Master's thesis

Maritime transport in the Gulf of Bothnia 2010-2030

Future scenarios for Maritime Spatial Planning purposes

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Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

Student‘s name

Abstract

The study aims to describe the main factors contributing to the development of maritime transport and to form future scenarios for shipping traffic in the Gulf of Bothnia by 2030. The goal is to identify future developments that should be taken into account when preparing a Maritime Spatial Plan for the Bothnian Sea area.

The methods include applying existing large scale quantitative scenarios for the volume of maritime traffic specifically in the Gulf of Bothnia context and Real-time Delphi round to find out the probability and desirability of the main factors having an impact on marine traffic. The factors contributing to the future of maritime traffic in Gulf of Bothnia are assessed and debated by an expert group. The study concludes with implications and recommendations for planning. Moreover, due to the spatial nature of the project, one of the most important outcomes of the study is the results shown on maps.

Area specific future scenarios have not been made concerning maritime transport in the Gulf of Bothnia. The future scenarios contribute to the area based, future oriented, participatory and adaptive nature of Marine Spatial Planning.

Maritime Spatial Planning is a fairly new approach to sustainable marine management. It is currently tested on trans-national scale in the Bothnian Sea area as a pilot project. Futures research and Delphi method have been used to aid logistics and traffic planning on land. This study explores how futures research methodology can be applied to planning on marine areas.

Foreword

This study serves as background data for Plan Bothnia –Project, funded by Directorate General for Fisheries and Maritime Affairs (DG MARE) and coordinated by Helsinki Commission (HELCOM). Centre for Maritime Studies has been responsible for the maritime transport section of the project. Plan Bothnia is a pilot project to test Maritime Spatial Planning between two countries, Finland and Sweden. Their common EEZ border runs in the middle of the planning area and both countries possess areas of approximately the same size. Similar marine activities can be found from both sides of the border, including shipping, environmental protection, wind park projects, military practise, fisheries, dredging and aquaculture.

The goal is to prepare a comprehensive, ecosystem based maritime spatial plan for Bothnian Sea, covering all main activities in marine areas. Overlap of spatial interests of different sectors is studied to find out possible conflicts between them. This study describes the development scenarios of maritime transport in the planning area, as well as in Bay of Bothnia. Future activities in Bay of Bothnia have a great impact on traffic within the planning area and therefore the scope of this study is widened from the Plan Bothnia area lineation to include Bay of Bothnia.

PLAN BOTHNIA

Table of Contents

List of Figures

List of Tables

Acronyms

In the order of appearance:

MSP: Marine Spatial Planning, Maritime Spatial Planning

TEN-T: Trans-European Transport Networks

BMO: Baltic Maritime Outlook

FMA: Finnish Maritime Administration (Currently FTA: Finnish Transport Agency)

BTO: Baltic Transport Outlook

SWOT: Strengths, Weaknesses, Opportunities, Threats

MARPOL 73/78: International Convention for the Prevention of Pollution from Ships (Marine Pollution, years 1973, 1978)

DG MARE: European Commission Directorate General for Fisheries and Maritime Affairs

HELCOM: Helsinki Commission, Baltic Marine Environment Protection Commission

EEZ: Exclusive Economic Zone

IMO: International Maritime Organization

TSS: Traffic Separation Scheme

GDP: Gross Domestic Production

AIS: Automatic Identification System

VTS: Vessel Traffic Service

UNCLOS: United Nation Convention on Law of the Sea

GOFREP: Gulf of Finland Reporting System

RO-RO: Roll-On Roll-Off ship

SECA: Sulphur Emission Control Area

NECA: Nitrogen Emission Control Area

EEDI: Energy Efficiency Design Index

RT Delphi: Real-Time Delphi

NSR: North Sea Route

TEU: Twenty-foot Equivalent Unit

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1 INTRODUCTION

1.1 Maritime Spatial Planning

Maritime Spatial Planning (MSP) is gaining importance as a new approach to manage marine areas. The pressure on offshore areas has grown as relatively new forms of using marine areas, such as wind parks and aquaculture installations compete of space with more traditional uses such as fisheries and maritime transportation. Various MSP projects have already been initiated in small scale as well as on national level all around the world. Backer (2011) notes that there is a difference in terminology: while in international context "Marine Spatial Planning" is commonly used, European Community refers to "Maritime Spatial Planning" when discussing the concept. Due to the EU context, the term Maritime Spatial Planning (MSP) will be used in this study. Maritime Spatial Planning is defined as follows: "Maritime spatial planning is about planning and regulating all human uses of the sea, while protecting marine ecosystems. It focuses on marine waters under national jurisdiction and is concerned only with planning activities at sea. It does not cover management of coastal zones or spatial planning of sea-land interface" (EC Maritime Affairs, 2012).

European Union is promoting Maritime Spatial Planning as the key to modern, sustainable management and works on setting common principles for European MSP policy and cross-border cooperation on marine areas. In Gulf of Bothnia (GoB), a pilot project to test Maritime Spatial Planning between two countries has begun in 2010. The aim is to make a plan for the Bothnian Sea, a small brackish water basin divided between Finland and Sweden.

Ehler (2011) describes Marine Spatial Planning as follows "Marine spatial planning is a public process of analyzing and allocating the spatial and temporal distribution of human activities to specific marine areas to achieve ecological, economic, and social goals and objectives that are specified through a political process. MSP is *integrated, future-oriented,* *participatory, adaptive, ecosystem-based, and area-based.* The process of MSP answers three questions: (1) where are we today?; (2) where do we want to be?; and (3) how do we get there?" (Ehler, 2011, 41)

Integrated approach is needed as the users of marine areas represent various powerful sectors competing of the limited space in Bothnian Sea. Integration is also needed to overcome the challenges of cross-governmental planning systems. Due to the differences in planning systems of Finland and Sweden, creative solutions are needed to facilitate trans boundary cooperation.

Future-oriented and adaptive planning framework is important, as results of the planning process should be long-term and there is no absolute certainty of the future. It is important to be able to adapt to changes as they come and assess procedures continuously based on the lessons learned.

Participatory approach is vital for proper management. Participatory planning takes in account the needs of the main livelihoods and other stakeholders and aims to identify and solve possible user-user as well as user-environment conflicts in the area.

Ecosystem-based approach is widely accepted framework to ensure sustainability as it takes in account the biodiversity and ecosystem services of the area (Douvere & Ehler, 2008).

Area-based management is important due to the uniqueness of each area planned; plans must be made considering the jurisdictional, socio-economic and ecological special characteristics of the area (Ehler, 2011).

To make a Maritime Spatial Plan responding to the needs of the planned area, area-specific information is needed on the present day situation as well as the future development. There is a satisfactory amount of information available on present day situation of maritime transport and cargo flows in Gulf of Bothnia. Baltic Sea-wide cargo volume scenarios for the following decades have also been made. However, area specific future scenarios do not exist concerning maritime transport in the Gulf of Bothnia. Scenarios can offer ideas on how the situation might look in future and how these developments could be considered in the Maritime Spatial Plan. Scenarios contribute to the area-based, future oriented and adaptive nature of Maritime Spatial Planning and therefore it should be explored how they can be best utilized in the MSP process.

This study seeks the answers to the following questions:

- How much the transportation continues to grow in the Gulf of Bothnia?
- What are the key factors for development of maritime transport in the area?
- What kind of possible futures there are for maritime transportation in the Gulf of Bothnia?
- What are the implications and benefits of the scenarios for Maritime Spatial Planning in the area?

Somewhat similar projects have been conducted before using expert participation to find out future developments, key factors and even to build visions on different topics, including transport and urban planning. However, applying a Delphi method and an anonymous expert panel to collect information and views on future developments, to build scenarios used for Maritime Spatial Planning has not to my knowledge been done before.

This study begins with a detailed research area overview describing the characteristics of maritime transport in Gulf of Bothnia. The information is gathered from a variety of sectorial reports. Current status of transportation as well as development of transportation of different commodity groups is described in this chapter. The study is divided in two parts, firstly to make scenarios for cargo volume development and secondly, to make scenarios for transport routes and patterns in the area. The theoretical overview is therefore presented partly below in chapter 1.2. Literature review and is continued for each part separately in chapters 4 and 5. The study concludes with implications for planning, recommendations and lessons learned as well as suggestions for further research.

1.2 Literature review

This study is a unique pilot project for testing a futures research method for MSP purposes. A similar idea was in a recent Finnish Transport Agency project, which collected expert information in several stakeholder meetings for “Conditions for traffic 2035” vision and long term plan (Finnish transport agency 2011a). The report identified and drew together the needs, future visions, goals and objectives of main actors in the field of traffic to get a solid basis for Finnish development plans. The result was three alternatives for transportation based on stakeholder views and a common vision for development. Forming alternatives for development is a common step of planning processes, especially in an Environmental Impact Assessment process.

Making future predictions and forecasts is common in the business world. According to Hoyer (2000), when it comes to traffic, it is mostly done on a fairly deterministic basis. With this Hoyer means that rather than asking the question on how to direct transport towards a more sustainable direction, the research concentrates often on questions like “How something will affect transport specifically?” Hoyer’s study concentrates on the use of new technology in transport and more specifically, “how can information technology help in the transformation of the transport system towards sustainable development”. The focus was on urban planning and infrastructure planning.

The existing scenarios for maritime transport in Baltic Sea area are largely based on the traditional question: how the developing economic situation will affect maritime transport. Kuronen, Helminen, Lehikoinen & Tapaninen (2008) have studied maritime transport future scenarios in the Gulf of Finland. Baseline data for the study was maritime transport in 2007. The future scenarios for different commodity groups and ports were based on Baltic Maritime Outlook (BMO, 2006) and scenarios made by the Finnish Maritime Administration (FMA) in 2006. Information from various sources was also gathered, including ports of the research area and predictions of the economic situations of the adjacent countries. This information was combined to form the scenarios for cargo and oil transportation. Probability of the three scenarios becoming reality was assessed by an expert group.

Of the Scenarios Kuronen et al. (2008) used, the one conducted by FMA is only for Finland and Finnish ports. The other, BMO (2006), concentrates on the whole Baltic Sea Region. BMO was a cooperation project between Sweden, Finland, Estonia, Lithuania, Poland, Denmark and Norway. Maritime administrations and port authorities from each country were involved. The document was also a part of larger project on Trans-European Transport Network (TEN-T) and it aimed to contribute to the Baltic Sea Region transportation planning. Both scenarios are discussed further and their main results are presented in chapter 4 as these scenarios are also used as a basis in this study to make forecasted scenarios for Gulf of Bothnia cargo volume. The idea is same as in the study conducted by Kuronen et al. (2008) but due to the different nature of transportation in Gulf of Bothnia and Gulf of Finland and somewhat different goal of this study, there are changes in the way the scenarios are formed and assessed.

The results are compared to Baltic Transport Outlook (BTO) scenarios for maritime transport in the Baltic Sea Region. According to BTO (2011, 1) “Baltic Transport Outlook 2030 is an EU funded project and a strategic priority within the Baltic Sea Strategy that was adopted by the European Council in October 2009. The overall aim of the project is to achieve better prerequisites for national long term infrastructure planning in the Baltic Sea region to make the region more accessible and competitive.“ BTO is the latest scenario for maritime transport in Baltic Sea. It was published in November 2011 after the forecast part of this study was done, which is why its results are mainly used as comparison and not in formation of the scenarios in this study. A SWOT analysis of Baltic Regions was also conducted during BTO project. The SWOT results for Bothnian Sea transport was used in key factor identification phase of this study.

None of the scenarios mentioned above concentrate on development of individual ports or transport routes, which is what this study is aiming to do.

In addition to the two larger scenarios for the whole maritime transport sector, more specific sectorial scenarios are used to offer detailed information on industries in the Gulf of Bothnia. Pöyry (2011) has made future scenarios for new products of forest industries, such as biofuels in Finland. The Swedish Environmental Research Institute has published a scenario for Energy Use in Sweden for 2050, including a future scenario for the use and production of biofuels (Gustafsson, Särnholm, Stigson & Zetterberg, 2011).

Sundberg, Räsänen, Posti & Pöntynen (2010) have made scenarios for Russian transit traffic in Finland. Due to the new MARPOL 73/78 Annex VI regulations on air emissions, Swedish maritime administration has made scenarios for the magnitude of the possible modal shift in Sweden (Sjöfartsverket, 2009). Increasing costs of shipping could direct more and more transportation to road and rail within the Swedish side of the Gulf of Bothnia. These scenarios are used to estimate the possible decrease or increase in shipping in Gulf of Bothnia.

The point of view in this study is on the other hand traditionally deterministic: how the economic situation will affect the maritime transportation since most the data used is based on this question. On the other hand, this study is also trying to find out if this is what stakeholders and main actors in the field of maritime transport see as probable future developments for the Gulf of Bothnia. This is done by means of Delphi method, developed in 1950-1960 by RAND Corporation to collect expert judgements on a variety of topics and described in detail by Linstone and Turoff (1975).

The Delphi method has not been widely used in a marine context. Perhaps the most relevant example has been a study prepared by Myllylä and Iikkanen (1995): Changing freight transport market in the Baltic Sea area – The position of South-Western Finland in the context of Baltic Sea freight Network. In this study, a panel consisting of 15 experts was considering the future developments until 2010, concerning mainly transit traffic, ferry traffic between Sweden and Finland and positioning of North European distribution centres and evaluating three scenarios for transport. Garrod (2003) has used Delphi panel to find definitions for Marine Ecotourism and explore the perceptions of European Union and Atlantic experts on this concept. Scenarios were not built in that study, Delphi method was simply used to gather expert information. In the field of transport, Delphi method has been used for example to find out future developments in European air traffic (Mason & Alamjari, 2007).

2 RESEARCH AREA DESCRIPTION

2.1 Scope of the study

Definition of Gulf of Bothnia in this study is based on The HELCOM COMBINE manual. (HELCOM, 2006) The research area includes the sub areas Bothnian Bay, Bothnian Sea and The Quark. Åland Sea and Archipelago Sea have been left out from this study in order to use the same southern limit as is used in the Plan Bothnia project. The Sea of Bothnia (or Bothnian Sea) is the sea area between the line drawn on Northern side of Åland Island between Ormön and Understen in Sweden to Emskär-Eckerö-Sälskär-Uusikaupunki and Hörnefors-Vaasa in North. The Quark and Bay of Bothnia have been considered as a one sea area in this study. Therefore the definition of the Bay of Bothnia is the sea area north of a line drawn between Hörnefors-Vaasa. EEZ's of Finland and Sweden cover the whole sea area. The sea is divided between these two countries based on an agreement on borders, which was checked the last time in 1981. (Law on Finnish Territorial Sea, 1956, article 1)

The Gulf of Bothnia coastline consists of seven regions on the Finnish side and five on the Swedish side. Within those, there are 41 municipalities having coastline to the Gulf of Bothnia in Finland and 19 in Sweden. In 2010, around 1,4 million people inhabited the municipalities with direct coastline to GoB. In Continental Finland there are about 627 000 inhabitants, Åland around 6000 and Sweden 773 000. (SVT, 2011, SCB, 2011)

This study concentrates on finding out the transport patterns mainly in the offshore areas of the Gulf of Bothnia. However, as the main drivers for development are on land, the scope of the scenarios is wider than the marine areas in the Gulf of Bothnia.

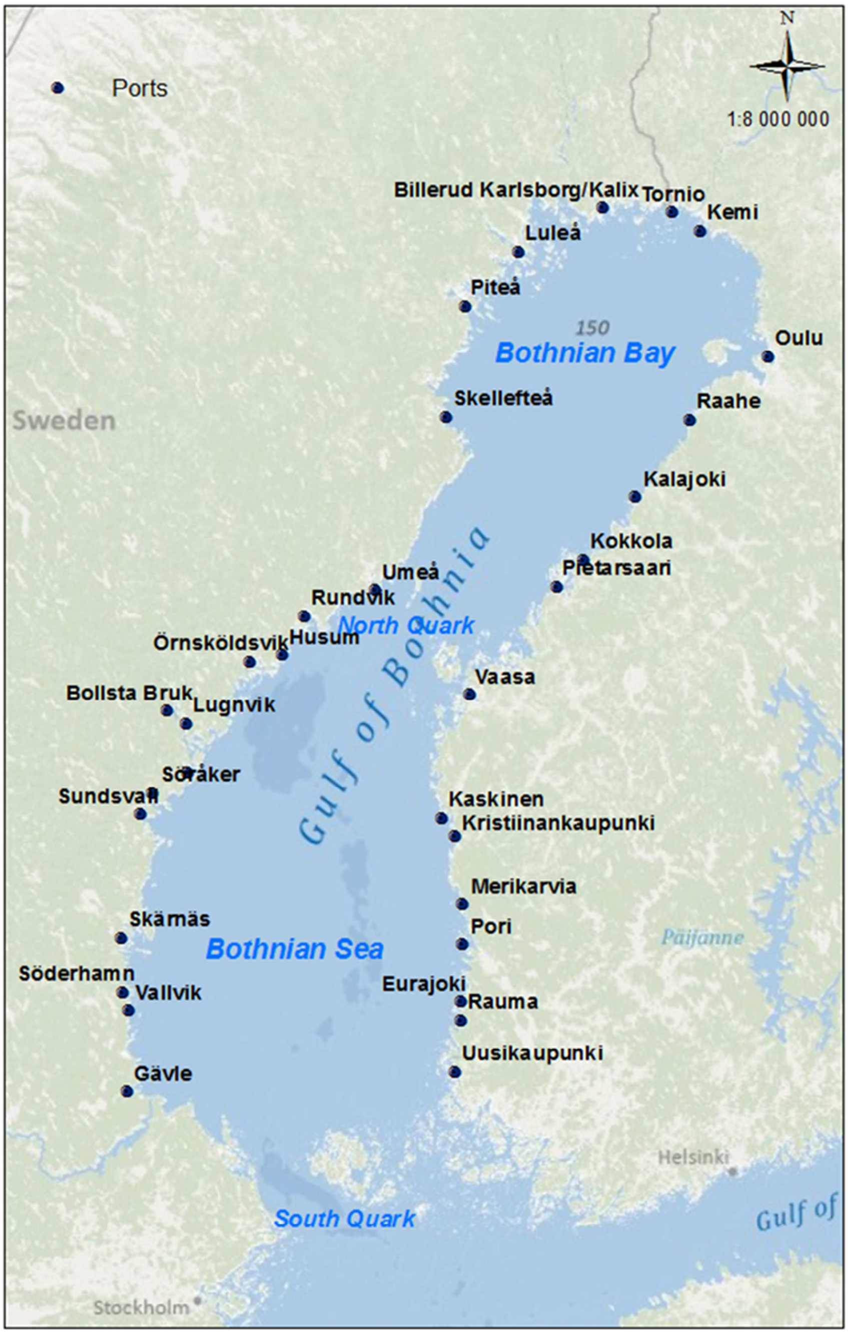

Figure 1: Ports of the research area

2.2 Navigation in offshore areas of Gulf of Bothnia

2.2.1 Legal background

The right to set rules for maritime transport in coastal states Exclusive Economic Zone (EEZ) is based on the United Nations Convention on the Law of the Sea (UNCLOS, 1982). The Baltic Sea has a Particularly Sensitive Sea Area (PSSA) status given by IMO as well as a Special Area under MARPOL-status, which gives the coastal states of the Baltic somewhat larger variety of means to govern maritime transport in their EEZs. For example establishing routing measures in EEZs is possible and this has been done in Baltic Proper as well as Gulf of Finland with Traffic Separation Schemes (TSS) and Deep Water Routes.

An interesting example of enforcing governance on Maritime Transport is the Norwegian-Russian Barents Sea case where Norway has been exploring measures to manage the potentially increasing oil and gas transports from Russia through the Norwegian EEZ. The measures include for example extended territorial water limit, Vessel Traffic Services, PSSA-status for parts of Barents Sea and Traffic Separation Scheme. A physical Marine Spatial Plan of Norwegian Barents Sea was included in the Barents Sea Management plan. The Barents Sea case has similarities with the Baltic Sea case as it concerns Maritime transport in ice covered areas. UNCLOS article 231 handles specifically rights to govern navigation in ice-covered EEZ's and gives the coastal states a right to take measures to prevent pollution from vessels in harsh climatic conditions (Stepanov & Brubaker 2005).

Another possibility to get legal backing for Maritime Spatial Planning is establishing mandatory or recommended Areas To Be Avoided (ATBA). These kinds of areas also exist in Baltic Proper, namely the Hoburg bank south of Gotland. For example particularly sensitive natural areas with higher risk of accidents, such as banks, could be stated areas to be avoided by commercial shipping. Unlike nature protection areas such as Natura 2000, the ATBAs are marked in navigational charts.

According to IMO, the measures that coastal states are allowed to take within their EEZs concerning maritime transport must be limited to such actions that have been approved by IMO. These are therefore the main opportunities to govern maritime transport in EEZ, with a legal basis. The measures must also be taken so that ships do not have to take unnecessarily long alternative routes to comply with set regulations. Most of the approved means to enforce rules on navigation in EEZs are already in use in the Baltic Sea.

2.2.2 Routing system for marine transportation in the Gulf of Bothnia

No fairways exist or are planned within Finnish and Swedish EEZs in the Bothnian Sea. All fairways for commercial ships begin when they enter the territorial waters of coastal states. From the starting point the fairways are usually 1-2 nautical miles wide and get narrower towards the coastline. There is no standard for fairway width; planning of a fairway is done case by case. The width is dependent on geography and hydrographic characteristics of the area. In the Bothnian Sea area, the difficult ice conditions must be taken in account when planning fairways. Generally the ships need more space when operating in ice (Hartikainen & Reilimo, 2011).

If there is special need for a marked shipping route in open sea area, the solution is setting a routing system such as TSS or Deep Water Route. At the moment there is a TSS and Deep Water Route in South Quark in the narrow channel between Sweden and the Åland Islands. Another TSS is planned for the narrow part of North Quark between the cities of Vaasa and Umeå, where increasing traffic requires actions to ensure the safety of shipping.

Outside the TSS areas, the ships generally navigate shortest possible way to the ports. The Automatic Identification System (AIS) tracks (HELCOM, 2012a) show that most of the ships follow the same, mostly straight-line routes to main ports, as if they were navigating on a fairway. This data gives good basis for MSP when defining the important areas for maritime transportation.

Even though the official fairways are lacking from EEZs, Sweden has identified National Interest fairways within the whole Swedish EEZ. In the Bothnian Sea area these identified areas are the straightest routes to the main ports as well as the Swedish coastal route, which can have great importance during the ice navigation season. National interest fairways are also partly in Finnish side. In the Bay of Bothnia the route between port of Raahe and the port of Luleå is marked as National interest fairway due to the regular iron ore transports to the Raahe steel mill (HELCOM 2012b).

Using Finnish and Swedish fairways adds costs for the shipping companies. The costs are piloting fees and fairway fees. In the beginning of 2012, Finnish piloting fees increased by about 9.5%. However, even after the increase the fees are still lower than in Sweden (Finnpilot, 2011). Sweden has planned increases in fairway fees, piloting fees and railway fees. The analysis of impacts (Vierth & Mellin, 2010) stated that they can be expected to be greatest for the Bothnian Bay transport, except when it comes to railway fees which were considered to be low compared to some southern railways such as Gävle railway. The impacts of the price increase were generally considered to be modest compared to the Sulphur directive impacts on transports. According to the study, increase of prices in the Bothnian Bay would be about 7.5-11%, depending on the scenario.

2.2.3 Maritime Safety

Maritime traffic in the Gulf of Bothnia is at the moment observed in two Vessel Traffic Service units in Finnish coast. West Coast VTS is located in Kallo, Pori and Bothnia VTS in Vaasa. These two units will combine in near future with Archipelago-VTS of Nauvo, to form a Gulf of Bothnia VTS. The new centre will be located in Turku. Sweden has VTS centers in Stockholm and Luleå.

Traffic observations are done mostly by AIS data. The Gulf of Bothnia piloting areas in Sweden are Umeå, Luleå, Skellefteå and Örnsköldsvik. They offer mandatory piloting to their responsibility ports in Swedish territorial waters. In Finland there are two areas, the Bothnian Bay and Bothnian Sea pilotage areas, which are divided in pilot centers of Bothnian Bay, Kokkola, Vaasa and Rauma.

2.2.4 Navigation in ice

Ice conditions in the Gulf of Bothnia are difficult during the winter time. Finland and Sweden set winter restrictions for ships navigating in their waters. Only the ships with specific ice classes are qualified to get assistance from the states' ice breakers during the winter season. The restrictions are set depending on the severity of ice conditions and they vary yearly. In the Bay of Bothnia, the ice conditions are the most severe and the bay is frozen also during the mild and short ice winters.

During an average winter, such as 2009-2010, Bothnian Bay restrictions are likely to begin in December. Bothnian Sea restrictions begin later in end of December-January. In February-March the ice cover reaches the maximum and restriction can be set higher in the whole Gulf of Bothnia. The last days of restrictions are usually in April-May.

Finland and Sweden cooperate in organizing ice breaking services in the Bothnian Sea. For example during the winter 2009, five icebreakers operated in the Bothnian Bay, of which one was Swedish and four Finnish owned. In the Bothnian Sea the icebreaker fleet consisted of five icebreakers and two tugboats (BIM, 2010).

Winter changes navigation procedures. During the ice breaking season the ships cannot often take similar routes as during the ice free season. Ships navigating to ports in the Gulf of Bothnia during the ice restrictions must make an announcement for ice info via VHF radio. The operating ice breaker will give the ships route points or instructions on how to navigate. The importance of the routes running along the coast grow in winter time, while in summertime they are used more seldom as ships navigate the shortest possible way to ports. During the winter time ice breaking services might be restricted for coastal fairways only. Ships must comply with set speed limits and generally they must have a pilot on board. During difficult ice conditions the traffic separation schemes can also be temporarily not in use in the Quark and Åland Sea narrow channels (Finnish Transport agency 2011b).

2.2.5 Environmental regulations concerning Maritime transport in offshore areas

During the next decade the new air emission restrictions that are set in MARPOL Annex VI by IMO are likely to have a great effect in shipping in the research area. The aim of the regulations is to tackle most of the Sulphur and Nitrogen emissions from shipping. IMO is also considering market based measures to reduce CO_2-emissions. A brief description of main maritime transport induced pollution and regulations concerning the Gulf of Bothnia can be found below.

SOx

The Baltic Sea is designated as a Sulphur Emission Control Area (SECA). The sulphur content of fuel that is used in the Baltic Sea was reduced in 2010 from 1,5% to 1%. EU has set an additional requirement; 0,1% fuel must be used when operating in harbor area. In 2015 all fuel used by ships in the Baltic Sea area must contain no more than 0,1% sulphur. Alternatively, SOx scrubbers resulting in same SOx abatement may be used. Adverse environmental and health impacts from sulphur emissions and particulate matter (PM) will be reduced with implementation of the SECA regulations (Kalli & Tapaninen, 2008).

NOx

Designation of the Baltic Sea as Nitrogen Emission Control Area (NECA), to reduce air-emitted nitrogen that adds to the eutrophication problems of Baltic Sea is mentioned in HELCOM Baltic Sea Action Plan. If the Baltic Sea will become a NECA, newly built ships operating in the Baltic Sea area must install a system to tackle nitrogen emissions from 2016 onwards. The only viable method at the moment is a SCR exhaust gas after treatment device, which would reduce the nitrogen load from ships more than 80% (Kalli, Repka & Karvonen, 2010).

CO^2

Currently there are no binding goals to reduce CO2 emissions of shipping. The latest achievement on the matter is the new Energy Efficiency Design Index (EEDI) for new ships to promote energy efficiency in shipping and therefore reduce CO2 emissions. IMO has evaluated that with currently available technical and operative measures, energy savings could be between 25% and 75% in 2050 (Finnish Transport Agency 2011a). IMO is also currently working on the best available market based measures to tackle CO^2 emissions (IMO 2009).

Oil pollution

Although the amount of oil transports in the Gulf of Bothnia is considerably smaller than in the Gulf of Finland, the risk of oil accidents should not be overlooked. Ice conditions are difficult and the narrow navigational routes of North and South Quark pass archipelago areas with valuable natural features. The Baltic Sea Action Plan has set an obligation for member states to participate preparing a mutual plan for places of refuge in case of emergency. The plan will be a new HELCOM recommendation. The place for refuge could be in the area of another country than the one where the distress situation originally begun. In the Gulf of Bothnia this could mean that oil spill hazard could be directed to the nearest place for refuge in Finland or Sweden, independent on which country's response zone the accident occurs. Requesting shelter in neighboring country could be based on weather conditions or lack of shelter in each country's own response zone, not on financial reasons or lack of emergency response resources (HELCOM, 2010).

A risk analysis and a development plan for oil accident response are currently being prepared for the Finnish side of the Bay of Bothnia. The results will be published in 2012. The previous plan for the Finnish side was made in 2005 by regional environment centers and it covered the area North of Vaasa. The new plan aims to take into account the increasing maritime traffic due to mining activities (SYKE, 2011).

Sweden has a national strategic plan for oil accident emergency response covering all national, regional and municipal actors that are involved in the process (Räddningsverket, 2004). BRISK project by HELCOM does risk analysis on oil spills for the whole Baltic Sea Region.

Illegal oil discharges

According to HELCOM (2010) "altogether 149 oil spills were observed in 2010, which is 29 less than in 2009 and 61 less than in 2008. In general, the number of detected oil spills in the Baltic Sea has been constantly decreasing, even though the density of shipping has rapidly grown and the aerial surveillance activity in the countries has been substantially improved". Surveillance is done with small aircrafts and all Baltic Sea countries except Latvia contributed to the total 4279 flight hours in the Baltic Sea area. Oil discharges are also detected by using satellite images. 91 % of all detected spills were smaller than 1 m^3 and none of the detected spills were in the Gulf of Bothnia area.

Alien species and Ballast water management

Alien species spreading with ballast waters of ships or attached to surfaces is an interesting question in the Baltic Sea context. The shallow and small sea area enables some of the local species to spread on their own. The IMO Ballast Water Management Convention (BWMC), to be ratified by HELCOM countries by 2013, will reduce the risk of alien species spreading to the Baltic Sea from other sea areas, but Intra Baltic transportation is an issue that must be addressed separately. A pilot risk assessment was recently conducted. The study addresses the BWMC regulations that apply to Intra Baltic Voyages and makes suggestions for HELCOM. Especially the concept “Same Location” is considered, referring to areas that are ecologically similar and do not require Ballast water management for voyages within the areas (HELCOM, 2011a).

2.3 Maritime transport in the Gulf of Bothnia 2010

The Gulf of Bothnia coasts are characterized with several small ports rather than large centralized port complexes. Organizational changes in ports are a common trend in Finland and Sweden. Most of the ports used to be municipal corporations but privatization is expected to be more common in the future due to the EU regulations about the special status of municipal corporations (Mylly, 2010). Port of Gävle recently went through a major organizational change as the Gävle Hamn AB (Joint stock Company) bought the whole port infrastructure from Municipality of Gävle. There are also several private industrial ports in the Gulf of Bothnia. The large port complexes often include private port units.

About 11 770 ship calls were made in Gulf of Bothnia Ports in 2010. As a comparison, the port of Helsinki alone had about 8000 ship calls, the port of St. Petersburg 9000 and the port of Helsingborg 30 000 in the same year. Of all the ship calls in the Baltic Sea, about 3,8% was made in Gulf of Bothnia Ports. The total cargo volume handled in the Gulf of Bothnia ports was about 66,5 million tons. This is about 0,8% of the cargo volume in the whole Baltic Sea. The rather shallow fairways to the ports set limits to the size of the ships and the amount of cargo they can carry. The Gulf of Bothnia is characterized with a fleet of relatively small ships.

2.3.1 Ship types

Ship types are presented in % for the whole Gulf of Bothnia (Figure 1) and Bay of Bothnia (Figure 2). Figures are based on AIS data from 2010 (HELCOM 2011b), ships that cross passage line drawn to south Quark. According to the AIS data, general cargo ships are the most common ship type in the Gulf of Bothnia. The term general cargo ship includes several different ship types. General cargo ships can be for example multi-purpose vessels carrying both containers and other types of cargo, Ro-Ro vessels handling also wheeled containers or barges. It should be kept in mind when looking at the figures that the ship type marked in AIS is often done by the crew and not according to any common standards. Also, it is up to the AIS device user to decide whether the designation. „General cargo vessel” or for example more specific „Ro-Ro” ship is used. Bulk carriers are for the dry bulk transports such as foodstuff or coal and coke. Maybe the most notable differences between the Bay of Bothnia and the situation in general are the amount of support ships, which is relatively high in the Bay of Bothnia, most likely due to ice conditions. Container ships are rare in the Bay of Bothnia. According to AIS data, in 2010 399 container ships crossed the Gulf of Bothnia passage line and only 82 of these also crossed the Bay of Bothnia passage line. It should be also noted that calculations were made for each month separately and each ship was calculated only once (maximum 12 passages/year) even though there were a few examples of for example support ships crossing the passage line from South to North almost daily.

The size of ships used in Gulf of Bothnia is generally small. The straits of Denmark have the depth of 15 m, which limits the size of ships in the whole Baltic Sea area. Only the port of Pori in the Gulf of Bothnia can receive these maximum size ships. Luleå is considering dredging to same depth to be able to receive the largest ships but currently the permission is for deepening the channel to 13.2 m.

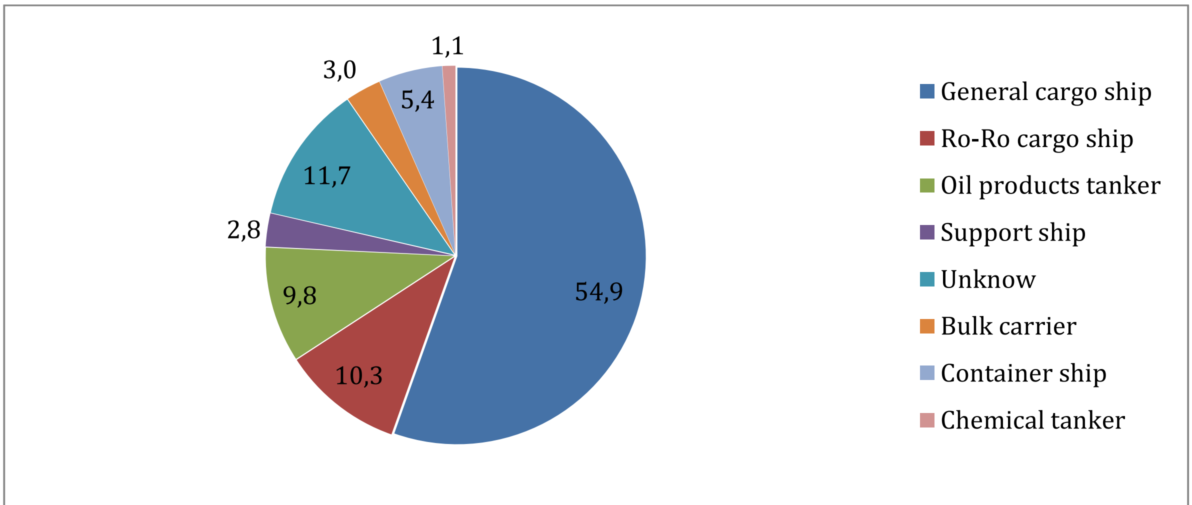

Figure 2: Ship types in the whole Gulf of Bothnia (%) (HELCOM, 2011b)

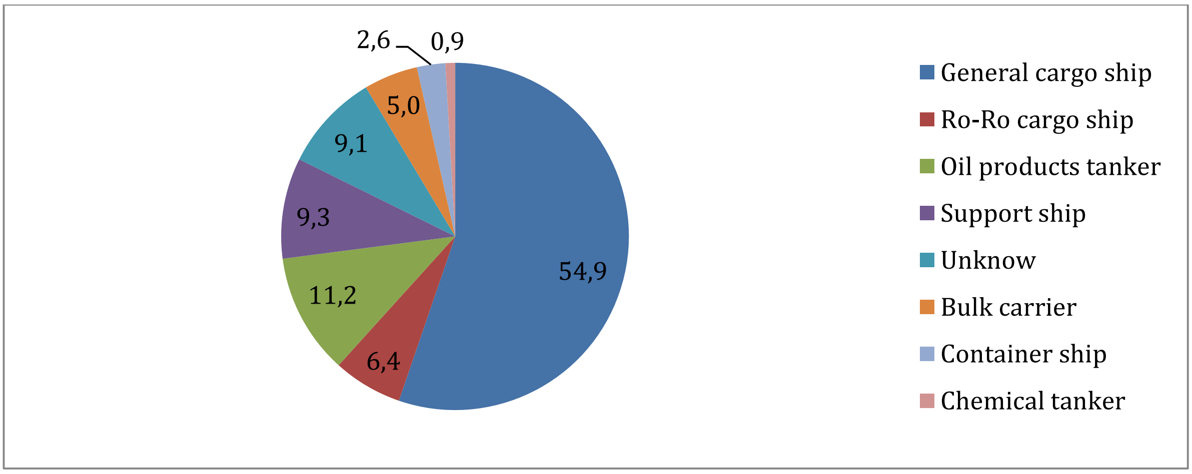

Figure 3: Ship types in Bay of Bothnia (%) (HELCOM, 2011b)

2.3.2 Main commodity groups

Figure 3 presents a summary of main commodity groups transported in the Gulf of Bothnia area. On a general level it can be said that ores and metal waste transports are concentrated to the Bay of Bothnia and wood transports to the Bothnian Sea area. The largest Finnish commodity group is ores and metal waste and the second largest is wood products. In Sweden the situation is opposite, forest industry being the largest transporter in the area. The cargo volumes are also distributed unevenly; The 14 ports of Finland transported about 60% of the total cargo volume while the 18 Swedish ports handled only 40% of the total volume.

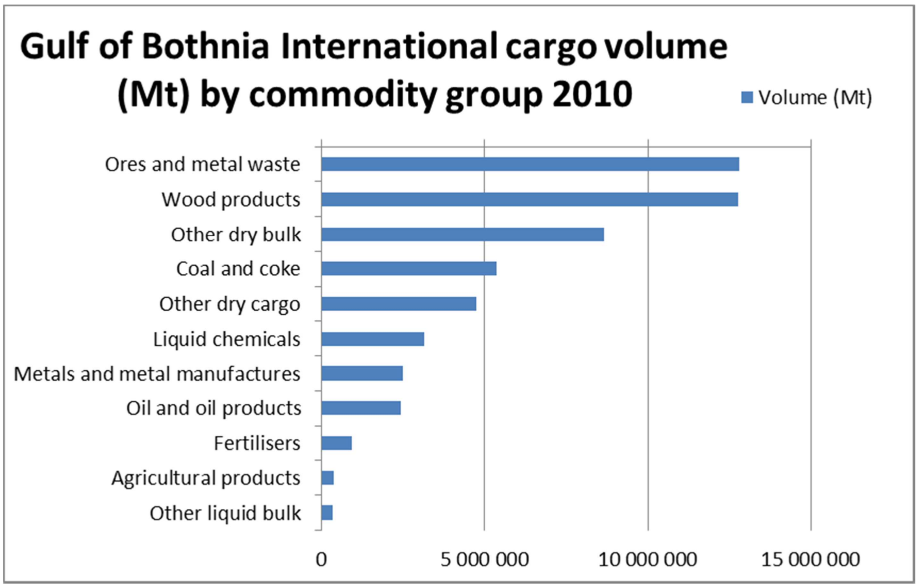

Figure 4: Main commodity groups transported in the Gulf of Bothnia 2010 (Mt) (Baltic Port List, 2011)

2.4 Analysis of current status of transports and economic development

Finnish and Swedish transport statistics and descriptions from 2010 have been used as current status data for this study. The shares of ports in the Gulf of Bothnia of the total international cargo volumes are based on these figures. Some of the main assumptions concerning the quantitative scenarios for Gulf of Bothnia are based on the descriptions of economic situations in Finland and Sweden.

2.4.1 Finland

Economic development of Finland

Finnish Bank estimated in March 2011 that GDP growth for 2011 would be 3,8% and for years 2012-2013 about 2,5%. This estimation has come down in the latest Finnish estimation, which predicts an average growth of 1,9 % for years 2012-2015.

Economic growth can be expected to slow down in future due to aging of Finnish population as large post-world war II age groups will retire during the next decade. Finland has highly specialized export sector and the public services development has been weak.

According to the ministry of finances, industries will be further supported with energy taxation reductions for energy intensive industries, subsidies for shipping companies to invest in innovations and environmentally friendly technology. Opportunities for financing of exports will be enhanced by internationally competitive export financing model and a free guarantee by state (Ministry of Finances, 2011).

Cargo volumes in 2010

The numbers presented in tables 1 and 2 include the international transports of Finland and Gulf of Bothnia in 2010, including transit traffic.

Table 1: International transports of Finland in 2010 including transit. (FTA 2011)

FINLAND International transports 2010 (Mt)		
Imports	Exports	Total
51,49	41,79	93,28

Table 2: International transports in the Gulf of Bothnia 2010 (Baltic Port List 2011)

FINLAND Gulf of Bothnia ports 2010 (Mt)		
	Mt	**% of Finnish transports**
Total	**33,33**	**39,7**
Import	17,84	34,7
Export	15,49	37,1

2.4.2 Sweden

Economic development of Sweden

The economic crisis had a strong effect on Swedish economic growth, which had been high for over a decade before the year 2009. Exports are a strong driver for the Swedish economy; therefore Sweden is greatly dependent on the world economic situation and external demand. The recession, although short lived, hit mainly on the export-oriented industries. However, the economic situation recovered greatly by 2010.

According to Swedish predictions, 2011-2014 the GDP growth is on average 3,7% annually. This prediction estimated 3,8% growth for GDP in 2012 (Regeringskansliet, 2011a). However, according to the latest information, the Government Offices of Sweden has predicted that the unstable global financial situation will lower the GDP of 2012 to 1,3% due to low investments on industries and low domestic demand. For following years the GDP is projected to bounce back to an average of 3,7% for years 2013-2015. (Regeringskansliet, 2011b). Generally Sweden has predicted very modest growth for future years due to low resource utilization growth in European Union and United States.

A long term economic growth scenario for Sweden has predicted an average annual growth of 2.2% until 2030 (Hill, Löf & Petterson, 2008).

Cargo volumes in 2010

The numbers in tables 3 and 4 represent only international transport. Domestic transport has been excluded from this analysis because the cargo volumes are quite marginal (About 2,6 Mt/year in Gulf of Bothnia).

Table 3: International transports of Sweden in 2010 (Sjöfartsverket, 2011)

SWEDEN International transports 2010 (Mt)		
Imports	**Exports**	**Total**
82,31	70,91	153,30

Table 4: International transports in the Gulf of Bothnia 2010 (Baltic Port List 2011)

SWEDEN Gulf of Bothnia ports 2010 (Mt)		
	Mt	**% of Swedish transports**
Total	**20,935**	**13,7**
Import	9,754	11,8
Export	11,18	15,8

2.5 Ports

Ports in the Gulf of Bothnia are relatively small. Only one of the ten largest Swedish ports is located in the Gulf of Bothnia: The port of Luleå. In Finland, Raahe, Kokkola, Pori and Rauma are in the top ten of ports listed by cargo volume and the three largest Finnish dry bulk ports are all in Gulf of Bothnia (Kokkola, Raahe, and Pori). The international total cargo volumes handled in Gulf of Bothnia ports as well as volumes of different cargo types and main commodity groups are presented in figures 4 and 5 for Finland and figures 6, 7 and 8 for Sweden. It should be noted that the ports are often port complexes, consisting of smaller units. The units have often different owners from private and public sectors. The ports mentioned here are based on Baltic Port List (Holma, Heikkilä, Helminen & Kajander, 2011).

Finland

Port of *Uusikaupunki* consists of two ports. Hepokari is the general cargo port and Yara Suomi Oy has its own industrial port. The fairway to the harbor will be dredged deeper in the near future to enhance transport opportunities. (Liikennevirasto, 2012)

Port of *Rauma* has major importance on a national level for importing raw wood and exporting wood products. Rauma also has importance in handling general cargo. Rauma has a RoRo-service connection with a Gävle harbor three times per week. It handles the largest amount of container traffic in the whole Gulf of Bothnia. Rauma also had the most ship calls in 2010, followed by Gävle, Umeå and Pori.

Pori is the largest harbor by cargo volume in the Finnish side of Bothnian Sea. Pori imports coal and coke, crude minerals, ores and ore manufactured products. Exported goods from the port of Pori are sawn wood, ores and ore manufactures, chemicals and cement.

Kristiinankaupunki and Eurajoki are small import ports for coal, coke and crude minerals.

	Uusikaupunki	Rauma	Eurajoki	Pori	Kristiinan-kaupunki	Kaskinen	Vaasa
TOTAL TRAFFIC (t)	**1204000**	**5 696 000**	**170 000**	**4 985 000**	**381 000**	**1 433 000**	**1 084 000**
International traffic (t)	1 080 000	5 606 000	170 000	4 224 000	381 000	1 070 000	969 000
Import	356 000	1 761 000	108 000	3 119 000	370 000	433 000	762 000
Export	723 000	3 845 000	62 000	1 106 000	11 000	637 000	207 000
Domestic traffic (t)	125 000	90 000	0	761 000	0	4 000	427 000
International cargo traffic by types of cargo (t)							
Dry bulk	827 000	1 092 000	103 000	3 161 000	372 000	241 000	576 000
Liquid bulk	157 000	241 000	0	523 000	9 000	94 000	20 000
Oil products	**0**	**36 000**	**0**	**130 000**	**9 000**	**0**	**16 000**
Other dry cargo	95 000	4 273 000	67 000	540 000	0	735 000	373 000
Number of transport units (international)							
Containers (TEU)	0	160 600	0	21 400	0	0	0
Cars	0	0	0	0	0	0	14 300
Buses	0	0	0	0	0	0	100
Trucks and trailers	0	33 200	0	0	0	0	10 300
Train wagons	0	0	0	0	0	0	0
Passengers (international)	0	0	0	0	0	0	56 500
Ship calls (total)	370	1 280	70	820	30	310	520
Main commodities							
Imports	Crude minerals	Timber	Crude minerals	Coal and coke	Coal and coke	Timber	Coal and coke
Exports	Fertilizers	Wood products	Ores and manufactures	Ores and manufactures	Crude minerals	Wood products	Cereals

Figure 5: Transports in Finnish Ports in Bothnian Sea (tons/a), main types of cargo and commodities in 2010. Red columns illustrate ports that have more imports than exports and blue columns stand for mainly exporting ports. (Baltic Port List 2011)

	Pietarsaari	Kokkola	Kalajoki	Raahe	Oulu	Kemi	Tornio
TOTAL TRAFFIC (t)	**2 095 000**	**5 799 000**	**411 000**	**6 112 000**	**3 203 000**	**1 825 000**	**2 138 000**
International traffic (t)	1 510 000	5 785 000	408 000	5 526 000	2 825 000	1 816 000	1 959 000
Import	1 034 000	1 764 000	123 000	4 624 000	1 463 000	721 000	1 205 000
Export	476 000	4 021 000	285 000	902 000	1 363 000	1 095 000	754 000
Domestic traffic (t)	148 000	555 000	3 000	677 000	776 000	379 000	5 000
International cargo traffic by types of cargo (t)							
Dry bulk	400 000	4 710 000	55 000	4 666 000	751 000	440 000	1 080 000
Liquid bulk	169 000	544 000	4 000	50 000	1 018 000	128 000	92 000
Oil products	**26 000**	**69 000**	**0**	**0**	**95 000**	**29 000**	**79 000**
Other dry cargo	941 000	530 000	349 000	810 000	1 056 000	1 249 000	787 000
Number of transport units (international)							
Containers (TEU)	1 000	12 200	0	4 700	29 000	4 600	13 600
Cars	0	0	0	0	0	0	0
Buses	0	0	0	0	0	0	0
Trucks and trailers	0	0	0	0	1 300	200	0
Train wagons	0	0	0	0	0	0	0
Passengers (international)	0	0	0	0	0	1 800	0
Ship calls (total)	380	580	110	730	520	430	430
Main commodities							
Imports	Timber	Crude minerals	Crude minerals	Ores and manufactures	Chemicals and cements	Timber	Ores and manufactures
Exports	Wood products	Ores and manufactures	Wood products	metals and metal products	Wood products	Wood products	metals and metal products

Figure 6: Transports in Finnish ports in Bothnian Bay (tons/a), main types of cargo and commodities in 2010. Red columns illustrate ports that have more imports than exports and blue columns stand for mainly exporting ports. (Baltic port list 2011).

Kaskinen is facing changes in the future. Industrial activity in Kaskinen has decreased in past years. Currently Kaskinen is still importing raw wood and exporting wood products. A new opportunity is the Mid-Nordic Corridor. Due to the unused capacity in the port of Kaskinen, there are possibilities for development. Kaskinen is planning a regular cargo liner to Sundsvall.

Vaasa imports coal and coke and handles general cargo. Vaasa has a regular freight service to Umeå, transporting cars, buses and trucks and trailers. The Vaasa-Umeå connection is also the only passenger traffic service in the Gulf of Bothnia, transporting about 56 500 people in 2010. The connection has great local importance. However, the shipping company declared bankruptcy in November 2011. The line continues operating until further notice.

Pietarsaari is one of the main raw wood importers in Finland. In addition the port imports chemicals. Exports consist mainly of sawn wood and paper products.

Kokkola is currently the only port in the Gulf of Bothnia handling transit traffic to and from Russia. The transit goods are mainly iron pellets transportation from North West Russia through Vartius railroad to Kokkola harbor and onwards. In 2010 the volume of transit traffic was 2,7 million tons, which is about a third of the Finnish transit volume. In addition Kokkola handles local metal industry transports.

Kalajoki (former Rahja) is a small harbor exporting mainly sawn wood.

Raahe harbor imports ores from Luleå to the local steel mill and exports metals and metal products. The route from Luleå to Raahe has regular transportation and it is marked as national interest fairway of Sweden.

Oulu is the third largest container port in the whole Gulf of Bothnia after Rauma and Gävle. In addition, wood products and liquid bulk such as oil products and chemicals are imported. Oulu handles almost the same amount of exports and imports; the main export item is paper.

Most of the *Kemi* imports are raw wood and exports wood products. Northern mining products from Kolari-Pajala were expected to be transported through Kemi but the mining company decided to transport the Pajala products through Narvik in Norway. The other new mining activities in Northern Finland can have an effect since Kemi is the nearest port for several mining sites. More potential growth for the harbor is offered by planned biofuel production plant and carbon dioxide liquefaction project in Kemi area (Viitala 2011).

Tornio is a typical stainless steel and metal industry harbor, importing mainly crude minerals and ores and exporting metals and metal products.

Olkiluoto nuclear power plant has also port facilities.

Sweden

	Gävle	Vallvik	Söderhamn	Skärnäs	Sundsvall	Söråker
TOTAL TRAFFIC (t)	3 928 000	104 000	682 000	834 000	1 995 000	89 000
International traffic (t)	3 269 000	104 000	563 000	834 000	1 962 000	89 000
Import	2 225 000	0	175 000	273 000	935 000	22 000
Export	1 044 000	104 000	388 000	561 000	1 027 000	67 000
Domestic traffic (t)	658 000	0	119 000	0	33 000	0
International cargo traffic by types of cargo (t)						
Dry bulk	1 091 000	0	135 000	209 000	362 000	59 000
Liquid bulk	1 087 000	0	58 000	35 000	563 000	0
Oil products	**713 000**	**0**	**58 000**	**0**	**519 000**	**0**
Other dry cargo	1 092 000	104 000	47 000	5 000	1 070 000	31 000
Number of transport units (international)						
Containers (TEU)	100 000	0	0	0	21000	0
Cars	0	0	0	0	0	0
Buses	0	0	0	0	0	0
Trucks and trailers	0	0	0	0	0	0
Train wagons	0	0	0	0	0	0
Passengers (international)	0	0	0	0	0	0
Ship calls (total)	930	70	190	340	530	50
Main commodity						
	Other dry bulk	Wood products	Wood products	Wood products	Wood products	Wood, Roadsalt

Figure 7: Swedish Ports in South Bothnian Sea 2010 (tons/a), their main cargo types and commodities Red columns illustrate ports that have more imports than exports and blue columns stand for mainly exporting ports. (Baltic port List 2011)

Gävle handles the most containers in the Swedish side of Gulf of Bothnia. It is also the biggest importer of oil products, for example airplane fuels for Arlanda airport. Dry cargo and bulk consists of wood and metal products as well as imports of foodstuff. There are two private ports transporting forest industry products belonging to Gävle port.

Söderhamn is a port consisting of several smaller units handling bulk and forestry products as well as oil products. *Vallvik* is a small private export harbor for pulp wood transport in Söderhamn. There is also a private port for the chemical industry.

Skärnäs terminal in Hudiksvall is a typical private forest industry harbor, specialized in handling the raw materials and products of a paperboard company.

Sundsvall is the second largest importer of oil products in Gulf of Bothnia. Most of the transports are however wood and wood products. Sundsvall also handled 21 000 TEU of containerized goods in 2010. In addition to the pier owned by Sundsvall Hamn AB, the port has several small private units handling forest industry products, raw materials and bulk. Söråker handles mainly dry bulk and forestry products.

	Härnösand	Lugnvik	Bollsta (bruk)	Örnsköldsvik	Husum	Rundvik
TOTAL TRAFFIC (t)	103 000	59 000	108 000	1 061 000	1 879 000	82 000
International traffic (t)	103 000	59 000	108 000	882 000	1 789 000	70 000
Import	59 000	0	0	592 000	989 000	0
Export	44 000	59 000	108 000	290 000	800 000	70 000
Domestic traffic (t)	0	0	0	179 000	90 000	12 000
International cargo traffic by types of cargo (t)						
Dry bulk	37 000	0	0	65 000	133 000	70 000
Liquid bulk	39 000	0	0	79 000	16 000	0
Oil products	**35 000**	**0**	**0**	**16 000**	**0**	**0**
Other dry cargo	27 000	59 000	108 000	917 000	1 640 000	0
Number of transport units (international)						
Containers (TEU)	0	0	0	0	0	0
Cars	0	0	0	0	0	0
Buses	0	0	0	0	0	0
Trucks and trailers	0	0	0	0	14 600	0
Train wagons	0	0	0	0	0	0
Passengers (international)	0	0	0	0	0	0
Ship calls (total)	30	..	..	260	510	50
Main commodity						
	Oil products	Wood products	Wood products	Wood products	Wood products	Other dry bulk

Figure 8: Swedish ports in North Bothnian Sea 2010 (tons/a), main cargo types and commodities. Red columns illustrate ports that have more imports than exports and blue columns stand for mainly exporting ports. (Holma et al, 2011).

	Umeå	Skellefteå	Piteå	Luleå	Billerud karlsborg	Kalix
TOTAL TRAFFIC (t)	1 772 000	1 535 000	1 568 000	9 287 000	135 000	184 000
International traffic (t)	1 615 000	1 348 000	1 508 000	6 313 000	135 000	184 000
Import	665 000	693 000	833 000	2 087 000	22 000	184 000
Export	950 000	655 000	675 000	4 226 000	112 000	0
Domestic traffic (t)	157 000	187 000	60 000	2 974 000	0	0
International cargo traffic by types of cargo (t)						
Dry bulk	92 000	862 000	700 000	5 781 000	4 000	50 000
Liquid bulk	242 000	330 000	133 000	249 000	19 000	0
Oil products	**242 000**	**6 000**	**130 000**	**217 000**	**0**	**0**
Other dry cargo	1 281 000	156 000	675 000	283 000	111 000	134 000
Number of transport units (international)						
Containers (TEU)	17 600	0	900	0	0	0
Cars	15 900	0	100	0	0	0
Buses	100	0	0	0	0	0
Trucks and trailers	10 300	0	100	600	0	0
Train wagons	0	0	0	0	0	0
Passengers (international)	68 300	0	..	1 500	0	0
Ship calls (total)	870	290	320	680	..	70
Main commodity						
	Wood products	Other dry bulk	Other dry cargo	Ores and metal waste	Wood products	Other dry cargo

Figure 9: Swedish ports in Bothnian Bay 2010 (tons/a), main cargo types and commodities Red columns illustrate ports that have more imports than exports and blue columns stand for mainly exporting ports. (Baltic port List 2011)

Härnösand has oil storage facilities and it imported 35 000 tons of oil products in 2010. Before 2009 Härnösand had a regular RoRo-connection to port of Kaskinen in Finland but this line does not have service anymore. Härnösand port is owned by Härnösands municipality but port is managed and operated by the company owning Söråker port.

Lugnvik and *Bollsta (Bruk)* in Ångermanälven are small private wood products exporters.

Örnsköldsvik handles mainly sawn wood and other bulk goods. There is also transportation of building materials for wind parks construction. A biofuel production plant in Örnsköldsvik produces ethanol from black liqueur wood pulp and paper mill waste. Örnsköldsvik also imports ethanol from Brazil for distribution to Swedish markets (Dahlbacka, 2009).

Husum is a large industrial harbor concentrated on forest industry, wood and paper products.

Rundvik is a small private industrial port of a company producing and exporting different types of sawn goods.

Umeå exports mainly forestry products and imports a substantial amount of oil products for further distribution. The passenger/unitized cargo ship RG-Line operates between Umeå and Vaasa.

Skellefteå has chemicals and oil products transported for industries as well as pellets imported for the local energy company. There is also a metal and other industrial waste recycling company, importing waste material and exporting recycled materials. Skellefteå has a regular cargo line to England.

Piteå is a traditional forest industry harbor importing raw materials and exporting wood products and paper. Future plans include a new factory building cement parts for wind power plants, which would require investments for the port, for example lengthening of piers. Piteå has experience in transporting materials for wind power construction sites. The port has a regular Ro-Ro connection to England and Germany. There is also a fuel terminal and a biodiesel factory in the area.

Luleå is one of the five biggest Swedish ports and the largest bulk harbor. The other end of the Swedish iron ore railway (Malmbanan) is in Luleå, running through main mining sites to Narvik in Norway. There is also a cement factory in Luleå and a pier for ice breakers operating in Bothnian Bay.

Kalix/Billerud Karlsborg is forestry products harbor handling raw wood and sawn wood. The industry pier handles pulp wood and paper for Billerud factory.

Skellefteå, Piteå, Luleå and Kalix have a cooperation project called North Sweden Sea Port. The aim is to enhance the northern shipping competition to benefit the industries and society and coordinate ice breaking and Northern cargo line services.

In addition to the abovementioned ports there is a port in *Forsmark nuclear power plant*.

2.5.1 Priority Ports

Strategically and nationally important ports have been identified in Sweden. The strategic ports include Sundsvall, Gävle and Luleå in Bothnian Sea area (Regeringskansliet, 2007). The Swedish National interest harbor list is longer. The list includes the ports that:

- Belong to European Commissions Trans-European Transport Networks (TEN-T)
- Show remarkable growth during the last five year period: increase of 100 000 tons of cargo or 200 000 passengers per year.
- Is essential for the country's transport: transporting the goods by some other mode or through another port would compromise the public interest.

The ports that fulfill the above criteria in Sweden are **Forsmark Nuclear power plant, Gävle, Söderhamn/Ljusne/Orrskär, Söderhamn, Örnsköldsvik, Sundsvall, Skellefteå, Umeå, Luleå and Piteå.**

National priority ports and fairways of Finland are the ports that fulfill the TEN-T criteria and the fairways leading to those. They include:

- Ports with cargo volumes more than 1,5Mt/year or 0,2 million passengers/year
- Fairways that lead to these ports and winter fairways of the coast
- Saimaa fairway network and ports

- Connection from Saimaa to Gulf of Finland

In the Gulf of Bothnia, the ports that fulfill the above criteria in 2010 were **Rauma, Pori, Pietarsaari, Raahe, Kokkola, Oulu, Kemi and Tornio.**

Baltic Transport Outlook (2011a) has identified "strategic port network" ports for Baltic Sea Region. Principles for choosing the ports were as follows: size and cargo volume of harbor should not be the only criteria used and strategic network should consist of fewer ports than the TEN-T network. The assessment was based on multi-criteria analysis in three phases. The criteria for non-bulk ports were the same as in TEN-T, but for bulk cargo ports the criteria was set six times higher. This means that the smaller TEN-T ports that are mainly concentrated on bulk cargo (such as minerals, oil etc.) were excluded from the analysis on the first round (BTO, 2011a).

Based on the analysis, only two ports qualify to be part of the strategic network in the Gulf of Bothnia. These are Rauma-Pori in Finland, which was considered as a one port entity and industrial port Husum in Sweden, in Örnsköldsvik municipality. The explanation for excluding most of GoB ports in the assessment was that the port infrastructure consists of several small ports scattered along the coastline. Concentration of cargo volumes in certain ports would therefore change the basic settings of the analysis. The potential increase in cargo volumes due to northern mining activities was considered likely to add at least one more port in the list in the Bay of Bothnia.

In the final version of BTO, several ports in Gulf of Bothnia were added due to their connectivity to the strategic railway and road networks. The ports that are part of strategic network for the Gulf of Bothnia are therefore **Rauma, Pori, Vaasa, Kokkola, Oulu and Kemi in Finland and Luleå, Umeå, Husum, Sundsvall and Gävle in Sweden**. Of these Sundsvall and Gävle were specifically mentioned as intermodal terminals.

2.6 Description of transportation developments

2.6.1 Development projects and ports investments in Gulf of Bothnia ports

Several ports have development plans that are justified with the future increase in marine transportation in the Gulf of Bothnia. In appendix B are listed the main development projects for the next years and the main reasons behind these plans. Dredging operations are the most common investments in the area, partly due to the post-glacial land uplift. In the Gulf of Bothnia, the land uplift can be as much as 0,9cm/year. (HELCOM Mariners Routeing guide, 2009).

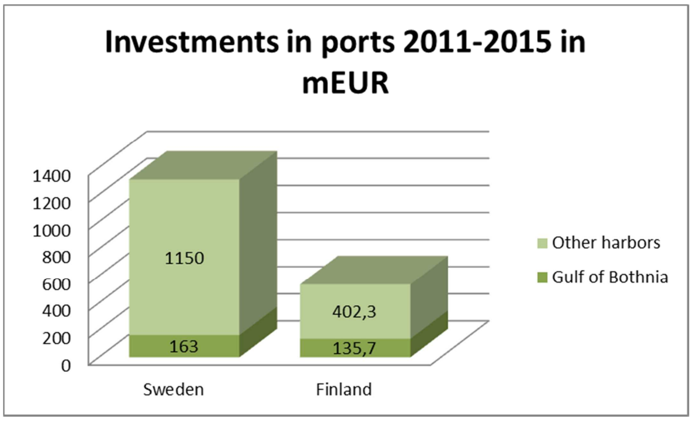

Figure 10: Investments in ports 2011-2015 and the shares of investments in the ports of the Gulf of Bothnia. (Sjöfartsverket, 2011, Karvonen, 2010)

The shares of investments in the ports of the Gulf of Bothnia are presented in figure 9. For Sweden, the investments for northern coast ports during years 2011-2015 are about 163 million euros and this is 12% of all investments planned for Swedish ports during these years. (Sjöfartsverket, 2011). In Finland the planned investments for Gulf of Bothnia ports for 2011-2015 are 135,7 million euros, which is about 25% of all Finnish planned investments for ports. The Finnish figure for the Gulf of Bothnia does not contain investments for private ports.

The largest planned investment in Finland is for Port of Rauma with 66 million euros. Port of Kemi plans to invest about 40 million euros if the mining projects decide to transport goods through Kemi. Port of Kokkola plans to invest about 34 million euros and port of Pori about 26 million euros. Ports of Vaasa and Pietarsaari are also planning to invest over 10 million euros during the next four years (Karvonen, 2010). In Sweden, the greatest investments are planned for ports of Luleå and Gävle (Sjöfartsverket, 2011).

2.6.2 Mining industry transports

Northern Sweden, Finland, Norway and Russia are rich in mineral resources. Mining activities have a long history in the area, yet new deposits are actively explored and found in the area. Increase of raw materials prices and in some cases new technology has also made previously found nonviable deposits extractable (Lahtinen, Hölttä, Kontinen, Niiranen, Nironen, Saalmann, & Sorjonen-Ward, 2011). In global context the quantities mined in Finland and Sweden are relatively small but mines have great importance for the European Union which is dependent on imports of metals and has a strategy to strengthen the domestic sources of raw materials (TEM, 2011a).

Luleå is an important link in mining products transport, as it is connected to iron ore deposits and enrichment plants in Kiruna. Over 90% of ores produced in the European Union area come from Sweden. Ores are transported from Kiruna for example to Raahe steel mill. Raahe has also a recently opened a gold extraction site. Tornio has a stainless steel production unit aiming to double its production by 2015. Kemi has the only chromium mine in the European Union and together with the Tornio smelter it forms an important ferrochrome production area in Europe.

Kokkola in Finland has a zinc processing plant. The plant is part of a Swedish corporation which has extensive gold, silver, copper and zinc operations in Boliden area in Skellefte, a copper mine in Aitik, Gällivaara, zinc-copper mine Garpenberg in Dalarna region and copper, nickel and sulphuric acid plants in Harjavalta. Harjavalta near the port of Pori is an extensive metal industry centre. For example Talvivaara mine in central Finland transports ores to Harjavalta nickel smelter. If all the required permits are obtained, Talvivaara could also begin transporting relatively small amounts of radioactive uranium ore through ports of Oulu or Kokkola.

Dalarna region next to Gävleborg in Sweden has long history with mining industry. In addition to products from Garpenberg, value added stainless steel products are produced in the area. Dannemora iron ore mine in Uppsala region south of Gävle is currently sought to be reopened.

The mining activities and processing plants increase exports in the area but also require extensive amount of imports, such as coal and coke for smelters. Luleå, Pori and Raahe with connections to main metal industry areas are the largest coal and coke importers in the Gulf of Bothnia. The current ore and metal waste transport to and from the Gulf of Bothnia ports is illustrated in figure 10.

New mining projects and Northern railroad projects

The new mining projects in Northern Finland and Sweden are likely to increase transportation if they are realized. Kevitsa Copper-Nickel mine in Sodankylä begins production in 2012. About 5 million tons of ores will be mined yearly and research is being made on expanding the production to 7,5-10 million tons. Another mining company has found potentially the largest nickel deposit in Europe from Viiankiaapa, in the vicinity of Kevitsa. Viiankiaapa is a Natura 2000 protection area, so the realization of this project depends on the stated approval of EU and Finnish governments (Nilsen 2011a). The economic viability of the Rovaniemi-Kirkenes railway is dependent on this project (Lohi, 2012). The existing and potential mining sites as well as proposed new railway connections for transport of the mining products are presented in the figure 11.

A new phosphate mine in Sokli is projected to begin operations in 2014-2015. The current plan is to ship the ores to Kovdor, Russia for processing and onwards through Murmansk Port to Norway (Nilsen 2011b). The iron ore deposits of a mine in Kolari-Pajala extend on both the Finnish and Swedish side of the border. Pajala mining products are planned to be transported to Narvik and onwards via Narvik-Luleå iron ore railway. The same company is considering opening another mine in Hannukainen, Kolari in Finland. The amount or enriched products would add about 2 million tons yearly. Decision on the transport route has not been made but Kolari-Kemi railroad and Port of Kemi is one potential alternative.

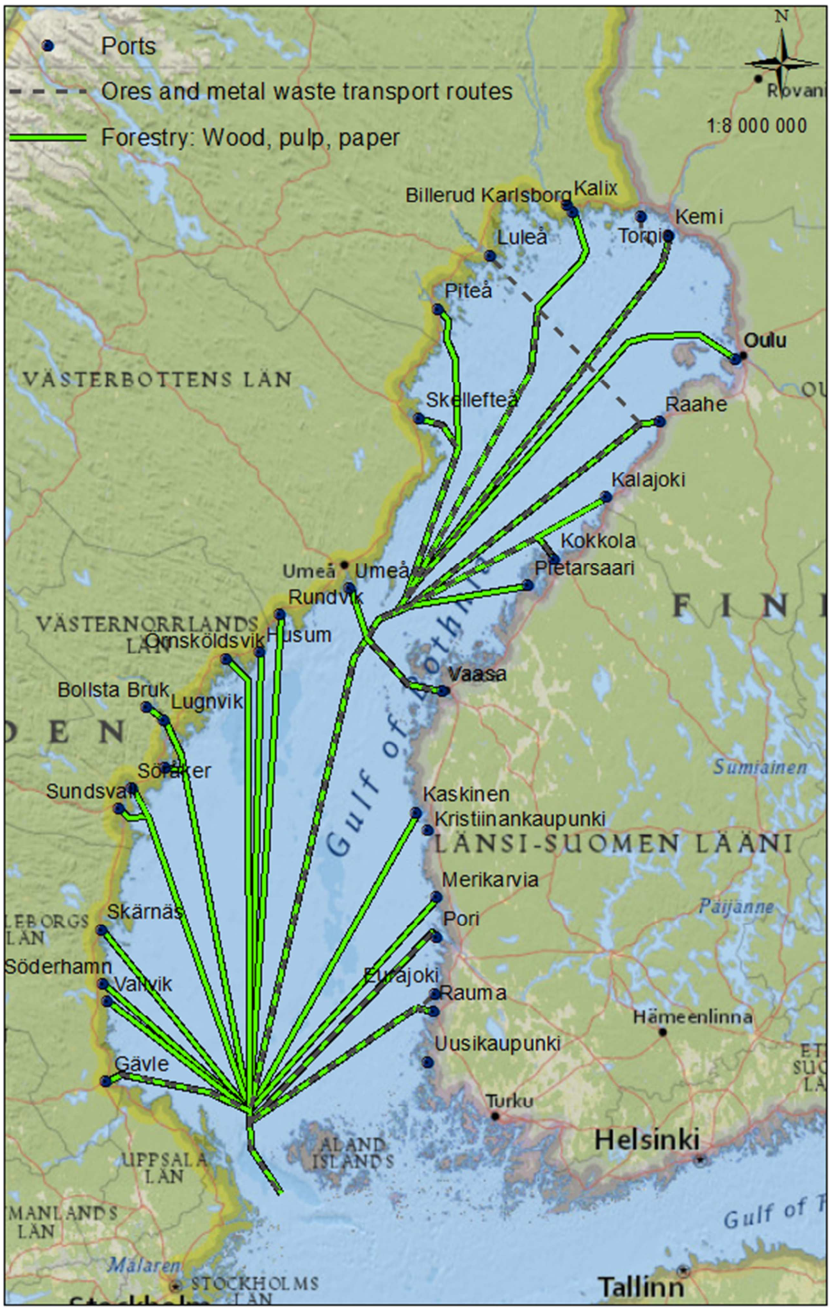

Figure 11: Forestry and mining industry transports in the Gulf of Bothnia 2010 (Baltic port List 2011)

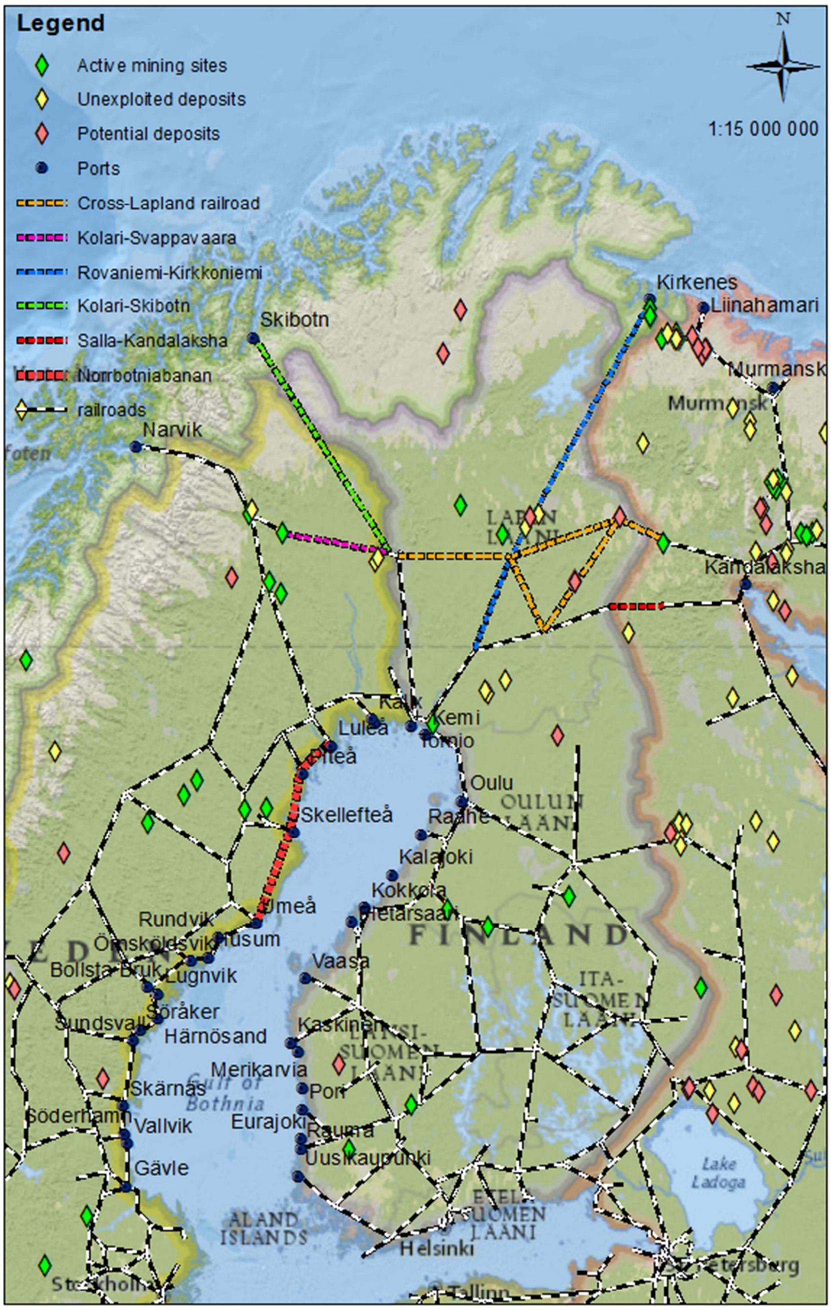

Figure 12: Existing railroads, mining activities in the area and proposed new railroads. (Lohi, 2012, Rautajoki, Oikarinen, Somero & Väyrynen, 2007, Mid-Lapland railroad, 2011, Corneliussen & Allertsen, 2009, Trafikverket, 2011b, FODD, 2011, Data on mining sites reproduced with the permission of GTK, SGU, MNRRF, NGU. All rights reserved.)

2.6.3 Forest industry transports

Forest industry transports are the largest commodity group in the Gulf of Bothnia. Forest industry transports include for example wood pulp and paper, pellets and sawn wood. Wood is also used to produce bioenergy and heat with pellets and the latest pilot projects are making biofuels from paper industry waste. These kinds of pilot projects exist in Piteå and Örnsköldsvik and are planned in Kemi and Rauma. Sweden and Finland use mainly domestic wood for production. Raw wood is also imported for example from other Baltic countries or South America.

About 70% of forest industry products of Sweden are transported with ships. Forestry products cover about 10-12% of the value of Swedish exports (Skogsindustrierna, 2011). Most of the Swedish ports in the Gulf of Bothnia are handling wood products. The largest forestry and forestry products ports in Sweden are Örsnköldsvik, Husum, Sundsvall and Umeå. Additionally there are smaller exporters for wood and wood products, such as Skärnäs Terminal, Vallvik, Lugnvik and Bollsta (Bruk). The current forest industry transports are illustrated in figure 10.

According to Iggesund Holmen group (2011), which owns the Skärnäs terminal, the company has recently invested in railway transport and about 35-40% of previous shipments are redirected from sea to rail. This is part of a larger project of forest industries cooperating to increase railway transports. The aim is to redirect about 40% of the exports from sea to rail.

Finland used to get about 20% of its raw wood from Russia, but new customs regulations have made Russian imports economically non-viable. Russian wood was replaced with domestic production and increased imports in 2007-2009. Shipped imports of raw wood have tripled from the year 2000 and it has been assumed that imports from South and North America will increase (Venäläinen & Utriainen, 2009). The ports receiving the raw wood transports are largely in the Gulf of Bothnia area; Rauma, Kemi, Kaskinen and Pietarsaari are mainly importing timber. FTA has made a report on raw wood transports in Finland after the Russian customs regulations changed the supply paths. According to this report, timber transports in Kaskinen are likely to reduce as the raw wood terminal along the railroad will only be used as long it does not need further investments. On the other hand, fairway to port of Pietarsaari is planned to be dredged deeper in near future due to projected imports of raw wood (Iikkanen & Sirkiä, 2011). The situation could change as Russia joins the World Trade Organization in 2012. This will enhance the economic cooperation between EU countries and Russia substantially and lower tariffs for imports and exports. The adaptation period for lower tariffs will however take several years (WTO 2011).

2.6.4 Domestic traffic

In Sweden domestic transports totaled 4,5 million tons and the largest ports handling the domestic traffic were Luleå (67% of all domestic cargo volume) and Gävle (15% of volume). Domestic transports in Luleå were mostly iron ores, sand and gravel and petroleum products. Domestic traffic cargo volume in Finland was 3,9 million tons. Volumes were distributed more evenly between the ports than in Sweden. The five ports handling the most domestic transports were Oulu (20%), Pori (19%), Raahe (17%), Kokkola (14%) and Vaasa (10%) (Holma et al, 2011). Domestic transport in the Gulf of Bothnia ports is illustrated in figure 12. Domestic transport is not considered in the scenarios, although it can have considerable local effects, as in the case of Luleå. It is however likely that greatest changes in transport volumes will be due to international transport.

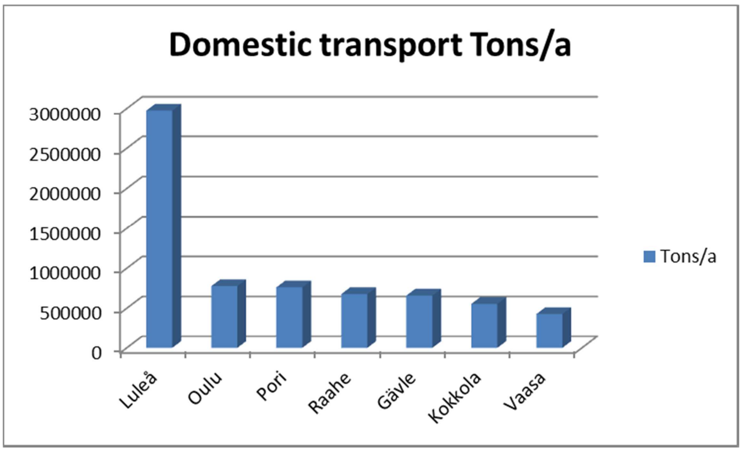

Figure 13: Ports handling domestic tranport. (Baltic Port List 2011)

2.6.5 Transit traffic

The only port currently handling Russian transit transports is Port of Kokkola. The amount of transit cargo handled in Kokkola in 2010 was about 2,7 million tons. The cargo handled is mainly Russian exports, consisting of iron pellets from Kostomuksha and smaller amount of aluminum clay imports to Russia. According to a report of current status and future of Transit in Finland (Sundberg et al, 2010), transit traffic through Finland is considered a competitive route and transit transports can be expect to remain in Finland even if most of Russian transports are directed in domestic ports.

2.6.6 Container and other unitized cargo transport

Rauma and Gävle were the largest container ports by far. There is also constant container transportation between these two ports. When it comes to other transport units, Vaasa and Umeå were the major transporters for cars (10 000), buses (100) and trucks and trailers (15 000 units) in 2010. Oulu is the largest container port in Bay of Bothnia. However, the amount of containers handled in all of the ports of Gulf of Bothnia is similar to the amount Port of Helsinki alone handled in 2010 (Baltic Port List 2011). The current amount of containers transported in the Gulf of Bothnia ports in illustrated in figure 13.

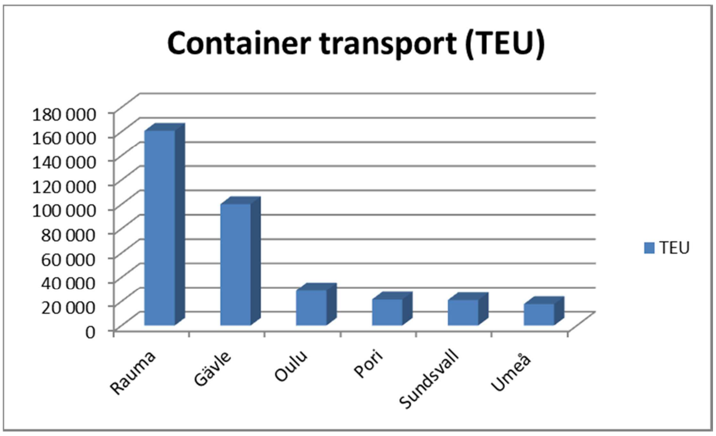

Figure 14: Container transport in Gulf of Bothnia 2010 by Twenty-foot Equivalent Unit (TEU) (Baltic port List 2011)

It has been estimated that within the Baltic Sea context, great growth for transports can be expected for unitized cargo, as intermodal transport chains develop further (Meriläinen, Mäenpää, Kunnas, Lundberg, Ramstedt, Quistgaard, Isberg, 2010). Transbaltic scenarios and oversight –report (2010) mentions increasing container transports from overseas as one of the likely drivers of transports in the Baltic Sea area. It also considers the effects of North Sea Route and growth of the Barents Region to be possible factors for development in Baltic Sea transport. Global warming can ease the ice conditions in Northern Sea route as multi-year ice packs disappear from the Arctic Ocean. The Northern sea route could shorten the navigation time for example from Rotterdam to Yokohama with as much as 10 days (Liu & Kronbak 2010).

2.6.7 Nuclear power plants and radioactive cargo

There is a nuclear power plant in Forsmark in Sweden with three reactors. The nuclear power plant has been operational for 30 years. There is also a nationally important geological storage for nuclear waste in Forsmark area (Vattenfall, 2011).

Olkiluoto in Finland has 2 reactors and third one is currently being built. The owners of Olkiluoto reactors have also left an application for fourth reactor to Finnish Parliament in 2008 and it was approved in 2010. Olkiluoto reactors are owned largely by Finnish energy and forestry industries. Uranium for the reactors is imported and a geological storage for nuclear waste is currently built in Olkiluoto. (TEM, 2011b) Due to building projects there is regular maritime transportation in Olkiluoto.

Nuclear waste is transported by sea in Sweden and Finland. Sweden has a special ship, MS Sigyn, for nuclear transports which also operates in Finland when needed (Jalovaara, 2011). Swedish nuclear waste is currently handled and stored in two places: Oskarshamn has a temporary storage for higher radioactivity nuclear fuel and waste with lower radioactivity is handled in Forsmark (SKB, 2012). Finland has temporary storages for high activity waste in the power plant areas. In future also the nuclear waste from Loviisa reactors in Gulf of Finland will be transported to Olkiluoto or Rauma, to be placed in the geological storage. (Jalovaara, 2011)

The nuclear transports in the Gulf of Bothnia are generally rare but mentioned here due to their special status and the risks associated with the transport. Radioactive transports could get slightly more common if Talvivaara nickel mine begins to sell uranium as side product. Talvivaara received permit to sell uranium in 2011 and is currently waiting for other governmental approvals for production. The uranium ore production would be relatively small in Talvivaara: 350 tons/year. The ore would be transported through Port of Oulu or Kokkola. Sweden has large deposits compared to Finland, but the Swedish Uranium concentration of ores is not currently economically viable. The new nuclear power plant project in Bothnian Bay, Pyhäjoki, will begin operating at the earliest in 2020. This project will potentially increase radioactive transports in the Gulf of Bothnia in the future (Fennovoima, 2012).

2.6.8 Liquid bulk: Oil products and chemicals transport in the Gulf of Bothnia

Oil transports development

Oil transports within the Gulf of Bothnia consisted mainly of oil products i.e. no raw oil was transported to or from the Gulf of Bothnia ports. The liquid bulk transport in the Gulf of Bothnia ports is illustrated in figure 14 and the amounts of oil products transported are presented in table 5.

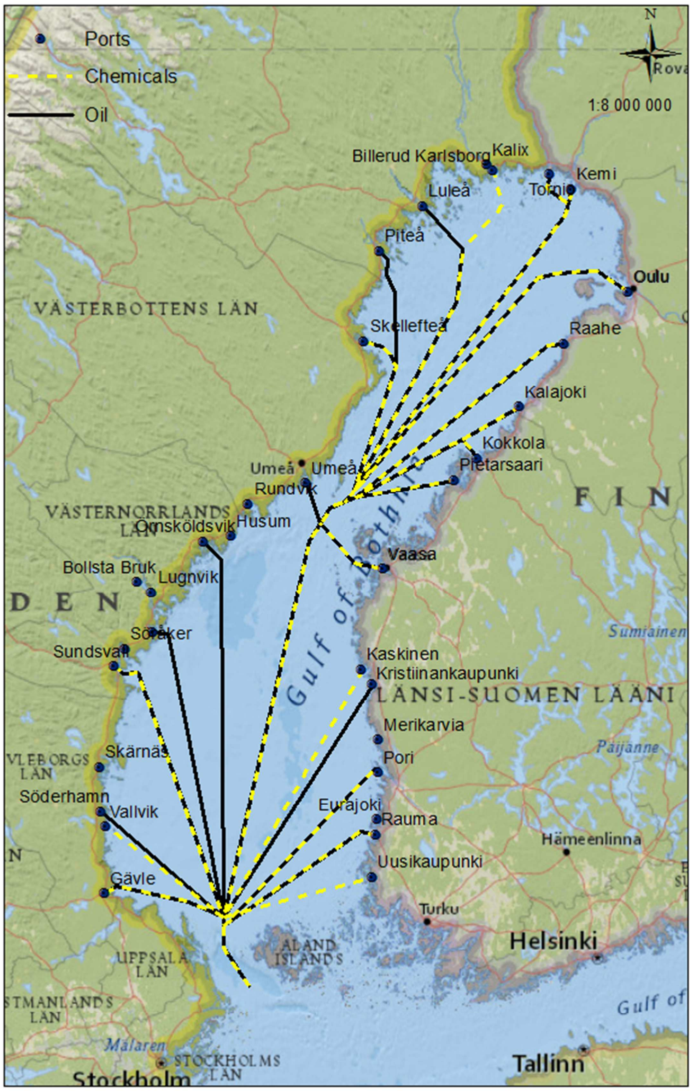

Figure 15: Liquid bulk transports in the Gulf of Bothnia 2010 (Baltic Port List 2011)

Of all oil product transports in the Gulf of Bothnia 93.6% were imports. Only 59 000 tons of oil products were exported from Finnish ports and 96 000 tons from Swedish ports. If the Swedish targets of all cars running with biofuels in 2030 (Dahlbacka, 2009), were realized, impacts on oil transport volumes in some ports could be expected. If LNG-powered ships become more common in Baltic Sea, this could also have effects on oil transport. The oil transportation would decrease as there would be a significant drop in crude oil usage of ships.

Table 5: Oil transports in the Gulf of Bothnia (Baltic port List 2011)

GoB oil and oil products transports			
Ports: Sweden	**tons/a**	**Ports: Finland**	**tons/a**
Gävle	713 000	Pori	130 000
Sundsvall	519 000	Oulu	95 000
Umeå	242 000	Tornio	79 000
Luleå	217 000	Kokkola	69 000
Piteå	130000	Rauma	36 000
Söderhamn	47000	Kemi	27 000
Härnösand	35000	Pietarsaari	26 000
Örnsköldsvik	16000	Vaasa	16 000
Skellefteå	6000	Kristiinankaupunki	9 000
Total	**1 925 000**	**Total**	**487 000**

Chemical transports development

Chemical transports in the Gulf of Bothnia consist of mainly caustic soda, tall oil, ethanol and sulphuric acid (Hänninen & Rytkönen, 2006). Oulu, Pori, Kokkola, Skellefteå and Gävle were largest liquid chemicals transporters in 2010. Biofuels getting more common could increase the transportation of certain liquid chemicals, such as tall oil and ethanol. Ethanol is needed for biofuel production and tall oil is currently used to produce biodiesel in Piteå. Sulphuric acid transports could increase if new nickel smelters would be built in the area due to newly found nickel deposits.

2.6.9 European Union projects developing transport chains

Important projects and programmes concerning Maritime Transport and Traffic chains are presented below, as they are likely to contribute to future developments within the research area.

TEN-T

TEN-T projects aim to build the missing links and remove the bottlenecks in the European Union transport infrastructure and ensure the sustainability of transport networks. TEN-T consist of 30 priority projects, one of which is the Motorways of the Sea, which has a great role in the Baltic Sea Maritime transport development. TEN-T offers different kinds of financial instruments, loans and grants, for implementation of the TEN-T priority projects (EC Mobility and Transport, 2011).

Mona Lisa

Mona Lisa (Motorways and Electronic Navigation by Intelligence at sea) project aims to develop Motorways of the Sea concept in Baltic Sea and contribute to EU's strategy for Baltic Sea. The project is funded by TEN-T and it is one the 21 projects that make up the Motorways of the Seas priority project. In the Gulf of Bothnia context, Green corridors and Baltic fairway re-survey are under focus in the Mona Lisa project. Mona Lisa contributes also to development of e-navigation applications and optimized shipping routes to reduce emissions, basically offering the ships a possibility to make the shortest possible route plan. Lead partner of the project is Swedish Maritime Administration.

The Baltic Sea Harmonized re-Survey scheme was requested already in HELCOM Copenhagen 2001 Ministerial Declaration. The scope of the re-survey scheme was widened in Moscow 2010 Ministerial Declaration. Mona Lisa is speeding up this Baltic Sea -wide process in the Bothnian Sea area (Finnish Transport Agency 2011c).

MidNordic green corridor

Green Corridors is an EU initiative to promote sustainable logistics and transport corridors. North East Cargo Link II (NECL) —project aims to develop and promote the Mid-Nordic Green corridor and intermodal connections across Bothnian Sea in East-West direction. The project is funded by European Union Regional Development fund and European neighborhood and partnership instrument. The partners include transport agencies and regional actors in Finland, Sweden and Norway.

The corridor begins from Norway and continues through Sweden and Finland towards Russia and Asia. If the project is successful, the cross-Bothnian Sea marine traffic could increase across the Quark. (NECL II, 2011). NECL II studies the investments to ports and hinterland connections of Kaskinen and Vaasa in Finland and Örnsköldsvik and Sundsvall in Sweden. As an example, the port of Kaskinen has ordered a feasibility study for cargo liner between Kaskinen and Sundsvall.

Bothnian corridor

The Bothnian corridor railway transport route is currently under development. Running along the coast around the Bothnian Bay it strengthens the North-South connections. The Bothnian corridor includes 11 ports on the Finnish side and 14 on the Swedish side as "secondary transport network"-ports enhancing the intermodal transport chains. Ten of these Ports (Rauma, Pori, Kaskinen, Vaasa, Pietarsaari, Kokkola, Raahe, Oulu, Kemi and Tornio) are located in the research area on the Finnish side and nine (Gävle, Söderhamn, Sundsvall, Örnsköldsvik, Umeå. Skellefteå, Piteå, Luleå and Kalix) are on the Swedish side. These ports could benefit from the increasing transports through Bothnian corridor railway, and the maritime traffic to and from these ports would grow correspondingly (Meriläinen et al, 2010).

3 METHODOLOGY

3.1 Methodology for Future Scenarios

Höjer (2000, 16) states, that "the choice of methodology is a reflection of the aim of the study." He then presents three methodologies, namely backcasting, forecasting and explorative scenario technique and describes where these methodologies can be best applied.

Backcasting is generally described as a method where the first step is setting targets for the future. The image of a future where these targets are fulfilled is then compared to forecast of the future. If future forecast does not fulfill these set targets, it is necessary to create alternative scenarios about how the targets could be reached. According to Höjer (2000, 16): "Backcasting is motivated when there is a target, when forecasts indicate that this target will not be met, and when the changes needed to reach the targets seem to be beyond the scope of current policy." Basically, backcasting aims to describe an issue and find a solution for it by preparing alternative scenarios.

Forecasting is the more traditional form of future studies. In simplest form, it can be made for example by extrapolation of past development into the future. This method is used especially in forecasts for economic development and examples are often from business studies. For long-term forecasts, scenario methods are commonly utilized. Scenario methods aim for a more holistic point of view than linear extrapolation and they can be considered as a "softer" method than other forecasting methods. Scenarios can be a description of future development path or description of the future state, a so called "image of the future" (Höjer, 2000, 10). Forecasting aims to answer a question "What will or will not happen", by researching external factors that have an effect on the studied topic.

The third methodology presented by Höjer (2000, 16) is **Explorative scenario techniques**, that are "…appropriate when the character of the external factors is known but the uncertainty of their values is great."

There is in fact not a great variety of strict methods available for each specific field of future studies. Predictions or forecasts for future are often made using a combination of existing methods, adapted specifically for the topic under research. For example Höjer (2000) used a self-developed method in a study he calls a “Backcasting Delphi study” to find out potential paths of development for sustainable urban transport systems.

For this study, a combination of methodologies is also used, and it could be called a forecasting Delphi study. From the three methodologies presented above, the explorative scenario technique is chosen as the external factors affecting the future of maritime transports in the Gulf of Bothnia are quite well known, but there is great uncertainty concerning them. Carlsson-Kanyama (et al, 2008) pairs the explorative approach with normative approach as the methods that can be used for studying *possible* or *desirable* futures, in contrast for studying *probable* futures by forecasting methods. The explorative approach aims to answer to the question “what could happen” and normative approach to the question “how a solution to a particular problem might look”.

3.1.1 Part I

Firstly, in order to make the forecasted future scenarios, following topics were studied:

- Current situation -Maritime transportation in the Gulf of Bothnia in 2010
- Economic development
- Development of key industries
- Development of infrastructure in the Gulf of Bothnia
- Existing scenarios

All of these topics were not researched in detail here but information was gathered from existing studies, plans and strategies and development of different industries to construct scenarios for Maritime Transport in the Gulf of Bothnia in 2030.

Part I of this study aims to answer the question: How much the cargo volumes could grow in the Gulf of Bothnia. The future scenarios were constructed by means of forecasting, applying existing quantitative scenario for maritime transport made by Baltic Maritime Outlook (2006) for the Bothnian Sea context. Basically, new scenarios were not prepared but the GoB-specific scenarios are based on combining existing scenarios and analysis of other relevant factors. The cargo volume scenarios obtained in this way are:

- Strong growth scenario
- Average growth scenario
- Modest growth scenario

As the BMO scenario was only made until 2020, the scenarios for the Bothnian Sea were continued until 2030 by making a few assumptions based on Finnish Maritime Administration scenario for Finnish Maritime Transports (2006). Such assumptions were for example that the development of Finnish exports follows the development of GDP from 2020-2030. A further assumption was made that this is true also for Sweden.

The existing scenarios were further adjusted for the Bothnian Sea by combining the possible futures of certain key factors, such as transit traffic (Scenario by Finnish Maritime Administration, 2006) and modal shift forecasts (Scenario based on ENTEC 2010). This type of methodology has been previously used by Kuronen et al. (2006) to prepare future scenarios for Gulf of Finland. The cargo volumes of the scenarios were assessed by an expert panel, to find out the margins for the scenarios. In this study, the role of the expert panel was extended as described below in part II.

3.1.2 Part II

Rubin (2004) writes: „Even though quantitative methods have traditionally been used to produce models of one future without alternatives, it is possible to use the produced results to build different alternative scenarios, or combine both quantitative and qualitative methods for the same purpose. On the point where quantitative methods produce forecasts that are unambiguous and punctual, but at the same time limited at some degree and inflexible, qualitative methods bring about images of the future which are more ambiguous and perhaps somewhat unpunctual, but also flexible, descriptive and wide and point at alternatives between images rather than at details within them“.

As cargo volume scenarios do not consider and answer the question about what causes the changes and what are the spatial implications, part II of the study aimed to identify and assess key factors for development and what kind of spatial developments they could cause in the Gulf of Bothnia. The key factors were identified by literature review, telephone and e-mail interviews as well as the group work discussions about Maritime transport in the Bothnian Sea in Plan Bothnia MSP 3 meeting in Helsinki. The probability and significance of identified key factors were assessed using Real-Time Delphi method, described by Gordon & Pease (2006). As the future scenarios serve as background material for marine spatial planning, it is important to ensure stakeholder participation and expert views in evaluating the probability and significance of key factors as well as general quality of different scenarios. Delphi method gives the stakeholders an opportunity to express their personal ideas and opinions more freely, as the panel is anonymous and panelists do not know who the other participants are. The aim is that also the more delicate opinions and speculations that would not necessarily be expressed in a regular round-table stakeholder meeting can be considered.

Real Time Delphi-method differs from the traditional Delphi-method mainly in number of questionnaire rounds. While the traditional Delphi is often done in three or more rounds to reach consensus, Real time Delphi requires only one round and the goal can be getting new ideas concerning future developments and not necessarily reaching consensus. It is more efficient and fast way of conducting a Delphi study than the traditional Delphi method. The expert group is also somewhat smaller than in traditional Delphi. According to Gordon & Pease (2006) RT Delphi expert group can consist of about 10-15 panelists in contrast to recommended 20-50 for traditional Delphi. The panelists receive a report of the answers of other participants immediately after answering and they are encouraged to comment and elaborate on their arguments.

Panelists were chosen based on a panel table with three interest groups and four groups of expertise. One panelist could belong to more than one group. The panel structure is presented in table 14.

The panelists were asked to assess the probability and significance of the 18 key factors as well as the quantitative cargo volume scenarios constructed during phase I. The theses were formed in a way that aimed to raise discussion over the key factors. The panelists were asked to provide comments to support their choice as well as mention if the effects concentrate on a specific port/area in the Gulf of Bothnia, to get data that could be interpreted in spatial form. The Delphi round was made with an internet based open source program developed specifically for conducting Delphi studies (www.edelphi.fi). The panel website is available in the address http://www.edelphi.fi/en/groups/maritime/content/index and the panel theses and themes are presented in detail in appendix B.

Based on the results from the Delphi-round, a futures table was constructed to serve as a basis for scenario building. The table is presented in appendix A. Using futures tables for scenario building is an analysis method described by Seppälä in his book „84 thousand futures“ (1984). The idea is to identify the developments that cannot exist simultaneously and construct scenarios that do not contain conflicting elements. The aim is that the scenarios seem plausible and relevant for those who use them and to find out what could be the implications of probable future developments for Marine Spatial Planning. The futures table was constructed by making a matrix of the comments received during the RT-Delphi round and marking whether or not the described events and ideas

- Support each other (Green color)
- Do not have considerable effect on each other (Orange color)
- Cannot coexist at the same time or in the same scenario (Red color)

The scenarios were then built by following paths in the matrix and finding possible combinations of the events and ideas described by the panelists.

4 PART I: FORECASTED CARGO VOLUME SCENARIOS

4.1 Existing scenarios

As for the forecasted Gulf of Bothnia-specific cargo volume scenarios are based on existing large scale maritime transport scenarios, their main findings are described here briefly.

4.1.1 FMA Scenario

The figures for development of transit traffic, as well as some general assumptions for continuing the scenarios until 2030, are obtained from the scenarios published by FMA in 2006 (Lehto, Venäläinen & Hietala, 2006). The scenarios are based on econometric modeling and are a relatively traditional future forecast based on external factors. The data used was time series of maritime transport 1981-2005 provided by Finnish Maritime Administration, development scenarios of Finnish Gross Domestic Production (GDP), energy use scenarios and the estimated relationship between GDP and export volumes (Lehto et al, 2006). International maritime transports were divided in three groups: 1) transport of oil energy products and fuels, 2) transit traffic and 3) other marine transports. The development of these three groups was considered to be dependent on different factors and was therefore forecasted separately.

The average growth of GDP per year is considered to be 2.37 %, but growth slows down in the end of the timeline. Portion of exports from GDP is expected to grow from 39% in 2005 to 49% in 2020 and stay on that level until 2030.

This scenario also divided the projected transport volumes to regions, based on their current shares of transports. Most of exports were thought to be processed forestry products and general cargo. The share of ores and minerals of future exports in the Gulf of Bothnia was quite low in this scenario. The numbers do not show for example the future increase caused by new mining projects in Northern Finland, due to the mechanical calculations based on the shares of transports in 2005. Imports were mainly ores and minerals, general cargo and energy products and fuel.

The economic crisis has altered the picture since the scenarios were made. Recent development of exports has been the opposite as predicted in the scenario and the share of exports of the GDP is currently about 29% (Tilastokeskus, 2011). Also, the projected average GDP growth for 2012-2015 is only 1,9%. GDP is projected to drop to 1,6% in 2015 whereas according to the 2006 minimum scenario this low growth was supposed to occur in 2025. Therefore the growth scenario of FMA is fairly optimistic considering the current situation.

Tables 6 and 7 are scenarios based on FMA report and were calculated to serve as comparison for the quantitative scenarios made in this study. The scenarios were made in 2006 and what the situation would be in 2010 was calculated as follows: In table 6, the numbers for "2010 (Realized)" are the actual cargo volumes for 2010 published by Finnish Transport Agency. The numbers for "2010 (Scenario)" based on FMA forecasts are calculated by the following formula:

$$a+((b-a)/t*y)=c$$

where:
a=volumes in 2005
b=volumes in 2030
t=total years (25)
y=years from 2005 to 2010

The growth is assumed to be linear through the years. Transit growth had five different scenarios for the year 2030. From these the one labeled "WSP" was chosen as it yielded the volume that was closest to the realized transit volumes in 2010, calculated with the formula presented above. The WSP-scenario for transit was a consultant estimate of the growth of each commodity group.

For Table 7, the share of the Gulf of Bothnia ports is calculated by dividing the volumes of FMA scenario for 2010 and 2030 by the realized shares of its ports in 2010. In the FMA 2006 Scenario all figures were presented without transit traffic, which was calculated separately. The realized figures for 2010 are presented in the same way below; the realized transit traffic has been reduced from total international import and export volumes and presented separately.

Table 6: International transports in Finland 2030 according to FMA (2006)

Finland in 2010 and 2030 following the FMA scenario (Mt/year)				
	Imports	Exports	Transit	Total
2010 (Realized)	49,43426	36,43688	7,4	93,27114
2010 (Scenario)	52,396	41,624	7,76	101,78
2030 (Scenario)	73,34	60,56	14,67	148,57

Table 7: International transports in the Gulf of Bothnia 2030 according to FMA (2006)

The Gulf of Bothnia in 2010 and 2030 following the FMA scenario and % of transports in GoB ports in 2010. Mt/year				
	Imports	Exports	Transit	Total
2010(Realized)	17,64253	12,99314	2,69	33,32567
2010(Scenario)	18,69954	14,84283	2,7936	36,33597
2030(Scenario)	26,17422	21,59527	5,2812	53,05069

4.1.2 Baltic Maritime Outlook scenario

This scenario was used as the main basis for the forecasted scenarios of this study. The Baltic Maritime Outlook used forecasts for GDP, exports and imports and elasticity for different commodity group transports as a basis for the scenarios. Maritime transport in 2003 was used as the baseline data. Three scenarios were formed, the baseline scenario, where TEN-T network is operational and fuel prices increase 3% per year, a scenario for the situation where the competitiveness of transport increases and a scenario for increasing container traffic and road fees (Kuronen et al. 2006). The results of Baltic Maritime Outlook Scenario for the year 2020 are presented below in table 8.

Table 8: International transports 2020 according to BMO (2006)

BMO SCENARIO for 2020 (Mt/year)			
	Imports	Exports	Total
Finland 2010	66,4	41,4	107,8
Finland 2020	86,8	52,4	139,2
Growth factor	1,027153	1,023842	1,025893

Sweden 2010	80,3	82,6	162,9
Sweden 2020	100,2	97,2	197,4
Growth factor	1,022387	1,016409	1,019395

The figures for Finnish imports are notably larger in BMO scenario than in FMA scenario, already in 2020. The scenario in general suggested great growth in import volumes for both Finland and Sweden. Almost half of the projected Finnish imports for 2020 would come from Russia (46,6%). Russian imports to Finland would not have a great effect for the traffic in the Gulf of Bothnia, unless part of these volumes would continue onwards as transit traffic from Kokkola or to some other Bothnian port.

Swedish imports are projected to come mainly from Norway, Denmark, Russia and Latvia. Part of these Russian and Latvian imports could at some extent be transported through the Gulf of Bothnia, as well and imports from Finland. All imports from these three countries would amount 29% of total imports to Sweden in 2020, but it is unlikely that all imports from these countries would be transported through the Gulf of Bothnia.

Basically for both countries, the projected great increase in imports would not necessarily have major impact on the Gulf of Bothnia’s ports.

4.1.3 BTO scenario

Baltic Transport Outlook (BTO) future scenario is the latest scenario for the Gulf of Bothnia area (2011b). BTO aims to be a comprehensive study of the Baltic Sea Region Transports (BSR). BTO also makes recommendations for management based on the findings. BTO consists of two sets of maps and six different reports for each project task, namely methodology, drivers of demand and supply, scenarios, Strategic network analysis, SWOT analysis and Multi-criteria analysis and transport planning.

The scenarios consist of a baseline model representing one possible future based on population, transport infrastructure and costs and three sensitivity tests based on the transport costs variation. The scenarios were formed with a TRANS-TOOLS model, including 1535 zones across the Europe. The model is a broad strategic model, and it had not been used in this context of analyzing macro-regions before.

BTO scenarios present lower future transport volumes for the Finnish Gulf of Bothnia in 2030 than FMA scenario and BMO scenario. An increase of average 31,4% is predicted for regions surrounding the Gulf of Bothnia compared to 2010. The smallest increase was predicted for Västernorrland, which covers the northern parts of the Bothnian Sea coastline in Sweden. The greatest increase was projected for Ostrobothnia, which is the corresponding coastline in Finnish side and for Gävleborg and Stockholm provinces.

BTO SWOT analysis lists future opportunities for the Baltic Sea Region until 2030. According to the analysis, the strengths of the Finland-Sweden-Norway-North West Russia area are their strong maritime sector for ferry transport and Murmansk port. Opportunities are port bottle neck removal. Weaknesses are that there is no strong hub port in the area and the limited port capacity in Narvik. Overcharging of Port infrastructure due to Asian/intercontinental transit is seen as a threat.

Cooperation with Russia and intermodal transport chains enhancing Asian transit are generally seen as strengths/opportunities. Bothnian corridor is a major opportunity for intermodal transportation. Threats for development are complicated port procedures in Russia and one mentioned weakness for intermodal transport chains are un-harmonized packaging units. Cross-Bothnian connections are mentioned as a weakness, forming a barrier between Finland and Sweden. Problems in cross-Border logistics with Russia are another barrier.

4.2 Results

The scenarios used as a basis for the three cargo volume scenarios were Baltic Maritime Outlook, which was chosen as it presented actual numbers for both Finland and Sweden. This scenario was made only until 2020, so to extend the Gulf of Bothnia scenarios until 2030 a few assumptions were made based on Finnish Maritime Administration Scenario as described below. The magnitude of modal shift in The Gulf of Bothnia was estimated based on ENTEC (2010) report about effects of MARPOL annex VI regulations as well as Swedish Maritime Administrations report on the same topic. Transit traffic estimations for 2030 were taken from FMA scenario.

All these figures were then applied to the Gulf of Bothnia context based on the share of the Gulf of Bothnia ports for all international transports of Finland and Sweden in 2010 (Baltic Port List 2011).

4.2.1 Strong growth

The transports in the Gulf of Bothnia will grow 60% by the year 2030

The figures of the strong growth scenario, presented in table 9, are based on the BMO scenario. However, the starting point (year 2010) has been adjusted so that instead of the BMO scenario figures for the year 2010, the realized cargo volumes of Finland and Sweden have been used as the basis for calculations. The growth factors for the years 2010-2020 is calculated from the original BMO scenario. The growth is assumed to be linear, so the scenario for 2030 has been extrapolated based on the same growth factors as for the decade 2010-2020. The Transit traffic figures have been added based on the "Näkymä-WSP" in the FMA scenario which was an estimate of the growth of each commodity group transport made by consultants. Transit growth had five different scenarios for the year 2030. The "Näkymä-WSP" was chosen as it gave a cargo volume that was closest to the realized transit volumes in 2010, calculated with the formula described above in chapter 4.1.1.

It is assumed that 1 million tons of cargo will be shifted from maritime transport to railways and roads due to MARPOL restrictions in the Gulf of Bothnia area. This figure is estimated based on study prepared by Swedish Maritime Administration Sjöfartsverket (2009).

Table 9: Strong growth scenario for the Gulf of Bothnia 2030

STRONG GROWTH (TOTAL TRANSPORT Mt/year)				
	Import	**Export**	**Total**	**+ Transit**
FI 2010	49,43426	36,43688	85,87114	7,4
FI 2020	64,62189	46,11818	110,74007	
FI 2030	84,47561	58,3718	142,84741	14,67
SWE 2010	84,372	70,624	154,996	
SWE 2020	105,2811	83,10718	188,3883	
SWE 2030	131,372	97,79682	229,16879	

STRONG GROWTH Gulf of Bothnia (Mt/year)	Import	Export	Transit/Modal shift	Total
FI 2010	17,64253	12,99314	2,69	33,32567
FI 2020	22,4238	17,10984		39,53364
FI 2030	29,31303	21,65594	5,2812	56,25017
SWE 2010	9,754	11,18		20,934
SWE 2020	12,46419	12,10325	1Mt modal shift	24,56744
SWE 2030	15,55307	15,10268		30,65576

4.2.2 Average growth

The transports in the Gulf of Bothnia will grow 43% by year 2030.

The average growth scenario is presented in table 10. The figures for the years 2010-2020 have been calculated in the same way as described above. The growth factor for the years 2020-2030 has been estimated as follows:

The FMA scenario predicts that the growth of Finnish exports follows the growth of GDP in 2020-2030. The GDP growth is generally predicted to slow down during the next decade. Finnish Bank estimated in March 2011 that GDP growth for 2011 would be 3,8% and for years 2012-2013 about 2,5%. This estimation has come down in the latest Finnish estimation, which predicts an average growth of 1,9 % for years 2012-2015 (Ministry of Finances 2011). Since these overall estimates have gone down from the time when FMA scenario was made, the minimum scenario of that study is considered to be the average growth scenario here. In FMA scenario, the minimum scenario for the annual GDP growth of Finland for the years 2020-2025 is 1,8% and for the years 2025-2030 1,6%. The average of these (1,7%) has been used as the growth factor for Finnish exports for the decade 2020-2030. The annual growth decreases therefore 26,08% compared to the growth between 2010 and 2020. A robust assumption was made; the growth rates for Finnish imports and exports as well as for Swedish imports and exports react in a similar way. Therefore all growth rates are 26,08% lower than in the strong growth scenario.

For transit, it is estimated that the cargo volumes stay on the same level as in 2010. It is assumed that a modal shift of 2 million tons will occur in Swedish side due to MARPOL regulations in 2010-2020.

Table 10: Average growth Scenario for the Gulf of Bothnia 2030

AVERAGE GROWTH (TOTAL TRANSPORT Mt/year)				
	Import	**Export**	**Total**	**+ Transit**
FI 2010	49,43426	36,43688	85,87114	7,4
FI 2020	64,62189	46,11818	110,7401	
FI 2030	78,8278	54,58605	133,4139	7,4
SWE 2010	84,372	70,624	154,996	
SWE 2020	105,2811	83,10718	188,3883	
SWE 2030	124,0618	93,75653	217,8183	

AVERAGE GROWTH Gulf of Bothnia (Mt/year)				
	Import	**Export**	**Transit/Modal shift**	**Total**
FI 2010	17,64253	12,99314	2,69	33,32567
FI 2020	22,4238	17,10984		39,53364
FI 2030	27,35325	20,25143	2,69	50,29467
SWE 2010	9,753994	11,18		20,93399
SWE 2020	12,46419	11,10325	2Mt modal shift	23,56744
SWE 2030	14,68762	12,52602		27,21364

4.2.3 Modest growth

The transports in the Gulf of Bothnia will grow 30% by 2030

The figures of table 11 are obtained as follows: For Finnish exports it is assumed that there is a doubled decrease for the growth rate compared to the average scenario. Therefore the annual growth for exports is only 1%, which is 56,52% lower than the annual growth in strong growth-scenario. A rough assumption is made that all growth rates react the same way.

It is assumed that transit transports through the Gulf of Bothnia ports will stop and a modal shift of 3 million tons occurs on the Swedish side of the Gulf of Bothnia during the decade 2010-2020.

Table 11: Modest growth Scenario for the Gulf of Bothnia 2030

MODEST GROWTH Total transport (Mt/year)				
	Import	**Export**	**Total**	**+ Transit**
FI 2010	49,43426	36,43688	85,87114	7,4
FI 2020	64,62189	46,11818	110,7401	
FI 2030	77,28824	50,94316	128,2314	0
SWE 2010	84,372	70,624	154,996	
SWE 2020	105,2811	83,10718	188,3883	
SWE 2030	115,9853	89,2265	205,2118	

MODEST GROWTH Gulf of Bothnia (Mt/year)				
	Import	**Export**	**Transit/Modal shift**	**Total**
FI 2010	17,64253	12,99314	2,69	33,32567
FI 2020	22,4238	17,10984		39,53364
FI 2030	26,81902	18,89991	0	45,71893
SWE 2010	9,753994	11,18		20,93399
SWE 2020	12,46419	10,10325	3Mt modal shift	22,56744
SWE 2030	13,73146	10,84717		24,57863

The results of the three scenarios: Strong, Average and Modest growth are presented in figure 15.

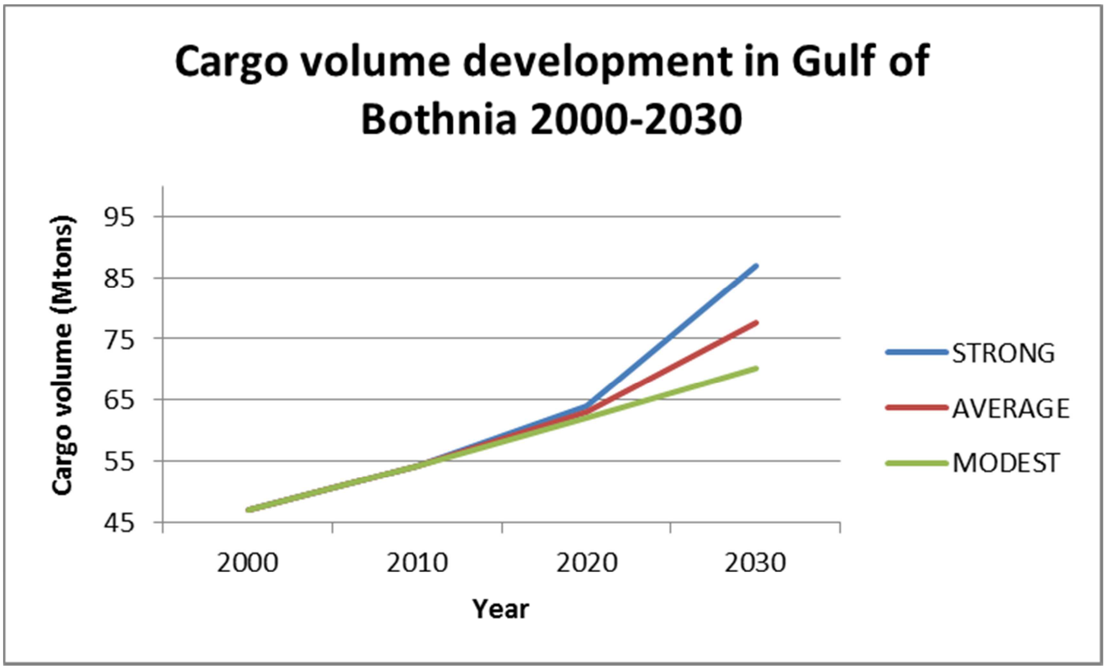

Figure 16: Cargo volume scenarios for the Gulf of Bothnia 2000-2030 (in million tons).

4.2.4 Comparison to other existing scenarios

According to the FMA scenario (table 12), the Finnish transports in 2030 would total 148,6 million tons, with transit traffic. The figures presented by FMA are therefore between the average (141 million tons with transit) and the strong growth (158 million tons with transit) scenarios above.

Table 12: International transports in Finland in 2030 according to FMA 2006

FINLAND in 2010 and 2030 following the FMA scenario (Mt/year)				
	Imports	**Exports**	**Transit**	**Total**
2010 (Realized)	49,43426	36,43688	7,4	93,27114
2010 (Scenario)	52,396	41,624	7,76	101,78
2030 (Scenario)	73,34	60,56	14,67	148,57

According to the BTO-Scenario (table 13), cargo volumes in 2030 will be somewhat lower than for the minimum scenario above. BTO predicts over 10 million tons more transports to Swedish GoB area, but the Stockholm area is included in the BTO area figures so these numbers cannot be compared in that sense. For Finland the figures are more easily comparable, although Varsinais-Suomi with for example Port of Uusikaupunki is considered to be part of Southern Finland (Uusimaa) and not GoB area.

Table 13: International Transports in Finland according to BTO (2011)

BTO		
	Total transports 2030 (Mt/year)	GoB 2030
FI	125,3	44,3
SWE	201,4	44,7

4.3 Discussion

The quantitative scenarios are a rough simplification of the real situation and their idea is to give an impression of the possible cargo tonnage in 2030 rather than describe specifically how the situation develops. The quantitative scenarios based on estimated development of growth rates during 2020-2030 have some weaknesses. The scenarios for the timeline 2010-2020 were based on growth rates taken straight from BMO. For all three scenarios the general growth is assumed to be similar in 2010-2020. The only variation is the magnitude of the modal shift and transit traffic.

The effects of economic crisis in 2009 were taken in consideration by using the realized cargo volumes for 2010, rather than the projected ones from the BMO scenario. The projected scenarios for 2010 were somewhat larger than realized ones.

The three scenarios all forecast growth for the Gulf of Bothnia transports. For the purposes of this study, it is important to consider also a possibility of much lower growth and even decreasing trend of Maritime transports. Therefore a decision was made to make two more scenarios for the second part of this study, by calculating cargo volumes with +10% and -10% growth -rate compared to the situation in 2010, as shown in figure 16.

It is important to note that growth of cargo volume does not necessarily lead to increased marine traffic. The size of ships as well as loading of ships can be increased. However, the shallowness of the Gulf of Bothnia and the fairways leading to its ports restricts the size of ships as well as the amount of cargo they can take on board. It can therefore be assumed that in case of the Gulf of Bothnia, increase in cargo volumes would indeed cause increase in the amount of traffic.

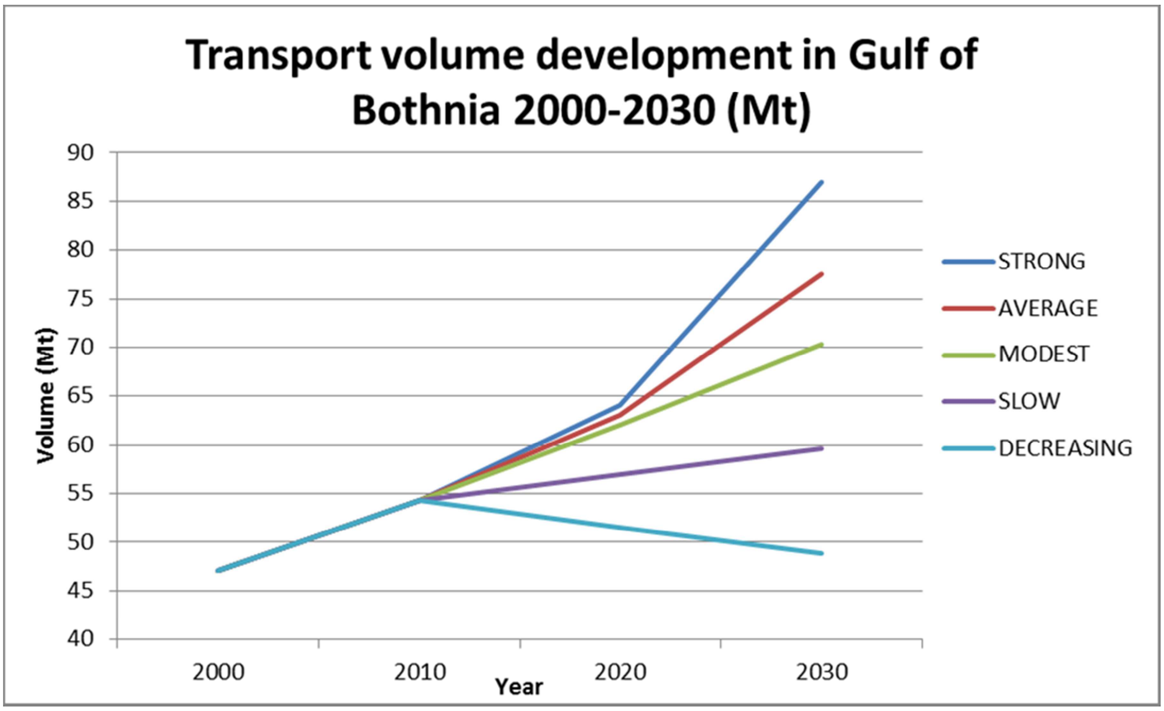

Figure 17: International transports in the Gulf of Bothnia 2000-2030 with two additional scenarios

5 PART II: RT-DELPHI ABOUT FUTURE OF MARITIME TRANSPORTATION IN THE GULF OF BOTHNIA 2030

5.1 Key concepts

5.1.1 Megatrends

When scenarios are formed, it is important to identify the factors that have an obvious and straight forward impact on the development. Additionally, there are megatrends which are the large scale driving forces. **Megatrends** are defined as developments that “should be characterized as megatrends because they overarch and impact on everything else. They are trends deemed so powerful that they have the potential to transform society across social categories and at all levels, from individuals and local-level players to global structures, and eventually to change our ways of living and thinking“ (Norden, 2011). Nordic cooperation project Norden has prepared a Megatrends report for the Arctic. They identified nine megatrends:

1. Increased urbanization
2. Demographic change in age structure
3. Dependency on transfers and exploitation of natural resources
4. Pollution and Climate change have a great effect in Arctic areas
5. More investments in human capital needed
6. Private and Public sector interaction impacts development
7. Renewable energy will contribute to greening of economy
8. Increased accessibility creates new risks
9. The arctic is a new player in the global game

All of these megatrends do not necessarily have a great impact on the Gulf of Bothnia maritime traffic, others are very relevant. Dependency on transfers and natural resources (Megatrend no. 3) is maybe the most important megatrend in the Gulf of Bothnia area. Mining activities in the old Fennoscandian shield with mineral resources are one of the main driving forces of transportation.

Pollution and Climate change (Megatrend no. 4) effect maritime transportation on two different ways. Firstly, climate warming might open new opportunities for maritime transport if ice conditions get easier in the Gulf of Bothnia and along the Northern Sea Route from the North Atlantic to the Pacific Ocean. If this sea route opens, it could create new business opportunities for the Gulf of Bothnia to operate as a strong hinterland connection to Murmansk hub port, a gateway for increasing transports between Europe and Asia. This kind of increased accessibility (Megatrend no. 8) and traffic would create new environmental risks for the whole Baltic Sea but also improve the global status of this area and direct more attention towards it as an important transportation corridor (Megatrend no. 9). Better connections to North and northern railroad projects have been studied in several occasions. Preliminary studies have been conducted for the Kolari-Skibotten railroad, Rovaniemi-Kirkenes railroad as well as the Salla-Kandalaksha railroad (see figure 11). The Salla Kandalaksha-study was made before the raw wood transports from Russia ended, reducing the transport potential remarkably. However, in future the connection could be feasible due to potential growth of Kola Peninsula and the Northern Sea Route transports.

The other point of view is the increased awareness of pollution and climate change, especially the contribution of shipping to these. New regulations concerning environmental aspects of shipping are a major contributor to the future of this transport mode. Renewable energy (Megatrend no. 7) is a part of this: biofuels are having an impact in ship building technology and marine transportation of energy resources.

The private and public sector interaction (Megatrend no. 6) is also relevant in the Gulf of Bothnia maritime transport sector. Not only it plays a key role in mining activities, as mining companies are private but public sector is still greatly responsible for infrastructure, but also in development of ports and different services for shipping.

5.1.2 Trends

Trends can be more short term or more limited phenomena compared to megatrends. For example market trends belong to this category. Cyclical trends in for example bulk shipping supply-demand pattern or forest industry profitability can be very important factors in the Gulf of Bothnia context. Privatization of ports and service sector for maritime transport can also be seen as a trend, which could make the ports more rapidly adaptable to changing business environment as slower municipal decision making processes would not be necessary to develop the ports.

Raw materials price development is one of the most important trends affecting the maritime transport in the Gulf of Bothnia. It is a grey area whether or not raw materials price development and increasing competition over limited resources are in fact a global megatrend. It is clear that in the future the prices will increase as competition and demand of limited natural resources will grow, provided that the general economic growth will continue. This will have great effects through global and local economics, societies as well as individuals and change the way of living and even thinking. Prices have fluctuated during last decades due to economic growth and strong increase of demand. Supply of certain raw materials cannot follow the demand fast enough, as launching of mining projects is slow process.

Unitized cargo is also a maritime transport trend. According to BTO scenarios, the greatest growth for maritime transport in the scale of the whole Baltic Sea Region can be expected to be containerized cargo. Directing the transports from roads to sea and rail to decrease the congestion could be mentioned as an important trend.

One important trend affecting the maritime transport in general is the recent great growth in Eastern and Southern economies and related to this: the shift of industries from West to East and from North to South. This is a phenomenon which is not likely to get weaker and it has a great effect on transportation of goods in global as well as local scale. Annual growth rate for container transports from Europe to Asia have been estimated to be of 5-6 % between 2008 and 2015 and 2-4 % between 2015 and 2030 (Transbaltic 2010).

5.1.3 Wild cards

Carbon dioxide liquefaction plants can be mentioned as a wild card. This technology is still in developing phase but it has a possibility to change the course dramatically. Transportation of liquefied carbon dioxide would require transportation capacity and special vessels. One plant is planned near the port of Kemi and the projected volume for this is about 0,5 Mtons/year. If this technology would be widely utilized, transportation of liquefied carbon dioxide could have effects on Maritime transport in Gulf of Bothnia.

Another wild card is the development of arctic shipping technology so that all ships that are operating in the Gulf of Bothnia would have capability to function as ice breakers. This would reduce the waiting time for ice breakers and secure timely shipping in all ice conditions as ships would not need to wait for assistance. At the moment ice breaking services guarantee a maximum 4 hour waiting time for ships requesting assistance.

5.1.4 Key factors

Megatrends and trends can be key factors for a maritime transport scenario but key factors can also be more specific, short term, single events that have an effect in the whole picture. Based on trends, megatrends and wild cards, 18 key factors were identified and formed into theses or multiple choice questions about future for the RT-Delphi round. The key factors were divided in five themes. They are listed below to give an image of what each thesis was concerning.

Theme I: Environment and physical conditions

Thesis 1: Ice conditions

Thesis 2: Northern sea route (North-east passage) opens for commercial shipping by 2030

Thesis 3: Sulphur Emission Control area (SECA)

Thesis 4: Nitrogen Emissions Control Area (NECA)

THEME 2: Innovations and industries

Thesis 5: New forestry products, such as biofuels

Thesis 6: Development of imports of raw wood to Finland and Sweden

Thesis 8: Carbon dioxide capture

Thesis 7: Northern mining products transport

THEME 3: Logistics and Transport corridors

Thesis 9: Mid-Nordic corridor

Thesis 10: Bothnian corridor

Thesis 11: Transit traffic

Thesis 12: Murmansk Port effect

Thesis 13: Transport centralizing in fewer large ports

Thesis 14: New railroad connections built to Northern Finland and Sweden

THEME 4: Economics

Thesis 15: Annual growth of GDP by 2030

Thesis 16: Fairway fees in Finland and Sweden

Thesis 17: Railway fees

Thesis 18: Raw materials prices

THEME 5: Conclusion on key factors and cargo volume

Assessment of three most important key factors

Assessment of cargo volume scenarios from Part I of this study

6 Results

From the 19 panelists that were invited to assess the key factors, 12 answered during the panel working time 1.2.-10.2.2012. The panel structure is presented in the table 14.

Table 14: Panel structure for the RT Delphi round.

	Ports/maritime transport actors	National agencies	Regional councils	Industries	Academics
Development	3	0	3	0	4
Planning/Environment	2	2	1	1	0
Transport/transport chains	2	3	4	0	4

Answers were divided between the five themes as follows:

Theme 1 Environment and physical conditions: 10

Theme 2 Innovations and Industries: 11

Theme 3 Logistics and transport corridors: 12

Theme 4 Economics: 11

Theme 5 Conclusion: 10

For each individual question, there was between 7 and 12 answers. The expert group was fairly small following the recommendations for RT Delphi. Therefore statistical analysis can be performed but does not yield very reliable results. The value of statistical analysis here is to support the scenario building based on the comments of panelists. Averages and medians of the results are presented in Figure 17.

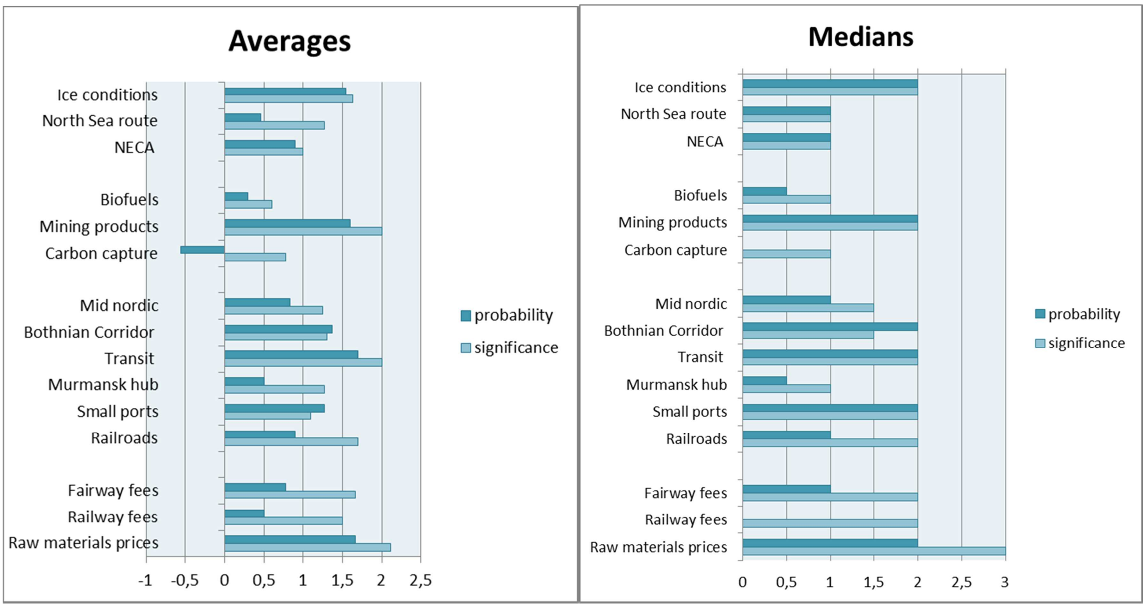

Figure 18: Averages and medians of the key factor-assessment

The results indicated that the most probable and significant factors contributing to Maritime Transport were the easing of ice conditions, Mining products transport, Transit traffic and Raw material prices. The least probable key factors were Carbon liquefaction processes and biofuel processes, the North Sea Route and Murmansk hub port as well as railway fees increase. It is important to note two things: Some of the factors with small probability were still considered significant; if they would become reality the effects could be great. This kind of factors were for example fairway and railway fees increase, newly built railroads for northern areas, Murmansk hub port and opening of the North Sea Route for commercial traffic.

Secondly, not all identified key factors were assessed in same way. The factors that were assessed by some other means (mainly multiple choice questions) were raw wood transports, SECA and general economic development based on GDP annual average growth. A small majority (four panelists) believed that raw wood transports would stay on same level as for now, although the options “Decrease and “increase” received almost as many answers (three panelist for both options). A small majority believed that mining products will be transported mainly through the Bothnian Sea (five panelists). The Barents Sea received four votes and option “Finnish products through Bothnian Sea and Swedish products through the Barents Sea received three votes. SECA options, “Major effect on shipping" and "Minor effect on shipping" received almost the same amount of votes; major effects were considered probable by six panelists and minor effects by five panelists.

The multiple choice questions that showed greatest consensus of answers were the ones about GDP development and new railroad alternatives (Figure 18). The Salla-Kandalaksha railroad alternative was considered the most probable to be built.

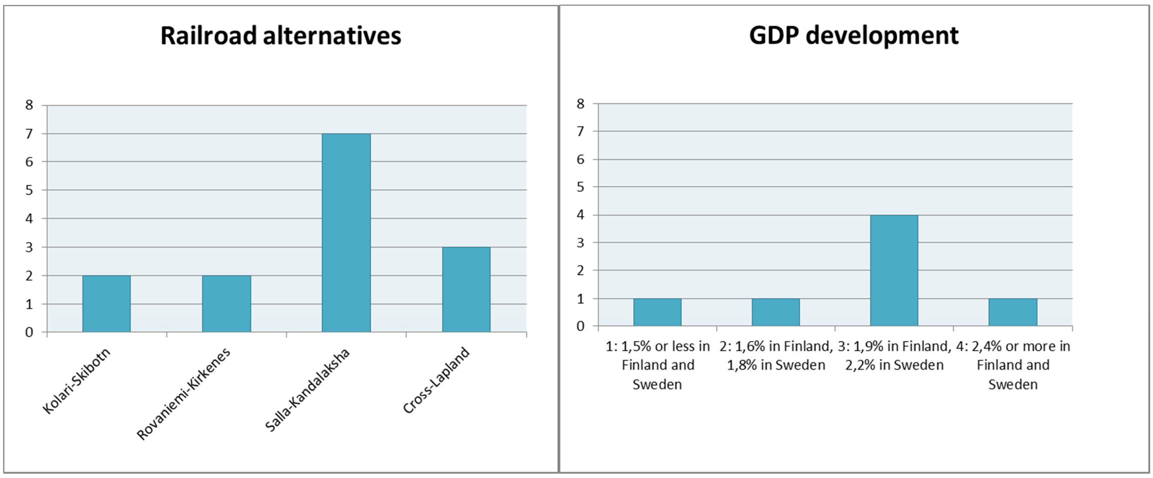

Figure 19: Results on railroad alternatives and economic development (Annual average growth of GDP) (Theses 14 and 15)

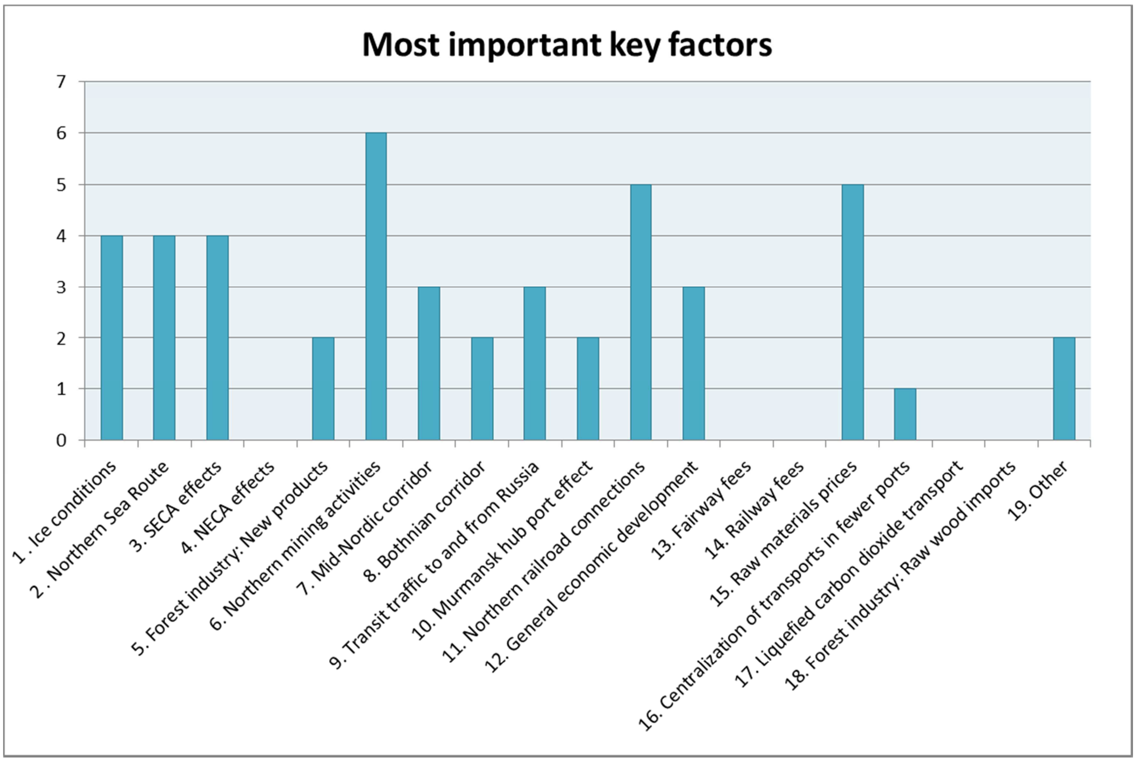

Figure 20: Results on question 19 concerning most important key factors.

In theme 5: conclusion part the panelists were asked to choose from a multiple choice list the three most important factors. The list included all the 18 key factors as well as the option „Other“. The results are presented in figure 19. The results indicated that Northern mining activities, Railroad connections and Raw materials prices were considered the most important. The next three were ice conditions, the North Sea Route and SECA regulations. The least important were NECA regulations, Fairway and railway fees, Liquefied carbon dioxide transport and raw wood imports. Transit traffic was considered a significant and probable factor earlier but received only three votes in this part. EEDI regulations were mentioned as „Other“ possible key factor, increasing the amount of low powered vessels in the Baltic Sea and therefore potentially increasing the need of ice breaking services.

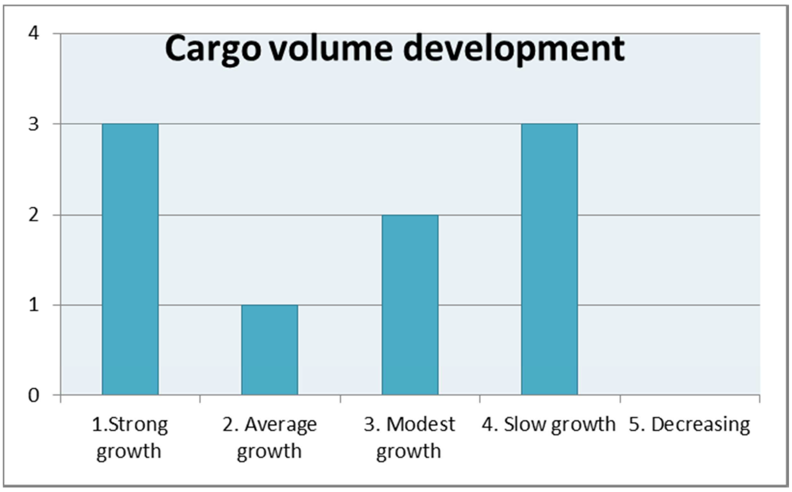

Figure 21: Results on Cargo volume scenarios assessment

The results of the question about cargo volume development are presented in Figure 20. Three panelists believed in strong growth (60% growth). Also three panelists chose the option „Slow growth: 10%“.

The most important results obtained from this study are the comments and discussions. The panelists provided 0-5 comments for each thesis. These comments were first assessed to evaluate the essential ideas and views behind them. These ideas and views were then assessed with a scenario table (Appendix A) to find out the ones that are incompatible with each other and which support each other.

Not enough data about the spatial implications of the key factors was obtained. Only one port was specifically mentioned (Kaskinen) and additionally some comments implicated that the ports and cities that belong to the international corridors are likely to benefit of the developments.

6.1 Scenarios

6.1.1 Basic assumptions for scenarios and maps

The scenarios are based on the comments and views of the panelists. The scenarios were created to offer insight to future states that could cause the most variation to shipping traffic in the Gulf of Bothnia so the probability of each scenario varies. They aim to consider the effects of most important and significant key factors identified by the panelists.

The comments and views were analysed with a scenario table to find out the developments that are so called "impossible paired events" and the developments that support each other. Based on the probability analyses, some basic assumptions were made for all scenarios to be true.

Not many comments from the RT-Delphi round indicated specific areas, ports and such. The spatial nature of this study is therefore more speculative than a direct result of the research. The scenarios and especially their physical consequences on shipping in Gulf of Bothnia are assumptions based on for example ports associated with different transport corridor projects, ports investments and existing or planned railroad connections. The maps are to be considered as speculation on how the different key factors and the three scenarios built on the comments provided by the panelists could direct transport flows in the Gulf of Bothnia and as an example of what kind of results could be obtained if the research was repeated following the recommendations presented later in the discussion part.

The basic assumptions for all scenarios:

- Raw materials prices will stay relatively high. The demand is high in Asia and/or Europe, and catastrophic wild card events such as economic crisis will not occur.

- Mining activities, raw materials prices and transit traffic are the strongest drivers for development in the area
- Ice conditions will eventually get easier but the speed of this development and effects in the Gulf of Bothnia vary between scenarios.
- Centralization of industries and port activities to larger entities is a common trend.

The basic assumptions for maps:

- The ports which are mentioned to be part of primary network of the Bothnian Corridor or the Mid-Nordic corridor are all considered to benefit equally if the corridors realize.
- The ports which are part of Mid-Nordic corridor are considered to grow in the East-West transit 2030-scenario.
- The main growth is assumed to be in bulk transport except in scenario 3 where the MidNordic corridor is assumed to handle also unitized cargo. The ports that are currently transporting unitized cargo in the Gulf of Bothnia are assumed to continue it as for now.
- The ports where pilot biofuel operations exist or are planned are considered to be the important ports of biofuel developments also in 2030.
- The ports that have recently planned or made investments in fairway dredging are considered to gain importance as it is one of the main limiting factors for transportation in the Gulf of Bothnia ports that will stay constant, due to post-glacial land uprising

Strong European industry 2030

“The Baltic Sea Region has tremendous potential for global transports with strengthening of the Baltic states and Eastern European Countries as a means to make manufacturing more sustainable i.e. closer to markets assuming they can make profits with globalization.”

Main logic:

- Production moves closer to markets

- The Gulf of Bothnia and Bothnian corridor is an important transport route for Northern mining products
- The North Sea route has not opened for commercial shipping
- Strong cooperation between the Northern countries

High demand of raw materials and warming trend makes conditions favorable to the Nordic countries and Russia. Sustainability is a key word for economic development and industries tend to move closer to markets.

Especially the Baltic countries and Eastern European countries act as strong drivers for the European economy and Baltic Sea Region is an area of global importance. The Bothnia corridor and associated investments prove necessary and goods flow to and from the Gulf of Bothnia ports belonging to this corridor as secondary links. Russia becoming part of WTO has improved trade conditions and relations. Finnish-Russian border operations have been made more efficient to handle cargo flows. Transit traffic increases in the Gulf of Bothnia ports. Kokkola has experience of handling transit traffic but as the cargo volume increases, some other ports with unused potential could take over part of it, provided that their railway connections are improved to handle future demand. For example port of Kaskinen could benefit from this if investments were made to improve the railroad connections from Seinäjoki in the future.

Of the proposed railway connections in Northern Fennoscandia, the Salla-Kandalaksha connection is built to increase the connectivity between the Nordic countries and Kola area to make it a strong mineral region for European needs. Northern Sea route has not opened for commercial traffic; maximum ice extent has been significantly reduced, however the ice conditions are still too unpredictable. The situation is likely to change in future. Murmansk port is strong due to Arctic gas transport and the Salla-Kandalaksha connection foresees great increase in cargo volumes as the importance of the Murmansk port keeps growing. The ports that are closely linked to the new railroad connection gain benefit. Closest port for the new railroad is Kemi.

There are fewer drivers, such as strong ocean currents, to ease the ice conditions in the Gulf of Bothnia than in the North Sea Route. The reliability of transport is insufficient for international container transports so Bulk cargo is the most common cargo type in the Bothnian Sea. Narvik railroad is improved to ensure flow of Northern minerals to the customers in Europe. Forest industries in Sweden have shifted a large part of their transports to the improved Bothnian railways and small private industrial ports have only marginal importance.

New MARPOL VI regulations has had a strong effect on shipping during the timeline 2015-2025, but it has also created tremendous possibilities for the ship building industry, railroad projects as well as LNG distribution networks. The shipping companies that have overcome the transition phase are strengthening by 2030. The renewable energy targets of Finland and Sweden have been more or less reached. Biofuel has global markets and the plants in Gulf of Bothnia area are viable. The Forestry of Finland and Sweden cannot provide for both Biofuel industry and traditional forest industries and raw materials are imported mainly from Russia and to smaller extent from other countries.

The Bothnia corridor has improved the connections also in east-west direction and there is activity in the Mid Nordic Green corridor to ensure the Cross-Bothnian trade flows with local importance. However, when it comes to international transport chains between Asia and North America, the Mid-Nordic corridor has not gained considerable importance.

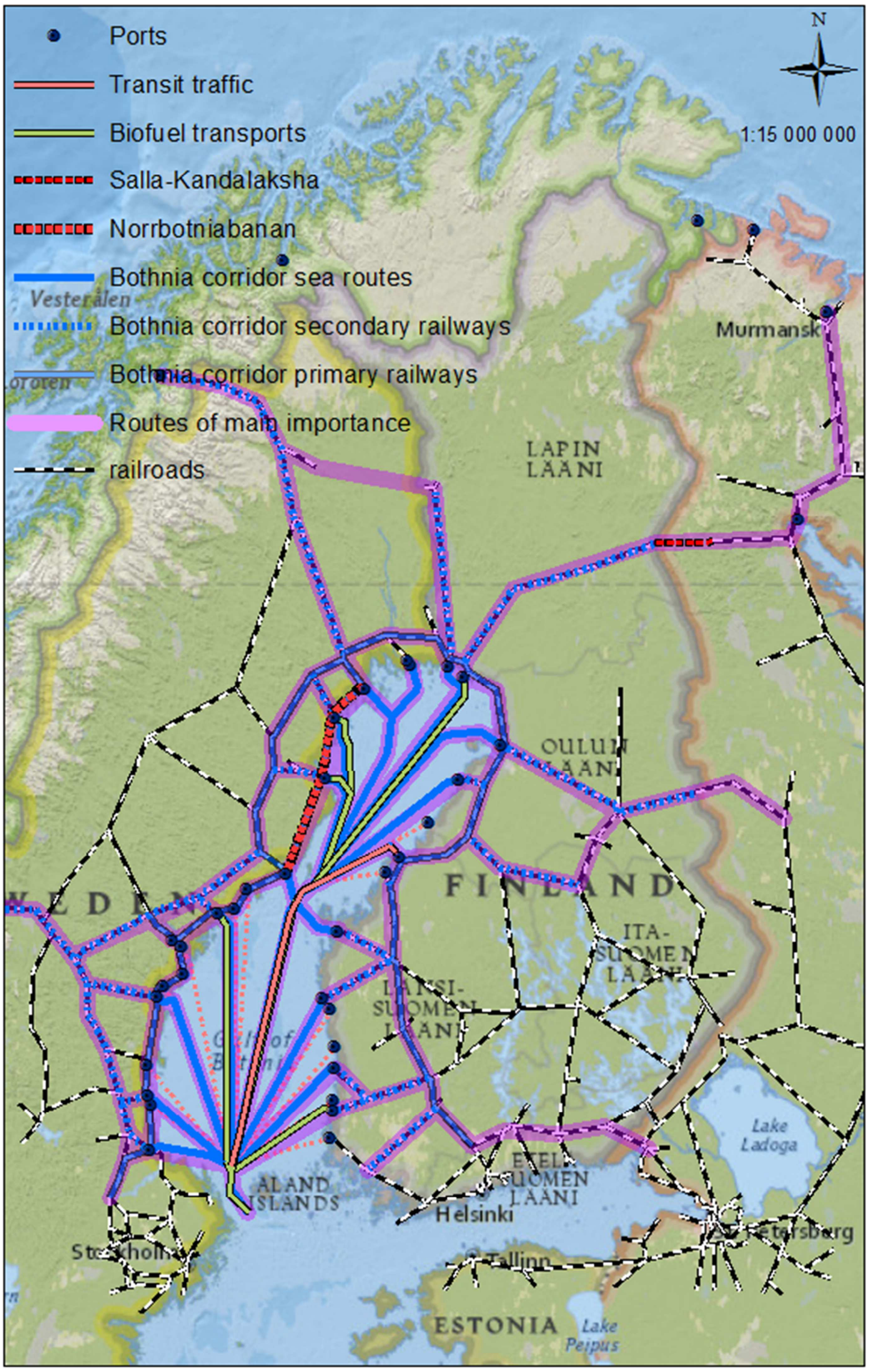

Figure 22: Strong Europe 2030 Map

Towards Arctic 2030

"Murmansk region will develop for energy industry and logistic center until 2030 for North-West Russia. It is also very important for the Northern Sea Route"

"No doubt Murmansk port will be a key hub for oil and gas, minerals, and timber transports between Eurasia and will enhance sustainability, but it will require a sense of Nordic trust"

"Kirkenes competes with port of Murmansk"

Main logic:

- Northern railroad projects are realized but cooperation between the Northern regions is not successful
- Northern Sea Route opens for commercial transport
- MARPOL regulations have a strong effect on transports in the Gulf of Bothnia
- Competition between Russian and Scandinavian ports in the Arctic

Global interest has shifted strongly towards the Arctic as the North Sea Route offers great possibilities for world trade. Strong effect on trade patterns come from European and Russian trading relations, which have not improved considerably even though Russia is part of WTO. Lack of trust between the Northern countries has led to Nordic countries trading with each other and competition between Murmansk and Kirkenes ports in the arctic.

Of the Northern railroad projects, the Salla-Kandalaksha has been built in the awaiting of Northern cooperation in transport but the route has not fulfilled the purpose as the bottleneck issues in the Murmansk-South Kola railroad have not been solved and border controls in Finnish-Russian border are still not efficient enough. Murmansk is a hub for oil and gas, minerals, and timber transports but this does not have considerable effects on the Gulf of Bothnia due to high cost of intermodal land transport through this transport chain. Transit traffic in the Gulf of Bothnia has reduced considerably.

As most of the customers for raw material trade are in Asia, Nordic mining industries need good connections to the Barents Sea and the North Sea Route. This has been ensured with building of the Kolari-Svappavaara and the Rovaniemi-Kirkkoniemi railroads as well as improving the Narvik Iron Ore railway to the Norwegian Sea coast.

The effects in the Gulf of Bothnia concentrate on the Bay of Bothnia. The Mid Nordic corridor is not realized as a large scale international transport route. Small Bothnian Sea ports could not grow as international hubs due to their remoteness. Investments are made elsewhere and the Gulf of Bothnia port connections are not prioritized. Some trade activity of local importance between Nordic countries exists in the area but cross-Bothnian connections are generally not profitable. Container transports continue in ports that are currently handling unitized cargo.

Centralization of Industries in the Gulf of Bothnia area is strong and smaller ports have lost importance. Transports have concentrated in larger ports that are part of the Bothnian Corridor. The Bothnia Corridor serves industries with connections to mainland Europe and modal shift has been strong in Sweden due to MARPOL VI regulations. The ice conditions get easier also in the Gulf of Bothnia but this has no considerable effects on cargo volumes.

Mining activities have generally increased their importance in the Gulf of Bothnia area, but the reducing of transports of other types of industries slow down the cargo volumes growth in the area. Russian raw wood transports remain economically non-viable and wood is imported through the Gulf of Bothnia ports to satisfy the needs of forest industry and biofuels production.

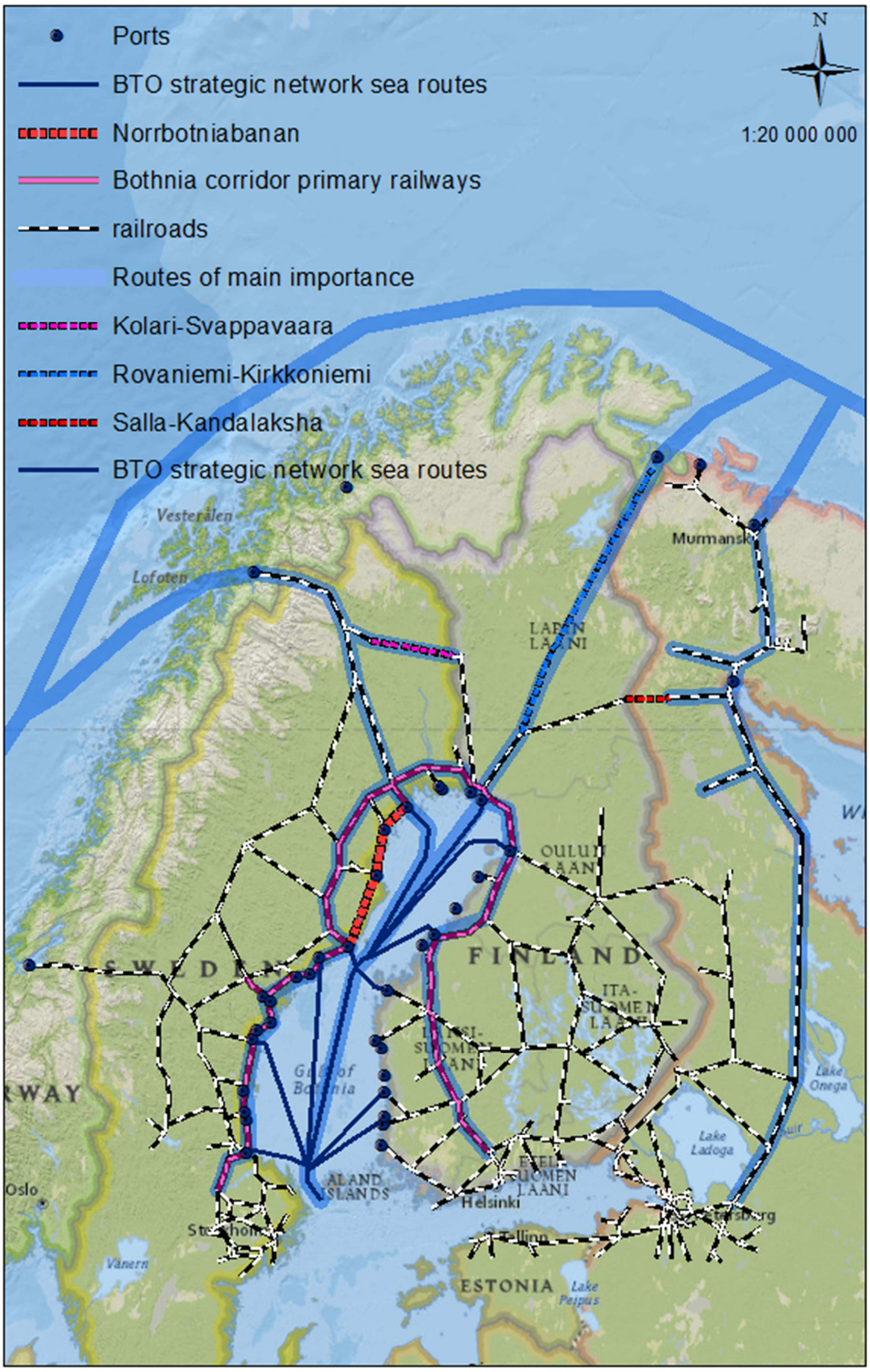

Figure 23: Towards Arctic 2030 Map

East-West Transit 2030

"The green corridors overcome the negative reasons to link through Lapland to Murmansk. Access to the NSR to Asia would flow West through Sweden to Norway and to North America and Europe… The cross Bothnia crossing would keep excess traffic out of the Baltic Sea due to congestion and pollution concerns"

Main logic:

- North sea Route does not open for commercial traffic
- No new northern railroad projects –development of existing routes
- Mid Nordic corridor is an important international transport chain between Atlantic and Asia

The North Sea Route has not opened for commercial traffic as the ice conditions are still not predictable enough for commercial traffic. Demand of raw materials has settled for a lower level in Asia and decreased the price pressure. Northern railroad projects have not realized due to profitability issues and the uncertainty concerning the North Sea Route. Some of the suggested mining projects have still been realized and there is North-South-direction transport through the Gulf of Bothnia and coastal railroads.

Environmental damage for remote areas of natural state has also been considered too great for new large railroad projects. A decision is made to develop existing connections instead of building new ones. The Narvik railroad has been improved. Baltic Proper is severely congested with oil and gas transport. The need of reliable trade connections between Finland, Sweden, Norway, Russia and Asia makes the Mid Nordic corridor a good option. East-west direction traffic in the Gulf of Bothnia increases greatly. MARPOL regulations do not have considerable effect on shipping in the Gulf of Bothnia. Regular Mid Nordic connections are operated by specialized fleet fulfilling the environmental regulations. Ice conditions are not considerably easier in Gulf of Bothnia but high ice class of operating ships makes the need of ice breakers rare.

This has required great investments in relevant infrastructure such as Mid-Scandinavian, Russian and Finnish railroads, railway connections to Russia, handling of cargo in the international borders and cargo handling facilities in relevant ports.

Mid-Nordic corridor offers employment and possibilities for the adjacent regions and communities and improves their connectivity and development as well as economic sustainability. It employs the under-used resources of the Mid-Bothnian ports.

Centralization of industries and port activities is a common trend so ports other than the ones participating in mining products transport, large centralized forest industry transports or international corridors have only marginal importance. Forestry raw materials are needed to satisfy the needs of Biofuels, paper pulp and sawn wood industries and imports are needed. The container ports in southern Gulf of Bothnia could benefit of the trend of increasing container transports in the Baltic Sea.

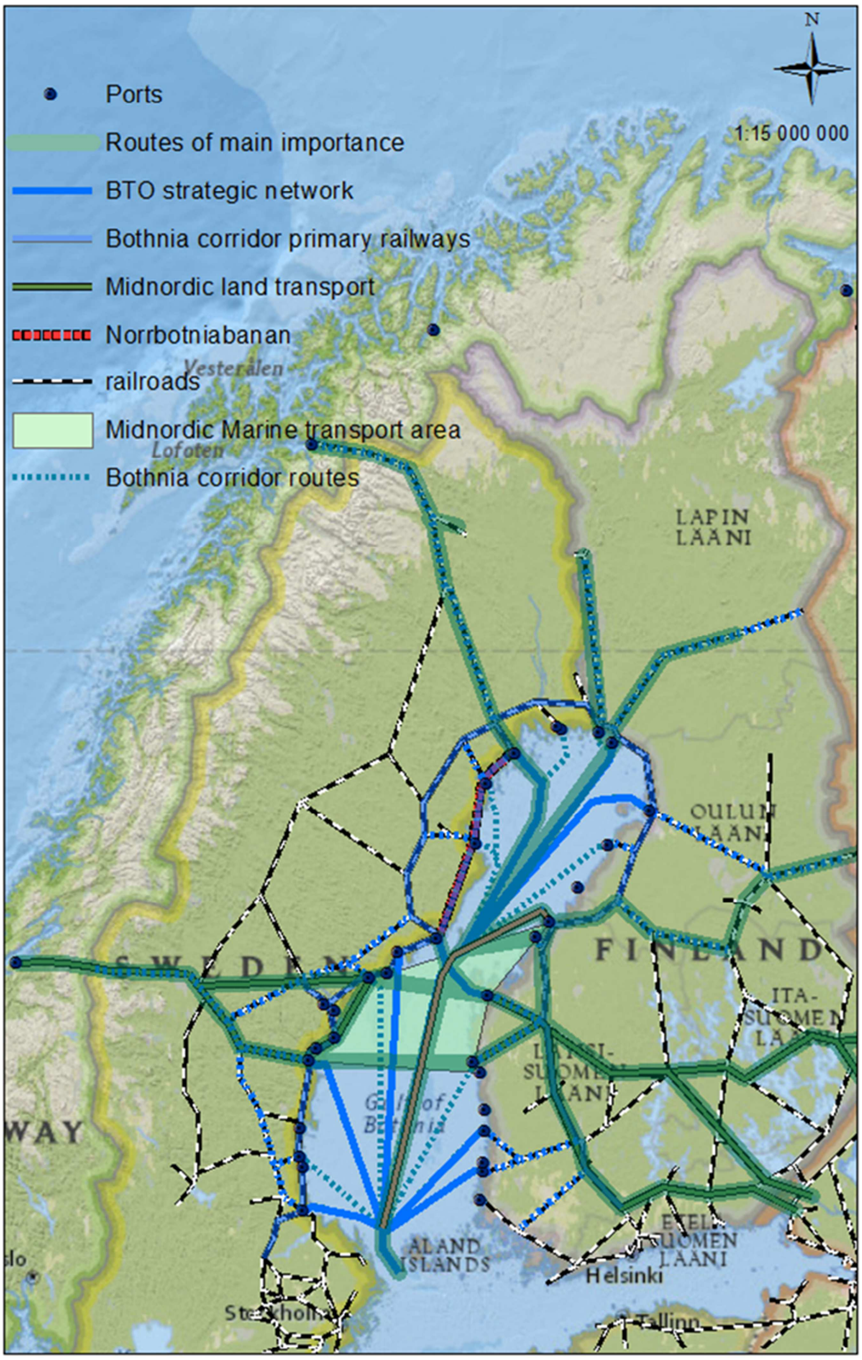

Figure 24: East-West transit 2030Map

7 DISCUSSION

In a Delphi study, statistical analysis of the results gives mainly support to the scenario building phase, rather than reliable statistical facts. This is due to choosing a small amount of panelists based on their areas of expertise in a very subjective manner. Despite the fact that the panel was lacking some expert groups, as shown in table 14, some important results were obtained from this study. The most important key factors seem to be ice conditions, mining projects, raw materials prices and transit traffic, which were considered both important and probable factors for future developments in the Gulf of Bothnia. The questions and theses were however made so that probability-results do not include some factors, such as SECA effects and raw wood transports. The reason for this is that these factors were handled with direct questions rather than probability-significance assessment. What could be noted is that it would be better to have all the factors assessed in similar way: the probability and significance assessment should have been attached to the direct questions.

The concluding question about importance of all key factors could therefore yield better results concerning the main drivers for development. It should be kept in mind that some respondents mentioned more than three "most important key factors" which makes the results somewhat compromised. However, the results of "Most important key factors" and the significance-results support each other well, which is why the results were considered reliable enough to be used in scenario building. Northern mining projects and raw materials prices would be the main drivers based on the results. Railroad projects were also considered important and significant, but not that probable.

What is interesting is that forest industry transports such as raw wood imports only came up in one comment and were not considered that important, although Forest industry transports are the main commodity group currently transported in the Bothnian Sea. This is most likely due to two reasons: Firstly: the panel was lacking input from local industries, both mining and forestry. Secondly, mining activities have been discussed widely recently and there are great future expectations for economic development driven by northern mining projects. Also, if the thesis was formed differently to mention also paper and pulp transports, the results could have looked somewhat different.

The SECA matter was handled with a simple question: Major effects on shipping or minor effects on shipping. The results were almost even, six panelists considering that effects will be minor and five voting for major effects. The comments for this thesis however offered important information on the views of panelists. Major effects on shipping could be seen as a possibility for several fields of industry offering technology to tackle the sulphur emissions as well as railways. And even though the effects can be great on shipping, impacts were considered to be rather short term and shipping could be expected to recover by 2030. One respondent stated that the accumulated impact of MARPOL 73/78 can be considered great but for example NECA alone does not have great effect on Maritime Transport in the Gulf of Bothnia.

Ice conditions getting easier were considered an important factor for development and significant for the Gulf of Bothnia. Some respondents however stated that there are less factors (ocean currents etc.) to affect the ice conditions in the Gulf of Bothnia than in the Barents sea or that even though ice conditions get easier, it might not have considerable effect on transport in the Gulf of Bothnia. Opening of the North Sea Route was not considered very important in the Gulf of Bothnia context. Panelists mentioned for example that land transport and intermodal routes add costs and the Gulf of Bothnia route is not reliable enough for extensive container transport.

The carbon liquefaction processes were considered the least probable factor in the Gulf of Bothnia, most panelists assessing zero probability and zero significance. Also, the only comment provided was “I do not know”, which suggests that this matter is not yet that commonly known or discussed as a realistic option.

It is important to note that even though the scenarios are based on the comments and views provided by the panelists, the spatial implications are mainly based on literature research. When it comes to spatial implications of the key factors, not many results were obtained. Some maps were presented to the panelists to serve as inspiration for spatial thinking but not many comments handled the specific areas or ports of importance. This could have been considered too detailed matter to be forecasted. The other possibility is that the panel with 20 theses or questions was too heavy. The theses may have aimed to get too many kinds of results which made answering the panel too complicated.

Also, in the end it is the industries deciding which transport option or route to use and their input would have therefore been important for this panel. Speculation on potential transport patterns can be made based on existing and planned railway and ports infrastructure and depth of fairways leading to ports. More than one comments mentioned the positive effects of transport corridors to the adjacent ports, cities and regions, so the maps were largely drawn based on ports belonging to these corridors.

Railway connections were prioritized as an important factor for transport patterns due to the trend of directing transports from road to rail and sea even though truck transports have also great importance in the research area.

The question concerning the forecasted cargo volume scenarios from Part I of this study did not give results that could be easily combined with the three scenarios formed in Part II. The opinions about the magnitude of annual cargo volume in 2030 vary greatly (From 10% to over 60% growth) but no one of the panelists believed that the cargo volume in the Gulf of Bothnia will decrease by 2030.

7.1 Implications for Planning

Considering that the maritime transport and shipping traffic from the Bothnian Bay can be expected to grow, maritime spatial planning should prepare for a possibility that new routing measures might become necessary to establish at some point. As mentioned earlier, IMO restricts the measures taken for directing shipping traffic in offshore areas for the ones that are already approved by IMO. These kinds of measures are for example Traffic Separation Schemes, Deep Water Routes and Areas To Be Avoided. Based on the scenarios it would be recommended to reserve space for a TSS or a deep sea route in the main route between the North and the South Quark. The width of this kind of area could be similar to the TSS areas in Gulf of Finland.

The question of Cross-Bothnian connections is interesting; how to consider the possibility of increase in the East-West direction transport in planning. If there was future developments of large scale cross-Bothnian transport, similar measures could be taken as in South Åland sea circular TSS.

When it comes to areas to be avoided, such status could be given for the ecologically important banks in the area, if considered necessary. There are current development plans for wind power installations for large bank areas in Sweden, which would basically have the same effect as shipping routes and wind power installations cannot exist in the same area. The remaining banks, such as the ones off the coast of Höga Kusten in Sweden could be considered as an area to be avoided for shipping if the transport routes over and around it would gain considerable increase in traffic as in the case of “East-West 2030” scenario.

As the areas round the shipping zones in offshore Gulf of Bothnia would most likely be classified as areas with no specially appointed activities or interests, establishing TSS or other routing measures is not an issue and there is plenty of space for them. However, if extensive offshore installations such as floating wind power parks or offshore aquaculture would be built in the research area in future, situation could change. Therefore it is necessary to consider the space requirements of routing measures in important shipping areas. However, both the required space for shipping and building of offshore installations is strongly dependent on future ice conditions in the Gulf of Bothnia. Ships need more space when operating in ice and the routing measures do not function in harsh ice conditions. Building of floating offshore installations is also to some level dependent on the development of ice conditions.

As for now there is no need to point out areas where exactly these routing measures would be established as this should be researched in detail if the matter becomes urgent. The map presented below (Figure 24) offers an idea of the possible space requirements of this kind of establishments rather than a suggestion of the exact position of each routing measure.

Non-binding priority areas for shipping could be established as recommendations, to encourage the ships to navigate in certain areas. This kind of priority areas are however not likely to be printed on navigational maps. If the information on the priority areas could be offered as supplementary information with for example electronic chart systems, good results could be obtained. There are projects aiming to enhance the route planning of ships, for example Mona Lisa. Cooperation with this project and using the information they have gathered from the area would be recommended. For example the depth-surveyed routes should be used as a basis for establishing priority areas for shipping.

The future scenarios can aid in giving an idea which routes can grow their importance in future. However, the plan itself should be made based on current situation as safe and short way to the ports used must be ensured in the plan independent of the amount of traffic. Therefore the shipping areas are categorized here in three groups in Figure 27. „Possible areas for routing measures“ include the routes to ports that seem to have very high importance in the scenarios. „Maritime transport areas I“-network includes the BTO network ports, the ports with largest investments in following years and the deepest fairways. It includes the areas that can be expected to have high international importance in future. For example, port of Uusikaupunki is included in this network due to recent investments in the fairway and growth expectations of the local fertilizer industry. „Maritime transport areas II“ -network includes the Swedish fairways of national interest, coastal fairways with ice navigation importance as well as potential new cross Bothnian connection (Sundsvall-Kaskinen). The Rauma-Gävle connection is presented as they are the largest container ports in Gulf of Bothnia, both planning on making considerable investments in ports facilities/fairways in upcoming years and they have also established a regular cargo liner in 2011. The Swedish coastal route is drawn based on National interest fairways of Sweden, the Finnish coastal fairway is drawn based on AIS tracks (HELCOM, 2012a, HELCOM, 2012b)

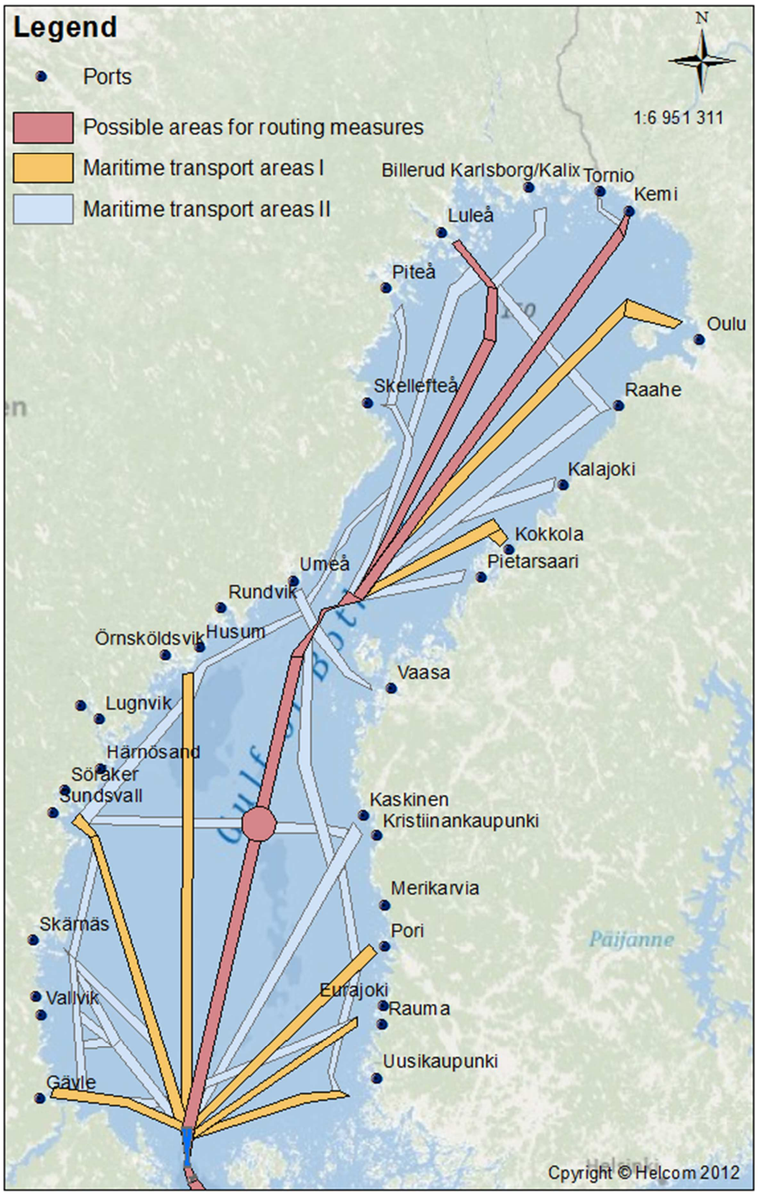

Figure 25: Implications for planning. "Possible areas for routing measures" include the areas that seem to have strong importance in all the scenarios. "Maritime transport areas I" include the areas that can be expected to have high international importance in future. "Maritime transport areas II" includes national interest areas and possible new Cross-Bothnian connections. Map data for existing routing measures as well as Swedish national interest fairways of Sweden are obtained from HELCOM Plan Bothnia Map and Data Service (2012b).

7.2 Recommendations and lessons learned

If this kind of research were to be repeated, better results could be obtained by making it with several rounds. This idea is somewhat conflicting with the basic idea of RT Delphi, making just one round during a short period of time. There are benefits in RT Delphi method: the instant availability of results can make answering more interesting, offer new ideas for the panelists and motivate to comment and provide their arguments. RT Delphi can therefore be considered as one anonymous, internet based stakeholder meeting. It can even be made as live event where all the panelists answer the questions simultaneously, although a strictly set panel working time can make it even harder to engage participants for the event.

The first round could contain just one type of question. All the factors identified by literature review/pilot interviews could be presented as a list and ask the panelists to pick three most important ones, just like in the conclusion-part of this panel. This would help focusing the actual probability-significance assessment to the most relevant factors, limiting the number of theses to the few most interesting ones and therefore increasing the motivation to provide comments.

The spatial implications should be researched with a separate third round. Based on the comments and probability-significance analysis obtained during the second round, scenarios could be written as in this study, based on futures table analysis or possibly some other futures research method. These scenarios could then be presented to the panelists and ask them to draw main patterns or circle areas of importance on a map for each scenario. This would make the maps a direct result of the panel work and therefore increase the stakeholder participation in the marine spatial planning practices. The forecasted cargo volume scenarios could also be presented here and ask the panelists to assess the probable cargo volume growth for each scenario.

To discuss the five characteristics of MSP presented by Ehler: Integrated, future oriented and adaptive, participatory, ecosystem based and area based, this type of method could improve MSP in at least four of the mentioned areas, provided that the panelists are chosen with careful consideration. Firstly, the panel should contain representatives from all powerful sectors from the field of transport, both transport industry and industries dependent on transports in the area. Different levels of governance should be represented in the panel. This would ensure the integrated approach. Future-oriented, participatory and area based approach is basically guaranteed with this type of methodology. This methodology does not improve the ecosystem based approach to MSP in any considerable way. Including the environmental and nature protection point of view is important for the panel but the actual spatial implications are more difficult to combine here.

However, this type of futures research methodology can offer a considerable amount of input for MSP projects. The maps obtained can be analyzed with existing spatial information on ecosystem characteristics of the area to find out the areas of potential future conflicts or areas where further management is needed in case the scenario realizes. In case of the Gulf of Bothnia and the Baltic Sea in general, it is rather unlikely that brand new shipping routes will be established but the amount of traffic could change in readily established routes and these developments are in some cases important to take into consideration in planning.

The methodology could be adapted to study future developments of other offshore marine sectors, such as wind power or aquaculture. In best case all the sectors could be combined to reach common visions for the area. Even though this panel combined several fields of expertise and governmental levels, it is still sectorial in the sense that the focus is limited on the development of transport and logistics and does not consider the other offshore activities in the area.

7.3 Further research

The main value of this study was to serve as pilot project for using futures research methodology for Maritime Spatial Planning purposes. During the process it was noticed that there is both great challenges and great possibilities with this sort of research. Based on the experiences gained from this project, more research are advisable to be made on following topics:

- More testing of futures research methodology and the benefits for MSP projects, especially concerning RT Delphi/traditional Delphi method providing stakeholder input to the planning process.
- The transport plans of all the northern mining industries should be studied in depth and considered as one entity to reach a conclusion on what would be the most sensible targets for infrastructure investments and development, from both economic and environmental point of view.
- Full summary should be made of regional and municipal development plans and physical plans. It should be studied how these plans should be taken in account and how to ensure compliance of all these development plans when making the Maritime Spatial Plan for Bothnian Sea.
- Full review of Marine Spatial Planning initiatives to find out the basis for their visions for maritime transport and how the methodology suggested in this paper could benefit these initiatives.

The research project in general received attention and was considered interesting and important based on discussions with panelists and people participating in the Plan Bothnia project. This serves as an incentive to develop the idea and adjust the methodology further to get maximum benefits for Maritime Spatial Planning initiatives.

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Appendix A

	Ice conditions will not get easier	Need for ice breakers becomes rare	Ice conditions get easier but no effect on GoB transport	Bulk transport vry probable, railroads needed. reliability for containers not good enough	If Europe is strong, intellectual property protected, close to markets production	SECA is a porssibility for gas network, ship building, railroad projects	SECA won't cause migration of industries, other factors stronger	Major effects during 2015-2025 but those who survive are ok by 2030	Cumulative effects of MARPOL are strong, NECA alone not	The forestry of Finland and sweden cannor provide for both biofuels and forest industry	Global markets for biofuel by 2030, plants in GoB viable	Energy independence from Russia due to biofuels
Ice conditions will not get easier												
Ice conditions ease: Need for ice breakers becomes rare												
Ice conditions get easier but no effect on GoB transport												
Bulk transport very probable, railroads needed. reliability for containers not good enough												
If Europe is strong, intellectual property protected, close to markets production												
SECA is a possibility for gas network, ship building, railroad projects												
SECA won't cause migration of industries, other factors stronger												
Major effects during 2015-2025 but those who survive are ok by 2030												
Cumulative effects of MARPOL are strong, NECA alone not												
The forestry of Finland and sweden cannot provide for both biofuels and forest industry												
Global markets for biofuel by 2030, plants in GoB viable												
Energy independence from Russia												
Imports needed to provide for biofuels and forest industry: from Russia												

Imports needed to provide for biofuels and forest industry: from Russia	Imports from other countries than russia	No large investments in new railroads but to Narvik tracks	Customers in Asia, good trading relations with russia	Customers in Europe	Mid nordic not realistic: Transport through Russia not possible, small ports cannot grow as hubs. Regional wish	Mid nordic eases the congestion in Baltic Proper and overcomes the Northern railroad project issues: employment and opportunities	Bothnia corridor is the best option for transport mainly from Sweden to mainland, Finland and Russia	Benefits the ports- also in east-west direction	Good trading relations: good transit	Not good trading relations- no nordic trust in 2030	Murmans hub no effect on GoB -land transport too expensive	No nordic trust - kirkkoniemi a strong competor	Murmansk hub- railway dependent importance

Salla-Kantalahti built - congestion in murmansk railroad overcome	Kolari-Svappavaara or Rovaniemi-Kirkkoniemi	The mining projects keep the GDP developm ent high	Fairway fees have a limit as better ice classes are built if fairway fees grow too much	New EEDI-requirements might increase low powered vessels operating in the Baltic sea. This will increase the need of ice breaking assistance and slow done the winter operations.	Railway fees decrease due to competition	Russian WTO membership has an effect	Chinas demand will stabilize at somewhat lower level and price pressure will decrease	Raw materials pricing will increase if global economy grows and wild cards (econ. Crisis will not stagnate the	Wild card: Strong growth-inflation-econ. Crisis	
										Ice conditions will not get easier
										Ice conditions ease: Need for ice breakers becomes rare
										Ice conditions get easier but no effect on GoB transport
										Strong Asia. Bulk transport very probable, railroads needed. reliability for containers not good enough
										Europe is strong, intellectual property protected, close to markets production
										SECA is a possibility for gas network, ship building, railroad projects
										SECA won't cause migration of industries, other factors stronger
										Major effects during 2015-2025 but those who survive are ok by 2030
										Cumulative effects of MARPOL are strong, NECA alone not
										The forestry of Finland and sweden cannot provide for both biofuels and forest industry
										Global markets for biofuel by 2030, plants in GoB viable
										Energy independence from Russia
										Imports needed to provide for biofuels and forest industry: from Russia
										Imports from other countries than russia
										No large investments in new railroads but to Narvik tracks
										Customers in Asia, good trading relations with russia
										Customers in Europe
										Mid nordic not realistic: Transport through Russia not possible, small ports cannot grow as hubs. Regional wish
										Mid nordic eases the congestion in Baltic Proper and overcomes the Northern railroad project issues: employment and opportunities
										Bothnia corridor is the best option for transport mainly from Sweden to mainland, Finland and Russia
										Benefits the ports-also in east-west direction
										Good trading relations: good transit

Not good trading relations-no nordic trust in 2030													
Murmans hub no effect on GoB -land transport too expensive													
No nordic trust -kirkkoniemi a strong competor													
Murmansk hub- railway dependent importance													
Salla-Kantalahti built - congestion in murmansk railroad overcome													
Kolari-Svappavaara or Rovaniemi-Kirkkoniemi													
The mining projects keep the GDP development high													
Fairway fees have a limit as new ice classes are built if fairway fees grow too much													
New EEDI-requirements might increase low powered vessels operating in the Baltic sea. This will increase the need of ice breaking assistance and slow done the winter operations.													
Railway fees decrease due to competition													
Russian WTO membership has an effect													
Chinas demand will stabilize at somewhat lower level and price pressure will decrease													
Raw materials pricing will increase if global economy grows and wild cards (econ. Crisis will not stagnate the demand)													
Strong growth-inflation-econ. crisis													
	Murmans hub no effect on GoB -land transport too expensive	No nordic trust -kirkkoniemi a strong competor	Murmansk hub- railway dependent importance	Salla-Kantalahti built - congestion in murmansk railroad overcome	Kolari-Svappavaara or Rovaniemi-Kirkkoniemi	The mining projects keep the GDP developm ent high	Fairway fees have a limit as new ice classes are built if fairway fees grow too much	New EEDI-requirements might increase low powered vessels operating in the Baltic sea. This will increase the need of ice breaking assistance and slow done the winter operations.	Railway fees decrease due to competition	Russian WTO membership has an effect	Chinas demand will stabilize at somewhat lower level and price pressure will decrease	Raw materials pricing will increase if global economy grows and wild cards (econ. Crisis will not stagnate the demand)	Strong growth-inflation-econ. crisis

Appendix B

Ports investments in the Gulf of Bothnia (Karvonen, 2010, Sjöfartsverket, 2011, Liikennevirasto, Trafikverket, Köjs, 2011, Elverheim, 2011)

Main improvements in the Gulf of Bothnia ports and hinterland connections			
Finland	**Timeline**	**Status**	**Purpose**
Kokkola	2013->	Planned	Dredging of fairway 13m -> 14m. Preparing for increasing transports to and from Russia, as well as Northern mining activities. Investments in crane infrastructure and land and water construction projects.
Rauma	2014->	Planned	Dredging of fairway 10m -> 11-12m. Improvements for container terminal infrastructure.
Uusikaupunki	2013->	Waiting for permission	Dredging of fairway 10m -> 12,5m, Increasing transports from Yara-Suomi Oy. Mainly fertilizers.
Pietarsaari	2012->	Waiting for permission	Dredging of fairway 9m -> 11m and dredging of harbor area, for imports of raw wood, biofuels and coal.
Vaasa	2011	Finished	Electrification of railway, planned investments for heavy lift crane and pier renovation
Kemi		Planned	The plans for transporting mining products from Pajala mines through Kemi did not fall through, ores transportation through Narvik. Mine products route to Kemi harbor was canceled. Planned deepening of fairway from 10m ->12m is dependent on Kolari mining products transportation.
Pori		Finished	Deepening of port, 11,5m->13,5m. New pier, depth 12m. To enhance the cost efficiency of transports.
Kaskinen		Planned	Rail replacement. Decision on realizing the plans not made yet.
Sweden			
Gävle	2011-2015	Ongoing	Large investments to increase capacity. Planned actions include Dredging of fairway (13,5m), improvements to free port terminal with RoRo-ramp, new oil pier
Umeå	2010	Finished	Straightening of road and rail connections to the harbor, Bothnia railway line
Luleå	2013->	Planned	Dredging of fairway 11,8-> 13,2m (new suggestion 15,7m)
Piteå		Planned	Possible expansion of harbor due to plans for building a cement tower factory producing wind turbine parts for export.
Sundsvall	2011	Finished	E4 motorway, Ådal line railway. Mid-Nordic

			Corridor and Bothnian corridor projects.
Härnösand	2011	Finished	Ådal railway line from Sundsvall via Härnösand, connection to Bothnia line
Örnsköldsvik	2010	Finished	Bothnia line railway, from Ångermanälven via Örnsköldsvik to Umeå
Kalix/Karlsborg	2011-2013	Ongoing	Dredging of fairway to 8,5m
Söråker	2012	Ongoing	Dredging of ports area 6m->8m

Appendix C

Maritime transport in Gulf of Bothnia 2030 –panel structure. The original panel is available at URL http://www.edelphi.fi/en/groups/maritime/content/index.

Theme I: Environment and physical conditions

Thesis 1: Ice conditions get easier by 2030

This allows more traffic in the Gulf of Bothnia and speeds up investments for Northern ports. Prospects for all year round transportation will increase. Reliability of winter transportation will enhance as ships can more commonly take the shortest possible route to the ports and the need for assistance is rare.

Thesis 2: Northern Sea Route (the North-East Passage) opens for commercial shipping by 2030

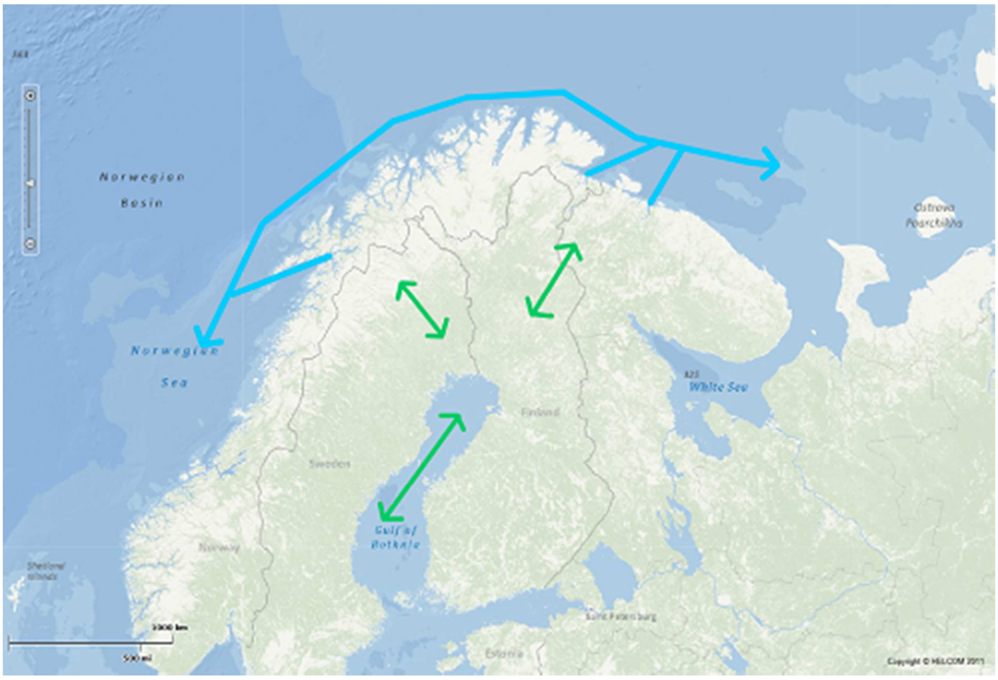

Figure 1: North Sea Route map (Copyright Helcom Map Service 2012)

Information: It has been estimated that global warming can ease the ice conditions in Northern Sea Route as multi-year ice packs would disappear. The Northern sea route could shorten the navigation time for example from Rotterdam to Yokohama with as much as 10 days (Liu & Kronbak 2010).

Goods flow through the Baltic Sea Region to and from the Barents Sea and the Norwegian Sea ports and back. The increase is greatest for containerized goods but also Northern Mining products and other bulk goods will be transported from ports of the Barents Sea. The Baltic Sea Region is a strong gateway for global transports. Investments are made for Gulf of Bothnia ports and transport corridors to enhance the North-South connection from the Southern Baltic to the Barents Sea.

Thesis 3: Sulphur Emission Control area (SECA)

Information: the Baltic Sea is designated as a Sulphur Emission Control Area (SECA). The sulphur content of fuel that is used in the Baltic Sea was reduced in 2010 from 1,5% to 1%. EU has set an additional requirement; 0,1% fuel must be used when operating in harbor area. In 2015 all fuel used by ships in the Baltic Sea area should not contain more than 0,1% sulphur. Alternatively, SOx scrubbers resulting in same SOx abatement may be used (Kalli & Tapaninen, 2008).

Choose the option closer to your views

a: Minor effect on shipping by 2030

Sulphur emissions control area (SECA) for the Baltic Sea and the North Sea will have a minor long-term effect on industries and maritime transport due to subsidization instruments for transportation modes using environmentally sound technology. The negative effects are short term and the transport sector will recover by 2030. Designation of North Sea as SECA area has a positive effect.

b: Major effect on shipping by 2030

SECA will have a major effect on shipping in Gulf of Bothnia. Industries that are highly dependent on transports will increasingly relocate their production units as they seek production areas with more economically viable transport options or shift their transports to roads and railways. The effects are greatest in the Northern Gulf of Bothnia as the transport distances are the longest.

Thesis 4: Nitrogen Emissions Control Area (NECA) will not decrease shipping by 2030

Information: Designation of the Baltic Sea as Nitrogen Emission Control Area (NECA), to reduce air-emitted nitrogen that adds to the eutrophication problems of the Baltic Sea is mentioned in HELCOM Baltic Sea Action Plan . If the Baltic Sea will become a NECA, newly built ships operating in the Baltic Sea area must install a system to tackle nitrogen emissions from 2016 onwards. The only viable method at the moment is a SCR exhaust gas after treatment device, which would reduce the nitrogen load from ships more than 80% (Kalli, Repka & Karvonen, 2010).

Nitrogen Emissions Control Area (NECA) will not have a significant effect on industries and maritime transport in the Gulf of Bothnia since the investments in technology are not as great as for SECA. The costs are gradual since technology must be applied for new ships only.

THEME 2: Innovations and industries

Thesis 5: New forestry products, such as biofuels increase their production greatly by 2030

New facilities are built in Finland and Sweden alike. Government's renewable energy strategy goal is fulfilled in Sweden: All cars run on biofuels by 2030. Great growth in biofuel production is experienced especially in the North where raw materials from forest industries are easily available. Traditional forest industries will experience growing competition over raw materials and this can have effects on maritime transportation in ports that are concentrated on forest industry cargo only.

Thesis 6: By 2030, imports of raw wood to Finland and Sweden are likely to..

A) Increase
B) Decrease
C) Stay on same level as for now

Thesis 7: Northern mining products transport will increase greatly by 2030.
The products will be mainly transported through

A) the Gulf of Bothnia

B) the Barents Sea via new railroads: Export ports Narvik, Skibotten and/or Murmansk.

C) Swedish products through the Barents Sea, Finnish products through Gulf of Bothnia ports

Thesis 8: Carbon dioxide capture increases shipping in the Gulf of Bothnia by 2030

Carbon dioxide capture and liquefaction plants will get more common in the Gulf of Bothnia area. Liquefied CO2 is transported for carbon storages with ships and this increases the marine traffic in the Gulf of Bothnia

THEME 3: Logistics and Transport corridors

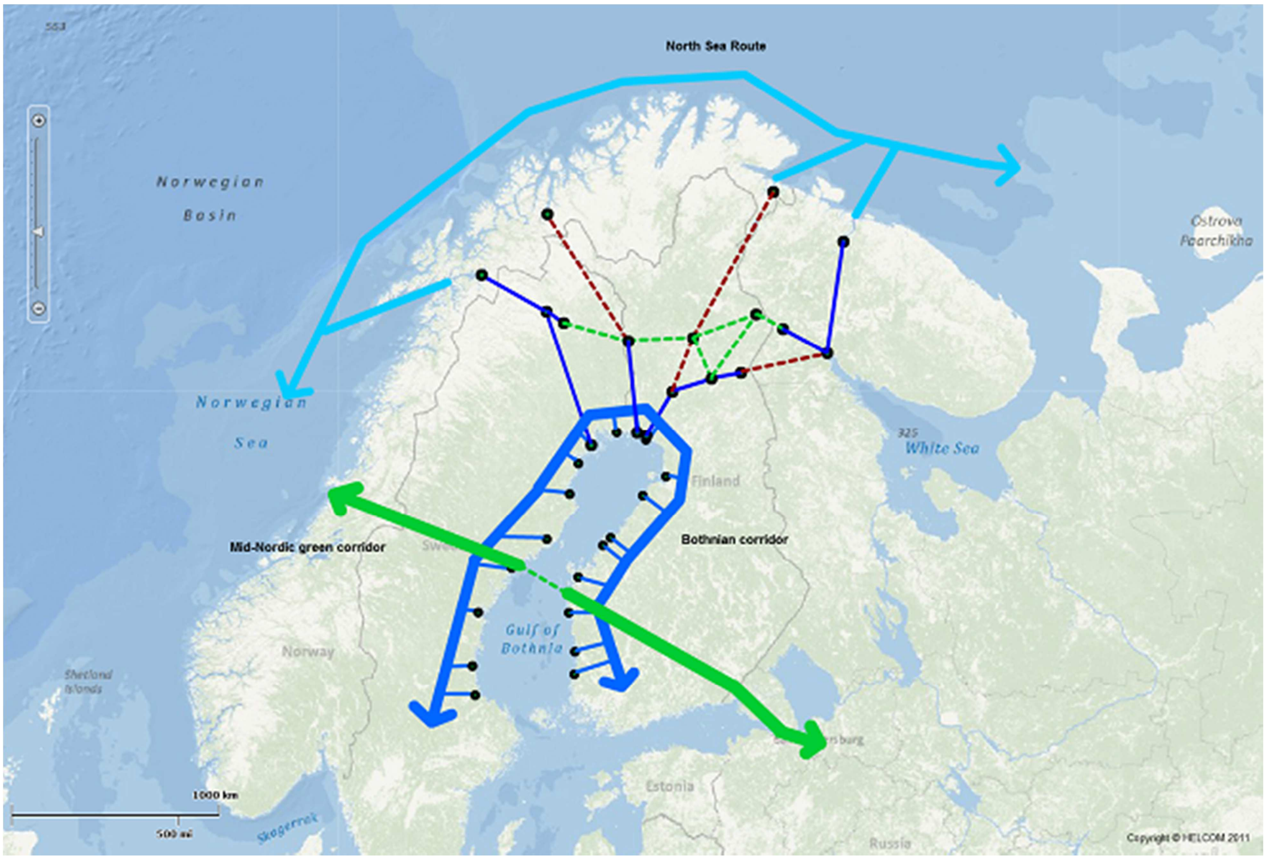

Figure 2: Transport corridors in the Gulf of Bothnia and proposed new railroads (Copyright Helcom Map Service 2012)

Thesis 9: Mid-Nordic corridor enhances cross-Bothnian transport opportunities and increases the East-West direction traffic

The Gulf of Bothnia is a strong link for transit transports in East-West direction. Transports will flow from Norwegian North Sea ports through Sweden and Finland to Russia and Asia and vice versa.

Thesis 10: Bothnian corridor enhances the North-South connections on both sides of the Gulf of Bothnia and increases intermodal transports in the ports

Intermodal transport chains will be effective and transports will generally grow in the Gulf of Bothnia due to the Bothnian Corridor.

Thesis 11: Transit traffic increases the traffic in the Gulf of Bothnia by 2030

Transit traffic will continue to be economically viable in the Gulf of Bothnia. New ports could benefit from transit traffic as intermodal transport chains develop, new railroad connections are built and the border controls will get more effective. Russia becoming a member of World Trade Organization has a boosting effect on transit traffic.

Thesis 12: Murmansk Port effect increases the traffic in Gulf of Bothnia by 2030

Murmansk is a large Northern hub port and the Gulf of Bothnia is a strong hinterland connection for increasing North-South direction transports.

Thesis 13: Transport will centralize in fewer large ports in the Gulf of Bothnia by 2030

This is mainly due to centralization of industries. Smaller ports, especially those without infrastructure for intermodal transports will have only marginal use.

Thesis 14: New railroad connections are built to Northern Finland and Sweden

One or more of the following railroad connections is built as the congestion on the railroad to Narvik demands more transport routes to the Barents Sea:

A) Kolari-Skibotten
B) Rovaniemi-Kirkenes
C) Salla-Kandalaksha
D) Cross-Lapland railroad/Sokli railroad or smaller parts of it

THEME 4: Economics

Thesis 15: Annual growth of GDP by 2030 will be closest to an average of..

Maritime transport scenario made by Finnish Transport Agency (Finnish Maritime Agency at the time) in 2006 predicted an average annual growth of 1,6% for Finland, as slow growth scenario. A Swedish long-term scenario has predicted an average annual growth of 2,2% for Sweden. The Baltic Maritime Outlook scenarios in 2006 used an annual average growth of 2,6% for Finland and 2,4% for Sweden. However the latest predictions for coming few years have been more careful. Annual growth of GDP by 2030 will be closest to an average of:

A) 1,5% or less in Finland and Sweden
B) 1,6% in Finland, 1,8% in Sweden
C) 1,9% in Finland, 2,2% in Sweden
D) 2,4% or more in Finland and Sweden

Thesis 16: Fairway fees in Finland and Sweden will grow substantially by 2030

This will have a decreasing effect on marine transport in the Gulf of Bothnia. Incentives for ships using environmentally sound technology will offer only small ease for shipping companies.

Thesis 17: Railway fees will increase significantly by 2030

Railway fees will grow due to magnitude of new investments in the railroad network.

Thesis 18: Raw materials prices will increase greatly by 2030

This is mainly due to competition over limited resources and future speculation of raw materials markets. This will have an increasing effect on maritime transport in the Gulf of Bothnia as economic viability of exploitation of raw material resources in the area will enhance.

THEME 5: Conclusion on key factors and cargo volume

Three most important key factors

In addition to these 18 theses or questions, there was a concluding part where the panelists were asked to mention the three most important key factors or write if there are some other important factors that were not mentioned.

Development of cargo volumes in 2010-2030

Figures are international imports and exports from Gulf of Bothnia ports of Finland and Sweden, including transit traffic. Growth from 2000-2010 is based on FTA and Trafikanalys statistics.

The Strong, average and modest growth in tonnage are calculated for the Bothnian Sea context based on the Baltic Maritime Outlook 2006, transit traffic scenarios made by Finnish Maritime Agency in 2006, scenarios for modal shift due to MARPOL annex VI reported by ENTEC (2010) and the shares of Gulf of Bothnia ports of the total cargo volume in 2010 (Baltic Port List 2011). Results were compared with Scenarios made by Finnish maritime agency (2006) and with the Baltic Transport Outlook (BTO 2011).

Slow and decreasing growth for 2010-2030 is calculated using the growth percentages +10% and -10% compared to the cargo volume in 2010.

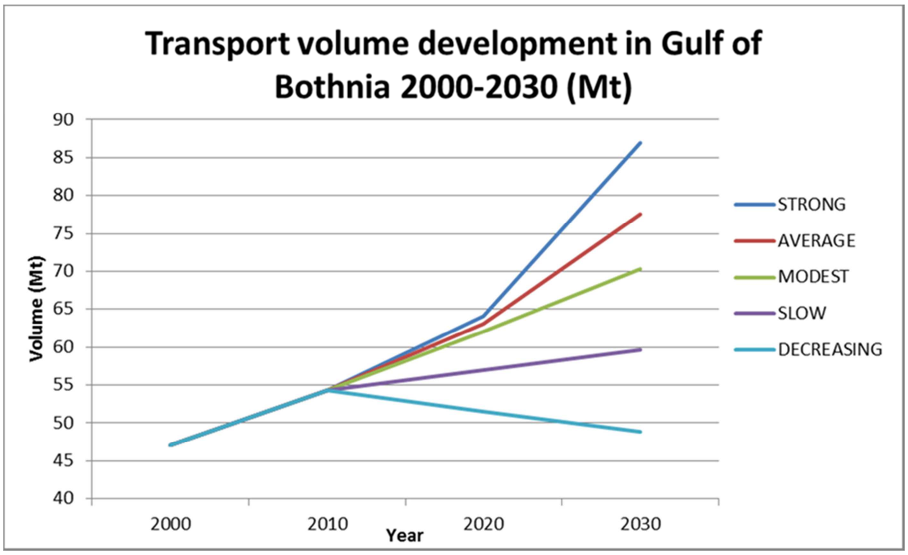

Figure 3: Cargo volume scenarios for Gulf of Bothnia

A) Strong growth: 60% volume growth or more
B) Average growth: 40% volume growth
C) Modest growth: 30% volume growth

D) Slow growth: 10% volume growth

E) Decreasing: -10% cargo volume.

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