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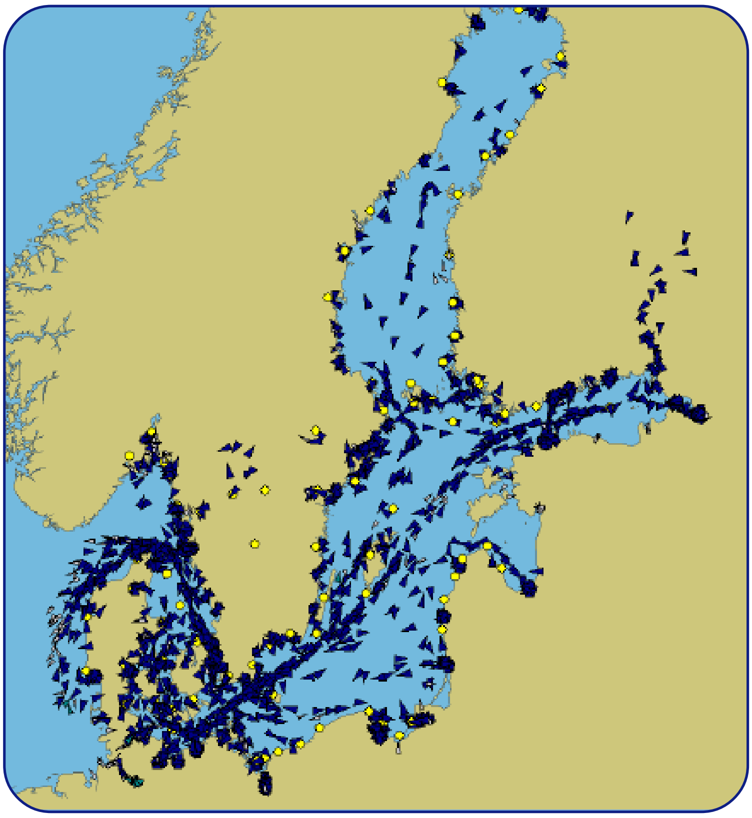

Hanna-Kaisa Huhta, Jorma Rytkönen
& Jukka Sassi

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Abstract

Maritime transport in the Baltic Sea area, and especially in the Gulf of Finland, has changed significantly over the last decade. The new oil terminals in Russia and the economic boom in the Baltic States have resulted in remarkable rise in maritime traffic, mainly tankers and cargo ships. At the same time, the vulnerable nature of the Baltic Sea and the ever-increasing eutrophication has made it necessary to reduce the nutrient load.

The purpose of this study was to estimate the nutrient load from waste waters originating from ships in the Baltic Sea area. The study also includes information about the maritime traffic, waste water management and legislation. The nutrient load originating from pleasure craft was not included in the study.

The estimated nutrient load from ship-generated sewage was calculated, assuming there is no waste water treatment onboard and all waste waters are discharged into the sea. The ship-borne nitrogen load represents approximately 0.05% of the total nitrogen load, and the phosphorus load represents approximately 0.5% of the total phosphorus load both into the Baltic Sea and into the Gulf of Finland. The nutrient load from ships' exhaust gases contributes to 6% of the total atmospheric deposition of nitrogen. The main nutrient load into the Baltic Sea is derived from water-borne inputs and atmospheric deposition.

On the basis of the calculations and references, the nutrient load originating from ships is rather small, but not negligible due to the sensitivity of the Baltic Sea marine environment. The nutrient load is concentrated along the shipping routes and is immediately available for uptake by, e.g., blue green algae, adding to the severe eutrophication of the Baltic Sea.

The nutrient load from ships is much easier to reduce, when compared to the atmospheric emissions or nutrient inputs from land-based sources, by ordering ships to discharge the sewage into the sewer network ashore or by installing waste water purification systems onboard. In the future, it is likely that limits will be set for the concentration of nitrogen and phosphorus in ships' waste waters.

Preface

Since the 1800s, the Baltic Sea has changed from an oligotrophic clear-water sea into a eutrophic marine environment. The Baltic Sea is one of the world's largest brackish water areas and ecologically unique. It is highly sensitive to the environmental impacts resulting from human activities in its catchment area. Eutrophication is a condition in an aquatic ecosystem where high nutrient concentrations stimulate the growth of algae, which leads to imbalanced functioning of the system: intense algal growth means excess of filamentous algae and phytoplankton blooms, production of excess organic matter, increase in oxygen consumption, oxygen depletion and death of benthic organisms, including fish.

Maritime transport in the Baltic Sea area, and especially in the Gulf of Finland, has changed significantly over the last decade. The new oil terminals in Russia and the economic boom in the Baltic States have resulted in a remarkable rise in maritime traffic, mainly tankers and cargo ships. Meanwhile, the customers' environmental awareness has become an important image and competition factor among the ship owners and ports.

This publication, commissioned by the Finnish Ministry of the Environment, the Ministry of Transport and Communications and the Finnish Maritime Administration, includes estimations concerning the nutrient load caused by ship-borne waste waters. In addition to the nutrient load calculations, maritime traffic data, waste water management and legislation information are also provided. The nutrient load originating from ships' waste waters has been evaluated against the atmospheric deposition and water-borne input of nitrogen and phosphorus. The nutrient load originating from pleasure craft was not included in the study.

The progress of the project was closely followed by the steering group, which consisted of the following people and organisations: Mrs. Maija Pietarinen from the Finnish Ministry of the Environment, Mrs. Outi Väkevä from the Ministry of Transport and Communications, Mr. Jorma Kämäräinen from the Finnish Maritime Administration, Mr. Seppo Knuuttila from the Finnish Environment Institute and Mr. Tadas Navickas (replaced by Ms. Monika Stankiewicz) from HELCOM.

The authors would like to acknowledge the Finnish Ministry of the Environment, the Ministry of Transport and Communications and the Finnish Maritime Administration for financing this study, the steering group for support and assistance during the project execution, and all the ports and ship owners who responded to the inquiries for their co-operation.

Espoo 15.2.2007

Authors

Contents

Executive summary

The purpose of this study was to estimate the nutrient load originating from ships' waste waters into the Baltic Sea and into the Gulf of Finland. The required background data was collected utilising various references in addition to inquiries of ship owners and ports.

Due to the low response rate in both port and ship owner inquiries, the number of passengers and the amount of received waste water in relation to the waste water produced onboard could not be reliably defined. However, the inquiry results constitute an average condition of the reception facilities in ports and the received waste water in relation to the number of ship calls.

Since inadequate information was available for the calculations, several assumptions were made. The estimated nutrient load from ship sewage into the Baltic Sea was calculated assuming that no waste water treatment onboard is utilised and all waste waters are discharged into the sea – i.e., a theoretical worst-case scenario. The calculation included cargo ships, cruise ships and passenger/car ferries. Pleasure craft were not included in the calculations since no up-to-date information concerning the nutrient load from pleasure craft was available.

The ship-borne nitrogen load represents approximately 0.05% of the total nitrogen load into both the Baltic Sea and the Gulf of Finland. The phosphorus load represents approximately 0.5% of the total load. The nutrient load originating from ships' exhaust gases contributes to 6% of the total atmospheric deposition of nitrogen in the Baltic Sea area. It should be noted that on the basis of inquiry results, some of the passenger/car ferry companies collect their waste waters onboard and utilise the port reception facilities.

The results indicate that the main nutrient load into the Baltic Sea derives from water-borne inputs and atmospheric deposition. On the basis of the calculations and references, the nutrient load originating from ships is rather small, but not negligible due to the sensitivity of the Baltic Sea marine environment. The nutrient load is concentrated along the shipping routes and is immediately available for uptake by, e.g., blue green algae, adding to the severe eutrophication of the Baltic Sea. It is also anticipated that air-borne and water-borne nutrient loads from ships will be reduced in the future due to state-of-the-art technology implementation onshore and onboard.

The vulnerable nature of the Baltic Sea area and the ever-increasing eutrophication is forcing a reduction in the nutrient load into the Baltic Sea. The nutrient load from ships is much easier to control, when compared to the atmospheric emissions or nutrient inputs from land-based sources. Due to the 'no special fee' system, the Baltic Sea ports have invested in waste reception facilities. However, only some of the shipping

companies utilise these facilities. In the future, new regulations on the discharge of sewage into the Baltic Sea area might be set. These regulations will likely set new discharge criteria for onboard sewage treatment plants concerning the nutrient concentration in discharged effluent.

The growing environmental awareness among customers and ship owners, and the technological innovations, together with public concern, may also create voluntary actions beyond the requirements.

1. Introduction

In recent years the Baltic Sea has suffered from excessive eutrophication caused by the long-lasting air-borne and water-borne nutrient load. The nutrient load has been restricted by setting limits on the discharges from sewage disposal plants. So far, the attempts to diminish the nutrient load into the Baltic Sea have been insufficient, e.g. the blue-green algal blooms are still occurring every summer. Restriction of the external nutrient load is extremely important because all the incoming nutrients only make the eutrophication of the Baltic Sea worse.

One source of the water-borne nutrient load is maritime traffic. According to the MARPOL regulations 73/78 Annex IV, the discharge of sewage into the sea is allowed if the ship is discharging comminuted and disinfected sewage using a system approved by Administration at a distance of more than 3 nautical miles from the nearest land, or sewage which is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land, provided that, in any case, the sewage that has been stored in holding tanks shall not be discharged instantaneously but at a moderate rate when the ship is en route and proceeding at not less than 4 knots, and the ship has in operation an approved sewage treatment plant which has been certified by the Administration. The effluent shall not produce visible floating solids nor cause discoloration of the surrounding water. The public disapproval that arose in Finland after it became known that some shipping companies discharge sewage into the Baltic Sea has particularly affected the passenger ship companies, and most of the passenger ship companies have started to discharge the sewage into the municipal sewer network ashore.

Finland has regarded the above-mentioned MARPOL 73/78 Convention as inadequate in relation to the Baltic Sea's sensitive marine environment. In 2006 Finland made a suggestion at HELCOM for defining the amount of nutrient load originating from ship sewage in the Baltic Sea area. VTT Technical Research Centre of Finland was commissioned to conduct a study of the nutrient load from maritime traffic discharged into the Baltic Sea. In practice, this study is an update of the earlier study made by SSPA Sweden AB in 1994 concerning the discharges of sewage and grey water from passenger ships in the Baltic Sea area. As part of this study, questionnaires on the waste water and passenger amounts were sent to the ports and ship owners in the Baltic Sea area. Approximately one-fourth of the ports and ship owners responded to the inquiry. VTT considers the received data constitutes an average of the conditions in the Baltic Sea area.

2. Nutrient load sources and inputs in the Baltic Sea area

2.1 General

This study covers the Baltic Sea area. For the purposes of the Helsinki Convention and MARPOL 73/78, the Baltic Sea area is defined as the Baltic Sea Proper, with the Gulf of Bothnia, the Gulf of Finland and the entrance to the Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57 degrees 44.8 minutes North. The Baltic Sea area does not include the internal waters of the Coastal States (HELCOM, 1992a). The catchment area of the Baltic Sea is ca. four times larger than the sea area itself and serves as home to some 85 million people. The Baltic Sea catchment area is presented in Figure 2-1.

Figure 2-1. The Baltic Sea catchment area (HELCOM, 2005).

The Baltic Marine Environment Protection Commission (HELCOM) describes the nature of Baltic Sea in the following way: “The Baltic Sea is connected to the North Sea by the narrow and shallow waters of the Sound and the Belt Sea. This limits the exchange of water with the North Sea, and means that the same water remains in the Baltic for up to 30 years – along with all the organic and inorganic matter it contains. The average depth of Baltic Sea is only 53 metres. It contains 21,547 km³ of water and every year rivers bring about 2% of this volume of water into the sea as runoff.” (HELCOM, 2006.)

The Baltic Sea is the largest area of brackish water in the world. Due to the slow rate of natural cleansing and the low salinity level, the Baltic Sea marine ecosystem is very vulnerable to pollution. Only relatively few animal and plant species live in the brackish ecosystems of the Baltic Sea. Some marine and freshwater species are adapted to the brackish conditions, and there are also a few true brackish water species living the Baltic Sea. The Baltic Sea’s special geographical, climatological and oceanographic characteristics make it highly sensitive to the environmental impacts of human activities in its catchment area. Therefore, several protected areas have been established in the Baltic Sea area. These areas include Baltic Sea Protected Areas (BSPA’s), the Convention on Wetlands of International Importance (COWI or Ramsar Convention), UNESCO’s Biosphere reserve areas and the EU’s Bird Directive areas. The Baltic Sea area is also one of the IMO’s particularly sensitive sea areas (PSSA). The protected areas are presented in Figure 2-2. (HELCOM, 2006; Hänninen & Rytkönen, 2004.)

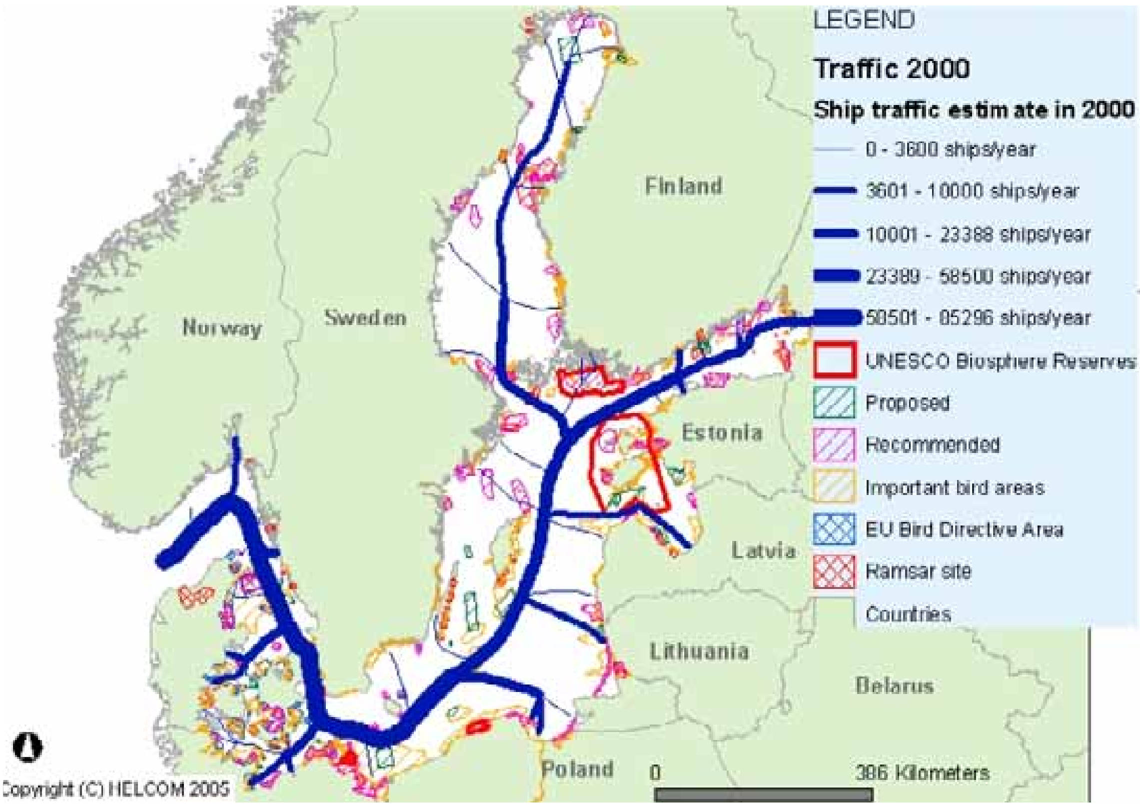

Figure 2-2. Baltic Sea protected areas.

Nowadays, the oxygen-depleted areas are unusually wide in the Baltic Sea. Due to the slow water exchange, excessive external nutrient input and the internal nutrient loading, intense blue-green algal blooms are a common phenomenon in the summertime. The Baltic Sea is also strongly affected by hazardous substances, increased maritime transport and fisheries. The major part of the pollution originates as water-borne from land-based sources. Other sources of pollution are atmospheric deposition and maritime traffic. (BMEPC, 1990; Hänninen & Rytkönen, 2004.)

The ship-based pollution is released either accidentally or deliberately. Oil and chemical spillages can create severe acute problems for the marine life. Chemical spillages can also cause danger to human health. Sewage discharges from ships disappear quicker from the water surface, but they are no less harmful than oil and chemical discharges. Human sewage can carry enteric bacteria, pathogens, diseases, viruses, the eggs of intestinal parasites and harmful nutrients. Grey water also contains pollutants such as faecal coliform, food waste, detergents, oil, grease, shampoos, cleaners, pesticides and heavy metals. Ingesting contaminated fish or direct exposure to water contaminated with sewage pose health risks for humans. Discharges of untreated or inadequately treated waste water from ships can cause bacterial and viral contamination of commercial and recreational shellfish beds, producing serious risks to public health. (The Ocean Conservancy, 2002.)

The eutrofying plant nutrients nitrogen and phosphorus are a significant part of the waste water. The quantity of nitrogen in the sewage water is 12–15 g/person/day. The quantity of phosphorus in the sewage water is remarkably lower than the quantity of nitrogen. Nowadays, the usual amount of phosphorus is between 3–5 g/person/day. (RIL, 2003.)

Nitrogen and phosphorus are among the main growth-limiting nutrients in aquatic ecosystems, and, as such, do not pose any direct hazards for the marine organisms. Eutrophication, however, is a condition in an aquatic ecosystem where high nutrient concentrations stimulate the growth of algae, which leads to an imbalanced functioning of the system (RIL, 2003):

- intense algal growth: excess of filamentous algae and phytoplankton blooms
- production of excess organic matter
- increase in oxygen consumption
- oxygen depletion
- death of benthic organisms, including fish.

2.2 Pathways, sources and amounts of nutrient input

The main pathways of the nutrient input are the following (HELCOM, 2005):

- Direct atmospheric deposition on the sea surface.
- River inputs to the sea. Rivers transport nutrients that have been discharged or leached to inland surface waters within the Baltic Sea catchment area.
- Point sources discharging direct to the sea.

Nitrogen enters the Baltic Sea either as air-borne or water-borne inputs; phosphorus mainly as water-borne.

The different sources for the inputs of nitrogen and phosphorus are shown in Figure 2-3:

- Atmospheric emissions of nitrogen compounds from traffic or combustion of fossil fuels (heat generation), and from animal manure and husbandry, etc.
- Point sources, including inputs from municipalities, industries and fish farms, both discharging into inland surface waters and directly into the Baltic Sea.
- Diffuse sources, which mainly originate from agriculture but also include nutrient losses from, e.g., managed forestry and scattered dwellings.
- Natural background sources, mainly referring to natural erosion and leakage from unmanaged areas, and the corresponding nutrient losses from, e.g., agricultural and managed forested land that would occur regardless of human activities.

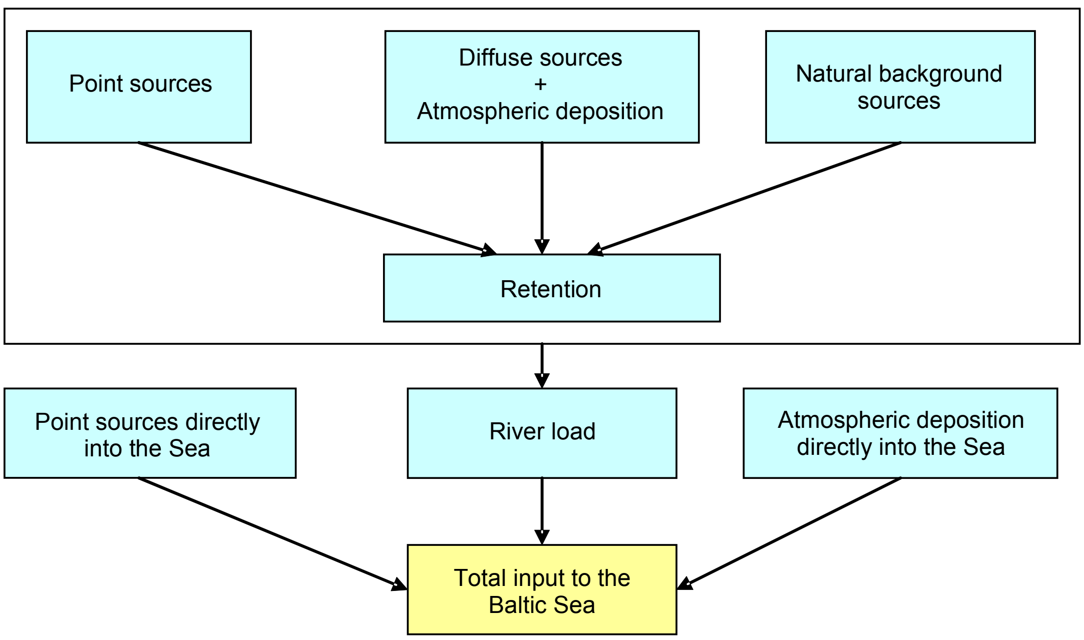

Figure 2-3. Sources of nutrients within the Baltic Sea catchment area (HELCOM, 2005).

In 2000 the atmospheric deposition of nitrogen amounted to 264,100 tonnes, and the total water-borne input of nitrogen was 744,900 tonnes. Thus the total input of nitrogen into the Baltic Sea was 1,009,000 tonnes (HELCOM, 2005).

The inputs of air-borne nitrogen have decreased recently. In 2003 the atmospheric supply of nitrogen was 217,000 tonnes. In 2004 the total water-borne load of nitrogen entering the Baltic Sea amounted to 502,000 tonnes. No data was submitted from Russia and Latvia for 2004 (Knuuttila, 2005).

About 75% of the nitrogen entered the Baltic Sea as water-borne input and 25% as air-borne input. Diffuse loading, mainly from agriculture and managed forestry, contributed almost 60% of the water-borne inputs to the sea, 28% entered from the natural background sources and 12% came from point sources.

Phosphorus mainly enters the Baltic Sea as water-borne input, but it can also enter as atmospheric deposition. However, it has been estimated that the air-borne contribution is only 1–5% of the total phosphorus input. The total phosphorus input was 34,500 tonnes in 2000. In 2004 the total phosphorus load was 22,500 tonnes, but no data was submitted by Russia and Latvia.

Concerning the phosphorus input, diffuse loading contributed nearly 50% of the total waterborne phosphorus inputs to the sea. Point sources and natural background sources each contributed approximately 25% of the phosphorus input (HELCOM, 2005).

The proportion of sources contributing to phosphorus inputs into the Baltic Sea sub-regions in 2000 is presented in Figure 2-4.

A large proportion of the nutrient loads originate far away from the sea, and even from outside the HELCOM area. Many processes occur after nutrient input into the catchment area, which affect their final input to the Baltic Sea. Rainfall and subsequent river run-off, as well as groundwater inflow to inland surface waters, are controlling factors that determine the final amounts of nutrients entering the Baltic Sea. Biological, physical, morphological and chemical factors also retain and/or transform nutrients within river systems.

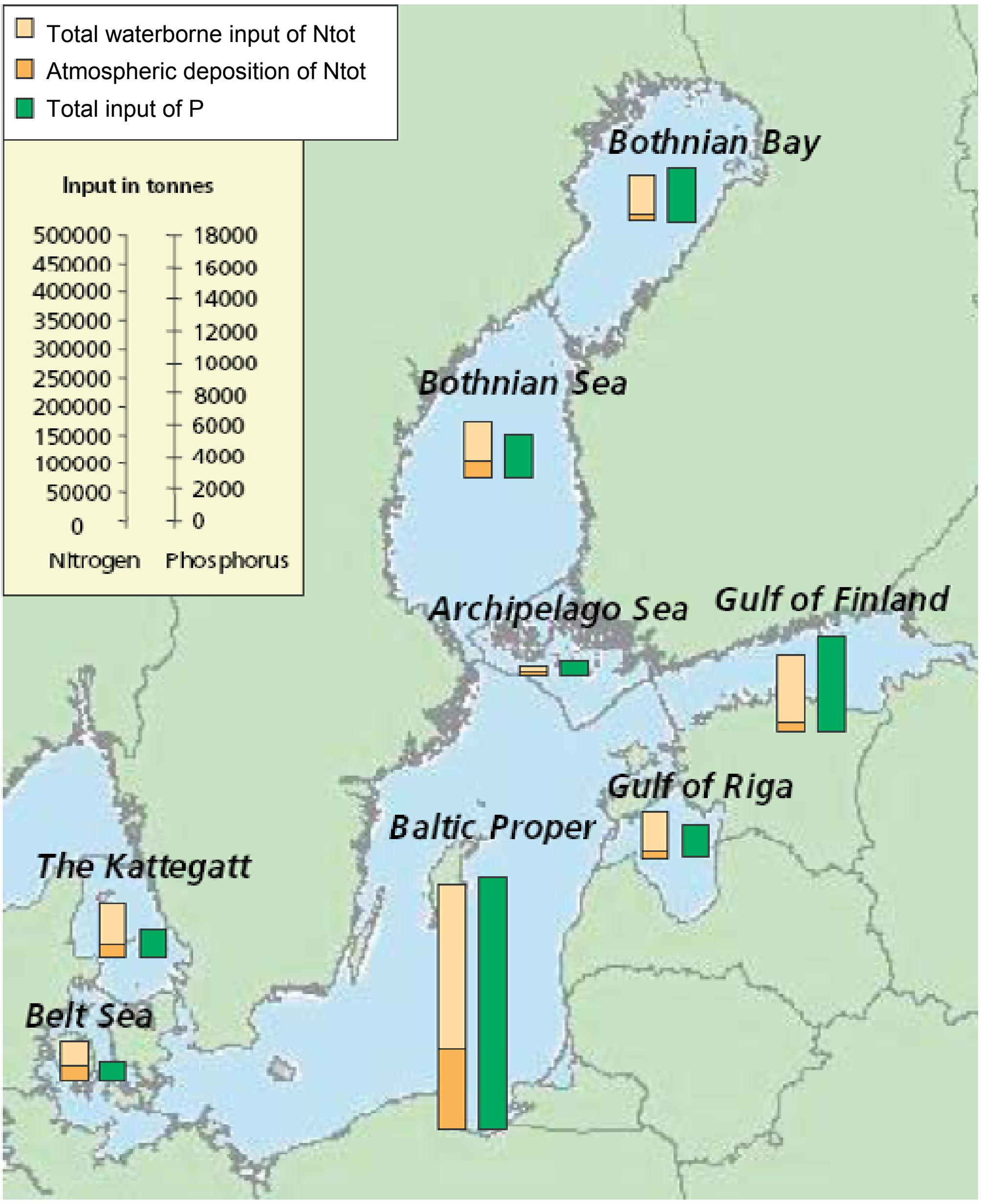

Figure 2-4. Proportion of sources contributing to phosphorus inputs into Baltic Sea sub-regions in 2000 (HELCOM, 2005).

Another cause of increased nutrient levels in the sea, especially in the case of phosphorus, is the "internal load": phosphorus reserves accumulating in the sediments on the sea bed are released back to the water under anoxic conditions (HELCOM, 2005).

High nitrate concentrations are still prevalent in the Bothnian Bay, the Gulf of Finland, the Gulf of Riga, the Pomeranian Bay, the Belt Sea and the Kattegat (Figure 2-5). Concentrations of both nitrogen and phosphorus have increased in deep waters (HELCOM, 2006).

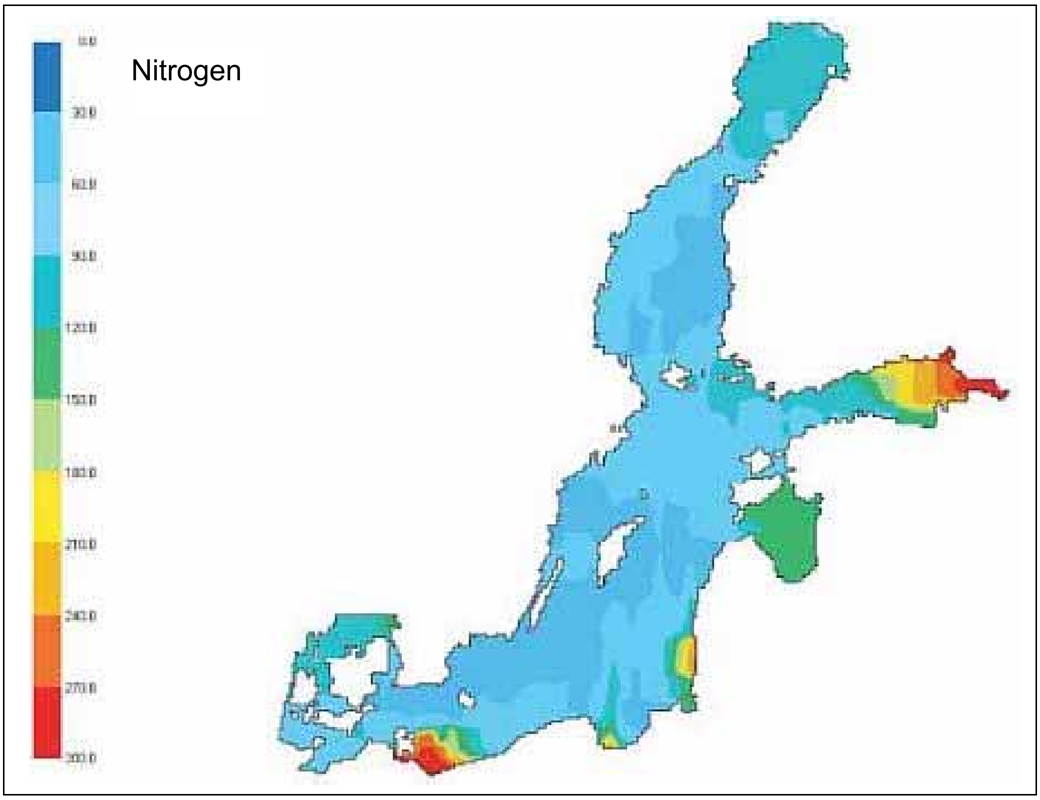

Figure 2-5. Regional distribution of nitrate nitrogen (µg/l) in the surface water, January–February 2000 (HELCOM, 2006).

In general, nutrient concentrations in the Baltic Sea have not decreased since the assessment period 1994–1998; instead, they have increased or remained persistently high. But, from a longer-term perspective, different trends can be seen. Winter surface concentrations of dissolved inorganic nitrogen compounds (nitrate + nitrite) have decreased significantly since 1980, but only in the northern Baltic Proper (HELCOM, 2006).

3. Maritime traffic in the Baltic Sea area

3.1 Traffic data collection

Traffic data was requested from harbours and ship-owners that operate in the Baltic Sea area. All the major harbours were contacted directly or via national port associations (Appendix 1). The following information was requested from each port (Appendix 2):

- number of passengers annually (latest available data)
- number of ship calls annually, divided in different ship types (passenger ships, oil tankers, bulk carriers, etc.)
- amount of received waste waters (black water and grey water separated)
- reception facilities for waste waters.

In addition to the Finnish ports, 9 ports from Estonia and Russia, 4 ports from Latvia, 3 ports from Poland, 2 ports from Lithuania, 20 ports from Denmark, 7 ports from Germany and 38 ports from Sweden were contacted and asked for the same information. A total of 29 answers were received, which means that only approximately 26% of the ports replied to the inquiry. The answers were received from ten cargo ports and 19 passenger ports. A summary of the responses is presented in Appendices 5 and 6.

In most of the ports the amount of received waste water compared to the number of ship calls was considerably smaller, as can be seen in Figure 3-1. The cargo ports had not received sewage in 2005 and only the biggest passenger ports had received waste water.

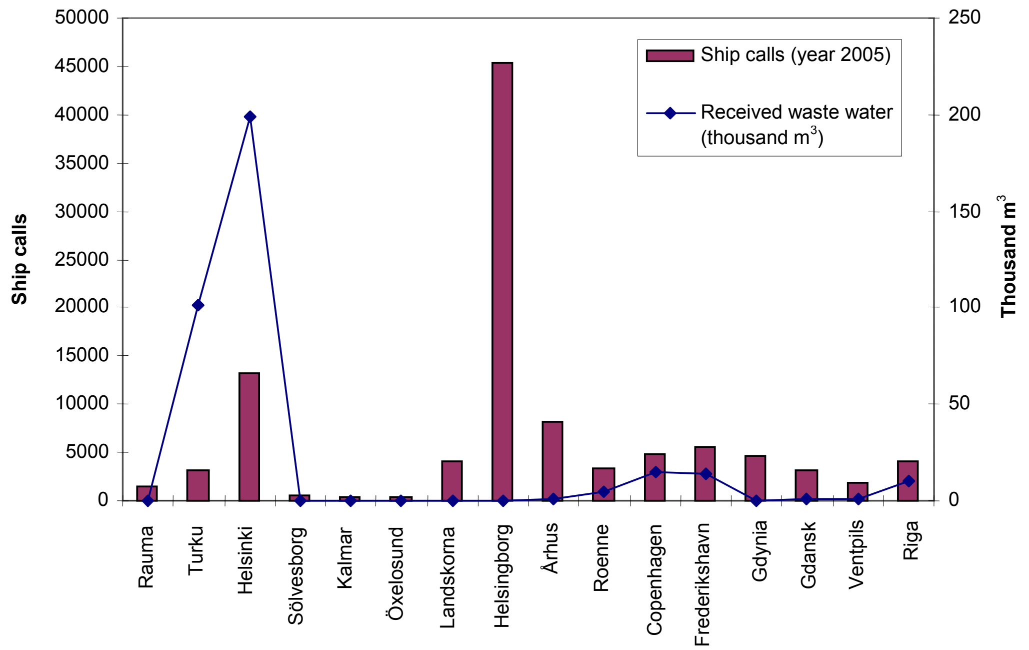

Figure 3-1. Received waste water and ship calls in 2005.

In most of the cargo and passenger ports the waste water from the ship is pumped to a tank truck. In some of the Finnish and Swedish passenger ports the sewage can be discharged directly into the sewer network. Of the 29 ports that replied, three Swedish ports announced that they do not have waste water reception facilities.

The ship-owners (Appendix 3) received the inquiry (Appendix 4) with the following questions:

- total number of passengers annually (year 2005) for different routes in the Baltic Sea area
- amount of waste waters (both black and grey) per person per journey
- average time for one journey (if you operate several routes, average time for each route)
- type of waste water treatment technology for black and grey waste waters utilised onboard your ships.

The inquiry was sent to 16 shipping companies in Finland. Because the contact information for foreign shipping companies was not known, the inquiry was sent to the ship owner's associations in Sweden, Denmark and Germany, and the port authorities in Russia, Estonia, Latvia, Lithuania and Poland. The port authorities and ship owners' associations were asked to forward the questionnaires to the shipping companies. The number of replies was quite low. The information was received from three shipping companies in Finland and three shipping companies in Denmark. No answers were received from companies that transport cargo. A summary of the responses is presented in Appendix 7.

The relationship between the travel time and waste water production on the basis of the inquiry is presented in Figure 3-2. The amount of sewage per passenger increases as the duration of the journey becomes longer. However the waste water production is not directly proportional to the travel time.

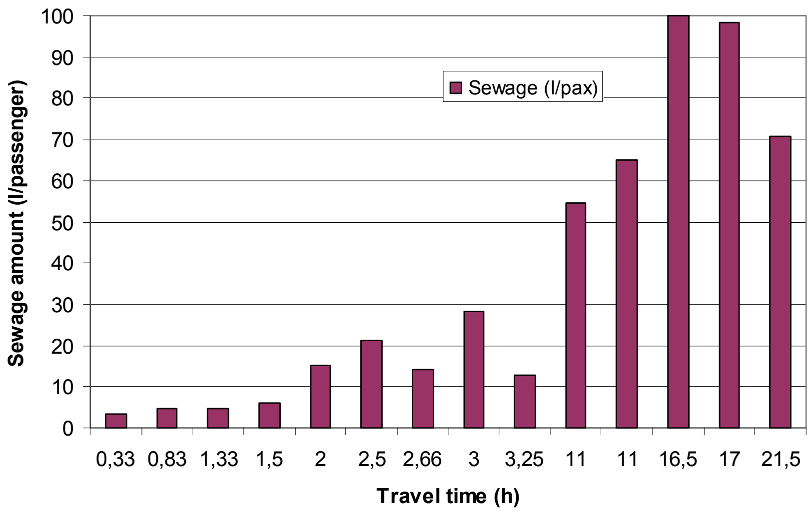

Figure 3-2. Waste water production vs. travel time.

The sewage production increases considerably when the travel time exceeds ten hours. This is due to the fact that there are passenger services, e.g. day spas and hairdressers, on the longer routes that increase the water consumption and hence the amount of waste water.

The MARPOL 73/78 Convention demands that every ship shall be equipped with one of the following systems:

- a sewage treatment plant
- a sewage comminuting and disinfecting system for the temporary storage of sewage when the ship is less than three nautical miles from the nearest land
- 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 shipping companies that did reply, waste water is not treated onboard. The passenger ferries that operate between the Danish straits and the passenger/car ferries that operate in the Gulf of Finland discharge sewage into the sewer network ashore. One shipping company reported that some chemicals are added to the sewage to prevent the formation of sulphuric hydrogen and their vessels are equipped with the chemical or biological waste water treatment plants, which are not operational but are on standby.

3.2 Present situation

The main ports for passenger and cargo traffic in the Baltic Sea are presented in Figure 3-3. The main flow of cargo traffic follows the Swedish coastline and turns east towards the Gulf of Finland and St. Petersburg on the eastern side of Gotland. Other cargo flows are directed to the Gulf of Bothnia and the ports of Riga, Gdansk and Klaipeda. The busiest passenger routes in the Baltic Sea area are the route across Öresund between Helsingborg and Helsingör with 10 M passengers per year, the route across Fehmarn Bælt between Rödby and Puttgarden with 7 M passengers, the route from Stockholm to Finland and between Finland and Estonia with 7 M passengers, and the route between Göteborg and Fredrikshavn with 2 M passengers (Figure 3-4). The routes from Sweden to Estonia, Lithuania and Poland have increased significantly in recent years, in both capacity and transportation; for example, there are more than 400,000 passengers per year on the route between Karlskrona and Gdynia (Baltic Maritime Outlook, 2006).

According to the statistics for 1998 the ten biggest passenger ports in the Baltic Sea were Helsingborg, Helsingør, Stockholm, Helsinki, Tallinn, Malmö, Göteborg, Fredrikshavn, Turku and Copenhagen. At that time, 35% of the 80 million annual ferry passengers recorded in Baltic Sea Region ports were going through the two ports of Helsingborg and Helsingør. In 2000 the biggest passenger ports were Helsingborg, Helsingør, Stockholm, Helsinki, Tallinn and Turku (Hanell et al., 2000).

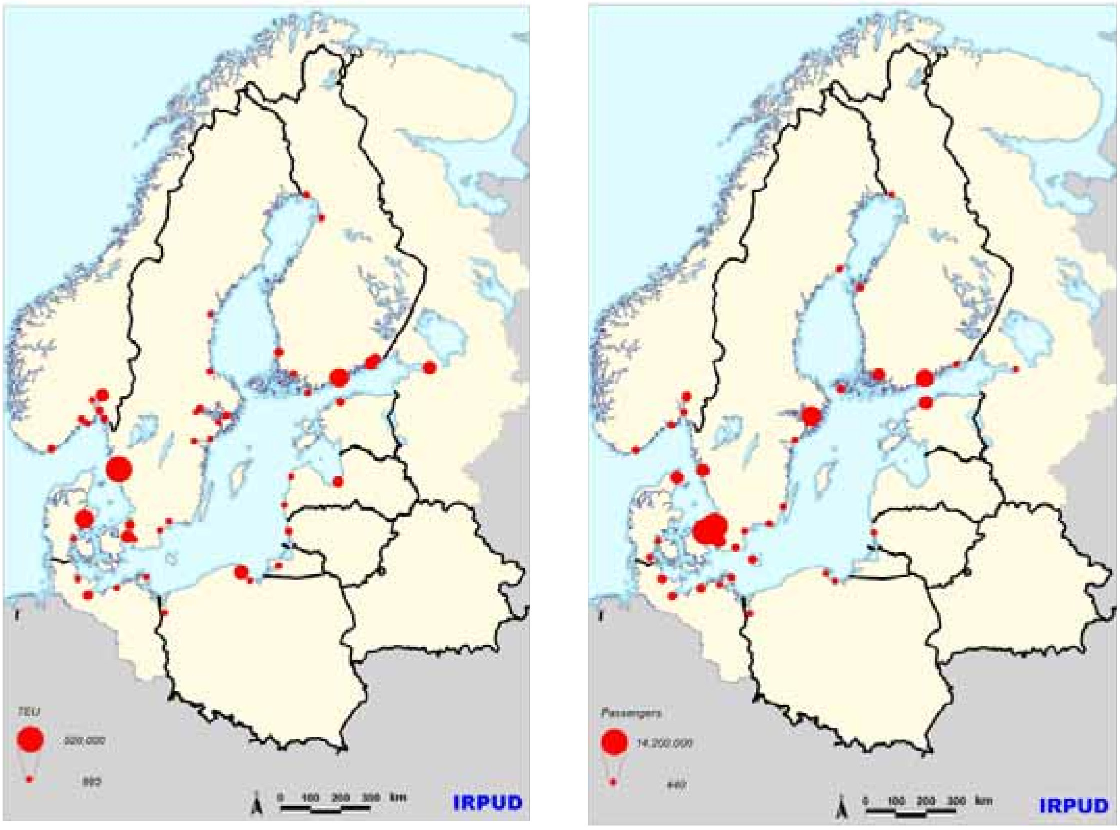

Figure 3-3. Container traffic (left) and passenger traffic (right) in the Baltic Sea area in 2000 (Hanell et al., 2000).

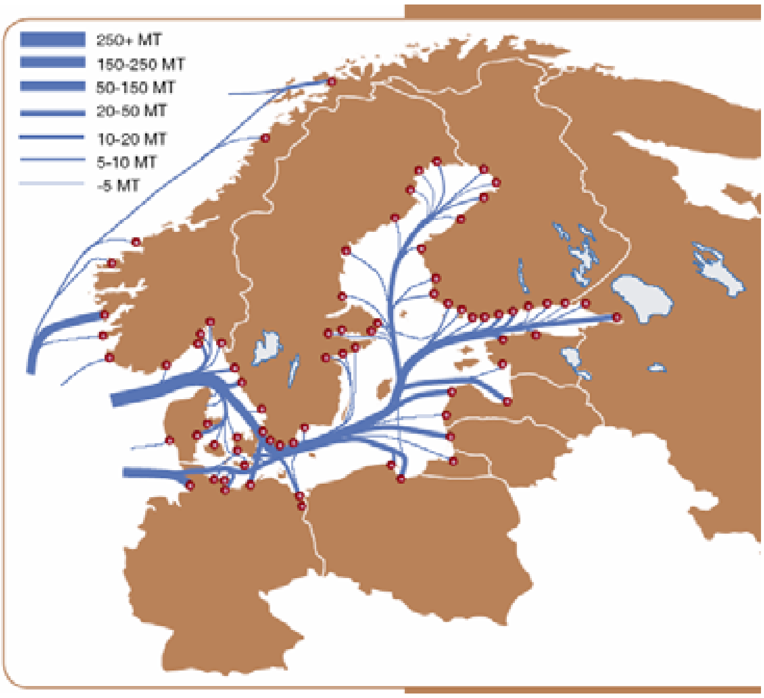

Figure 3-4. Passenger traffic and cargo routes in the Baltic Sea area in 2003 (Baltic Maritime Outlook, 2006).

In 1993 it was concluded that around 70 million passengers travelled on ferries in the Baltic Sea area, and that was regarded as a low estimate (SSPA, 1994). On the other hand, Wickens et al. (1994) estimated the number of passengers in the Baltic ferry traffic to be around 61 million. The Swedish Maritime Administration have estimated that a little more than 235,000 trips were made by ferries and a total of about 53 million passengers were transported in 1998 (SMA, 1999). Hanell et al. (2000) concluded that, based on the 1998 figures, the number of passengers in the top 20 harbours was around 87 million.

The figures in Table 3-1 represent the number of passengers in the various ports based on the figures presented in the references and the data received from ports during the execution of the project.

Table 3-1. The number of passengers in various ports in the Baltic Sea area.

Port	**Number of passengers**		
	Ref.: Hanell et al., 2000[1]	Ref.: Kalli et al., 2005[2]	Information received from ports (2005 Figures)
Helsingborg	14,200,000		11,102,138
Helsingør (in 1997)	13,657,000		
Stockholm	9,300,000	9,643,000	10,900,000[3]
Helsinki	8,620,000	8,685,000	9,067,000
Tallinn	5,441,000		7,007,558
Malmö	5,300,000		
Gothenburg	4,600,000		
Fredrikshavn	4,305,000		2,930,093
Turku	4,229,445	4,101,577	3,770,000
Copenhagen	4,202,181		1,504,773
Oslo	2,493,000		
Kiel	2,100,000		
Rostock	1,813,450	2,160,000	
Rønne	1,379,521		1,560,000
Lübeck	1,300,000	371,547	
Kristiansand	1,117,551		
Marienhamn	-	1,100,000	
Ystad	1,000,000		
Sassnitz-M	997,230		761,008
Szczecin and Świnoujście	-	807,580	
Vaasa	820,040		90,000
Larvik	713,000		
Total	**87,588,418**		

[1] Figures for 1998.
[2] As an average number for the years 2001–2003.
[3] Figures for 2004, excluding the traffic in the archipelago.

When the inquiry results are compared to the statistics presented by Hanell et al. (2000) and Kalli et al. (2005), it can be seen that in most of the ports the passenger numbers have decreased during recent years. The passenger numbers in Hanell's et al. report represent the situation in the late 1990s, when tax-free shopping between Scandinavian countries was still possible on a voyage. The EU ended the tax-free shopping on internal traffic on 1.7.1999, which can clearly be seen to have affected the passenger numbers. In addition, it is likely that the commission of the Great Belt Fixed Link between the Danish islands of Zealand and Funen across the Great Belt in 1998 also affected the passenger numbers, at least in Helsingborg, Helsingør, Copenhagen and Malmö.

On the other hand, the passenger numbers in Tallinn, Helsinki, Stockholm and Rostock have increased. One reason for this is the lower price level in Estonia and the release of alcohol importation after Estonia joined the EU in 2004. The increase in passenger numbers in the port of Rostock is probably due to the ferry connection from Hanko; the route opened in 2001 and car/passenger ferries operate daily between Hanko and Rostock.

An example of the ship type distribution in ports in the four Baltic Sea areas is presented in Figure 3-5.

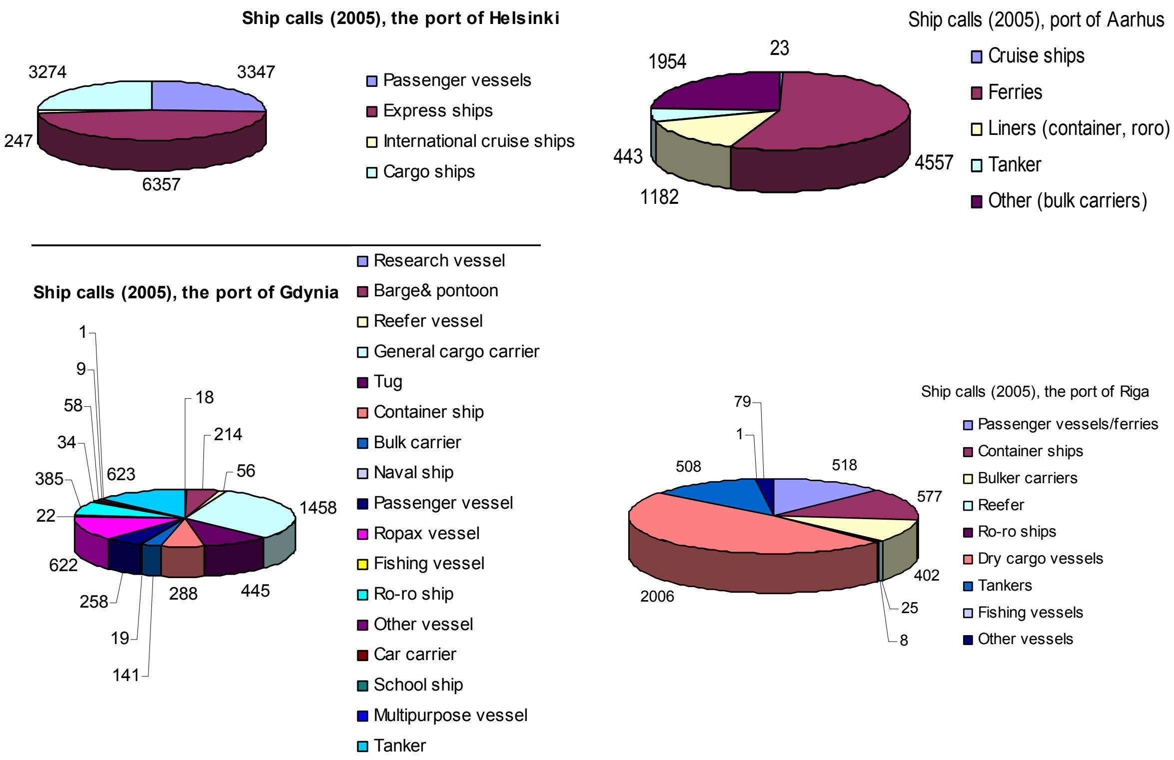

Figure 3-5. Example of ship type distribution in the Baltic Sea ports.

The maritime transport in the Baltic Sea region is directed from the northern ports to Germany. In 2003 the maritime transport in the Baltic Sea area totalled 178 M tonnes. Dry bulk was the largest commodity (75 M tonnes), followed by liquid bulk (62 M tonnes) and other cargoes (41 M tonnes). The oil and container trades are the fastest growing segments in the Baltic Sea area maritime transport (Baltic Maritime Outlook, 2006).

4. Waste water management

4.1 Origin

Waste waters can be divided into oily and non-oily waste waters. Oily waste waters originate from engine rooms and machinery spaces, e.g. pump rooms. Oily waste water handling is regulated by the bilge water regulations in Annex I to the MARPOL 73/78 Convention. Oily waste waters are not included in this study.

Non-oily waste waters are divided into other non-contaminated drains and contaminated, “sewage type” waste waters. The non-contaminated waste waters are drainage waters from exposed deck scrubber systems, dedicated sprinkler drainage systems, AC room condensation collecting system, etc. These non-contaminated waste waters are also left out of this study (Salama, 2005).

The sources of contaminated waste water on board ships are basically the same as in communities ashore. Annex IV to the MARPOL 73/78 Convention defines “Sewage” in the following way:

- 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
- other waste waters when mixed with the drainages defined above (for example a mix of sewage and grey water).

Sewage is also called black water and the discharge of ship sewage is restricted on the basis of the MARPOL 73/78 Convention. Sewage on board ships differs from that of municipalities by its short retention time and smaller water content. Onboard ship, the sewage ends up almost directly in the treatment plant; therefore the amount of dissolved BOD is lower than in municipal systems and the cleaning process is easier. The smaller water volume of the sewage onboard ship makes it more concentrated when compared to the municipal sewage. (BMEPC, 1990; The Ocean Conservancy, 2002.)

Grey water consists of non-sewage waste water, including drainage from dishwashers, showers, laundry, baths, galleys, and washbasins. Grey water represents the largest category of fluid waste generated by cruise ships. The discharge of grey water is not restricted by international law and in some cases it is discharged directly into the environment. However, in certain sea areas and during berthing the sewage and grey water must be stored or treated. (BMEPC, 1990; The Ocean Conservancy, 2002.)

The amount of waste water depends on the ship type. Passenger/car ferries usually leave the sewage ashore daily, so the storage of sewage on board does not cause remarkable problems. On the other hand, cruise trips typically last for seven days and during that time waste has to be processed in such a way that environmental hazards are avoided and the orders of the authorities are fulfilled (Saari, 2005). When compared to passenger ships, ro-ro-passenger (ropax) vessels have very modest sewage treatment systems. The ship owners' decision to discharge sewage into a port reception facility or to discharge black waters directly into the sea is based on the most economical way to fulfil the MARPOL requirements (Salama, 2005).

4.2 Quantity estimations

The quantity of black water (flush water excluded) can be estimated as 1.8 l per person per day. If the quantity of flush water is 10 litres at a time (gravitation system), the black water amounts to some 70 litres per person/day. The flux of the water varies considerably and the difference may range from 10 to 200 litres per person/day, depending on the sewage system. The smallest amount of waste water is gained with vacuum sewage systems, which generally produce 12 litres black water per person/day (BMEPC, 1990). The ocean conservancy has estimated the cruise ship black water production to range from 19 l to 38 l per person/day. (The Ocean Conservancy, 2002.)

Grey water amounts to approximately 120 litres per person/day (BMEPC, 1990). The ocean conservancy has estimated the cruise ship grey water production to range from 114 l to 322 l per person/day (The Ocean Conservancy, 2002).

Some estimates of waste water generation have been presented in Salama (2005):

- toilet flush (gravity feed): 6–8 litres per flush
- toilet flush (vacuum feed): 1.2 litres per flush
- 1 min. shower: 12–14 litres
- total daily grey water accumulation: < 300 litres per day per person
- total daily galley and laundry accumulation: < 70 litres per day
- total daily black water accumulation in vacuum system: < 20 litres per day per person (Salama, 2005) or 8–12 litres per day per person (Bachér, 2001)
- in large cruise ships the vacuum system produces 20–30 m^3 black water per day (Bachér, 2001).

HELCOM Recommendation 11/10 gives guidelines for the capacity calculation of sewage systems onboard passenger ships (HELCOM, 1990). The total flushing systems used onboard ships are the conventional system and the vacuum system. The capacity calculations apply to passenger ships engaged in voyages with a length of more than 24 hours. They are based on the flow rate in litres per day per person. The calculations are presented in Table 4-1.

Table 4-1. Capacity calculations for sewage systems onboard passenger ships (HELCOM, 1990).

	Litres per person per day	
	Conventional system	Vacuum system
Sewage (black water)	70	25
Sewage and grey water	230	185

When compared to a municipal sewage treatment plant, the sewage that is treated onboard has a short retention time. The sewage load onboard can also vary considerably. In cruise ships the sewage loads are generally biggest in the morning and in the evening. These variations are balanced out by using holding tanks and dimensioning the treatment plants sufficiently large enough. The capacity of the holding tank is calculated using the following equation:

$$Cr \geq A \cdot Np \cdot Da, \qquad (1)$$

where

- Cr = capacity of the holding tank (m^3)
- A = 0.06 (m^3/person/day), value of A may reduce according to the flushing system, etc.
- Np = the total number of people on board
- Da = the maximum number of days operating in areas where the discharge of sewage that is not comminuted or disinfected into the sea is prohibited (minimum 1 day).

4.3 Treatment options onboard ships

Sewage can be processed with three principal methods: mechanical, chemical and biological. The treatment of sewage includes the following stages (Kiukas, 2005):

1. waste water accumulation and management
2. waste water pre-treatment
3. waste water oxidation
4. waste water clarification and filtration
5. waste water disinfection
6. sludge treatment.

The sewage treatment is usually a combination of the three principal methods, such as mechanical-chemical, mechanical-biological and chemical-biological. The choice of method depends on the purification aims and operating conditions (BMEPC, 1990). The estimates of the reductions in the BOD and phosphorus concentration for different types of treatment plants are presented in Table 4-2.

Table 4-2. The reduction estimates for different treatment types (BMEPC, 1990).

	Reduction in BOD	Reduction in phosphorus
Biological plant	80–95%	20–40%
Chemical plant	50–70%	75–90%
Simultaneous thickening	90–98%	75–90%
Physical sedimentation	20–30%	5–10%

An example of a combined biological and chemical disinfecting system is presented in Figure 4-1.

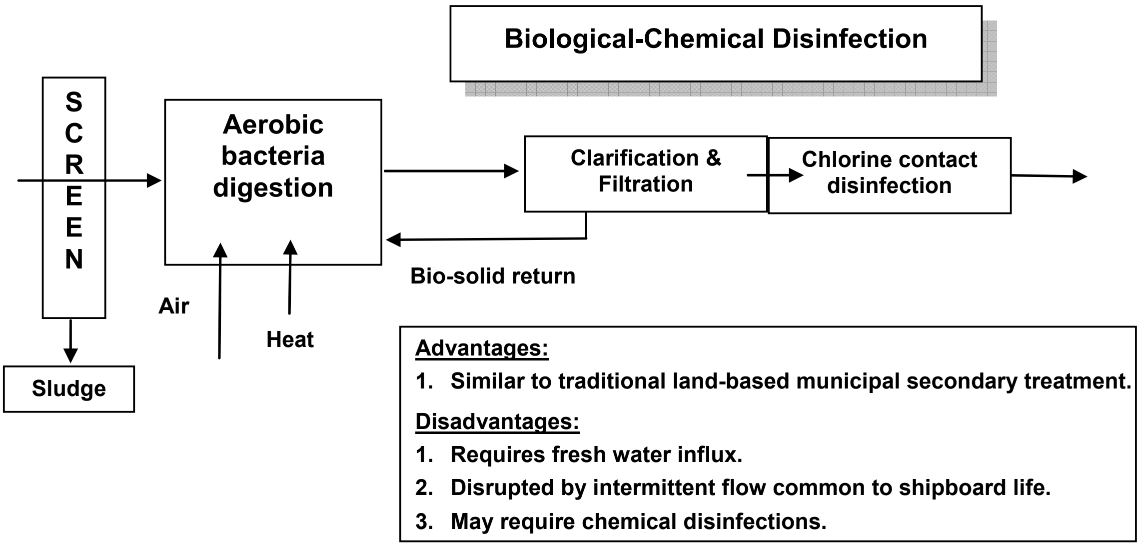

Figure 4-1. Simplified schematics of a biological-chemical disinfection (Eley & Morehouse, 2003).

Resolution MEPC.2 (VI) gives recommendations on international effluent standards and guidelines for performance tests for sewage treatment plants. The sewage treatment plant has to satisfy the effluent standards for its certificate of type test. The effluent standards include a faecal coliform standard, suspended solids standard and biochemical oxygen demand (BOD_5) (Resolution MEPC.2, 1976). In some cases even the amount of residual chlorine is restricted (Alaska waste water regulations). The MEPC.2 (VI) resolution standards for waste water quality are following:

- BOD_5: 50 mg/l
- TSS: 100 mg/l (shipboard test)
- Faecal coliforms: 250 cfu/100 ml.

It should be noted that the removal of nitrogen and phosphorus is not required. In the future, the limits for marine waste water discharge may become closer to the land-based criteria. It is possible that the nitrogen and phosphorus concentration of discharged waste water will be limited.

The shipboard sewage treatment plant should be small, simple, reliable and have moderate running costs. The treatment plant should function well in all waste water concentrations and during flow peaks. The plant should be also easy to maintain and operate, and fulfil current purification requirements. The plant operation highly depends on the technical personnel and the sewage being cleaned.

4.3.1 Waste water pre-treatment

Wastewater pre-treatment protects the other phases of the purification process. Sewage contains a lot of solid waste and grease that may cause problems in the later stages of the process. The pre-treatment process reduces the amount of solids in the waste water. Effective wastewater pre-treatment also reduces the need for oxidation (Kiukas, 2005). The pre-treatment is mechanical and consists of sieving and sedimentation units. The large particles pass through a shredding pump before sieving (BMEPC, 1990).

4.3.2 Oxidation

The mechanical filtering results in a maximum of 50% reduction in organic load. The remaining organic compounds have to be oxidized, either chemically or biologically.

Certain chemicals, e.g. ozone, chlorine, hydrogen peroxide, are added to the sewage in the chemical oxidation. The chemicals oxidize the organic impurities in the sewage water. When compared to the ozone and hydrogen peroxide, chlorine is not a very environmental friendly oxidant because of the carcinogenic compounds that develop as a by-product of the reaction. The added chemicals have an impact on the organic matter that has dissoluted slightly and the BOD reduction remains small. The estimated treatment results for reduction in BOD and phosphorus are good. (BMEPC, 1990.)

Chemical oxidation is utilized in the macerator-chlorinating system that is used in the Unites States. The macerator-chlorinating system reduces bio solids through oxidation, dilutes the effluent with ambient seawater, and disinfects the sewage water with the help of an "electro catalyst" process. (Figure 4-2.)

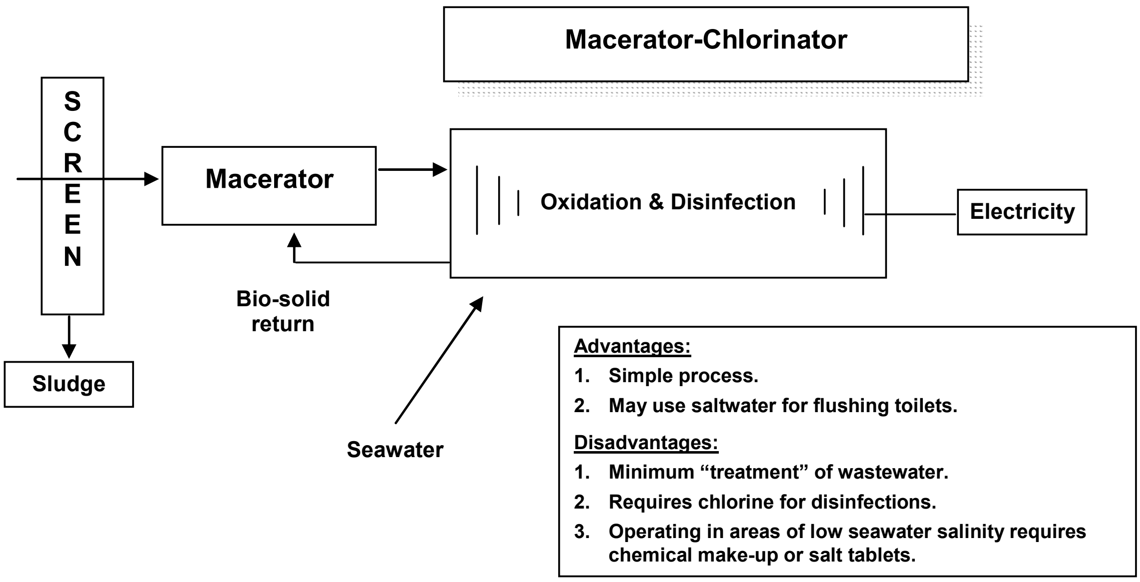

Figure 4-2. Simplified schematics of a macerator-chlorinator system (Eley & Morehouse, 2003).

The "electro catalyst" process produces sodium hypochlorite disinfectant from the salt in the seawater. Some operators add chlorine to the contact tank to ensure that the disinfection is complete. This "over-chlorination" results in high levels of residual chlorine in the discharge, which is lethal to marine organisms. (Eley & Morehouse, 2003.)

In the biological treatment the micro-organisms use the impurities in the sewage as their nourishment. There are several types of bioprocesses and the most common biological process is the active sludge treatment plant, where the sewage is mixed in a continuous-action aeration tank with active sludge. Biological filters and biorotors are also used as biological treatment plants. In these devices the bacteria that destroy the impurities attach to the filtering material. The biological treatment system is the most efficient way of reducing the BOD load. The estimated reduction in BOD is 80–95% and the reduction in phosphorus is 20–40%. The effectiveness of the bioprocess depends on the amount of active biomass and the bacteria living conditions. No additives are needed in the biological oxidation and the amount of sludge is small. The disadvantages of biological treatment are the long starting period and its sensitivity to external disturbances. The reasons for malfunction of the biological system are the following:

- Strong chemicals that have got into the plant are destroying the bacteria.
- Bacteria die due to the lack of oxygen when the ventilation does not work.
- The return of active sludge does not work.

When compared to the active sludge filter, the biofilters and biorotors are smaller in size, easier to start up, and recover from toxic shocks better. In addition, they have less energy consumption, better sludge sedimentation characteristics and better sustained loading variations. (BMEPC, 1990.)

4.3.3 Clarification and filtration

After oxidation, the sludge is separated in a sedimentation tank and returned to the aeration tank. Separating the active biomass, sediment particles and bacteria from the water is a critical phase in the wastewater purification process. The clarification and filtration processes used in the ships are membrane filtration, dissolved air flotation (DAF) and settling. (Kiukas, 2005.)

The DAF system relies on the injection of microscopic air bubbles into the feed water stream, causing the particles to float on the surface of a basin with inclined settling plates, from which they are continuously skimmed off and removed with a wastewater stream. It is useful when treating waters that are high in total suspended solids (TSS) or have highly variable suspended solids content. (Ionics Incorporated, 2005.)

4.3.4 Disinfection

The last phase in the wastewater purification process is disinfection. Depending on the previous treatment method, the disinfection enhances the quality of the wastewater or is an essential part of the purification process.

When the membrane clarification and filtration is used, the disinfection is performed with UV-light. If the water is very turbid, the UV-light is not suitable for disinfection. The other potential disinfectants are, for example, chlorine, radicals and ozone. With the help of these disinfectants it is possible to enhance the water purity even more. (Eley & Morehouse, 2003; Kiukas, 2005.)

4.3.5 Sludge treatment

The sludge production depends on the treatment process. Effective pre-treatment before the bioreactor reduces the sludge production and enhances the sludge drying. The sludge that comes straight from the process is centrifuged. The centrifugal treatment raises the dry-substance concentration to 17–27%, compared to the before treatment dry substance concentration of 2–3%. After the decanter centrifuge, the possible sludge handling techniques are holding, incinerator, steam dryer, filter press or an alternative sludge conditioning process so that combustion is possible. (Kiukas, 2005.)

4.3.6 New technologies for waste water purification

It said that the wastewater standards have distorted the development of treatment plants. Some plants collect sludge but do not destroy wastes. In the future the focus will be on systems that destroy wastes. Such systems could be purification through oxidation, chemical methods combined with sludge destruction, or biological-chemical methods such as simultaneous sedimentation. The advantages of biological-chemical treatment are a small amount of sludge, increased plant functionality and a good overall cleansing result. However, no method has proved so superior as to surpass the other methods. (BMEPC, 1990.)

Some treatment system manufacturers have provided advanced wastewater purification (AWP) systems that are designed to result in effluent discharges that are of a high quality and purity. Effluents meeting these high standards would not be subjected to the strict discharge limitations. AWP systems are at the development stage when it comes to performance and treatment costs (Saari, 2005; Salama, 2005). Generally advanced treatment systems utilize enhanced aerobic digestion with physical filtration to clean shipboard waste water. Other advanced treatment techniques are chemical treatment and mechanical decanting (Eley & Morehouse, 2003).

Moving bed bioreactor (MBBR) and flotation

MBBR is a bioreactor to which plastic carrier pieces have been added. These plastic carrier pieces maximize the area the bacteria can fasten onto.

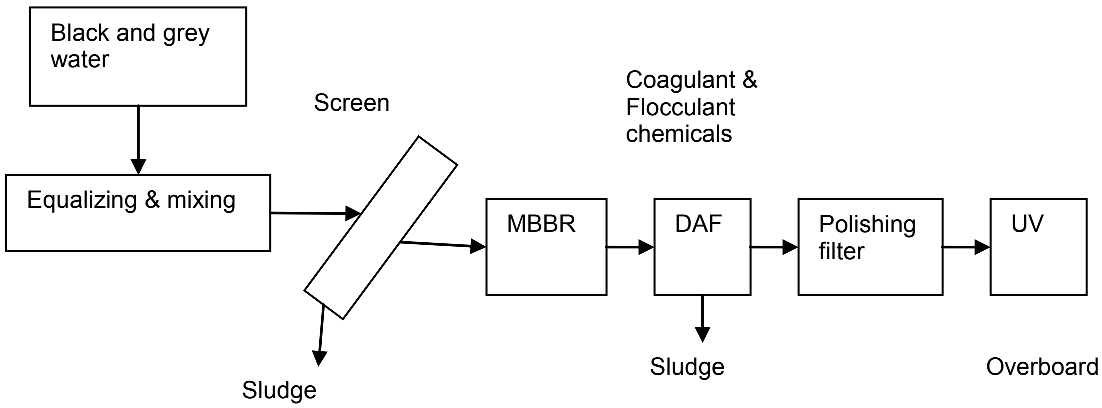

Figure 4-3. The principle of the moving bed bioreactor and flotation system (Kiukas, 2005).

In the MBBR there is no need to circulate the biomass back to the process. The sludge is separated after the bioreactor, either with the help of flotation or sedimentation. Because of the sludge separation, there is a great need for chemicals in the process and their adjustment is difficult. After the sludge separation there are still some particles in the water, so the water must be filtered before disinfection. (Figure 4-3.) The advantages of MBBR are simple control of bioreactor, reasonable investment costs, well-known and reliable structure, and low solid and pathogen content in the effluent. The BOD_5 value in the treated water is quite small, below 5 mg/l. (Kiukas, 2005.)

Bio-reactor/filtration

These treatment systems consist of enhanced aerobic digestion and low-pressure membrane filtration. The systems emphasize either aerobic digestion or membrane filtration.

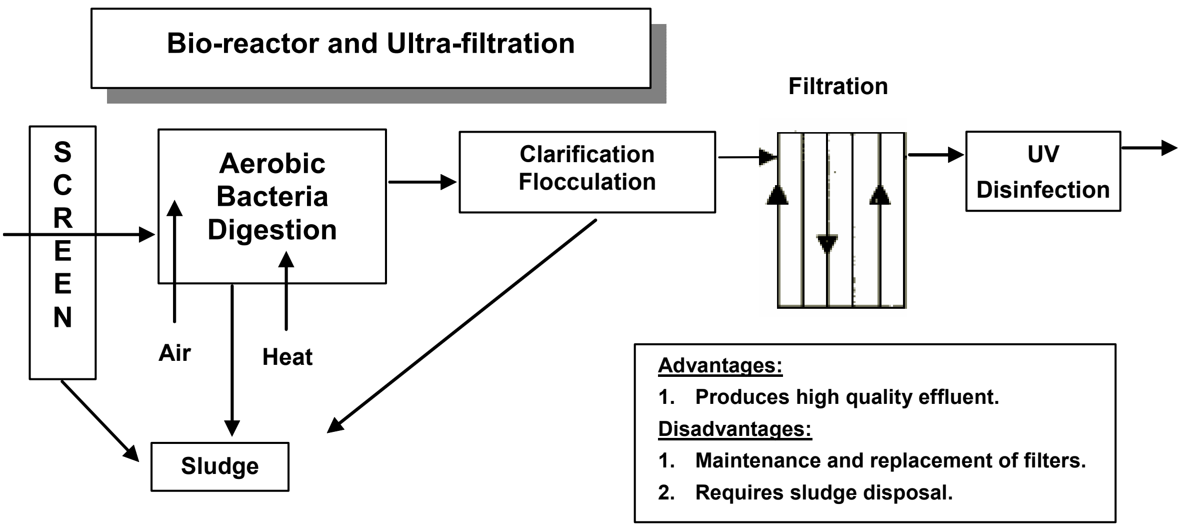

Figure 4-4. Simplified schematics of a bio-reactor and ultra filtration (Eley & Morehouse, 2003).

All bio-reactor/filtration units use ultraviolet irradiation before discharge overboard or to a holding tank. The system produces solid sludge that must be properly handled and disposed of. (Figure 4-4.) The biggest problem with the membranes is their clogging. The maintenance frequency of the filters depends on their type and the capacity calculation of the bioreactor. Usually, the filters are cleaned by a back flush every twenty minutes or every six months. The filters of the MBBR reactor can be assembled externally or they can be submerged in the water. (Eley & Morehouse, 2003.)

External filters

When external filters are used the water is pumped through a filter pack or filter tube under pressure. Only 10% of the water is filtered and 90% returns to the bioreactor. External filters have higher energy consumption than the submerged filters. The disadvantages of external filters are their short exploitation time and their clogging. On the other hand, they are much easier to change than submerged filters. (Kiukas, 2005.)

Submerged filters

In submerged filters the water is filtered with the help of hydraulic pressure and filters' low internal pressure. Submerged filters have low energy consumption and are very durable, but they are difficult to change. (Kiukas, 2005.)

Activated oxidation process

This treatment process consists of a primary screening system, a primary solids separation and oxidizing system, a secondary oxidation tank, and controls and oxidant generation equipment (Figure 4-5).

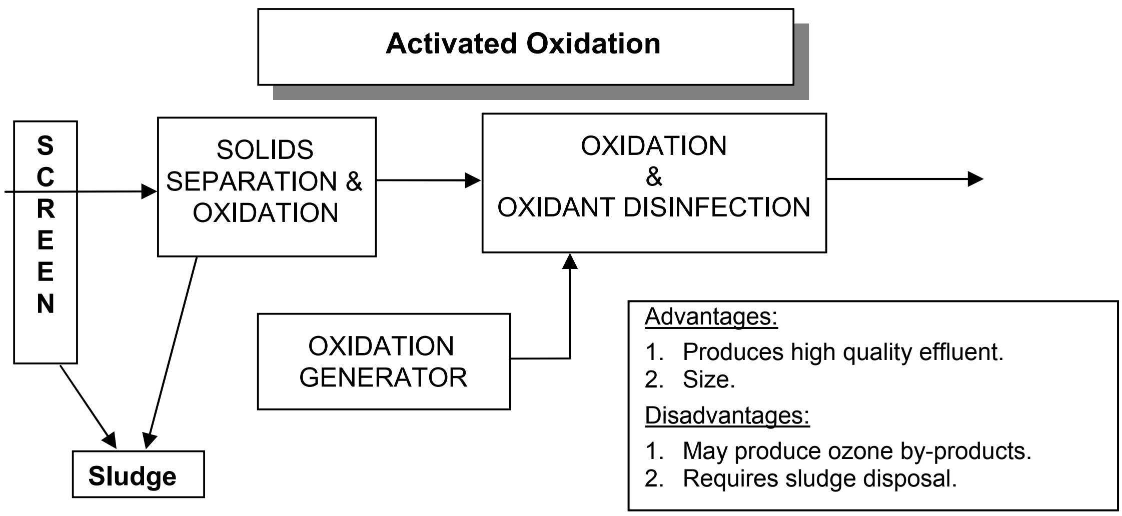

Figure 4-5. Simplified schematics of an activated oxidation (Eley & Morehouse, 2003).

Because the oxidants are produced electrically, there is no need for chlorine disinfection. The sludge is removed from the effluent using polymers. The sludge can be de-watered and incinerated onboard. The process is predicted to be less harmful to marine life than chlorine treatment because the ozone residuals dissipate quickly. The system has been tested in cruise ships. (Eley & Morehouse, 2003.)

Closed electro flotation

One of the innovations in waste water treatment systems concerns the use of closed electro flotation. The test scale treatment plant is completely automatic and very reliable. The system is said to treat the black and grey water and produce drinkable water that can be reused. According to the field tests, the system reduces the nitrogen and phosphorus concentrations in the effluent by just under 99%. The system also removes the dissolved matter and heavy metals. The system principle is presented in Figure 4-6.

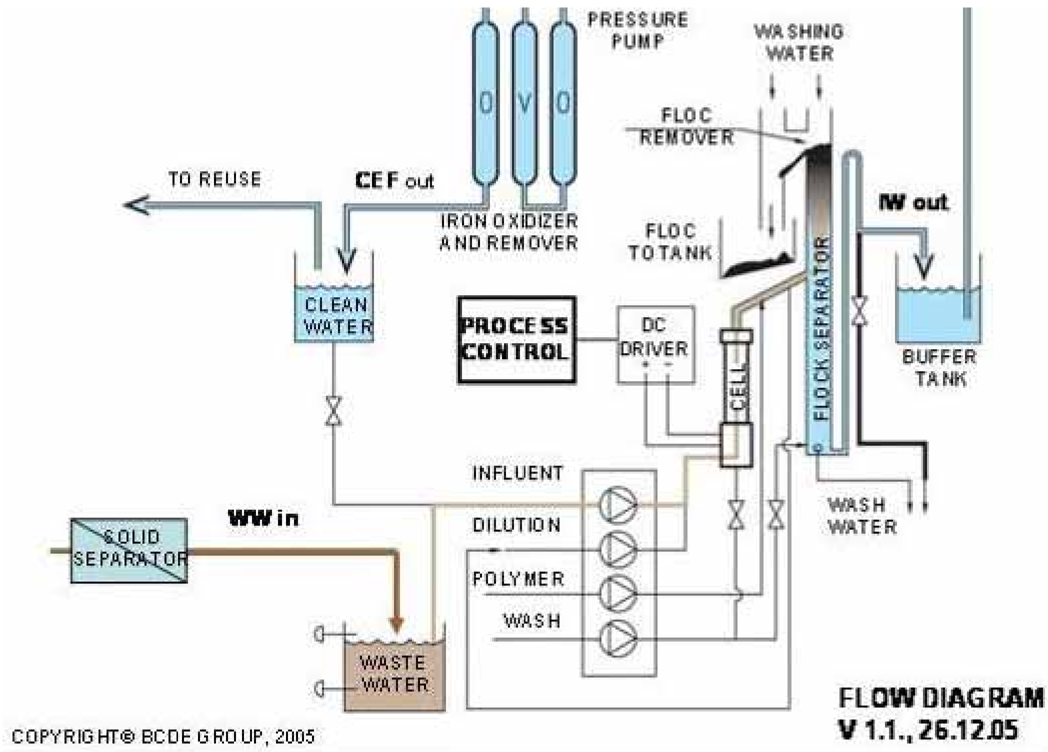

Figure 4-6. The principle of ECO-H20™ water purifier (Dynamic Design, 2006).

The closed electro flotation water purifier has only been tested on a laboratory scale so far, and the first treatment plant will most probably be installed onboard in October 2006 (Dynamic Design, 2006).

4.3.7 Grey water treatment systems

Reverse osmosis filtration

In the reverse osmosis filtration the grey water flows through a semi-permeable membrane into the pure water, after which it flows to the UV disinfection (Figure 4-7).

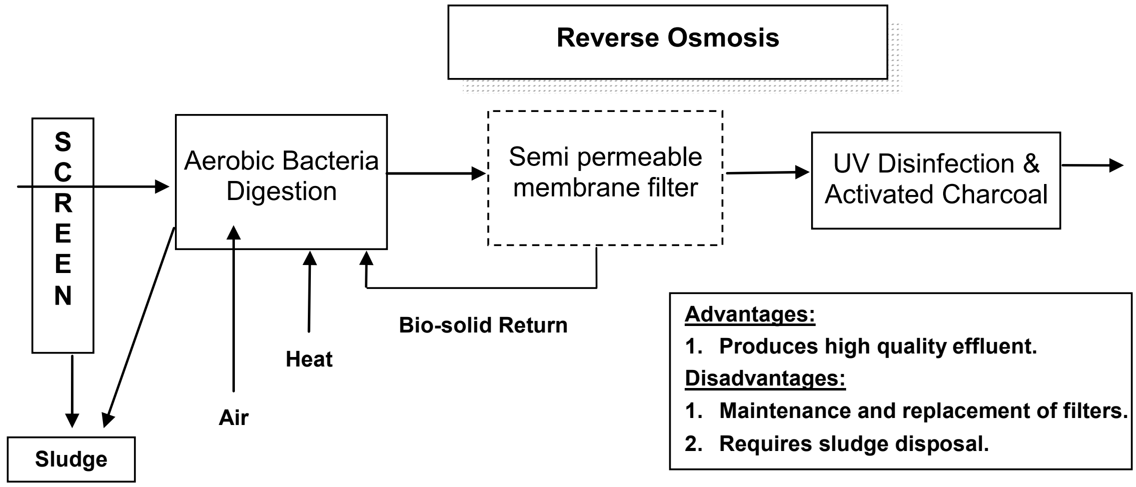

Figure 4-7. Simplified schematics of a reverse osmosis (Eley & Morehouse, 2003).

The treatment system has met the USCG standards for suspended solids and faecal coli forms. The system produces some sludge that must be incinerated, discharged at sea where legal, or landed ashore. Reverse osmosis treatment systems have been installed in cruise ships. (Eley & Morehouse, 2003.)

Electro coagulation

In electro coagulation aluminium and iron oxides are dissolved in the water. These oxides precipitate and flock the impurities from the water. The process produces radicals that oxidize the dissolved organic particles. The sludge is removed in the lamella separator. (Kiukas, 2005.)

4.4 Reception facilities

Ports are obliged to arrange reception facilities for waste that may not be discharged overboard. Reception of waste should not cause undue delays for ships. Ports need to ensure that the reception of waste is quick and easy, which encourages ships to leave waste ashore. The categories of waste that are to be received at ports are mentioned in the six annexes of the MARPOL 73/78 Convention (Table 4-3).

Table 4-3. MARPOL 73/78 categories of waste.

MARPOL 73/78 Annex	Category of waste	Entry in force
I	Oil	2.10.1983
II	Noxious liquid substances in bulk	2.10.1983
III	Harmful substances carried by sea in packaged form	1.7.1992
IV	Sewage	27.9.2003
V	Garbage from ships	31.12.1988
VI	Air pollution from ships	19.5.2005

Ports should have a waste management and handling plan in accordance with Directive 2000/59/EC. The treatment and disposal of ship-generated solid waste in ports should follow the national and local regulations of the port. (Kalli et al., 2005.)

Part of the traffic data collection from ports in the Baltic Sea area was to find out what kind of waste water reception facilities ports offer to the shipping companies. In the passenger ports sewage from the ships can be pumped straight into the municipal sewer network; in the cargo ports the ships' holding tanks can be emptied into tank trucks.

5. Ship-borne nutrient input into surface waters

5.1 Estimated nutrient load into the Baltic Sea area

The nutrient load calculations are based on the data collected from ports, ship owners and various references. As a result, it can be concluded that there are substantial fluctuations in the different studies and data collected. The ship-borne nutrient load calculations are estimations of the current situation in the Baltic Sea area. The calculations in Table 5-1 are based on the following assumptions described as a theoretical worst case:

- for ferries, 90 million voyages annually, average duration of 4 hours for one voyage
- for cruisers, 250 cruises annually, 3,000 passengers for each cruise, average duration of 10 days for one cruise
- for cargo vessels, 584,000 vessels annually (1,600 daily[4]), crew 15, average duration one day
- no waste water treatment onboard (0% reduction of N and P)
- all waste waters discharged into the sea
- nitrogen load 15 g/person/day and phosphorus load 5 g/person/day.

The coefficients for nitrogen (N) and phosphorus (P) have been defined in RIL (2003) as: the nitrogen content in sewage water is 12–15 g/person/day and the phosphorus content is between 3–5 g/person/day.

In SSPA (1994) it was concluded that 70 million passengers in 1993 could have discharged about 132 tonnes of nitrogen and 33 tonnes of phosphorus into the Baltic Sea.

Table 5-1. Nutrient input into the Baltic Sea from air-borne and water-borne sources and from ships in 2000.

	Nitrogen		**Phosphorus**	
	[ton/year]	**[%]**	**[ton/year]**	**[%]**
Atmospheric deposition (HELCOM, 2005) [5]	264,100	26.1657	-	0
Water-borne input (HELCOM, 2005) [5]	744,900	73.8009	34,500	99.6750
Ship-borne nutrient load (SSPA, 1994)	132	-	33	-
Ship-borne nutrient load (Knuuttila, 2006)	438		99	
Ship-borne nutrient load	469	0.0465	156	0.4510
– *ferries*	*225*		*75*	
– *cruisers*	*113*		*38*	
– *cargo vessels, incl. tankers*	*131*		*44*	

[4] Reference: HELCOM, 2005. Overview of the ship traffic in the Baltic Sea.
[5] From the HELCOM countries in 2000.

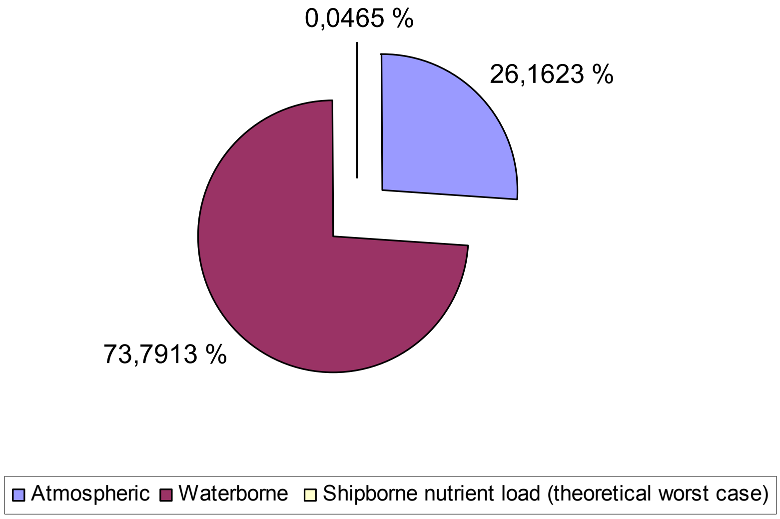

Figure 5-1. Total nitrogen input into the Baltic Sea.

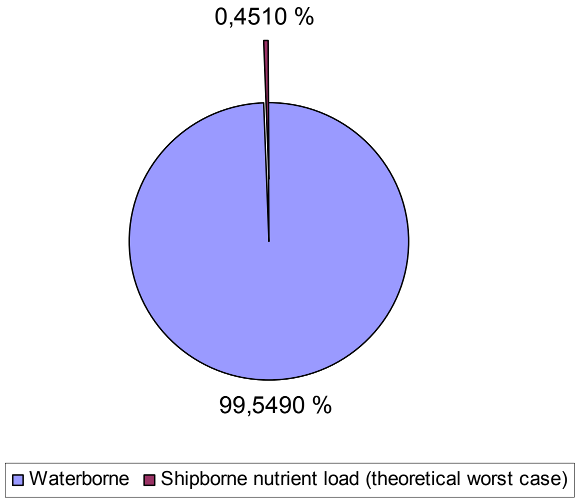

Figure 5-2. Total phosphorus input into the Baltic Sea.

The figures in Table 5-1 indicate that the nutrient input from ships' waste waters corresponds to about 0.0465% of the total nitrogen nutrient input (Figure 5-1) and 0.4510% of the total phosphorus input (Figure 5-2) into the Baltic Sea based on the data in the references and calculations conducted in this study. The air-borne phosphorus has been estimated to be about 1–5% of the total phosphorus input. (HELCOM, 2005.)

The coefficients for the nitrogen and phosphorus load may fluctuate in different countries. For example, in Denmark the coefficient of nitrogen is 12 g/person/day and the coefficient of phosphorus is 2.7 g/person/day. If these values are used in the calculation, the nitrogen input into the Baltic Sea corresponds about 0.0420% of the total nitrogen input and the phosphorus input corresponds about 0.3518% of the total phosphorus input.

5.2 Estimated nutrient load into the Gulf of Finland

In order to estimate the nutrient load originating from ships' waste waters, a closer look at the Gulf of Finland was conducted. According to HELCOM (2005), the total phosphorus input into the Gulf of Finland area is around 5,370 tonnes and total input of nitrogen is around 126,482 tonnes.

The nutrient load into the Gulf of Finland originating from ships' waste waters (Table 5-2) was estimated utilizing the following assumptions:

- for ferries, 10 million passengers annually, average duration of 4 hours for one voyage
- for cruisers, 250 cruises annually, 3,000 passengers per cruise and average duration of 3 days
- for cargo vessels, 26,600 vessels annually (73 vessels daily[6]), crew 15, average duration one day
- no waste water treatment onboard (0% reduction of N and P)
- all waste waters discharged into the sea
- nitrogen load 15 g/person/day and phosphorus load 5 g/person/day.

Table 5-2. The estimated nutrient load originating from ships' waste waters into the Gulf of Finland.

	Nitrogen		**Phosphorus**	
	[ton/year]	**[%]**	**[ton/year]**	**[%]**
Atmospheric deposition (HELCOM, 2005) [7]	31,621	24,9876	0	0
Water-borne input (HELCOM, 2005) [7]	94,861	74,9612	5,370	99,5997
Ship-borne nutrient load	65	0,0512	22	0,4002
– *ferries*	*25*		*8*	
– *cruisers*	*34*		*11*	
– *cargo vessels, incl. tankers*	*6*		*3*	

[6] Reference: Sonninen, 2006.
[7] From the HELCOM countries in 2000.

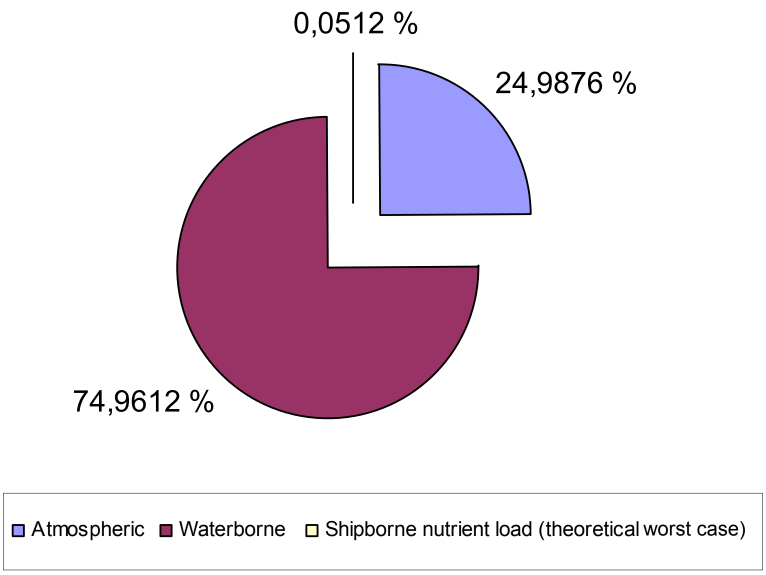

Figure 5-3. Total ship-borne nitrogen input into the Gulf of Finland area.

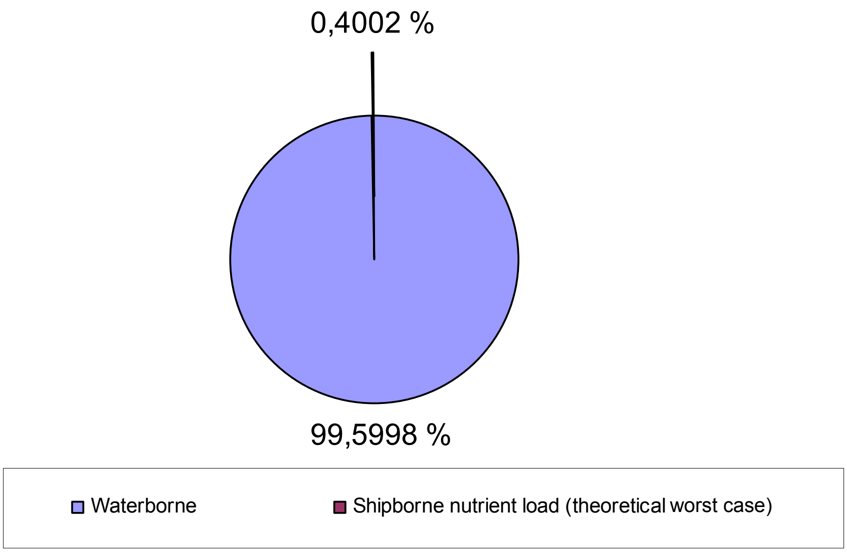

Figure 5-4. Total ship-borne phosphorus input into the Gulf of Finland area.

As the result of the estimation it can be concluded that waste water originating from ships corresponds to 0.0512% of the total nitrogen input (Figure 5-3) and 0.4002% of the total phosphorus input (Figure 5-4) into the Gulf of Finland area.

It must be emphasised that the theoretical worst-case scenario normally applies to cargo vessels and cruisers, which represent a small proportion of the estimated passenger figures. According to the data received, the major passenger/car ferries collect their waste waters in holding tanks and utilise the reception facilities provided by ports. The rules concerning the discharge of sewage are presented in Chapter 7.

Pleasure craft were not included in the calculations since no updated information concerning the nutrient load from pleasure craft was available. The latest available data was from the beginning of the 1990s and included inland waters and sea areas in both Finland and Sweden. (Knuuttila, 2006.)

5.3 Nutrient load from ship-borne waste waters compared to other sources of nutrients in the Baltic Sea

When comparing the nutrient load originating from ship-borne waste waters it is also relevant to be conscious of the fact that the exhaust gases from ships contributed to 6% (equal to around 16,760 ton/year) of the total atmospheric deposition of nitrogen in the Baltic Sea in 2000 (Figure 5-5). Data on the deposition from shipping is based on the emissions in only one year (1990).

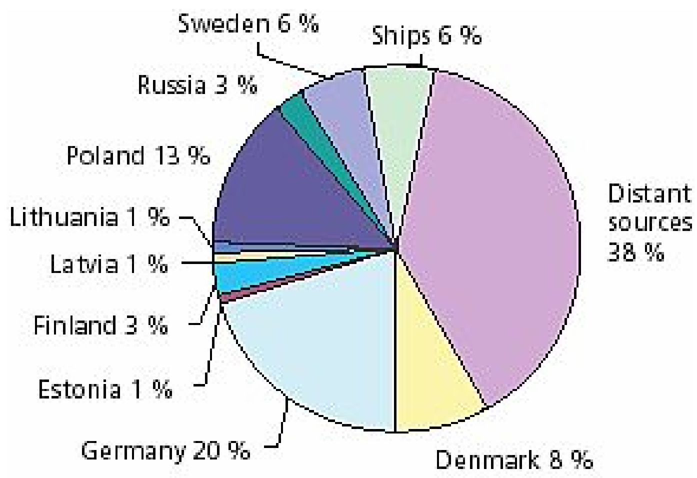

Figure 5-5. Proportion of atmospheric deposition of nitrogen in the Baltic Sea by HELCOM contributions in 2000. Note that the data ships' emissions only exist for the year 1990 and the same values have been used for all subsequent years (HELCOM, 2005).

Wahlström et al. (2006) refer to technologies for reducing emissions from ships, such as reduction by internal engine adjustments and engine process modifications, after-treatment technologies and alternative fuels and energy sources.

The municipal waste water plant in Helsinki Viikinmäki deals with waste waters from 750,000 citizens in the Helsinki metropolitan area in compliance with the requirements set by the authorities. The following effluent rates for nitrogen and phosphorus into the Baltic Sea were achieved in 2005 (City of Helsinki, 2006):

- nitrogen (89% reduction): 1.7 g/person/day (equals to 479 tons/year)
- phosphorus (97% reduction): 0.1 g/person/day (equals to 24 tons/year).

Nutrient loads from other municipal waste water plants are presented in Table 5-3.

Table 5-3. Phosphorus and nitrogen loads from various coastal cities in the Gulf of Finland in 2005.

Locality	Nitrogen load [ton/year]	Phosphorus load [ton/year]	Population
City of Hamina	66	0.9	22,000
City of Kotka	189	3.1	53,000
City of Porvoo	48	1.4	37,000
City of Espoo	439	15.5	295,000
Total	**742**	**20.9**	**407,000**
Ship-borne nutrient load into the Gulf of Finland	65	22	-

When comparing nitrogen and phosphorus loads from the four coastal cities in Finland with ships' waste water releases into the Gulf of Finland (Table 5-2), it can be concluded that the annual nitrogen load from the coastal cities presents a much higher amount while the phosphorus load appears to be about the same.

Knuuttila (2006) estimates that a ship with 2,000 passengers generates a phosphorus load of 2 ton and a nitrogen load of 9 ton annually.

It should also be noted that the fish farming corresponds to one per cent (equal to 10.090 tons of nitrogen and 345 tons of phosphorus) of all the nutrient input into the Baltic Sea area. In Finland, three per cent of the phosphorus load and two per cent of the nitrogen load originates from fish farming (Varjopuro, 2000). According to Knuuttila (2006) the nutrient load from fish farming in Finland in 2005 was 688 tons of nitrogen and 85 tons of phosphorus, which mainly ended up straight into the Baltic Sea. Regional and local fish farming may have significant consequence.

The outlet pipes from municipal waste water treatment plants are significant point sources while waste waters from ships create a line load along shipping channels. In addition, the nutrients from ships' waste waters are immediately available for uptake by blue green algae.

Minimum requirements have been set for municipality waste water treatment plants (Table 5-4). The values concerning the concentrations of total phosphorus and nitrogen refer to inhabitant equivalent.

Table 5-4. The minimum requirements for waste water effluent from municipal waste water treatment plants in Finland (RIL, 2003).

Parameter	**Concentration [mg/l]**	**Reduction rate min. [%][8]**
Biological Oxygen Demand (BOD_7 in 20 °C without nitrification)	30	70
Chemical Oxygen Demand (O_2)	125	75
Solids	35	90[9]
Total phosphorus	2 (10,000–100,000) 1 (> 100,000)	80
Total nitrogen	15 (10,000–100,000) 10 (> 100,000)	70

The Council of State in Finland has set the statute in order to reduce discharges from domestic waste waters and pollution of the environment. According to the statute (542/2003), the load from domestic waste waters must be reduced by 90% concerning organic matter (BHK_7), 85% concerning total phosphorus and 40% concerning total nitrogen compared to the untreated waste water. The statute applies to waste waters that originated from areas outside municipal water supply and sewerage systems. It is possible that in the future the discharge limits of nitrogen and phosphorus will be set for waste water treatment systems onboard ships.

[8] Calculated from load entering the waste water treatment plant.
[9] Concentration and reduction rate are optional.

6. Uncertainties and data gaps

At the beginning of this study the ports and ship owners were sent an inquiry concerning the traffic flows in 2005. The purpose of the inquiry was to figure out the current passenger numbers and the waste water reception facilities in the Baltic Sea area. Unfortunately, the response rate of both inquiries was low, so the current passenger amount had to be estimated on the basis of source material. It was also impossible to estimate the relationship between the received waste water and the total waste water accumulation from cargo and passenger traffic. The cargo ship companies did not respond to the inquiry at all, so the average journey time in the Baltic Sea had to be estimated based on the information available from various references. The average journey time for passenger ships in the Baltic Sea could be calculated from the responses.

While inadequate information was available for nutrient load calculations, several assumptions were made during the execution of the project. Nutrient load factors were based on the coefficients that are used for onshore waste treatment plants. The number of passengers was estimated utilising several references and data received from ports. The average duration of one voyage was estimated based on SSPA (1994) and the responses received from ports. The number of cruisers and the duration of one cruise are based on the data obtained from ports and shipping companies. The number of cargo vessels and number of crew are based on the HELCOM data. In addition, it was assumed that no reduction in nitrogen and phosphorus would be achieved and all waste water originating from ships would be discharged directly into the sea. As a result of the several assumptions discussed above, a theoretical worst-case scenario was generated. The theoretical worst-case scenario normally applies to cargo vessels and cruisers since, according to the references, the major passenger ships do not discharge waste waters into the sea.

7. Waste water legislation

The environmental regulations for shipping can be divided into the following levels:

- international regulations and conventions (MARPOL)
- regional conventions (Helsinki Convention, EU directives)
- national legislation
- local regulations and recommendations.

7.1 International regulations and conventions

Revised Annex IV of MARPOL 73/78. Regulations for the prevention of pollution by sewage from ships

The United Nations International Maritime Organization (IMO) sets international maritime vessel safety and marine pollution standards. Based in London, the IMO comprises representatives from 152 major maritime nations. The IMO has adopted the 1973 International Convention for the Prevention of Pollution from ships, as modified by the Protocol of 1978. This Convention is known as MARPOL 73/78. The MARPOL Convention contains protocol articles and six technical annexes. The original MARPOL protocol was signed on 17 February 1973, but never entered into force. The current protocol is a combination of two treaties (1973 and 1978), and over the years has been modified by many amendments. It entered into force on 2 October 1983.

The revised annex IV of the MARPOL 73/78 Convention and its later amendments concern the prevention of pollution by sewage from ships. The national legislation that regulates the prevention of pollution by sewage from ships in the Baltic countries is based on the content of the MARPOL 73/78 Convention. All Baltic Sea countries are parties to the Convention. (Wikipedia, 2006.)

The regulations for the prevention of pollution by sewage from ships apply to the following ships that are engaged in international voyages:

- new ships of 400 gross tonnage and above
- new ships of less than 400 gross tonnage that are certified to carry more than 15 persons.

Five years after the new annex entered into force (1st of August 2005), the regulations also applied to existing ships of 400 gross tonnages and above, and existing ships of less than 400 gross tonnage that are certified to carry more than 15 persons.

According to Regulation 9, every ship shall be equipped with one of the following systems:

- 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
- 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.

Standard dimensions for the discharge connections are presented in Regulation 10.

Discharge of sewage into the sea is prohibited in Regulation 11 of MARPOL 73/78 Annex IV with the following exceptions:

- The ship is discharging comminuted and disinfected sewage using a system approved by administration at a distance of more than 3 nautical miles from the nearest land, or sewage which is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land, provided that, in any case, the sewage that has been stored in holding tanks shall not be discharged instantaneously but at a moderate rate when the ship is en route and proceeding at not less than 4 knots; the rate of discharge shall be approved by the Administration based upon standards developed by the Organization.
- The ship has in operation an approved sewage treatment plant that has been certified by the Administration to meet the operational requirements and the test results of the plant are laid down in the ship's International Sewage Pollution Prevention Certificate. Additionally, the effluent shall not produce visible floating solids nor cause discoloration of the surrounding water.

Regulation 11 shall not apply to the discharge of sewage from a ship necessary for the purpose of securing the safety of a ship and those on board or saving life at sea, or the discharge of sewage resulting from damage to a ship or its equipment if all reasonable precautions have been taken before and after the occurrence of the damage for the purpose of preventing or minimizing the discharge.

In 2006 the IMO's sub-committee on bulk liquids and gases has made amendments to MARPOL 73/78 Annex IV Regulation 11 concerning the discharge of sewage to include un-treated sewage from spaces containing live animals (IMO, 2006):

- A standard rate of discharge of untreated and undiluted sewage from holding tanks of 1/200,000 of hourly swept volume as a maximum permissible discharge, which should apply to all ships, and a swept volume definition for the discharge of un-treated and undiluted sewage from holding tanks that is not comminuted or disinfected as “ship breadth x draught x distance travelled”.

- The standard rate for the discharge does not apply to sewage that is comminuted or disinfected that may be held in holding tanks.
- No recording requirements for sewage discharges under Regulation 11.1.1 of the revised MARPOL Annex IV are necessary.

Marine Environment Protection Committee: International effluent standards and guidelines for performance tests for sewage treatment plants

The Resolution of the Marine Environment Protection Committee (MEPC) gives recommendations on international effluent standards and guidelines for performance tests for sewage treatment plants / MEPC.2 (VI). The international effluent standards the sewage treatment plant should satisfy are:

- Faecal coliform standard: the geometric mean of the faecal coliform count of the samples of the effluent taken during the test period should not exceed 250 faecal coliforms/100 ml M.P.N (most probable number) as determined by a multiple tube fermentation analysis or an equivalent analytical procedure.

- Suspended solids standard:
    a) Where the equipment is tested on shore, the geometric mean of the total suspended solids content of the samples of effluent taken during the test period shall not exceed 50 mg/l.
    b) Where the equipment is tested aboard ship, the geometric mean of the total suspended solids content of the samples of effluent taken during the test period shall be not more than 100 mg/l above the suspended solids content of ambient water used for flushing purposes.

In addition, the plant should be so designed that the geometric mean of 5–6 day biochemical oxygen demand (BOD5) of the samples of effluent taken during the test period does not exceed 50 mg/l. The test standards for sewage treatment plants are given for onshore under shipboard simulated conditions or onboard ship under actual operating conditions.

In 2006 the IMO’s sub-committee on bulk liquids and gases made amendments to resolution MEPC.2 (VI) (IMO, 2006). The current effluent standards the sewage treatment plant should satisfy are:

- The geometric mean of the thermotolerant coliform count of the samples of effluent taken during the test period should not exceed 100 thermotolerant coliforms/100 ml as determined by membrane filter, multiple tube fermentation or an equivalent analytical procedure.
- The geometric mean of the total suspended solids content of the samples of effluent taken during the test period shall not exceed 35 mg/l.
- Where the sewage treatment plant is tested onboard a ship, the geometric mean of the total suspended solids content of the samples of effluent taken during the test period shall not be more than 70 mg/l above the suspended solids content of ambient water used for flushing purposes.
- The sewage treatment plant shall be designed to reduce both soluble and insoluble organic substances to meet the requirement that the geometric mean of 5-day Biochemical Oxygen Demand (BOD5) of the samples of effluent taken during the test period does not exceed 25 mg/l and the Chemical Oxygen Demand (COD) does not exceed 125 mg/l. Appropriate methods may include COD Manganese and/or COD Chromium.
- The pH of the samples of effluent taken during the test period shall be between 6 and 8.5.

Concerning the raw sewage quality, the effluent concentration of total suspended solids should be no less than 500 mg/l in the onboard and onshore testing. It should be noted, that the nutrient concentration of treated sewage is still not limited.

7.2 Regional conventions (Helsinki Convention, EU directives)

HELCOM recommendations

HELCOM has given guidelines on the sewage treatment systems and the capacity calculation of sewage treatment systems onboard passenger ships (Recommendation 11/10).

HELCOM has made amendments to Annex IV “Prevention of pollution from ships” to the Helsinki Convention (HELCOM, 1992b). The amendments place an obligation on Contracting Parties to apply the provisions of Annex I-V of MARPOL 73/78. Additionally, it includes some requirements for ships other than those referred to in Regulation 2 of Annex IV to MARPOL 73/78. The instructions to report inadequacies of reception facilities for sewage are presented in the HELCOM Recommendation 10/6 (HELCOM, 1989).

HELCOM Recommendation 26/1 regards the application of the no-special-fee-system for ship-borne wastes in the Baltic Sea area. The guidelines were adopted in 2005. The "no-special-fee" system constitutes a system with the dual purpose of encouraging ships to deliver waste ashore and to avoid undesirable waste streams between ports, thereby encouraging a sound sharing of the waste burden. The no-special-fee system is one of the prerequisites for a substantial reduction in the number of operational and illegal discharges and thus for the prevention of pollution of the marine environment from ships. HELCOM recommends that the governments of the Contracting Parties aim to establish a harmonised "no-special-fee" system for the operation of reception facilities in their ports as of 1 January 2000 for ship-borne wastes covered by Annex I (oily wastes from machinery spaces) to MARPOL 73/78 and as of 1 January 2006 for wastes covered by Annex IV (sewage) and Annex V (garbage) to MARPOL 73/78. According to HELCOM, the governments of the Contracting Parties should also support or seek active co-operation with the North Sea States for the purpose of establishing a similar "no-special-fee" system in the North Sea Region (HELCOM, 2005).

Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues – Commission declaration

The purpose of the directive is to reduce the discharges of ship-generated waste and cargo residues into the sea, especially illegal discharges, from ships using ports in the Community, by improving the availability and use of port reception facilities for ship-generated waste and cargo residues, thereby enhancing the protection of the marine environment. The directive applies to all ships, including fishing vessels and recreational craft, irrespective of their flag, calling at, or operating within, a port of a Member State, with the exception of any warship, naval auxiliary or other ship owned or operated by a State and used, for the time being, only on government non-commercial service; and all ports of the Member States normally visited by ships. According to the directive, Member States shall ensure the availability of port reception facilities adequate to meet the needs of the ships normally using the port without causing undue delay to ships.

7.3 Examples of national legislation

As mentioned before, the regulations concerning the prevention of pollution by sewage from ships in Finland and Sweden are based on the MARPOL 73/78 Convention. In Finland the valid decree on preventing water contamination caused by ship traffic in Finnish waters came into force in 1993. In Sweden a similar valid decree is presented in the Statutes of the Swedish Maritime Administration (SJÖFS 2005:8), dated 2005. (SJÖFS, 2005.)

7.4 Local regulations and voluntary measures

Cruise industry waste management practices and procedures

The members of International Council of Cruise Lines are committed to protecting the environment by using waste management technologies and procedures. In the case of grey water, ICCL member lines have agreed that grey water will only be discharged while the ship is underway and proceeding at a speed of not less than 6 knots; that grey water will not be discharged in port and will not be discharged within 4 nautical miles of the shore or such other distance as agreed to with the authorities having jurisdiction or provided for by local law experts in an emergency, or where geographically limited. Member lines have further agreed that the discharge of grey water will comply with all applicable laws and regulations. ICCL members have agreed that all black water will be processed through a marine sanitation device, certified in accordance with US or international regulations, prior to discharge. Discharge will only take place when the ship is more than 4 miles from shore and when the ship is travelling at a speed of not less than 6 knots. (ICCL, 2005.)

8. Future scenarios

The EU's White Paper on Transport includes an intention to develop maritime transport to become more competitive as a transport alternative and to integrate maritime transport into the whole transport chain in a more efficient way. Some estimates of the future freight flows in the Baltic Sea area have been presented in Baltic Maritime Outlook (2006). Transport by sea is expected to grow by 64% between 2003 and 2020. In 2020, shipping is expected to become the leading mode of transport in international Baltic Sea regional trade, carrying 54% of the total volume of internationally traded goods, compared to 48% in 2003.

The predicted increase in maritime transport in the Baltic Sea area is based on growing port capacities, modernisation of cargo carriers and improved environmental and safety values in the maritime transport chain. (Baltic Maritime Outlook, 2006.)

COWI (1998) has estimated the maritime traffic on the Baltic Sea to double by the year 2017. The growth in general cargo and bulk traffic is assumed to triple. For oil transportation, the growth is assumed to be only 10%, but this is probably an underestimation since oil transportation from Russia is expected to grow even more. The average annual growth rate is predicted to be 4.7% for general cargo, container, reefer and RoRo traffic, 2.2% for bulk carrier traffic and 1.4% for oil and gas tankers. The growth in the transportation figures will not directly increase the ship call figures or use of fairways at the same rate because the average size of the cargo vessels will also increase. (Wahlström et al., 2006.)

Predicting the development of passenger ship traffic is more difficult than forecasting the development of cargo traffic since there are more factors influencing the development. There are about 300 passenger ferries visiting St. Petersburg each summer and about 200 passenger ferries visiting Helsinki and Tallinn. The number of these vessels is expected to stay at the current level in the coming year's ship traffic forecasts. The passenger traffic on routes from Turku and Helsinki to Stockholm and between Helsinki and Tallinn are not expected to grow any further. It is anticipated that air-borne and water-borne nutrient loads will be reduced in the future due to state-of-the-art technology implementation onshore and onboard.

In recent years the public has become more conscious of the state of Baltic Sea. Even though discharge of ship sewage into the sea is allowed under certain conditions (MARPOL 73/78 Annex IV), public opinion is opposed to it. For example, public pressure made the Tallink and Superfast ferries pump their sewage into the sewer network ashore (Helsingin Sanomat 29.5.2006). It is probable that discharge limits for nitrogen and phosphorus will be set for the onboard sewage treatment systems in sensitive sea areas because a total prohibition on discharging sewage, either treated or untreated, into the Baltic Sea might be difficult to reach. However, a lot of research and development of waste water purification systems onboard ship is needed before the system’s ability to remove nutrients corresponds to the requirements of municipal treatment plants.

9. Conclusions and recommendations

The shipping companies, ship-owners and port authorities consider the environmental aspects to be a significant competitive advantage in the future when competition for market shares in both passenger traffic and cargo transport gets more stringent. For example, when the inquiry results of this study concerning the waste water amounts pumped ashore are compared to the inquiry results of the SSPA study in 1994, it can be seen that the passenger ports receive more waste water now than ten years ago. In the Gulf of Finland in particular, the passenger/car ferries have started to pump their waste water ashore as a result of public pressure. However, the cargo ships and the international cruise ships fulfil the MARPOL 73/78 requirements concerning the prevention of pollution by ships in the most economic way by discharging their sewage directly into the sea when it is possible according to the MARPOL 73/78 Annex IV regulations.

The HELCOM recommendation (26/1) regarding the no-special-fee-system has made the biggest passenger ports invest in sewer network systems at the pier for receiving the waste waters. In most of the responding ports, the black and grey water holding tanks can be emptied into tank trucks if the ship has ordered depletion. Further investments to the reception facilities may slow down unless the ships utilise the existing onshore waste water reception facilities.

In this study the nutrient load originating from ships' waste waters was compared to the airborne and water-borne nutrient loads. The nutrient load caused by nitrogen and phosphorus from ship sewage is not currently regulated. The standards for ship-borne waste water quality only concern BOD, total suspended solids and faecal coliforms. Hence the sewage that is discharged directly into the sea increases the nutrient load in the marine environment. The nutrient load calculations were prepared for the whole of the Baltic Sea and the Gulf of Finland. The ship-borne nitrogen load represents approximately 0.05% of the total nitrogen load and the phosphorus load approximately 0.5% of the total phosphorus load, for both the Baltic Sea and the Gulf of Finland. In addition, the nutrient load from ships' exhaust gases corresponds to 6% of the total atmospheric deposition of nitrogen in the Baltic Sea.

When comparing nitrogen and phosphorus loads from four coastal cities in Finland with ships' waste water releases into the Gulf of Finland it can be concluded that the annual nitrogen load from ships represents a much lower amount while phosphorus represents about the same load as the coastal cities.

Although different background data for the calculations was available, compared to the references, the results appear to be consistent with other studies. The results indicate that the main nutrient load into the Baltic Sea derives from water-borne inputs and atmospheric deposition. On the basis of the calculations and references, it can be concluded that the nutrient load originating from ships is rather small but not negligible due to the sensitivity of the Baltic Sea marine environment. The nutrient load is concentrated along shipping routes, and immediately available for uptake by e.g. blue green algae, adding to the severe eutrophication of the Baltic Sea.

In addition to the ship-borne nutrient load, waste water discharges from pleasure craft may have a local effect on archipelago areas and near coastlines. Since pleasure craft were not included in the study, the effect of their nutrient load should also be estimated if the total nutrient load from maritime transport needs to be defined.

The vulnerable nature of the Baltic Sea area and the ever-increasing eutrophication is forcing a reduction in the nutrient load into the sea. The nutrient load from ships is much easier to reduce, when compared to the atmospheric emissions or nutrient inputs from diffuse sources such as agriculture, by ordering ships to discharge their sewage into the sewer network ashore or by installing purification systems onboard. In the future, it is likely that limits will be set for the concentration of nitrogen and phosphorus in ships' waste waters to be discharged. It is also possible that the growing environmental awareness among customers and ship owners, and technological innovations in advanced onboard waste water purification systems, together with public concern, may also create voluntary actions beyond the requirements.

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Appendix 1: List of the harbours contacted

List of harbours contacted (x = answer to the inquiry received)

Finland	Web-page	Email
Hamina	www.portofhamina.fi	
Hanko (x)	www.portofhanko.fi	
Helsinki (x)	www.portofhelsinki.fi	
Inkoo Fortum		
Inkoo Shipping (x)	www.inkooshipping.fi	
Kaskinen (x)	www.kaskinen.fi	
Kemi	www.portofkemi.fi	
Kokkola	www.port.of.kokkola.fi	
Kotka	www.portofkotka.fi	
Kristiinankaupunki	www.edu.krs.fi/tcny/index.php	
Loviisa	www.loviisa.fi	
Merikarvia	www.merikarvia.fi/satama.html	
Naantali (x)	www.naantali.fi/satama	
Oulu (x)	www.ouluport.com	
Pietarsaari	www.portofpietarsaari.fi	
Pori (x)	www.pori.fi/port	
Raahe	www.portofraahe.fi	
Rauma (x)	www.portofrauma.com	
Sköldvik (x)	www.nesteoil.fi	
Tornio		
Turku (x)	www.port.turku.fi	
Uusikaupunki (x)	www.portofuki.fi	
Vaasa (x)	www.vaasa.fi/port	

Russia	Web-page	Email
Vyborg	http://www.vyborg.ru/org/baff/55.htm http://www.port.vyborg.ru/eng/index.html	baff@vyborg.ru wport@vbg.spb.ru
Vysotsk	http://www.vyborg.ru/org/baff/66.htm http://www.pgf.ru	baff@vyborg.ru map@pgf.ru
Primorsk	http://www.pasp.ru/rus/geninfo/ports/primorsk	primorskauthority@mail.pasp.ru
St. Petersburg (Big Port) – Seaport – Oil terminal – Petrolesport	http://www.pasp.ru/indexe.htm http://www.seaport.spb.ru/ http://www.oilterminal.ru/ http://www.petrolesport.ru/eng/	public@mail.pasp.ru info@seaport.spb.ru kkv@oilterminal.ru port@petrolesport.ru
Ust-Luga	http://www.ust-luga.ru/	info@ust-luga.ru
Kaliningrad	http://portfocus.com/russia/kaliningrad/index.html	na@transmarine.ru

Estonia	Web-page	Email
Tallinn – Old City – Muuga – Paldiski	http://www.ts.ee/	portoftallinn@portoftallinn.com vanasadam@portoftallinn.com muuga@portoftallinn.com paldiski@portoftallinn.com
Vene-Balti	http://www.bsr.ee	port@bsr.ee
Miiduranna	http://www.miidurannasadam.ee/eng/	kapten@miidurannasadam.ee
Bekkeri	http://www.bekker.ee/	bekker@bekker.ee
Pärnu sadam + shipyard	http://www.transcom.ee/parnusadam_eng.html	sadam@transcom.ee
Kunda	http://www.knc.ee/index.php?lang=est&main_id=23	knc@knc.ee

Latvia	**Web-page**	**Email**
Ventspils (x)	http://www.vbp.lv/	info@vbp.lv vbparvalde@apollo.lv
Liepaja	http://www.lsez.lv	port@lsez.lv lpa@lop.bkc.lv
Riga (x)	http://www.rop.lv/	rop@mail.rop.lv
Skulte	http://www.skulteport.lv/	skulte@skulteport.lv

Lithuania	**Web-page**	**Email**
Klaipeda	http://www.portofklaipeda.lt/	info@port.lt
Butinge	http://www.nafta.lt http://www.wijsmuller.co.uk/ops/butinge.html	post@nafta.lt jim.lorimer@wijsmuller.co.uk

Poland	**Web-page**	**Email**
Gdansk (x)	http://www.portgdansk.pl/	info@portgdansk.pl
Gdynia (x)	http://www.port.gdynia.pl/	marketing@port.gdynia
Port Szczecin-Świnoujście	http://www.port.szczecin.pl http://www.phs.com.pl/	j.kwiatkowski@port.szczecin.pl

Germany	**Web-page**	**Email**
Rostock	http://www.rostock-port.de/ http://www.scandlines.de	marketing@rostock-port.de info@scandlines.de
Lübeck + Travemünde	http://www.lhg-online.de/	info@lhg-online.de
Puttgarden	http://www.scandlines.de	info@scandlines.de
Kiel	http://www.port-of-kiel.de/	info@port-of-kiel.de
Sassnitz (x)	http://www.faehrhafen-sassnitz.de/ http://www.scandlines.de	unger@faehrhafen-sassnitz.de info@faehrhafen-sassnitz.de info@scandlines.de
Wismar	http://www.hafen-wismar.de/	info@hafen-wismar.de

Denmark	**Web-page**	**Email**
Fredericia	http://www.adp-as.dk/index_dk.html	post@adp-as.dk
Århus (x)	http://www.aarhushavn.dk/	maritim@port.aarhus.dk
Copenhagen + Malmö (x)	http://www.cmport.com/CMP/uk/uk_docs.nsf	cmport@cmport.com
Kalundborg + Asnaes Havn + Statoil harbour	http://www.portofkalundborg.dk/ http://www.e2.dk	info@portofkalundborg.dk ark@e2.dk doikapi@statoil.com
Frederikshavn (x)	http://www.frederikshavnhavn.dk/	info@frederikshavnhavn.dk
Aalborg Aalborg Portland	http://www.aalborghavn.dk/	info@aalborghavn.dk
Kolding	http://www.koldinghavn.dk	koldinghavn@kolding.dk
Odense	http://www.odensehavn.dk	odense.port@odensehavn.dk
Rödby	http://www.scandlines.dk	Torben.Christiansen @scandlines.dk
Gedser	http://www.scandlines.dk	scandlines@scandlines.dk
Rönne (x)	http://www.roennehavn.dk/	nl@roennehavn.dk havn@roennehavn.dk
Aabenraa	http://www.aabenraaport.dk/	port@aabenraakom.dk
Ensted Havn	http://www.elsam.com	ensted@elsam.com
Köge	http://www.koegehavn.dk	info@koegehavn.dk
Helsingör	http://www.helsingoerhavn.dk/ http://www.scandlines.dk	info@helsingoerhavn.dk scandlines@scandlines.dk
Grenå	http://www.port-of-grenaa.com	port@port-of-grenaa.com

Sweden	Web-page	Email
Göteborg	http://www.portgot.se/	info@portgot.se
Trelleborg	http://www.trelleborgshamn.se/ http://www.scandlines.se/	trelleborgs.hamn @port.trelleborg.se kundservice@scandlines.se
Helsingborg (x)	http://www.port.helsingborg.se/ http://www.scandlines.se/	information@port.helsingborg.se kundservice@scandlines.se
Luulaja	http://www.lulea.se/hamnen/	lulea.hamn@lulea.se
Malmö + Copenhagen	http://www.cmport.com/CMP/uk/uk_ docs.nsf	cmport@cmport.com
Stockholm – Kapellskär – Nynäshamn Nynäs AB	http://www.portsofstockholm.com/	nfo@stoports.com olle.steen@stoports.com nynas.hamn@stoports.com lars.laurell@nynas.com
Oxelösund (x)	http://www.oxhamn.se/	goran.lund@oxhamn.se oxelosunds.hamn@oxhamn.se
Kalmar (x)	http://www.kalmar.se/	carl-johan.nordheim@kalmar.se kalmar.hamn@kalmar.se
Karlskrona	http://www.karlskrona.se/	hans.hakansson@karlskrona.se
Karlshamn	http://www.karlshamnshamn.se/	info@karlshamnshamn.se
Norrköping	http://www.norrkoping-port.se/	info@norrkoping-port.se
Skellefteå	http://www.skelleftea.se/	goran.hillberg @kommun.skelleftea.se
Umeå (x)	http://www.umeahamn.se/	umeahamn@umea.se viktoria.larsson@umea.se
Husum	http://www.modopaper.com	mikael.johansson @modopaper.com
Sundsvall	http://www.sundsvallshamn.se/	info@sundsvallshamn.se
Gävle	http://www.gavle.se/hamn/	gavle.hamn@gavle.se
Ystad	http://www.port.ystad.se/	port@ystad.se
Brofjorden	http://www.scanraff.com/	vxl@preem.se
Halmstad (x)	http://www.halmstadharbour.se/	info@porthalmstad.com
Varberg	http://www.terminalwest.se/	info@terminalwest.se
Harbours at Gotland: – Visby – Storugns – Slite	 http://www.visbyport.com http://www.nordkalk.com http://www.cementa.se	 visby.port@gotland.se bjorn.mathiasson@nordkalk.com staffan.lindblom@cementa.se
Landskrona (x)	http://www.landskrona.se/hamn	milton.johansson@landskrona- hamn.se lars.nilsson@landskrona-hamn.se
Åhus	http://www.ahushamn.se/	info@ahushamn.se
Oskarshamn (x)	http://www.port.oskarshamn.se/	claes.winquist@port.oskarshamn.se
Sölvesborg (x)	http://www.stuverihamn.se/	info@stuverihamn.se jan.olsson@stuverihamn.se
Piteå	http://www.bottenvikens-stuveri.se/	info@bottenvikens-stuveri.se
Iggesund	http://www.skarnas-terminal.se/	postmaster@skarnas-terminal.se
Stenungsund	http://www.hamntjanst.se/	kontoret@hamntjanst.se
Uddevalla	http://www.uddevalla-hamn.se/	info@uddevalla-hamn.se
Wallhamn	http://www.wallhamn.se/	info@wallhamn.se
Södertälje	http://www.soeport.se/	soeport@soeport.se
Strömstad		rolf.massleberg@stromstad.se

Appendix 2: Covering letter to the ports

HARBOUR INQUIRY

Dear Sir / Madam,

VTT Technical Research Centre of Finland (http://www.vtt.fi/) has a commission from the Finnish Ministry of the Environment, which supports the initiative taken by Finland in the Helsinki Commission (HELCOM) concerning the nutrient load originating from ships into the Baltic Sea.

In order to conduct the study to an adequate extent, we need the following information from your harbour:

1. Number of passengers annually (latest available data)
2. Number of ship calls annually, divided into different ship types (passenger ships, oil tankers, bulkers, etc.)
3. Amount of received waste waters (black water and grey water separated)
4. Reception facilities for waste waters.

We would appreciate it if you could submit the requested data primary by email to the address below by **31 August 2006.**

If you have any further questions regarding this inquiry, do not hesitate to contact VTT.

Thank you for your co-operation!

Kind Regards,

Jukka Sassi
Research Engineer, B.Sc. (Eng.)
VTT Vehicle Engineering
Maritime Operations and Environment

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Finland

Tel. + 358 20 722 5322
Mobile + 358 50 307 5318
Fax + 358 20 722 7076
Email **jukka.sassi@vtt.fi**
Internet http://www.vtt.fi/

Appendix 3: List of the ship-owners contacted

Finland

Passenger ship owners

Company	Web-site	Address
Eckerö Line Ab Oy	http://www.eckeroline.fi/	Eckerö Line Ympäristöpäällikkö PL 307 00181 Helsinki
Finnlines Oyj	http://www.finnlines.fi/	info@finnlines.fi
Linda Line Express	http://www.lindaline.fi/	linda@lindaliini.ee
Nordic Jet Line Finland Oy	http://www.njl.fi/	Nordic Jet Line Ympäristöpäällikkö Kanavaterminaali K5 PL 134 00161 Helsinki
Silja Oy Ab	http://www.silja.fi/	henrik.bacher@silja.com
Tallink Finland Oy	http://www.tallink.fi/	Tallink Finland Oy Ympäristöpäällikkö PL 195 (Kalevankatu 56 A) 00181 Helsinki
Viking Line Abp	http://www.vikingline.fi/	VIKING LINE ABP Miljöchef Norragatan 4/PB 166 AX-22101 Mariehamn Åland, Finland
RG Line Oy Ab	http://www.rgline.com/	RG Line Oy Ab Ympäristöpäällikkö Satamaterminaali 65170 VAASA
Birka Cruises	http://www.birkaline.com/	ken.johansson@birkacargo.com

Cargo ship owners

Company	Web-site	Email
Containerships Ltd Oy	http://www.containershipsgroup.com/	sales@containerships.fi
Finnlines Oyj	http://www.finnlines.fi/	info@finnlines.fi
Neste shipping	http://www.nesteoil.com/	otto.vuorinen@nesteoil.com
Eckerö Line Ab Oy	http://www.eckeroline.fi/	Eckerö Line Ympäristöpäällikkö PL 307 00181 Helsinki
Bore	http://www.rettig.fi	info@boret.com
REDERI AB ENGSHIP		bengt.engblom@engship.fi
GODBY SHIPPING AB T		dan.mikkola@godbyshipping.fi
OY LANGH SHIP AB		leila.kinnunen@langh.fi
Birka cargo	http://www.birkacargo.com	ken.johansson@birkacargo.com

Sweden

Sveriges Redareförening	http://srf2.initiva.net/Sveriges_Redareforening/Om_SRF_DXNI-805_.aspx	bertil.arvidsson@sweship.se

Denmark

Danish Shipowners' Association	http://www.danmarksrederiforening.com/	info@shipowners.dk

Germany

German Shipowners' Association	http://www.reederverband.de/	info@reederverband.de

Russia

Vyborg / Transport expedite centre Ltd	http://www.port.vyborg.ru/eng/forwarder.html	chief@tec.vbg.ru
Vysotsk	http://www.vyborg.ru/org/baff/66.htm http://www.pgf.ru	baff@vyborg.ru
Primorsk	http://www.pasp.ru/rus/geninfo/ports/primorsk	primorskauthority@mail.pasp.ru
St. Petersburg (Big Port) – Seaport – Oil terminal – Petrolesport	http://www.pasp.ru/indexe.htm http://www.seaport.spb.ru/ http://www.oilterminal.ru/ http://www.petrolesport.ru/eng/	public@mail.pasp.ru info@seaport.spb.ru kkv@oilterminal.ru port@petrolesport.ru
Ust-Luga	http://www.ust-luga.ru/	info@ust-luga.ru
Kaliningrad	http://portfocus.com/russia/kaliningrad/index.html	sb@transmarine.ru

Estonia

	Web-page	**Email**
Tallinn – Old City – Muuga – Paldiski	http://www.ts.ee/	portoftallinn@portoftallinn.com vanasadam@portoftallinn.com muuga@portoftallinn.com paldiski@portoftallinn.com
Vene-Balti	http://www.bsr.ee	bsr@bsr.ee
Miiduranna	http://www.miidurannasadam.ee/eng/	kapten@miidurannasadam.ee
Bekkeri	http://www.bekker.ee/	bekker@bekker.ee
Pärnu sadam + shipyard	http://www.transcom.ee/parnusadam_eng.html	sadam@transcom.ee
Kunda	http://www.knc.ee/index.php?lang=est&main_id=23	aivar.reimus@knc.ee

Latvia

	Web-page	Email
Ventspils (x)	http://www.vbp.lv/ http://www.ventbunkers.lv/ (reception facilities)	andris@vok.lv; info@vbp.lv ventbunkers@ventbunkers.lv
Liepaja	http://www.lsez.lv	port@lsez.lv
Riga	http://www.rop.lv/	rop@mail.rop.lv
Skulte	http://www.skulteport.lv/	skulte@skulteport.lv

Lithuania

	Web-page	Email
Klaipeda	http://www.portofklaipeda.lt/	info@port.lt
Butinge	http://www.nafta.lt http://www.wijsmuller.co.uk/ops/butinge.html	post@nafta.lt jim.lorimer@wijsmuller.co.uk

Poland

	Web-page	Email
Gdansk	http://www.portgdansk.pl/	info@portgdansk.pl
Gdynia	http://www.port.gdynia.pl/	info.pl@stenaline.com
Port Szczecin-Świnoujście	http://www.port.szczecin.pl http://www.phs.com.pl/	j.kwiatkowski@port.szczecin.pl

Appendix 4: Covering letter to the ship owners

INQUIRY FOR SHIPOWNERS

Dear Sir / Madam,

VTT Technical Research Centre of Finland (http://www.vtt.fi/) has a commission from the Finnish Ministry of the Environment, which supports the initiative taken by Finland in the Helsinki Commission (HELCOM) concerning the nutrient load originated from ships into the Baltic Sea.

In order to conduct the study to an adequate extent, we would appreciate it if you could provide the following information from your company:

1. Total number of passengers annually (year 2005) for different routes in the Baltic Sea area Amount of waste waters (both black and grey) per person per journey
2. Average time for one journey (if you operate several routes, average time for each route)
3. Type of waste water treatment technology for black and grey waste waters utilised onboard your ships.

Any other information or comments you may have concerning the waste water management onboard is also welcome.

The response to this inquiry should be submitted primarily by email to the address below by **15 September 2006.**

If you have any further questions regarding this inquiry, do not hesitate to contact VTT.

Thank you for your co-operation!

Kind Regards,
Jukka Sassi
Research Engineer, B.Sc. (Eng.)
VTT Vehicle Engineering
Maritime Operations and Environment

Otakaari 7B, Espoo
PO Box 1000
FI-02044 VTT
Finland

Tel.	+ 358 20 722 5322
Mobile	+ 358 50 307 5318
Fax	+ 358 20 722 7076
Email	jukka.sassi@vtt.fi
Internet	http://www.vtt.fi/

Appendix 5: Traffic data

Ship calls, number of passengers and received waste water in the ports in the year 2005 based on the inquiry results.

Finland	Ship calls	Number of passengers	Received sewage	Note
Hanko	Ropax 350 Ro-Ro ship 1450	180,000	0 m^3	Since April 2006 ROPAX ships have started to leave sewage 2–3 times per week.
Helsinki	Passenger vessel 3347 Express boat 6357 International cruise ship 247 Cargo carrier 3274	9,067,000 (International cruise passengers: 240,000. Passengers in the scheduled traffic: 8,827,000)	International traffic 4119 m^3 and liner traffic 194469 m^3. Totally 198588 m^3.	
Inkoo Shipping	General cargo carrier 350	0	0 m^3	
Kaskinen	Lo-Lo ship 515 Tanker 15	0	0 m^3	
Naantali	Dry bulk carrier 109 Other vessel 4 Other dry cargo vessel 122 Ro-Ro ship/ ROPAX 1296 Container ship 27 Tanker 372 Docking 51 Tug 44	28,084	0 m^3	
Oulu	Ro-Ro ship 143 Tanker 117 General cargo carrier 109 Container ship 49 Dry bulk carrier 39 Oil tanker 8 Chemical tanker 7 Tug 1 Pusher tug 1 Pusher barge 1 Barge 1	0	No sewage was received in the last five years, except the sewage from harbour tugs.	
Pori	General cargo carrier 394 Tanker 89 Container ship 105 Dry bulk carrier 49 Chemical tanker 23 Tug / barge 43 Ro-Ro ship 4 Other vessel 4	0	0 m^3	
Rauma	General cargo carrier 682 Ro-Ro ship 398 Container ship 156 Tanker 58 Tug 46 Barge 35 Chemical tanker	0	15 m^3	
Sköldvik	Tanker 1289	0	0 m^3	
Turku	Passenger vessel 12 ROPAX 1423 Train ferry 849 Ro-Ro ship 305 Container ship 25 Dry bulk carrier 298 Tanker58 Oil tanker 28 Chemical tanker 21 Other vessel 18 Tug 45 Tug barge 8 Barge 5 Pusher barge 1 Pusher tug 1	3,770,000	101131 m^3	
Uusikaupunki	Ro-Ro ship 202 Bulk carrier 248	0	0 m^3	

Vaasa	General cargo carrier 175 Passenger vessel 430	90,000	0 m^3	
Denmark	**Ship calls**	**Number of passengers**	**Received sewage**	**Note**
Copenhagen	Tanker 1357 Offshore vessel 2 Oil platform maintenance ship 1 Oil tanker 45 Chemical tanker 28 Dry bulk carrier 140 Other (wet bulk carrier) 29 Bulk carrier 40 Bulk and tank carrier 5 Container ship 526 Other ship 36 Tug 39 Car carrier 71 Ropax 178 Passenger/car ferry 424 Passenger vessel 288 Fishing vessel 7 Marine research vessel 1 Naval ship 62 Ro-Ro ship 205 Cruise ship 281 Other dry cargo vessel 339 Barge 78 Dredger etc. 593	1,504,773	14634 m^3	
Frederikshavn	Passenger vessel 4889 Cargo ship 402 Tanker 63 Bulk carrier 79 Tug 133	2,930,093	13607 m^3	
Rönne	Cruise ship 33 Ferry 2094 Tanker 36 Bulk carrier 1176	1,560,000	4350 m^3	
Århus	Cruise ship 23 Ferry 4557 Liner (container, roro) 1182 Tanker 443 Other (bulk carrier) 1954	1,823,000	1307 m^3	
Germany	**Ship calls**	**Number of passengers**	**Received sewage**	**Note**
Sassnitz	Ferry and ro-ro ship 2142 Cruise ship 8 Bulk carrier and fishing vessel 961	761,008	0 m^3	
Latvia	**Ship calls**	**Number of passengers**	**Received sewage**	**Note**
Ventspils	Passenger vessel 484 Tanker 803 Dry cargo vessel 594	30,700	758.7 m^3	
Riga	Passenger vessel/ferry 518 Container ship 577 Bulk carrier 402 Reefer vessel 25 Ro-Ro ship 8 Dry cargo vessel 2006 Tanker 508 Fishing vessel 1 Other vessel 79	195,195	210.6 m^3 and 9934,58 m^3*)	*) Consists of black water, bilge, polluted ballast waters, oil polluted waste waters, etc.
Poland	**Ship calls**	**Number of passengers**	**Received sewage**	**Note**
Gdansk	Car carrier 41 General cargo carrier 825 Reefer vessel 39 Container vessel 413 Ro-Ro ship 17 Bulk carrier 235 Passenger vessel 34 Ferry 158 ROPAX 41 Tanker up to 38.000 GT 561 Tanker over 38.000 GT 88 Towing and pushing vessels 276 Other vessel 379	182,819	1122.3 m^3	

Gdynia	Research vessel 18 Barge 42 Reefer vessel 56 General cargo carrier 1458 Tug 361 Container ship 288 Bulk carrier 141 Naval ship 19 Passenger vessel 100 ROPAX 622 Ferry/cruise (inshore) 158 Pusher tug 84 Pontoon 172 Fishing vessel 22 Other ro-ro ship 276 Ro-Ro/container ship 109 Other vessel 34 Car carrier 58 School ship 9 Multipurpose vessel 1 Chemical tanker 226 Gas carrier 56 Other tanker 341	448,515	81.5 m^3	
Sweden	**Ship calls**	**Number of passengers**	**Received sewage**	**Note**
Halmstad	Oil tanker 125 Ro-Ro ship 245 General cargo/bulk carrier 953	0	0 m^3	
Helsingborg	Passenger vessel (Ferry) 44356 Bulk carrier 165 Oil tanker 96 Vegetable tanker 91 Ro-Ro ship 124 Lo-Lo ship 422 Other vessel 78 Private harbour of Kemira Kemi AB: – Bulk carrier 98 – Chemical tanker 88 – Other tanker 6	11,102,138	1 m^3	
Kalmar	Cruise ship 4 Tanker 88 Dry cargo carrier 336	2,100	108 m^3	
Landskrona	Bulk carrier 400 Passenger vessel 3750	320,000	100 m^3	
Oskarshamn	Passenger vessel 607 Oil tanker 12 Bulk carrier 222	399,881	0 m^3	
Oxelösund	General cargo carrier 111 Tanker 59 Bulk carrier 92 Barge/pusher 113	0	0 m^3	
Sölvesborg	General cargo carrier 500	0	70 m^3	
Umeå	Tanker 58 Bulk carrier 26 Container vessel 25 Special ships (?) 228 Ropax 389 Other Ro-Ro ship 209 Barge for dry bulk 6 Dry bulk carrier 223 Other vessel 1	88,590	0 m^3	

Appendix 6: Reception facilities

Waste water reception facilities in the ports in the year 2005 based on the inquiry results.

Finland	**Reception facility**
Hanko	ROPAX ships pump sewage straight into the sewer network. Ro-Ro ships can pump sewage to a tank truck.
Helsinki	Eteläsatama: 17 waste water reception points. Länsisatama: 9 waste water reception points. Sörnäisten satama: 1 waste water reception point. Other harbour parts: totally 24 waste water reception points. The waste water reception points are for passenger ships. The port of Helsinki arranges waste water reception for cargo ships using the tank truck if needed.
Inkoo Shipping	Ships can pump sewage to a tank truck.
Kaskinen	Ships can pump sewage to a tank truck.
Naantali	Ships can pump sewage to a tank truck; there are waste stations for solid waste.
Oulu	Ships can pump sewage to a tank truck.
Pori	Ships can pump sewage to a tank truck; Ekokem Oy Ab collects oily waste.
Rauma	Ships can pump sewage to a tank truck.
Sköldvik	Ships can pump sewage toa tank truck.
Turku	Silja and Viking Line ships pump the sewage straight into the sewer network. Other domestic traffic has a possibility to use a tank truck by Hans Langh Oy.
Uusikaupunki	There are waste wells near the pier where ships can pump sewage. Ships can also pump sewage to a tank truck.
Vaasa	In the passenger port there is a reception pipeline at ro-ro piers1&2. Ships can also pump sewage to a tank truck.
Denmark	
Copenhagen	Sewage is pumped to the tank trucks and is then discharged into the municipal waste water plant (biological and chemical waste water treatment).
Frederikshavn	Black water is pumped to the tank trucks and grey water is discharged into the Frederikshavn's sewer network.
Rönne	Black water and grey water are pumped to the tank trucks. Part of the grey water is discharged into the sewer network.
Århus	Private company collects sewage from ships.
Germany	
Sassnitz	No reception facilities for waste water. Sewage is pumped to the tank truck from a local waste disposal company.
Latvia	
Ventspils	Sewage is transported to JSC Ventbunkers for treatment.
Riga	Sewage is transported to Riga Municipal Waste Water Treatment Plant.
Poland	
Gdansk	Sewage is discharged into the sewer network from the tank trucks (WUKO) and after that there are several treatment plants: mechanical-biological sewage treatment plant in Port Północny, sewage treatment plant KOS 2x3 in Basen Górniczy, sewage treatment plant Bioclere at Przemysłowe Berth.
Gdynia	Sewage is pumped to the tank trucks.
Sweden	
Halmstad	Reception facilities only for oil sludge and bilge water.
Helsingborg	The passenger ships discharge sewage into the sewer network; other ships pump sewage to the tank truck.
Kalmar	Local waste management company collects the sludge from ships. It is transported by trucks to a terminal situated in the harbour.
Landskrona	Waste water is pumped into the sewer network.
Oskarshamn	No reception facilities.
Oxelösund	The type of reception facility is not described.
Sölvesborg	Sewage is pumped to the tank trucks.
Umeå	No reception facilities.

Appendix 7: Waste water amount vs. number of passengers

Summary of responses from shipping companies.

Company	Route	Journey time	Pax/Year	Sewage /pax	Treatment onboard
Færgeselskabet Læsø /Dk	Frederikshavn–Læsø	90 min	262,310	6.2 l	None – treated ashore
HH ferries /Dk	Helsingør–Helsingborg	20 min	1,830,124	3.3 l	None – treated ashore
Mols-Linien /Dk	Odden–Ebeltoft	50 min	964,456	4.7 l	None – treated ashore
Mols-Linien /Dk	Odden–Århus	80 min	1,346,021	4.7 l	None – treated ashore
Mols-Linien /Dk	Århus–Kalundborg	160 min	363,864	14 l	None – treated ashore
Eckerö Line /Fin	Eckerö–Grisslehamn	120 min	892,101	15.3 l	None – treated ashore
Eckerö Line /Fin	Helsinki–Tallinn	195 min	894,343	12.9 l	None – treated ashore
Silja Line /Fin	Helsinki–Stockholm	16,5 hours	1,430,000	100 l	None – treated ashore (*
Silja Line /Fin	Turku–Stockholm/Kapellskär	11 hours	1,850,000	65 l	None – treated ashore (*
Viking Line / Fin	Helsinki–Mariehamn–Stockholm (Gabriella, Mariella)	17 hours	1,134,683	98.29 l – 98.54 l	None – treated ashore
Viking Line / Fin	Helsinki–Tallinn (Rosella)	180 min	927,113	28.33 l	None – treated ashore
Viking Line / Fin	Mariehamn–Kapellskär (Ålandsfärja)	150 min	408,035	21.3 l	None – treated ashore
Viking Line / Fin	Stockholm–Mariehamn (Cinderella)	21.5 hours	988,320	70.64 l	None – treated ashore
Viking Line / Fin	Turku–Mariehamn/Långnäs–Stockholm (Amorella, Isabella)	11 hours	1,914,494	53.34 l – 55.52 l	None – treated ashore

(* According to the company, all categories of waste waters (black & grey) are collected onboard in various tanks and pumped ashore into the sewage system. Some chemicals are added to prevent formation of sulphuric hydrogen. All vessels are equipped with chemical or biological treatment plants; however, because all wastewaters are delivered ashore, these plants are not in operation but are standby only.

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Title

Estimated nutrient load from waste waters originating from ships in the Baltic Sea area

Abstract

Maritime transport in the Baltic Sea area, and especially in the Gulf of Finland, has changed significantly over the last decade. The new oil terminals in Russia and the economic boom in the Baltic States have resulted in remarkable rise in maritime traffic, mainly tankers and cargo ships. At the same time, the vulnerable nature of the Baltic Sea and the ever-increasing eutrophication has made it necessary to reduce the nutrient load.

The purpose of this study was to estimate the nutrient load from waste waters originating from ships in the Baltic Sea area. The study also includes information about the maritime traffic, waste water management and legislation. The nutrient load originating from pleasure craft was not included in the study.

The estimated nutrient load from ship-generated sewage was calculated, assuming there is no waste water treatment onboard and all waste waters are discharged into the sea. The ship-borne nitrogen load represents approximately 0.05% of the total nitrogen load, and the phosphorus load represents approximately 0.5% of the total phosphorus load both into the Baltic Sea and into the Gulf of Finland. The nutrient load from ships' exhaust gases contributes to 6% of the total atmospheric deposition of nitrogen. The main nutrient load into the Baltic Sea is derived from water-borne inputs and atmospheric deposition.

On the basis of the calculations and references, the nutrient load originating from ships is rather small, but not negligible due to the sensitivity of the Baltic Sea marine environment. The nutrient load is concentrated along the shipping routes and is immediately available for uptake by, e.g., blue green algae, adding to the severe eutrophication of the Baltic Sea.

The nutrient load from ships is much easier to reduce, when compared to the atmospheric emissions or nutrient inputs from land-based sources, by ordering ships to discharge the sewage into the sewer network ashore or by installing waste water purification systems onboard. In the future, it is likely that limits will be set for the concentration of nitrogen and phosphorus in ships' waste waters.

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