, speed and other details. Designed primarily for safety of navigation purposes, including collision avoidance.

A-3: Regulation A-3 of the BWMC (on exceptions).

A-4: Regulation A-4 of the BWMC (on exemptions).

AFS (Anti Fouling System)

Alaska Standard: A sewage treatment standard for onboard systems defined by the United States Coast Guard.

ASC (Aquaculture Stewardship Council)

AWTS (Advanced Wastewater Treatment System)

B

BALEX DELTA or HELCOM BALEX DELTA: Regional annual spill response exercise in the Baltic Sea, coordinated by the HELCOM Response Working Group.

BALTFISH (The Baltic Sea Fisheries Forum)

Baltic Strategy: Shorthand term for the Baltic Strategy for port reception facilities for ship-generated wastes and associated issues, a comprehensive strategy to develop port reception facilities in Baltic Sea ports, was developed within the maritime group during (1987)-1996 and endorsed by HELCOM in 1996. Included a series of recommendations and was later replaced by other initiatives.

BASREC (Baltic Sea Region Energy Cooperation): Cooperation forum on energy issues under the Council of the Baltic Sea States (CBSS).

BAT (Best Available Technology)

BEP (Best Environmental Practice)

BITS (Baltic International Trawl Survey): A regional joint bottom/demersal trawl survey coordinated by ICES.

Black water: Waste water from toilets.

BOD (Biochemical Oxygen Demand): A measure of the amount of organic compounds in water).

BOSB (Baltic Ordnance Survey Board)

BSAC (Baltic Sea Advisory Council)

BSAP (Baltic Sea Action Plan): The BSAP, adopted by the HELCOM Ministerial Meeting in Krakow, Poland, on 15 November 2007 has continued to provide long term guidance to HELCOM work even if supplemented by ministerial meeting outcomes in 2010, 2013 and 2018.

BSEP (Baltic Sea Environment Proceedings): The main publication series of HELCOM.

BSHC (Baltic Sea Hydrographic Commission)

BWE (Ballast Water Exchange)

BWMC (Ballast Water Management Convention): International Convention for the Control and Management of Ships' Ballast Water and Sediments. Adopted on 13 February 2004; in force 8 September 2017.

C

CART (Country Allocated Reduction Target): A quantity of nitrogen or phosphorus defined by HELCOM indicating how much nutrient inputs a HELCOM country needs to reduce compared to a reference period. First defined as part of the 2007 HELCOM BSAP.

CEPCO (Coordinated Extended Pollution Control Operation)
CLRTAP (Convention on Long-Range Transboundary Air Pollution): A multilateral treaty on air pollution in the wider European area, under the United Nations Economic Commission for Europe (UNECE), opened for signature on 13 November 1979, entered into force on 16 March 1983.
COD (Chemical Oxygen Demand): A measure of the amount of organic compounds in water
COFI (The Committee on Fisheries): Subsidiary body of the FAO council, focused on fisheries.
Cold ironing (or shore-to-ship power): Denotes use of electricity from a source on shore onboard a ship.
COLREGs: IMO International Regulations for Preventing Collisions at Sea.
COMPLETE (EU project acronym): The COMPLETE project, with full name Completing management options in the Baltic Sea Region to reduce risk of invasive species introduction by shipping, implemented in the Baltic Sea (2017-20).
CS (Cryptogenic Species): Either a native species or an introduced species, clear evidence for either origin being absent.
CSV (Comma-Separated Values, a computer file type)
CWA (Chemical Warfare Agent)

D

DCF (Data Collection Framework): The EU framework agreement for collection of fisheries data.
DME (Dimethyl Ether)
DMM (Discarded Military Material)
DNA Barcoding: A taxonomic method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species.
DSC (Digital Selective Calling): Modern type of radio communication technology which enables direct calling from VHF, or other type of radio device, to a specific ship or coastal station by using its MMSI (Maritime Mobile Service Identity) number.

E

EEZ (Exclusive Economic Zone)
EGR (Exhaust Gas Recirculation): Engine technology circulating exhaust gases back to the combustion process and thus achieving cleaner final exhausts.
EGR (Exhaust Gas Re-circulation, engine technology)
EIA (Environmental Impact Assessment)
EMEP (European Monitoring and Evaluation Programme): The monitoring and evaluation programme of the CLRTAP.
EMSA (European Maritime Safety Agency): The EU agency on maritime transport related matters.
EU (European Union)
EU –MAP (EU Multiannual programme on data collection)
EUROPOL (European Union Agency for Law Enforcement Cooperation)
EWEA (European Wind Energy Association)

F

FAO (Food and Agricultural Organization)
FMI (Finnish Meteorological Institute)

G

GDP (Gross Domestic Product)
GISIS (Global Integrated Shipping Information System): An IMO database with ship related information.
GND (Driftnet, banned fishing gear type)
GoF (Gulf of Finland)
GPS (Global Positioning System): A positioning system based on satellites. Similar global navigation satellite systems (GNSSs) include the Russian Global Navigation Satellite System (GLONASS) and the EU Galileo.
GREEN TEAM: HELCOM group on green technology and alternative fuels, established in 2014.
Grey water: Waste water which does not include black water (waste water from toilets)
GT (Gross Tonnage): A measure of ships size (interior volume).
GTR (Trammel net, fishing gear type)
GW (Gigawatt): 109 Watts which quantify the rate of energy transfer.

H

HAOP (Harmful aquatic organisms and pathogens): Undesired biota in the BWMC.
HELCOM (Helsinki Commission, or Baltic Marine Environment Protection Commission)
HELCOM AIS data: A regional AIS dataset (2006-) generated via the regional HELCOM AIS network which links national networks of coastal AIS base stations in the nine HELCOM member countries and Norway since 2005.
HFO (Heavy Fuel Oil, heavy fuel type)
HNS (Hazardous and Noxious Substance): Substances such as chemicals, which could threaten humans and marine life and interfere with legitimate uses of the sea, if spilled in the sea.
HPDF (High Pressure gas injection Dual Fuel, engine type)
Hz (Herz): SI unit of frequency, defined as one cycle per second.

I

IAEA (International Atomic Energy Agency)
IAPP Certificate (International Air Pollution Prevention Certificate)
IBC code (International Bulk Chemical code): The International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk is a compilation of IMO regulations that govern the design, construction, and outfitting of new built or converted chemical tankers.
IBSFC (International Baltic Sea Fisheries Commission)
ICES (International Council for the Exploration of the Seas)
ICPC (International Cable Protection Committee)
IFO (Intermediate Fuel Oil, fuel type)
IGO (Intergovernmental Organization)
IHO (International Hydrographic Organization)
IMCO (Inter-Governmental Maritime Consultative Organization, the old name of IMO)
IMO (International Maritime Organization)
IMO Ship: Vessel which has to be registered at IMO, and thus has a IMO number. The criteria depend on size or other criteria and vary according to ship type.
IMO ship:Vessel registered by the IMO and which consequently has an IMO identification number.
ISO (International Organization for Standardization)
IWGAS (Informal Working Group on Aerial Surveillance): The intergovernmental HELCOM group on aerial surveillance in the Baltic Sea region.

J

JHP (Joint Harmonized Procedure): Joint Harmonised Procedure for the Contracting Parties of OSPAR and HELCOM on the Granting of Exemptions under International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation A-4 (adopted 2013, amended 2015).

L

LNG (Liquefied Natural Gas)
LSF (Large Scale Fishing) vessel: A class of Fishing vessels. Larger in size (>12 m) or use towed gears.

M

MADS (Map and Data Service): HELCOM MADS is a regional web service on GIS data display and delivery
MAI (Maximum Allowable Input): A quantity of nitrogen or phosphorus defined by HELCOM indicating the maximal level of inputs of water- and airborne nitrogen and phosphorus to Baltic Sea sub-basins that can be allowed to fulfill the targets for non-eutrophied sea. First defined as part of the 2007 HELCOM BSAP.
MARITIME (group): HELCOM MARITIME Working Group (2003-), previously called Maritime Working Group (WG II) (1975-1980), Maritime Committee (MC) (1980-2000) and Sea Based Pollution Group (SEA) (2000-2003) is the permanent HELCOM working group on sea based pollution sources.
MARPOL (International Convention for the Prevention of Pollution from Ships): The International Convention for the Prevention of Pollution from Ships (MARPOL) was adopted on 2 November 1973, and entered into force on 2 October 1983 as combined instrument with the MARPOL Protocol of 1978. Includes six annexes (Annex I-VI) addressing specific pollution types.

MDO (Marine Diesel Oil, light fuel type)
MEPC (Marine Environment Protection Committee): The main IMO body working with matters related to pollution from ships.
MFO (Marine Fuel Oil, heavy fuel type)
MGO (Marine Gas Oil, light fuel type)
MONA LISA (EU project acronym)
MSD (Marine Sanitation Devices, 3 different types).
MSFD (Marine Strategy Framework Directive): EU Directive on marine environment adopted in 2008.
MW (Megawatt): 106 Watts which quantify the rate of energy transfer.

N

NaOH (Sodium hydroxide, reagent used in scrubbers)
NASA (National Aeronautics and Space Administration): A national agency in the US.
NECA (nitrogen emission control area): A regional emission control area on NOx established under the provisions of MARPOL Annex VI.
NGO (Non-Governmental Organization)
NIS (Non-indigenous species): A species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental. Also called introduced species, alien species, exotic species or non-native species.
NM (Nautical Mile): Defined as 1852 metres.
NMEA (National Marine Electronics Association): An industry organisation working with marine electronics standards.
NOx (nitrogen oxide): Refers commonly to nitrogen oxides that are most relevant for air pollution, namely nitric oxide (NO) and nitrogen dioxide (NO2).
NSF (No Special Fee): The commonly agreed approach to environmental fees related to port visits in the Baltic Sea countries according to which environmental fees are automatically charged from a ship, regardless of actual use. In practical applications extra fee is charged for large amounts in many ports.

O

ODS (Ozone Depleting Substances)
OPRC (International Convention on Oil Pollution Preparedness, Response and Cooperation)
OSPAR: Regional cooperation structure on the North-East Atlantic marine environment based on the 1992 OSPAR Convention.
OTB (Bottom otter trawl, fishing gear type)
OTT (Multi-rig otter trawl, fishing gear type)

P

P&A Manual (Procedures and Arrangements manual): A manual required by MARPOL Annex II.
PGP (polyvalent passive gears, fishing gear type)
PIB (Polyisobutene): A chemical used as raw material for synthetic rubber, legal release of which caused bird casualties along the UK coast in 2013.
PM (Particulate Matter): Atmospheric aerosol particles, also known as atmospheric particulate matter. Sometimes followed by a number which indicates the size class of the aerosol in µm.
PRF (Port Reception Facility): Facilities which international shipping ports must provide to collect waste such as residues, oily mixtures, sewage and garbage generated from ships.
PTB (Bottom pair trawl, fishing gear type)
PVC (Polyvinyl chloride): A common type of plastic.

R

RAS (Re-circulation Aquaculture System)
RESPONSE (group): The HELCOM RESPONSE Working Group (2003-), previously called Expert Group on oil combatting (1976-1980), Combatting Committee (1980-2000) and Sea Based Pollution Group (SEA) (2000-2003) is the permanent HELCOM working group on preparedness and response to spills at sea and on the shore.
RoPax or ROPAX (roll-on/roll-off passenger): A type of RORO vessel with passenger capacity.
Ro-Ro or RORO (Roll-on/Roll-off): Vessels designed to carry wheeled cargo, such as cars, trucks, semi-trailer trucks, trailers, and railroad cars, that are driven on and off the ship on their own wheels or using a platform vehicle.

S

SCR (selective catalytic reduction): A technology for converting nitrogen oxides, also referred to as NOx, into diatomic nitrogen (N2) , and water (H2O) with the aid of a catalyst such as urea.
Scrubber: In maritime usage the word scrubber denotes an exhaust gas cleaning system, a pollution control device to clean ships exhaust gases from SOx.
SEA (Strategic Environmental Assessment)
SECA (nitrogen emission control area): A regional emission control area on SOx established under the provisions of MARPOL Annex VI.
SHEBA (project acronym): Sustainable Shipping and Environment of the Baltic Sea region (SHEBA, 2015-18).
SOLAS (The International Convention for the Safety of Life at Sea)
SOx (sulphur oxide): Refers to many types of sulphur and oxygen -containing compounds such as SO, SO2, SO3, S7O2, S6O2 & S2O2.
Special Area (MARPOL Annex IV): Special Area is the MARPOL Annex IV equivalent to Emission Control Areas of Annex VI (including SECA & NECA), or a special designated area where more stringent requirements apply to sewage discharges.
SPL (Sound Pressure Level): A local pressure deviation from the ambient (average or equilibrium) atmospheric pressure, caused by a sound wave. Measured in Pascal.
SRS (Ship Reporting System): A traffic management system for maritime traffic.
SSF (Small Scale Fishing) vessel
STCW (Convention on Standards of Training, Certification and Watch keeping for Seafarers)
STECF (Scientific, Technical and Economic Committee for Fisheries): An EU committee on fisheries matters.
STM (EU project acronym): Acronym for the STM Validation project developing STM. Based on previous projects, including MONA LISA.
STM (Sea Traffic Management): A concept to implement e-navigation, developed under the lead of the Swedish Maritime Administration.
STW (SeaTrackWeb): The official HELCOM drift model used in response to spills in the Baltic Sea. Developed by a group of inistitutions around the Baltic Sea led by SMHI in Sweden.

T

TBB (Beam trawl, fishing gear type)
TBT (Tributyl-tin): Active substance causing imposex, used historically in anti-fouling paints. Breakdown products include dibutyl-tin (DBT) and monobutyl-tin (MBT).
TEN-T (Trans-European Transport Networks)
Tier I, II, III: Levels of NOx emission abatement requirements according to MARPOL Annex VI and the related NOx technical code. Tier III denotes the most stringent requirement level, applied within NECAs.
TNT (Trinitrotoluene): A type of explosive commonly used in warfare material.
TSS (Total Suspended Solids): A measure of the amount of solid particles in water.

U

UKC (Under Keel Clearance): The minimum clearance available between the deepest point on the vessel and the bottom.
ULSFO (Ultra Low Sulphur Fuel Oil): A term for various modern heavy fuel types with low sulphur content.
UNCLOS (United Nations Convention on the Law of the Sea)
UNECE (United Nations Economic Commission for Europe)
UNEP (United Nations Environment Programme, currently called UN Environment)
UV (Ultra Violet): Type of radiation with a wavelength from 10 nm to 400 nm. Used in some ballast water treatment systems.
UXO (Unexploded Ordnance)

VW

VDSI (Vas Deference Sequence Index): A metric to measure the degree of imposex, or the phenomenon that female marine gastropod molluscs develop male sex organs such as a penis and a sperm duct (vas deferens).
VHF (Very High Frequency): The default short- to medium range radio communication technology used at sea.
VMS (Vessel Monitoring System): A vessel tracking system exclusively for fisheries control purposes, based on satellite communications.
VOC (Volatile Organic Compounds)
WHO (World Health Organization) and WWF (World Wide Fund for Nature)

Annex VI IMO convention ratifications

by HELCOM countries and European Union (associate member) Feb 2018

Status of IMO conventions 8 Feb 2018	DK	EE	FI	DE	LV	LT	PL	RU	SE	EU
IMO Convention 48	x	x	x	x	x	x	x	x	x	
SOLAS Convention 74	x	x	x	x	x	x	x	x	x	
SOLAS Protocol 78	x	x	x	x	x	x	x	x	x	
SOLAS Protocol 88	x	x	x	x	x	x	x	x	x	
SOLAS Agreement 96	x	x	x	x	x		x		x	
LOAD LINES Convention 66	x	x	x	x	x	x	x	x	x	
LOAD LINES Protocol 88	x	x	x	x	x	x	x	x	x	
TONNAGE Convention 69	x	x	x	x	x	x	x	x	x	
COLREG Convention 72	x	x	x	x	x	x	x	x	x	
CSC Convention 72	x	x	x	x	x	x	x	x	x	
CSC amendments 93		x			x					
SFV Protocol 93	x			x		x			x	
Cape Town Agreement 2012	x			x						
STCW Convention 78	x	x	x	x	x	x	x	x	x	
STCW-F Convention 95	x				x	x	x	x		
SAR Convention 79	x	x	x	x	x	x	x	x	x	
STP Agreement 71									x	
Space STP Protocol 73									x	
IMSO Convention 76	x		x	x	x		x	x	x	
INMARSAT OA 76	x		x	x	x		x	x	x	
IMSO amendments 2006										
IMSO amendments 2008	x		x	x	x				x	
FACILITATION Convention 65	x	x	x	x	x	x	x	x	x	
MARPOL 73/78 (Annex I/II)	x	x	x	x	x	x	x	x	x	
MARPOL 73/78 (Annex III)	x	x	x	x	x	x	x	x	x	
MARPOL 73/78 (Annex IV)	x	x	x	x	x	x	x	x	x	
MARPOL 73/78 (Annex V)	x	x	x	x	x	x	x	x	x	
MARPOL Protocol 97 (Annex VI)	x	x	x	x	x	x	x	x	x	
London Convention 72	x		x	x			x	x	x	
London Convention Protocol 96	x	x	x	x					x	

Status of IMO conventions 8 Feb 2018	DK	EE	FI	DE	LV	LT	PL	RU	SE	EU
INTERVENTION Convention 69	x	x	x	x	x		x	x	x	
INTERVENTION Protocol 73	x	x	x	x	x		x	x	x	
CLC Convention 69	d	d	d	d	d		d	d	d	
CLC Protocol 76	x		x	x			x	x	x	
CLC Protocol 92	x	x	x	x	x	x	x	x	x	
FUND Protocol 76	x		x	x			x	x	x	
FUND Protocol 92	x	x	x	x	x	x	x	x	x	
FUND Protocol 2003	x	x	x	x	x	x	x		x	
NUCLEAR Convention 71	x			x	x				x	
PAL Convention 74		x			d		x	x		
PAL Protocol 76		x			d		x	x		
PAL Protocol 90										
PAL Protocol 02	x		x		x	x			x	x
LLMC Convention 76	d	x	d	d	x	x	x		d	
LLMC Protocol 96	x	x	x	x	x	x	x	x	x	
SUA Convention 88	x	x	x	x	x	x	x	x	x	
SUA Protocol 88	x	x	x	x	x	x	x	x	x	
SUA Convention 2005		x		x	x				x	
SUA Protocol 2005		x		x	x				x	
SALVAGE Convention 89	x	x	x	x	x	x	x	x	x	
OPRC Convention 90	x	x	x	x	x	x	x	x	x	
HNS Convention 96						x		x		
HNS PROT 2010										
OPRC/HNS 2000	x	x	x	x			x		x	
BUNKERS CONVENTION 01	x	x	x	x	x	x	x	x	x	
ANTI FOULING 01	x	x	x	x	x	x	x	x	x	
BALLASTWATER 2004	x		x	x				x	x	
NAIROBI WRC 2007	x		x	x					x	
HONG KONG CONVENTION	x									

x=ratification
d=denunciation

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This HELCOM Maritime Assessment 2018 presents
to the reader an overview of maritime activities in the Baltic Sea,
covering developments over time, environmental issues
as well as future perspectives.