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Antti Posti

Jani Häkkinen

European Union
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FOREWORD

The Baltic Sea is classified as Particularly Sensitive Sea Area by the International Maritime Organization. Navigation in the Baltic Sea is challenging due to its relative shallowness, narrow navigation routes, and ice cover in wintertime. Besides of the shallowness, the Baltic has slow water circulation between the North Sea and the Baltic Sea. The transport volumes in the Baltic Sea have increased significantly in recent years and this trend is expected to continue in the future. This in turn increases the risk of shipping accidents in the Baltic Sea. Updated information about transported chemicals in the Baltic Sea is the first step in the risk assessment of the chemicals.

This study is conducted as a part of the Chembaltic (Risks of Maritime Transportation of Chemicals in Baltic Sea) project which gathers information on the chemicals transported in the Baltic Sea. The purpose of this study is to provide an overview of transport volumes of liquid bulk chemicals (including liquefied gases) in the Baltic Sea and to find out what the most transported liquid bulk chemicals in the Baltic Sea are. Data gathered in this study will be used as background information in later stages of the Chembaltic project when the risks of the chemicals transported in the Baltic Sea are assessed to highlight the chemicals that require special attention from an environmental point of view in potential marine accident situations in the Baltic Sea area.

The Chembaltic project is implemented in co-operation with the University of Turku Centre for Maritime Studies, Aalto University and Kotka Maritime Research Centre. The project is funded by the European Regional Development Fund (ERDF) and the Finnish Funding Agency for Technology and Innovation (Tekes) as well as the following companies: Neste Oil Oyj, Vopak Chemicals Logistics Finland Oy, Port of HaminaKotka Ltd, Crystal Pool Ltd, and Finnish Transport Safety Agency (Trafi). Other support is given by the Finnish Port Association and the Finnish Shipowners Association.

The authors of the report would like to thank the project partners and steering group of the Chembaltic project. M.Sc. Reima Helminen and M.Sc. (Tech.) Olli-Pekka Brunila are acknowledged for reviewing the report.

Kotka 24th April, 2012
Jani Häkkinen
Project Manager
The Centre for Maritime Studies, University of Turku

THE FINANCIERS AND PARTNERS OF THE CHEMBALTIC PROJECT

European Union
European Regional Development Fund

Leverage from the EU 2007–2013

Tekes

NESTE OIL

CRYSTAL POOL GROUP

Vopak

PORT OF HAMINAKOTKA

TraFi

Suomen Satamaliitto
Finlands Hamnförbund

Suomen Varustamot
Rederierna i Finland
Finnish Shipowners' Association

CENTRE FOR MARITIME STUDIES

Aalto-yliopisto

MERI KOTKA

ABSTRACT

This study is made as a part of the Chembaltic (Risks of Maritime Transportation of Chemicals in Baltic Sea) project which gathers information on the chemicals transported in the Baltic Sea. The purpose of this study is to provide an overview of handling volumes of liquid bulk chemicals (including liquefied gases) in the Baltic Sea ports and to find out what the most transported liquid bulk chemicals in the Baltic Sea are. Oil and oil products are also viewed in this study but only in a general level. Oils and oil products may also include chemical-related substances (e.g. certain bio-fuels which belong to MARPOL annex II category) in some cargo statistics. Chemicals in packaged form are excluded from the study.

Most of the facts about the transport volumes of chemicals presented in this study are based on secondary written sources of Scandinavian, Russian, Baltic and international origin. Furthermore, statistical sources, academic journals, periodicals, newspapers and in later years also different homepages on the Internet have been used as sources of information. Chemical handling volumes in Finnish ports were examined in more detail by using a nationwide vessel traffic system called PortNet.

Many previous studies have shown that the Baltic Sea ports are annually handling more than 11 million tonnes of liquid chemicals transported in bulk. Based on this study, it appears that the number may be even higher. The liquid bulk chemicals account for approximately 4 % of the total amount of liquid bulk cargoes handled in the Baltic Sea ports. Most of the liquid bulk chemicals are handled in Finnish and Swedish ports and their proportion of all liquid chemicals handled in the Baltic Sea is altogether over 50 %. The most handled chemicals in the Baltic Sea ports are methanol, sodium hydroxide solution, ammonia, sulphuric and phosphoric acid, pentanes, aromatic free solvents, xylenes, methyl tert-butyl ether (MTBE) and ethanol and ethanol solutions. All of these chemicals are handled at least hundred thousand tonnes or some of them even over 1 million tonnes per year, but since chemical-specific data from all the Baltic Sea countries is not available, the exact tonnages could not be calculated in this study. In addition to these above-mentioned chemicals, there are also other high volume chemicals handled in the Baltic Sea ports (e.g. ethylene, propane and butane) but exact tonnes are missing. Furthermore, high amounts of liquid fertilisers, such as solution of urea and ammonium nitrate in water, are transported in the Baltic Sea. The results of the study can be considered indicative.

Updated information about transported chemicals in the Baltic Sea is the first step in the risk assessment of the chemicals. The chemical-specific transportation data help to target hazard or e.g. grounding/collision risk evaluations to chemicals that are handled most or have significant environmental hazard potential. Data gathered in this study will be used as background information in later stages of the Chembaltic project when the risks of the chemicals transported in the Baltic Sea are assessed to highlight the chemicals that require special attention from an environmental point of view in potential marine accident situations in the Baltic Sea area.

TIIVISTELMÄ

Tämä tutkimus on tehty osana Chembaltic (Kemikaalikuljetusten riskit Itämerellä) -hanketta, jonka tavoitteena on kerätä tietoa Itämerellä kuljettavista kemikaaleista. Tutkimuksen tavoitteena on tehdä yleiskuvaus Itämeren satamissa irtolastina kuljetettavien nestemäisten kemikaalien (pitäen sisällään myös nestemäiset kaasut) käsittelymääristä ja saada selville Itämerellä eniten kuljetettavat nestemäiset kemikaalit. Tutkimuksessa on tarkasteltu myös öljy- ja öljytuotteiden kuljetusmääriä yleisellä tasolla. Öljyt ja öljytuotteet saattavat pitää sisällään myös kemikaaleja (esim. biopolttoaineet kuuluvat MARPOL II -kategoriaan) joissakin tavaratilastoissa. Pakattuina kuljetettavat kemikaalit on jätetty tutkimuksessa tarkastelun ulkopuolelle.

Raportissa esitetyt kemikaalien kuljetustiedot perustuvat pääasiassa tehtyyn kirjallisuustutkielmaan, jossa käytettiin lähteinä sekä kansallisia että kansainvälisiä julkaisuja. Käytetyt lähteet vaihtelivat logistiikka-alan aikakauslehdistä virallisiin tilastoraportteihin ja -tietokantoihin sekä tieteellisiin julkaisuihin. Myös satamien, terminaalien ja operaattorien omat Internet-sivut toimivat tietolähteinä tutkimuksessa. Suomen satamien osalta kemikaalien käsittelymäärät tutkittiin tarkasti hyödyntäen kansallista PortNet-alusliikennejärjestelmää.

Monien edeltävien tutkimusten mukaan Itämeren satamissa käsitellään vuosittain yli 11 miljoonaa tonnia nestemäisiä irtolastina kuljetettavia kemikaaleja. Tämän tutkimuksen perusteella vaikuttaa siltä, että kemikaalien kuljetusmäärä voi olla tätä suurempikin johtuen eri maiden erilaisista kemikaalien tilastointitavoista. Kemikaalien osuus kaikista Itämerellä kuljetettavista nestemäisistä irtolastikuljetuksista on noin 4 % tonnimäärässä mitattuna. Suomen ja Ruotsin satamat käsittelevät yhteensä yli puolet kaikista Itämerellä irtolastina kuljetettavista nestemäisistä kemikaaleista. Itämeren satamissa selvästi eniten käsiteltäviä kemikaaleja ovat metanoli, natriumhydroksidi, ammoniakki, rikki- ja fosforihappo, pentaanit, ksyleenit, metyyli-tert-butyylieetteri (MTBE) sekä etanoli ja etanoliliuokset. Kaikkia näitä kemikaaleja käsitellään Itämeren satamissa vähintään sata tuhatta tonnia vuosittain. Edellä mainittujen kemikaalien lisäksi Itämeren satamissa käsitellään muitakin kemikaaleja, joiden kuljetusmäärät voivat olla yhtä suuria. Näistä kemikaaleista esimerkkejä ovat etyleeni, propaani ja butaani. Lisäksi monia nestemäisiä lannoitteita kuljetetaan huomattavan suuria määriä. Tutkimuksen tuloksia tarkasteltaessa on huomattava, ettei kaikkien Itämeren maiden ja satamien osalta ollut saatavissa kemikaalikohtaisia tietoja. Tämän vuoksi tutkimuksessa ei ollut mahdollista laskea tarkkoja tonnimääriä Itämeren satamissa käsiteltäville kemikaaleille. Tutkimuksessa saatuja tuloksia voidaan kuitenkin pitää suuntaa-antavina.

Päivitetty tieto Itämeren satamissa käsiteltävistä kemikaaleista luo perustan kemikaalikuljetusten riskien arvioimiseksi. Tiedon avulla kemikaalikuljetusten riskienarviointi voidaan kohdistaa niihin kemikaaleihin, joita kuljetetaan Itämerellä eniten ja/tai jotka ominaisuuksiensa puolesta pitävät sisällään suurimman ympäristöriskipotentiaalin. Tämä raportti toimii taustatietona Chembaltic-hankkeen myöhemmissä vaiheissa toteutettavalle Itämeren kemikaalikuljetusten riskienarviointityölle.

TABLE OF CONTENTS

1 INTRODUCTION

The Baltic Sea is one of the world's busiest seas. Around 15 % of the world's maritime transportations are carried out in the Baltic Sea. Navigation in the Baltic Sea is challenging due to its relative shallowness, narrow navigation routes, and ice cover in wintertime (HELCOM 2009). Besides of the shallowness, the Baltic Sea has slow water circulation between the North Sea and the Baltic Sea (Uggla 2008). Since November 2005, the Baltic Sea has been classified as Particularly Sensitive Sea Area by the International Maritime Organization. The transportation volumes in the Baltic Sea have increased significantly in recent years and this trend is expected to continue in the future (Kuronen et al. 2008). This in turn increases the risk of shipping accidents in the Baltic Sea.

At present, 25 % of the vessels in the Baltic Sea are oil tankers or tankers carrying chemicals (HELCOM 2009). In 2010, the international liquid bulk transports in the Baltic Sea ports contained around 290 million tonnes of oil and oil products, 11 million tonnes of liquid chemicals, and 4 million tonnes of other liquid bulk (Holma et al. 2011). The amount of transported chemicals is much less than the amount of transported oil and oil products. However, the risks related to possible oil accidents are easier to identify than risks caused by chemicals. The problem is the high variety and complexity of the environmental risk profiles and potentials of the chemicals, chemical compounds and other substances (Malmsten 2001). Chemical accident could have both acute and long-term effects (Bucas & Saliot 2002). Most shipping accidents have a local impact on the environment through polluting the shoreline in a certain area, but accidents have also wider effects. Depending on the chemical, different spills of the same size can also have tremendously different effects on the environment (HELCOM 2006).

Chemical substances/compounds exist as solids, liquids, or gases. These chemicals include substances that are for example flammable, explosive, radioactive, corrosive, oxidizing, and toxic. Chemicals are used as raw materials in various industry sectors, related for example in forestry, pharmacy, electronics, and manufacturing of plastics, paints, rubbers, etc. The transportation of chemicals differs from the transportation of oils and oil products. Chemical transportations require more advanced tankers and handling. Chemicals can be transported either in bulk or in packaged form. Bulked substances can be further divided into solids, liquids and gases, and those can be transported either by chemical carriers or by gas carriers. In the Baltic Sea, most of the chemical transportations are done by chemical parcel tankers, which typically consist of 10 to 60 separate cargo tanks (Hänninen & Rytkönen 2006). Several different chemicals can thus be carried in one ship at the same time although usually no more than 10 different chemicals are transported in the same vessel.

Whereas the transportation amounts of oil and oil products are well-known, chemical transportations have not been excessively studied in the Baltic Sea region. There are only a few comprehensive studies on the chemicals transported in the Baltic Sea covering the whole Baltic Sea area and including chemical-specific information (e.g. Hänninen & Rytkönen 2006; Suominen and Suhonen 2007). In addition, some chemical-specific studies have been conducted on a national level at least in Finland and

Sweden (Häkkinen 2009; Molitor 2006; Räddningsverket 2008). Since the latest comprehensive studies are from few years ago, there is a need for a new comprehensive study on marine chemical transportations in the Baltic Sea. Generally, the whole shipping industry is growing rapidly in the Baltic Sea region, and the amount of cargo transportations has also increased significantly. As time passes, the relative importance of ports and chemicals may also change. All this means that the data gets old very fast and new information is needed all the time. The updating of chemical-specific information offers tools for different stakeholders to be prepared in advance in case an accident happens.

This report is written as a part of the Chembaltic (Risks of Maritime Transportation of Chemicals in Baltic Sea) project. The project gathers information on the chemicals transported in the Baltic Sea. The risk for chemical accidents in open water and ice conditions is being modelled in the project. The risks caused by the port operations of chemicals are being studied as well. In addition, the impact of other special environmental risk factors (e.g. new renewable fuels) in chemical transportation is being evaluated. This report gives an overview of the transport volumes of liquid bulk chemicals and liquefied gases in the Baltic Sea. The Chembaltic project is scheduled between February 2011 and December 2013 and it is carried out in co-operation with the University of Turku Centre for Maritime Studies, Aalto University and Kotka Maritime Research Centre. The project is funded by the European Regional Development Fund (ERDF) and the Finnish Funding Agency for Technology and Innovation (Tekes) as well as the following companies: Neste Oil Oyj, Vopak Chemicals Logistics Finland Oy, Port of HaminaKotka Ltd, Crystal Pool Ltd, and Finnish Transport Safety Agency (Trafi). Other support is given by the Finnish Port Association and the Finnish Shipowners Association. The publication reflects the views of the authors. The Managing Authority of the project cannot be held liable for the information published in this report.

2 PURPOSE AND METHODOLOGY OF THE STUDY

The purpose of this study is to provide an overview of the transport volumes of liquid bulk chemicals including liquefied gases in the Baltic Sea and to find out what the most transported liquid bulk chemicals in the Baltic Sea are. In this study, chemical transport volumes in the Baltic Sea are based on the chemical handling volumes of different Baltic Sea ports. Data gathered in this study will be used as background information in later stages of the Chembaltic project when the risks of the chemicals transported in the Baltic Sea are assessed to highlight the chemicals that require special attention from an environmental point of view in potential marine accident situations in the Baltic Sea area.

The study focuses on liquid bulk chemicals but also bulk gases (mainly transported as a liquefied form) are taken into account. Oil and oil products are observed only on a general level. The commodity group ‘oil and oil products’ may include chemical-related substances (e.g. certain bio-fuels which belong to the MARPOL annex II category, i.e., which are classified into a group as chemicals) in some cargo statistics. Chemicals in packaged form are excluded from the study. For example in Finnish ports, 97 % of hazardous cargoes are transported as bulk and only 3 % as packaged cargo (Häkkinen 2009). Liquid bulk chemicals are determined as liquid chemical cargo that is unpacked (un-bundled or un-bound) and is of the same or a similar kind or nature (homogeneous) and transported in a bulk carrier’s hold (Apparel Search 2011).

Most of the facts about the transport/handling volumes of chemicals presented in this study have been based on secondary written sources of Scandinavian, Russian, Baltic and international origin. Furthermore, statistical sources, academic journals, periodicals, newspapers and Internet sites of different stakeholders (e.g. ports, operators and terminals) have been used as sources of information. For Finland, more specific statistics about chemical transports could be recovered directly from a nationwide vessel traffic system called PortNet, in which each and every ship calling at a Finnish port has to provide information regarding its timetable, route, cargo, hazardous cargo and maritime fees. The transport volumes (export and import all together) of chemicals in two years (2008 and 2010) were collected on the basis of dangerous goods declarations gathered from the PortNet information system. More information about the PortNet review and its limitations is given in section 3.1.2. In addition, some inquiries about the chemicals handled or transported in the Baltic Sea were sent by email to terminals, ports and authorities (the Baltic countries and Denmark), but this did not result in any further information.

3 CHEMICALS HANDLED IN THE BALTIC SEA PORTS

In 2010, in total approximately 730 million tonnes (Mt) of international cargo was handled in the Baltic Sea ports (Table 3.1). Around 305 million tonnes (42 %) of the cargo was liquid bulk, 233 million tonnes (32 %) other dry cargo and 191 million tonnes (26 %) dry bulk. Approximately 175 million tonnes (24 %) of the international cargo traffic in the Baltic Sea was transported through Russian ports, 151 million tonnes (21 %) through Swedish ports, 93 million tonnes (13 %) through Finnish ports, and the rest 310 million tonnes (42 %) through Latvian, Polish, Danish, German, Estonian and Lithuanian ports. The largest Baltic Sea ports in 2010 by international cargo volumes were Primorsk (78 Mt), St. Petersburg (58 Mt), Gothenburg (40 Mt), Klaipeda (31 Mt) and Riga (30 Mt) (Holma et al. 2011).

Table 3.1 International cargo traffic in the Baltic Sea ports in 2010, thousand tonnes. (Holma et al. 2011)

	Dry bulk	Other dry cargo	Liquid bulk			International cargo total
			Oil and oil products	Liquid chemicals	Other liquid bulk	
Russian ports	26,656	35,335	112,842	85	317	175,235
Swedish ports	26,094	68,661	53,634	930	1,826	151,145
Finnish ports	27,351	38,846	20,240	6,266	301	93,004
Latvian ports	29,737	10,227	20,485	690	73	61,212
Polish ports	24,015	17,055	16,242	811	447	58,570
Danish ports	17,617	23,148	15,967	218	857	57,807
German ports	17,351	25,170	4,153	0	42	46,716
Estonian ports	10,145	5,354	28,575	1,157	53	45,284
Lithuanian ports	11,774	9,694	17,780	792	255	40,295
Baltic ports total	**190,740**	**233,490**	**289,918**	**10,949**	**4,171**	**729,268**

According to Holma et al. (2011), the international liquid bulk cargo handled in the Baltic Sea ports in 2010 contained approximately 290 million tonnes of oil and oil products, 11 million tonnes of liquid chemicals, and 4 million tonnes of other liquid bulk. In this study, the focus is put on liquid chemicals. Almost 6.3 million tonnes (57 %) of liquid chemical transports in the Baltic Sea were handled in Finnish ports. However, it should be noted that in the Finnish statistics, liquid and solid chemicals cannot be separated from each other and, therefore, the amount of liquid bulk chemicals handled in Finnish ports can be considered to be slightly lower than 6.3 million tonnes. Holma et al. (2011) stated that the estimated share of liquid bulk chemicals handled in the Finnish ports in 2010 is over 80 % of the class ‘liquid chemicals’. Therefore, the volume of liquid bulk chemicals handled in Finnish ports in 2010 can be considered to be between 5.0–6.3 million tonnes. In addition to Finnish ports, large amounts of liquid chemicals are also handled in Estonian (1.2 Mt), Swedish (0.9 Mt), Polish (0.8 Mt), Lithuanian (0.8 Mt) and Latvian ports (0.7 Mt). In the case of Swedish ports, the volume of liquid chemicals is most probably much higher than 0.9 million tonnes since in the Swedish statistics reported by Holma et al. (2011), most of the cargo reported in the class ‘other liquid bulk’ is most probably liquid chemicals. Therefore, the estimated share of liquid chemicals handled in Swedish ports in 2010 is supposedly over 2 million

tonnes (Holma 2012). Molitor (2006) and Suominen (2007) have also reported that the annual chemical handling volume in Swedish ports has been over 2.5 million tonnes. In addition, this study showed that also German ports situated in the Baltic Sea handle liquid chemicals in large quantities, but exact amounts are unknown.

3.1 Finnish ports

3.1.1 Overview of the liquid bulk handling volumes

The Finnish National Board of Customs compiles statistics on the foreign trade of Finland. According to the statistics of Finnish foreign trade transports (Finnish Customs 2012), the total volume of transported chemical substances and products in Finland has varied annually between 9,500 thousand tonnes and 11,400 thousand tonnes during the period of 2005–2010 (Figure 3.1). There was an ascending trend in the volumes during the years 2005–2007 but the volumes turned into a descending trend during the years 2008 and 2009, mainly due to a global economic recession. In 2010, the total volume of transported chemical substances and products in Finland began to grow again. Every year in the period observed, over 75 % of all the chemical substances and products in Finnish foreign trade have been transported by sea. The annual share of rail transports has varied between 13–16 % or 1,260–1,730 thousand tonnes and annual share of road transports between 6–10 % or 700–980 thousand tonnes. Air transports and other transport modes have had a minor role in the transports of chemical substances and products in Finnish foreign trade. In 2010, around 10,900 thousand tonnes of chemical substances and products were transported in Finnish foreign trade. Around 8,630 thousand tonnes (80 %) of these transports was carried by sea, 1,430 thousand tonnes (13 %) by rail, 780 thousand tonnes (7 %) by road and 7 thousand tonnes (0.1 %) by air or other transport mode.

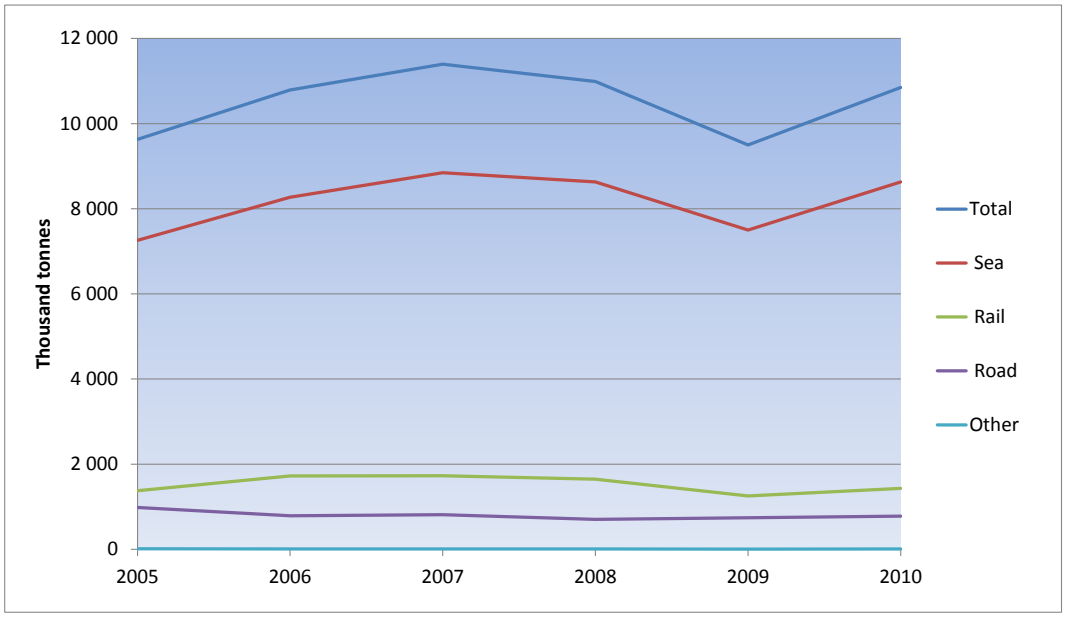

Figure 3.1 Transports of chemical substances and products in Finnish foreign trade by transport mode in the period of 2005–2010. (Finnish Customs 2012)

According to the statistics of Finnish foreign trade transports provided by the Finnish National Board of Customs, the annual volume of chemical substances and products transported by sea has varied between 7,260–8,850 thousand tonnes over the period of 2005–2010 (Figure 3.2). The import volume of chemical substances and products has almost every year been higher than the export volume. The only exception was the year 2009. In 2010, the total volume of chemical substances and products transported by sea in Finland was approximately 8,630 thousand tonnes, of which import accounted for 4,500 thousand tonnes and export for 4,130 thousand tonnes.

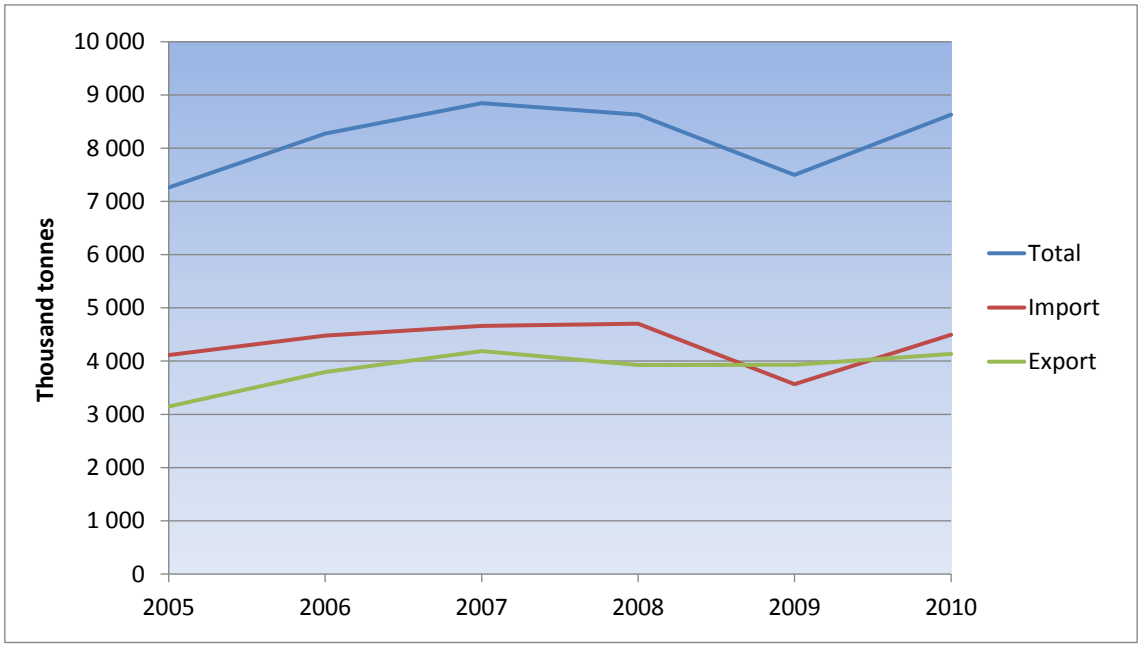

Figure 3.2 Transports of chemical substances and products in Finnish foreign trade by sea in the period of 2005–2010. (Finnish Customs 2012)

The Finnish Transport Agency is responsible for compiling statistics on marine traffic flows in Finland. The basic classification of cargo includes 16 classes. One of these classes is named ‘chemicals’ (Finnish Transport Agency 2011). It should be noted that the ‘chemicals’ class contains both liquid and dry chemicals, and these cannot be separated from each other. The estimated share of liquid chemicals is over 80 per cent of the class ‘chemicals’ (Holma et al. 2012).

According to the Finnish Transport Agency’s statistics, the chemical handling volume in Finnish ports in international cargo traffic has increased by approximately 38 % from 4.5 million to 6.3 million tonnes over the period of 1993–2010 (Figure 3.3). There was a descending trend of chemical volumes in Finnish ports in the years 1994–1999 but after that period the trend of annual chemical volumes has been ascending. The highest annual chemical handling volume has so far been recorded in 2008 when about 6.4 million tonnes of chemicals were handled in Finnish ports. During the period of 1993–2010, annual import volumes of chemicals (excluding transit cargo) have every year been higher than the export volumes (excluding transit cargo). The annual share of import volumes of chemicals (excluding transit cargo) have varied between 1.4–2.9

million tonnes and share of import volumes of chemicals (excluding transit cargo) between 0.8–2.0 million tonnes over the period observed.

It has been typical that a large amount of chemicals has transported through Finnish ports as transit cargo – the annual transit volume of chemicals in Finnish ports has varied between 1.1–2.6 million tonnes over the period of 1993–2010. Every year approximately 95–100 % of the transit volume of chemicals has been westbound transit cargo and only 0–5 % eastbound transit cargo. In the year 2010, the export of chemicals in Finnish ports accounted for 3.4 million tonnes (55 %) and the import of chemicals for 2.8 million tonnes (45 %) when both Finland's own export/import and transit traffic were taken into account. The annual share of chemical handling volumes of the Finnish ports' total international cargo volumes has varied between 5–7 % over the period of 1993–2010.

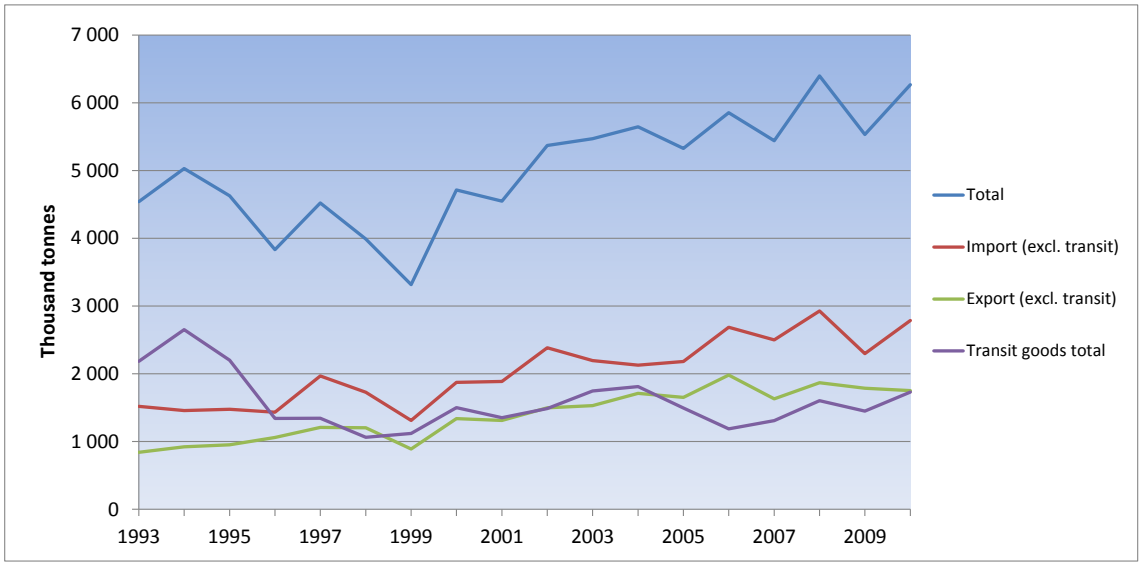

Figure 3.3 Chemical handling volumes in Finnish ports in international cargo traffic in the period of 1993–2010. (Finnish Transport Agency 2012a)

In the year 2010, there were 24 Finnish ports that handled chemicals in international cargo traffic (including transit cargo). Half of these ports handled over 100 thousand tonnes (kt) of chemicals. Hamina was clearly the largest chemical handling port with the volume of 1,600 thousand tonnes handling over 25 % of all the chemicals transported through Finnish ports in 2010 (Figure 3.4). Oulu (920 kt), Kotka (670 kt), Kilpilahti (670 kt) and Kokkola (480 kt) were next in rank in terms of chemical handling volumes. In export, Hamina was the largest chemical port by volume, handling approximately 1,270 thousand tonnes or 37 % of all the chemicals transported through Finnish ports in 2010. Kotka (560 kt), Kilpilahti (410 kt), Pori (280 kt) and Helsinki (230 kt) held the next largest share in export of chemicals. In import, Oulu was the largest chemical port by volume, handling around 750 thousand tonnes or 27 % of all the chemicals transported through Finnish ports in 2010. Hamina (330 kt), Kokkola (280 kt), Kilpilahti (260 kt) and Helsinki (220 kt) held the next largest share in the import of chemicals.

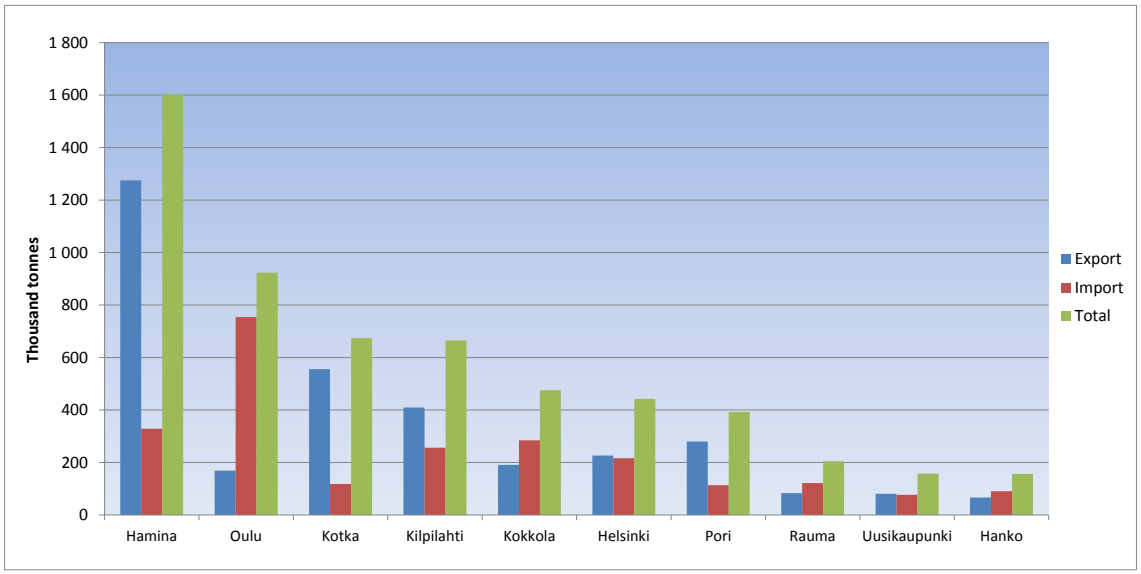

Figure 3.4 Ten largest chemical handling ports in Finland's international cargo traffic in 2010 by volumes. (Finnish Transport Agency 2012a)

3.1.2 Chemical-specific handling volumes

Finnish Transport Agency's general cargo statistics provide only coarse-level information about cargo handled in Finnish ports. More detailed information about cargo traffic in Finnish ports can be found in the PortNet system (www.portnet.fi) provided by the Finnish Transport Agency. PortNet is a nationwide vessel traffic system in Finland allowing authorities and business organisations exchange information electronically, using commonly agreed formats of data. Each and every ship calling at a Finnish port has to provide information regarding its timetable, route, cargo, hazardous cargo and maritime fees. All this information can be exchanged through the PortNet system (Rautiainen and Rinta-Keturi 2005).

In this study, the hazardous cargo declarations provided by the PortNet system was reviewed to get chemical-specific information about chemicals handled in Finnish ports. Only bulk chemicals were included in this review. The review focused on liquid and gaseous chemicals but also some solid chemicals may be included in the statistics provided by the PortNet system but for example coal and lead batteries were excluded as solids. The estimated share of liquid chemicals is over 80 % of the class 'chemicals' (Holma et al. 2011). Since the focus in this study is put on chemical transport, conventional oil and oil products (aviation gasoline, be95/98, conventional diesel, gasoline, kerosene, naphta etc.) were excluded from the review. All Finnish ports handling chemicals were included in the review. The years 2008 and 2010 were chosen in the review, and both export and import of chemicals were examined.

There are some considerations to take into account when the results of the PortNet hazardous cargo review are examined. First, it was noted during the review that there was some missing or unclear information in the hazardous cargo declarations in the PortNet system. In these cases, the cargo manifests of these deliveries were reviewed

one by one to complement the missing or unclear information since cargo manifests provide more detailed information about cargo than hazardous cargo declarations. Second, UN numbers of chemicals were missing in many cases in the hazardous cargo declarations provided by the PortNet system and common chemical names might have different meanings (e.g. toluene's common name may be benzene in some cases). Third, there may be minor differences between the reported cargo volumes in the hazardous cargo declarations and in the cargo manifests. The reason for this is that the cargo volumes reported in the hazardous cargo declarations are usually estimated numerical values that have to be entered into the PortNet system 24 hours before the ship will arrive at port, and the verified figures are given in the cargo manifests after unloading. Fourth, there were some hazardous cargo declarations and cargo manifests where the amount of the cargo was reported in cubic metres instead of tonnes. In these cases, the conversion from cubic metres to tonnes was made using density of different chemicals provided by material safety data sheets. Fifth, in addition to the international cargo traffic, the Finnish domestic cargo traffic is also included in the review since separating it would have required a huge amount of extra work and it was not seen appropriate for the study. Sixth, although the PortNet system is well-suited for the gathering of information about export, which is mandatory in Finnish ports, the amounts of import may have some deficiencies (Arkima 2012).

Chemicals imported to Finnish ports in 2008 and 2010

According to the result of the PortNet hazardous cargo review, around 945 thousand tonnes of liquid and gaseous bulk chemicals were imported to Finnish ports in 2010 (Table 3.2). Since the corresponding figure was 1,184 thousand tonnes in 2008, the amount of liquid and gaseous bulk chemical imports to Finnish ports has decreased by approximately 20 % from 2008 to 2010. The three most imported chemicals have remained the same in both years studied. Sodium hydroxide solution has clearly been the most imported chemical with a share of 374 thousand tonnes or 40 % of the total volume in 2010 and 360 thousand tonnes or 30 % in 2008. Ethanol and propane have been next in rank in terms of chemical handling volume. Ammonia and benzene have also handled quite large amounts in both years studied.

There are some differences when the chemicals imported to Finnish ports in 2010 and in 2008 are compared (Table 3.2). First, the number of imported chemicals to Finnish ports has decreased from 36 in 2008 to 29 in 2010. Most of the chemicals missing from the list of 2010 were imported to Finnish ports in only small quantities in 2008, but for example 53 thousand tonnes of butane, 48 thousand tonnes of crude palm oil, 17 thousand tonnes of raffinate and 9 thousand tonnes of vinyl acetate were imported in 2008 while these chemicals were not imported at all in 2010. There are also some chemicals that were imported to Finnish ports in 2010 but not at all in 2008 (e.g. pyrolysis gasoline 27 kt, alcohol fuel mixture 10 kt and palm stearine 10 kt). Second, quantities of some imported chemicals have significantly increased/decreased from the year 2008 to the year 2010. Chemicals whose imports to Finnish ports have significantly increased are styrene (+44 kt), benzene (+22 kt) and sodium hydroxide solution (+15 kt). Respectively, chemicals whose imports to Finnish ports have

significantly decreased are sulphuric acid (-51 kt), ethyl tert-butyl ether (-45 kt), propane (-29 kt), butadiene (-27 kt) and tert-amyl ethyl ether (-27 kt).

Table 3.2 Chemicals imported to Finnish ports in 2008 and 2010, tonnes. (Finnish Transport Agency 2012b)

2008	
Sodium hydroxide solution	359,424
Ethanol and ethanol solutions	127,898
Propane	107,260
Ammonia	72,088
Ethyl tert-butyl ether (ETBE)	64,889
Sulphuric acid	55,047
Butane	53,491
Tert-amyl ethyl ether (TAEE)	50,697
Crude palm oil	48,413
Butadiene	35,177
Benzene	31,830
Butane + propane	19,702
Hydrogen peroxide	19,362
Styrene	18,658
Raffinate	17,269
VERSENEX 80/100	15,463
Butyl acrylate	13,797
Methyl tert-butyl ether (MTBE)	10,094
Vinyl acetate	9,414
Nitric acid	8,378
Methanol	8,132
Phenol	7,378
Other chemical products (NOS)	6,502
Methylmetacrylate	4,105
Propylene	3,464
Nexbase	3,031
Propylene glycol	2,326
Diisononyl phthalate	1,999
Sulphur Granular	1,796
Tall pitch oil	1,732
Crude sulphate turpentine	1,038
Nytro 11 Gbx	1,000
NExBTL	918
Xylenes	518
Terpene	400
BT450	202
Total	**1,182,890**

2010	
Sodium hydroxide solution	374,031
Ethanol and ethanol solutions	110,581
Propane	78,392
Styrene	63,162
Benzene	54,229
Ammonia	51,632
NExBTL	34,798
Pyrolysis gasoline	26,614
Tert-amyl ethyl ether (TAEE)	23,186
Hydrogen peroxide	20,001
Ethyl tert-butyl ether (ETBE)	19,273
VERSENEX 80/100	12,968
Alcohol fuel mixture	10,372
Palm stearine	10,009
Butadiene	7,944
Propylene	7,427
ETBE/TAEE	7,069
Nexbase	4,498
Sulphuric acid	4,189
Butyl Acrylate	4,153
Methyl tert-butyl ether (MTBE)	3,158
Rapeseed oil	3,152
Diisononyl phthalate	2,999
Cumene	2,611
Phenol	2,500
Coal tar	2,217
Hexane	1,950
Acetone	925
Propylene glycol	500
Total	**944,540**

Chemicals exported from Finnish ports in 2008 and 2010

According to the result of the PortNet hazardous cargo review, around 2,510 thousand tonnes of liquid and gaseous bulk chemicals were exported from Finnish ports in 2010 (Table 3.3). Since the corresponding figure was 2,380 thousand tonnes in 2008, the amount of liquid and gaseous bulk chemical exports from Finnish ports has increased

approximately 5 % from 2008 to 2010. Methanol has been the most exported chemical from Finnish ports in both years studied. In 2010, approximately 746 thousand tonnes of methanol were exported, which is 112 thousand tonnes or 13 % less than in 2008. The other chemicals whose exports amounted to over 100 thousand tonnes in 2010 were pentanes (315 kt), xylenes (162 kt), methyl tert-butyl ether (156 kt), aromatic free solvents (155 kt) and parafines (111 kt). Respectively, the other chemicals whose exports amounted to more than 100 thousand tonnes in 2008 were xylenes (206 kt), phosphoric acid (133 kt), pentanes (125 kt), phenol + acetone (119 kt), aromatic free solvents (111 kt) and methyl tert-butyl ether (109 kt).

There are some differences when the chemicals exported from Finnish ports in 2010 and in 2008 are compared (Table 3.3). First, the number of exported chemicals from Finnish ports has decreased from 60 in 2008 to 46 in 2010. Most of the chemicals missing from the list of 2010 were exported to Finnish ports only in small quantities (< 5,000 kt) in 2008 but 28 thousand tonnes of monoethylene glycol were exported in 2008 while this chemical was not exported at all in 2010. There are also some chemicals that were exported from Finnish ports in 2010 but not at all in 2008 (e.g. pyrolysis gasoline 13 kt, sodium hydroxide solution 6 kt and propane 6 kt). Second, quantities of some exported chemicals have significantly increased/decreased from 2008 to 2010. Chemicals whose exports from Finnish ports have significantly increased are pentanes (+191 kt), formic acid (+62 kt), parafines (+60 kt), methyl tert-butyl ether (+47 kt) and aromatic free solvents (+44 kt). In contrast, chemicals whose exports from Finnish ports have significantly decreased are methanol (-112 kt), phenol + acetone (-47 kt), xylenes (-44 kt), phosphoric acid (-41 kt), propylene (-41 kt) and styrene (-32 kt).

Table 3.3 Chemicals exported from Finnish ports in 2008 and 2010, tonnes. (Finnish Transport Agency 2012b)

2008	
Methanol	858,191
Xylenes	206,040
Phosphoric acid	133,147
Pentanes	124,548
Phenol + acetone	119,065
Aromatic free solvents (e.g. white spirit and NESSOL)	111,479
Methyl tert-butyl ether (MTBE)	109,445
Phenol	65,662
Propylene	63,354
Hexafluorosilicic acid	57,896
Acetone	53,074
Parafines	51,450
Styrene	40,765
Nitric acid	32,288
Nonylphenol ethoxylates	29,160
Ethylene	27,795
Monoethylene glycol	27,725
CO2	27,253
Butadiene	25,163

2010	
Methanol	746,141
Pentanes	315,978
Xylenes	161,894
Methyl tert-butyl ether (MTBE)	156,502
Aromatic free solvents (e.g. white spirit and NESSOL)	155,363
Parafines	111,079
Phosphoric acid	91,797
Phenol	84,859
Acetone	72,890
Phenol + acetone	72,427
Formic acid	68,427
Butanole	67,890
Hexafluorosilicic acid	56,006
Ethylene	45,166
NExBTL	38,500
Coal tar	33,897
Butadiene	30,908
Propylene	22,492
Sulphuric acid	20,983

Benzene	25,012
Butanoles	24,399
Ethanol and ethanol solutions	21,636
Butyl acrylate	13,845
Butyl acetate	12,026
NExBTL	11,888
Tert-amyl methyl ether (TAME)	10,148
Epichlorohydrin	9,328
Ethyl tert-butyl ether (ETBE)	8,757
Sulphuric acid	7,775
Alpha-olefines	7,058
Linear alkyl benzene	6,740
Formic acid	6,614
Hydrocarbon, liquid (NOS)	4,807
ETBE + TAEE	4,653
Ethylene glycol diethyl ether	4,073
Coal tar	4,021
Hydrogen peroxide	4,017
Tall pitch oil	4,002
Piperylene	3,879
Tert-amyl ethyl ether (TAEE)	3,542
Polymers (NOS)	3,346
Nexbase	1,998
Octene	1,896
Diethylbenzene	1,727
Other chemical products (NOS)	1,260
X IMO class chemicals (NOS)	1,020
Hexene	996
Environmentally hazardous substance (NOS)	839
Methyl metacrylate	658
Octanol (all isomers) 2-ethyl hexanol	533
Diethylene glycol	514
Hydrocarbon gas mixture (NOS)	160
Alcohols (NOS)	75
Ammonium nitrate	48
Liquids transported in elevated temperature (> 100 C) (NOS)	44
Resine solution	40
Isoprene	39
Propylene glycol monomethyl ether	25
Toluene diisocyanate	23
Organic acid (NOS)	21
Total	**2,376,982**

Nitric acid	16,838
Nexbase	15,903
Benzene	15,011
CO_2	13,592
Pyrolysis gasoline	12,811
Ethanol and ethanol solutions	11,437
Nonylphenol ethoxylate	11,082
Styrene	8,772
Linear alkyl benzene	6,779
Sodium hydroxide solution	6,300
Propane	5,634
ETBE + TAEE	5,239
Butyl acrylate	5,120
Butyl acetate	4,558
Piperylene	4,476
Alpha-olefines	3,737
Butane	2,257
Dioctyl phthlate	1,994
Sodium chlorate	1,801
c9-Hydrocarbons	1,593
Acetic acid	1,497
Di ethylene glycol	1,000
Epichlorohydrin	480
C9 resin oil	383
Liquids transported in elevated temperature (> 100 C) (NOS)	75
Hydrogen peroxide	58
Toluene diisocyanate	23
Total	**2,511,649**

Chemicals handled in Finnish ports (export + import) in 2008 and 2010

The total volumes (import + export) of different chemicals handled in Finnish ports in 2008 and 2010 are presented in Table 3.4, based on result of the PortNet hazardous cargo review. According to the review, in total approximately 3,460 thousand tonnes of liquid and gaseous bulk chemicals were handled in Finnish ports in 2010. Since the corresponding figure was 3,560 thousand tonnes in 2008, the amount of liquid and gaseous bulk chemicals handled in Finnish ports has decreased approximately 3 % from 2008 to 2010. When the 10 most handled chemicals in Finnish ports in 2008 and 2010 are compared, it can be seen that 9 out of 10 chemicals are the same. Only the amounts of these nine chemicals vary in the years observed. Methanol has clearly been the most handled chemical in both years studied. Approximately 746 thousand tonnes and 866 thousand tonnes of methanol were handled in 2010 and 2008, respectively. Sodium hydroxide solution has been next in rank in both years studied in terms of chemical handling volume. Pentanes, xylenes, methyl tert-butyl ether, aromatic free solvents, ethanol, phosphoric acid and phenol have also been handled in quite large quantities both in 2008 and 2010.

As the import and export volumes of different chemicals in Finnish ports presented above revealed, there are some differences when the chemicals handled in Finnish ports in 2010 and in 2008 are compared (Table 3.4). First, the number of chemicals handled in Finnish ports has decreased from 76 in 2008 to 57 in 2010. Most of the chemicals missing from the list of 2010 were handled in Finnish ports only in small quantities (< 5,000 kt) in 2008. However, e.g. 48 thousand tonnes of crude palm oil, 28 thousand tonnes of monoethylene glycol, 17 thousand tonnes of raffinate, 10 thousand tonnes of tert-amyl methyl ether and 9 thousand tonnes of vinyl acetate were handled in 2008 while these chemicals were not handled at all in 2010. There are also some chemicals that were handled in Finnish ports in 2010 but not at all in 2008 (e.g. pyrolysis gasoline 39 kt, alcohol fuel mixture 10 kt and palm stearine 10 kt). Second, quantities of some chemicals handled in Finnish ports have significantly increased/decreased from 2008 to 2010. Chemicals whose handling volumes in Finnish ports have increased the most are pentanes (+191 kt), formic acid (+62 kt), NExBTL (+60 kt), parafines (+60 kt), aromatic free solvents (+44 kt), butanoles (+43 kt) and methyl tert-butyl ether (+40 kt). In contrast, chemicals whose handling volumes in Finnish ports have significantly decreased are methanol (-120 kt), ethyl tert-butyl ether (-54 kt), butane (-51 kt), phenol + acetone (-47 kt), xylenes (-45 kt) and phosphoric acid (-41 kt).

Table 3.4 Chemicals handled in Finnish ports (export + import) in 2008 and 2010, tonnes. (Finnish Transport Agency 2012b)

2008	
Methanol	866,323
Sodium hydroxide solution	359,424
Xylenes	206,558
Ethanol and ethanol solutions	149,535
Phosphoric acid	133,147
Pentanes	124,548
Methyl tert-butyl ether (MTBE)	119,539
Phenol + acetone	119,065
Aromatic free solvents (e.g. white spirit and NESSOL)	111,479
Propane	107,260
Ethyl tert-butyl ether (ETBE)	73,646
Phenol	73,040
Ammonia	72,088
Propylene	66,818
Sulphuric acid	62,822
Butadiene	60,340
Styrene	59,423
Hexafluorosilicic acid	57,896
Benzene	56,841
Tert-amyl ethyl ether (TAEE)	54,239
Butane	53,491
Acetone	53,074
Parafines	51,450
Crude palm oil	48,413
Nitric acid	40,666
Nonylphenol ethoxylates	29,160
Ethylene	27,795
Monoethylene glycol	27,725
Butyl acrylate	27,641
CO_2	27,253
Butanoles	24,399
Hydrogen peroxide	23,379
Butane + propane	19,702
Raffinate	17,269
VERSENEX 80/100	15,463
NExBTL	12,806
Butyl acetate	12,026
Tert-amyl methyl ether (TAME)	10,148
Vinyl acetate	9,414
Epichlorohydrin	9,328
Other chemical products (NOS)	7,762
Alpha-olefines	7,058
Linear alkyl benzene	6,740
Formic acid	6,614
Tall pitch oil	5,734
Nexbase	5,029

2010	
Methanol	746,141
Sodium hydroxide solution	380,331
Pentanes	315,978
Xylenes	161,894
Methyl tert-butyl ether (MTBE)	159,660
Aromatic free solvents (e.g. white spirit and NESSOL)	155,363
Ethanol and ethanol solutions	122,018
Parafines	111,079
Phosphoric acid	91,797
Phenol	87,359
Propane	84,027
Acetone	73,815
NExBTL	73,298
Phenol + acetone	72,427
Styrene	71,934
Benzene	69,240
Formic acid	68,427
Butanoles	67,890
Hexafluorosilicic acid	56,006
Ammonia	51,632
Ethylene	45,166
Pyrolysis gasoline	39,426
Butadiene	38,852
Coal tar	36,114
Propylene	29,919
Sulphuric acid	25,172
Tert-amyl ethyl ether (TAEE)	23,186
Nexbase	20,401
Hydrogen peroxide	20,059
Ethyl tert-butyl ether (ETBE)	19,273
Nitric acid	16,838
CO_2	13,592
VERSENEX 80/100	12,968
ETBE + TAEE	12,309
Nonylphenol ethoxylates	11,082
Alcohol fuel mixture	10,372
Palm stearine	10,009
Butyl acrylate	9,273
Linear alkyl benzene	6,779
Butyl acetate	4,558
Piperylene	4,476
Alpha-olefines	3,737
Rapeseed oil	3,152
Diisononyl phthalate	2,999
Cumene	2,611
Butane	2,257

Hydrocarbon, liquid (NOS)	4,807
Methylmetacrylate	4,763
ETBE + TAEE	4,653
Ethylene glycol diethyl ether	4,073
Coal tar	4,021
Piperylene	3,879
Polymers (NOS)	3,346
Propylene glycol	2,326
Diisononyl phthalate	1,999
Octene	1,896
Sulphur Granular	1,796
Diethylbenzene	1,727
Crude sulphate turpentine	1,038
X IMO class chemicals (NOS)	1,020
Nytro 11 Gbx	1,000
Hexene	996
Environmentally hazardous substance (NOS)	839
Octanol (all isomers) 2-ethyl hexanol	533
Diethylene glycol	514
Terpene	400
BT450	202
Hydrocarbon gas mixture (NOS)	160
Alcohols (NOS)	75
Ammonium nitrate	48
Liquids transported in elevated temperature (> 100 C) (NOS)	44
Resine solution	40
Isoprene	39
Propylene glycol monomethyl ether	25
Toluene diisocyanate	23
Organic acid (NOS)	21
Total	**3,559,868**

Dioctyl phthlate	1,994
Hexane	1,950
Sodium chlorate	1,801
c9-Hydrocarbons	1,593
Acetic acid	1,497
Diethylene glycol	1,000
Propylene glycol	500
Epichlorohydrin	480
C9 resin oil	383
Liquids transported in elevated temperature (> 100 C) (NOS)	75
Toluene diisocyanate	23
Total	**3,456,192**

Comparison of the result of the PortNet hazardous cargo review with earlier studies

The latest more detailed list of chemicals handled in Finnish ports is available from 1994 (Sormunen 2011, originally presented in Hänninen & Rytkönen 2006). According to the list (Table 3.5), in total 3,900 thousand tonnes of chemicals, including both liquid and gaseous chemicals, were handled in Finnish ports in 1994. Since the corresponding figure was 3,560 thousand tonnes in 2008 and 3,460 thousand tonnes in 2010, the amount of liquid and gaseous bulk chemicals handled in Finnish ports has slightly decreased since 1994 although the size range has remained the same. The number of different chemicals has also remained approximately the same when the years 1994 and 2008 are compared. In 2010, the number of different chemicals decreased by approximately 20 chemicals. It can also be seen that the most handled chemicals in Finnish ports have remained almost the same from 1994 to 2008 and 2010. The most

handled chemicals in all these years contain chemicals such as methanol, sodium hydroxide solution, xylenes, ammonia, phosphoric acid and ethanol. However, there are some chemicals whose quantities in Finnish ports have significantly increased/decreased from 1994 to 2008 and 2010. Examples of chemicals whose quantities have increased are pentanes, methyl tert-butyl ether, propane and aromatic free solvents. Respectively, examples of chemicals whose quantities have decreased are pyrolysis gasoline, ammonia and monoethylene glycol. There are also some chemicals that were handled in Finnish ports in 1994 but not at all in 2008 and 2010. Examples of these chemicals are fluosilicic acid and magnesium sulphonate. In contrast, there are some new chemicals that were transported in 2008 and 2010 but not at all in 1994, such as ethyl tert-butyl ether (ETBE), tert-amyl ethyl ether (TAEE), NExBTL and palm oil.

Table 3.5 Chemicals handled in Finnish ports in 1994. (Adapted from Sormunen 2011, originally presented in Hänninen & Rytkönen 2006)

Chemical	Tonnes
Methanol (methyl alcohol)	742,410
Sodium hydroxide solution	396,298
Pyrolysis gasoline	262,017
Orthoxylene [xylenes]	226,565
Ammonia aqueous	213,338
Phosphoric acid	183,351
Paraxylene [xylenes]	172,742
Styrene monomer	136,316
Ethanol [ethyl alcohol]	114,645
Monoethylenglycol [ethylene glycol]	109,180
Benzene	108,168
Acetone	104,526
Phenol	94,446
Synthetic ethanol	78,767
Styrene [-monomer]	75,000
Benzene/toluene/xylene mixtures [mixtures having 10% ≥ benzene]	57,171
N-Paraffin [n-Alkanes (C10+)]	48,794
Tall oil	48,738
N-Butanol [n-Butyl alcohol]	46,454
Sulphuric acid	45,400
Isopropylbenzene (cumene) [all isomers]	44,816
Propylene trmer	42,00
Fluosilicic acid [- (20-30%)in water solution}	34,24
Ethyl acetate	29,672
C2/C9 fractions [nonene (all isomers)]	28,696
Coal tar	27,500
Nitric acid	26,912
Magnesium sulphonate [long-chain alkaryl sulphonate (C11-C50)]	24,848
Isobutanol [isobutyl alcohol]	22,005
Cyclohexanone	14,772
Vinyl acetate	14,326
Tall oil fatty acid	13,519
Alpha methyl styrene	12,245
Trichloroethylene	11,867

Chemical	Tonnes
Calcium ammonium nitrate [ammonium nitrate solution (93% or less)]	4,989
Monoammonium sulphate	4,898
Acetic anhydride	4,882
Methyl tert-butyl ether	4,372
White spirit	3,790
Monochlorbenzene [chlorobenzene]	3,441
Ethylene glycol monoethyl ether [Poly(2-8)alkylene glycol monoalkyl(C1-C6) ether]	3,318
Cyclohexane	3,037
Hexan fraction C [hexane all isomers]	2,682
Ethyl glycol, ethylene glycol	2,446
Xylene[-s]	2,397
Sodiumborohydride (Borol)	2,042
Potassium hydroxide solution	2,030
Chlorobenzene	1,903
Glycerine	1,739
Formic acid	1,700
Dioctylformamide [formamide]	1,611
Monopropylene glycol [propylene glycol]	1,587
Alpha-methylstyrene fr.	1,555
Ethyl glycol ether [ethylene glycol monoalkyl ethers]	1,276
Glyoxal 40 [Glyoxal solution (40 % or less)]	1,200
1,3-Pentadiene (piperylene)	1,017
1,1,1-Trichloromethane (methylchloroform)	979
Perchloroethylene	951
Hydrocarbon solvent (Solvent K)	876
Carbon tetra chloride	780
C8/C10 fatty alcohols [octanol (all isomers)]	515
Ethanol ethyl acetate [ethyl acetate]	504
Coal tar naphtha solvent	470

Aniline oil	11,450
Butyl acetate	11,324
Dichloromethane (methylene chloride)	9,985
Ethylene dichloride	8,645
Turpentine	7,805
Nonyphenol ethoxylate [nonylphenol poly(4+)ethoxylate]	6,592
Alkyl benzene [-distillation bottoms]	6,567
Toluene	6,480
Acetic acid	6,470
Isopropyl alcohol (IPA)	6,170
Monoammonium phosphate	5,672
Butyl acrylate	5,624

MPG	397
Methyl metacr. Monomer [methyl methacrylate]	300
Methyl ethyl ketone	270
Ethyl hexyl acrylate monomer [2-Ethylhexyl acrylate]	120
TOTAL CHEMICALS:	**3,769,146**
GASES:	
Butane	74,429
Propane	36,000
Gas condensate	20,816
TOTAL GASES:	**131,245**
TOTAL ALL GASES AND CHEMICALS:	**3,900,391**

The Finnish Ministry of Transport and Communications publishes reports that combine the Finnish statistics on transport of dangerous goods by sea, road, rail, and air. The reports are compiled every five years. The newest ones are from 2004 and 2009 (Häkkinen 2004; Häkkinen 2009) and they compiled data from 2002 and 2007. These reports contain the volumes of the most handled chemicals in Finnish ports but they list only about 10 of the most handled chemicals (Table 3.6). When the most handled chemicals in Finnish ports in 2007 presented in Table 3.6 and results of the PortNet review presented earlier in this section are compared, it can be seen that the chemicals handled the most are the same. However, surprisingly, in the year 2002 the most handled chemical was ethylene glycol and also the volume of acetone was much higher than in other years studied.

Table 3.6 Most handled chemicals in Finnish ports (import + export) in 2002 and 2007, thousand tonnes. (Adapted from Häkkinen 2004; Häkkinen 2009)

2002	
Ethylene glycol	1,196
Methanol	669
Sodium hydroxide solution	512
Phenol	350
Acetone	319
Sulphuric acid	306
Phosphoric acid	258
Styrene	210
Xylenes	175
Methyl tert-butyl ether	161
Other chemicals	750
Total	**4,906**

2007	
Methanol	814
Sodium hydroxide solution	506
Xylenes	190
Phosphoric acid	166
Methyl tert-butyl ether	158
Phenol	128
Sulphuric acid	112
Other chemicals	778
Total	**2,852**

Hänninen & Rytkönen (2006) studied chemicals transported through Finnish and other Baltic Sea ports using an inquiry that was sent to over 50 Baltic Sea ports. The study covered information on 16 Finnish ports and the chemicals handled in these ports. Since Hänninen's & Rytkönen's (2006) study did not cover all Finnish ports and some of the ports provided inaccurate statistics of the handled chemicals, the results of the study is

difficult to compare with the results of the PortNet hazardous cargo review presented in this report.

3.2 Swedish ports

3.2.1 Overview of the liquid bulk handling volumes

In Sweden, Transport Analysis publishes the country's official statistics about foreign trade. According to the Transport Analysis's shipping goods statistics, the total cargo traffic handled in Swedish ports, including both international and domestic traffic, has varied annually between 153–188 million tonnes over the period of 2001–2010 (Figure 3.5). The annual share of liquid bulk of the total cargo volume has varied between 34–40 % or 55–70 million tonnes during the period observed. There has been an ascending trend in liquid bulk handling volumes in Swedish ports from 2001 to 2010. In the year 2010, approximately 67 million tonnes of liquid bulk was handled in Swedish ports. Depending on the year, approximately 62–65 % of the liquid bulk handling volumes have been imports to Swedish ports and respectively 35–38 % exports from Swedish ports.

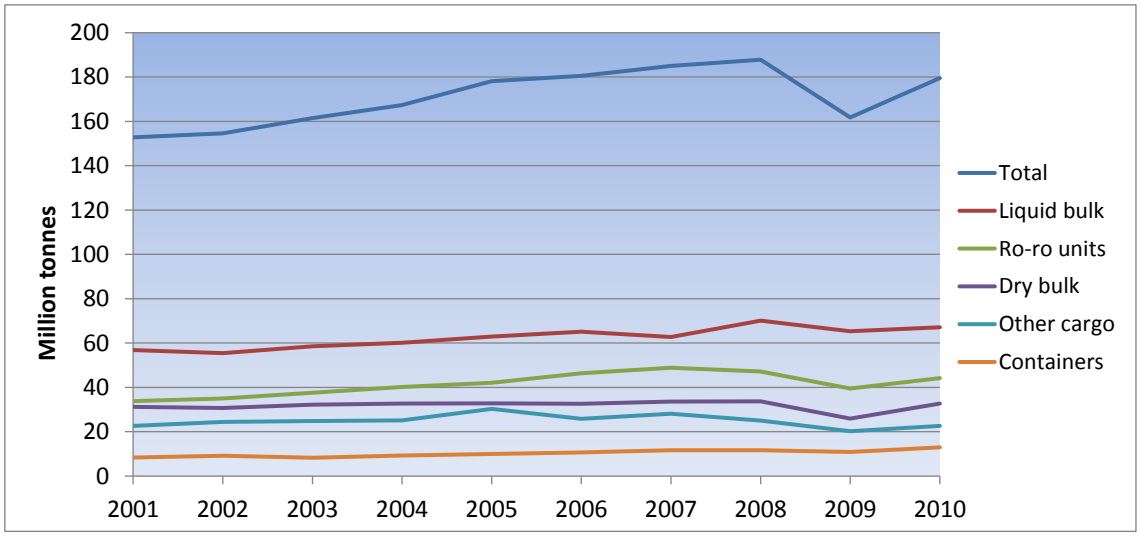

Figure 3.5 Cargo traffic in Swedish ports in the period of 2001–2010 by cargo types. (Transport Analysis 2012)

According to Ports of Sweden (2012), every year in the period of 2003–2010 at least 93 % of the liquid bulk handled in Swedish ports has been mineral oils and 7 % or less other liquid bulk (Table 3.7). The volume of mineral oils has increased from 54.2 million tonnes to 63.6 million tonnes over the period observed. The highest figure was recorded in 2008 when 66.7 million tonnes of mineral oils were handled in Swedish ports. Correspondingly, the volume of other liquid bulk has decreased from 4.4 million tonnes to 3.5 million tonnes during the period observed. The highest figure was recorded in 2006 when 4.6 million tonnes of other liquid bulk was handled in Swedish ports. Chemicals and chemical products are included in the commodity group 'Other liquid bulk' but the volume of chemicals is not specified in the statistics of Ports of

Sweden. Therefore, estimating the exact amount of chemicals handled in Swedish ports is difficult on the basis of the statistics provided by Ports of Sweden.

Table 3.7 Liquid bulk handling volumes in Swedish ports in the period of 2003–2010. (Ports of Sweden 2012)

	2003	2004	2005	2006	2007	2008	2009	2010
Mineral oils	54,180	55,639	58,588	60,576	59,410	66,711	62,052	63,636
Other liquid bulk	4,359	4,510	4,338	4,560	3,337	3,405	3,268	3,478
Liquid bulk total	**58,539**	**60,149**	**62,926**	**65,136**	**62,747**	**70,116**	**65,320**	**67,114**

Baltic Port List publications produced by the University of Turku Centre for Maritime Studies (Särkijärvi et al. 2010; Holma et al. 2011) categorise liquid bulk handled in Swedish ports into three groups: oil and oil products, liquid chemicals and other liquid bulk. According to Holma et al. (2011), Swedish ports handled approximately 56.4 million tonnes of international liquid bulk cargo in 2010 (Table 3.8). About 53.6 million tonnes (95 %) of the liquid bulk was oil and oil products, 0.93 million tonnes (2 %) liquid chemicals and 1.83 million tonnes (3 %) other liquid bulk (Holma et al. 2011). By contrast, in 2009 Swedish ports handled approximately 53.1 million tonnes of international liquid bulk, of which about 50.1 million tonnes were oil and oil products, 1.13 million tonnes liquid chemicals and 1.9 million tonnes other liquid cargo (Särkijärvi et al. 2010). However, when these figures are viewed, it should be noted that most of the cargo reported in the class ‘other liquid bulk’ is most probably liquid chemicals. Therefore, the estimated share of liquid chemicals handled in Swedish ports both in 2009 and 2010 is supposedly over 2 million tonnes (Holma 2012).

Table 3.8 Liquid bulk handling volumes in international cargo traffic of Swedish ports in 2009 and 2010, thousand tonnes. (Särkijärvi et al. 2010; Holma et al. 2011)

	2009	2010
Oil and oil products	50,116	53,634
Liquid chemicals	1,131	930
Other liquid bulk	1,895	1,826
Liquid bulk total	**53,142**	**56,390**

According to Holma et al. (2011), international liquid bulk cargo was handled in 38 Swedish ports in 2010. Oil and oil products were handled in 30 Swedish ports, liquid chemicals in 10 Swedish ports and other liquid bulk in 19 Swedish ports. In Table 3.9, all Swedish ports that handled liquid chemicals and/or other liquid bulk in 2010 are listed (oil and oil products are excluded since the focus in this study is put on the chemicals handled in the Baltic Sea ports). As stated earlier, in addition to the ‘liquid chemicals’ commodity group, most of the cargoes reported in the ‘other liquid bulk’ commodity group are most probably chemicals (Holma 2012). As Table 3.9 shows, there were 8 Swedish ports that in total handled over 100 thousand tonnes of liquid chemicals and other liquid bulk in 2010. Helsingborg, Gävle, Skellefteå, Gothenburg and Norrköping were the top 5 Swedish ports when both liquid chemical and other liquid bulk handling volumes are taken into account.

Table 3.9 Liquid chemicals and other liquid bulk handled in Swedish ports in the year 2010, tonnes. (Holma et al. 2011)

	Liquid chemicals	Other liquid bulk	Total
Helsingborg	0	438,000	438,000
Gävle	212,000	162,000	374,000
Skellefteå	324,000	0	324,000
Gothenburg	0	217,000	217,000
Norrköping (including sub-port of Braviken)	0	211,000	211,000
Mälarhamnar	0	196,000	196,000
Stenungsund	0	173,000	173,000
Höganäs	121,000	0	121,000
Malmö	0	99,000	99,000
Kalmar	87,000	0	87,000
Sölvesborg	0	86,000	86,000
Örnsköldsvik	0	63,000	63,000
Karlshamn	60,000	0	60,000
Sundsvall (including sub-ports: Tunadal, Vindskärsudde and Mojaken)	0	44,000	44,000
Södertälje	0	36,000	36,000
Skärnäs Terminal	35,000	0	35,000
Mönsterås	34,000	0	34,000
Kristinehamn	34,000	0	34,000
Luleå	0	32,000	32,000
Uddevalla	0	23,000	23,000
Billerud Karlsborg	19,000	0	19,000
Husum	0	16,000	16,000
Söderhamn	0	11,000	11,000
Bergs Oljehamn	0	10,000	10,000
Trelleborg	0	4,000	4,000
Härnösand	4,000	0	4,000
Piteå	0	3,000	3,000
Visby	0	2,000	2,000
Total	**930,000**	**1,826,000**	**2,756,000**

Since the year 2008, the cargo classification system used in Sweden by Transport Analysis has been NST 2007. The data from the years before 2008 followed the classification system NST/R. In the NST/R cargo classification system, there are two categories that include chemicals: 1) Coal-based chemicals and tar and 2) Other chemicals than coal-based chemicals and tar. In the NST 2007 cargo classification system, one of its categories includes chemicals, chemical products and man-made fibres, rubber and plastic products, and nuclear fuel. Table 3.10 presents the cargo handling volumes of these cargo categories in Swedish ports in the period of 2000–2010. The table shows that the total annual volumes of these chemical-related categories have varied between approximately 2,900–4,200 thousand tonnes over the period observed. The annual volumes of the commodity group ‘Coal-based chemicals and tar’ have fluctuated quite considerably over the period while the annual volumes of the other two commodity groups observed have remained almost the same during the period. Since the presented chemical-related cargo categories contain also other substances than

chemicals, it is difficult to estimate the share of chemicals on the basis of the volumes of these cargo categories. However, the size range of the annual volumes of chemicals and related substances are almost the same when the statistics provided by Transport Analysis (Table 3.10) and by Holma et al. (2011) (Table 3.9) are compared.

Table 3.10 Shipping of chemicals and related substances between Sweden and foreign countries in the period of 2000–2010, thousand tonnes. (Transport Analysis 2012)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Coal-based chemicals and tar	201	152	228	834	781	1,169	1,183	149			
Other chemicals than coal-based chemicals and tar	2,795	3,114	3,326	3,052	3,362	2,797	3,023	2,971			
Chemicals, chemical products and man-made fibres, rubber and plastic products, and nuclear fuel									3,194	2,875	3,122

3.2.2 Chemical-specific handling volumes

During the literature review, three studies (Hänninen & Rytkönen 2006; Molitor 2006; Räddningverket 2008) dealing with chemical-specific information on chemicals handled in Swedish ports were found. Even though the chemical volumes presented in the studies of Hänninen & Rytkönen (2006) and Molitor (2006) are from 2004, these studies can be used to give an indicative overview of the chemicals handled in Swedish ports. Räddningverket (2008) listed the most handled chemicals in Swedish ports but the volumes of the chemicals were not mentioned in the study.

Molitor (2006) studied the chemical handling volumes in Swedish ports using a questionnaire that was sent to all members of the Swedish Ports. Replies were received from 24 ports, which together represented 91.5 % of all other liquid bulk (including chemicals and excluding oil and oil products) handled in the member ports of Ports of Sweden and 54 % of all other liquid bulk traffic handled in Sweden. The Swedish Plastics and Chemicals Federation also gave some statistics, including about 385,000 tonnes of other liquid bulk handled in Sweden in 2004. This tonnage was merged with the data received from Ports of Sweden, after which the data of the study covered 62.6 % of all liquid bulk handled in Sweden in 2004.

According to the results of Molitor (2006), in 2004 approximately 2,322 thousand tonnes of chemicals were handled in Swedish ports that were covered in the study (Table 3.11). The number of different chemicals listed in the study was 32. Sulphuric acid was clearly the most handled chemical with 830 thousand tonnes or 36 % of the

total volume. Sodium hydroxide solution (370 kt or 16 %), ammonia (198 kt or 9 %), propane (189 kt or 8 %) and ethanol (152 kt or 7 %) were next in rank in terms of chemical handling volumes. Approximately 664 thousand tonnes (29 %) of the chemicals were handled in Swedish ports located on the south coast, 650 thousand tonnes (28 %) in Swedish ports located in the Gulf of Bothnia, 396 thousand tonnes (17 %) in Swedish ports located in the Bothnian Sea, 232 thousand tonnes (10 %) in Swedish ports located on the shores of Stockholm-Mälaren, 193 thousand tonnes (8 %) in Swedish ports located on the east coast, 154 thousand tonnes (7 %) in Swedish ports located on the west coast and 33 thousand tonnes (1 %) in Swedish ports located in Lake Vänern.

Table 3.11 Chemicals handled in Swedish ports in 2004, tonnes. (Molitor 2006)

Chemical	Volume
Sulphuric acid	827,322
Sodium hydroxide solution	369,736
Ammonia	198,038
Propane	188,549
Ethanol	151,812
Phosphoric acid	72,239
Fluorinated Silica	65,800
Coal tar	56,244
n-Butanol	42,200
2-ethylhexanol	40,600
Xylene	39,700
Calcium chloride	39,600
Methanol	35,871
2-ethylhexanoic acid	28,200
Styrene	23,920
Tall oil pitch	23,900
Aluminium sulphate	23,800

Chemical	Volume
Ethyl acetate	22,620
Aluminium chloride	14,200
Acetic anhydride	10,991
Nitric acid	10,733
Benzene	7,000
Ammonium nitrate	6,100
Acetic acid	5,500
Propionic acid	3,600
Acetone	3,292
Ferric chloride	3,200
Turpentine	2,127
Toluene	1,982
Ammonia solution	1,964
Butyl acetate	1,550
Methyl ethyl ketone	150
Total	**2,322,540**

Hänninen & Rytkönen (2006) presented in their study the chemicals handled in 13 Swedish ports in 2004 (Table 3.12). According to the results of the study, these 13 Swedish ports together handled over 2.5 million tonnes of chemicals in 2004. Helsingborg was the largest chemical handling port (in tonnes) with 837 thousand tonnes. However, it should be noted that in the case of the Port of Helsingborg the volumes presented in the table may contain both liquid and dry chemicals. The ports of Skelleftehamn (579 kt), Gävle (>213 kt), Stenungsund (>200 kt), Mälarhamnar (>170 kt), Örnsköldsvik (135 kt) and Stockholm (118 kt) were next in rank in terms of chemical handling volumes.

Table 3.12 Chemicals handled in 13 Swedish ports in 2004, tonnes. (Adapted from Hänninen & Rytkönen 2006)

Port	Chemical(s)	Volume
Gävle	Caustic soda	123,000
	Sulphuric acid	50,000
	Vanicell (lignosulphonate)	40,000
	Turpentine	Small amount
Helsingborg	Caustic soda, aluminium chloride, phosphoric acid, ferric chloride, calcium chloride, potassium sulphate, sodium chloride and silicon acid (both in liquid and dry form).	500,000
	Sulphuric acid	207,000
	Sulphur	130,000
Luleå	Coal tar	25,000
	Benzene	7,000
	Ethanol	6,000
Malmö	Ethanol, xylenes, ethyl acetate, toluene, acetone, isopropanol, methyl-ethyl-ketone and methanol	52,000
Mälarhamnar	Ammonia	170,000
	Phosphoric acid, nitric acid, vanicell (lignosulphonate), ethanol and sulphate pitch oil	Small amounts
Oxelösund	Sulphuric acid	20,000
	Caustic soda	12,000
Piteå	Propane	31,000
	Ethanol	Small amount
Skelleftehamn	Sulphuric acid	504,593
	Caustic soda solution	74,706
Stenungsund	Ethene, ammonia, butanol, ethylhexanol and dioctyl phtalate	200,000
	Virgin naphtha and steam cracked naphtha	N/A
Stockholm	Sulphate pitch	70,000
	Fat in some form	48,000
Sundsvall	Propane	50,000
	Ethanol	8,000
Södertälje	Pitch tall oil, carbon dioxide and some other chemicals	77,000
Örnsköldsvik	Ethanol, acetic acid and ethyl acetate	135,000

The results of Hänninen & Rytkönen (2006) and Molitor (2006) can also be compared with the study of Räddningverket (2008), although most transported chemicals are only mentioned in the study of Räddningverket while no actual volumes are presented. Räddningverket (2008) surveyed the most transported chemicals through Swedish ports in the Baltic Sea. The chemicals that were transported the most in *the Gulf of Bothnia* maritime traffic area were sulphuric acid, acetic acid, coal tar, sodium hydroxide, and also smaller volumes of benzene, turpentine and ethanol. Most of the transported substances belonged to Class 8 ("Corrosive substances"). Furthermore, ammonia was the most transported chemical in the Stockholm–Mälaren maritime traffic area. There were also shippings of tall oil pitch, some volumes of nitric acid and phosphoric acid and small volumes of ethanol and acetone.

In the Swedish East coast traffic area, significant volume of coal tar, styrene, smaller volumes of xylene, acetic anhydride, ethanol and butyl acetate were transported. In the East Coast traffic area, numerous chemicals were transported but they belonged to only

two different classes, namely, to Class 3 (“Flammable liquids”) and, the majority of the chemicals, to Class 8 (“Corrosive substances”).

In the Swedish South Coast, a wide variety of chemicals were transported. In terms of volume, sulphuric acid, fluorosilicic acid, phosphoric acid, calcium chloride and methanol were the most commonly transported chemicals. Approximately two thirds of the transported chemicals were in Class 8 (“Corrosive substances”). The other chemicals belonged to Class 2 (“Gases”), 3 (“Flammable liquids”), 5 (“Oxidizing substances”) and 9 (“Other threads”) (Räddningverket 2008).

In the Swedish West Coast maritime traffic area, the most transported chemical was 2-ethylhexanol. Other chemicals transported in high volumes were ammonia, ammonium nitrate, sodium hydroxide, propionic and n-butanol. Almost one fifth of all the transported chemicals consisted of 2-ethylhexanoic acid, which is classified according to the IMDG Code. Among the hazardous chemicals transported were Class 2 (“Gases”), Class 3 (“Flammable liquids”) and Class 6 (“Toxic”), which represented about a quarter each. Small quantities of Class 5 (“Oxidizing substances”) and Class 8 (“Corrosive substances") were also transported in the Swedish West Coast maritime traffic area (Räddningverket 2008).

Räddningverket (2008) also identified a large number of new chemicals in the study. In the group of gases, the new chemicals included propane, butane, ethyl chloride, ethane, butane and ethylene. In the group of flammable fluids, ETBE (ethyl tertiary butyl ether) and hexane represented the new chemicals.

3.3 Russian ports

3.3.1 Overview of the liquid bulk handling volumes

According to the Baltic Port List publications produced by the University of Turku Centre for Maritime Studies (Saurama et al. 2008; Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011), annual international cargo volume in Russian ports located in the Baltic Sea has increased by over 20 million tonnes from 153.7 million tonnes in 2006 to 175.2 million tonnes in 2010 (Figure 3.6). Every year, over 60 % of the cargo volume has been liquid bulk. The annual volumes of liquid bulk have varied between 102.9–115.2 million tonnes. Other dry cargo has been the second most handled cargo type in Russian ports located in the Baltic Sea with the annual volumes of 26.3–38.4 million tonnes in the period of 2006–2010. The annual volumes of dry bulk have varied between 23.7–26.7 million tonnes during the period observed.

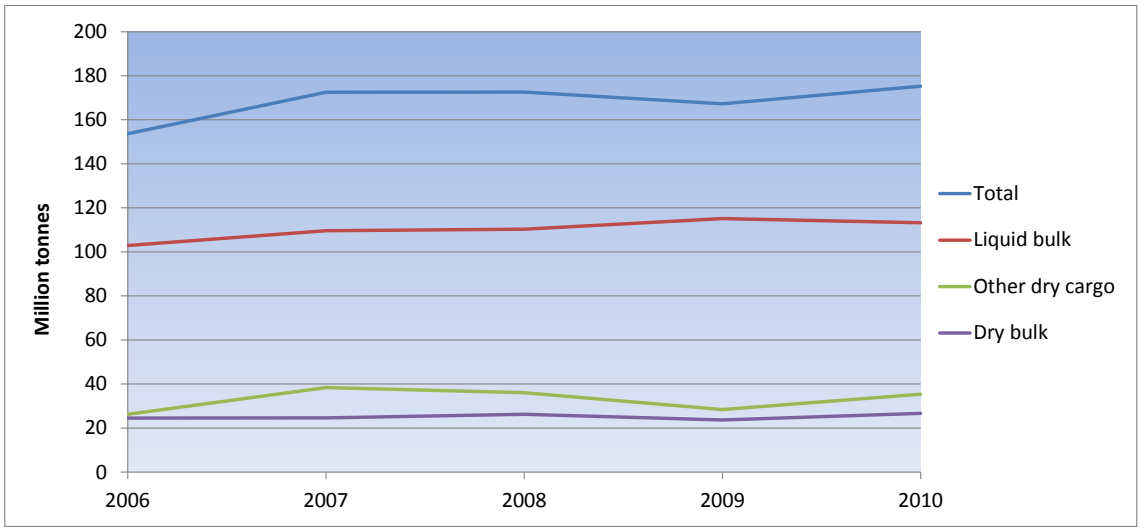

Figure 3.6 International cargo traffic in Russian ports located in the Baltic Sea in the period of 2006–2010 by cargo types. (Saurama et al. 2008; Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

The Baltic Port List publications (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011) categorise international liquid bulk cargo handled in Russian ports into three groups: oil and oil products, liquid chemicals and other liquid bulk. According to the publications, almost all of the liquid bulk handled in Russian ports located in the Baltic Sea has been oil and oil products in the period of 2008–2010 (Table 3.13). The annual volumes of oil and oil products have varied between 110–115 million tonnes in the years observed while the annual volumes of liquid chemicals have varied between 85–119 thousand tonnes and the annual volumes of other liquid bulk between 71–317 thousand tonnes.

Table 3.13 Liquid bulk handled in international cargo traffic of Russian ports located in the Baltic Sea in the period of 2008–2010, thousand tonnes. (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

	2008	**2009**	**2010**
Oil and oil products	110,128	114,839	112,842
Liquid chemicals	119	111	85
Other liquid bulk	71	223	317
Liquid bulk total	**110,318**	**115,173**	**113,244**

3.3.2 Liquid bulk and chemical handling volumes in Russian ports

Russia has six main ports in the Baltic Sea: Kaliningrad, Primorsk, Saint Petersburg, Ust-Luga, Vyborg and Vysotsk. According to Holma et al. (2011), all of these ports, except Ust-Luga, handled international liquid bulk in 2010 (Table 3.14). As stated above, most of the liquid bulk handled in Russian ports located in the Baltic Sea is oil and oil products. Primorsk is a pure oil port and it handled 77.6 million tonnes of oil and oil products in 2010. All of the liquid bulk handled in the Port of Vysotsk and almost all

of the liquid bulk handled in the Port of Saint Petersburg was oil and oil products as well. Liquid chemicals were handled only in the Ports of Kaliningrad and Vyborg. The total volume of liquid chemicals handled in these two ports in 2010 was 85 thousand tonnes, of which 53 thousand tonnes were handled in the port of Vyborg and 32 thousand tonnes in the Port of Kaliningrad. The Ports of Kaliningrad, Saint Petersburg and Vyborg also handled some amounts of other liquid bulk.

Klaipeda State Seaport also provides some cargo statistics of the ports of Kaliningrad, Saint Petersburg and Primorsk. The liquid bulk volumes presented in Klaipeda State Seaport (2012) coincide well with the liquid bulk volumes presented in Table 3.14 provided by Holma et al. (2011).

Table 3.14 Liquid bulk handled in Russian ports located in the Baltic Sea in the year 2010, thousand tonnes. (Holma et al. 2011)

	Liquid bulk total	Oil and oil products	Liquid chemicals	Other liquid bulk
Primorsk	77,640	77,640	0	0
St. Petersburg	16,157	16,117	0	40
Vysotsk	12,010	12,010	0	0
Kaliningrad	7,345	7,073	32	240
Vyborg	92	2	53	37
Total	**113,244**	**112,842**	**85**	**317**

Port of Primorsk

The Port of Primorsk has been in operation since 2001, and it is led by Spetsmornefteport Primorsk, a company which is a part of Transneft (oil pipe monopoly) (Kuronen et al. 2008). Currently, Primorsk is the largest port in the Baltic Sea by cargo volume. The port is specialised solely on export of crude oil and oil products. It is also the final point of the Baltic Pipeline System, which transports raw oil from the Timan-Pechora oil field basin and from Western Siberia and the Urals – Volga regions (Kämärä 2010). The Port of Primorsk handled approximately 77.6 million tonnes of oil and oil products in 2010 (Holma et al. 2011). There are two terminals in the Port of Primorsk. One terminal is specialised in crude oil and its turnover in 2009 was approximately 74.5 million tonnes. The other terminal is specialised in light oil products (diesel oil) and its turnover in 2009 was approximately 4 million tonnes (International Harbour Masters' Association 2010).

Port of Saint Petersburg

The Port of St. Petersburg is the main logistic gateway to Russia from the west. It is a port complex, which consists of several ports in the Neva river mouth. The Port of Saint Petersburg handles different kinds of goods including containers, cars and machinery, metal and piping, heavyweights and long measures, timber, coal, grain, and many other goods. In 2010, the Port of St. Petersburg handled 16.3 million tonnes of liquid bulk, of which 16.3 million tonnes was oil and oil products and 0.04 million tonnes food-related

liquid cargoes. Approximately 6.1 million tonnes of mineral fertilizers were also handled in the port (Port Authority of St. Petersburg 2012).

Most of the oil and oil products transported through the Port of Saint Petersburg are handled by the terminal called Petersburg Oil Terminal. The terminal offers transhipment and storage services for oil products. The terminal has a 354,000 m^3 tank farm, of which 303,000 m^3 is meant for heavy oil products and 51,000 m^3 for light oil products. The annual handling capacity of oil products of the terminal is 12.5 million tons (Petersburg Oil Terminal 2012).

In 2008, only 1.8 thousand tonnes of liquid chemicals were handled in the Port of St. Petersburg (World Port Source 2012a) and in 2010 the volume of liquid chemicals was reported to be zero (Holma et al. 2011).

Port of Vysotsk

The Port of Vysotsk has concentrated on oil and oil products and dry bulk (coal and coke) (Holma et al. 2011). The oil and oil products (mainly diesel fuel, naphtha and fuel oil) in the port are handled by Lukoil Oil Company (Portnews 2012). In 2004, Lukoil opened the first stage of its oil and oil product terminal with an annual capacity of 4.7 million tonnes (Seanews 2004). The second stage of the oil terminal construction was completed in 2006, which increased the annual oil handling capacity of the terminal to 11.6 million tonnes (Lukoil 2006). In 2007, Lukoil started to expand the transportation infrastructure around the port area (Lukoil 2007). In 2010, the Port of Vysotsk handled approximately 12 million tonnes of liquid bulk, all of which was oil and oil products. Chemicals are not handled in the Port of Vysotsk (Holma et al. 2011).

Port of Kaliningrad

The Port of Kaliningrad is a general port that handles various types of general cargo (cellulose, paper, food products, chemicals, cars, containers, steel sheets, pipes, different equipment, timber, nonferrous metals etc.), various dry bulk cargoes (coal, ores, coke, soya) and various liquid cargoes (Kaliningrad Maritime Port Administration 2012). According to Holma et al. (2011), in 2010 the Port of Kaliningrad handled 7,350 thousand tonnes of liquid bulk, of which 7,070 thousand tonnes was oil and oil products, 30 thousand tonnes liquid chemicals and 240 thousand tonnes other liquid bulk. Liquid cargoes are handled by 10 companies in the port (Baltic Transport Journal 2012):

- Baltic Top, BNK Baltiysk Oil Handling Terminal, Kaliningrad Oil Terminal, LukOil Terminal, Rosbunker, TDKN and TransBaltService handles only oil and oil products (Baltic 2012; Schnegelsberg and Willnow 2011; TransBaltService 2012).
- Kaliningrad Sea Commercial Port handles all types of cargo, also including oil cargoes (fuel oil) and chemicals fertilizers. In 2010, the company handled about 450 thousand tonnes of liquid bulk, all of which were oil products. Liquid chemicals were not handled at all but 76 thousand tonnes of fertilizers were handled by the company in 2010 (Kaliningrad Sea Commercial Port 2012).

- Kaliningrad State Fishery Port handles general cargoes, mainly frozen fish and meat, bagged cargoes, export bulk fertilizer, liquid fertilizer, oil, and ro-ro cargoes. The State Fishery Port has a tank capacity of 70 thousand cubic metres. The liquid terminal at the Port of Kaliningrad's State Fishery Port includes three complexes with a capacity for about 32 thousand tons of cargo. Declared loading and discharging rates of refrigerated cargoes in the terminal are up to 1,000 tons per day, bagged fertilizer up to 2,000 tons per day, bulk fertilizer up to 2,000 tons per day, liquid fertilizer up to 8,000 tons per day and oil up to 8,000 tons per day (TransMarine 2012; World Port Source 2012b).
- Sodrugestvo is the largest oilseed crusher in Russia. Sodrugestvo-Soy Terminal located in the Port of Kaliningrad handles soy oils, soya beans, and soya meal (Sodrugestvo 2012; TransMarine 2012; World Port Source 2012b). The cargo handling volume of the terminal was not available.

Port of Vyborg

The Port of Vyborg is specialised in handling different types of general cargoes, bulk cargoes (fertilizers, coal, ore, iron, and metal scrap), food cargoes, chemical liquid cargoes and containers. There is a special complex for handling mineral fertilizers in the Port of Vyborg with a capacity of 500 thousand tonnes (Port of Vyborg 2012). According to the statistics of the Port Authority of St. Petersburg (2012), in 2010 the Port of Vyborg handled 92 thousand tonnes of liquid bulk, of which 53 thousand tonnes were chemical cargoes, 37 thousand tonnes food cargoes and 2 thousand tonnes oil. In addition, 545 thousand tonnes of chemical fertilisers were handled in the port. There was no exact information available on what chemicals were handled in the Port of Vyborg. According to Hänninen & Rytkönen (2006), at least caustic soda was one of the exported products in the Port of Vyborg in 2004.

Port of Ust-Luga

The construction of the Port of Ust-Luga was started in 1997 in order to increase the capacity of Russian ports in the Baltic Sea and to move Russian cargo traffic flows away from the Baltic countries (Sundberg et al. 2011). The multipurpose Port of Ust-Luga is still under construction. The annual capacity of the port is planned to be up to 180 million tons of various cargoes by the year 2018. There are seven terminals currently operating in the Ust-Luga port: a Coal Terminal, the Universal Cargo Terminal, a Sulphur Terminal, an Auto-Railway Ferry Complex, the actively developing Multipurpose Terminal ‘Yug-2’ and the Factor’ Timber Terminal (Ust-Luga Company 2012). In 2010, the Port of Ust-Luga handled 11,270 thousand tonnes of international cargo, of which 10,040 thousand tonnes was dry bulk (mainly coal and coke) and 1,230 thousand tonnes other dry cargo (mainly metals and metal manufacturers and wood products). Liquid bulk was not handled in the port (Holma et al. 2011).

There are three terminals under construction in the Port of Ust-Luga that will handle liquid cargoes in the future: Bunker Terminal, Oil Terminal / Oil Products Terminal and Liquefied Petroleum Gas Terminal. *Oil Terminal / Ust-Luga Bunker Terminal* will be

the terminal for the Baltic Pipeline System 2 (BPS-2) that is planned to be operational by the year 2012 (UK Trade & Investment 2010). The annual capacity of the BPS-2 is planned to be 50 million tonnes, of which 38 million tonnes will be delivered to Ust-Luga and 12 million tonnes to the Kirishi oil refinery (Orlov & Shikorova 2010). *Oil Products Terminal* was started by Rosneftbunker JSC, affiliated with Zarubezhneft JSC and then sold in March 2009 to the Swiss oil trader Gunvor, which is controlled by the Russian businessman Gennady Timchenko. Initially, the start of operations was scheduled for late 2009, with a phase 1 capacity of 10 million tonnes of oil and bunker fuel per year, increasing to a full project capacity of 25 million tonnes per year (UK Trade & Investment 2010). *Liquefied Petroleum Gas Terminal* is expected to be put into operation in the near future. The estimated cargo turnover for this terminal is planned to be 4.0 million tons of liquefied hydrocarbon gases per year and up to 2.5 million tons of light oil products per year (Ust-Luga Company 2012).

3.4 Estonian ports

3.4.1 Overview of the liquid bulk handling volumes

Estonian official shipping data is published by Statistics Estonia. According to the cargo statistics of Statistics Estonia (2012), the total cargo traffic handled in Estonian ports has varied annually between 36–50 million tonnes over the period of 2006–2010 (Figure 3.7). During the years 2007 and 2008, the volume of the cargo traffic (mostly transit traffic) transported through Estonian ports significantly declined. The main reason for the decrease was the political dispute (the Bronze soldier statue) between Russia and Estonia. As a result of the dispute, Russia transferred its foreign trade transports from Estonian ports to its own ports (Posti et al. 2009). In 2009 and 2010, Estonian seaborne cargo traffic returned to growth, despite of global economic recession. In 2010, Estonian ports handled approximately 46.1 million tonnes of cargo, of which 7.3 million tonnes were outgoing goods (excluding transit), 5.6 million tonnes incoming goods (excluding transit), 27.2 million tonnes outgoing transit goods and 6.0 million tonnes incoming transit goods (Statistics Estonia 2012). According to Holma et al. (2011), in 2010 Estonian ports handled approximately 45.3 million tonnes of international cargo, of which 29.8 million tonnes was liquid bulk, 10.1 million tonnes dry bulk and 5.4 million tonnes other dry cargo.

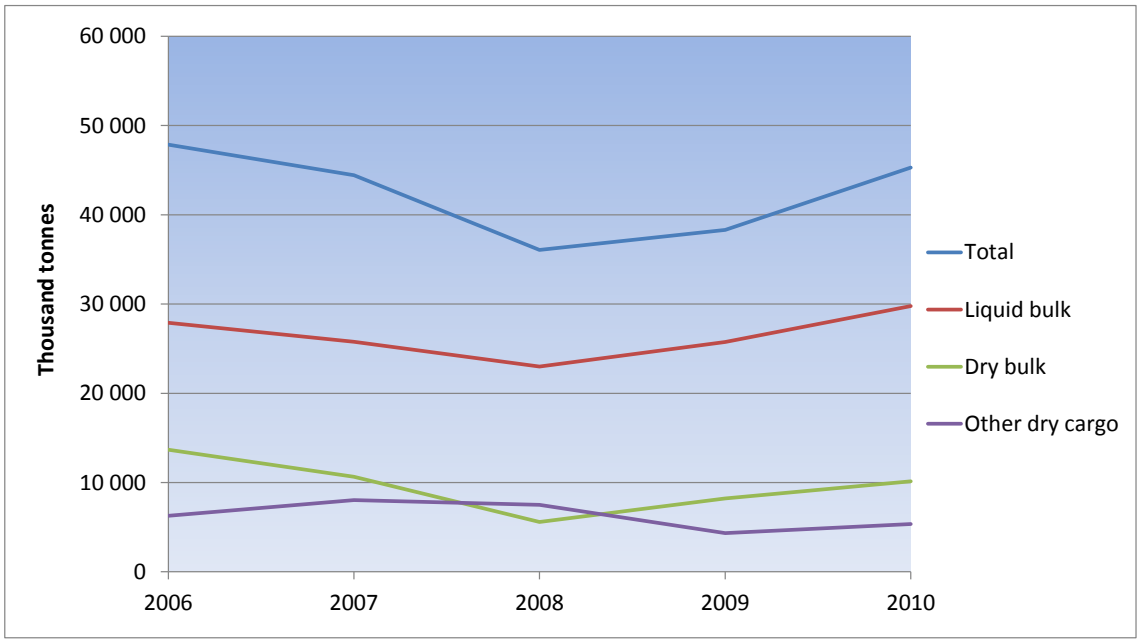

Figure 3.7 International cargo traffic in Estonian ports in the period of 2006–2010 by cargo types. (Saurama et al. 2008; Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

According to the Baltic Port List publications (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011), oil and oil products have clearly been the most handled type of liquid bulk in Estonian ports, as the annual share of oil and oil products of the total liquid bulk volume has varied between 96–98 % or 22,600–28,600 thousand tonnes in the period of 2008–2010 (Table 3.15). During the same period, the volume of liquid chemicals has varied between 110–1,160 thousand tonnes and other liquid bulk between 53–806 thousand tonnes.

Table 3.15 Liquid bulk handling volumes in international cargo traffic of Estonian ports in the period of 2008–2010, thousand tonnes. (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

	2008	**2009**	**2010**
Oil and oil products	22,585	24,826	28,575
Liquid chemicals	110	121	1,157
Other liquid bulk	296	806	53
Liquid bulk total	**22,991**	**25,753**	**29,785**

The cargo classification of the water transport statistics of Statistics Estonia (2012) contains three chemical-related cargo groups in the years 2002–2008: 1) natural and chemical fertilizers, 2) coal chemicals, tar, and 3) chemicals other than coal chemicals and tar. During the period observed, the annual volumes of these three chemical-related cargo groups in total have varied between 1,420–3,010 thousand tonnes. Each year, most of this tonnage has consisted of ‘natural and chemical fertilizers’ even though the annual volumes of this cargo group have decreased towards the end of the period observed (Table 3.16). The annual volumes of ‘chemicals other than coal chemicals and tar’ have, in turn, increased towards the end of the period observed. In 2008,

approximately 875 thousand tonnes of 'natural and chemical fertilizers' and 530 thousand tonnes of 'chemicals other than coal chemicals and tar' were transported through Estonian ports. The annual volumes of 'coal chemicals, tar' have been very low during the whole period. In 2008, only 13 thousand tonnes of 'coal chemicals, tar' were handled in Estonian ports.

After the period of 2002–2008, the cargo classification of the water transport statistics of Statistics Estonia (2012) has been changed and, since 2009, chemical-related cargoes have been included in the cargo group called 'chemicals, chemical products and man-made fibres, rubber and plastic products'. The volume of this cargo group accounted for 1,640 thousand tonnes in 2009 and 2,560 thousand tonnes in 2010 (Table 3.16). In both years, approximately 90 % of these volumes were outgoing transit goods.

Table 3.16 Chemical-related cargoes handled in Estonian ports in the period of 2002–2010, thousand tonnes. (Statistics Estonia 2012)

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Natural and chemical fertilizers	2,751	2,228	2,613	2,748	2,521	1,980	875		
Coal chemicals, tar	0	2	0	1	0	0	13		
Chemicals other than coal chemicals and tar	8	11	82	261	270	399	528		
Chemicals, chemical products and man-made fibres, rubber and plastic products								1,641	2,563

3.4.2 Liquid bulk and chemical handling volumes in Estonian ports

According to Holma et al. (2011), 7 Estonian ports/harbours handled international liquid bulk cargoes in 2010. Oil and oil products was handled in 6 Estonian ports, liquid chemicals in 2 Estonian ports and other liquid bulk in 5 Estonian ports. Table 3.17 lists all Estonian ports that handled liquid bulk in 2010. As the table shows, the harbours of Muuga and Paldiski South and the Port of Sillamäe were the three largest oil handling harbours/ports in Estonia by cargo volume. Almost all (1,130 thousand tonnes) of the liquid chemicals transported through Estonian ports were handled in the Port of Sillamäe. Kunda was another Estonian port that handled liquid chemicals with a volume of 29 thousand tonnes. The harbours of Muuga, Paljassaare and Paldiski South and the ports of Kunda and Sillamäe also handled small amounts of other liquid bulk which may also include chemicals on the basis of this study.

Table 3.17 Liquid bulk handling volumes in international cargo traffic of Estonian ports in 2010, thousand tonnes. (Holma et al. 2011)

	Liquid bulk total	Oil and oil products	Liquid chemicals	Other liquid bulk
Muuga	23,527	23,505	0	22
Sillamäe	3,325	2,196	1,128	1
Paldiski South	2,074	2,065	0	9
Vene-Balti	374	374	0	0
Miiduranna	340	340	0	0
Paljassaare	114	95	0	19
Kunda	31	0	29	2
Total	**29,785**	**28,575**	**1,157**	**53**

Port of Sillamäe

The Port of Sillamäe has an infrastructure to handle different kinds of liquid bulk cargoes including oil products, liquid petrochemicals and liquefied petroleum gas. These liquid bulk cargoes are handled in three liquid bulk terminals: Alexela Sillamäe AS, Baltic Chemical Terminal and Tankchem (Port of Sillamäe 2012).

Alexela Sillamäe AS terminal handles fuel oil, shale oil and vacuum gasoil. The terminal is equipped with 32 tanks with a total capacity of 506,000 m^3. Alexela Sillamäe can receive up to 100,000 DWT vessels, and it has a connection with the Estonian Railway. Terminal accepts oil products from railway tanks, trucks and vessels and loads back to railway tanks, trucks and vessels. The maximum rate of loading the products on a tanker is 6,000 m^3/h. The terminal is capable of handling vessels on three jetties (Alexela Sillamäe 2012; Port of Sillamäe 2012).

Baltic Chemical Terminal (AS BCT) is a terminal for handling liquid fertilizers. The terminal began to operate in 2008, and its activities are directed to Russian fertilizer exporters. The terminal is designed to handle over a million tonnes of ammonia and a similar quantity of UAN solutions (a solution of urea and ammonium nitrate in water used as a fertilizer). Two deep-sea berths with depths of up to 13 metres give the terminal an opportunity to handle fertilizer carriers of Panamax-size with a loading speed of 1200 t/hour. Terminal is equipped with 5 tanks with a total capacity of 120,000 tons. Three of these tanks are meant for UAN solutions with a capacity of 20,000 tons each, and two are meant for liquid ammonia with a capacity of 30,000 tons each. The terminal has a railway unloading area for liquid ammonia with an unload speed of up to 130 t/hour, a railway unloading area for UAN solutions with an unload speed of up to 600 t/hour and 2 marine loading arms with a loading rate of up to 1,200 t/hour each (Baltic Chemical Terminal 2012 & 2011; Port of Sillamäe 2012). According to Baltic Chemical Terminal (2012), by the end of March 2012 approximately 307,000 tons of ammonia and 1,340,000 tons of UAN solutions have been handled in the Baltic Chemical Terminal since its foundation in 2008.

Tankchem AS is a terminal for handling liquid chemical products. The terminal began its operation in December 2006. The depot capacity of the terminal is up to 55,500 m^3, and the planned transhipment capacity is up to 1 million tons per year. Terminal

facilities include 3 reservoirs of 12,500 m^3 for methanol and 6 reservoirs of 3,000 m^3 for different chemicals. The range of chemicals handled at the terminal includes methanol, acetic acid, vinyl acetate, butyl acetate, toluene and mono ethylene glycol. The customers of the company are the major chemical concerns and manufacturers in Russia and Europe (Port of Sillamäe 2012; Tankchem 2012).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least benzene was shipped from the Port of Sillamäe to Finnish ports.

Port of Tallinn

The liquid bulk cargo amounts to the highest volume of goods in maritime freight in the Port of Tallinn. Liquid bulk handled in the port includes crude oil (petroleum) and petroleum products, liquid chemicals and gas, alcoholic beverages and foodstuffs (vegetable oils, juice concentrate etc.). Generally, the liquid bulk cargo is transported with tanker vessels, though there is a rising trend to carry liquid bulk in containers. Most of the liquid bulk volume handled at the harbours of the Port of Tallinn is produced by crude oil and petroleum chemicals. Vegetable oils are also received by the Port of Tallinn (Port of Tallinn 2012a). Most of the cargo supply is provided by the Russian plants (about 85 %), Belarus and Kazakhstan. For the most part the petroleum processed at the Port of Tallinn is transhipped to Europe (about 45 % of which 26 % to Netherlands) and to the United States (37 %). Storage capacity of the liquid bulk in the Port of Tallinn is in total about 2.0 million cubic metres. When available infrastructure and superstructure are taken into account, the transhipment capacity of liquid bulk in the Port of Tallinn is up to 40 million tonnes per year. In 2010, the Port of Tallinn handled 25.8 million tonnes of liquid bulk, of which 20.9 million tonnes (81 %) was fuel oil, 2.3 million tonnes (9 %) gasoline, 1.0 million tonnes (4 %) vacuum gas oil, 0.8 million tonnes (3 %) crude oil, 0.3 million tonnes (1 %) gasoil and 0.5 million tonnes (2 %) other liquid bulk (Port of Tallinn 2012b).

The Port of Tallinn consists of five constituent harbours: Old City Harbour / Vanasadam (including Old City Marina), Muuga Harbour, Paldiski South Harbour, Paljassaare Harbour and Saaremaa Harbour. Muuga, Paljassaare and Paldiski are focused on cargo handling, the Old City Harbour handles both passengers and Ro-Ro cargo, and Saaremaa is a pure passenger harbour (Port of Tallinn 2012a).

Petroleum products are handled at the harbours of Muuga, Paldiski South and Paljassaare. Petroleum product transit has concentrated into the Muuga Harbour that has three major terminals engaged storage and transhipment of liquid bulk: Vopak E.O.S., Vesta Terminal Tallinn, and Oiltanking. In addition to these three operators, the Muuga Harbour also hosts terminals of Neste Estonia and Nynas. Neste Estonia is involved in retail and whole sale of liquid fuels and lubricating oils and Nynas is handling the import and marketing of bitumen, bitumen oils, and fluxed bitumen emulsion. Alexela Terminal handles the petroleum products in the Paldiski South Harbour and Scantrans in the Paljassaare Harbour (Port of Tallinn 2012a).

A terminal for *biodiesel production and vegetable oils* was launched in the Paldiski South Harbour in 2008. The capacity of the refining process of the vegetable oils and the production of biodiesel is 100,000 tons per year. Approximately 10,000 tons of glycerol per year is produced as a side product. The container fleet covering the production need for the raw vegetable oils is 15,000 cubic metres (94,350 barrels) per year, and the container fleet for the biodiesel fuel is 9,000 cubic metres (56,610 barrels). The terminal is capable of loading and receiving tanker vessels with a capacity of 12,000 cubic metres (75 480 barrels) for the transport of vegetable oils and biodiesel fuel. The terminal for vegetable oils allows the transhipment of 300,000 tons of vegetable oils per year (Port of Tallinn 2012a; Port of Tallinn 2012b).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least methyl tert-butyl ether (MTBE), ethanol, toluene diisocyanate, hydrogen peroxide and aromatic free solvents were shipped from Finnish ports to the Port of Tallinn.

Port of Vene-Balti

The Port of Vene-Balti handles oil and oil products, general cargo, timber, metals and containers. The covered storage area of the port is 5,000 m^2, open storage area 25,000 m^2 and oil tank capacity 115,000 m^3 (Terk et al. 2007). In 2010, the port handled 615 thousand tonnes of cargo, of which liquid bulk accounted for 374 thousand tonnes, dry cargo 108 thousand tonnes and other dry cargo 133 thousand tonnes. All of the liquid bulk handled in the port was oil and oil products. Liquid chemicals were not reported to be handled in the port in 2010 (Holma et al. 2011).

Port of Miiduranna

In 2010, the Port of Miiduranna handled 341 thousand tonnes of cargo, of which 340 thousand tonnes was oil and oil products and 1 thousand tonnes some sort of dry cargo (Holma et al. 2011). The oil products are kept in an oil terminal of Milstrand AS, situated 500 meters from the port (Terk et al. 2007). The Milstrand terminal handles different light oil products, including diesel fuel, heating oil, naphtha and jet fuel. The terminal has 11 tanks with a total capacity of 125,000 m^3. For loading oil, the Port of Miiduranna is using a 195-metre-long quay that is suitable for the mooring of tankers up to 45,000 DWT with a maximum draught of 12.3 metres (Milstrand AS 2012). Liquid chemicals were not reported to be handled in the port in 2010 (Holma et al. 2011).

Port of Kunda

The Port of Kunda belongs to AS Kunda Nordic Tsement (HeidelbergCement Group 2012a). The port handles both dry bulk cargoes and liquid bulk cargoes. The largest customers of the port are exporters of roundwood and other wood products. The main export cargoes handled in the port include timber, wood chips, wood pellets, peat, gravel and agricultural products while the main import cargoes include macadam and saw logs. In addition, Kunda Nordic Tsement uses the port for producing constructional cements, cement clinker and other related products (HeidelbergCement Group 2012b).

Liquid bulk cargoes in the Port of Kunda are handled by Baltic Tank AS, whose chemical and oil terminal in the port was opened in 2005. The terminal is equipped with 21 tanks with a total storage capacity of 51,000 m^3. The terminal is capable of storing different kinds of chemical and oil products (Baltic Tank 2012). At least diesel oil is handled in the Port of Kunda (OSPA 2011). In 2010, the Port of Kunda handled 31 thousand tonnes of liquid bulk, which consisted of 29 thousand tonnes of liquid chemicals and 2 thousand tonnes of other liquid bulk (Holma et al. 2011). There was no exact information available on what chemicals were handled in the Port of Kunda.

3.5 Latvian ports

3.5.1 Overview of the liquid bulk handling volumes

According to the Baltic Port List publications produced by the University of Turku Centre for Maritime Studies (Saurama et al. 2008; Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011), the annual international cargo volumes in Latvian ports have varied between 59.5–63.6 million tonnes over the period of 2006–2010 (Figure 3.8). Each year, dry bulk has been the most handled cargo type in Latvian ports by cargo volume, and liquid bulk and other dry cargo, in this order, have been the second and third most handled cargo types. The annual volumes of all cargo types have remained quite stable during the whole period. In 2010, Latvian ports handled in total 61.2 million tonnes of cargo, of which 29.7 million tonnes was dry bulk, 21.2 million tonnes liquid bulk and 10.2 million tonnes other dry cargo.

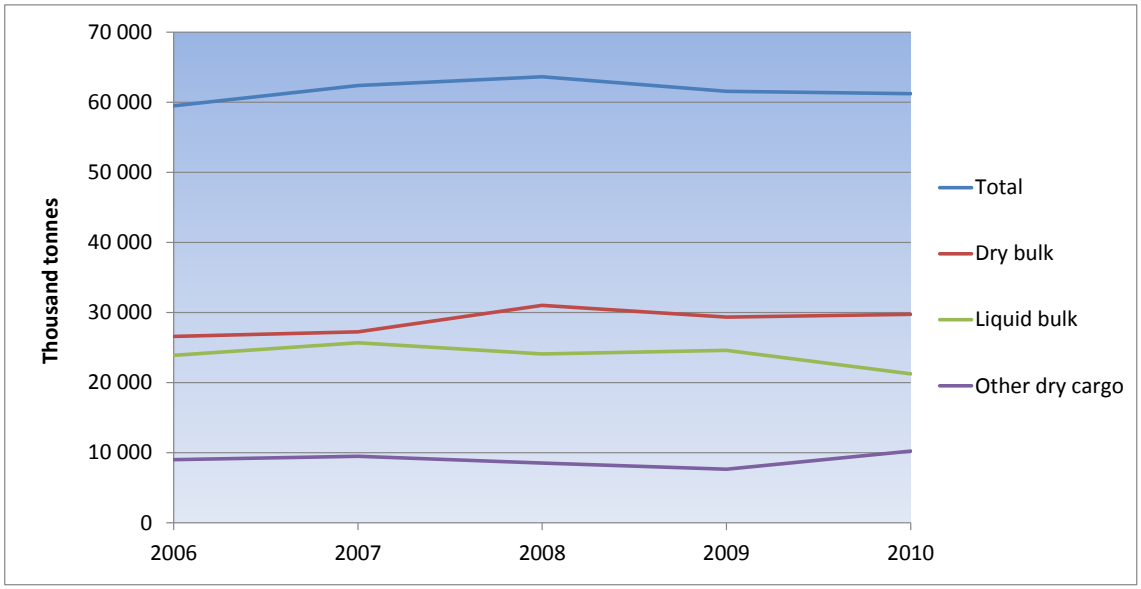

Figure 3.8 International cargo traffic in Latvian ports in the period of 2006–2010 by cargo types. (Saurama et al. 2008; Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

The Baltic Port List publications (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011) categorise international liquid bulk handled in Latvian ports into three groups:

oil and oil products, liquid chemicals and other liquid bulk. According to these publications, oil and oil products have clearly been the most handled type of liquid bulk in Latvian ports, as the annual share of oil and oil products of the total liquid bulk volume has varied between 94–96 % or 20,490–23,560 thousand tonnes in the years 2008–2010 (Table 3.18). The amount of liquid chemicals handled in Latvian ports has decreased by almost 50 % over the period observed – in 2008, the volume of liquid bulk was 1,330 thousand tonnes while the corresponding figure in 2010 was 690 thousand tonnes. The annual volumes of other liquid bulk handled in Latvian ports have varied between 72–85 thousand tonnes during the years 2008–2010.

Table 3.18 Liquid bulk handling volumes in international cargo traffic of Latvian ports in the period of 2008–2010, thousand tonnes. (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

	2008	**2009**	**2010**
Oil and oil products	22,678	23,563	20,485
Liquid chemicals	1,327	946	690
Other liquid bulk	85	72	73
Liquid bulk total	**24,090**	**24,581**	**21,248**

The official transport statistics in Latvia are provided by Central Statistical Bureau of Latvia. The cargo classification includes two chemical-related cargo groups: dry chemicals and liquid chemicals. According to the statistics of Central Statistical Bureau of Latvia (2012), most of the chemicals handled in Latvian ports are dry chemicals (Table 3.19). However, the annual volumes of dry chemicals have decreased over the period of 2002–2010 – in 2005, approximately 6,540 thousand tonnes of dry chemicals were handled in Latvian ports while the corresponding figure in 2010 was 3,750 thousand tonnes. The annual volumes of liquid chemicals handled in Latvian ports have varied between 550–1,430 thousand tonnes. In 2010, approximately 670 thousand tonnes of liquid chemicals were handled in Latvian ports. All chemicals transported through Latvian ports were reported to be exports.

Table 3.19 Chemical-related cargoes handled in Latvian ports in the period of 2002–2010, thousand tonnes. (Central Statistical Bureau of Latvia 2012)

	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Dry chemicals	6,430	6,817	5,967	6,537	5,123	5,173	4,562	3,059	3,750
Liquid chemicals	546	972	976	1114	994	1187	1430	964	686

3.5.2 Liquid bulk and chemical handling volumes in Latvian ports

According to Holma et al. (2011), international liquid bulk cargo was handled in 4 Latvian ports in 2010. Table 3.20 lists all of these ports. As the table shows, oil and oil products were handled in the ports of Ventspils, Riga and Liepaja, liquid chemicals in the ports of Ventspils, Liepaja and Skulte, and other liquid bulk in the ports of Riga, Ventspils and Skulte.

Table 3.20 Liquid bulk handling volumes in international cargo traffic of Latvian ports in 2010, thousand tonnes. (Holma et al. 2011)

	Liquid bulk total	Oil and oil products	Liquid chemicals	Other liquid bulk
Ventspils	14,062	13,446	599	17
Riga	6,585	6,535	0	50
Liepaja	579	504	75	0
Skulte	22	0	16	6
Total	**21,248**	**20,485**	**690**	**73**

In the cargo statistics of the Central Statistical Bureau of Latvia (2012), there are four different cargo groups that include liquid bulk cargoes: oil products, crude oil, chemicals and liquid gas. In 2010, Latvian ports handled approximately 20,280 thousand tonnes of oil products, of which the Port of Ventspils accounted for 13,380 thousand tonnes (66 %), the Port of Riga 6,520 thousand tonnes (32 %) and Liepaja 380 thousand tonnes (2 %) (Table 3.21). Crude oil was handled in only small amounts in the ports of Liepaja and Ventspils. Approximately altogether 500 thousand tonnes of liquid gas was handled in Latvian ports, all of it in the Port of Ventspils. All the chemicals were handled in the Port of Liepaja with a volume of 75 thousand tonnes. In addition to these four liquid bulk cargo groups, about 1,370 thousand tonnes of mineral fertilisers were handled in the Port of Riga.

Table 3.21 Liquid bulk cargoes and chemical-related substances handled in Latvian ports in 2010, thousand tonnes. (Adapted from Central Statistical Bureau of Latvia 2012)

	Oil products	Crude oil	Liquid gas	Chemicals	Mineral fertilisers
Ventspils	13,376	74	496	0	0
Riga	6 522	0	0	0	1 371
Liepaja	381	123	0	75	0
Minor ports	0	0	0	0	0
Total	**20,279**	**197**	**496**	**75**	**1,371**

Port of Ventspils

The Port of Ventspils has an infrastructure to handle different kinds of liquid bulk cargoes, including oil and oil products, liquid chemicals, juice concentrates and other liquid bulk. The overall liquid bulk cargo storage capacity of the port is 1,700,000 m^3 (Ventspils Free Port 2010). The liquid cargo area of the Port of Ventspils has 9 berths ranging between 11.5 and 17.5 metres in depth. These berths can accommodate AFRAMAX type vessels of 150,000 DWT. Liquid cargoes are handled in 4 terminals: Ventspils Nafta Terminal LTD, JSC Ventbunkers, JSC Ventamonjaks and Baltic Juice Terminal (Ventspils Free Port 2012).

The Ventspils Nafta Terminal LTD handles crude oil and petroleum products, including transhipment of gas oil (2000ppm) delivered by pipeline and transhipment of clean oil products (e.g. petrol-76, petrol-80, petrol-92, petrol-98, diesel fuel (10ppm), diesel fuel (50ppm), diesel fuel (350ppm), diesel fuel (2000ppm) and diesel fuel (5000ppm). The

total storage capacity of crude oil and petroleum products at the Ventspils Nafta Terminals is 1,195,000 m^3. The terminal is equipped with 105 shore tanks with volumes ranging from 5,000 to 50,000 m^3 (Ventspils Free Port 2010). The total cargo turnover of the Ventspils Nafta Terminals was 11,650 thousand tonnes in 2011 (Ventspils Free Port 2012).

JSC Ventbunkers is specialised in the handling of light and heavy oil products. The annual handling and storage capacity of the terminal is approximately 7 million tonnes. The Ventbunkers terminal is equipped with 11 storage tanks for diesel fuel with a total capacity of 200,000 m^3 and with 17 storage tanks for fuel oil with a total capacity of 150,000 m^3. Ventbunkers operates five berths with a maximum draught of 15 metres, which is enough for tankers that are up to 267 metres in length (Ventspils Free Port 2010). The total cargo turnover of the JSC Ventbunkers terminal was 2,350 thousand tonnes in 2011 (Ventspils Free Port 2012).

JSC Ventamonjaks has an infrastructure and equipment for the storage and transhipment of different liquid chemicals and oil products (Ventspils Free Port 2010). The main types of cargo handled by the company include ammonia, different spirits, methanol, oils and petrochemicals. Company also provides ballast and bilge water treatment. The total cargo turnover of the JSC Ventamonjaks terminal was 490 thousand tonnes in 2011 (Ventspils Free Port 2012).

The Baltic Juice Terminal is specialised in the storage, mixing, blending and transportation of juice concentrates. The terminal is focused on juice concentrate transports from global juice producers to bottling plants in Russia and other CIS countries (Ventspils Free Port 2010). The throughput capacity of the terminal is 200,000 tons per year and the storage capacity 11,000 tons (Ventspils Free Port 2012). The terminal has a berth depth of 11 metres and it can receive refrigerated vessels with a DWT of up to 42,000 tonnes (Ventspils Free Port 2010).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least ammonia was shipped from the Port of Ventspils to Finnish ports.

Port of Liepaja

The Port of Liepaja has an infrastructure to handle liquid bulk, including oil (crude oil), oil products (masut, diesel oil, vacuum gas oil, base oil), chemical products (coal tar) and liquid foodstuffs group cargoes (molasses, vegetable oils) (Port of Liepaja 2012). According to Hänninen & Rytkönen (2006), in 2004 chemical products handled in the Port of Liepaja included bitumen and mineral fertilisers. Bitumen amounted to 37,100 tons in 36 vessels and mineral fertilisers to 78,600 tons in 44 vessels.

Port of Riga

According to the cargo traffic statistics provided by the Freeport of Riga, in 2010 approximately 22 % of the total cargo volume handled in the Port of Riga was liquid bulk. The port handled approximately 6,580 thousand tonnes of liquid cargo, of which

6,540 thousand tonnes (99.2 %) was oil and oil products, 44 thousand tonnes (0.7 %) liquid gas and 6 thousand tonnes (0.1 %) other liquid cargo. In addition, the Port of Riga handled 1,372 thousand tonnes of dry bulk chemicals, of which 1,370 thousand tonnes were fertilisers. Up to 80 % of the Freeport of Riga's cargo turnover consists of transit cargoes forwarded to or received from the CIS (Freeport of Riga Authority 2012a).

The total tank farm capacity of liquid bulk in the Port of Riga is 309,500 m^3. Liquid bulk cargoes in the Port of Riga are handled in 10 terminals: B.L.B. Baltijas Termināls, Latvija STATOIL, Latvijas Propāna gāze, Latvijas-Rietumu Termināls, Naftimpeks, NESTE Latvija, OVI, Rīgas Universālais termināls, VL Bunkerings and Woodison Terminal. Most of these terminals handle only oil and oil products but for example Latvijas Propāna gāze handles propane-butane gas, Latvija STATOIL fuel with bio-additives and VL Bunkerings methanol and natrium hydroxide in the process of bio-diesel production (Freeport of Riga Authority 2012b).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least carbon dioxide was shipped from Finnish ports to the Port of Riga.

Port of Skulte

The Port of Skulte has originally served only fishing vessels but in 1997 the port started to handle timber and in later years other types of cargo traffic as well. Nowadays, the Port of Skulte handles mainly timber, wood chips, salt, granite, peat, coal and fish (Skultes ostas pārvalde 2012). According to Holma et al. (2011), in 2010 the Port of Skulte handled 647 thousand tonnes of international cargo, of which 619 thousand tonnes was dry bulk and 22 thousand tonnes liquid bulk and 6 thousand tonnes of other dry cargo. Liquid bulk consisted of 16 thousand tonnes of liquid chemicals and 6 thousand tonnes of other liquid cargo. There is no more exact information available on the chemicals handled in the Port of Skulte.

3.6 Lithuanian ports

3.6.1 Overview of the liquid bulk handling volumes

Statistics Lithuania produces statistics on maritime transport in Lithuania. According to these statistics (Statistics Lithuania 2012), the annual volume of cargo handled in Lithuanian ports has increased from 22.7 million tonnes in 2000 to 40.3 million tonnes in 2010 (Figure 3.9). Every year during the period observed, liquid bulk has been the predominant cargo type in Lithuanian ports. The annual volumes of liquid bulk have varied quite a lot, from 9.5 million tonnes to 20.0 million tonnes, over the years 2000–2010. In 2010, the cargo handled in Lithuanian ports consisted of 18.8 million tonnes of liquid bulk, 11.8 million tonnes of dry bulk and 9.7 million tonnes of general goods. Approximately 59 % or 23.6 million tonnes of all the cargo transported through Lithuanian ports was exports and 41 % or 16.7 million tonnes imports in 2010.

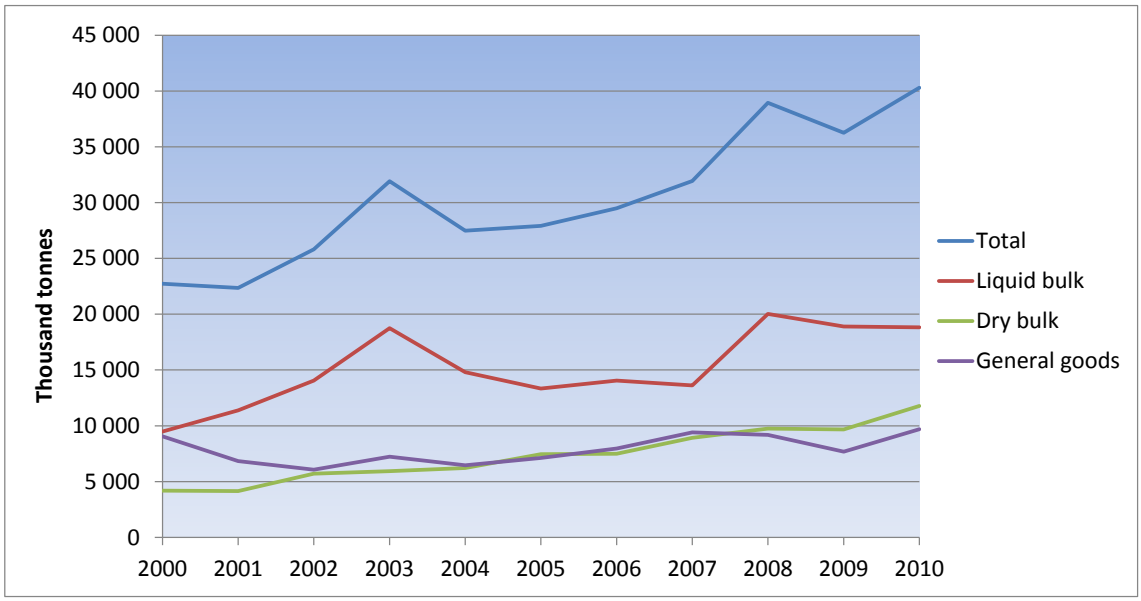

Figure 3.9 Cargo traffic in Lithuanian ports in the period of 2006–2010 by cargo types. (Statistics Lithuania 2012)

Since the year 2005, the liquid bulk handled in Lithuanian ports has been divided into four sub-classes in the public maritime transport statistics provided by Statistics Lithuania. These sub-classes are crude oil and petroleum products; natural and chemical fertilisers; molasses and other liquid bulk goods. Every year in the period of 2005–2010, most of the liquid bulk cargo handled in Lithuanian ports has been crude oil and petroleum products (Table 3.22). The annual amount of crude oil and petroleum products has increased from 11,910 thousand tonnes in 2005 to 17,780 thousand tonnes in 2010. The second most handled liquid cargo type has been natural and chemical fertilisers. Its annual volumes have varied between 790–1,590 thousand tonnes during the period observed. Other liquid bulk goods and molasses, in this order, have been the next most handled liquid cargo types. In 2010, Lithuanian ports handled in total 18,830 thousand tonnes of liquid bulk, of which 17,780 thousand tonnes (94.4 %) was crude oil and petroleum products, 790 thousand tonnes (4.2 %) natural and chemical fertilisers, 30 thousand tonnes (0.2 %) molasses and 220 thousand tonnes (1.2 %) other liquid bulk. The liquid bulk volume handled in Lithuanian ports in 2010 was divided equally between exports and imports (Statistics Lithuania 2012).

Table 3.22 Liquid bulk handled in Lithuanian ports in the period of 2005–2010, thousand tonnes. (Statistics Lithuania 2012)

	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Crude oil and petroleum products	11,910	12,661	11,715	18,430	17,617	17,780
Natural and chemical fertilisers	1,291	1,188	1,590	1,301	975	792
Molasses	68	105	59	32	48	31
Other liquid bulk goods	72	92	249	262	264	224
Liquid bulk total	**13,341**	**14,047**	**13,613**	**20,024**	**18,903**	**18,827**

3.6.2 Liquid bulk and chemical handling volumes in Lithuanian ports

According to Holma et al. (2011), all the international liquid bulk cargo in Lithuanian ports in 2010 was handled in the ports of Klaipeda and Butinge. The Port of Butinge handled only oil and oil products with a volume of 9,020 thousand tonnes. According to the cargo statistics provided by the Klaipeda State Seaport, in 2010 the Port of Klaipeda handled 9,810 thousand tonnes of liquid cargo, of which 8,760 thousand tonnes were oil products, 792 thousand tonnes liquid fertilisers, 61 thousand tonnes vegetable fats and oils, 31 thousand tonnes liquid raw sugar and 163 thousand tonnes other liquid cargoes (Table 3.23). Approximately 97 % or 9,480 thousand tonnes of all the liquid cargo handled in the Port of Klaipeda in 2010 was export and only 3 % or 325 thousand tonnes import. The Port of Klaipeda also handled 395 thousand tonnes of fertilisers and 63 thousand tonnes of chemical products and chemicals as a general cargo (Klaipeda State Seaport 2012).

Table 3.23 Liquid bulk and chemical-related cargoes handled in Lithuanian ports in 2010, thousand tonnes. (Holma et al. 2011; Klaipeda State Seaport 2012)

	Butinge	Klaipeda
Liquid cargo		
Oil and oil products	9,020	8,760
Liquid fertilisers	0	792
Liquid raw sugar	0	61
Vegetable fats and oils	0	31
Other liquid cargoes	0	163
General cargo		
Fertilisers	0	395
Chemical products and chemicals	0	63

Butinge terminal

The Butinge terminal is owned by an energy company named ORLEN Lietuva (former Mažeikių Nafta). The terminal is concentrated on exporting crude oil. The first tanker was loaded in Butinge in 1999. The Butinge terminal can export up to 14 million tons of crude oil a year. In addition to the export cargoes, the terminal is capable of accepting import cargoes as well. The complex of the Butinge Terminal consists of a crude oil pipeline (91.5 km), which connects the facility with the Mazeikiai Refinery, onshore terminal equipment and tanks at Butinge, offshore pipeline, and a single point mooring (SPM) buoy. These units form the onshore and offshore parts of the Terminal (ORLEN Lietuva 2012). In 2010, approximately 9.0 million tonnes of oil and oil products were handled in the Port of Butinge (Holma et al. 2011).

Port of Klaipeda

The Port of Klaipeda has an infrastructure to handle different kinds of liquid cargoes, including oil and oil products, chemical products, liquid fertilisers and liquid food products. The total capacity of the storage tanks for liquid cargoes in the port is 738,300 m^3. Liquid cargoes in the Port of Klaipeda are handled by 6 companies: Klaipeda Stevedoring company AB (KLASCO), Klaipedos nafta AB, Klaipedos keleiviu ir

kroviniu terminalas UAB, Kroviniu terminalas UAB, Stevedoring Company Bega UAB and Vakaru krova UAB.

Klaipeda Stevedoring company AB (KLASCO) handles liquid fertilisers and oil/chemical products. The company's liquid fertiliser terminal serves the needs of Lithuanian and Byelorussian fertiliser producers to export their products to the countries of intensive farming. The terminal was put into operation in 2000. Terminal is equipped with 5 shore tanks for liquid fertilisers with a total storage capacity of 87,000 tonnes and with 1 shore tank for chemical products with a storage capacity of 5,000 tonnes. The annual capacity of the terminal is 2,600,000 tonnes. The company has also operated an ethylene glycol terminal in the Port of Klaipeda since the year 2005. The annual capacity of the terminal is 80,000 tonnes (Klaipeda Stevedoring company AB 2012).

Klaipedos nafta AB is concentrated on the handling of oil products, including crude oil, fuel oil M-100 (of the preliminary and cracking distillations), fuel oil M-40 (of the preliminary and cracking distillations), marine fuel oil F-5, technological fuel E-4, vacuum gas oil, diesel fuel various sorts, gasoline various sorts, jet fuel A-1 and other oil products. The terminal is equipped with 30 storage tanks for crude oil and oil products with a total storage capacity of 404,500 m^3. The capacity of the whole terminal is 9,000,000 tons a year (Klaipedos nafta AB 2012).

The main activity of *Klaipedos keleiviu ir kroviniu terminalas UAB* is associated with oil water collecting and cleaning in the Port of Klaipeda. The services in the terminal include collection of oily and contaminated water, collection of oil water from ships and motor transport, molasses loading, diesel oil loading for bunkering purposes, the loading of other liquid cargoes and the safeguarding of cargoes (Klaipedos keleiviu ir kroviniu terminalas UAB 2012).

Kroviniu terminalas UAB has a permit to handle crude oil and petroleum products (gas condensate, diesel fuel, marine fuel, gasolines, jet fuel and heavy fuel oil); petrochemical and chemical products (ethylene glycol, isobutanol, butanol, ethanol, methanol, glycerine, methyl tert-butyl ether and ethyl tert-butyl ether); and vegetable oils. Currently, the terminal handles gasolines, diesel fuel oil, methyl tert-butyl ether (MTBE) and gas condensate. The capacity of the terminal is up to 2 million tons per year (Kroviniu terminalas UAB 2012).

Stevedoring Company Bega UAB handles bulk, liquid and packed fertilisers, wheat vegetable oil as well as cement, soda ash, inert mineral substances and general cargo. The main clients of the company are producers of fertilisers from Russia, Belorussia and Lithuania. The warehousing capacities and annual throughputs of the terminal for liquid bulk cargoes are the following:

- Liquid fertilisers; a warehousing capacity of 40,000 tons and an annual throughput of 1.2 million tons.
- Liquid chemicals; a warehousing capacity of 6,500 m^3 and an annual throughput of 100,000 tons.

– Liquid food products; a warehousing capacity of 11,500 m^3 for vegetable oil and technical oil or other liquid products and an annual throughput of 150,000 tons (Stevedoring Company Bega UAB 2012).

Vakaru krova UAB has three specialised (liquid, bulk and general cargo) terminals for loading and storing a variety of cargo including bio-diesel, wood and wood products, metal products, cocoa beans, agricultural products and non-standard, bulky loads. The liquid bulk terminal has a storage capacity of 4,000 m^3.

3.7 Danish ports

3.7.1 Overview of the liquid bulk handling volumes

The official shipping data of Denmark is published by Statistics Denmark. According to the cargo statistics of Statistics Denmark (2012), international cargo traffic handled in Danish ports has varied annually between 63–74 million tonnes over the period of 2007–2010. Each year, mixed cargo has been the predominant type of cargo in tonnes handled in Danish ports. The annual cargo volume of solid bulk and liquid bulk cargo has been nearly on the same level every year in the period observed. In 2010, Danish ports handled 63 million tonnes of international cargo, of which 26.6 million tonnes was mixed cargo, 18.8 million tonnes solid bulk and 17.4 million tonnes liquid bulk. It should be noted that the cargo volumes presented above and in Figure 3.10 comprise all Danish ports, not only Danish ports located in the Baltic Sea.

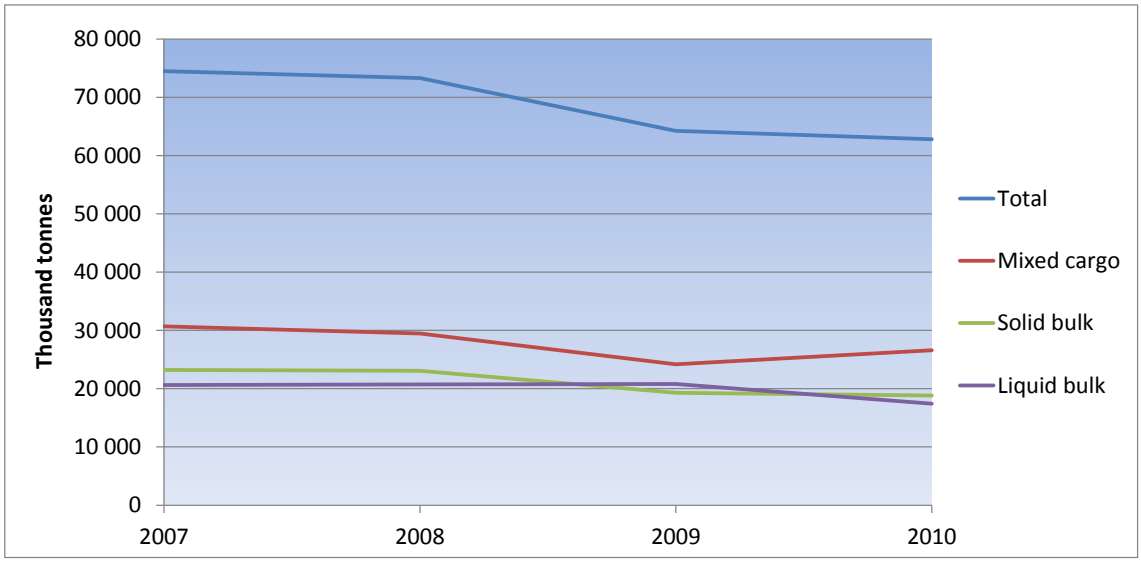

Figure 3.10 International cargo traffic in Danish ports in the period of 2007–2010 by cargo types. (Statistics Denmark 2012)

The annual share of liquid bulk of the total cargo volume in Danish ports has varied between 28–32 % or 17.4–20.8 million tonnes during the period of 2007–2010. The liquid bulk in the statistics of Statistics Denmark consists of crude oil, mineral oil products, other liquid bulk, liquid chemicals and liquid gas. Crude oil and mineral oil

products have been the predominant liquid cargo groups over the period of 2007–2010 (Table 3.24). In 2010, Danish ports handled 8,570 thousand tonnes of crude oil and 7,340 thousand tonnes of mineral oil products. In addition, 1,030 thousand tonnes of other liquid cargo, 290 thousand tonnes of liquid chemicals and 170 thousand tonnes of liquid gas were handled in Danish ports. Approximately 56 % of the liquid bulk traffic in Danish ports in 2010 was export and 44 % import. In addition, Danish ports have handled 44–86 thousand tonnes of solid chemicals annually during the period of 2007–2010 (Statistics Denmark 2012). It should be noted that the cargo handling volumes presented in this paragraph and in Table 3.24 comprise all Danish ports. When only Danish ports located in the Baltic Sea are taken into account, the handling volumes of liquid bulk are slightly lower. In 2010, Danish ports located in the Baltic Sea handled 17,040 thousand tonnes of international liquid bulk, of which 15,970 thousand tonnes was oil and oil products, 220 thousand tonnes liquid chemicals and 860 thousand tonnes other liquid cargo (Holma et al. 2011).

Table 3.24 Liquid bulk handled in Danish ports in the period of 2007–2010, thousand tonnes. (Statistics Denmark 2012)

	2007	2008	2009	2010
Crude oil	9,717	9,222	10,611	8,571
Mineral oil products	9,216	10,049	8,665	7,341
Other liquid bulk	1,146	1,016	1,036	1,033
Liquid chemicals	377	317	322	286
Liquid gas	155	131	157	173
Liquid bulk total	**20,611**	**20,735**	**20,791**	**17,404**

3.7.2 Liquid bulk and chemical handling volumes in Danish ports

Table 3.25 lists all Danish ports that handled international liquid bulk cargoes in various forms and/or solid chemicals in 2010 based on the cargo statistics provided by Statistics Denmark (2012). In total 36 Danish ports handled liquid bulk cargoes and/or solid chemicals in 2010 – 31 of these ports are located in the Baltic Sea and 5 in the North Sea. According to the cargo statistics of Statistics Denmark (2012), approximately 48 % of all the international liquid cargo volumes recorded in Danish ports were handled in the Port of Fredericia, 26 % in the Port of Statoil-Havnen, 8 % in the Port of Copenhagen, 6 % in the Port of Aarhus, 5 % in the Port of Aalborg and 8 % in other Danish ports. All crude oil recorded in Danish ports located in the Baltic Sea in 2010 was handled in the ports of Fredericia and Statoil-Havnen. Majority of the mineral oil products were handled in the ports of Fredericia, Statoil-Havnen, Copenhagen, Aalborg and Aarhus. Liquid chemicals were handled in 10 Danish ports located in the Baltic Sea, of which Copenhagen, Fredericia, Aarhus and Horsens recorded the highest volumes in 2010. Liquid gas was handled only in the ports of Fredericia and Statoil-Havnen. Other liquid bulk was handled in 17 ports, of which Aarhus, Fredericia, Skagen and Gulfhavn recorded the highest volumes. Solid chemicals were handled in the ports of Kalundborg and Holbæk, and small amounts in some other Danish ports as well.

Table 3.25 Liquid bulk handling volumes in Danish ports in international cargo traffic in 2010, thousand tonnes. (Statistics Denmark 2012)

	Crude oil	Mineral oil products	Liquid chemicals	Liquid gas	Other liquid bulk	Solid chemicals
Fredericia	5,952	2,077	42	103	143	5
Statoil-Havnen	2,618	1,742	0	71	0	0
Copenhagen	0	1,314	54	0	0	0
Aarhus	0	537	39	0	381	0
Aalborg	0	902	3	0	30	1
Nyborg	0	229	0	0	2	0
Aabenraa	0	148	2	0	30	0
Kalundborg	0	35	13	0	0	50
Skagen	0	29	0	0	67	0
Køge	0	38	0	0	37	0
Gulfhavn	0	0	0	0	61	0
Frederikshavn	0	57	0	0	0	0
Rønne	0	50	0	0	0	0
Grenaa	0	0	16	0	24	0
Horsens	0	0	37	0	0	0
Thyborøn	0	4	24	0	5	0
Odense	0	4	0	0	28	0
Rødby	0	31	0	0	0	0
Kolding	0	0	0	0	23	0
Korsør	0	18	0	0	0	0
Sønderborg	0	0	0	0	17	0
Holbæk	0	0	0	0	0	15
Masnedø Gødningshavn	0	0	0	0	12	0
Vejle	0	0	12	0	0	0
Næstved	0	0	0	0	0	9
Aalborg Portland	0	3	0	0	0	6
Vordingborg	0	0	0	0	6	0
Nordjyllandsværkets	0	5	0	0	0	0
Fåborg	0	0	0	0	4	0
Avedøreværkets	0	3	0	0	0	0
Nakskov	0	0	0	0	3	0
Danish ports in the Baltic Sea total	**8,570**	**7,226**	**242**	**174**	**873**	**86**
Other Danish ports total	**0**	**113**	**45**	**0**	**158**	**0**
All Danish ports total	**8,570**	**7,339**	**287**	**174**	**1,031**	**86**

Port of Fredericia

Associated Danish Ports A/S (ADP) is the name of the limited liability company which privately owns and runs the ports in the Danish cities of Fredericia, Nyborg and Middelfart. In the Port of Fredericia there are six shipping operators, of which Associated Danish Ports, Shell Marine Terminal and Samtank Oil terminal handle liquid bulk. Associated Danish Ports also handles dry cargo and, in addition, Fredericia

has a grain and bulk terminal that handles mainly dry cargo. Shipping.dk Jyllandsterminalen is also a dry cargo terminal (Baltic Transport Journal 2012). Denmark has one crude oil pipeline connecting some of the offshore production to the refinery and export terminal, both at Fredericia. Owned and operated by DONG Oil Pipe A/S, the pipeline is 330 km long and has a capacity of 360 kb/d (International Energy Agency 2011).

Today, the crude oil terminal in the Port of Fredericia is primarily intended for storing and exporting crude oil from the North Sea. However, propane and butane, having high commercial value, are produced as by-products and shipped as liquefied gases from the port terminal (Miljøministeriet, miljøcenter Odense 2010).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least methanol was shipped from Finnish ports to the Port of Fredericia.

Port of Kalundborg

The Statoil refinery at Kalundborg in Denmark refines crude oil and condensate (light oil) to petrol, jet fuel, diesel oil, propane, heating oil and fuel oil. Countries around the Baltic Sea represent the principal market for products of the refinery. Annual production capacity at Kalundborg is close to 5.5 million tonnes of oil products, depending on the type of feedstock. The Statoil refinery began to produce agricultural fertiliser in 2000, utilising a completely new facility designed in cooperation with Denmark's Haldor Topsøe Ltd. This plant converts sulphur and nitrogen from the desulphurisation process for oil products into liquid ammonium thiosulphate (ATS). Kalundborg also delivers petrol and diesel oil with less than 50 ppm (0.005%) of sulphur. The refinery primarily processes various crude oils and condensates from the North Sea, which are brought in by ship (Kalundborg Tank Terminal A/S 2012a).

Kalundborg Tank Terminal A/S was founded in 2009 as a 50/50 partnership between Schultz Shipping and the Port of Kalundborg. Long-term agreements have been made for fish oil, base/waste oil, and de-icers with a total storage capacity of 17,800 cubic metres. Tank Terminal A/S (KTT) has signed an agreement on the construction of the tanks for containing the nitric acid. KTT has a total of 12 tanks, of which 6 belong to Pronova BioPharma, 3 to Danska Oil Recycling A/S, one for Addcon Nordic and now 2 new nitric acid tanks for Haldor Topsøe (Kalundborg Tank Terminal A/S 2012b).

Port of Aarhus

Aarhus is Denmark's busiest port. Approximately 8,000 ships visit the port per year, carrying approximately 11 million tonnes of goods. This can be broken down into roughly 6 million tonnes of container goods, 2 million tonnes of oil products and 3 million tonnes of bulk material, principally animal feedstuffs and coal. The port's largest customer is Maersk-Sealand, which operates its own container terminal. The port is divided into separate areas for handling container, bulk, oil, and ferry traffic, as well as a multi-purpose terminal for mixed goods (Focus Denmark 2006). At least the Tank Terminal is handling mineral oil products, petrol, molasses, fluiding fat products etc.

together with bulk goods such as cement, stone and gravel in the Port of Aarhus (Oiltanking 2012). Samtank Oil also has a terminal in the Aarhus Port (Baltic Transport Journal 2012).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least methanol was shipped from Finnish ports to the Port of Aarhus.

Port of Copenhagen

In 2001, the Port of Copenhagen merged with the Port of Malmö. This is the only known fully administrative and organisational merge of two ports from different countries in Europe. In Copenhagen, the annual liquid bulk turnover is 3 million tonnes, and the Copenhagen terminal Prøvestenen handles most of Copenhagen's liquid-bulk traffic. This port area has seen a significant growth in turnover of particularly bunker oil for shipping and jet fuel for Copenhagen International Airport in Kastrup. Copenhagen bulk terminal includes 834,000 m^2 of land and a 1-million-cubic metre tank capacity. Yara Chemicals A/S has constructed a new terminal to Prøvestenen for nitric acid. The new terminal is located with easy access to the quays and thereby ship transport. The new terminal is to be the new hub for Yara Chemicals in Denmark. The facility will replace an existing terminal in Fredericia. The Fredericia terminal is taken out of use because the Kemira Grow-How factory is being demolished (Copenhagen Malmö Port AB 2012).

3.8 Polish ports

3.8.1 Overview of the liquid bulk handling volumes

The Central Statistical Office of Poland publishes statistics on maritime shipping in Polish ports. According to these statistics, the total international cargo traffic in Polish ports has varied annually between 44.3–58.6 million tonnes over the period of 2005–2010 (Figure 3.11). There was a descending trend in the volumes during the years 2005–2009 but in 2010 the volumes started growing significantly. Dry bulk and liquid bulk have been the main cargo types handled in Polish ports. In 2010, Polish ports handled 58.6 million tonnes of international cargo, of which 24.1 million tonnes was dry bulk, 17.5 million tonnes liquid bulk, 7.8 million tonnes large containers, 5.9 million tonnes ro-ro cargo and 3.4 million tonnes other general cargo. Approximately 30.5 million tonnes (52 %) of all the cargo transported through Polish ports in 2010 was export and 28.1 million tonnes (48 %) import (Central Statistical Office of Poland 2009 & 2011).

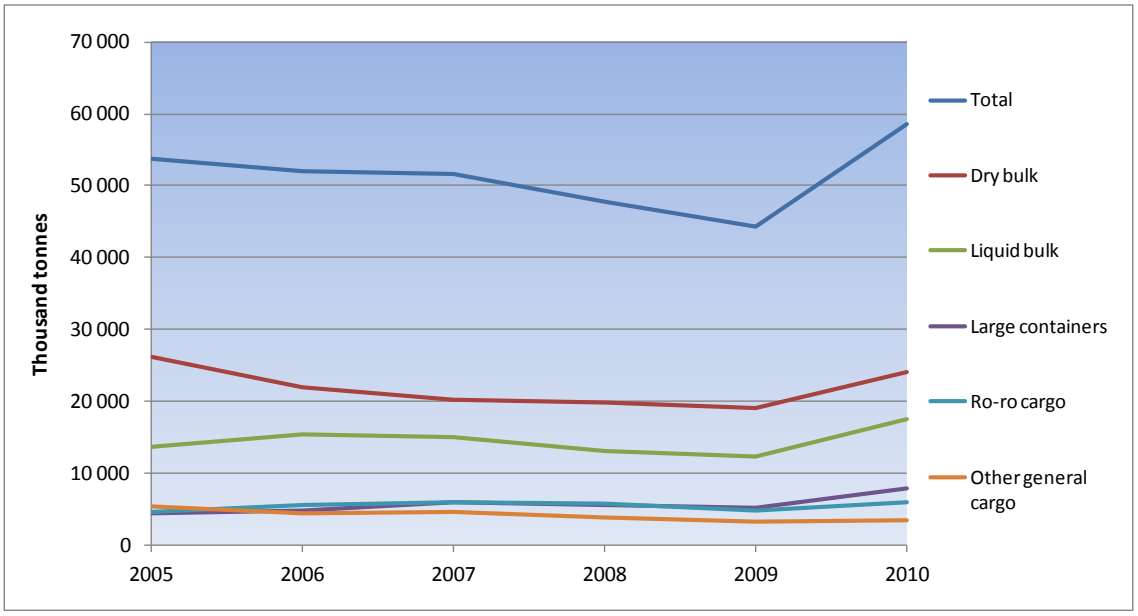

Figure 3.11 International cargo traffic in Polish ports in the period of 2005–2010 by cargo types. (Central Statistical Office of Poland 2009 & 2011)

The Central Statistical Office of Poland (2011) divides the liquid bulk cargo handled in Polish ports into five sub-classes: crude oil, oil products, liquefied gas, other liquid bulk and unknown liquid bulk. Crude oil has clearly been the most handled type of liquid bulk cargo in Polish ports during the period of 2007–2010, as every year 50 % or more of the liquid cargo has been crude oil (Table 3.26). Oil products have been the second most handled type of liquid bulk in Polish ports in the years observed. Chemicals are not separated in the statistics provided by the Central Statistical Office of Poland but the cargo groups 'other liquid bulk' and 'liquefied gas' probably include chemicals and related products. The annual volumes of other liquid bulk handled in Polish ports have varied between 1,380–2,350 thousand tonnes and the annual volumes of liquefied gas between 130–550 thousand tonnes in the years 2007–2010. During the period observed, the export volume of the liquid cargo transported through Polish ports has each year been higher than the import volume. In 2010, approximately 65 % or 11,400 thousand tonnes of the liquid bulk handled in Polish ports was export and 35 % or 6,100 thousand tonnes import.

Table 3.26 International liquid bulk cargo handled in Polish ports in the period of 2007–2010 by cargo types, thousand tonnes. (Central Statistical Office of Poland 2011)

	2007	**2008**	**2009**	**2010**
Crude oil	7,4885	6,659	6,693	11,344
Oil products	4,682	4,222	3,928	4,635
Other liquid bulk	2,349	1,595	1,444	1,378
Liquefied gas	547	485	160	134
Unknown liquid bulk	-	2	-	9
Total	**15,067**	**12,963**	**12,225**	**17,500**

3.8.2 Liquid bulk and chemical handling volumes in Polish ports

Holma et al. (2011) divide liquid bulk handled in Polish ports in 2010 into three sub-classes: oil and oil products, liquid chemicals and other liquid bulk. According to Holma et al. (2011), in 2010, Polish ports handled approximately 17,500 thousand tonnes of liquid bulk, of which 16,240 thousand tonnes was oil and oil products, 810 thousand tonnes liquid chemicals and 450 thousand tonnes other liquid bulk (Table 3.27). There were 6 Polish ports that handled liquid bulk cargoes in 2010. Over 85 % of the oil and oil products handled in Polish ports were transported through the Port of Gdansk. Liquid chemicals and other liquid bulk were handled mainly in the Ports of Gdynia, Gdansk and Szczecin.

Table 3.27 International liquid bulk cargoes handled in Polish ports in 2010 by cargo types and by ports, thousand tonnes. (Holma et al. 2011)

	Liquid bulk total	Oil and oil products	Liquid chemicals	Other liquid bulk
Gdansk	14,497	14,107	272	118
Gdynia	1,354	945	301	108
Swinoujscie	900	893	2	5
Szczecin	727	277	234	216
Police	13	11	2	0
Kolobrzeg	9	9	0	0
Total	**17,500**	**16,242**	**811**	**447**

The Central Statistical Office of Poland reports the liquid bulk handled in Polish ports slightly differently from Holma et al. (2011). In the cargo statistics of the Central Statistical Office of Poland (2011), liquid bulk has been divided into four sub-classes including crude oil, oil products, liquefied gas and other liquid bulk. Approximately 65 % or 11,340 thousand tonnes of the international liquid bulk handled in Polish ports in 2010 was crude oil (Table 3.28). Almost all of the crude oil was handled in the Port of Gdansk. Oil products was the second most handled type of liquid cargo with a total volume of 4,630 thousand tonnes. Oil products were handled in the ports of Gdansk, Swinoujscie, Gdynia and Szczecin. Other liquid bulk accounted for approximately 8 % or 1,390 thousand tonnes of the total liquid cargo volume in Polish ports in 2010. Other liquid bulk was mainly recorded in the ports of Szczecin, Gdynia and Gdansk. Polish ports, mainly Gdansk and Szczecin, also handled liquefied gas with a total volume of 134 thousand tonnes.

Table 3.28 International liquid bulk cargoes handled in Polish ports in 2010 by cargo types and by ports, thousand tonnes. (Central Statistical Office of Poland 2011)

	Liquid bulk total	Crude oil	Oil products	Liquefied gas	Other liquid bulk
Gdansk	14,497	11,226	2,778	95	397
Gdynia	1,353	117	788	3	446
Szczecin	727	0	179	25	523
Swinoujscie	901	0	881	5	15
Police	12	0	0	7	6
Total	**17,490**	**11,343**	**4,626**	**134**	**1,387**

Port of Gdansk

The Port of Gdansk has two terminals for handling liquid fuels and liquefied gas. *The Liquid Fuel Terminal* consists of four berths for the handling of crude oil and crude oil derivatives. The terminal can accommodate the largest vessels navigating the Baltic Sea and it offers four docking berths. The annual throughput capacity of the terminal amounts to 34 million tonnes. *Liquefied Petroleum Gas Terminal* is designated for the reception, storage, partial blending and distribution of liquefied propane-butane gas by means of tank cars and trucks. The terminal has been designed for an annual throughput capacity of up to 500 thousand tonnes. The terminal also constitutes a storage base for LPG in export relations. The storage base consists of 16 dugin tanks of a total storage capacity of 13.2 thousand tonnes (Port of Gdansk Authority Spolka Akcyjna 2012).

Liquid chemicals and other chemical-related substances are also handled in the Port of Gdansk. *Chemikow Quay* provides the location of handling facilities for inorganic fertilisers, phosphate raw material, molasses and sulphuric acid with the warehouse capacity of 75,000 tonnes. *Przemyslowe Quay* provides the location of handling facilities for syenite and dry bulk (including inorganic fertilisers, sodium and salt) at a capacity of 400 tonnes per hour and the location of handling facilities for liquid cargoes (e.g. liquid fertilisers, molasses and hydrochloric acid) at a capacity of 300 tonnes per hour. *Obroncow Poczty Polskiej Quay* is suited to the handling of dry bulk and liquid cargo such as granulated sulphur, molasses, heating and base oils, as well as aggregates (Port of Gdansk Authority Spolka Akcyjna 2012).

According to Hänninen & Rytkönen (2006), the number of chemical tankers visiting the Port of Gdansk in 2004 was 112. The destinations were mainly Baltic Sea and North Sea ports, the United Kingdom and occasionally the USA. The most common chemicals handled in the Port of Gdansk in 2004 were urea ammonium nitrate solution (318 kt), caustic soda (81 kt), sulphuric acid (64 kt), carbon dioxide liquefied (20 kt) and hydrochloric acid (15 kt) (Table 3.29). Unfortunately, any updated statistical information about chemical handling volumes in the port was not found.

Table 3.29 The most common chemicals handled in the Port of Gdansk in 2004. (Hänninen & Rytkönen 2006)

Substance	Tons	Number of ships
Urea ammonium nitrate solution (D)	318,045 loaded	15
Caustic soda (D)	81,172 loaded	31
Sulphuric acid (C)	63,742 loaded	6
Carbon dioxide liquefied	19,511 unloaded	23
Hydrochloric acid (D)	15,464 loaded	11

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least propane and phosphoric acid were shipped from Finnish ports to the Port of Gdansk and sodium hydroxide solution and sulphuric acid from the Port of Gdansk to Finnish ports.

Port of Gdynia

The Port of Gdynia has four terminals that handle liquid bulk. *Baltic Bulk Terminal Ltd* is intended for operating export of ammonium nitrate solution and import of fuel oils. The terminal is equipped with 3 steel tanks with 7,000 m^3 of storage capacity each and the capacity of the terminal is 500,000 tonnes per year (Baltic Bulk Terminal Ltd 2012). *Maritime Bulk Terminal Gdynia Ltd* handles liquid cargoes including crude oil and its derivatives and chemicals of the 3rd, 6th, 8th and 9th classes of the IMDG code (Maritime Bulk Terminal Gdynia Ltd 2012). *Petrolinvest S.A.* has focused on fuel trade, mainly relating to liquefied petroleum gas (LPG) (Petrolinvest S.A. 2012). *Westway Terminal Poland Ltd* handles biofuels, molasses, fertilisers, vegetable oils and fats, fuel oils and chemicals. The terminal is equipped with 10 tanks and the capacity of the terminal is 27,920 m^3 (Westway Terminal Poland Ltd 2012).

According to Hänninen and Rytkönen (2006), the number of chemical tankers visiting the Port of Gdynia in 2004 was 100. Most of the vessels came from the Netherlands, Belgium, Finland and Estonia. In total 143,390 tons of chemicals in liquid bulk were handled in the port, of which 95,565 tons were import and 49,825 tons export. Methyl-butyl ether (30 kt), paraxylene (24 kt), diethylohexyl (22 kt), dioctyle phthalate (16 kt), phosphoric acid (15 kt) and mosstanol were the most handled chemicals in the Port of Gdynia in 2004 (Table 3.30). Unfortunately, any updated statistical information about the chemical handling volumes in the port was not found.

Table 3.30 Chemicals handled in the Port of Gdynia in 2004. (Hänninen & Rytkönen 2006)

Substance	Tons	Number of ships
Methyl-butyl ether (MTBE)	29,619	19
Paraxylene	23,538	18
Diethylohexyl (2EH)	21,686	14
Dioctyle phthalate (DOP)	15,827	10
Phosphoric acid	14,791	9
Mosstanol	10,134	6
Butane (n-butanol)	8,196	5
Ethylene glycol (MEG)	6,361	4
Toluene	6,067	4
Benzol/benzene	1,553	1

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least xylenes and aromatic free solvents were shipped from Finnish ports to the Port of Gdynia.

Ports of Szczecin and Swinoujscie

The Szczecin and Swinoujscie Seaports Authority provides management for both the Port of Szczecin and the Port of Swinoujscie. Both of these ports have the potential for servicing liquid cargo including oil products, vegetable oils and molasses. According to the Internet site of the Szczecin and Swinoujscie Seaports Authority (2012), there are 5 companies in the Ports of Szczecin and Swinoujscie handling liquid bulk.

- *Baltchem S.A. Chemical Works* has two plants in operation for the handling of liquid bulk cargoes. The plant of Szczecin Kujota has a storage capacity of 47,000 m^3 for the handling of vegetable oil, petroleum products and methanol. Świnoujście Karsiborska has a storage capacity of 72,200 m^3 for the handling of heavy oil, base oil, diesel oil and petrols. In addition, the company has the hard-pumping equipment for the reloading of low temperatures liquid substances as well as liquid fertilisers (Baltchem S.A. 2012; Szczecin and Swinoujscie Seaports Authority 2012).
- *Bulk Cargo – Port Szczecin Sp. z o.o.* has 3,000 m^3 of tank storage for liquid bulk cargoes. The liquid cargoes and chemical-related cargoes handled by the company include e.g. fertilisers, sodium sulphate, sodium silicate, liquid tar and pitch (Bulk Cargo – Port Szczecin 2012; Szczecin and Swinoujscie Seaports Authority 2012).
- *Fast Terminals Ltd* provides storage and handling services for bulk cargo, unitized general cargo and semi-products, including also chemicals (Szczecin and Swinoujscie Seaports Authority 2012).
- *Krono-Chem sp. z o.o.* provides storage and handling services for bulk cargo and methanol. In order to handle methanol, the terminal is equipped with two methanol holders 14,250 m^3 each and two methanol discharging arms (Szczecin and Swinoujscie Seaports Authority 2012).
- *Polski Koncern Naftowy Orlen S.A.* has a Logistic Department in Szczecin which deals with the import and export of fuel oils and the import of petrol (Szczecin and Swinoujscie Seaports Authority 2012).

In addition to the companies above, there are two companies in the Port of Szczecin handling fertilisers. *Fosfan S.A.* produces fertilisers with a capacity of 200,000 tonnes per year and *DB Port Szczecin Sp. z o.o.* handles fertilisers in big bags and palletised chemicals (Szczecin and Swinoujscie Seaports Authority 2012).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least methanol was shipped from Finnish ports to the Port of Szczecin.

Port of Police

The Police Seaport is the fourth largest port in Poland and it handles approximately 2.5 million tonnes of cargo annually. The Police Seaport operates as a handling terminal for bulk cargoes such as phosphates, apatites, ilmenite ore (iron titanium oxide), potassium salt, fertilisers, ammonia and sulphuric acid (Police Port Authority Sp. z o.o. 2012). According to the Central Statistical Office of Poland (2011), in 2010 the Port of Police handled 12 thousand tonnes of liquid bulk, of which 7 thousand tonnes were liquefied gases and 6 thousand tonnes other liquid bulk.

3.9 German ports

3.9.1 Overview of the liquid bulk handling volumes

According to Holma et al. (2011), Germany has 32 sea ports that handled more than 50,000 tonnes of cargo in 2010, where at least part of this cargo was international. Of these ports, 14 are located in the Baltic Sea. The annual international cargo volumes in German ports located in the Baltic Sea have varied between 46.7–57.3 million tonnes over the period of 2007–2010 (Figure 3.12). There was an ascending trend in the volumes during the years 2007–2008 but the volumes turned into a descending trend in the years 2009 and 2010. Every year during the period of 2007–2010, other dry cargo has been the most handled cargo type and dry bulk the second most handled cargo type in German ports located in the Baltic Sea. Liquid bulk has been the third most handled cargo type in German ports located in the Baltic Sea. The annual volumes of liquid bulk have remained quite stable, between 3.4–4.2 million tonnes, during the whole period. In 2010, German ports located in the Baltic Sea handled in total 46.7 million tonnes of cargo, of which 25.2 million tonnes was other dry cargo, 17.4 million tonnes dry bulk and 4.2 million tonnes liquid bulk (Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011).

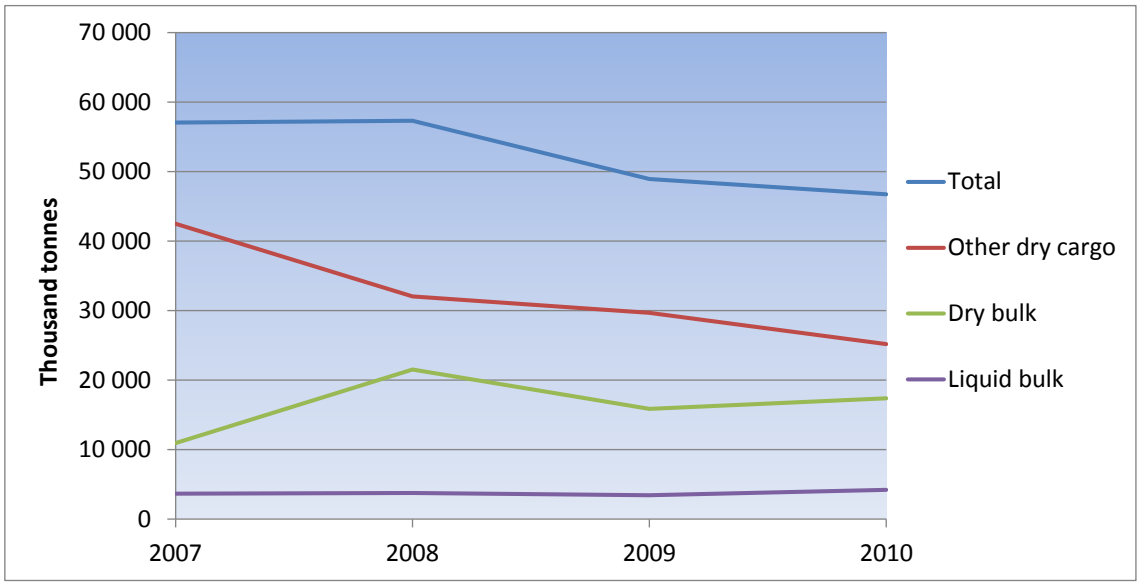

Figure 3.12 International cargo traffic in German ports located in the Baltic Sea in the period of 2006–2010 by cargo types. (Särkijärvi et al. 2008; Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011)

The Baltic Port List publications produced by the University of Turku Centre for Maritime Studies (Särkijärvi et al. 2009; Särkijärvi et al. 2010; Holma et al. 2011) categorise international liquid bulk handled in German ports into three groups: oil and oil products, liquid chemicals and other liquid bulk. According to the publications, almost all of the liquid bulk handled in German ports located in the Baltic Sea has been oil and oil products in the years 2008–2010. The annual volumes of oil and oil products have varied between 3,380–4,150 thousand tonnes during the period observed. In addition to the oil and oil products, very small amount of other liquid bulk was reported to have been handled in German ports in the Baltic Sea in 2009 and 2010. The volume of liquid chemicals was reported to be zero in the period of 2008–2010. However, it came out in this Chembaltic study that even high amounts of liquid bulk chemicals are handled in German ports each year.

3.9.2 Liquid bulk and chemical handling volumes in German ports

According to the Baltic Port List 2011 publication (Holma et al. 2011), Rostock, Kiel, Greifswald (Landkreis), Lübeck (including Travemünde) and Sassnitz were the only German ports in the Baltic Sea that handled liquid bulk cargoes (Table 3.31). The publication stated that the above-mentioned ports handled only oil and oil products. According to Holma (2012), the information on liquid chemicals handled in German ports reported in the Baltic Port List 2011 publication (Holma et al. 2011) is based on transport statistics provided by German authorities. In the German statistics, chemicals handled in German ports are roughly divided into different commodity groups and categorised also according to how the chemicals are transported (in bulk or as packaged goods and also solids or liquid goods). Based on this division, the Baltic Port List 2011 has included only four commodity groups which include liquid bulk chemicals, namely the groups ‘sulphuric acid’, ‘caustic soda’, ‘benzene’ and ‘pitches, tars, creosote, etc.

distillation products'. These groups are the only chemical groups in German statistics that are in the Baltic Port List publications considered to be liquid and transported as bulk. However, this German classification is very rough and also other commodity groups marked as solids may have liquid bulk or liquefied gases in it, since in this Chembaltic study some liquid bulk was found at least in three German ports in the Baltic Sea. In the German statistics, for instance in Rostock, there is a group 'other chemical raw materials (except aluminium oxide and hydroxide)' (Holma 2012). In this group, there were 616 thousand tonnes of transported goods in 2010 in the Port of Rostock and based on the ports' own information and also PortNet system, some portion of these should have been liquid bulk (see the ports´ details later). The German statistics also classify gases as solids, which is why these are not included as liquid bulk.

Table 3.31 International liquid bulk handled in German ports located in the Baltic Sea in 2010 by cargo types and ports, thousand tonnes. (Holma et al. 2010)

	Liquid bulk total	Oil and oil products	Liquid chemicals	Other liquid bulk
Rostock	3,926	3,884	0	42
Kiel	195	195	0	0
Greifswald, Landkreis	69	69	0	0
Lübeck (including Travemünde)	4	4	0	0
Sassnitz	1	1	0	0
Total	**4,195**	**4,153**	**0**	**42**

Port of Rostock

The main types of cargoes handled in the Port of Rostock are ro-ro cargo, combined cargo, bulk cargo (incl. coal, construction materials, fertilisers and grain), general cargo and liquid cargo (Rostock Port 2012a). Liquid cargoes are handled in two areas of the port, in the oil port and in the chemical port.

The oil port is operated by Großtanklager Ölhafen Rostock GmbH, a joint holding of the companies Seehafen Rostock Umschlaggesellschaft and TOTAL Deutschland GmbH. The oil port is equipped with three tank storage facilities with a total capacity of approximately 700,000 cubic metres that are used for storing and handling mineral oils, vegetable oils and other liquid products. Cargoes handled in the oil port are discharged at six berths, two of which are used by bunker ships and four of which are connected via pipelines for crude oil to the refineries in Schwedt and Leuna and for petroleum naphtha to Böhlen. In addition to mineral oils, the oil port handles naphtha, rapeseed oil, biodiesel, bioethanol, methanol, pyrolytic petrol, xylol-toluol and liquid fertiliser (Grosstanklager-Ölhafen Rostock GmbH 2012; Rostock Port 2012b).

The chemical port is concentrated on the handling of liquid fertilisers (ammonia). The chemical port is equipped with a berth that is used exclusively by the YARA fertiliser production facility located near Rostock. Two pipelines connect the tanker berth with the production plant. One of the pipelines is used for the discharge of cooled liquid

ammonia from liquid gas tankers to the plant. The second pipeline is used to pump liquid ammonium nitrate urea (LAU) fertiliser to the port for the loading onto tankers. (Rostock Port 2012b; Rostock Port 2012c).

According to the PortNet hazardous cargo review made as a part of this study, in 2010 at least ethanol was shipped from the Port of Rostock to Finnish ports and methanol from Finnish ports to the Port of Rostock.

Port of Wismar

Seehafen Wismar GmbH operates the Port of Wismar. It handles various types of cargo including wood logs, forest products, renewable raw materials, metals, scrap, bulk cargoes, peat, liquid cargoes, general cargo, project cargo, and containers. Liquid cargoes handled in the port serve the needs of local industrial enterprises with basic materials such as methanol, pentane, styrene and biodiesel. The storage capacity of liquid bulk of the port is 16,000 m^3 (Seehafen Wismar GmbH 2012).

According to the PortNet hazardous cargo review made as a part of this study, in the year 2010 at least methanol was shipped from Finnish ports to the Port of Wismar.

Port of Greifswald

The main cargoes handled in the Port of Greifswald are building materials, wood, pig iron, oil, used tires and agricultural products (fertilisers). The maximum annual capacity of the port is 1,000,000 tons (Greifswalder Hafengesellschaft mbH 2012). According to Holma et al. (2011), in 2010 the Port of Greifswald handled 69 thousand tonnes of liquid bulk, all of which was oil and oil products. About 30 thousand tonnes of fertilisers were also handled in the port. Liquid chemicals were not reported to be handled in the port.

Port of Lübeck

The Port of Lübeck is a major port in the state of Schleswig-Holstein in northern Germany. The port handles over 400 thousand tons of dangerous goods annually (World Port Source 2012c). Unfortunately, more detailed information about dangerous goods handled in the port is not available. Therefore, the dangerous goods handled in the port may include oil, oil products, chemicals and other dangerous cargoes in both solid and liquid state, and they may be transported both as bulk cargo and as packaged cargo.

4 SUMMARY AND CONCLUSIONS

This report is written as a part of the Chembaltic (Risks of Maritime Transportation of Chemicals in Baltic Sea) project which gathers information on the chemicals transported in the Baltic Sea and on risks related to these transportations. The purpose of this study is to provide an overview of the handling volumes of liquid bulk chemicals, including liquefied gases, in the Baltic Sea ports and to find out what the most handled liquid bulk chemicals in the Baltic Sea ports are. Oil and oil products are also viewed in this study but only on a general level. Data gathered in this study will be used as background information in later stages of the Chembaltic project when the risks of the chemicals transported in the Baltic Sea are assessed to highlight the chemicals that require special attention from an environmental point of view in potential marine accident situations in the Baltic Sea.

According to Holma et al. (2011), the international liquid bulk cargo handled in the Baltic Sea ports in 2010 contained approximately 290 million tonnes of oil and oil products, 11 million tonnes of liquid chemicals, and 4 million tonnes of other liquid bulk. Based on this study, it appears that the volume of liquid bulk chemicals handled in the Baltic Sea ports could be even higher than 11 Mt. Finnish ports handled almost 6.3 million tonnes of liquid chemicals in 2010. In addition to Finnish ports, large amounts of liquid chemicals were also handled in Estonian (1.2 Mt), Swedish (0.9 Mt), Polish (0.8 Mt), Lithuanian (0.8 Mt) and Latvian (0.7 Mt) ports. However, there are some considerations to take into account when above mentioned chemical handling volumes are examined. Different countries in the Baltic Sea area classify cargo handled in ports in different way. In some countries (e.g. in Germany and Sweden) it is very difficult to identify liquid bulk chemicals from other type of cargo. Therefore, the amount of liquid bulk chemicals handled in the Baltic Sea ports can be estimated only in a rough level. In case of Finland, liquid and solid chemicals cannot be separated from each other, but the share of liquid chemicals handled in the Finnish ports in 2010 has been estimated to be over 80 per cent (Holma 2012). Therefore, the volume of liquid chemicals handled in Finnish ports in 2010 can be considered to be between 5.0–6.3 million tonnes. In case of Sweden, the volume of liquid bulk chemicals is most probably higher than 0.9 million tonnes. For example, Molitor (2006) and Suominen (2007) have reported that the annual chemical handling volume in Swedish ports has been over 2.5 million tonnes. In addition, Holma et al. (2011) stated that no liquid chemicals are handled in German ports, but results of this study indicate that high amounts of chemicals are also handled in these ports.

Before this report, the latest more detailed list of chemicals handled in Finnish ports is available from 1994 (Sormunen 2011, originally presented in Hänninen & Rytkönen 2006). In 1994, altogether 3,900 thousand tonnes of chemicals, including both liquid and gaseous chemicals, were handled in Finnish ports. Since the corresponding figure was 3,560 thousand tonnes in 2008 and 3,460 thousand tonnes in 2010, the amount of liquid and gaseous bulk chemicals handled in Finnish ports has slightly decreased from the year 1994 but the size range has remained the same. The number of different chemicals has also remained approximately the same when the years 1994 and 2008 are compared. In 2010, the number of different chemicals decreased by approximately 20

chemicals. It can also be seen that the most handled chemicals in Finnish ports have remained almost the same from 1994 to 2008 and 2010. The most handled chemicals in all these years include chemicals such as methanol, sodium hydroxide solution, xylenes, ammonia, phosphoric acid and ethanol. However, there are some chemicals whose quantities in Finnish ports have significantly increased/decreased from 1994 to 2008 and 2010. Examples of chemicals whose quantities have increased are pentanes, methyl tert-butyl ether, propane and aromatic free solvents. By contrast, examples of chemicals whose quantities have decreased are pyrolysis gasoline, ammonia and monoethylene glycol. There are also some chemicals that were handled in Finnish ports in 1994 but not at all in 2008 and 2010. Examples of these chemicals are fluosilicic acid and magnesium sulphonate. In contrast, there are some new chemicals that were transported in 2008 and 2010 but not at all in 1994, such as ethyl tert-butyl ether (ETBE), tert-amyl ethyl ether (TAEE), NExBTL and palm oil.

Swedish ports handled in 2010 approximately 67.1 million tonnes of international liquid bulk cargo, of which 63.6 million tonnes were mineral oils and 3.5 million tonnes other liquid bulk (Ports of Sweden 2012). According to the results of Molitor (2006), in 2004 approximately 2,322 thousand tonnes of chemicals were handled in Swedish ports that were covered in the study. The number of different chemicals listed in the study and handled in the Swedish ports studied was 32. Sulphuric acid was clearly the most handled chemical with 36 % of the total volume. Sodium hydroxide solution, ammonia, propane and ethanol were next in rank in terms of chemical handling volumes. In another Swedish study (Räddningverket 2008), a large number of new chemicals handled in Swedish ports were identified. In the group of gases, new chemicals included propane, butane, ethyl chloride, ethane, butane and ethylene. In the group of flammable fluids, ETBE and hexane represented new chemicals.

Polish ports handled in 2010 approximately 17.5 million tonnes of international liquid bulk cargo, of which 11.3 million tonnes was crude oil, 4.6 million tonnes oil products, 0.1 million tonnes liquefied gases and 1.4 million tonnes other liquid bulk (Central Statistical Office of Poland 2011). There were 6 Polish ports that handled liquid bulk in 2010. Most of the oil and oil products was transported through the Port of Gdansk. Liquid chemicals and other liquid bulk were handled mainly in the ports of Gdynia, Gdansk and Szczecin, and liquefied gases in the ports of Gdansk and Szczecin (Central Statistical Office of Poland 2011; Holma et al. 2011). Regarding chemical handling in the Polish ports, the Port of Gdansk handles at least liquefied propane-butane gas, fertilisers (e.g. urea ammonium nitrate solution), sodium hydroxide solution, sulphuric acid, sulphur, carbon dioxide liquefied and hydrochloric acid. The Port of Gdynia handles at least ammonium nitrate solution, liquefied petroleum gas, biofuels, vegetable oils and fats, methyl-butyl ether (MTBE), paraxylen, diethylohexyl (2EH), dioctyle phthalate (DOP), phosphoric acid, mosstanol, butanes, ethylene glycol, toluene and benzene. The ports of Szczecin and Swinoujscie handle at least vegetable oils, methanol, liquid fertilisers, sodium sulphate, sodium silicate, and liquid tar and pitch. The Port of Police handles chemicals such as fertilisers, ammonia and sulphuric acid.

Estonian ports handled in 2010 approximately 29.8 million tonnes of international liquid bulk, of which 28.6 million tonnes was oil and oil products, 1.2 million tonnes

liquid chemicals and 50 thousand tonnes other liquid bulk. Liquid bulk cargo was handled in 7 Estonian ports/harbours in 2010 (Holma et al. 2011). Oil and oil products were handled mainly in the harbours of Muuga and Paldiski South and the Port of Sillamäe, and other liquid bulk in the harbours of Muuga, Paljassaare and Paldiski South and the ports of Kunda and Sillamäe. Almost all of the liquid chemicals transported through Estonian ports were handled in the Port of Sillamäe but also the ports of Kunda and Tallinn handled small amounts of chemicals. In the Port of Sillamäe, ammonia and UAN are handled in high quantities and in addition to these also at least methanol, acetic acid, vinyl acetate, butyl acetate, toluene and mono ethylene glycol are handled in Sillamäe. The Port of Tallinn handles at least vegetable oils, biodiesel and glycerol. The information about chemicals handled in the Port of Kunda was not available.

Lithuanian ports handled in 2010 approximately 18.8 million tonnes of international liquid, of which 17.8 million tonnes was crude oil and petroleum products, 0.8 million tonnes natural and chemical fertilisers, 30 thousand tonnes molasses and 220 thousand tonnes other liquid bulk (Statistics Lithuania 2012). All of the liquid bulk cargo was handled in the ports of Klaipeda and Butinge. The Port of Butinge handled only oil and oil products with a volume of 9.0 million tonnes. The Port of Klaipeda handled about 9.8 million tonnes of liquid cargo, of which 8.8 million tonnes were oil products, 0.8 million tonnes liquid fertilisers, 60 thousand tonnes vegetable fats and oils, 30 thousand tonnes liquid raw sugar and 160 thousand tonnes other liquid cargoes. In 2010, the Port of Klaipeda also handled approximately 400 thousand tonnes of fertilisers and 60 thousand tonnes of chemical products and chemicals as general cargo. At least ethylene glycol, isobutanol, butanol, ethanol, methanol, glycerine, methyl tert-butyl ether and ethyl tert-butyl ether, vegetable oils and especially liquid fertilisers are handled in the Port of Klaipeda (Klaipeda State Seaport 2012).

Latvian ports handled in 2010 approximately 21.2 million tonnes of international liquid bulk, of which 20.5 million tonnes was oil and oil products, 0.7 million tonnes liquid chemicals and 70 thousand tonnes other liquid bulk. International liquid bulk cargo was handled in 4 Latvian ports in 2010. Oil and oil products were handled in the ports of Ventspils, Riga and Liepaja, liquid chemicals in the ports of Ventspils, Liepaja and Skulte, and other liquid bulk in the ports of Riga, Ventspils and Skulte (Holma et al. 2011). The chemicals handled in the Port of Ventspils include e.g. ammonia, different spirits and methanol. In the Port of Riga, at least propane-butane and methanol and natrium hydroxide are bunkered and needed for biodiesel production. The Port of Liepaja handles chemicals such as coal tar, vegetable oils and fertilisers. The information about chemicals handled in the Port of Skulte was not available.

Russian ports handled approximately 113.2 million tonnes of international liquid bulk in 2010, of which 112.8 million tonnes was oil and oil products, 90 thousand tonnes liquid chemicals and 300 thousand tonnes other liquid bulk. Russia has six main ports in the Baltic Sea: Kaliningrad, Primorsk, Saint Petersburg, Ust-Luga, Vyborg and Vysotsk. All these ports, except Ust-Luga, handled international liquid bulk in 2010. Primorsk is a pure oil port and it handled almost 78 million tonnes of oil and oil products in 2010. All of the liquid bulk handled in the Port of Vysotsk and almost all of the liquid bulk

handled in the Port of Saint Petersburg was oil and oil products as well. Liquid chemicals were handled only in the ports of Kaliningrad and Vyborg (Holma et al. 2011). No chemical-specific data was available but at least liquid fertilisers and sodium hydroxide was handled in Russian ports located in the Baltic Sea, but surely some other chemicals must be handled in these ports as well.

According to Holma et al. (2011) the volume of liquid chemicals handled in German ports located in the Baltic Sea was reported to be zero. However, based on our study, at least in the ports of Rostock and Wismar some chemicals were handled and shipped. In the Port of Rostock chemicals shipped include at least biodiesel, methanol, ethanol, xylol-toluol, ammonia and liquid ammonium nitrate urea. The Port of Wismar handles liquid cargo based on needs of local industrial enterprises with basic materials such as methanol, pentane, styrene and biodiesel. In addition, some chemicals are handled in the Port of Lübeck. Nevertheless, Germany is shipping most chemicals through North Sea/Atlantic ports such as Hamburg, Stade, Bützfleth and Brunsbüttel. Furthermore, Germany uses in its chemical transportations e.g. the Dutch Port of Rotterdam where a million tonnes of chemicals are shipped every year.

Danish ports located in the Baltic Sea handled in 2010 approximately 17.1 million tonnes of international liquid bulk, of which 8.6 million tonnes was crude oil, 7.2 million tonnes oil products, 240 thousand tonnes liquid chemicals, 170 thousand tonnes liquid gas and 870 thousand tonnes other liquid bulk. Approximately 48 % of all the international liquid cargo volume recorded in Danish ports was handled in the Port of Fredericia, 26 % in the Port of Statoil-Havnen, 8 % in the Port of Copenhagen, 6 % in the Port of Aarhus, 5 % in the Port of Aalborg and 8 % in other Danish ports. All crude oil recorded in 2010 in Danish ports located in the Baltic Sea was handled in the Ports of Fredericia and Statoil-Havnen. Most of the mineral oil products were handled in the ports of Fredericia, Statoil-Havnen, Copenhagen, Aalborg and Aarhus. Liquid chemicals were handled in 10 Danish ports located in the Baltic Sea, of which Copenhagen, Fredericia, Aarhus and Horsens recorded the highest volumes in 2010. However, the volumes of liquid chemicals in Danish ports are very small. Liquid gas was handled only in the ports of Fredericia and Statoil-Havnen. Other liquid bulk was handled in 17 ports of which Aarhus, Fredericia, Skagen and Gulfhavn recorded the highest volumes. Solid chemicals were handled in the ports of Kalundborg and Holbæk, and small amounts in some other Danish ports as well. No detailed chemical-specific data about chemicals handled in Danish ports was available, but based on the information presented on the webpages of Danish ports or their terminals´ environmental assessment reports etc. at least propane and butane are handled in high amounts in the Port of Fredericia and nitric acid in the ports of Kalundborg and Copenhagen.

The results of this study revealed that the most handled chemicals in the Baltic Sea ports are methanol, sodium hydroxide solution, ammonia, sulphuric and phosphoric acid, pentanes, aromatic free solvents, xylenes, methyl tert-butyl ether (MTBE) and ethanol and ethanol solutions. All of these chemicals are handled at least hundred thousand tonnes or some of them even over 1 million tonnes per year, but since chemical-specific data from all the Baltic Sea countries is not available, the exact tonnages could not be

calculated in this study. Besides above mentioned chemicals, there are also other high volume chemicals (e.g. ethylene, propane, butane) and large amounts of fertilisers and vegetable oils handled in the Baltic Sea ports, but exact tonnes of these substances are unknown as well. Chemicals transported/handled the most in the Baltic Sea are mainly similar when compared to chemicals transported the most in other seas in the world. For example according to AMRIE (2005), the most handled chemicals in the largest Atlantic EU ports were palm and other vegetable oils, methanol, benzene and its mixtures, sodium hydroxide solution, xylenes, styrene, MTBE, molasses and ammonia.

This report gives an overview about the most handled chemicals in the Baltic Sea ports and updates the information about the most transported chemicals in the sea area. The study revealed that data on the chemical transportation volumes in the Baltic Sea and in the EU is limited and decentralized. Except for Finnish and Swedish ports, the exact quantities of different chemicals transported in the Baltic Sea are not available. At the moment, information seems to be scattered in different companies, ports and agencies and classified as confidential. The SafeSeaNet system enables European Union Member States, Norway, and Iceland to provide and receive information on ships, ship movements, and hazardous cargoes, but the data of the system is not available for a scientific use. If this chemical-specific information will also be available for the scientific community, it would be a lot easier to make e.g. environmental risk assessment studies, which in turn would make preparing for accidents and the rescue services overall a lot easier to manage and arrange. Awareness of potential risks of the most transported chemicals is the key factor in increasing the preparedness for and mitigating the effects of possible accidents.

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