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Project on sub-regional risk of spill of oil and hazardous substances in the Baltic Sea (BRISK)

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1 Introduction

This report describes the prognosis for the future cargo ship traffic in the Baltic Sea for the situation in 2020. Included in the report is a description of the basis of the data, the methodology, assessments and uncertainties.

In section 2 the basis and principles are described, while section 3 describes the predicted future development of the cargo fleet. The prognosis for the development of the transported goods tonnage in percent is provided in section 4.

2 Basis and principles

The basic principles for the preparation of the prognoses, i.e. of the future movement of ship traffic in the Baltic Sea area, are described in this section.

The principles are the same as applied for the earlier Danish oil spill analysis (1) unless otherwise indicated.

2.1 Scope

The overall scope is to estimate the increase of ship traffic until the year 2020 distributed to the respective ship types. The relevant ship types of vessels are discussed separately in the following subsections.

2.2 Basis

The prognosis is developed based on existing studies, among theses especially the Baltic Maritime Outlook 2006, described in more detail in Section 4. As far as ship movement information is concerned, AIS data from July 2008 to June 2009 described in Part 1 of the Model Report are used.

During the earlier Danish oil spill analysis (1), MSR Consult provided valuable input with respect to fleet development and other prognosis issues. This information is also part of the considerations in this note. MSR Consult used data regarding the world fleet of vessels from Clarkson Research Services and Lloyd's Register Fairplay, together with their own prognoses for the development in the global sea transport and shipping trade.

2.3 Segmentation of vessel types

The prognoses for the future shipping traffic include a large number of vessel types. How each of the types of vessels are categorised is shown in the table below.

Table 2-1 Segmentation for the prognosis (numbers based on AIS data)

Main group for prognosis	**Ship type**	**Share of sailed miles in the Baltic Sea**
Cargo transport	Others	0.3%
	Car transport	1.6%
	Bulk	6.0%
	Bulk/Oil	0.1%
	Container	8.4%
	Reefer ship	2.6%
	RO-RO	7.8%
	General cargo	35.0%
	Tanker, Food	0.2%
	Tanker, Chemistry/Product	9.2%
	Tanker, Chemicals	1.5%
	Tanker, LNG	0.0%
	Tanker, LPG	0.8%
	Tanker, Others	0.2%
	Tanker, Product	2.8%
	Tanker, Crude oil	2.9%
Passenger transport	Ferry/RO-RO	16.1%
	Passenger	0.5%
	Cruise ship	1.2%
Other transport	Work vessel	0.9%
	Fishing vessel	0.7%
	Offshore	0.1%
	Nuclear fuel	0.0%
	Tug boat	1.2%
	Navy	0.0%

The focus has been on the preparation of detailed prognoses for the types of vessels that are assessed to have the greatest effect on the future risk of oil and chemical pollution in the Baltic Sea.

The types of vessels that render the biggest contribution to the shipping traffic in the Baltic Sea are:

- General cargo vessels
- Container carrier
- Product tankers ('Tanker Product' and 'Tanker Chemical/Product')
- Crude oil tankers
- Chemical tankers
- Bulk carriers
- Ferry/RO-RO
- RO-RO

These eight categories make up approximately 90% of the sailed miles in the Baltic Sea.

It is worth mentioning that general cargo vessels constitute a great share of the total share of vessel movements, but that most of them are rather small vessels. Thus, rectifying for the size differences the general cargo vessels will have a less essential part than what is indicated in the table above. In relation to the risk analysis, general cargo vessels are not assumed to possess the same importance as e.g. oil tankers, container ships and bulk vessels.

From an essential consideration the focus has been on preparing detailed analyses for oil and chemical transports, container ship traffic, general cargo ships and RO-RO vessels. In addition, a further investigation has been made on future transportations of liquid natural gas (LNG). The reason for this is that Gazprom and PetroCanada are planning to build a facility for production of LNG in Primorsk as well as building a LNG terminal in Poland. However, releases from LNG vessels are not a primary problem for the marine environment since the released gas will evaporate.

Separate analyses for the vessel types categorised as “other transport” have not been prepared, since these do not provide an essential contribution to the total risk of oil and chemical pollution in the Baltic Sea.

Since the future development of certain types of vessels is expected to be similar, these have been treated together. The table below shows how the vessel types have been grouped for the analysis. The grouping is partly based on the considerations given above, on the importance of the vessel type for the risk analysis and partly on the data available. For each grouping, the different trends in the development of vessel sizes is accounted for (see section 3). It is worth mentioning that the classification is an expression of a simplification, since e.g. chemicals can be transported not only by chemical tankers but also with containerships.

The analysis for passenger transport is divided into "passenger transport" and "cruise", since it is different factors that drive the development of these types of transport. The analysis of passenger transport and cruise is carried separately in Appendix 2.

Table 2-2 Classification of vessel types in market segments for the purpose of analysis.

Main group for prognosis	**Market segment**	**Type of vessel**
Cargo transport	Cars	Car transport
	Container	Container
	Ro-Ro	Ro-Ro
	Bulk goods	Bulk
	Liquid natural gas (LNG)	Tanker LNG
	Chemicals	Tanker Chemicals, Tanker Other
	Oil transport	Tanker Chemistry/Product, Tanker LPG, Tanker Product, Tanker Crude oil, Bulk/Oil
	General cargo	General cargo
	Tanker Food	Tanker Food
	Reefer ship	Reefer ship
	Other	Others

3 Fleet development

There is a tendency that ships are getting bigger and bigger. This means that the number of passages through the Baltic Sea is not expected to increase as much as the increase in cargo volumes. The transports will merely be done by larger ships (which has an influence on the consequences given the occurrence of an accident).

This is handled in the analysis. In the following, it is accounted for how the increase of the average vessel size is estimated for each type of vessel and trade flow.

The actual adjustment compared to the prognoses is described in section 4.

3.1 Methodology, basic data and background

In this analysis, the ship size is indicated in terms of cargo-carrying capacity, also named dead weight (DWT) or by volume, also named gross tonnage (GT).

The average size is of each vessel type is estimated based on data from Clarkson Research Services on the entire world fleet in those cases, where the data is consistent with Lloyd's Register Fairplay (comprising vessels down to approx. 100 GT).

Calculations of the averages have been made based on the status of the global fleet ultimo 1995 and the following years to ultimo 2005. Based on these calculations the annual growth rates are calculated for the periods 1995-2000 and 2000-2005 (1).

A change, e.g. an increase, in the average vessel size for a specific vessel type is the result of new ships entering the fleet being bigger than the old ships leaving the fleet. Rebuilding of ships can occur.

The reason for increasing vessel sizes is primarily found in economics of scale and a shift in trade patterns. There are economical advantages from using large ships, e.g. because the total transport volumes increases, the distances of transportation increases, the consignors, the transporters and/or the consignees consolidate into larger units. The vessel size must of course be proportioned to the capacity of the additional infrastructure, such as harbours, channels, navigation conditions (water depths), storage capacities, production capacities etc. It is therefore a question of an interaction of a series of factors and the development often occurs in "jumps" or "generations". Furthermore, these factors often lead to the development of "clusters" of load sizes and/or vessel sizes. As an example, the size distribution of crude oil tankers is not continuous, but instead clumped around certain typical vessel sizes. In shipping terms these are among others panamax, aframax, suezmax, VLCC and ULCC. Panamax are vessels that can pass the Panama Canal, aframax are vessels that can enter most US-harbours (max. depth 12m), suezmax are vessels that can pass the Suez Canal and VLCC are Very Large Crude Carriers larger than 160,000 DWT, whereas Ultra Large Crude Carriers (ULCC) can carry more than 320,000 DWT.

A prognosis of the growth rate of the average ship size in each ship class is made based on

- a synoptic analysis of the development of vessel sizes for the global fleet over the last 10 years,
- a similar analysis of the development of the world trade per cargo type with respect to volume and distribution upon main transportation routes,
- and similar analyses of main size groups per vessel type, an extrapolation of the growth rate for the average vessel size per vessel type is made.

Data describing the development of the average vessel size specifically for the Baltic Sea has not been available for the analysis.

Subsequently, the trend of the development of vessel sizes is "transferred" to the Baltic Sea. In this relation, the considerable restrictions concerning size have been considered, especially:

- restrictions on load draught during entrance to the eastern part of the Baltic Sea
- restrictions in the Kiel Canal

In relation to the entrance to the eastern Baltic, the minimum water depth is 15 meters, which means that there is an upper boarder for fully loaded tank-, bulk and container vessels of approximately 100,000 DWT. Nevertheless, larger vessels are able to pass in a semi-loaded condition, which in fact is common practice (compare section on STS transfers in part 4 of the Model Report).

Regarding the Kiel Canal the following restrictions apply:

- Maximum length: 235.0 meters
- Maximum width: 32.5 meters
- Air draft: 40 meters
- Load draught for vessels with a length of up to 160 meters: 9.5 meters, decreasing to 7.0 meters for longer vessels

It is impossible to define an upper limit for the size of fully loaded vessels, but for tanker and bulk vessels and container ships the upper limit it can be said to be approx. 20,000 DWT. From Table 3.1 it appears that the average size per passage (units per movement) of the Kiel Canal for dry bulks is larger (24,629 DWT) than the given upper limit. The reason for this is assumed to be that a fair amount of large vessels are passing in ballast. Presumably, it is mostly vessels sailing in ballast when entering the Baltic through the Kiel Canal and sailing fully loaded out of the Baltic through the Great Belt.

3.2 Fleet development vs. development of cargo volumes

As discussed further below in Section 4.5, it is assumed that cargo volumes will be unchanged from 2008 to 2012 due to the global financial crisis. It is assumption that this does not affect the fleet development, as ships are assumed to be replaced by larger ships on a regular basis as they reach the end of their service life.

3.3 Results

The results are shown in Table 3-1 below and are commented according to type of vessel.

Please note that the numbers in Table 3-1 are made up of the global fleet, vessels entering/leaving the Baltic Sea via the Danish Straits and vessels entering/leaving the Baltic Sea via the Kiel Canal. In the table there are two columns with the average vessel sizes. The first column shows the average of the vessels registered while the second column shows the estimated average of vessel passages, so that vessels passing multiple times is weighted more.

It has shown to be appropriate to use the general numbers for the traffic in the Baltic Sea as a whole. These are presented in Table 3-2.

Table 3-1 Analysis of and prognosis for the development of vessel sizes distributed on type of vessel and trade flow

Cargo group	Trade flow	Unit	Average size of vessels in 2005	Average size of vessels per passage in 2005	Average growth in vessel size, % per year		
					Historic		Prognosis
					1995-2000	2000-2005	2010-2020
Crude oil	Globally	DWT	118883		1.0	2.7	0.8
	Gr. Belt		109950	105353			0.3
	Kiel Can.		47679	19668			0.0
Oil Products	Globally	DWT	23061		2.1	3.7	2.0
	Gr. Belt		25976	17492			1.3
	Kiel Can.		10598	9475			1.3
Chemicals	Globally	DWT	14568		1.6	1.8	1.0
	Gr. Belt		10815	5727			0.8
	Kiel Can.		5465	4499			0.8
LPG	Globally	DWT	16494		-0.7	0.6	1.5
	Gr. Belt		11137	7891			2.0
	Kiel Can.		5125	6643			0.5
LNG	Globally	DWT	66914		0.8	1.3	2.0
	Gr. Belt		73705	73705			0.0
	Kiel Can.		N/A				-
Containers	Globally	DWT	30453		1.6	3.7	2.8
	Gr. Belt		48488	30673			2.5
	Kiel Can.		9451	8579			1.8
Reefer	Globally	DWT	5590		0.4	0.1	0.3
	Gr. Belt		8009	7259			0.3
	Kiel Can.		6379	6141			0.3
RO/RO	Globally	DWT	8835		0.5	1.2	0.7
	Gr. Belt		8593	9455			0.7
	Kiel Can.		7801	8105			0.7
Cars	Globally	DWT	13671		1.9	1.2	0.8
	Gr. Belt		16926	13158			0.8
	Kiel Can.		5279	4747			0.5
General cargo	Globally	DWT	6445		-1.8	-1.2	-0.7
	Gr. Belt		6767	4370			-0.7
	Kiel Can.		4127	3731			0.0
Dry bulk	Globally	DWT	55778		1.5	1.8	1.4
	Gr. Belt		49524	36960			0.5
	Kiel Can.		29096	24629			0.0

Sources: MSR-Consult, Clarksons Research Services and LR-Fairplay data

Crude oil tankers

This group of vessels includes in addition "Bulk/oil". Since 1995 there has been an annual growth of approx. 1.8% per year, but with a considerable growth during recent years due to a large admission in the large vessel segments. This development is expected to continue, since the growth in transport labour primarily result from the long distances of transportation and thereby on the largest vessel types, thus the average vessel size is expected to increase from approx. 120,000 DWT today up till approx. 145,000 DWT in 2020.

Regarding traffic passing through the Danish Straits, the distribution of size is already concentrated on vessels over 100,000 DWT in spite of the restrictions on load draught when entering the Baltic. Therefore, a further increase of the average vessel size is assumed to be lower than for the global fleet. This is among others seen form the average vessel size and per vessel passage is very close to each other and to the "size limit" for fully loaded vessels in and out of the Baltic. The regarded area will only have limited import of crude oil from the Middle East and West Africa, where the majority of discharging over very large distances take place. On the contrary the export of crude oil will be from Russia over very long distances to the Far East. To this many larger tankers are used which sail out with partial load and is filled up later using STS operations, see part 4 of the Model Report.

For traffic through the Kiel Canal and internally in the Baltic Sea, the vessel sizes are presumed to be unchanged due to the limitations on capacity and a well established and stabile transport pattern. Among others this includes that the average per passage is close to the assumed limit for fully loaded vessels.

Product tankers
This group of vessels includes partly the "clean" product tankers and partly the combined product/chemical tankers, which typically have coated tanks for transportation of less dangerous chemicals, the so-called "easy chemicals". For this type of vessels a much larger increase of average vessel size is expected than for the crude oil tankers. This increase is primarily due to a large increase in admission of medium-sized ("MR vessels") and large vessels ("LR1" and "LR2 vessels") on expense of the smaller vessels i.e. vessels under 35,000 DWT. This development is expected to continue, so that the average vessel size will increase from approx. 23,000 DWT in 2006 to approx. 33,000 DWT in 2020.

Today the traffic passing through the Danish Straits is operated by product tankers with an average size of approx. 26,000 DWT, and therefore bigger than the average of the global fleet. Thus a general shift toward large vessels and a reasonable smaller share or very small vessel of approx. 5,000 DWT/vessel is seen. The majority (58%) of the sail through tonnage falls within the group of 20-50,000 DWT, giving the opportunity for further increase of the average. A relatively large difference is seen between the average based on vessel and on passage. A certain increase in the average is therefore expected from the average today to approx. 33,000 DWT/vessel in 2020. This could relate to the serious growth in export of oil products from Russia.

The traffic through the Kiel Canal it is also expected to increase, from approx. 10,500 DWT today to approx. 12,500 DWT/vessel in 2020. The average per vessel and per passage are small compared to the estimated maximum for fully loaded vessels and compared to the global fleet. Similar levels of increase is assessed for the internal traffic in the Baltic Sea, which is also based on the relatively small number for average sizes compared to the global fleet and the other traffic.

Chemical tankers
The fleet of chemical tankers has through the last 10 years shown an annual increase in average vessel size of approx. 1.7%, though the increase in 1999-2000 and the last couple of years have been reasonably bigger up till 3%. The background for this is the increasing load size, increasing load volumes and the increasing distances. A proceeding change of older tonnage of up to 10,000

DWT/vessel to newer tonnage of approx. 15,000 DWT/vessel together with a large expansion in the size segment 30,000+ DWT/vessel -- the so-called parcel tankers. This development is expected to continue, thus the average size reaches approx. 18,000 DWT/vessel compared to approx. 14,500 DWT/vessel today.

The average size of the vessels in the north/south bound traffic is also expected to increase, though with a somewhat lower growth rate than expected for the global fleet. However, the biggest change in the composition of traffic could be a shift in the exploitation of bigger vessels, thus the average size per passage, which not necessarily will cause a higher average per vessel. A similar growth in vessel size is estimated for the traffic through the Kiel Canal, while a smaller annual growth of 0.5% is estimated for the internal traffic in the Baltic Sea.

LPG tankers
The development in average size of tankers carrying liquefied petroleum gas (LPG), has shown a uneven development. This is primarily caused by the very different weight of the extension of the very different size segments of the fleet. During the period 1995-2000, smaller size segments dominated, while during the last 5 years the focus has been on the larger segments. In the last couple of years, especially very large LPG vessels of over 60,000 cubic meters have been contracted in great numbers. This will result in a large increase in average size during the next couple of years. Thus, an increase in vessel size is expected from 16,500 DWT today to over 22,000 DWT/vessel in 2020.

This development is primarily caused by the ongoing large increase in the production of natural gas in the Middle East, designed for export in liquid form.

In the LPG tanker traffic passing through the Danish Straits an obvious shift toward smaller ships compared to the global fleet is seem, and presumably only very moderate increases in average sizes can be expected, although a possible large growth in refining crude oil and a possible production and discharging of liquid natural gas in and from Russia can increase the volumes of LPG considerably and thereby the basis for the use of the larger vessels. For additional routes an annual growth of the average vessel size of only 0.5% is expected, due to the expectation of primarily local distribution and a stabile traffic pattern.

LNG tankers
Historically and globally the average vessel size of LNG tankers has had an annual growth of approx. 1%. The growth rate has been increasing and is expected to continue for at least the next 5 years, due to the introduction of larger vessels needed for the above mentioned increase in export of liquefied natural gas (LNG) from the Middle East and the rest of the world. The vessel sizes was and still is within the interval 130-150,000 cubic metres, while larger vessels of approx. 215,000 and 265,000 cubic meter has been contracted the last few years. Further increase to 320,000 cubic metres in the future can be expected. based on the data regarding the present fleet and the vessels in order for delivery before 2010, the average vessel size is expected to increase with approx.

15-20% from approx. 67,000 DWT in 2006 to more than 79,000 DWT/vessel in 2010 and approx. 97,000 DWT/vessel in 2020.

Provided that discharging of LNG from Russia in the area around St. Petersburg will be possible in the future, the vessel size of approx. 73,000 DWT is expected unchanged. Traffic with smaller vessels with compressed natural gas (CNG) may also be expected due to the current planning in Norway.

Container ships
The fleet of container ships has drastically grown since the introduction of the container in the world trade during the 1960ies. A continuous strengthening of the growth is seen up through the 1990ies and into the 2000ies due to a strengthened globalisation and the industrial production and world trading - not least regarding the political and economical liberations in China. In the same period there has been a constant growth in the average vessel size, among other in relation to the introduction and vessels with a width larger than possible for passage of the Panama Canal, the so-called "post-panamax" vessels. In later years especially the size and the number of post-panamax container ships has drastically increased. In addition there is a very large number of this type of vessel in order for delivery during next 3-4 years. This corresponds to 72% measured in number and 85% measured in TEU. Since this drastic growth rate is expected to flatten after 2010, an increase in the average vessel size is expected to from 30,500 DWT/vessel today to more than 48,500 DWT/vessel in 2020.

The development of the average vessel relevant for the four main routes in the regarded area is hard two assess due to a series of special circumstances: The average vessel size of the traffic sailing via the Danish Straits is considerably larger than the global average, which is probably partly due to the smaller container ships -- the "feeder ships" -- distributing containers from the large receiving harbours to distribution and containers from the large receiving harbours for the over seas traffic to medium and small sized harbours, using the Kiel Canal and partly due to the weekly call of Gothenburg and Aarhus from Maersk Lines weighing heavily in the statistics.

At the same time, the expectation of a drastic increase of transport flow of containers to/from Russia, Poland and the Baltic countries will cause an increasing number of direct routes over seas to harbours in these countries, and thereby an increase of traffic with large container ships. In total the annual increase is estimated to approx 2% with an increasing tendency over the period, corresponding to the growth in vessel size from approx. 48,500 DWT/vessel today to more than 65,000 DWT/vessel in 2020.

For the traffic in the Kiel Canal a certain increase in average vessel size can be expected, due to the general increase in container traffic together with the larger vessels used for over seas traffic. Today the average size is approx. 9,500 DWT/vessel and there have been no registration of passages with vessels over 20,000 DWT. For the Danish and Swedish domestic traffic a moderate to low annual growth of 1% is expected.

Reefer ships
The development of the average vessels size regarding ships used for transportation of cooled or frozen products, as fruit, meat, fish and poultry, is slightly increasing. This increase is a result of the scrapping of small and medium-sized refrigerator ships, while the admission of new tonnage is almost non-existing. Even though the market for transportation of cooled and frozen products is increasing, the fleet of container ships is decreasing. This is because the normal container ships are taking more and more of the total market of transportation of refrigerator containers. Therefore a continuous small increase of vessel size is expected.

Ro-Ro cargo ships
Ro-Ro cargo ships only include Ro-Ro-vessels that do not bring passengers in large numbers (12 persons or above). This type of vessel is almost solely used on short distances, so-called "short sea shipping". The average vessel size for vessels in the global fleet is therefore only approx. 8,800 DWT. The same order of magnitude is valid for the four main routes. For the global fleet the annual average vessel size has increased by approx. 0.8% since 1995. An increase of the same magnitude is assumed for the coming 15 years. This is based on the observation of a general increasing need for transportation and a smooth use of larger vessels.

Car carriers
Transportation of cars at sea using car carriers has increased drastically over the last 10 years, especially for the routes overseas, e.g. from South Korea and Japan to the rest of the world and from Europe to North America. An equal drastic increase in the fleet due to new vessels is seen. The majority of these new vessels are large vessels, especially vessels from 20,000 DWT/vessel and up. The average size has from 1995-2005 annually increased by approx. 1.6% from 11,700 DWT to 13,700 DWT.

The increase of the need of transportation is expected to continue at a moderate level, thus it is very likely that the vessel size will follow and reach approx. 16,000 DWT/vessel in 2020.

While the average vessel size for the on the route via the Danish Straits is similar to the global fleet, the vessels in the Kiel Canal are considerably smaller. This can be due to the fact that the large car carriers need a larger air draft than what is possible on the Kiel Canal or that from a logistic point of view is unattractive. For the three first mentioned routes it is asses that the increase of average vessel size is equal to the increase assessed for the global fleet, while the annual increase for the vessels going through the Kiel Canal is assessed to be 0.5%.

General cargo ships
The fleet of general cargo ships is composed of a series of sub-types that cannot directly be identified; examples are semi-container ships, single deck ship under 10,000 DWT together with older general cargo ships. In addition there are the special heavy lifting vessels etc.

The average vessel size has an annual decrease of 1.5% primarily due to the destruction of older, smaller vessels without a similar replacement and the shift of transportation to container ships. The admission of new tonnage occurs primarily within the special vessels together with cargo ships up to approx. 10.000 DWT/vessel for the short sea shipping and transportation of low value cargo, primarily bulk cargo. This tendency is expected to continue without change within the relevant time horizon, due to the fact that there is a large fleet to take from.

The average vessel size of general cargo ships using the route via the Danish Straits is within the same size as for the global flees, which could indicate that these are a representative sample of the global fleet. For that reason the same tendency regarding average vessel size can be expected. For the remaining routes the vessel sizes are considerably smaller. Unchanged values are assessed for theses routes, since there cannot be argued for neither an increase nor a decrease.

Bulk ships
During the period from 1995-2005 the average vessel size of the bulk ships has increased from 47,250 to 55,750 DWT/vessel, representing an annual growth of 1.7%. The growth is a result of a large admission of medium large bulk ships, while at the same time the fleet of smaller bulk ships of up to 40,000 DWT/vessel is decreasing. Especially the admission of the so-called handymax vessels (40-60,000 DWT/vessel) and capsize vessels (80,000+ DWT/vessel) is high, while the admission of panama vessels (60-80,000 DWT/vessel) is more moderate. This development is expected to continue at a steady rate corresponding to an annual growth rate of approx. 1.5% until 2020. This will result in an additional increase of average vessel size to approx. 70,000 DWT/vessel.

The relative distribution of vessel sizes for the traffic using the Danish Straits corresponds well to the size distribution of the sailing fleet. With the exception of an underrepresentation of vessels above 100,000 DWT/vessel due to load draught restrictions, together with the transportation of Swedish ore between Narvik in Norway and Oxelösund in Sweden, where large vessels are dominating.

For these reasons together with e.g. the load draught restrictions, a smaller annual development of vessel size of 0.5-1%. This development is smaller than the one expected for the global fleet. For the remaining routes a 0% growth is assessed due to the stagnation of the markets or even the decreasing need of transportation.

Other commercial vessels
The fleet of "other commercial vessels" include a series of special vessels that do not fit into the other categories; cargo, passenger or off-shore vessels. Since 1995 the annual increase of average vessel size has been approx. 1%. It is assessed that this tendency will continue, though with decreasing growth rates. For the traffic in Danish waters a small annual increase of 0.5% is assessed.

Result overview

In the risk analysis the growth rates of the average vessel sizes per passage, shown in Table 3.2, is used. These rates are found as the weighted average of the average vessel sizes per traffic flow projected with the, in Table 3.2 shown, growth rates. The ship traffic given in number of passengers per traffic flow is used as weights.

Table 3-2 A prognosis for the growth of vessel sizes of vessels in the Danish waters distributed on vessel types.

Cargo group	Unit	Average size of vessels per passage in 2005	Average growth in vessel size Prognosis, % per year 2010-2020 %
Crude oil	DWT	102667	0.3
Oil products	DWT	13474	1.2
Chemicals	DWT	5345	0.7
LPG	DWT	7655	1.9
LNG	DWT	73705	0.0
Containers	DWT	21326	2.4
Reefer	DWT	7230	0.2
RO/RO	DWT	9282	0.7
Cars	DWT	11237	0.8
General cargo	DWT	4000	-0.4
Dry bulk	DWT	34339	0.5
Other commercial	DWT	2527	0.5

Sources: MSR-Consult and LR-Fairplay

4 Cargo transport

This chapter describes the prognosis of the future transport of cargo ships in the Baltic Sea.

More specifically the scope is to assess the future growth in the number of cargo ships passing through the Baltic Sea area until 2020.

Note that Sections 4.1 to 4.4 correspond to the prognosis made in the earlier Danish oil spill analysis (1), whereas Section 4.5 describes additional adjustments that are specific for BRISK.

4.1 Approach for analysis of cargo transport

The extrapolation of cargo transports in the Baltic Sea is based on the approach illustrated in the formalised figure below.

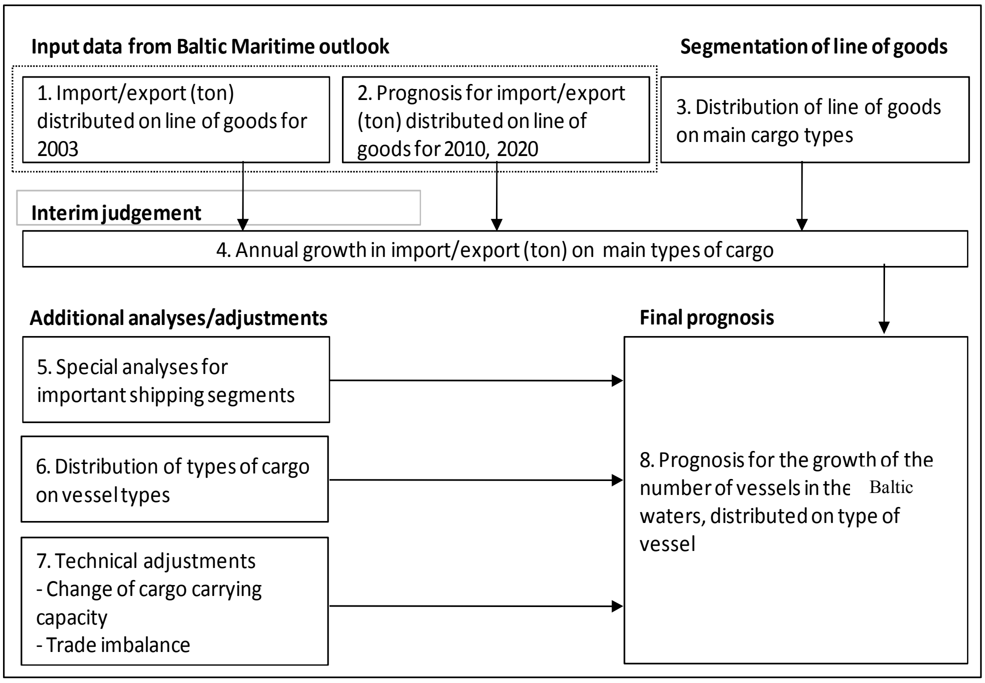

Figure 4-1 Approach applied to cargo transport

The figure shows that the analysis in principle consists of 8 elements, each of them described shortly in the figure. Items 1 to 4 are described at more detail in section 4.2, while items 5 to 8 are described in section 4.3. The latter section also includes a run-through of the prognosis for each vessel type.

The basic data of total import and export volumes distributed on the line of goods for the year 2003 (item 1) and a prognosis for the same for 2020 (item 2) is taken from the report *Baltic Maritime Outlook* from 2006. The report refers to results from a new and thorough analysis of the current and future trade flows in the Baltic Sea area.

Based on the above mentioned and an assessment of segmentation of the line of goods on cargo types (item 3), the annual growth in tons transported through Baltic waters distributed on main cargo type (item 4) is estimated.

These growth factors form the basis of the total extrapolation, but a series of additional analyses of the most important shipping segments (item 5) is performed. As mentioned earlier the focus is on oil transports, chemical transports, container traffic, bulk vessels, general cargo ships and LNG[1]. In addition a link between the main line of goods and vessel types is made (item 6).

Based on the above the future growth in the number of vessels passing through the Baltic area is estimated (item 8). The prognosis is developed for 2010, 2015 and 2020 for each type of vessel (main prognosis). In addition 2 alternative prognoses (high/low) is established, reflection the general uncertainty assess-

[1] And Ro-Ro, treated separately in section 5.

ment. The prognosis of the future growth is, in section 4.4, weighed against the historical development of transport in the Baltic waters.

4.2 Basic data and technical adjustments

The basic data which the analysis is based on is, as mentioned earlier, taken form the *Baltic Maritime Outlook (2006)* (BMO), which is a thorough analysis of the trade flows in the Baltic area.

The methodology used in BMO is briefly described in the text box below:

Baltic Maritime Outlook 2006
The scope of the analysis is to contribute with additional knowledge on the present and future maritime transport in the Baltic area, incl. trading to/from following countries: Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Sweden, Norway, Finland and Russia.

The analysis consists of both trading within the region and trading with countries outside the region. The analysis focuses on maritime tranport, but generally includes data for all forms of transport.

The analysis is based on trading statistics from national bureaus of statistics, Eurostat and FN. In case of discrepancies, information from the national bureaus of statistic is assessed to be most reliable.

The future transport is evaluated from a relative aggregated traffic model, calibrated from existing data from ports, national statistics etc. Prognoses for 2010 and 2020 have been prepared. The analysis results in, among others an estimation of the future growth in transport in and out of the Baltic area through the Kiel Canal and north of Jutland.

The analysis is prepared by *The Institute of Shipping Analysis, SAI (Gothenburg, Sweden), MBT Transport Solutions (Hamburg, Germany) and Centre for Maritime Studies, (Turku, Finland)*, for a range of national authorities (among these The Danish Maritime Authority) and the EU Commission.

4.2.1 Import/export distributed on line of goods

The following two tables present the estimates of the present and the future total (sea, road, train, and air) import and export distributed on the 19 lines of goods used by BMO[2]. Additionally is shown the total growth and annual growth for the periods 2003-2010 and 2010-2020, and also the corresponding numbers for the entire period of 2003-2010.

[2] The numbering from 1-20 in the tables refers to SITC goods. Please notice that SITC goods type 6 is not included

It is noted that the analysis below shows the extrapolations of BMO. Following certain adjustments are done as a result of the special analyses performed for chosen segment, e.g. Russian oil transport.

In addition it is worth mentioning that the table below covers both land and sea transport- Therefore it is investigated further; if transport by sea is assessed to increase faster and the general increase of trade flows.

Though, it is noted that transport by sea already constitutes the majority of the trade, at approx. 55%[3] of the intra-regional trade (constituting 24% of the total import/export) and 77%[4] of the trade between countries from the Baltic Sea region and countries outside the region (which corresponds to 76% of the total import/export). It is therefore assessed that the general numbers gives a realistic picture of the increase of sea traffic for the majority of lines of goods.

Table 4-1 Import to countries within the Baltic Sea region in 2010 and 2020. Shown by line of good (mil. ton)

Commodity Group		Imports			2010-2020	
		M tonnes **2003**	M tonnes **2010**	M tonnes **2020**	Growth	Yearly growth
1	Non ferrous ore, scrap	4.24	5.09	6.70	31.6%	2.8%
2	Iron, steel	51.80	57.84	70.56	22.0%	2.0%
3	Non ferrous metal	8.29	9.79	12.60	28.7%	2.6%
4	Food and beverages	40.25	46.65	60.42	29.5%	2.6%
5	Fresh fruit and vegetables	15.54	16.88	19.80	17.3%	1.6%
7	Chemicals	64.57	77.22	99.85	29.3%	2.6%
8	Vehicles and parts	16.74	21.80	31.75	45.6%	3.8%
9	Machinery, electronic goods, electronic equipment	24.38	30.18	41.43	37.3%	3.2%
10	Leather and textile goods	10.61	12.31	15.61	26.8%	2.4%
11	Other manufactured goods	56.64	68.32	91.61	33.2%	2.9%
12	Pulp and waste paper	9.35	11.05	14.08	27.4%	2.5%
13	Wood	39.80	47.54	61.54	29.4%	2.6%
14	Grain and animal feed	25.88	30.17	38.16	26.5%	2.4%
15	Coal	39.68	48.00	66.94	39.5%	3.4%
16	Crude oil and oil products	223.58	245.78	289.80	17.9%	1.7%
17	Iron ore	19.90	19.48	18.94	-2.8%	-0.3%
18	Copper ore and bauxite	2.68	3.11	4.21	35.4%	3.1%
19	Building materials	75.98	78.51	89.89	14.5%	1.4%
20	Fertilizer	14.14	14.50	15.82	9.1%	0.9%
	Total	**744.05**	**844.22**	**1049.11**	**24.3%**	**2.2%**

[3] 178.078 ton (BMO, page 43) vs. 327.464 ton (BMO, page 30)

[4] 156.842 ton + 395.774 ton (both BMO, page 43) vs. 1.043.600 (BMO, page 32) -327.464 (BMO, page 30).

Table 4-2 Export from countries in the Baltic Sea region 2010 and 2020. Shown by line of goods (mil. ton)

Commodity Group		Exports			2010-2020	
		M tonnes **2003**	M tonnes **2010**	M tonnes **2020**	Growth	Yearly growth
1	Non ferrous ore, scrap	2.95	3.04	3.51	15.5%	1.4%
2	Iron, steel	70.21	80.66	101.17	25.4%	2.3%
3	Non ferrous metal	8.90	10.44	13.31	27.5%	2.5%
4	Food and beverages	43.69	49.50	63.32	27.9%	2.5%
5	Fresh fruit and vegetables	4.90	6.27	8.77	39.9%	3.4%
7	Chemicals	61.95	75.62	101.34	34.0%	3.0%
8	Vehicles and parts	20.82	26.64	37.75	41.7%	3.5%
9	Machinery, electronic goods, electronic equipment	25.90	32.16	43.24	34.5%	3.0%
10	Leather and textile goods	7.26	8.24	10.14	23.1%	2.1%
11	Other manufactured goods	100.04	118.68	150.68	27.0%	2.4%
12	Pulp and waste paper	17.53	19.91	24.17	21.4%	2.0%
13	Wood	68.54	79.74	101.69	27.5%	2.5%
14	Grain and animal feed	27.31	30.80	38.23	24.1%	2.2%
15	Coal	62.85	76.99	107.97	40.2%	3.4%
16	Crude oil and oil products	258.11	324.82	456.75	40.6%	3.5%
17	Iron ore	29.85	30.73	32.89	7.0%	0.7%
18	Copper ore and bauxite	0.44	0.53	0.77	45.3%	3.8%
19	Building materials	80.56	84.99	95.74	12.6%	1.2%
20	Fertilizer	18.42	21.19	27.22	28.5%	2.5%
	Total	**910.23**	**1080.95**	**1418.66**	**31.2%**	**2.8%**

Source: Baltic Maritime Outlook (2006), Annex A

From the tables it is seen that the import from the whole period is assessed to increase by 2.2% p.a., while the export is expected to increase by 2.8% p.a.

Crude oil and oil products (*no. 16*) are the most important line of goods. They constitute approx. 28% of the total import (in ton) and 30% of the export.

Building materials (19), iron and steel (1-3), chemicals (7), wood (13) and manufactured goods (8-11) are also important trading goods.

The composition of the trade in the Baltic Sea region will change in the following years, as the growth rates of the different lines of goods will differ. The trade with all types of goods, except the export of iron ore, is expected to increase in the future.

4.2.2 Link between line of goods and main cargo types

For every line of goods the shares that can be categorized as *dry bulk, liquid bulk* or *other* is assessed.

The categories are used to extrapolate the development for the type of vessels assessed to be of less importance in relevance to the risk of pollution in the Baltic Sea (after the adjustment of the increasing share of cargo volumes transported by sea and the adjustment for transportations through Baltic Sea to/from increasing faster than the general increase of cargo volumes see below).

It is noted that *chemicals* are not accounted for here due to 'compliance' between the line of goods (chemicals) and vessel type (Tanker, chemicals).

Similarly, *vehicles and parts* are not included, due to compliance with the vessel type *car carriers*.

Table 4-3 Distribution of lines of goods on main cargo types

Category	Dry bulk	Liquid bulk	Other
1. Non ferrous ore, scrap	100%	0	0
2. Iron, steel	100%	0	0
3. Non ferrous metal	100%	0	0
4. Food and beverages	50%	0	50%
5. Fresh fruit and vegetables	0	0	100%
7. Chemicals[1]	-	-	-
8. Vehicles and parts[2]	-	-	-
9. Machinery, electronic goods, electrical equipment	0	0	100%
10. Leather and textile goods	0	0	100%
11. Other manufactured goods	0	0	100%
12. Pulp and waste paper	100%	0	0
13. Wood	100%	0	0
14. Grain and animal feed	100%	0	0
15. Coal	100%	0	0
16. Crude oil and oil products	0	100%	0
17. Iron ore	100%	0	0
18. Copper ore and bauxit	100%	0	0
19. Building materials	0	0	100%
20. Fertilizer	100%	0	0

[1] Is not accounted for here, due to compliance between line of goods (chemicals) and vessel type (tanker, chemicals). The prognosis for the future growth of volume is therefore not used as a direct expression for the increase in transport of chemical tankers. [2] As 1, just regarding *vehicles and parts* and car carriers.

As mentioned, two adjustments are made before the data above is used to extrapolate the growth in cargo carried by ships with less importance for the risk of oil and chemical spills in the Baltic Sea:

- A general assessment of how much the share of sea transport will increase in the future compared to the total trade. This is done based on numbers from BMO showing an increase in sea transport by 18 percentage points more than the land transport until 2020.

- An adjustment adjusting that BMO finds that transports to/from the Baltic Sea region via the Danish Straits will grow faster than the general increase of cargo volumes. BMO estimates that the cargo volumes transported through the Danish Straits will increase by 13 percentage-points more than the total trade flows in the Baltic Sea until 2020.

The resulting assessment for the volume-increase is presented in the table below.

Table 4-4 Basic assessment of increase of volume distributed on type of cargo

	Exports			Imports		
Period	Dry bulk	Liquid bulk	Other	Dry bulk	Liquid bulk	Other
2010-2020	2.5%	3.5%	1.4%	2.3%	1.7%	2.3%

4.2.3 Technical adjustments

The preparation of the prognosis for ship traffic through the Baltic Sea is adjusted for:

1. Vessels are generally getting bigger, increasing the average cargo-carrying capacity

2. Trade imbalance

The approach is briefly described below.

1. Change of cargo-carrying capacity

At first the number of vessels sailing through the Baltic Sea will not increase at the same rate as the increase of cargo volumes, due to the increase of vessel sizes.

As described in section 3, the cargo-carrying capacity for most new vessel types is expected to increase 0.5%-2.0% p.a., which moderates the increase of the number of vessels passing through Baltic Sea.

In the final estimation of the increase of number of vessels through the Baltic Sea, the estimations on average cargo-carriage capacity from section 3 has been taken into account.

2. Trade imbalances

It is difficult to determine whether the increase of sea transport is determined by the increase of the rate of import or export. It depends on the volume of the import and export.

For example, if more cargo is transported to Aarhus Port, than transported out of the port, an increase of the export rate will not immediately result in an increase of ships going to Aarhus, due to the excess capacity on the ships when leaving the port. An increase of the import rate will, on the contrary, immediately affect the ship traffic. Therefore the increase in ship traffic will often be determined by "the dominating" trade flows.

4.3 Prognosis for each type of vessel

In this section the prognosis for each type of vessel is treated. As mentioned, the focus of the prognoses has been on the type of vessels considered to have the greatest influence on the risk of oil and chemical spills in the Baltic Sea.

Oil transports (section 4.3.1) are treated first, where after the prognosis of the other vessel types are treated (section 4.3.2).

4.3.1 Oil and chemical transport

The future traffic of oil products through Baltic Sea are to a great extent determined by the development of the Russian oil export. This type of transportation is therefore treated separately. The analysis is presented below.

Subsequently is the prognosis for the number of ship passages through Baltic Sea for the following vessel types presented: "Bulk/oil", "Tanker, Chemical/Product", "Tanker, LPG", "Tanker, Product", "Tanker, Crude oil".

Russian oil export

BMO estimates that the export of oil products from the Baltic Sea region will increase by 3.5% p.a. from 2010-2020. However it is problematic to use these figures as an estimate for the increase of the west-bound oil transports through Baltic Sea, as the figures for oil export also include export of oil through pipelines and export of oil from Norway.

For this reason export of oil from Russia through the Baltic Sea is treated separately to obtain a more accurate estimate.

The oil production in Russia and the other former Soviet Union countries constituted in 2005 approx. 11.7 mill. barrels per day (mb/d), equivalent to approx 585 mill. tonnes per year, where as the consumption only constituted 3.8 mb/d or approx. 190 tons per year. Thereby giving an export surplus of approx. 395 mil. tonnes.

Figure 4-2 shows the development of consumption, production and export surplus since 1985. Before the fall of the Berlin wall the export surplus was approx. 3-3.5 mb/d. After a drop to less than 2 mb/d in 1992, the export surplus has had a constant increase due to the increasing production and a falling/stagnant consumption.

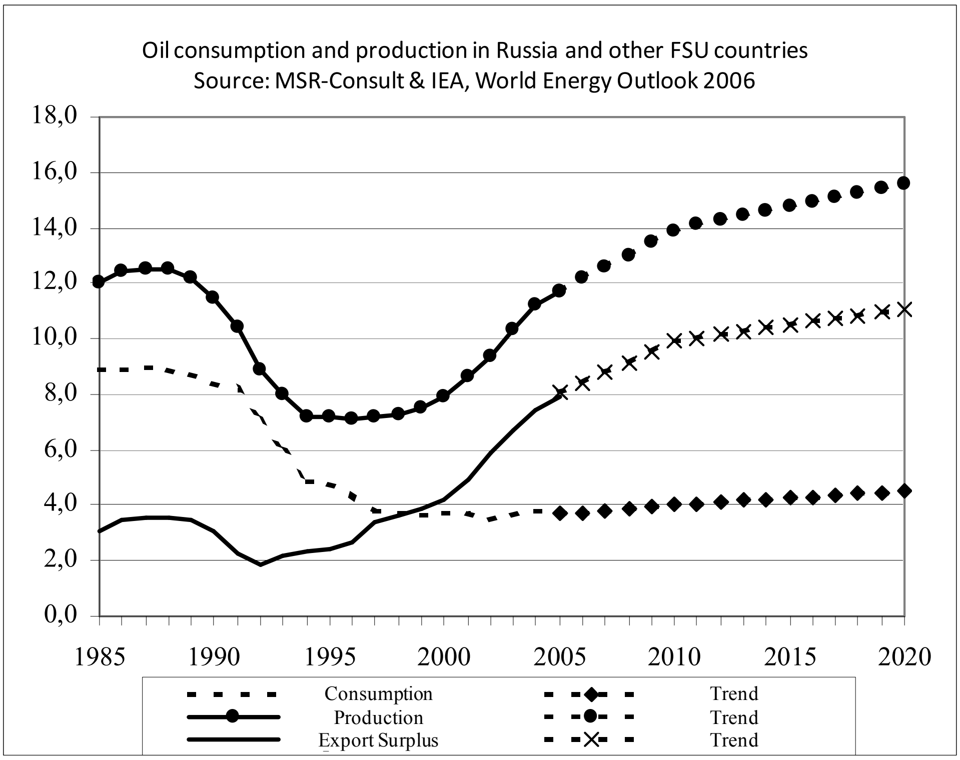

Figure 4-2 Oil consumption and production in Russia and other Baltic Sea countries

On a short-term basis, a continuous increase in oil production is expected, while on long term it is expected to decrease, such that the production reaches a level of approx. 15.5 mb/d in 2020 in relation to IEAs prognosis[5] in year 2006. In the period 2010 until 2020 the IEA expects the increase with rate of 1.1% p.a. The increase is seen as a consequence of growing living standards, a growing fleet of cars and growing needs of transportation. This results in a growth rate of the export surplus of approx. 1% p.a. until 2020. In absolute figures the export surplus will in 2020 constitute 555 mill. tonnes.

In IEA's prognosis report a second alternative scenario is used, which is based on a large increase in energy efficiency and smaller increase in the use of fossil fuels. This scenario will, presumably have a very limited influence on the Russian export surplus, corresponding to a maximum increase of 10 mil. tons or 565 mill. tons in 2020.

Approx. a third of Russian oil export (approx. 125-130 mil. tons) were in 2006 estimated to have been discharged as crude oil or oil products from Baltic Sea ports, where Primorsk today is by far the largest. The remaining export runs through pipeline together with discharging ports in the Black Sea, Barents Sea and the Pacific Ocean. If the share of export surplus can be assumed constant, the export from Baltic Sea ports will increase to approx. 180 mil tons in 2020.

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[5] IEA - World Energy Outlook 2006

The above confirms that the BMO's general export figures are not appropriate for the west-bound oil transports via the Baltic Sea (see also the table below).

Table 4-5 Comparison of growth forecast for oil transport

Year	Export surplus (mb/d)	Own estimate of growth in oil transport through Baltic Sea	BMO estimate of overall growth in oil exports (including pipeline and Norwegian exports.
2010-2020	9.9 to 11.1	1.2% p.a.	3.5%

In the risk analysis is therefore used an estimated of the annual increase of 1.2% for west-bound oil transports via the Baltic Sea up until 2020.

The extrapolation is associated with some uncertainties, partly due to the general development of the oil export from Russia and partly due to the distribution of forms of transportation. Regarding the latter, it seems relevant to look at a possible replacement of transport of up to 60-65 mill. tonnes of oil per year from the pipeline "Druzhba", running through Belarus and branch off in Europe to, among others, Germany (Leipzig and Rostock) and Hungary (Lloyd's list 14 February 2007 and IEA Oil Market Report 18 January 2007). The possibility could arise due to political discrepancies between Russia and Belarus concerning the conditions for the passage of Belarus. The 60-65 mill. tonnes of oil per year corresponds to approx. half of the current oil export from Russia through the Baltic Sea. This information from (1) has not been updated.

Bulk/oil

Transports with "Bulk/Oil"-vessels constitute 0.1% of the ship traffic in the Baltic Sea.

"Bulk/Oil"-vessels transport, as shown in the table below, both oil products and "other cargo" (bulk cargo). When the vessels enters the Baltic Sea they are typically loaded with other cargo, while they are typically are loaded with oil products when leaving the Baltic Sea.

As mentioned earlier, it is difficult to determine whether the increase of sea transportation is determined by growth rate of the import or export. It depends on the volumes of the import and export. The table below therefore includes information on the volume of both import and export.

Here it is assumed that the increase of ship traffic is determined by the "dominating" trade flow[6]. In this regard, it is export.

[6] In the circumstance that no information regarding possible trade imbalances, an average of the import and export growth rate is used.

Table 4-6 Goods transported in/out of the Baltic Sea with bulk/oil ships

	Percentage of cargo				Freight Volume
	Chemical	Oil product	Others	Total	(1,000 ton)
Import	0.0%	27.6%	72.4%	100.0%	635
Export	0.0%	87.0%	13.0%	100.0%	5,097

Source: SHIPPOS, data for 113 days

The annual increase in export of bulk goods is assessed, based on the BMO figures, to 2.5% from 2010-2020 (see Table 4-6).

The export of oil products is assumed to be determined from the increase of Russian oil export (see above).

If the vessels sizes are unchanged, the number of "Bulk/Oil" vessels in the Baltic Sea should annually increase by 1.4% in 2010-2020 (weighted average of the export growth rate for bulk and oil products[7].)

If adjusting for the assumption that the vessels are getting 0.3% larger each year up till 2020 (see Table 3.2 "crude oil"), the estimation of growth of passages by "Bulk/Oil" vessels through the Baltic Sea is found (1.1% = (1+0.014)/(1+0.003)-1).

The average annual growth for Bulk/oil ships in number of ship passages is estimated as 1.1% for 2010-2020.

Tanker, Chemical/Products
This vessel type constitutes for approx 9.2% of the traffic in the Baltic Sea. It transport, as shown in the table below, mostly oil products but also small volumes of chemicals. Also for this type of vessel the export is dominating.

Table 4-7 Goods transported in/out of the Baltic Sea with chemical/product tankers

	Percentage of cargo				Freight Volume
	Chemical	Oil product	Others	Total	(1,000 ton)
Import	7.7%	92.3%	0.0%	100.0%	13,841
Export	6.6%	93.4%	0.0%	100.0%	69,241

The annual export growth rate of chemicals is assessed, based on BMO figures, to 3% for 2010-2020 (see Table 4.2).

[7] Based on the %-distribution of the export in Table 4-6 and the growth estimation of the oil export presented in Table 4-5 and the estimation for "dry bulk" in Table 4-4

The export of oil products is assumed to be determined from the increase of Russian oil export.

Using an unchanged vessel size, this results in an increase, of "Tanker, Chemical/Products" vessels in the Baltic Sea, of 1.3% p.a. in 2010-2020.

If adjusting for the assumption that the vessels are getting bigger (see Table 3.2 "oil products"), the estimation of growth of passages by this type of vessels through Baltic Sea is found.

The average annual growth for chemical/product tanker in number of ship passages is estimated as 0.1% for 2010-2020 in the Baltic Sea.

Tanker, LPG

LPG-tankers constitute approximately 0.8% of the ship traffic in the Baltic Sea.

This type of vessel mainly transports, as shown in the table below, gas products when entering the Baltic Sea, and mainly chemicals when leaving.

In contrast to the situation of most other types of vessel, this type carries more cargo when entering the region than when leaving. It is therefore assumed that the increase of import is determining for the growth of passages for this type of vessel.

Table 4-8 Goods transported in/out of the Baltic Sea with LPG tankers

	Percentage of cargo			Freight Volume
	Chemical	Oil product	Total	(1,000 ton)
Import	99.2%	0.8%	100,0%	2,814
Export	14.0%	86.0%	100,0%	1,919

The annual import growth rate of gas products is assessed based on BMO figures to 1.7% for 2010-2020, due to the assumption that the growth follows the volumes of the main cargo group "liquid bulk" (see Table 4.4).

Similarly, the import growth rate of chemicals is determined based on BMO figures to 2.6% p.a. for the entire period.

Adjusting for the assumption, that the vessels are getting bigger (see table 3.2 "LPG") the growth of number of passages by "Tanker, LPG" in the Baltic Sea is found.

The average annual growth for “Tanker, LPG) in number of ship passages is estimated as -0.2% for 2010-2020 in the Baltic Sea.

Tanker, Product
This type of vessels constitutes approx 2.8% if the ship traffic in the Baltic Sea. They mainly transport, as seen in the table below, oil products but also smaller volumes of chemicals out of the Baltic Sea.

Also for "Tanker, Product" vessels the export is dominating.

Table 4-9 Goods transported in/out of the Baltic Sea with product tankers

	Percentage of cargo				Freight Volume
	Chemical	Oil product	Others	Total	(1,000 ton)
Import	0.0%	100.0%	0.0%	100.0%	3,951
Export	5.3%	94.7%	0.0%	100.0%	17,889

Source: SHIPPOS, data for 113 days, see (COWI 05 2007)

Using an unchanged vessel size, this results in an increase of "Tanker, Product" vessels in the Baltic Sea of 1.3% p.a. in 2010-2020 (based on the above mentioned growth rates for chemical and oil products).

If adjusting for the assumption that the vessels are getting bigger (cf. Table 3.2 "oil products"), the estimation of growth of passages by this type of vessels through the Baltic Sea is found.

The average annual growth for “Tanker, Product” in number of ship passages is estimated as 0.1% for 2010-2020 in the Baltic Sea.

Tanker, Crude oil
This type of vessel constitutes 2.9% of the ship traffic in the Baltic Sea, but due to nature of the load it has a big influence on the risk of oil and chemical spills in the Baltic Sea.

These vessels transport almost only oil (either crude or product). Although marginal volumes of chemicals are carries out of the Baltic Sea.

Also for "Tanker, Crude oil" vessels the export is dominating.

Table 4-10 Goods transported in/out of the Baltic Sea with crude oil tankers

	Percentage of cargo				Freight Volume
	Chemical	Oil product	Others	Total	(1,000 ton)
Import	0.0%	100.0%	0.0%	100.0%	9,040
Export	0.2%	99.8%	0.0%	100.0%	86,405

Source: SHIPPOS, data for 113 days, see (COWI 05 2007)

Using an unchanged vessel size, this results in an increase of "Tanker, Crude oil" vessels in the Baltic Sea of 1.2% p.a. for 2010-2020 (based on the above mentioned growth rates for chemical and oil products).

If adjusting for the assumption that the vessels are getting bigger (see Table 3.2 "crude oil"), the estimation of growth of passages by this type of vessels through Baltic waters is found to 0.9% p.a. in year 2020.

However, it is expected that some of the oil that is exported via ports in the Baltic countries today will be exported via the port of Ust-Luga in the near future, causing a significant increase of oil tanker traffic in the Gulf of Finland. This development is discussed in section 4.5.

Tanker, Chemicals and Tanker, Other
Vessels categorized as this (hereafter Tanker, Chemicals) carry both chemicals, oil products and other goods (see table below)

As for most other vessel types, the export is also dominating for this type of vessel, constituting 1.7% of the ship traffic in the Baltic Sea.

Table 4-11 Goods transported in/out of the Baltic Sea with chemical tankers

	Percentage of cargo				Freight Volume
	Chemical	Oil product	Others	Total	(1,000 ton)
Import	53.6%	46.4%	0.0%	100.0%	2,737
Export	51.9%	35.1%	13.0%	100.0%	3,988

Source: SHIPPOS, data for 113 days, see (COWI 05 2007)

Using an unchanged vessel size, this results in an increase of "Tanker, chemicals" vessels in the Baltic Sea of 2.3% p.a. in 2010-2020 (based on the above mentioned growth rates for chemicals, oil products and other goods).

If adjusting for the assumption that the vessels are getting bigger (see Table 3.2 "chemicals"), the estimation of growth of passages by this type of vessels through Baltic waters are found to 1.6% p.a. in 2010-2020.

4.3.2 Other transports

In this section the prognoses for vessels not categorized as oil and chemical transports are presented.

Car carriers
These vessels constitute 1.6% of the passage through Baltic Sea.

Based on the figures in *Baltic Maritime Outlook 2006*(2) an annual increase of car carriers of approx. 3.5-3.8% is estimated.

The prognosis for the future growth of car carriers is based on the average of the estimation of the import and export growth, due to the insufficient amount of detailed information available regarding trade imbalances. In reality this does not have a great influence, since the estimations of the growth of both import and export is almost identical.

Using an unchanged vessel size, will result in an increase of car carriers of 3.7% p.a. for 2010-2020.

If adjusting for the assumption that the vessels are getting bigger (see. section 3), the estimation of growth of passages by this type of vessels through the Baltic Sea is found to 2.9% p.a. for 2010-2020.

Bulk

Bulk vessels constitute 6% of the passages through Baltic Sea Region. As seen from the table below, they mainly transport "other products", but they also transport chemicals, especially out of the Baltic Sea.

Table 4-12 Goods transported in/out of the Baltic Sea with bulk carrier

	Percentage of cargo				Freight Volume
	Chemical	Oil product	Others	Total	(1,000 ton)
Import	10.6%	0.0%	89.4%	100.0%	26,038
Export	21.4%	0.0%	78.6%	100.0%	80,014

Source: SHIPPOS, data for 113 days, see (COWI 05 2007)

Using an unchanged vessel size, will result in an increase of bulk vessels in the Baltic Sea of 2.6% p.a. in 2010-2020 (based on the above mentioned growth rates for chemicals and other goods).

If adjusting for the assumption that the vessels are getting bigger (see Table 3.2 "dry cargo"), the estimation of growth of passages by this type of vessels through Baltic Sea is found to 2.1% p.a. for 2010-2020.

Container and refrigerator vessels

Container ships constitute approx 8.4% of all passages through Baltic Sea, while refrigerator vessels only constitute less than 3%.

Based on the figures in *Baltic Maritime Outlook 2006* an annual increase of container ships of approx. 4% is estimated. This is a larger increase than for the remaining vessel types, which means that it can be expected that container ships in the future will constitute an increasing share of the passages in the Baltic Sea.

However, a series of conditions are indicating that the container traffic in the Baltic Sea will increase even faster in the future, than what the figures from BMO indicate.

The table below shows estimations of the annual global growth in the demand for container, refrigerator and Ro-Ro vessels, including low/high estimations.

These figures indicate that the basic figures are underestimating the growth in transports with container ships, while the growth for refrigerator vessels is underestimated.

Table 4-13 Annual growth in world tonnage demand

Ship type	Central estimates	Low/high estimates
Container	6.6%	5.6%/ 7.6%
Reefer ships	-1.6%	-2.1/ -0.6%
Ro-Ro	2.6%	1.6%/ 3.6%

Source: MSR-Consult

The market for transportation of cooled goods is generally increasing on a global level and in the Baltic Sea Region. See among others, the estimated growth in trade within the Baltic Sea region of "food and beverages" and "fresh fruit and vegetables" (see table 4.1 and table 4.2). In spite of this, the transport using refrigerator vessels are decreasing, as these goods increasingly are carried by container ships with refrigerator containers.

This is adjusted for in the analysis. It is assessed that the demand for refrigerator vessels in the Baltic Sea region is similar to the global decreasing tendency (-1.6% p.a.) and for that reason that container ships will win market shares in this area.

The growth estimation for container ships is therefore increased by 0.2% point p.a. based on the assessment that the size of the cooling market in relation to the transportation of other container cargo.

The prognosis for the future growth of container ships and refrigerator vessels is based on the average of the estimation of the import and export growth, due to the insufficient amount of detailed information available regarding trade imbalances. In reality this does not have a great influence, since the estimations of the growth of both import and export is almost identical.

Using an unchanged vessel size will result in an increase of container ships in the Baltic Sea of 3.9% p.a. in 2010-2020. Correspondingly the number of refrigerator vessels will decrease with 1.6% p.a., as mentioned above.

If adjusting for the assumption that the vessels are getting bigger (see section 3), the estimation of growth of passages by this type of vessels through the Baltic Sea is found to be 1.5% p.a. for container vessels and -1.8% p.a. for refrigerator vessels in year 2010-2020.

Ro-Ro
These vessels constitute 7-8% of all passages in the Baltic Sea.

The prognosis for Ro-Ro vessels is based on the prognosis from BMO. It indicates that the volume of Ro-Ro transports entering the Baltic Sea will increase by 2.3% p.a. in 2010-2020.

The prognosis for the future growth of Ro-Ro vessels is based on the average of the estimation of the import and export growth, due to the insufficient amount of detailed information available regarding trade imbalances.

Using an unchanged vessel size, will result in an increase of Ro-Ro vessels in the Baltic Sea of 1.8% p.a. for 2010-2020.

If adjusting for the assumption that the vessels are getting bigger (see section 3), the estimation of growth of passages by this type of vessels through the Baltic Sea is found to be 1.1% p.a. for 2010-2020.

Tanker, Foods
These vessels constitute a very small share (0.2%) of the passages through the Baltic Sea.

Based on the figures from BMO and the estimations on the future growth of the size of chemical tankers (see Table 3.2), the estimation of the growth of passages with food tankers is found to be 1.1% p.a. for 2010-2020.

Tanker, LNG (Liquefied Natural Gas)
There are no shipping and docking facilities for LNG tankers in the Baltic Sea today.

Russian Gazprom and PetroCanada had considered building a facility for production of LNG with a capacity of 5 mil. tons per year. The facility was to be supplied with natural gas transported in pipelines[8]. A memorandum of understanding was signed in 2004 with the purpose of opening in 2009. The facility is to be located at Primorsk, from where a fleet of 5 LNG tankers are to carry the LNG to Quebec.

In 2006, Gazprom and Petro-Canada agreed to proceed with initial engineering design of the Baltic LNG project, but the project was dropped by Gazprom in February 2008 when it decided that it was less attractive than the Nord Stream pipeline and a dedicated Shtokman LNG plant on the Kola Peninsula. Concerns over icing in the Baltic Sea and congestion in the Gulf of Finland and the Danish Straits contributed to the decision to drop the project (3). This information has been updated for the present study.

General cargo vessels
These vessels constitute a large share (35%) of the total number of passages in the Baltic Sea, but it is typically done from very small vessels. In average, the vessels on the route via the Danish Straits are only approx. 4,500 DWT[9], while

[8] Source: www.gazprom.ru/eng
[9] DWT/passage, see section 3

e.g. container ships are in average 30,500 DWT. If adjusting for size difference, then the general cargo vessels will play a less significant part than the share of passages indicates. In relation to the risk analysis, the general cargo vessels are not of same importance as e.g. oil tankers, container ships and bulk vessels.

General cargo ships are a relatively inhomogeneous size, covering among others single-deck vessels under 10,000 DWT and older general cargo vessels, but also special vessels carrying heavy loads.

As increased use of containers it is observed that older and smaller general cargo vessels are scrapped, while there is an increase in the segment following the admission of special vessels and freight vessels up to 10,000 DWT for short sea shipping.

It is assessed that the volume of general cargo transported in through the Baltic Sea is increasing by 0.5% p.a. for 2010-2020.

If adjusting for the assumption that the vessels are getting smaller (see section 3), the estimation of growth of passages by this type of vessels through the Baltic Sea is found to be 0.9% p.a. for 2010-2020.

4.4 Summary of the prognosis for cargo transport in the Baltic Sea

Based on the above the size of the annual growth in percentage in number of (still bigger) vessels passing through Baltic Sea region distributed on vessel type is estimated. The result is rendered in table below.

Table 4-14 Forecast for shipping (annual growth in number of Ship passages)

	2010-2020
Car carrier	2.9%
Bulk	2.1%
Bulk/Oil	1.1%
Container	1.5%
Refrigerated and freezer ships	-1.8%
RO-RO	1.1%
General cargo	0.9%
Tanker, Food	1.1%
Tanker, Chemical/Product	0.1%
Tanker, Chemical	1.6%
Tanker, LNG	0.0%
Tanker, LPG	-0.2%
Tanker, Others	1.6%
Tanker, Product	0.1%
Tanker, Crude Oil	0.9%
Weighted Average	**0.9%**

From the table above it is seen that the growth for oil and chemical carriers is at level with the other segments, except for product tankers. In total it is anticipated that the traffic will grow by 0.9% p.a. for 2010-2020.

4.5 Current situation

The above analysis is based upon the oil spill study in Danish waters carried out in year 2006. It is necessary to analyse current situation, e.g. credit crunch and the development of new ports in Russia, before the implementation of these results.

Russia has been one of the fastest growing economies in the world. This economic growth has been supported by the high world market prices of oil and gas. The annual volume of Russian exports has more than quadrupled from 105 billion dollars to 472 billion dollars in the period 2000–2008. The value of Russian imports has grown by 6.5 times from 45 billion dollars to 292 billion dollars in 2002–2008. The economic recession that started in autumn 2008 and still continues has had an impact on the economic development of Russia. The export income has decreased, mainly due to the reduced world market prices of energy products (oil and gas) and raw minerals. The economic crisis is reflected in the Finnish transit traffic. The volume of goods transported through Finland to and from Russia decreases almost in the same proportion as the imports of goods to Russia (4).

Russia aims to redirect as much of the country's foreign trade traffic as possible to its own ports. The ports of Russia and the associated infrastructure are under continuous development such as the port of Ust-Luga and Vyborg. The Ministry of Transport of the Russian Federation has agreed to a plan with the management of the port, under which the capacity of the port of Ust-Luga is due to grow to 120 million tons by the year 2015. The targeted share of oil products will be 36 million tons, that of cargo in containers 34 million tons, bulk goods about 13 million tons, forest products 3 million tons and Ro-Ro cargo about 3 million tons. It is obvious that with the development of Russian ports in the Baltic Sea region, transit traffic through the ports of Finland will decrease in proportion to the total imports of Russia, but the Finnish ports will maintain their significant role as a gateway to the Russian market. The volumes of the ports in the Northwest of Russia have increased remarkably, and the ports of Ukraine, Latvia, Lithuania and Estonia have lost out in their transit volumes.

The transport strategies of the Russian Federation aim at increasing the share of the country's own ports in foreign trade transports from 75% in 2003 to 90–95% by 2020.

In the same report (4), it is analyzed based upon statistics that the forecast figures of the economy in 2012 do not reach the maximum figures of the year 2008 even with the remarkable growth of raw oil market price.

Based upon the above discussion, it can be concluded that;

1 Due to the development of new ports in Russia, there will be a shift of trade from other Baltic Sea ports to Russian ports. The average growth rate p.a. in the Baltic Sea region will not be affected and thus remain the same as in Table 4-14 (compare Section 5.2.4).

2 Due to the economic recession, it is assumed that the growth rate p.a. in the Baltic Sea region will be the same in 2012 as in 2008. Thus, 0% growth rate is assumed for the period 2010-2012. After that it will be the same as indicated in Table 4-14.

The final growth p.a. for 2012-2020 is shown in the below table.

Table 4-15 Adjusted forecast for shipping (annual growth in number of Ship passages)

	2012-2020
Car carrier	2.9%
Bulk	2.1%
Bulk/Oil	1.1%
Container	1.5%
Refrigerated and freezer ships	-1.8%
RO-RO	1.1%
General cargo	0.9%
Tanker, Food	1.1%
Tanker, Chemical/Product	0.1%
Tanker, Chemical	1.6%
Tanker, LNG	0.0%
Tanker, LPG	-0.2%
Tanker, Others	1.6%
Tanker, Product	0.1%
Tanker, Crude Oil	0.9%
Weighted Average	**0.9%**

4.6 Uncertainties

There is a considerable uncertainty on the prognoses for the future cargo transport through Baltic Sea region. Some of the essential sources for the uncertainties are considered to be:

- The economical development
- The Russian oil export (including the political priorities and the domestic demand for oil). See discussion in section 3.2.

5 Implementation

5.1 Introduction

This chapter describes how the figures for cargo ship traffic in 2020 are implemented in the BRISK traffic model.

Separate descriptions have been given for cargo traffic and other merchant traffic.

5.2 Cargo traffic

5.2.1 Introduction

In the prognosis report, the changes of the total ship traffic in and out of the Baltic Sea for year 2020 described for relevant vessel types. For each type of vessel is given:

- The annual increase on number of vessels in % for the period 2012-2020 (the figures can be negative representing a decrease). These figures are provided in Table 4-14.
- The annual increase in the average vessel size measured in DWT in % in the period 2012-2020. These figures are provided in Table 3-2.

The increase is the same for traffic into the Baltic Sea as for traffic out of the Baltic Sea, due to the need of balance. The estimated growth rates are used for all routes in the Baltic Sea.

Different methods are used for vessels with cargo in bulk and vessels with general cargo:

- Vessels with cargo in bulk:
  Extrapolation is made in accordance with the dominating traffic flow (i.e. the direction in which few vessels are in ballast). For most vessel types the dominating traffic flow is out of the Baltic Sea.
- Vessels with general cargo:
  The extrapolation is made in accordance with the average of the two traffic flows, as the dominating traffic flow is unknown.

It is noted that the distribution on cargo group in % (including ballast) is assessed to be the same in the future as it is today. This is an approximation, as an increased imbalance between traffic in and out will give relatively more vessels in ballast (typically in) and reversed at a reduced imbalance.

The extrapolation is performed in one step:

- Extrapolation from 2012 to 2020

The extrapolation in this section includes following vessel types:

- Vessels with load in bulk
  - Bulk

   - Bulk/Oil (For the development in size, values for "crude oil" is used in the prognosis report)
   - Tanker, LPG
   - Tanker, Chemical/Product (For the development in size, values for "Tanker, other" is used in the prognosis report)
   - Tanker, Product (For the development in size, values for "oil products" is used in the prognosis report)
   - Tanker, crude oil
   - Tanker, Other. The small number of vessels in this group is treated with Tanker, Chemicals. This choice is made based on information on loads.
   - Tanker, Food. They are also handled even though they are treated very simplified using assessments on load. The growth rates for chemical tankers are used.
- Vessels with general cargo:
   - Car carriers
   - Container
   - Refrigerator vessels
   - Ro-Ro
   - General cargo

5.2.2 The development of the total traffic in and out of the Baltic Sea
The total traffic in and out of the Baltic Sea includes traffic through The Great Belt, the Sound and the Kiel Canal.

For every vessel type and passage the traffic is extrapolated using the methodology below. The extrapolation from 2012 to 2020 is given as an example (0% growth rate is estimated for year 2010-2012 as discussed in section 4.5):

- The extrapolation is made using two parameters, t_s and α_s by performing the following calculation:

$$N_{i2020} = N_{i2012} \times (1 + t_s + \alpha_s \times D_i)$$

$$D_i = \frac{DWT_i - DWT_{\min}}{DWT_{\max} - DWT_{\min}}$$

Where:

   - N_{i2012} and N_{i2020} is respectively the number of vessels in size class *i* for year 2012 and for year 2020.
   - DWT_i is the average size of the vessel size *i*
   - DWT_{min} and DWT_{max} is the average size of the smallest and the largest size classes respectively noted in AIS for the vessel involved.

These equations corresponds to, that the increase of the number of vessels is proportional to the relative vessel size D_i. This leaves only two unknown parameters, which makes it possible to calculate theses parameters described below.

t_s and α_s is estimated based on the following two equations

$$N_{2020} = N_{2012} \times (1 + \Delta N)$$

$$DWT_{g2020} = DWT_{g2012} \times (1 + \Delta DWT)$$

where:

- N_{2012} and N_{2020} are the number of vessels in 2012 and in 2020.
- DWT_{g2012} and DWT_{g2020} are the average vessel size in year 2012 and in 2020.
- ΔN is the relative increase in the number of vessels from 2012 until 2020 determined by $(1+\Delta n)^8 - 1$, where
  - Δn is the annual increase as given in the prognosis report.
  - 8 is the number of years from 2012 to 2020.
- ΔDWT is the relative increase in average size from 2012 until 2020, determined by $(1+\Delta dwt)^8 - 1$, where
  - Δdwt is the annual increase of the average vessel size as given in the prognosis results.
  - 8 is the number of years from 2012 to 2020.

The two equations above can be revised to the following two equations, which are directly solved regarding t_s and α_s:

$$t_s \times N_{2012} + \alpha_s \times \sum_i N_{i2012} \times D_i = N_{2012} \times \Delta N$$

$$t_s \times DWT_{g2012} + \alpha_s \times \frac{\sum_i N_{i2012} \times D_i \times DWT_i}{N_{2012}} = DWT_{g2012}(\Delta DWT + \Delta N + \Delta DWT \times \Delta N)$$

It is noted that if ΔDWT is positive, then α_s will also be positive, even though the number of vessels are decreasing (ΔN negative). I.e. an increasing average size of the vessels will always result in relatively more large vessels.

In principle it can be said that the methodology above presumes a general development of the size of the vessels going in and out of the Baltic Sea, independently of the size limitations in the Kiel Canal and the Sound. This is a good approximation as the reroute via Skagen compared to the route through the Kiel Canal for the majority of the vessels is relatively small compared to the length of the total journey. This is even more relevant for the reroute via Great Belt compared to the route through the Sound.

5.2.3 Use of the results for the individual routes
From the methodology described in the section above, a growth rate of the number of vessels for each vessel type, size and direction of passage the size and sailing directions are given from 2012 to 2020:

$$Growthrate_i = N_{i2020} / N_{i2012} = (1 + t_s + \alpha_s \times D_i)$$

This growth rate is used on all routes in all waters.

Corresponding growth rates are estimated for 2012-2020.

This is apparently a rough approximation, but aside from being simple this procedure has the advantage that it does not change the balance between the traffic on the different routes that lead to the same point in the route grid.

For every vessel type the $Growthrate_i$ is largest for large vessels. In Great Belt the number of larger vessels is relatively bigger for almost all vessel types compared to the vessel sizes in the Sound and Kiel Canal. This procedure therefore leads to a larger increase in traffic through Great Belt than in the Sound and the Kiel Canal, both for the individual vessel type as for the traffic as a whole. With this procedure there will be no need to assess whether a vessel is "too large" to e.g. pass through the Sound. An extrapolation of the number of vessels in the different size groups based on the registered passages is made. A regulation based on the vessels actually passing the location in question, which therefore cannot be "too large". (But they can be too big to pass fully loaded, and the large vessels in the Sound are usually also in ballast)

The result from the procedure described above can also be described as the total traffic in and out of the Baltic Sea, for each type of vessel and size distributed in percent between the routes in the Baltic Sea.

The growth rate for each type and size is then implemented in the model for year 2020.

5.2.4 Effects of the new port at Ust-Luga
Small adjustments have been carried out in implementing these growth rates as the port Ust-Luga will be in operation in year 2020. The targeted share of oil products will be 36 million tonnes, containers 34 million tonnes, Bulk goods about 13 million tonnes, forest products about 3 million tonnes and ro-ro cargo about 3 million tonnes (4). Russia is investing in its own ports with the target of transporting 90-95% of all foreign trade cargoes through its own ports by 2020. Because of this the Baltic countries Latvia, Lithuania and Estonia will lose some of their transit volumes.

It is difficult to estimate the exact amount of shift of oil from Baltic countries to the Ust-Luga port because the statistics are not available for each individual port in Baltic countries. By keeping this in view, half of the amount of oil cargo is transferred from Baltic countries to Ust-Luga port. Some new fictitious ships are added for Ust-Luga. All the routes which are being affected by this shift of cargo are updated by new growth rates.

For general cargo, only 5 mill. tonnes cargo is added in Ust-Luga port as it is difficult to predict the ports in Baltic countries from which this cargo will be shifted to new Russian port. This may slightly underestimate the spill risk in Gulf of Finland and slightly overestimate the risk in the Baltic proper. However, it is assumed that it will not have any significant affect in overall risk.

The port St. Petersburg is already reaching its full capacity so it is assumed that there will be no future growth in the port St. Petersburg area.

5.3 Other vessels

These vessels include, with the specification of % of the total traffic:

- Other (0.7 %)
- Offshore (0.1%)
- Working vessels (1.0 %)
- Nuclear power (0.0 %)
- Tug boats (1.2 %)
- Navy (0.0 %)

The traffic with these vessels, that constitutes 3.0% of the total traffic, is for simplicity counted as unchanged regarding both number and size. This is acceptable, as these vessels can only pollute with bunkers.

6 References

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