Master's degree thesis

LOG950 Logistics

Reallocation of seafood freight flows from road to sea

Irina Karlsen and Shulin Huang

Number of pages including this page: 94

Molde, 23.05.2016

Molde University College
Specialized University in Logistics

Mandatory statement

Each student is responsible for complying with rules and regulations that relate to examinations and to academic work in general. The purpose of the mandatory statement is to make students aware of their responsibility and the consequences of cheating. Failure to complete the statement does not excuse students from their responsibility.

Please complete the mandatory statement by placing a mark ***in each box*** *for statements 1-6 below.*		
1.	**I/we hereby declare that my/our paper/assignment is my/our own work, and that I/we have not used other sources or received other help than mentioned in the paper/assignment.**	☒
2.	**I/we hereby declare that this paper** 1. Has not been used in any other exam at another department/university/university college 2. Is not referring to the work of others without acknowledgement 3. Is not referring to my/our previous work without acknowledgement 4. Has acknowledged all sources of literature in the text and in the list of references 5. Is not a copy, duplicate or transcript of other work	Mark each box: 1. ☒ 2. ☒ 3. ☒ 4. ☒ 5. ☒
3.	I am/we are aware **that any breach of the above will be considered as cheating, and may result in annulment of the examination and exclusion from all universities and university colleges in Norway for up to one year, according to the** Act relating to Norwegian Universities and University Colleges, section 4-7 and 4-8 **and** Examination regulations section 14 and 15.	☒
4.	**I am/we are aware that all papers/assignments may be checked for plagiarism by a software assisted plagiarism check**	☒
5.	**I am/we are aware that Molde University College will handle all cases of suspected cheating according to prevailing guidelines.**	☒
6.	**I/we are aware of the University College's** rules and regulation for using sources	☒

Publication agreement

ECTS credits: 30

Supervisor: Arild Hoff and Per Engelseth

Agreement on electronic publication of master thesis

Author(s) have copyright to the thesis, including the exclusive right to publish the document (The Copyright Act §2).
All theses fulfilling the requirements will be registered and published in Brage HiM, with the approval of the author(s).
Theses with a confidentiality agreement will not be published.

I/we hereby give Molde University College the right to, free of charge, make the thesis available for electronic publication: ☒**yes** ☐**no**

Is there an agreement of confidentiality? ☒**yes** ☐**no**
(A supplementary confidentiality agreement must be filled in)
- If yes: **Can the thesis be online published when the period of confidentiality is expired?** ☒**yes** ☐**no**

Date: 20.05.2016

Acknowledgements

The Master Thesis is a general requirement for the Master Program in Logistics at Molde University College. Work on the thesis begun on December 2015 and finished on May 2016.

We would like to express our sincere gratitude to our main supervisor, associated professor Arild Hoff for helping with insightful comments, his precious assistance, support and continuous guidance.

We would also like to express our special thanks to our supervisor professor Per Engelseth for providing us with the research topic and continued support, suggested ideas and enthusiasm that were helpful and have encouraged us in making improvements to the research during our work.

We are very thankful to all help that we received from all our informants, and especially to sea captain Geir Kjønnøy for providing us with important overall information about the project and all provided working documents,
Liesbet Pauwels, Project Manager of "Food Port" for providing working documents, which were very useful in our work,
Grete Leren Kroknes, Branch Manager of Sea-Cargo, for taking the time to meet with us and giving information about logistics challenges for current project from a practitioners` point of view.

We would like to express our deepest gratitude to Jan Erik Netter, Managing Director of Netter Analyse, for his assistance despite his busy schedule and for providing us during thesis writing with essential information on the project details.

We would like to express our deepest gratitude to Fire Chief and Head of Hitra Municipality Dag Robert Bjørshol who coordinates the development of Hitra Coastal Port and has a central role in the project realization. Dag Robert Bjørshol has kindly provided us with up to date information from first hands.

We would like to express our special thanks to all our lecturers at Molde University College for their assistance and academic knowledge.

Abstract

Norway is the largest producer of Atlantic salmon and the second biggest exporter in the world. Established 45 years ago, Norwegian aquaculture industry has progressively grown to become one of major importance. If the future development of the oil sector continues at the same rate as today, the seafood industry will become the largest in Norway. Salmon production is particularly important for the economic development of coastal Norwegian communities where some of the other industries face a number of challenges. Aquaculture brings the labor force into production and retailed services, creating thousands of jobs, promotes the development of transport industry and contributes to market development. Nowadays, most of the fresh salmon commercial flows is carried by road transport. However, short sea shipping (SSS) offers a greater potential as a transportation solution with regards to salmon export. SSS is an environmentally friendly transport mode characterized by a low level of pollution and high efficiency.

This paper argues the reliability of short sea shipping as a means of fish export from two Norwegian municipalities, Hitra and Frøya, located in Mid-Norway. Both Hitra and Frøya municipalities are the cradle of salmon farming in the world's leading aquacultural area, often referred to as the "Salmon Region". Their export volumes are expected to experience a 5-fold increase which, if continued to be transported by land, might lead to heavy deterioration of roads and especially the so called "Salmon road" Fv-714, notorious for its heavy traffic and numerous accidents.

In autumn 2014, as a result of cooperation between Kristiansund, Nordmøre Harbor and North Trøndelag Harbor Rørvik IKS, the Coastal Harbor Alliance was established. The mission of this alliance is to consolidate satisfactory export volumes of fresh fish to reallocate the Hitra/Frøya municipality goods` flows from road to sea. This can be accomplished through relocating fresh and frozen fish freight flows from Mid-Norway to continental Europe. Hirtshals and Zeebrugge harbors are intended to serve as entry gates from which the goods will be transported to customers in the EU. The main focus of the project is a solution satisfying demand of the end customers in terms of frequency, cost and reliability.

The empirical, case-based approach used in this study creates a description of the shipping network in its entirety and contains a detailed picture of the transportation chain. Our main informants are KNH Kristiansund and Nordmøre port Company and Hitra Municipality authorities. They are actively building a new Hitra Coastal Port and Hitra Industrial Hub.

The qualitative study provides a basis for the quantitative part where we employed quantitative analysis of the intermodal indicators located on the sea. Thus, the paper includes cost calculations comparing road transport to maritime transport and highlighting the determinants of these costs.

Another important objective of our study is to demonstrate the huge emission reduction possibilities in this multi-modal environment as opposed to road transportation.

The informants have provided their comments on the final analytical conclusions.

Contents

List of content

List of Abbreviations

SSS	Short sea shipping
Knot	Nautical mile (1.852 km)
KNH	Kristiansund & Nordmøre Port
NTP	National Transport Plan
Ro-Ro	Roll-on-Roll-off
Lo-Lo	Lift-on-Lift-off
Float-on-Float-off	Float-on-Float-off
CO_2	Carbon dioxide
CH4	Greenhouse gas methane
N_2O	Nitrous oxide
HFC	Hydrofluocarbon
NOx	Mono-nitrogen oxides
SECA	Sulfur Emission Control Areas
COLT	Customer order lead time
SCLA	Supply chain lead time allowance
SCU	Stock Keeping Unit
NSR	North Sea Region
ROPAX	Roll-on/Roll-off passenger
MAP	Modified atmosphere packaging
WWF	World Wildlife Found
ASC	The Aquaculture Stewardship Council
INTERREG	The North Sea Region Programme 2014 - 2020
LM	Lane Meter

1 Introduction

1.1 Background

Norway is the largest producer of salmon in the world. Norwegian salmon export volumes resulted in highest value in 2015 worth NOK 47, 7 billion where export to the EU is NOK 35, 2 billion (NSC 2016). Currently, the salmon export from Norway to EU markets is growing steadily and powerfully in both volume and value (Figure 1.1). Volume growth in the Norwegian seafood industry already runs faster than the development of the road network.

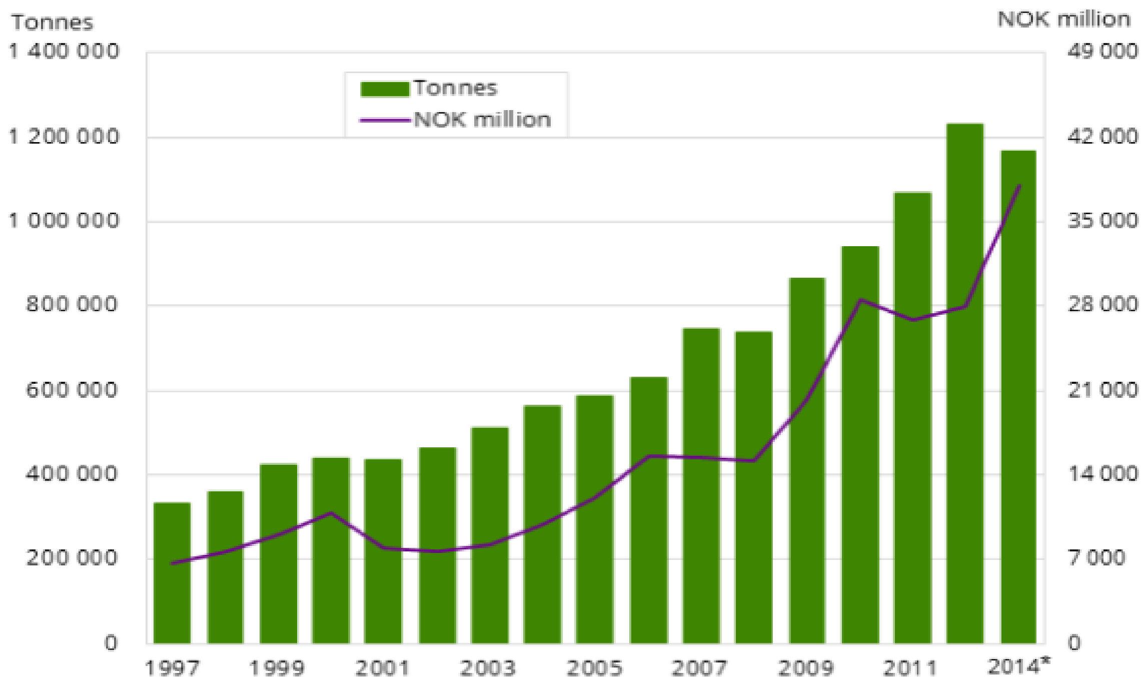


Figure 1.1: Sale of salmon. Quantity and first hand* value. (Statistics Norway 2015a)

The main solution for transportation of fresh salmon export flows is transportation by road as can be seen from Figure 1.1. The transport flows generated by the salmon production, create considerable pressure on certain roads and ferry crossings. Additionally, there is also a tendency towards structural changes in salmon production: concentration of production and slaughterhouse facilities. These factors lead to centralization and together with volume

---

*The first hand value corresponds to the value of sold fresh and frozen slaughtered fish.

growth – to significant logistical challenges. The larger volumes of salmon are transported from fewer plants / clusters, the more significant will be the transport load on the roads used for transportation from the plants to the borders crossing (Samferdsel 2014).

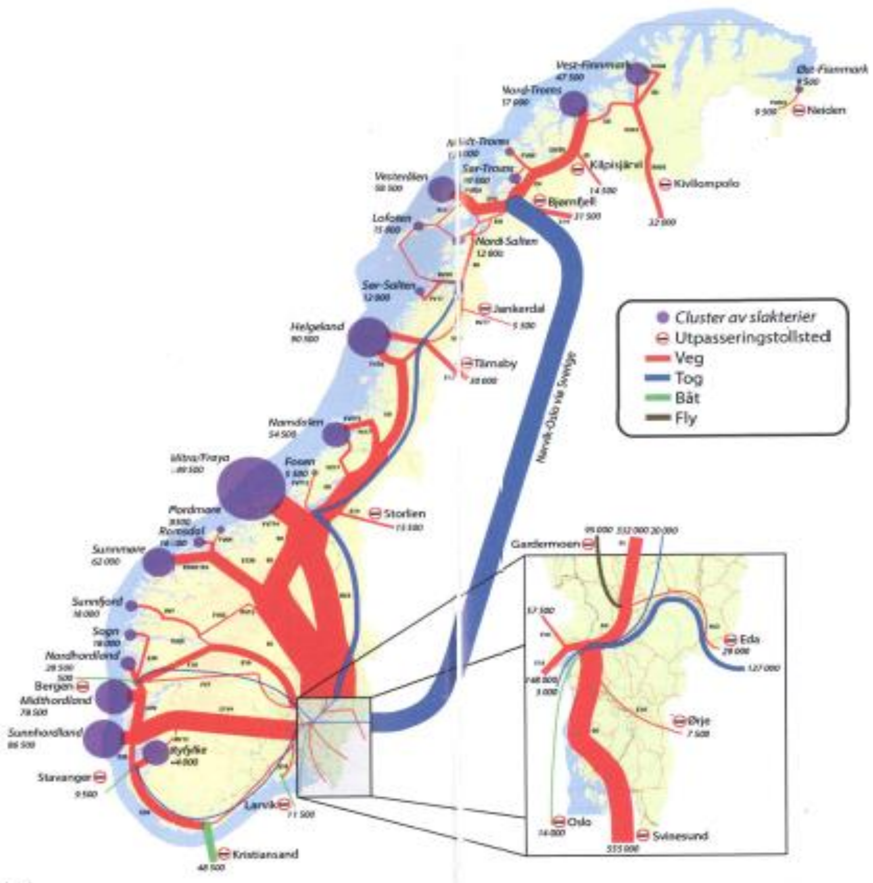


Figure 1.2. Transportation of fresh salmon and trout for export in 2013. Figures in tons (net weight) (Samferdsel 2014).

In addition, there is a challenge - export that consists of fresh products requires a rapid sustainable logistics chain, a high level of flexibility and predictability of transportation.

A lot of different goods are transported by sea, the fresh fish is still an exception. Nevertheless, a gradual development is taking a place. The Coastal Harbor Alliance creation and its project implementation is a significant step in development of intermodal solution for fresh fish supply using ships as the transport mode. By opening a new route system between the key ports as well as through inland link improvement, The Coastal Harbor Alliance offers outstanding growth possibilities for the seafood transport system. A member of the Alliance, Hitra coastal port is a new and specially adapted fishing hub. In fact, the three major aquaculture companies located on Hitra/Frøya Lerøy, Marine Harvest and SalMar produce enough to consolidate freight flows and to export fish by ship. The production volume (2014) was about 280000 ton per day and it is estimated to be doubled by 2020 and fivefold increase by 2050 (Enova project 2015). The new intermodal approach to transport will reduce environmental and health-damaging emissions from trailers, reduce transportation costs for businesses and contribute to better road safety. This concept already became a part of the Norwegian National Transport Plan.

In our thesis we would like to exam and compare possible seafood transportation solutions from Hitra and Frøya municipalities to Zeebrugge port and further to European countries. Thus, in our work we would like to prove and demonstrate in details the advantages of an intermodal solution combining maritime and road transport modes.

The main efforts of the Coastal Harbor Alliance aimed at establishment of Hitra-Hirtshals direct sea transport connection and as the next step, at development of Hitra-Zeebrugge corridor. Zeebrugge is supposed to be an important supplement to the Hirtshals connection. It is necessary due to estimated production volume development in both Hitra/Frøya and Ytre Namdalen area (North-Trøndelag). In addition, Kråkøya costal port (Rørvik) in Nord-Trøndelag will be opened for collaboration with Hitra as a twin port in the Coastal Port Alliance (Enova project 2015).

The specificity of maritime transportation in our case is Short Sea Shipping.

Short Sea Shipping (SSS) is efficient, safe and it is the most environmentally friendly transport mode that is highly supported by the government. SSS could take considerable volumes of fresh salmon transportation off Norwegian and Europe’s saturated roads and decrease pollutions and injuries caused by road transportation.

1.2 Research questions and primary objectives of the study

The purpose of this study is to focus on the Zeebrugge alternative and explore it, compare indicators of multimodal transportation with road transportation indicators and to assess advantages of the modal split with different traffic and number of trips. An important issue here is the change in the cost associated with acquiring of a new vessel.

It is obvious that the sea transport alternative is more preferable than road transport regarding costs and emissions’ reduction and road safety. The main constraints in our case are the capacity of the ship and lead-time.

The additional purpose of the study is to dedicate attention to the intermodal transport solution and to increase the transparency and attractiveness of intermodal services, by defining its cost structure and highlighting the terms of pricing.

Thus, we are going to analyze the Zeebrugge alternative. To demonstrate the savings and competitiveness of short sea shipping solution with Roll-on-Roll-off ships in comparison to road prices, our work will include the cost analysis. To demonstrate environmental benefits of intermodal solution, we are going to calculate the emissions in a multi-modal environment and to compare the results with road transport alternative.

Thus, the main research questions of paper are:

- **Research question 1** is linked to the customer service concerns (time-to-market):
  Are we able to gain a satisfactory service level for the customer when applying intermodal concept?
  By answering this question, we are going to prove the viability of fresh fish transportation in terms of time and analyze the risks associated with intermodal concept.

- **Research question 2** is related to the cost structure of both transportation alternatives:
  What are the cost determinants of the sea/road transportation?
  Is there possibilities to improve cost structure from practitioners` point of view?

- **Research question 3** is related to the environmental concerns:
  How significant are the possibilities for emission reduction in a multi-modal environment compare to the road transportation?
  How reasonable is the investment in this project and how much can society gain through use of environmentally friendly transport?

- **Research question 4** is the conclusion, based on the findings:
  The comparison of two modes of transport-road-sea-in terms of costs and time and the analysis of the economic viability of the sea transport as the alternative for road transportation.

1.3 Value

In our thesis, we have created overview of networked firms, working together to promote reallocation of seafood transport flows from road to sea to achieve sustainability of transportation chain. We have highlighted main challenges for the realization of the project based on the latest information and previous studies. To prove the viability of the intermodal solution, we conducted cost comparison of two transport solutions: all-road transportation and intermodal supply chain road-sea-road. Similar intermodal solutions can be very attractive in other regions of the Norwegian coast where the concentration of export volumes is possible and current traffic situation dictates the need for some changes due to growing export volumes.

1.4 Structure of the Thesis

Chapter 1 represents the objectives of the research and its background. The primary objectives of the study, research questions and research problems are presented here.

Chapter 2 represents the literature review. Here we have mentioned the theory approaches, which are relevant for our study.

Chapter 3 is a qualitative case description which will provide the foundation for our analysis in the following chapter.

The chapter includes detailed description of the participants of the project. The chapter includes the information on the structure of the current transportation chain and alternative intermodal solution truck-sea-truck. The participants of the project are the key ports, the main producers exporting fresh salmon from the region Hitra/Frøya to the European countries, logistics providers, government side and the customers. We have provided information on customers` demand and the specificity of their geographical location.

Chapter 4 provides the analytical part that includes the calculations part. The data collection process and the approaches applied for the analysis of transportation modes` determinants, their performance and comparison in the research described here.

Chapter 5 and 6 are the interpretation of the results. In this chapter we have discussed the analytical findings in communication with the supply chain structure.

Chapter 7 represents the limitations of this case study.

Chapter 8 will discuss potential future challenges and further investigations.

Chapter 9 is the part of conclusion and findings.

2 Literature review

The purpose of this part of the paper is to refer to the literature that is relevant to the topic of the research and create a theoretical background for the project. The relevant theories are described in details and the previous studies related to the current project are taken into consideration.

2.1 Greenhouse Gas Emissions from transport sector

The processes of goods production, transportation, inventory storage and end customers` consumption are causing greenhouse gases emissions. Greenhouse gases are the gases in the atmosphere that cause the greenhouse effect. These gases are making the climate of our planet warmer through their absorption and radiation emission in the thermal infrared range (IPCC 2007). As it was estimated by ecology specialists (Mora et al. 2013), if the greenhouse gas emissions will not be reduced, humanity can face the excess of the historical planet`s temperature already in 2047 "with its impact on ecosystems, biodiversity and the livelihoods of people worldwide" (Statistics Norway 2014a).

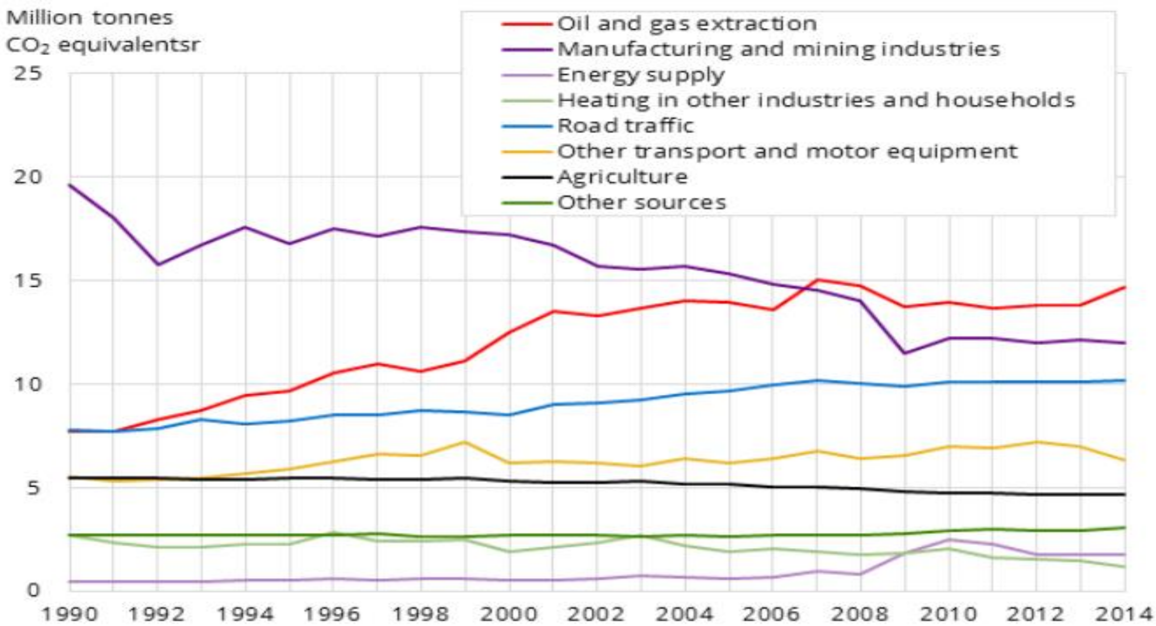


Figure 2.1. Domestic emissions of greenhouse gas emissions, by source (Statistics Norway 2014a)

As it shown in Figure 2.1, transportation of goods represents most important challenges for the environment after oil and gas extraction, manufacturing and mining. Road freight transport is a major source of carbon dioxide (CO2) emissions that comes from the burning of petroleum-based products in cars engines. The amount of other greenhouse gases emitted during fuel combustion is quite small (Figure 2.2). There are gases as methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbon (HFC) emitted from mobile air conditioners and refrigerated transport (EPA 2016).
CO2 emissions caused by sea transport are significantly lower compared to road transportation. However, construction and renovation of port area cause large amount of pollutants into air and water, which threatens the lives of local people and natural surroundings. (Rondinelli and Berry 2000)

Figure 2.2. Types and amount of greenhouse gases emitted by different sources (Statistics Norway 2014b)

Reduction of emissions is an important objective of the national environmental policy. The national Norwegian transport plan (NTP) approved for the period 2014-2023 presents goals and strategies for the transport sector during the next ten years. To meet national targets and Norway`s international health and environment commitments, the NTP is aimed to make contribution from the national transport policy to greenhouse gas emissions limitation to reduce transport environmental effects. (The Government 2013). According to the international Kyoto agreement (UNFCCC 1998), Norway should aim to reduce greenhouse gas emissions to 84 per cent of the emissions produced in the country in 1990. There is also an agreement implied by Norwegian parliament in 2008, where the emission reduction is set as a national target. The Ministry of Transport is working to achieve these goals by stimulating public transport and innovative types of transport, by investment in new technologies and encouraging a change to vehicles with lower emissions. This policy is also supported by the economic instruments: CO2 taxes and green energy subsidies. These tools will make environmentally friendly transport modes more attractive.

From the environmental perspective, no transport mode is absolutely superior to others.

Trucks consume a large amount of unclean fossil fuel per day, which emits CO2, NOx, sulfur compounds and other toxic substances. This seriously reduces air quality. Dekker et al. (2012) analyzed choices within transportation (transportation mode, intermodal transport, equipment choice and fuel choice) and their environmental impact. Obviously, consolidation of cargo leads to lower CO2 emissions per g/t/km. Although, ships emit more NO2 compared with other modes (container vessel, rail, truck and plane), nevertheless transport by vessel is most CO2 efficient and consumes the least fuel. Therefore, short see shipping is very attractive as it is an economically competitive and a sustainable transportation mode (Medda and Trujillo 2010).

It is worth noting, that there is own tax system for sea transportation. The new Sulphur Emission Control Areas (SECA)` Protocol came into effect in September 2015 under new EU legislation. There have been inroduced certain taxes and requirements for shipping companies as to use fuel where the sulphur content should not exceed 0.1% when operating within the SECA. The SECA includes the North Sea, which Norwegian shipping companies are crossing during their import/export operations. Therefore, it will have impact on the operation costs and will transport factor price rises to the customers (DSV 2015).

In fact, there is a variety of possibilities to reduce transportation:

- fuel-switching,
- development of new technologies and vehicles that are more efficient,
- minimization of fuel use by adopting driving practices,
- improvement on maintenance,
- switching from one transport mode to another during a transportation chain (EPA 2014).

In our case, all transportation related to export of fresh fish to the EU countries represents about 130 mill.ton.km/year with emissions equal 76 g CO_2-ekv./ton.km that gives possibility CO_2 emissions reduction of about 10000 tons per year. Further, assuming a possibility of 50% of return cargo flows, the reduction of emission will be definitely increase to 15000 tons per year (Enova project 2015).

2.2 Transport Mode

The main choices on transportation are the following: truck, vessel, airplane, pipelines, and rail. Cost will be the priority in the mode selection at most of time to achieve profitability. However, the choices are limited by distance and characteristics of goods. Air mode is applied to deliver high perishable goods due to the advantage of short time accessibility. Recent innovation on technology makes the shift between different modes possible. The invention of reefer containers changes the flow of fresh seafood freight from air to road-based transportation. Temperature control enables one to maintain a standard of freshness of fish products for a longer time.

2.2.1 Intermodal transport

Intermodal transport is a combination of at least two transport modes in a particular transportation chain without any change of container. The main part of the route in the intermodal structure is travelled by rail, inland shipping canal or ocean-going vessel. Initial and final road transportation has to be as short as possible (Macharis and Bontekoning 2004). Intermodality is a process of transporting freight by means of a system of interconnected networks, involving various combinations of modes of transportation, in which all the component parts, are seamlessly linked and efficiently coordinated. (Boske 1998)

Simina et al. (2012) has discussed the pricing of intermodal transport. The cost structure of intermodal transport may consist of infrastructure costs, maintenance costs for terminals, costs for purchase of vehicles and equipment, costs of transfer and storage of load. Thus, the cost structure for the transportation at each phase is unclear and it is thereby hard to break down the total cost precisely. It shows that intermodal transport is cost-efficient over long distances and in large volume.

The overall economic benefits of intermodal transportation proposed by Yevdokimov (2000) are divided into four elements: (1) an increase in the volume of transportation in an existing transportation network; (2) a reduction in logistic costs of current operations; (3) the economies of scale associated with transportation network expansion; (4) better accessibility to input and output markets.

In the studied case, combination of sea and road transportation is interconnected with the intention to achieve efficient transportation performance. Another reason to use multi-modal concept here is reduction of road accidents and reduction of traffic congestion in urban area. Road transport creates noise pollution and unsafe conditions for human life. Additionally, less greenhouse gas emission is also desired in the long term from the perspective of green logistics. The term "Green logistics" refers to a form of logistics which is designed not to only be environmentally friendly, but also economically functional (Rodrigue et al. 2001). There is no evidence that taking environmental considerations into logistics system would have a negative influence on logistics performance (Wu and Dunn 1995).

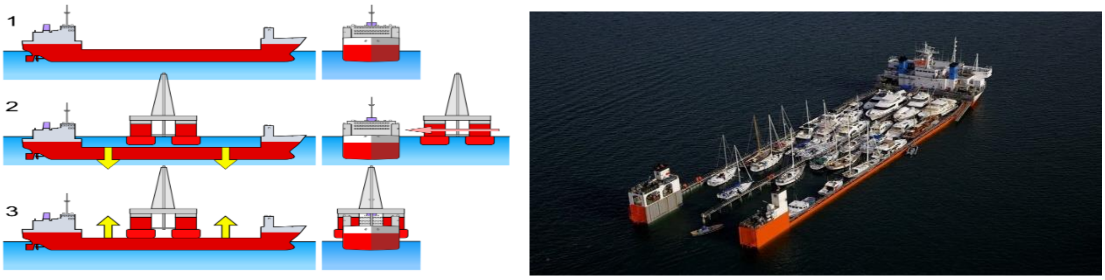
Another important aspect for supply chain management is the integration of a multimodal transportation system. The aim of this integration is lead time minimization and improvement of resource utilization. Thus, intermodal transportation ensures optimization of its modes not only separately but also as a part of transport network as a whole system (Macharis and Bontekoning 2004).

2.2.2 Short Sea Shipping (SSS)

Short Sea Shipping usually defined as the shipping of cargo flows for quite short distances along a coastline between European and non-European ports located in the seas bordering Europe. By the EU Commission SSS considered as "the only freight mode that can offer a realistic prospect of substantial modal shift from road, as well as improve competitiveness and reduce environmental damage" (EU Commission 2009). In the current transport chain as a whole system, SSS is a supplement of the road transportation by truck and its competitor providing services in the same market. The intermodal concept requires identification of the correct implementation, use and capability of SSS as an alternative transport mode and as a supplement.

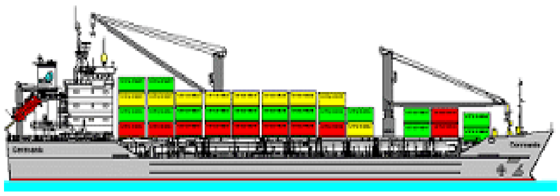
Viability of Short Sea Shipping also depends on type of transported cargo that determines the choice of transport. To achieve its functionality in transportation chain and execute delivery rapidly, the SSS market uses specific type of ships and applies advanced technologies. The main technologies of the SSS are Float-on-Float-off (Flo-Flo),
Lift-on-Lift-off (Lo-Lo) and Roll-on-Roll-off (Ro-Ro).

The "float in and float off ships are also known in which the floating cargo is floated into the ship's cargo space in superposed tiers in order to avoid the disadvantages of the use of ship borne lifting devices (Picture 2.1). A disadvantage of this arrangement is however that the ship must be lowered for each tier to an immersion of the ship, which allows the floating vessels to be stowed into a stowage level vertically fixed within the ship. In addition, they must be adjusted to fix deck or girder structures which segregate the cargo containers at various cargo levels" (GlobalSecuirity 2016).



Picture 2.1: Float-on-Float-off ship (plusgoogle.com 2016)

Shown on the Picture 2.1, the Lo-Lo vessels are container vessels transporting a wide range of products that must be loaded and discharged in the port by cranes and derricks. The cargo is lifted on the vessel according to a particular plan that is required by technical characteristics of the vessel, “not equipped with ballast-adjusting mechanisms” (GlobalSecurity 2016). The Lo-Lo solution will be relevant for other types of cargo and included in use at Hitra.



Picture 2.2: Lo-lo ship (Combi Lift 2016) Picture 2.3: Ro-Ro-Lo-Lo contaner ship (Container Handbook 2016)

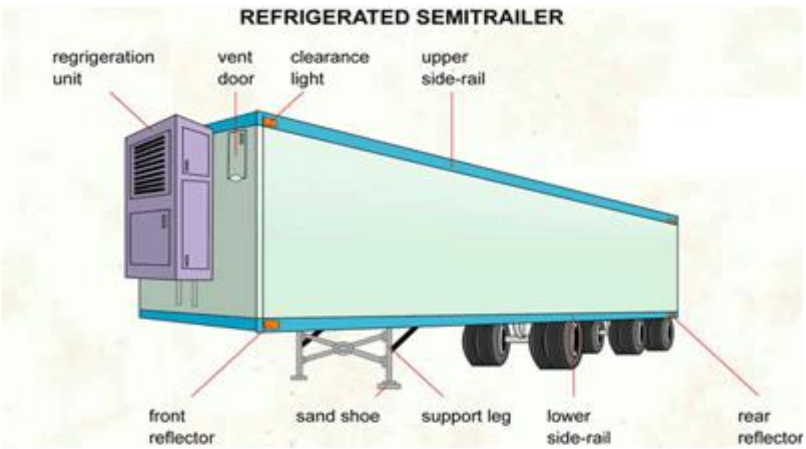
The Ro-Ro technology is used for the fresh fish transportation in the studied case. Roll-on-Roll-off is the technology, which is applied in the design of ships and allows to carry wheeled cargo. This is the only solution for sea transportation of heavy wheeled freight such as trucks and other bulky constructions and road machinery. There also exist Ro-Ro-Lo-Lo vessels, combining both technologies (Picture 2.3). The Ro-Ro vessels represent a considerable investment and therefore require a satisfactory level of the commercial operations (Medda and Trujillo 2010).

2.2.3 Shortsea Ro-Ro ships

Ro-Ro vessels built-in or shore-based ramps allow the cargo to be efficiently driven on and off the ship during loading/discharging in the port. In this way, the load (in our case trucks) is rolled on/off the deck on its wheels as shown on the Picture 2.4. Advanced engineering technologies enable the ship owners to compete in the SSS market through the functionality optimisation of Ro-Ro ships and flexibility in cargo access equipment. The use of stern ramps suitable for the different types of quays and port facilities, custom-made shore ramps provides a highly efficient and quick loading and unloading (MacGregor 2016).

Picture 2.4: Shortsea Ro-Ro ship (MacGregor 2016)

2.2.4 Refrigerated semitrailer



Picture 2.5: Refrigerated semitrailer (Fix on road 2016)

“A refrigerated semi-trailer is a heavy truck for transporting goods that must be kept cold. Reefers all contain refrigeration units. A vent door is made of movable panels that are used to regulate the air intake. Clearance lights indicate the form and dimensions of the specific reefer truck. An upper side-rail is a truck part that in essence is a beam that runs the length of the upper frame of the reefer. The rear reflector is a light-reflecting device that marks the back end of the reefer. The lower side-rail is a beam that runs the length of the lower frame. Support legs hold the semitrailer in a horizontal position. A piece of metal that protects the end of the support leg of the reefer is called the sand shoe. A front reflector marks the front end of the reefer using a light-reflecting device. Much of the long-distance refrigerated transport by truck is done using articulated trucks pulling refrigerated semi-trailers (reefers)” (Fix on road 2016). Layout of the refrigerated semitrailer can be seen on Picture 2.5. As the whole system is based on a road/sea intermodal concept, the semitrailers without drivers on the board will be delivered to Zeebrugge Port by shortsea Ro-Ro vessels. There the semitrailers will be connected to new trailers and deliver the production to the final destination. The number of the trailers involved in the transportation process is estimated to be at most 200 semitrailers due to ship capacity. Return cargo will however be a crucial factor. The project is based on the concept of collaboration between suppliers, recipients, a shipping company, a road logistics provider and harbors. The trailer will function both as a cargo carrier and a distribution unit. A tractor unit towing a semitrailer is disconnected from the port of loading and a new tractor unit connected at the receiving port for further distribution. Thus, a ship stands for main transport (long-distance transport) and through this the transport work on the Norwegian roads will be reduced. The customer will still receive a trailer with load as before (Enova project 2015).

2.3 Transport speed

Slower steaming gets more concern in maritime transport in the 21st century due to the issue of cost efficiency and emission. Speed reduction benefits both environment and shipping operators in terms of pollutant reduction and cost saving. It is important that the economic benefits will be also secured. However, there exists a negative correlation between slow steaming and vessel loading capacity. Therefore, maintaining a certain vessel size is the basis of speed control. (Woo and Moon 2014). Taking decision managers count economic savings from slow speed and extra income which is raised by speed-up service. However, when considering the environmental performance, slower speed is the preferable choice in maritime shipping if it is still possible given certain time limits.

In the model of speed optimization on the fixed shipping routes, the main objective is to reduce fuel consumption. This is possible to achieve by adjusting the sailing speed. At the same time, the sailing will be more CO2 efficient if fuel consumption goes down. The critical constraint in this problem is the time window, since ships have to arrive to each port node within the time setting along the shipping route.

2.4 Sustainability in transportation

As it was defined by The Center for Sustainable Transportation in 2002 sustainable transportation is a transportation that satisfies individuals and society`s needs without harm and in a way appropriate to human and environmental health, in equal conditions for current and future generations. As can be seen from Figure 2.3, sustainable transport is economically efficient and energy effective, competitive, operating offering alternative transport solutions and accomplished by use of innovative technologies.

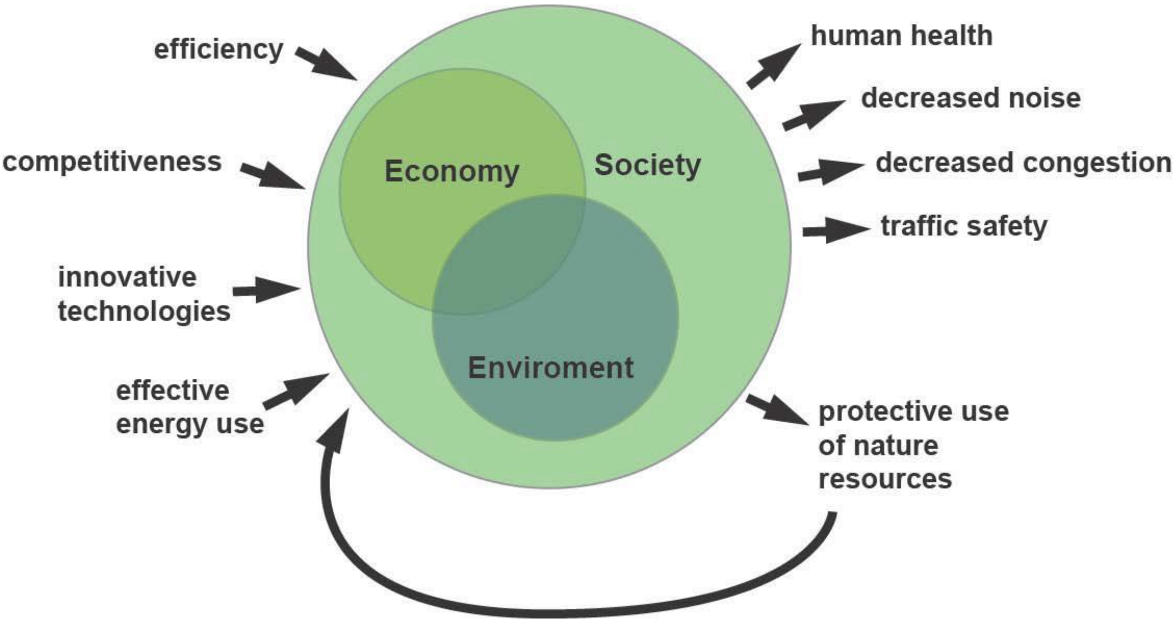


Figure 2.3. Structure of sustainable transport (Thomaeus 2011)

Sustainable transport is a system taking into consideration the environment and aimed to reduce emissions and waste, minimize consumption of rare natural resources, and decrease the use of land noise. In addition to this, there is a strong transport link between sustainable transport and reduced accidents and congestion on roads. Sustainable transport contributes to economic development. Social progress and living quality are improved by implementing the concept of sustainable transport. (Thomaeus 2011) points out that a transport system can be characterised as sustainable where economic efficiency and environmental protection complement each other.

The adjusted system of information sharing and integration is vital for supply sustainability of fresh fish as perishable goods. This system greatly influences the waste reduction.

The estimated food waste from manufacturer to the end customer in different supply chains is about one-third of the production volume. The possible causes of the waste in fresh fish supply are weather conditions, lack of coordination of supply flows, road accidents, failures in the transportation process, shortcomings in the shelf-life management, inconsistency between demand and supply etc.

The ways to reduce waste are correspondence of production volumes to customers 'demands and implementation of improvements on the efficiency and performance of the supply chain as a whole system. In the case of fresh fish supply, it is necessary to take into account the specificities of transportation and features of the product, affecting management and performance of the whole chain (Kaipia and Dukovska-Popovska 2012). The logistics providers in fresh fish supply chain targeted to deliver the product to the end customer in perfect condition and maximize available shelf life time.

Three main characteristics of the food market, affecting the structure of the supply chain were identified by Kyttipania-ngam et al. (2010):

1. Demand uncertainty. Customer demand is influenced by natural factors as weather conditions and seasonality and also encouraged by promotion actions (Taylor and Fearne 2009)
2. Customer order lead time (COLT). Usually, lead time required by customers is quite short.
3. Supply chain lead time allowance (SCLA). Perishable goods characterized by limited lifecycle. Efficiency in the supply chain lead time (SCLT) sharing between the elements of supply chain is of crucial importance.

Perishability of the goods does not allow to create an inventory buffer against demand changeability and failures in the transportation. This can be compensated by flexibility in the supply and increased speed (Ahumada and Villalobos 2009).

Collaboration between participants at an operational level of the chain and at least a partly integrated support system together with use of advanced forecasting techniques allows to achieve the required level of flexibility and speed (Kittipania-ngam et al. 2010).
The unit of analysis in our case study is the fresh fish supply chain that consists of the following main elements: producer, port of loading, logistics provider, port of discharge and end customer.

2.5 Food supply chain

Food supply chain is a network of food-related business enterprises through which products move from production to consumption, including pre-production and post-consumption activities as can be seen from Figure 2.4. (Stevenson and Pirog 2008)

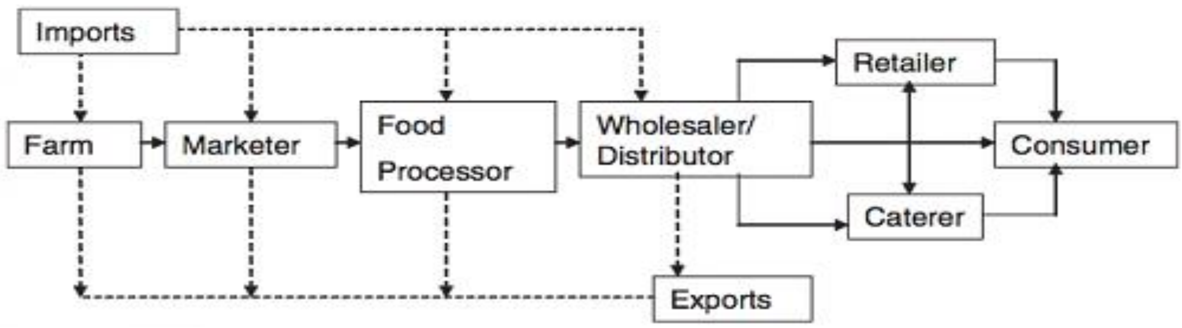


Figure 2.4: Food Supply Chain Schematic (Dani and Deep, 2010)

The chain is spilt into three sectors: agricultural sector, food processing industry and distribution. Agricultural sector encompasses the product manufacturing, which is the source of food. And food processing may consist of various value-added activities such as refine, mill, clean, cut or dry. Distribution sector connects directly to the end actors in food supply chain and provide relative customer services. And in general, wholesalers and retailers in the distribution sector are responsible for product sale and promotion.

2.5.1 Key characteristics of Food Supply Chain

Key characteristics of conventional food supply chains are: (1) Business relationship within the supply chain are framed in win-lose terms. (2) Input suppliers operate in restricted markets or under short-term contracts. (3) Benefits and profits from the selling of finished food products are unevenly distributed. (4) Operations are located and coordinated on a national and international scale. (Stevenson and Pirog 2008)

2.5.2 Qualitative and quantitative characteristics of a Food Supply Chain

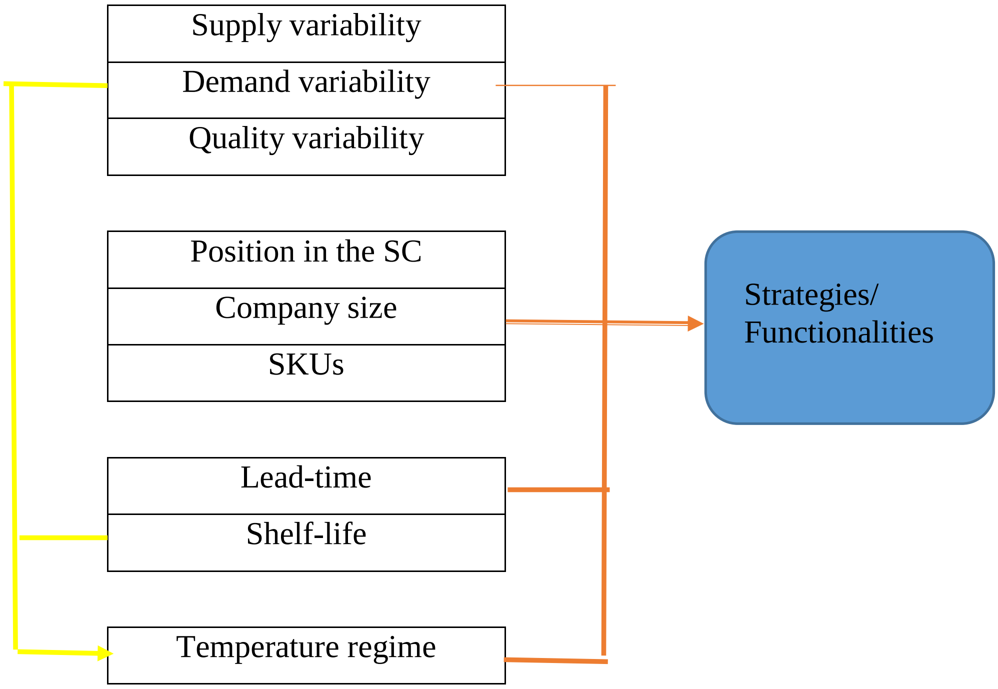


Figure 2.5: Qualitative and quantitative characteristics of a Food Supply Chain (Liljestrand 2012)

Figure 2.5 shows qualitative and quantitative characteristics of a Food Supply Chain. In fact, seasonal supply and demand variabilities of the fresh salmon are low. The quality variability is medium. The shelf life of fresh salmon varies from 14 to 16 days. Lead time is 4 days to processing. The temperature has to be quite low. Main producers are large companies: Marine Harvest, Lerøy, SalMar. There are a narrow range of Stock Keeping Units (SKUs) (Liljestrand 2012). Collaboration with other producers is important to reduce the logistics cost of transportation and to reach new markets.

2.6 Value-based supply chain

Value-based supply chains have to combine product differentiation and cooperation with competition to achieve collaborative advantages in the marketplace. It makes commitments to the welfare of all strategic partners, including appropriate profit margins, fair wages and long-term business agreements. It emphasizes high levels of performance and inter-organizational trust. Additionally, the system of information sharing includes shared values, visions and shared decision-making tools. (Stevenson and Pirog 2008)

2.7 Effectiveness and efficiency of logistics services

Effectiveness is the right goal setting for the project that can be achieved in a specific time period. Efficiency is completing the object in an optimal way, input fewer resources on goal achievement in order to maximize profit.

The members of The Coastal Harbour Alliance aimed to develop an efficient and effective logistical solution for the food supply chain. The effectiveness in this case study is measured by the service level. The service level of logistics services is affected by the factors like time to market, product quality, customization and flexibility. The efficiency is measured by transportation costs and positive contributions to environment protection.

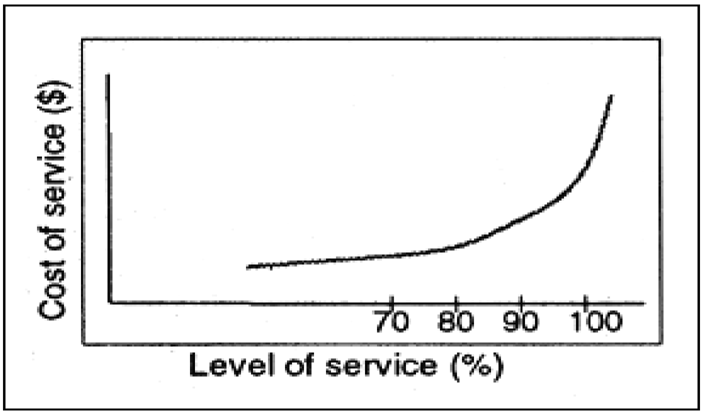


Figure 2.6: The relationship between customer service level and cost (Crawford 1997)

From the figure 2.6, we can conclude that high service level follows with cost increasing. Even though business owners want to become more competitive in the market place through high customers' satisfaction, they have to find a balance between service level and relative cost.

Integration in supply chain obviously strengthen supplier`s competiveness in market. They benefit from it in terms of production cost, resources utilization, working capacities and so on. Koufteros et al. (2005) suggest that integration consists of two dimensions, supplier product integration and supplier process integration.

The transaction cost of integration should be take into account. Reasonable decision makers always balance saving on supplier integration and relative expense raised by it. In the research, Perols et al. (2013) presents two types of supplier integration: supplier process integration and product integration. They have opposite impacts on time-to-market. Time-to-market can be accelerated by supplier process integration, while product integration slower time-to-market.

2.8 Previous studies

Kristiansund & Nordmøre Port (KNH) and the Hitra Port participated in several projects that have had fresh fish export and logistics as main issues. Sea transport solution can provide a desired level of sustainability for the aquacultural sector, where there is still room for improvement. The projects have attracted considerable interest from participants and key market actors.

The previous studies our work based on are listed here:

1) **Project « Sustainable sea transport solutions for fresh salmon exports from Mid Norway to Continental Europe"**

   The project was funded by Enova and Hitra Municipality and finished on 1. September 2015. Enova is owned by Norwegian Ministry of petroleum and Energy public enterprise (Enova 2016). Established in 2001, Enova is aimed to support and forward an environmentally friendly restructuring of energy consumption and production, as well as contribute to the development of energy and climate technology. This is done mainly through advice and financial support from funds based on the Energy Fund. This Enova-project resulted in the suggestion of a specific corridor n Hitra (Norway) - required frequency and reduce cost (Enova project 2015). The results of the project were used during our research work as a guideline for investigations while taking into account the latest information and current changes in the project`s stages.

The main contribution for future investigations was made during the INTERREG Projects: data, requirements, constraints, limitations and professional contact network which were also useful for the Enova project, "StratMos" and "Food Port". The specificity of the product, perishability of fresh salmon, was taken as a crucial point for fresh fish supply from Hitra to Esbjerg (Denmark). During the INTERREG projects, sailing plan from Hitra to Esbjerg were developed and total costs of transportation were calculated. Some of the outcomes from previous projects were mentioned here, but the main receiving Port was changed from Zeebrugge to Esbjerg. The projects resulted in

government reports, studies, notes, articles and seminar presentations of these projects. Unfortunately, these projects did not come to a concrete action plan for the implementation of intermodal solution (North Sea Region 2016).

.

2) **"Food Port" project**

The project was realized during 2011-2014. The full name of the project was "Connecting Food Port Regions – Between and Beyond". "Food Port" was a part of the Interreg IVB North Sea Region (NSR) Program and continued the StratMos` project initiative to establish a new green sea transport corridor for transportation of food in North Sea. "The North Sea Region Programme 2007-2013/2014-2020 workes with cutting edge policy areas in regional development through transnational projects. A principal aim of the programme is to expand the scope of territorial cooperation and focus on high quality projects in innovation, the environment, accessibility, and sustainable and competitive communities. The 2007-2013 Programme connected regions from seven countries around the North Sea, incorporating policy level planning and the long lasting and tangible effects of projects. These are the foundations of the future transnational projects, which will create added value for partner regions and beyond. The aim of the programme is to make the North Sea Region a better place to live, work and invest." (The North Sea Region Programm 2007-2013).

The Ro-Ro solution was considered for fresh fish supply from aquaculture factories on Hitra/Frøya in Norway to Zeebrugge in Belgium. Port of Zeebrugge was chosen as the main receiving port. Zeebrugge was accepted as the preferable hub for inbound and outbound cargo. The project "Food Port" proved that sea transport is a viable alternative to the road transport in terms of logistics costs and time. The project was concluded with a B2B seminar on Hitra. Additionally, the project created a basis for establishment of the program "Hitra Case". Program "Hitra Case" was executed from 2011 to 2013. From September 2011 to April 2012 was made a significant data collection and mapping by a work group Jan Erik Netter KNH representative, Emmanuel Van Damme from Zeebrugge Harbor and Kevin

Lyen POM representative. The work included active participation of farming companies SalMar, Marine Harvest and Lerøy. The project was stopped due to lack of funding and was continued in Belgium. Later, when possibilities did not change, the project was completed. The work yielded positive results for sea transportation in terms of technology, port`s offer and return cargo opportunities. The frequence and organization of transportation chain were and remain a challenge.

3) **StratMos project**

"Strategic Motorways of the Seas" was completed during 2007-2011 under North Sea Region Programme Interreg IVB. The project consisted of three parts:

a) Minoro: Mid-Norway-Rosyth Connection.

The project started with an investigation of the route between Kristiansund and Zeebrugge for a combined passenger/cargo vessel (Ro/Pax). The increased fuel costs and the following speed reduction, led to a change of ship concept to pure ro-ro solution. The project did not get further development due to lack of interest from shipping companies.

b) Norway-Shetland/UK-Continent Connection

Møre and Romsdal Municipality and company Møregruppen AS with base in Kristiansund and KNH executed assessment of a sea transport solution NORSHUKON. The target was to find a sea transport solution for transport corridor Kristiansund (Norway)-Shetland (UK)-The Kontinent. The results of the study did not satisfy certain evaluation criteria and the project was cancelled.

c) NORTREX- Norway Trailer Express

It was the last effort under the "StratMos" project to connect Zeebrugge and Mid-Norway by effective sea transport Ro-Ro solution. The Hitra Coastal Port was introduced as a specialized fish hub Port with great opportunities for fresh fish export. According to sea transportation, the project did not get enough response from the partners, but attractiveness of the sea transport solution in terms of costs and good impact on the climate had already been proven. In addition, the project considered rail transportation. During the processing of applications, priority was given to rail transport.

4. **Project "Sustainable infrastructure development in Trondheimsleia"**

The project was performed from June 2012-Oktober 2013 in parallel with "Food Port" project. During the project, initiatives and challenges of establishing

customized port facilities and effective maritime transport solutions for the aquaculture industry in central Norway were studied. The work resulted in a positive outcome: the NTP 2014-2023
was submitted in 2013, and several important aspects of the development of The Hitra Coastal Port and The Hitra Industrial Park were put in place.

3 Background of the project

In this section we will present background of the project. This chapter will provide a general overview of the networked firms. Here we will give information on details of current transport solution - all-road transportation and the alternative intermodal solution, describing disadvantages and advantages of the transport modes. In this chapter we will also mention specificity of fresh fish supply.

3.1 Economic background of the project

The main participants of the project are seafood producers at Hitra, shipping services providers and The Coastal Harbor Alliance members. All of them cooperate together to detect and reduce environmental impact, the carbon footprint and pollutions in the whole supply chain. The municipalities Hitra and Frøya characterized by the country`s largest production of salmon in Mid-Norway (Hitra Kommune2016). The possibilities of reallocation of seafood freight flows from road to sea here are great due to a favorable location of key ports in municipalities as well as the government's efforts, collaboration willingness among aquaculture companies and logistics providers. The establishment of The Coastal Harbor Alliance, promising sufficient volumes for shipping, have already increased interest for sea transportation among Norwegian ship owners and transport companies. Transport companies as well as shipping companies show evident interest for collaboration. Norwegian truck companies will benefit from this cooperation and will be able to reach their target markets due to the favorable conditions thus displacing foreign transport companies in the transportation chain. The restructuring will take time. Sea transportation in start-up phase will be as a supplement to road transportation. Currently, the participants of the project are actively seeking the opportunities for return cargo flows. There is a lot of opportunities, for example fruit and vegetables freight flows from the EU countries to Mid-Norway and Western Norway which can be combined together. Cooperation with ports which are not members of the Coastal Harbor Alliance will play a major role (Enova project 2015).

In this chapter, we have studied companies` business activity to obtain a detailed picture of the supply. There is a list of key companies involved into the transportation chain:

Municipalities:

- Hitra

- Frøya,

Members of The Coastal Harbor Alliance:

- Kristiansund and Nordmøre Harbour IKS with Hitra Coastal Port as a part,
- Vikna port authority Rørvik Harbour KF.

Producers/aquaculture:

- Marine Harvest,
- Lerøy,
- SalMar

Logistics providers:

- road transportation: DB Shenker, Bring, OTTS
- shipping companies: Blue Water

The main markets in the EU:

- Paris
- Madrid
- Ruhr Area
- London
- Brussels

Kristiansund and Nordmøre Intermunicipal Port Company, North Trøndelag Rørvik harbour IKS together with the "Blue Water" shipping company are aimed to prove the economic feasibility of a gradual transition from road transport to the preferred use of ships in transporting seafood in the Hitra region.

Collaborating with Kristiansund and Nordmøre Intermunicipal Port Company North Trøndelag Rørvik harbour IKS owned by municipalities Vikna, Nærøy and Leka. The main industries in the region are aquaculture and maritime industries. The North Trøndelag Rørvik port company aims to offer the best logistics services to the business community, and to be an active contributor to future growth in the region. At the moment, North Trøndelag Harbor aims at establishing a new coast harbor on Kråkøya, located in the main shipping lane in the north of Rørvik.

The advantageous location of Hitra Port in the leading region of Norwegian aquafarming conduces to a considerable interest from end customers and suppliers. The Hitra Port participated in different projects as "StratMos" and "Food Port" financed by the EU. Such projects show that transport by sea is preferable for the environment (low CO_2 emissions) and competitive in terms of transportation costs and time.

It is expected, that the production of aquaculture will grow to 800.000 by 2020. The forecasting is shown in Figure 3.1. Production expected in 2050 will be 5 times larger than the current volume. According to long and short term forecasting, considerable increase in the production of seafood and other goods is estimated and will require new transportation solutions that will reduce CO2 emissions, road accidents and road maintenance costs.

Kråkøya Coastal Harbour (Picture 3.1) in Vikna Municipality is under construction and will be a twin harbor to Hitra Coast Harbour. They are both included in cooperation with the Coastal Harbour Alliance and directed towards the export of fresh salmon / seafood.

Picture 3.1: Nord-Trøndelag Rørvik Port located on Kråkøya (Tidens Krav 2015)

The specificity of harbors` locations is that they are on the main shipping lane. Upon the realization of the project, this will lead to no or insignificant sailing deviations for the vessels sailing along the coast. This will increase sea transport capacity, contribute to new sailing programs and better planning and coordination of infrastructure and sea/land transport.

3.2 Current transportation conditions

Due to road transport 'features, trucks are usually the main choice for freight transportation which provides a high level of flexibility. New automotive technologies, improved fuel, development and improvement of the road system, promote a sustainable growth of road transport.

All export flows of fresh salmon are transported by road between South Norway and the EU markets. Salmon road Fv. 714 (Figure 3.2) is connecting the coastal municipalities Snillfjord, Hitra and Frøya, Orkanger and Trondheim. The 57.6 km-long stretch between Haugen in Orkdal municipality and Sunde in Snillfjord Municipality has low standard (Vegvesen 2016). Daily salmon freight flow amounts to 50-80 semitrailers per day. This corresponds to 17 000 semitrailers from Hitra/Frøya yearly. 60 percent of them are oriented to the EU -markets. Traffic figures from Nord-Trøndelag add up to more than 3000 per year. Considering these volumes together, there is a possibility to reduce the number of semitrailers between Mid-Norway and Europe to 12000-13000 not taking into account the return cargo flows (Enova project 2015).

Road safety and accidents pose a serious problem. Participating in the supply foreign transport logistics companies make the competition even stronger and increase the number of accidents. For some constantly damaged due to traffic parts of roads, the solution can only be an alternative transportation. During winter period, transportation becomes especially challenging. Such conditions are an important reason for development of the terminals and harbors of intermodal transportation chain.

Figure 3.1: Fv.714 Salmon road (Vegvesen 2016))

3.3 Phases of development of maritime transport offer

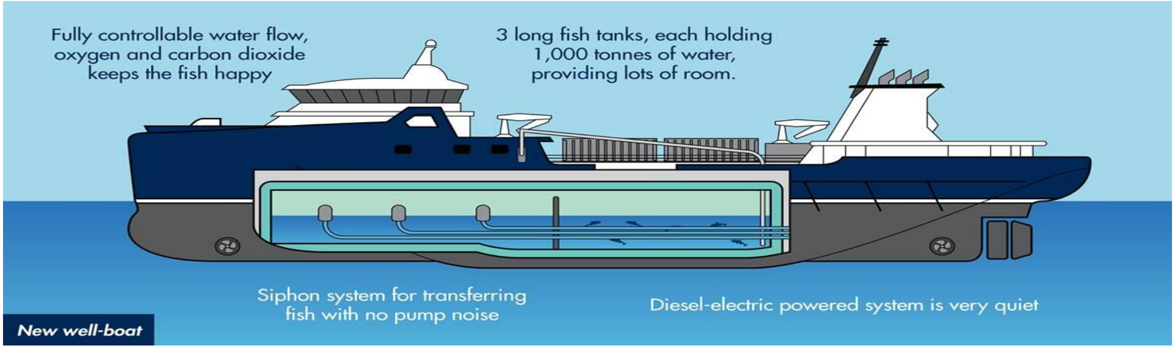
1. Hirtshals corridor and Hitra Coastal Port as the export port (2016)
2. Hirtshals corridor and both Hitra and Rørvik Ports as the export ports (2016-2017)
3. Zeebrugge corridor as a separate supplemental solution or in combination with Hirtshals (from 2017+)

   Hirtshals Harbor is a starting point for the establishment of a sea transport connection. The sea transport solution will reduce the current cost of road transportation by 20-25%. The price depends on volumes of return cargo flows. The return cargo volumeswill be gained over some time. Government support and financing are of high importance in implementation phase. The calculations that have been done show that an increase in return cargo flows by 10-50% can reduce prices about 10-45% depending on the distance from receiving port to the end destinations (Enova project 2015).

3.4 Fresh fish logistics

"Aquaculture is the farming of aquatic organisms in both coastal and inland areas involving interventions in the rearing process to enhance production. It is probably the fastest growing food-producing sector and accounts for nearly 50 percent of the world`s fish that is used for food" (FAO 2016). Salmon production starts on land an incubator tray. Then the wild roe`s fertilization takes place in fresh water conditions. The roe hatch after being 60 days at temperature 8ºC. Then, the salmon is kept in fresh water for 10-16 months before it grows to 60-100g and is ready for reallocation into seawater in fjords. The salmon is growing under constant condition control in 40-50 m deep nets in seawater in average 2 years. During this time is salmon fed by granulated food, including "fishmeal, fish oil, vitamins and antioxidants" until it is about 4-6 kg (Lerøy 2016). Then the fish will be taken by well-boats to the processing factory "where it is stunned, gutted, washed and sorted by size and quality" (Lerøy 2016).

About 95 percent of Norwegian fish production is exported to more than 130 countries. The largest volumes go to the EU countries (FAO 2010). Grown live fish are delivered from the plants to slaughterhouse facilities in 20-200 tons well-boats. A new well-boat system is shown on Picture 3.3.



Picture 3.3: New well-boat (Huon Tasmania 2016)

The harvesting stations are equipped in such a way as to ensure the best conditions for fish welfare and the quality of the product. Adequate water quality with satisfactory oxygen level and sufficient space are very important during the transportation. All offal resulting from the process are used to produce fishmeal and do not affect the environment. 70 percent of salmon is exported in fresh condition: gutted with head or chilled, the rest is frozen, smoked or filleted (FAO 2016). Fresh fish as a product imposes many requirements for transportation in terms of time, quality and safety.

The pilot project for modal shift is the transport of fresh salmon from suppliers – aquaculture plants and their slaughterhouse facilities by combined transportation modalities truck and short sea Ro-Ro ship from Port of loading Hitra in Norway to the receiving port Zeebrugge in Belgium and further by truck to the consumers in the EU countries as it demonstrated in Figure 3.3.

Producer/ Supplier	Logistics Provider 1 Road	Port of loading Hitra	Logistics providers 1, 2 RORO ship	Port of discharging Zeebrugge	Logistics Provider 3	End Customer

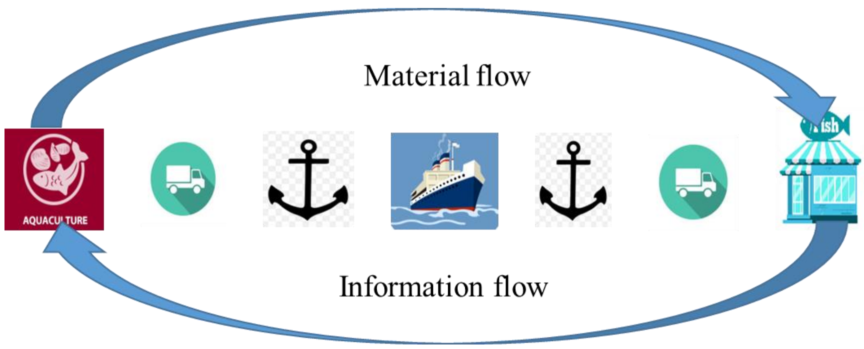


Figure 3.2. Fresh fish supply chain

The project involves use of innovative transportation and cooling and packaging solutions aimed to achieve longer shelf life. The are 3 possible technologies of fish transportation:

- “Wet”: ice, open boxes,
- “Dry”: ice, not dripping boxes
- “Dry”: Atmosphere controlled sealed boxes without, e.g. Modified Atmosphere Packaging (MAP) or CA-Containers and prechilling is used if necessary (Workshop Hitra 2012a).

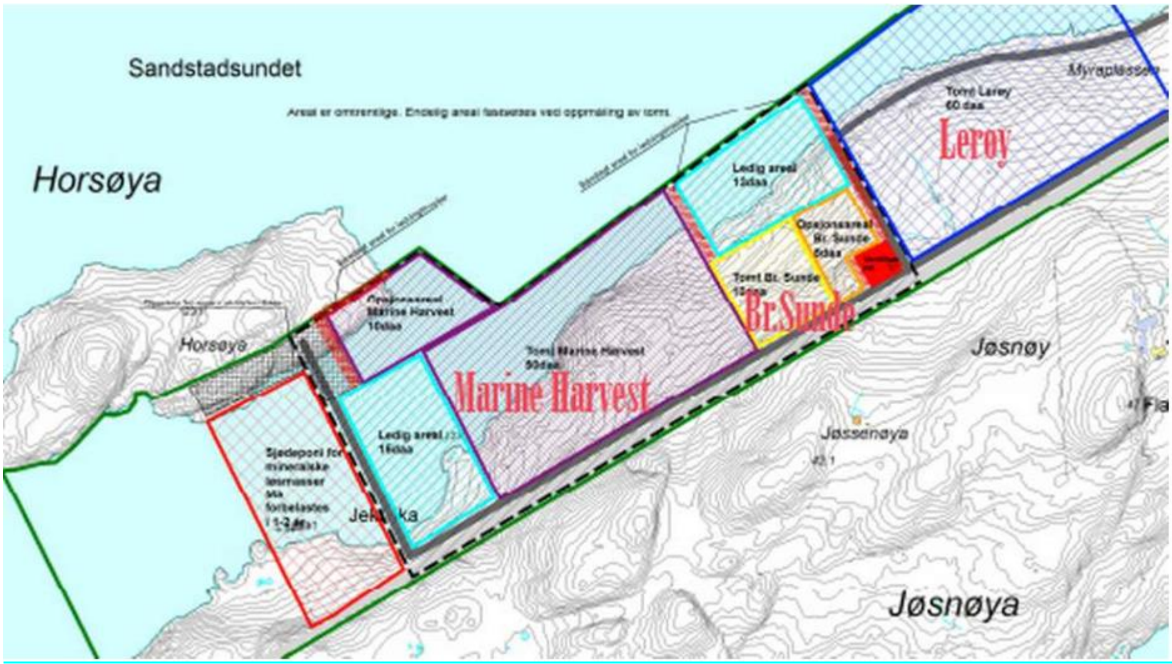
Technologies applied on standard 20`reefer container basis. Fish is loaded in open boxes with ice or without ice in atmosphere controlled boxes. Temperature, gas composition and humidity can be adjusted.

Regarding ship design, the ship used for seafood transportation has 170 m length and capacity at least 100 and most 200 trailers with power outlets for all of them on the deck. Thus, there is a combination ship-semitrailer. This utilizes ship`s characteristics as the main transportation mode (for long distances) and trailer`s properties as a load carriers and a distribution unit. The optimal speed of the ship is 19 kn as it was defined by calculations in Part 5.2.2. Product knowledge must be part of the basic knowledge for designing logistics solutions related to fresh seafood. Sailings plan must be adapted to the production process at Hitra/Frøya. For fresh fish transportation, an option like the containers stacked on a boat is a poor choice because of the danger of runoff (contagion).

Regarding the investment in a ship, it's taken a T / C ratio for the current ship size (capacity around 100 semi-trailers)

Hitra Coastal Port

Hitra Municipality became a part of KNH in 2011 when the Municipality was already oriented to aquaculture and development of Hitra Port with Industry Park has been in progress. The plan of the Industrial park is demonstrated on Picture 3.4. Official opening of Hitra Port took place on 16 October 2014. Regular container ship calls started in November 2014. After 5 years, the main elements of the infrastructure were already in place. The infrastructure of the port includes production and social components as engineer communication, gas, electricity and water supply system with huge water reservoirs and a drainage system. Salmon production requires a lot of fresh water due to its technology.



Picture 3.4: The Industrial Park on Hitra (Hitra-Frøya 2016)

Handling equipment, communication lines, two new aquaculture plants, warehouses, facilities of the companies providing service and maintenance for aquaculture and marine industry, other buildings and facilities are included into the project and will be built after some time.

Hitra port is located right in the fairway between Trondheim and Kristiansund, and is thus a natural traffic and logistics hub for seafood and fishing industry on Hitra / Frøya and in the region. Hitra Coastal Port and its underlying commercial space, Hitra Industrial Park, represent a development area of around 1.5 million m2 (1500 acres). They are labeled as a “seafood logistics center”. The seafood logistics center is directly connected to the main origins of seafood production in Mid-Norway.

A well connected transport network and a vast logistics capacity makes it possible to manage further increase on seafood transport demand. The salmon production industry is growing steadily. Indeed, it exhibits great opportunities for cooperation with the EU markets and excellent possibilities to service Mid-Norway and Northern Norway. Many shipping companies and transportation companies are very interested in using the Hitra port as both a seafood and general cargo/unit loads hub, storage hotel, a regional distribution center, transshipment terminal, hub for speed boats and ferry passengers, special storage, etc. Several companies have expressed interest in establishing in the area, some companies are in the state of negotiation. The world's largest salmon group, Marine Harvest, has now secured 50 acres (+ option for another 10 acres) to build a new salmon factory in this area. There will also be good opportunities for Hurtigruten and cruise vessels in the port. Hitra municipality will be able to establish a future-oriented and sustainable environment. The convenient location, along with great and new quay and harbor facilities will provide great opportunities for economic development in the region and within the company.

Picture 3.5. Hitra and Industrial park (Hitra kommune 2016)

A lot was built up on Hitra for the last two years. Hitra port has a direct and easy access to the quay and industrial area in Trondheimsleia, the main and mandatory shipping lane. The cargo terminal Hitra Coastal Port is operational from this year and includes terminal facilities, areas and equipment appropriate for both Ro/Ro and Lo/Lo services. The port`s logistics center provides possibilities for frozen and cold storage, offers warehousing and transit storage. It contributes to the efficiency of the terminal in Hitra Coast Harbour. There are sites for trailers and areas for containers with electricity. Dry / cold storage facilities have also been built.

The Hitra Coastal port has a good distribution system via Fv714 that is connected to the port through Hitra tunnel. The upgraded Fv714 is 75 km long to Orkanger and 40 to Frøya and is conducive to efficient cargo distribution (Kristiansund and Nordmøre Harbor 2016).

Industrial park is extended on Jøstenøya as it was decided by Hitra Municipal Council in 2014. The background of this development is the agreement with Lerøy, which required even more space. Previously, the municipality decided to build the 120 acres industrial area of north-west side of Jøstenøya. First plots are already sold to Marine Harvest AS and

Brødrene Sunde AS, that secured themselves the land for development. Now BEWi, Sunde Group and Lerøy also entered the field. The BEWi company and their competitor Sunde Group each will build a new factory for the production of polystyrene boxes -fish crates factories. They do this in order to increase capacity and to be even closer to the aquaculture companies that will also establish themselves in the region. The company BEWi, headquartered in Hamarvika, is already in full swing with the planning of the new factory. This will contribute to greater security of supply for BEWi`s customers in the region. BEWi considers that it is important to be established in an industrial hub that Jøstenøya will be. Their overall strategy is to be a supplier of packaging for both aquaculture and agriculture and building industry. Their overall goal is to provide even better quality, flexibility and sustainability through their innovative and trend-setting products (Hitra-Frøya 2014 a, b, c).

Picture 3.6: Lerøy factory in Hestvika (Hitra-Frøya 2014d)

By the building of a new factory Lerøy Mid plans to merge factories in Hestvika (Picture 3.6) and Dolmøya to one factory in Jøstenøya (Hitra-Frøya 2014d). These two factories work reasonably well today. The company Lerøy has been working for several years to merge the two factories and make the production process more efficient. They will now see whether it is rentable pays to retain them or whether they will be merged.

Thus, the industrial area must expand eastward for another 60 acres. The cost of the expansion is estimated to 46 million, the municipality finances it by borrowing. It is important that companies build their facilities urgently and begin their activity soon, so that the municipality can start getting tax receipts to pay back the investment in Jøstenøya (Hitra-Frøya 2015d).

The Hitra Municipality has a strong position and an extraordinary potential for industrial growth in the national context. It may be possible to apply for start-up support for fresh fish exports after the meeting with the Ministry of Transport took place in 2015.
Full restructuring of transportation chain must happen during this year (Enova project 2015).

3.5 Aquaculture companies in Mid-Norway region

In Norway there are 78 companies in total producing 100% of the supply. On Hitra / Frøya about 200,000 tons of salmon or 20% of the total in Norway are slaughtered. Currently fresh fish export flows are centralized. They are managed and controlled by the farming companies `logistics departments which are located in Bergen (Marine Harvest and Lerøy) and in Frøya Municipality(SalMar). The aquaculture companies are focused on environmentally friendly logistics and oriented to collaboration with customers and logistics` providers. The optimal solution for them should satisfy environmental requirements and reduce the costs of transportation. The possible transport solution will be considered in the form of a concrete offer from shipping providers. Sufficient frequency of transprtation and favorable cost conditions are essential. Therefore, it is very important to clarify logistics costs and effects on environment (Enova project 2015).

	Top 10 Norway	Harvest	Top 5 UK [1)]	Harvest	Top 5 North America [1)]	Harvest	Top 10 Chile	Harvest
1	Marine Harvest	258 000	Marine Harvest	48 900	Cooke Aquaculture	34 000	Marine Harvest	67 500
2	Salmar	141 000	The Scottish Salmon Com	30 200	Marine Harvest	26 700	Salmones Multiexport	54 200
3	Lerøy Seafood	133 000	Scottish Seafarms	27 600	Cermaq	19 000	Empresas AquaChile	52 000
4	Cermaq	53 000	Grieg Seafood	19 200	Northern Harvest	15 000	Cermaq	49 000
5	Nordlaks	38 000	Cooke Aquaculture	17 400	Grieg Seafood	6 300	Pesquera Los Fiordos	47 000
6	Nova Sea	38 500					Camanchaca	35 400
7	Grieg Seafood	37 500					Blumar	34 900
8	Alsaker Fjordbruk	25 500					Australis Seafood	25 500
9	Norway Royal Salmon	22 500					Salmones Humboldt	19 500
10	Sinkaberg-Hansen	20 500					Cooke Aquaculture	18 000
	Top 10	767 500	Top 5	143 300	Top 5	101 000	Top 10	403 000
	Market size	1 079 100	Market size	154 350	Market size	109 260	Market size	524 610
	Market share top 10	71%	Market share top 5	93%	Market share top 5	92%	Market share top 10	77%

Note: All figures in tonnes GWE for 2014E

*GWE is harvest volume

Figure 3.3: Aquaculture Industry structure. Top 5-10 players of farmed Atlantic salmon. (Marine Harvest 2016)

Marine Harvest is the largest aquaculture company in the world producing 1/5 part of total world`s consumption (Figure 3.5). The company is represented in 24 countries and oriented on high standards and safe, healthy and sustainable fish production/supply in long terms. In Norway the company is the largest food producer (in proteins) and the largest aquiculture company, which covers all value chain from fish food production to distribution of salmon and sales. The Norwegian part of company celebrated 50 anniversary in 2015. Over these 50 years, the company has grown and changed in many ways and has always been in the forefront of the development of the aquaculture sector. Salmon produced by company, is exported to more than 50 markets around the world.

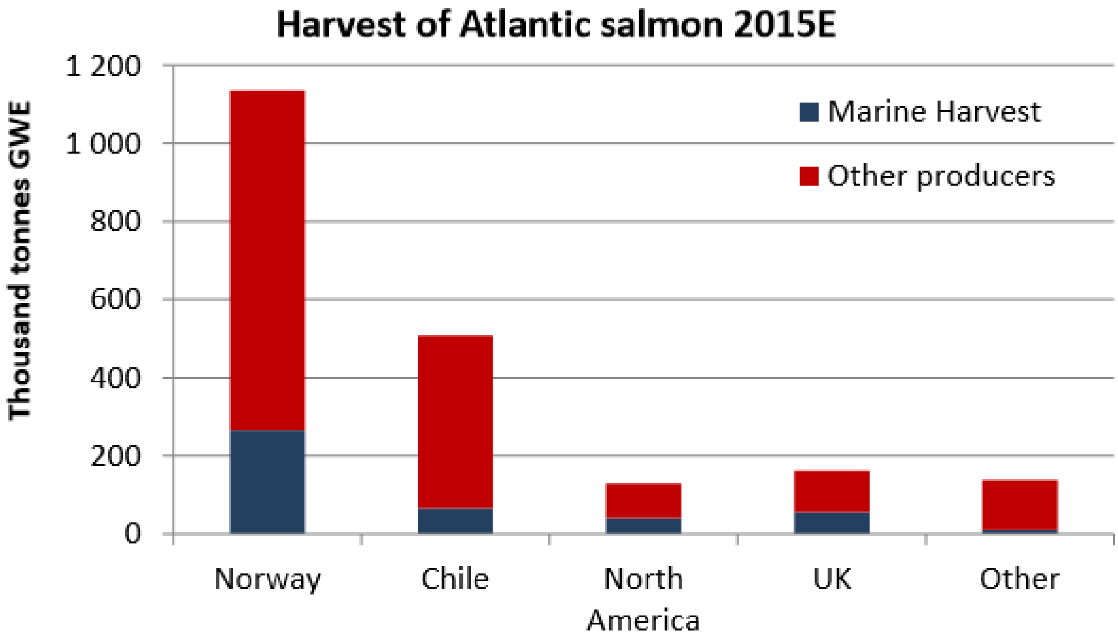


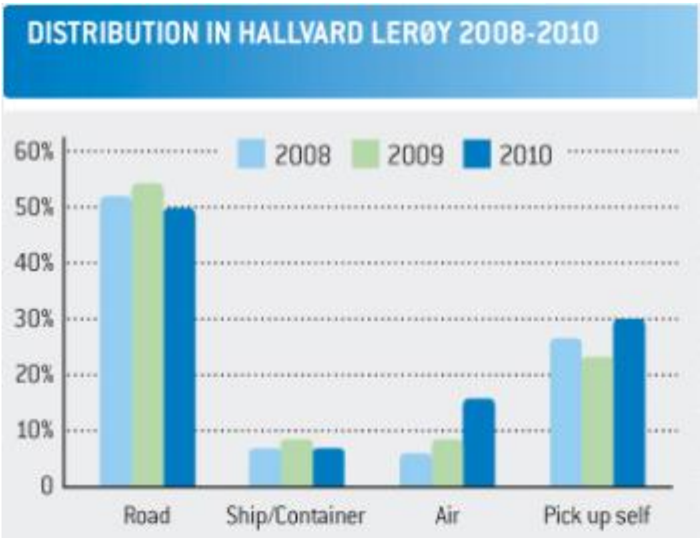
Figure 3.4: Harvest of Atlantic salmon 2015 (Marine Harvest 2016)

Most of the salmon, produced in Norway, is exported to the EU, Asia and the USA. The impact on environment is considered in all company`s activities. Marine Harvest Group is collaborating with The World Wildlife Found WWF-Norway from 2008 to reduce ecological footprint of aquaculture.

The factory facility of Marine Harvest producing salmon in Mid-Norway located on Ulvan on Hitra Municipality. Mid-Norway region has one of the oldest and most competent aquaculture environment, which roots back to the first license issued in Trøndelag.

Lerøy Seafood Group

Lerøy is the world`s largest seafood concern aimed on choice and development of sustainable solutions in all of its operations. The sustainability concept is very important in the company`s strategy. Lerøy offers ASC (The Aquaculture Stewardship Council) certified salmon. The ASC certification founded by WWF determines extraordinary standards for sustainable food production and requires high level of transparency from egg to end product. The deliveries are carried out 52 weeks per year. The production volume amounted to 25000 tons of certified salmon in 2015. For production process, Lerøy chooses the best location with optimal water quality and provision. Norwegian part of the Lerøy Seafood Group, Hallvard Lerøy AS, that located in Mid-Norway is the largest in sales and distribution within the company. A lot of competency gathered behind the walls of the Lerøy Midnor factory in Hestvika. The factory buildings are from the 1950s, and the fishing industry in Hestvika has a long history. In 1998 the company Astor merged with Midnor. In 2003 Lerøy Seafood AS acquired the factory.



Picture 3.7: Distribution of transport in Hallvard Lerøy (Lerøy 2016)

Many customers of Hallvard Lerøy AS use their own transport for transportation and pick up the fish themselves from the companies ‘facilities. Currently the existing solution mostly allows fish transport by road. The distribution of transport in Hallvard Lerøy is shown on the Picture 3.7. To Asia, Australia and the USA fish are transported by air which is accomplished by use of modern and most environmentally friendly planes. From North Norway to South Norway the products transported by rail. The company owns processing facilities in France in Arras and Lyon. This fact gives a possibility to improve the process of delivery, transporting vacuumed fish without ice, reducing cost per unit.

In total, the company exports 10.334 truckloads including the airfreight flows, that is alone about 19 million kg of fish. Regarding the transportation concept, the company aimed at green transportation to contribute to CO2 emissions reduction (Lerøy 2016). The company already transports frozen fish by sea and has an expressed interest for development of similar transport solutions for fresh fish transportation to the continent.

SalMar ASA is an international concern, founded in 1991, one of the world`s leading producers of seafood and third largest Norwegian producer of Atlantic farmed salmon. The company is one of the most profitable companies in the industry and its growth has always been accompanied by very good financial results. Harvested volume in 2015 was 150,000 tons. The company has 100 licenses for fish farming in Norway and has a significant production and distribution activity, co-located with the headquarters at Frøya in Sør-Trøndelag. SalMar is a fully integrated breeder with significant potential for further growth and development.

SalMar considers that growth must be sustainable, environmentally, socially and economically. They work systematically to prevent undesirable impact on the environment. This includes daily efforts of all employees, commitment to research and development, cooperation with other aquaculture companies and suppliers of goods and services. SalMar 2014 established a new vision expressed in three words: "Passion for salmon". It will now focus not on results but on achievements (SalMar 2016)

3.6 Kråkøya (Rørvik) Port

Rørvik is the biggest harbor in central Norway with vast capacity situated on the main shipping line along the coast. Equipped with modern facilities, the Harbor is a base for fishing boats and a passenger hub (Rørvik Harbor 2016). The Port is under construction and will be ready for collaboration in 2017.

The Coastal Harbour Alliance established contacts with the receiving ports Hirtshals and Zeebrugge, which will provide transportation of goods to the final destinations. The Main receiving Port in Europe is Hirtshals. Hirtshals is definitely selected. It is desirable that Zeebrugge corridor opens later. Esbjerg Harbor that was considered in the previous projects is no longer present. Hirtshals Port in Denmark characterized by favorable geographical location for the west coast of Europe, Great Britain, Scandinavia and the Baltics. The Port has an efficient infrastructure and provides effective logistics services (Port of Hirtshals 2014) The research efforts of the current study concentrated on the Zeebrugge Port as a supplement in the longer term. Zeebrugge Port has a well-suited location regarding markets in Central Europe and South Europe, importing significant volumes of fresh salmon from Norway. “The port is located in the world`s most densely populated area. 60% of the European purchasing power lies within a radius of 500 km” (Food Port –Hub realisation 2013).

3.7 Port of Zeebrugge

Port of Zeebrugge in Belgium has its advantages on seafood logistics services. It is the Europe`s leading Ro-Ro port. Annually more than 405 million tons cargo are handled by the port before its further transportation by road, rail or sea.

Picture 3.8. Continental EU and UK markets covered by Zeebrugge Port (Port of Zeebrugge 2016)

The Port provides weekly Ro-Ro Short Sea Shipping services to Scandinavian countries and is excellent in general cargo and food handling. There are good opportunities for realization of the strategic objective of Costal Harbor Alliance in terms of return cargo flows to the Norwegian market. The transport network of the port Zeebrugge is demonstrated on the picture 3.8. The high speed of cargo handling at the port efficiently reduces transition time for seafood delivery.

Picture 3.9: European Seafood Port of Zeebrugge (Port of Zeebrugge 2016)

Picture 3.9.1: Logistics infrastructure of the port (Port of Zeebrugge 2016)

A full connection to the European hinterland ensures a fluent cargo flow from and to Zeebrugge Port (Picture 3.9). The port equipped with state-of-the-art cold stores with a capacity of more than 200,000m3, 1,200 reefer plugs of container terminals and multi-temperature cross-docking (Picture 3.9.1). Excellent seafood logistics infrastructure within the port allows for quality control, labelling, wrapping, multiple certifications, stock management and traceability through RF and scanning, pallet picking/box picking, periodical reporting on stock and goods flow of bonded warehouses and provision of value added services. The port is in partnership with variety of transport companies and custom agencies specialized in reefer transport (Zeebrugge port 2016).

3.8 Zeebrugge corridor

The Zeebrugge alternative is clear. It shows that maritime transport can compete on time and cost, but one ship can only carry a sailing per week. The solution therefore doesn’t satisfy the requirements the industry has set to frequency. The Zeebrugge corridor should be considered in combination with traffic from Hirtshals.

Due to distance, there is only room for one round trip per week with one ship loaded with 100 trailers per sailing. During the Food Port project, a model was developed, enabling one to calculate the logistics costs. The Food Port project concluded that there are objective reasons for establishing a connection between Hitra and Zeebrugge. There is a room for an additional call on the coast with return cargo and an additional call to South bound with fresh fish may be required. Rørvik will be included into the sailing program from late 2016/2017.

Markets	Main transport solution today	Intermodal transport solution road/sea Short term	Intermodal transport solution road/sea Long term	Comments Zeebrugge Corridor
Continental Europe with France, Benelux countries and Germany	Covered by road transport	Can be covered by sea 40-50%	Can be covered by sea 60-70%	The Port of Zeebrugge is located near the major recipients of fish in France and Benelux countries
South Europe with Italia/ Spain and Portugal	Covered by road transport	Can be covered by sea 30%	Can be covered by sea 30-40%	Gives the shortest way choice.
Central Europe (Poland, Czech Republic, Slovakia, Hungary)	Covered by road transport	Can be covered by sea 40%	Can be covered by sea 60-70%	More transport work than in Hirtshals corridor.
The United Kingdom	Can be covered by combination Road/sea	Can be covered by combination sea/road	Can be covered by combination Road/sea	The Port has Ro-Ro connection to UK, but correspondence is uncertain
Russia/ Ukraine	Covered by road transport	Covered by road transport	Covered by road transport	Irrelevant
Baltic States	Covered by road transport	Can be covered by sea	Can be covered by sea	Irrelevant
Scandinavia	Covered by road transport	Covered by road transport	Covered by road transport	Irrelevant
Asia and the USA	Covered by road transport/ air transport from	Covered by road transport/ air transport from	Can be covered by road/sea transport With preferred use	Can be covered by road/sea or sea/sea

	Norwegian/foreign airports	Norwegian/foreign airports	Of new freezing technology	accomplished with use of new freezing technologies. Possible flight connections from Brussels/Shiphol

Figure 3.7: Zeebrugge corridor towards the end user (Enova project 2015)

As it shown in Figure 3.8, the Zeebrugge corridor has a favorable location for its main customers in France, Germany and Benelux countries and is very important for connection with the continent. Zeebrugge is an optimal solution for transportation to South Europe because of the shortest possible routes. Central Europe and Great Britain can be better covered by Hitra-Hirtshals corridor. Transportation to East Europe, Ukraine, Baltic States and Scandinavia can be only executed by all-road transport. Transportation by ship to Asia and The USA requires new freezing technologies because of the increase in shipping time (Enova project2015).

3.9 Ro-Ro solution from Hitra/ Mid-Norway to Zeebrugge/Belgium.

The ship which is assumed here is a Ro-Ro ship with bow door, length 170 m and with room for at least 100 semi-trailers with power outlets for all aboard.

A sailing per week with direct freight delivery from the Hitra port to the Port of Zeebrugge and back to the Hitra port. The planned departure time is every Friday evening (loading the production from Thursday and Friday), sailing lead time is depended on sailing speed, which varies from 16 knot to 22 knot. When calculating the total lead time, cargo handling time and transit time are also taken into account.

There is an emphasis on adapting sailing schedule to the production process on Hitra and Frøya since initially will be offered one ship with a sailing per week. It will be necessary to consider extension of freight volumes and market development in the long term. Sailing plan must be adapted to the production situation in Hitra / Frøya and Ytre Namdal, and will be done in collaboration between transport, ports and aquaculture (Liljestrand 2012).

1	2	3	4	5	6	7	8	9	10	11	12	13	14
				Time in sale for customers									

Figure 3.8: Time in sale for customer (Enova project Marine Harvest 2015)

Aquaculture company Marine Harvest has added a time commitment after slaughter. It is required that the 100-hour rule from slaughter to shop holds as a useful guideline for transport organizations. A transport solution based on both Zeebrugge- and Hirtshals corridors observe this requirement (Marine Harvest).

3.10 Blue Water Shipping Company

The partner of The Coastal Harbour Alliance, Blue Water Shipping company is a huge Danish company with a large network and years of experience in different fields of logistics such as General Cargo and Reefer Logistics, Energy and Projects, Port Operations, Marine Logistics and the North Atlantic. The company offers freight solutions by sea, road, rail and air through their network and partnership, providing a varied range of additional services. Blue Water is experienced in the shipping of fresh seafood. The company distributes seafood products from Norway, Faroes, Denmark to the markets in Europe. The cooperation between the Coastal Harbor Alliance and the company Blue Water will give good economic results and contribute to the establishment of an efficient intermodal logistic system in long-term perspective, as it was analyzed by the specialists of the company Blue Water. Blue Water`s experience with seaborne fresh fish exports will make an important contribution in shaping the maritime transport solutions with Hirtshals as the main harbor. Zeebrugge solution will be taken up later. The main corridors for intermodal solution sea-road-sea are shown on the Picture 3.8.

There is a developed weekly sailing plan from Hitra to Zeebrugge with transportation frequency equal to one sailing per week on the start-up phase:

Picture 3.8. The main corridors for maritime transport & intermodal solutions (NTHR 2016)

3.11 OTTS AS

OTTS AS is a part of the transportation chain providing transportation by truck. Its headquarters are located in Trondheim. The company is a very important transport provider in mid-Norway with huge resources equaling about 470 trucks owned by 90 car owners. The trucks equipment has all climatic zones for transportation of wide range of refrigerated freeze and dry goods. The company's distribution terminal in Orkanger is located close to the salmon road to Hitra Rv714, Rv710, E6 and E39. The transported cargo is all kinds of goods from food, fish, building products etc. (OTTS Transport 2016).

The company sees great opportunities for collaboration with Hitra port in terms of transportation of fish, other consumables they are transporting to wholesalers and container transportation. Today OTTS AS operates many trucks in destinations to and from Hitra/Frøya. Most of these trucks are returned to the terminal empty. The load capacities could be utilized much better trough solutions via Hitra Port with return cargo flows of fruit and vegetables (Workshop Hitra 2012b).

3.12 Target markets in the EU

The main markets and their respective preferable transport solutions have been reviewed and clarified. Some markets are not suitable for sea transport, but this will be a competitive supplement / alternative to road transport solutions to several important and heavy markets in Europe. Ro-Ro ships are chosen as the main transport but the trailer will still remain a distribution unit to the customer / recipient. The challenge is to establish "outsourcing" solutions in which the receiver itself is responsible for and manages internal transport. Regarding the organization, it could be a feasible option to build a private transport company, owned by the industry, offering sea transport solutions (Enova project 2015). The phases of the project and expected results are shown in the Figure 3.7.

Start Up 2016	2020	2040
50-60% of production can be transported by sea. Capacity of a ship=120 semitrailers/sailing, 80% capacity utilization.	50-60% of production will be sea oriented Capacity of a ship=120 semitrailers/sailing, 100% capacity utilization	50-60% of production will be sea oriented Capacity of a ship=120 semitrailers/sailing, 100% capacity utilization. Requires more ships/ large capacity
reduction of the number of ton kilometers on Norwegian roads with 160000 ton km(2 sailings per week, 1 ship, 30% return cargo flows	reduction of the number of ton kilometers on Norwegian roads with 400000 ton km(4 sailings per week, 2 ships, 40% return cargo flows	reduction of the number of ton kilometers on Norwegian roads with 700000 ton km(every day sailings, 2 large ships, 50% return cargo flows
Reduce the number of semitrailers on Fv714 and Norwegian roads with about 13000 units yearly	Reduce the number of semitrailers on Fv714 and Norwegian roads with about 35000 units yearly	Reduce the number of semitrailers on Fv714 and Norwegian roads with about 65000 units yearly

Figure 3.9: Phases of the project and expected results (Enova project 2015)

StartUp phase assumes use 25-30% of production volume and 20-30% of return cargo flows. It will give a transport price which is 50-60% higher than today sea transport prices. But this price will still be lower than road transport price.

4 Methodology

This section represents the research approach applied to the study and its implementation procedures.

4.1 Case study approach

Case study is a united information system that allows to understand the main problems of the project. Meredith (1998) defined case study-based investigation as a research method that: "…typically uses multiple methods and tools for data collection from a number of entities by a direct observervation, in a single, natural setting that considers temporal and contextual aspects of the contemporary phenomenon under study, but without experimental controls or manipulations". This approach illustrates several aspects of economic life-to-date and does not become obsolete too quickly. Case study describes the state of the market in a particular area (products, customers, production and distribution), strengths and weaknesses, organizational relations, business partnership, production operations, products and processes. The technology of case study-based approach involves analytical work with the classification of the problems: the identification of research questions, data collection guidelines, development of a research protocol, selection of informants, interview guidelines, identifications of patterns of development, consequences, determining the resources needed to solve the problem. The pragmatic analysis involves understanding the process in terms of efficient use in practical life, the study of system capabilities, its potential and available resources. Case study-based research differs from quantitative research (Ellram, 1996; Halldorsson and Aastrup, 2003) and requires separate evaluation. The research involves a case study of the network firms with focus on describing the flow of seafood products from Hitra/Frøya and Rørvik to the markets in the EU. The collaboration issue between the major producers and establishment of the clusters is currently being-studied in a PhD study.

As the operation research, our study is based on statistical survey analysis and cost analysis of both competing alternatives: road transportation and intermodal solution. However, since "…the explanations of quantitative findings and the construction of the theory based on those findings will ultimately have to be based on qualitative understanding (Meredith 1998), case research is very important for our field (Voss et al. 2002). In the initial stage, the exploration of research task is needed to develop research problems and questions. The next step is theory building which consists of four steps: definitions of terms of variables, a domain-the exact setting in which the theory can be applied, a set of relationships and specific predictions (Wacker 1998). Theory in the case research can be described as a system of constructs and variables (Baccarach, 1989). As the starting point for the case research is a building of the conceptual network to understand the most important issues to be studied. Research focus must be well formulated from the start to avoid an unnecessary amount of data. When the information was obtained, we selected a particular number of cases to study. This is important in order to achieve quality of observations.

4.2 Unit of analysis

The unit of analysis is fresh fish supply chain that includes producers/suppliers, logistics providers, port services and end customers. Logistics providers offer all-road transportation and intermodal transport solutions, including transportation by road and sea.

4.3 Sources of data

Sources of data in case-based research are structured/unstructured interviews and interactions, personal observations, conversations, meetings, collection of the objective data, review of information from previous periods, project documents provided by the port company.

All objective data was collected with accuracy and reliability. The collected data was documented .To the end, cross-case analysis should be provided to increase the validity of the findings (Voss et al. 2002).

The data collection in this research is related to primary data: direct interview with participants and secondary data: company reports, research reports, official documents, literature on transport and logistics for the fish farming sector, scientific articles and books. In addition, a lot of information was obtained from online research linked to the company we are doing research upon and companies which are main players on this segment of market. The research includes analysis of the current situation, perspectives and challenges, an investigation of intermodal sustainable alternative for door-to-door road transport of seafood and comparison of the alternatives.

4.4 Data collection methods and sources of the information

4.4.1 Direct interviews:

1. Interview with the sea captain Geir Kjønnøy-representative of the KNH port authority and one of coordinators of the project was conducted on 23.11. 2015 in order to get the information about general strategic views and detailed figures/data, about how different processes are carried out. Through the interview we have obtained the information about short and long term objectives, facilities and capacity, available equipment. After the meeting, we have received information about Coastal Harbour Alliance, Kristiansund & Nordmøre Port and a lot of working documentation regarding previous projects.
2. An interview with the project manager of Sea Cargo company which is a company providing the same type of transportation services as Blue Water Company was conducted in January 2016 to obtain the information about transport characteristics and challenges in the realization of the project from the practitioners point of view.
3. The fire chief at Hitra Municipality Dag Robert Bjørsol kindly organized for us an excursion around the Hitra Port and the Industrial Park. The trip to Hitra was very informative. During the interview, Dag Robert Bjørslol gave us a complete picture of the project, current work, challenges and the relationship between the logistics providers.

   Also, during the excursion we had an opportunity to visit one of the Lerøy`s factories producing salmon, where we were able to observe all stages of salmon production.
4. We kept in touch with representative and marketing manager of Kristiansund and Nordmøre Harbor Jan Erik Netter, our key informant, during the thesis writing. Jan Erik Netter provided us with a lot of practical information and data from previous related project he participated in.
5. Phone interview with the producers;

The qualitative and quantitative interviews with the port representatives and logistic service providers shed light on detailed information about flow characteristics, technical characteristics of trailers and vessels, routing, transportation features, best possible utilization of transport, coastal and short sea traffic frequency, special product handling on a short and long term basis. When it comes to detailed information and data on cost determinants of both transport solutions all-road and intermodal, transport companies are closed. Hirtshals is a new solution that will be studied further by the working group supported by Enova. Esbjerg Harbor that was in the project before is no longer applicable. The data on costs of transportation, distances and demands was obtained through our informant in KNH Jan Erik Netter. The obtained data allowed us to study the Zeebrugge corridor. The qualitative and quantitative interviews of seafood suppliers were conducted in order to identify: opportunities of collaboration, shipping communities, production volumes, statistical data on production and consumption, volumes and their seasonal variation, statistical data on freight flows in various food sectors. Because the main fish-farming companies are listed on the stock exchange, the data is restricted and direct interviews with the companies are of great importance. Most relevant possible traffic and cargo information must be provided and port statistics should be given priority.

4.4.2 Data of transportation cost and emission performance

The main source we included in the calculation section is an Excel table provided by our informant. The analytics is based is based on this table. In order to ensure the reliability of data parameters, we have kept in touch with the informant to get his confirmation. The main parameters we made us of in our calculation were: distances between two points, transit time, yearly demand on trailers, shipping route, unit cost per km for road transport, emission coefficient, handling cost and fuel consumption for maritime transportation.

4.5 Calculation part

The performance of two modes of transportation (road transport and intermodal transport) are derived in terms of cost efficiency, environmental pollution and lead time.

Firstly, we will apply the given parameters (distances, unit cost per km, demand for five end users, fuel consumption per day at different speed) in the table for cost calculating. Even though the result of cost comparison is presented in the Excel table, we are not able to verify the accuracy of the available data.

Secondly, we will estimate the carbon footprint emission from these two transportation modes. The amount of emission depends on weight (tons), distance (km) and the emission coefficient.

As we observed from the tables, the emission coefficient for the road mode (0.109 Kg / Ton * Km) is at least four times the emission coefficient for the intermodal transport.

Finally, we also will make a comparison of lead time. In order to ensure on-time delivery, sailing speed control is critical and service. We have discussed the factors which affect the sailing time at sea and driving time on road.

When doing the calculation, we also will pay attention to the maximum capacity of the vessel. No more than 200 semi-trailers can be boarded at once. We will assume what will that the demand for semi-trailers increased to 200 trailers per week.

5 Comparison and calculation

The port alliance has the aim to explore a new shipping alternative, the Hitra to Zeebrugge shipping line will be planned as a supplement route for fresh fish supply in the following years, since the external demand of fresh fish is estimated to be 3 or 4 times as the current export volume. The Hitra to Hirtshals connection is the main shipping corridor for the project, with further distribution to the end market destinations. However, if the demand keeps increasing in a high rate in the future, it will become a challenge to manage the huge demand from outside market. Therefore, it is necessary to explore a supplement line for sea food freight.

The shipping route we will study here is: Hitra-Kristiansund-Risavika-Zeebrugge. Kristiansund Port and Risavika Port are two members in the Coastal Port Alliance, the port authorities have committed the agreement to cooperate.

Due to fish producers in Hitra, a new shipping route is vital to be developed, with the aim of full utilization of food port capacity and market accessary.

With the goal of doing comparison between two transportation modes, we have proposed some basic assumptions in order to reach the research purpose.

The basic assumptions are listed below:

(1) Semitrailers are the main transport choice for fresh seafood export, for both door-to-door road transport and intermodal transport. The loading capacity of a semitrailer is 23 tons, 18 tons of fish and 5 tons of ice. They use the same type of semitrailer for both road transport and intermodal transport.

(2) Semitrailers roll on and roll off the ship, and no changes in trailers requires. Therefore, no extra transit-time of semitrailers are required.

(3) Since the production site in Hitra is close to the port terminal, we do not need to consider pre-haulage cost in the intermodal transportation.

(4) The ship type used for weekly freight is 2000 Lane Meter (2000 LM), one ship is enough for weekly based transport, maximum loading capacity of a ship is 200 trailers.

(5) The fuel for maritime transport is diesel with a price of 2948 DKK/ton, which corresponds to NOK 3638 with the exchange rate by April 21 2016.

With the purpose to increase the carriage volume of fresh fish, participants in the food port project have expected new technologies on cutting down the weight of ice.

Hitra coastal port is established to export local seafood products to continental markets in EU. It is under construction and it is estimated that it will begin to operate in 2016.

Hitra Coastal Port and industrial park is labeled as "seafood logistics center".

As the hub of fresh fish fright flows, connective and multimodality are two main features for it.

It is direct connected to Hitra industrial Park which is the main origin of seafood production in Mid-Norway. Well connected transport network and plentiful logistics capacity makes it possible to manage further increase on seafood transport demand.

Many shipping and transport companies are very interested in using the port as a transshipment hub for seafood and general cargo, storage hotel, regional distribution center, hub for speed boats and ferry passengers, special storage, spare parts stores/ supplies and crew changes, etc.

The demand for fresh fish sailing is estimated to be two or three times as current output. However, other potential usage for Hitra coastal port need to be explored in the future.

5.1 Transportation cost

5.1.1 Road transport

There are five predesigned delivery destinations in the current driving plan: Paris, Madrid, Ruhr area, London, and Brussels.

Distance (km) between Hitra and consuming point					
Loading point	Hitra				
End destination	Paris	Madrid	Ruhr area	London	Brussels
Distance (km)	2291	3539	1752	2315	1595
Transport cost per semi-trailer (23 ton)					
Unit cost	17.59 Nok/ Km				
Destination	Paris	Madrid	Ruhr area	London	Brussels
Total cost (door-to-door)	40298.69	62251.01	30817.68	40720.85	28056.05
Average	40428.86				

Table 5.1: Distance and transport cost

Semi-trailers are the main traffic mode for fresh fish freight, the reefer container keeps the temperature very low to retain freshness.

Road transport cost based on loading tons			
Destination	Number of trailers	Unit cost (23 ton)	Total cost
Paris	27	40298.69	1088064.63
Madrid	6	62251.01	373506.06
Ruhr area	23	30817.68	708806.64
London	9	40720.85	366487.65
Brussels	9	28056.05	252504.45
Sum up	74	40428.86	2789369.43

Table 5.2: Total cost of road transportation

The transport distance is shown in the table, with km as distance unit. Since the transport cost for one 23-ton semi-trailer is 1.916 Euro per km, according to the original table from informant, it is equal to 17.59 Nok. The distance is already known, the transport cost for one semi-trailer to different destination can be calculated.

We already have the yearly demand of trailers for transportation to each destination, the total road transport cost is depended on both trailers quantity and unit cost. The cost comparison will be based on week, so it has to be transferred to weekly demand, the yearly demand for Paris, Madrid, Ruhr area, London and Brussels are 1420,319, 1183, 473, and 473 trailers respectively.

The weekly demand can be calculated by this way: yearly demand/52 weeks. In order to fully cater the customers' demand, we will take integer 74 trailers per week.

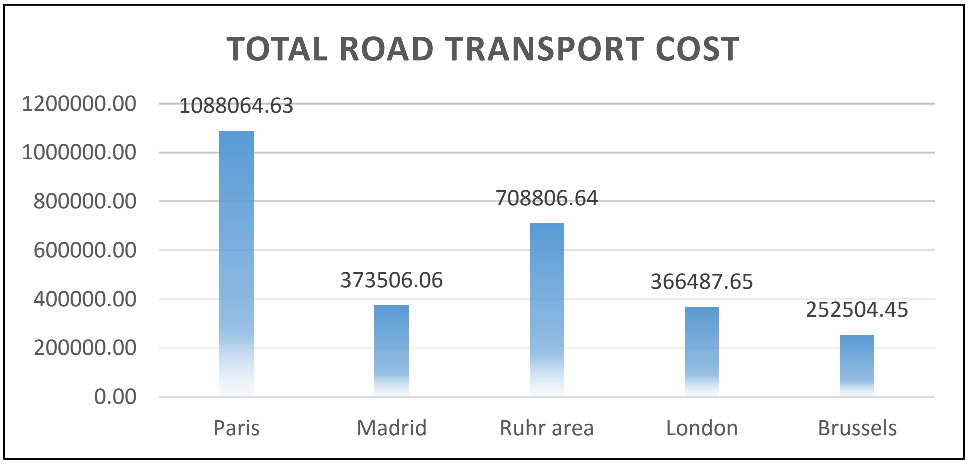


Figure 5.1: Comparison on road transport cost of five end destinations

Among five consumer destinations in EU, Paris is the one with highest freight cost (1088065) and Brussels is the one with lowest freight cost (252504).

5.1.2 Intermodal transport

Transportation cost consists of main-haulage cost (sea side) and post-haulage cost (road side). The transit time period is from Hitra Coastal Port to Zeebrugge Port. Diesel is the fuel for the ship, which have the price of 3637.54 Nok/ton.

The range of handling cost includes: maritime navigation and radio communication equipment and systems (11500 Euro / Day); intermediate fuel oil with a maximum viscosity of 180 Centistokes (<3.5% sulphur); marine diesel oil; port tariff; loading or unloading the cargo of a ship; marine gas oil; trailer rental cost and others.

The data of fuel consumption per day we applied in calculating the main-haulage cost of intermodal mode is from our informant. We are informed that the data is not exactly, but is the estimates they have today.

It is obvious that the relation between fuel consumption and sailing speed is non-linear, it is inclined to the quadratic function.

Main-Haulage cost						
Speed (knot)	Consumption (Ton / Day)	Transit time	Total consumption (tons)	Transport cost (Nok)	Handling cost (Nok)	Total
17	45	3.00	135.00	491067.90	240569.72	731637.62
18	51	2.90	147.90	537992.17	240569.72	778561.89
19	57	2.80	159.60	580551.38	240569.72	821121.11
20	62	2.60	161.20	586371.45	240569.72	826941.17
21	74	2.50	185.00	672944.90	240569.72	913514.62
22	87	2.40	208.80	759518.35	240569.72	1000088.07

Table 5.3: Main-haulage cost

The consequence of speed up is less sailing time, but higher fuel consumption. It will not be reasonable under the condition of high fuel price. If the speed swift from 17 to 22 knot, transit time can save 0.62 day, but fuel consumption goes up to 87 tons/day, nearly two times of 45 tons/day. Therefore, it is inclined to select slow sailing speed.

Post-Haulage cost				
Destination	Distance (km)	unit cost	number of trailers (23 ton)	Total
Paris	310	5452.90	27	147228.30
Madrid	1550	27264.50	6	163587.00
Ruhr area	350	6156.50	23	141599.50
London	290	5101.10	9	45909.90
Brussels	110	1934.90	9	17414.10
sum up	2610	45909.90	74	515738.80

Table 5.4: Post-haulage cost

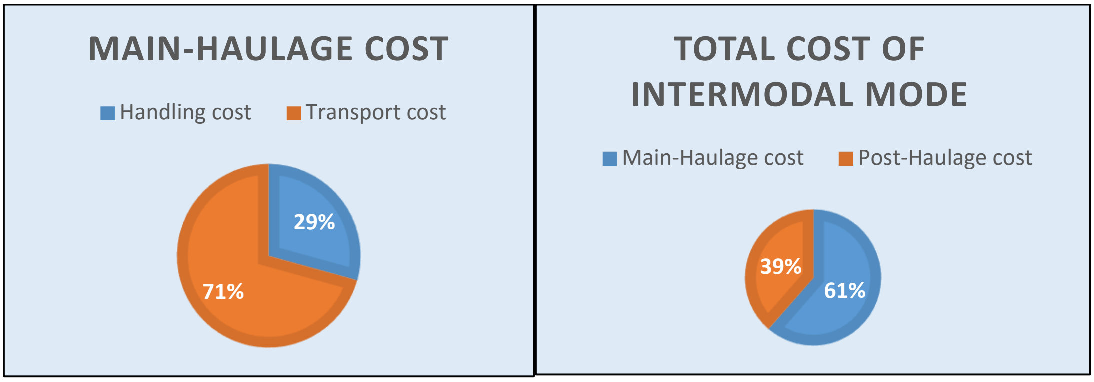


Figure 5.2: Proportion distribution

If we adopt 19 knot as sailing speed, then the total cost becomes 1336860 Nok. (The combination of main-haulage cost and post-haulage cost)

The total transportation cost of door to door road mode is 2789369 Nok per week, which is twice as transportation cost of intermodal mode (1336860 Nok). It proves that intermodal transport takes the advantage of cost saving.

We can further calculate at which value will the cost of road mode equal to intermodal mode. The proportion of trailers at each destination can be known from the data, the sum of proportion equal to 1. (Proportions are 0.36, 0.085, 0.305, 0.125, 0.125 respectively)

We get the result that when the trailers number is equal to 27, the cost of road mode and intermodal mode is approximate equal, the difference is very small. When it over 27, the intermodal mode will be profitable.

5.2 Carbon footprint emission

5.2.1 Road transport

As illustrated in the table below, the method of collecting carbon footprint emission adopted in this research is from CE Delft, who is the previous partner of this project.

Emission coefficient (per kg/Ton*Km)		
Road	0.1090	Kg / Ton * Km
Shortsea 17kn	0.0132	Kg / Ton * Km
Shortsea 18kn	0.0150	Kg / Ton * Km
Shortsea 19kn	0.0168	Kg / Ton * Km
Shortsea 20kn	0.0182	Kg / Ton * Km
Shortsea 21kn	0.0218	Kg / Ton * Km
Shortsea 22kn	0.0256	Kg / Ton * Km

Table 5.5: General input (Meetlat CE Delft)

The emission is based on the weight of cargo and freight distance. In addition, emission coefficient of road and sea transport (depend on sailing speed) has also been included. The range of sailing speed is between 17 and 22 knot.

Carbon footprint emission of road transport (kg)				
Destination	Distance (km)	23 ton trailer	number of trailers	Total emission
Paris	2291	5743.54	27	155075.50
Madrid	3539	8872.27	6	53233.64
Ruhr area	1752	4392.26	23	101022.07
London	2315	5803.71	9	52233.35
Brussels	1595	3998.67	9	35987.99
			Sum up	397552.54

Table 5.6: Emission of road mode

As the distance and loading capacity of trailer is already known, therefore carbon footprint emission per trailer and total emission for per week freight can be calculated (emission coefficient 0.1090 Kg / Ton * Km). The total emission of road transport per week is 397552.54 kg.

5.2.2 Intermodal transport

The current sailing route to Zeebrugge goes through the ports of Kristiansund and Risavika close to Stavanger. The overall distance from Hitra to Zeebrugge is 2134 km. The maritime distance from Hitra to Zeebrugge includes distance from Hitra to Kristiansund, from Kristiansund to Risavika, from Risavika to Zeebrugge, where the sub distances are 90, 594, and 1450 respectively.

Zeebrugge is the discharge port, the logistics provider will then apply road transport to deliver products to final destinations. We have not taking the distance from production point to Hitra coastal port into consideration, the distance is between two ports.

Carbon footprint emission of maritime transport (kg)		
Sailing speed	emission coefficient	emission
Shortsea 17kn	0.0132	47943.30
Shortsea 18kn	0.0150	54481.02
Shortsea 19kn	0.0168	61018.74
Shortsea 20kn	0.0182	66103.64
Shortsea 21kn	0.0218	79179.08
Shortsea 22kn	0.0256	92980.94
Average		66951.12

Table 5.7: Emission of maritime transport

Since all semitrailers to different destinations will be loaded on the ship, and then go further the Zeebrugge Port, therefore the total weight of 74 semitrailers multiplied by loading capacity 23 ton, which equal to 1702 tons.

As shown in table, emission goes up with increased sailing speed due to a coefficient. Here we take the number of 19 knot speed (61018.74 kg) to count the emission of intermodal transport. The reason of taking sailing speed 19 knot is that it is the medium speed in the speed range. Even though the operators would like to sail as slow as possible, the transit time will become longer, and the products are time-sensitive, therefore in practice they may adopt faster speed. The maximum speed is not reasonable due to the cost.

Distance and trailer quantity of road transport		
Destination	Distance (km)	number of trailers
Paris	310	27
Madrid	1550	6
Ruhr area	350	23

London	290	9
Brussels	110	9
sum up	2610	74

Table 5.8: Emission of landside transport

For the landside transport, we figure out single emission to each destination, which also based on weight and distance (emission coefficient for road transport is 0.1090). After that, we sum up the total emission of landside transport (73505.24).

We combine the maritime transport emission and landside transport emission to obtain overall emission of intermodal mode, then it becomes 134523.98 kg per week.

Emission amount for two modes	
Road mode	397552.54
Intermodal mode	134523.98

Table 5.9: Emission amount for two modes

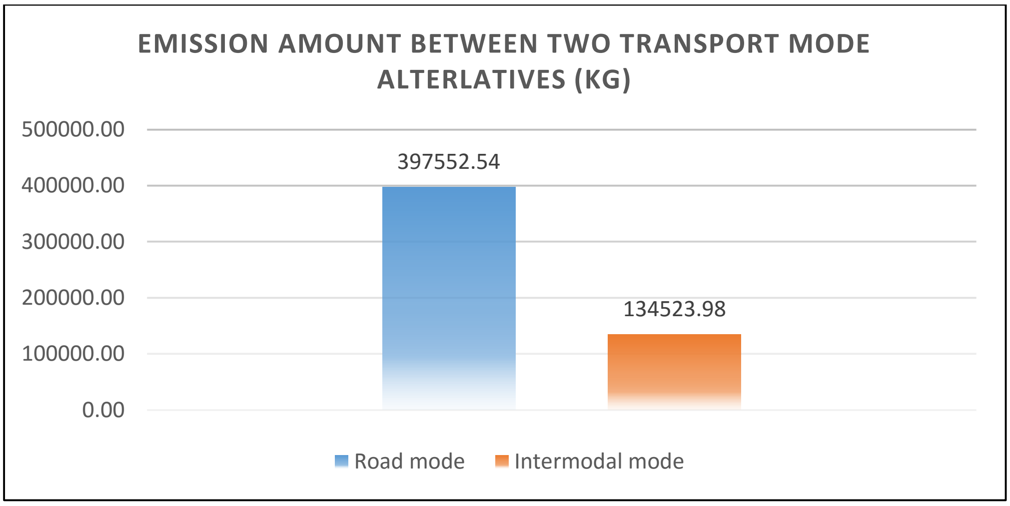


Figure 5.3: Comparison of emission between the two transport modes

After we got the result of emission, it obviously proves that intermodal mode which combined maritime transport and road transport together has positive contribution on controlling and reducing carbon footprint emission (The total emission of intermodal mode is only 33.84% of road transport).

If the demand on fish export dramatic goes up in the upcoming years, the environmental impact of intermodal transport mode will become more significant. From the perspective of environmental concern, we recommend the intermodal mode for seafood freight in the EU area.

5.3 Lead time

5.3.1 Road transport

Transit time for door to door road transport is the total transportation lead time, from the point of set out to the point of arrival.

Transit time of door to door transportation					
End destination	Paris	Madrid	Ruhr area	London	Brussels
Lead time	3.82	5.90	2.92	3.86	2.66

Table 5.10: Transit time of road mode

It assumes the truck driving under the constant speed. However, it could be difficult to control the speed on the road. In addition, other unpredictable factors such as road congestion could also prolong the arrival time.

5.3.2 Intermodal transport

Transit time of intermodal transport (days)							
Sailing speed (knots)	17kn	18kn	19kn	20kn	21kn	22kn	Average
Paris	3.21	3.05	2.92	2.80	2.69	2.59	2.88
Madrid	6.64	6.49	6.35	6.23	6.12	6.02	6.31
Ruhr area	3.25	3.10	2.96	2.84	2.73	2.63	2.92
London	3.29	3.14	3.00	2.88	2.77	2.67	2.96
Brussels	3.08	2.93	2.80	2.67	2.56	2.47	2.75

Table 5.11: Lead time of intermodal transport

The lead-time of seaside transport depends on the sailing speed, and will become shorter if ship sail faster. Since we do not obtain more accurate information on time window for the end destinations, we use some values from different speed to compare with lead-time of road transport.

Service level and cost are two main factors to decide the speed, the optimal speed is that it can be as slow as possible but observes the time constraint.

Comparison of lead time between two types of transport mode						
Sailing speed (knots)	17kn	18kn	19kn	20kn	21kn	22kn
Paris	0.61	0.77	0.90	1.02	1.13	1.23
Madrid	-0.74	-0.59	-0.45	-0.33	-0.22	-0.12
Ruhr area	-0.33	-0.18	-0.04	0.08	0.19	0.29
London	0.57	0.72	0.86	0.98	1.09	1.19
Brussels	-0.42	-0.27	-0.14	-0.01	0.10	0.19

Table 5.12: Comparison of lead time in days

Potential elements which will prolong lead time of intermodal transport, such as switch of trailers at the discharge port, cargo handling time will rise corresponding with increased cargo weight, seasonal conditions or sea waves could also cause delay for good receipt. Finding solutions to reduce delay risk is critical due to the reason of losing orders from clients and damage on fish quality.

5.4 Conclusion

After completed the comparison of two transportation modes in respect of cost, carbon footprint emission and lead time, we can summarize that intermodal transport bring positive impacts on economic benefits and environmental protection.

We have also mentioned some potential factors will extend lead time, and we are cognizant of difficulties to avoid these unpredictable factors in advance. In general speaking, short handling time at port can be achieved by systematic handling technique at port area. In addition, intermodal mode will lower the risk of road accidents and be considered as safe enough. However, the delivery amount and capacity constraints will weaken the flexibility.

6 Discussion

In this section, we will investigate about what kind of impact will occur on cost and environmental emission from seafood transportation in our case study for increased future demand. Two situations of increase in demand volume are considered.

6.1 Demand volume: 200 semi-trailers per week (vessel capacity)

Door to door road transport cost based on loading tons				
Destination	Distance (km)	Number of trailers	Unit cost (23 ton)	Total cost
Paris	2291	74.00	40298.69	2982103.06
Madrid	3539	17.00	62251.01	1058267.17
Ruhr area	1752	61.00	30817.68	1879878.48
London	2315	24.00	40720.85	977300.40
Brussels	1595	24.00	28056.05	673345.20
Sum up	11492	200.00	202144	7570894.31

Table 6.1: Transport cost of road mode (200 semi-trailers)

Item	Number
current demand (trailers)	74
unit cost of road transport (per km)	17.59
fuel price (Nok/ton)	3637.54

Table 6.2: General input of calculation

The current demand for semi-trailers is 74 per week. We suppose that the demand increase rate at each consumer point is the same when the weekly demand for semi-trailers go up to 200, the increase rate is equal to 200/74 = 2.70. The new demand of semi-trailers becomes the original demand (trailers demand at each destination) multiplied by the increase rate. The unit cost per km for road transport is 17.59 Nok, according to the exchange rate of April, 21. Transport cost for road mode is variable cost and it changes in pace with number of trailers.

Main-Haulage cost						
Speed (knot)	Consumption (Ton / Day)	Transit time	Total consumption (tons)	Transport cost (Nok)	Handling cost (Nok)	Total
17	45	3.00	135.00	491067.90	240569.72	731637.62

18	51	2.90	147.90	537992.17	240569.72	778561.89
19	57	2.80	159.60	580551.38	240569.72	821121.11
20	62	2.60	161.20	586371.45	240569.72	826941.17
21	74	2.50	185.00	672944.90	240569.72	913514.62
22	87	2.40	208.80	759518.35	240569.72	1000088.07

Table 6.3: Main-haulage cost of intermodal mode (200 semi-trailers)

The main-haulage cost is derived from the sailing from Hitra Coastal Port to Zeebrugge Port. Since the fuel consumption and transit time are depended on sailing speed, speed increasing will consume more bunker but shorten the lead time in total.

We assume that the handling cost is fixed, no matter how many trailers are loaded on ship.

Post-Haulage cost				
Destination	Distance (km)	unit cost	number of trailers (23 ton)	Total
Paris	310	5452.90	74.00	403514.60
Madrid	1550	27264.50	17.00	463496.50
Ruhr area	350	6156.50	61.00	375546.50
London	290	5101.10	24.00	122426.40
Brussels	110	1934.90	24.00	46437.60
sum up	2610	45909.90	200	1411421.60

Table 6.4: Post-haulage cost of intermodal mode (200 semi-trailers)

We sum up the main-haulage cost and post-haulage cost of intermodal mode (2232543) at sailing speed 19 knot to compare it with road mode (7570894).

If the sailing speed adds to 22 knot from 19 knot, the lead time for round trip will be less than 5 days. The ship will be able to sail continuously within a week, and operators will use the same vessel to deliver cargo two times a week which are utilized for fish freight.

At the same time, the cost will arrive to 2411510 Nok, increasing by 178967 Nok.

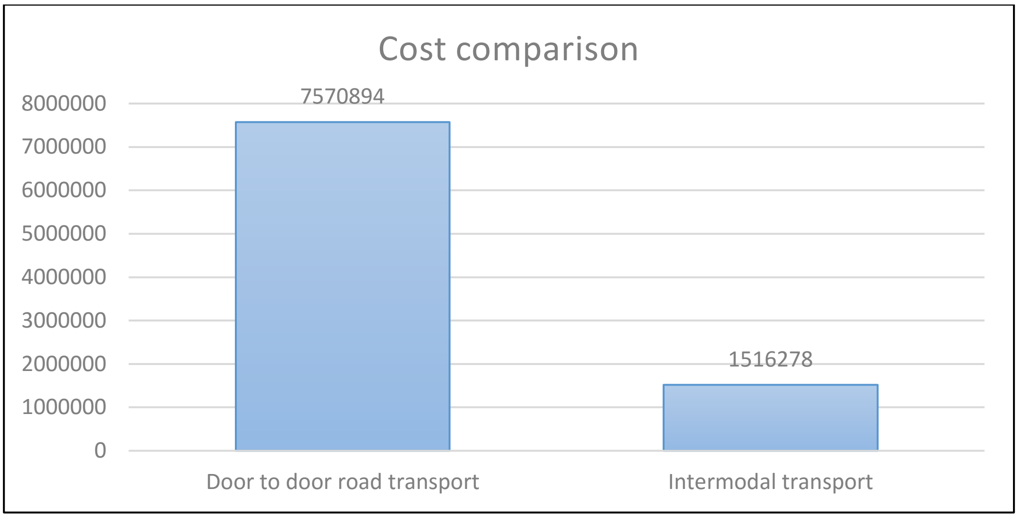


Figure 6.1: Cost comparison of two modes (200 semi-trailers)

The total transport cost of intermodal mode accounts for 29.49% of road mode when trailer number ascends to 200.

It is beneficial for the logistics operators when the ship is loaded, up to the maximum capacity of ship, due to utilization and no surplus capacity. Then consumers will enjoy lower freight price when the shipping demand is big enough to reach the economy of scale.

Carbon footprint emission of road transport (kg)				
Destination	Distance (km)	23 ton trailer	number of trailers	Total emission
Paris	2291	5743.54	74.00	425021.74
Madrid	3539	8872.27	17.00	150828.64
Ruhr area	1752	4392.26	61.00	267928.10
London	2315	5803.71	24.00	139288.92
Brussels	1595	3998.67	24.00	95967.96
			Sum up	1079035.36

Table 6.5: Carbon footprint emission of road transport (200 semi-trailers)

When the number of total trailers increase to 200, the emission will increase correspondingly. We can observe that the emission amount per trailer is unchangeable if distance, loading capacity and emission coefficient are fixed numbers.

Carbon footprint emission of maritime transport (kg)		
Sailing speed	emission coefficient	emission
Shortsea 17kn	0.0132	129576.48
Shortsea 18kn	0.0150	147246.00
Shortsea 19kn	0.0168	164915.52

Shortsea 20kn	0.0182	178658.48
Shortsea 21kn	0.0218	213997.52
Shortsea 22kn	0.0256	251299.84
Average		180948.97

Table 6.6: Emission of sailing at sea (200 semi-trailers)

The weight of 200 trailers is 200*23 = 4600 tons. Then the seaside emission for full-loaded Ro-Ro ship at speed 19 knot is 0.0168* 4600* 2134 = 164915.52 kg.

Distance and trailer quantity of road transport				
Destination	Distance (km)	number of trailers (23 ton)	unit emission	total emission
Paris	310	74.00	777.17	57510.58
Madrid	1550	17.00	3885.85	66059.45
Ruhr area	350	61.00	877.45	53524.45
London	290	24.00	727.03	17448.72
Brussels	110	24.00	275.77	6618.48
sum up	2610	200	6543.27	201161.68

Table 6.7: Emission of landside transport (200 semi-trailers)

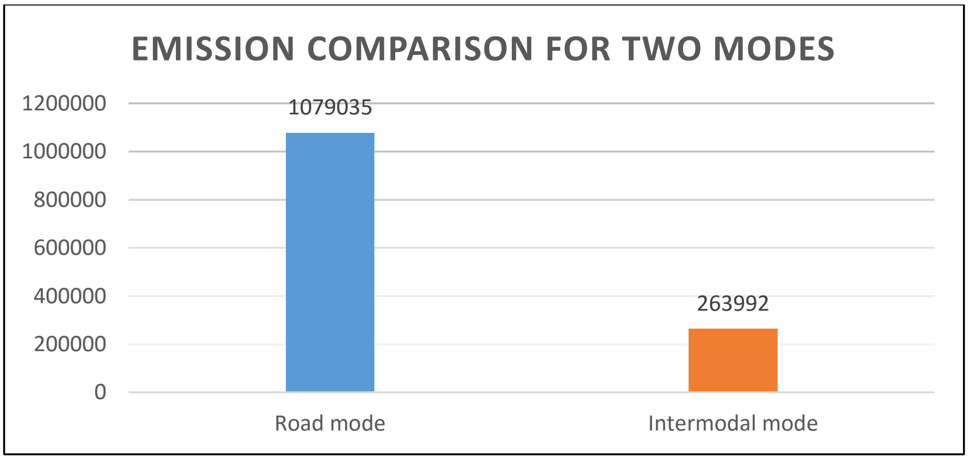


Figure 6.2: Carbon footprint emission for two modes (200 semi-trailers)

The total emission of carbon footprint for intermodal mode is 366077 kg, accounting for 34% of emission from door to door road transport. In other words, shifting on transportation mode can lighten the environmental pollution in the global scope.

6.2 Demand volume: 300 semi-trailers per week

The sea food exporters have made the expectation on continual volume increase. They consider that one ship per week is not enough for future sea food delivery, two trips per week will be required. Therefore, we suppose the demand over the loading capacity of the vessel and the cargo have to be delivered by two ships.

Door to door road transport cost based on loading tons				
Destination	Distance (km)	Number of trailers	Unit cost (23 ton)	Total cost (23 ton)
Paris	2291	111	40298.69	4473154.59
Madrid	3539	25	62251.01	1556275.25
Ruhr area	1752	92	30817.68	2835226.56
London	2315	36	40720.85	1465950.60
Brussels	1595	36	28056.05	1010017.80
Sum up	11492	300	202144	11340624.80

Table 6.8: Transport cost of road mode (300 semi-trailers)

The increase rate of semi-trailers (total demand per week is 300) switches to 4.05, which is calculated as total demand per week divide by original demand (74).

When the requirement on semi-trailers is 300 per week, it overs the maximum capacity of vessel, therefore two Ro-Ro ships are applied for fish freight.

The main-haulage cost doubles (821121.11 * 2) when it requires two trips per week.

Therefore, the general cost of main-haulage part is 1642242 Nok.

Post-Haulage cost				
Destination	Distance (km)	unit cost	number of trailers (23 ton)	Total
Paris	310	5452.90	111	605271.90
Madrid	1550	27264.50	25	681612.50
Ruhr area	350	6156.50	92	566398.00
London	290	5101.10	36	183639.60
Brussels	110	1934.90	36	69656.40
sum up	2610	45909.90	300	2106578.40

Table 6.9: Post-haulage cost of intermodal mode (300 semi-trailers)

The total freight cost for intermodal mode is 3748820 Nok.

Even though considering the additional cost raise by the extra ship, intermodal mode still takes the absolute advantage of economic benefits. It cuts down 67% of freight cost, which improve the profits of logistics service providers and make them more competitive.

Carbon footprint emission of maritime transport (kg)		
Sailing speed	emission coefficient	Total emission
Shortsea 17kn	0.0132	194364.72

Shortsea 18kn	0.0150	220869.00
Shortsea 19kn	0.0168	247373.28
Shortsea 20kn	0.0182	267987.72
Shortsea 21kn	0.0218	320996.28
Shortsea 22kn	0.0256	376949.76

Table 6.10: Emission of seaside transport (300 semi-trailers)

Based on the calculation results, the total emission of intermodal-mode transportation (547612) accounts for only 34% of road-mode transportation (1616313).

An alternative of that is one ship under full loaded (200 semi-trailers) and driving 100 semi-trailers on road.

Door to door road transport cost based on loading tons				
Destination	**Distance (km)**	**Number of trailers**	**Unit cost (23 ton)**	**Total cost**
Paris	2291	37.00	40298.69	1491051.53
Madrid	3539	8.00	62251.01	498008.08
Ruhr area	1752	31.00	30817.68	955348.08
London	2315	12.00	40720.85	488650.20
Brussels	1595	12.00	28056.05	336672.60
Sum up	11492	100	202144	3769730.49

Table 6.11: Transport cost of road mode (100 semi-trailers)

The transportation cost of road mode for 100 trailers is 3769730, and transportation cost of intermodal mode for 200 trailers is 2232543 Nok.

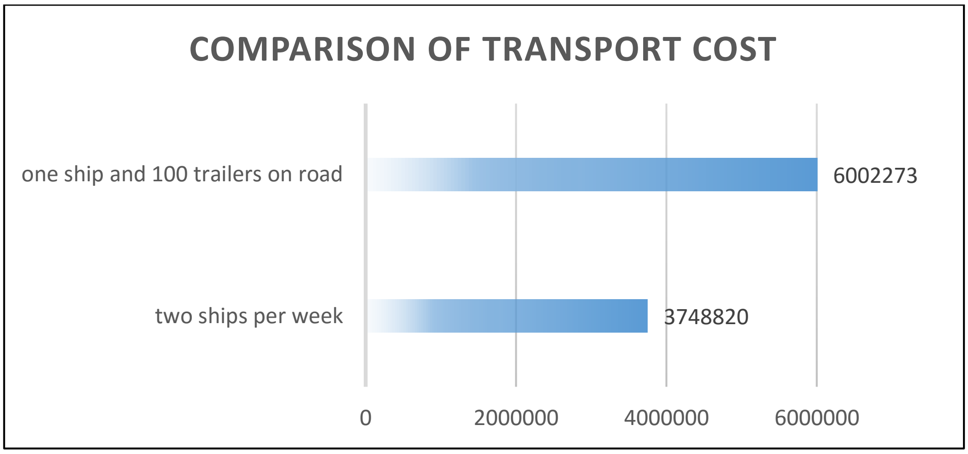


Figure 6.3: Comparison on cost for two alternatives (300 semi-trailers)

The total cost of this alternative (6002273) is much higher than two ships per week (3748820).

Carbon footprint emission of road transport				
Destination	Distance (km)	23 ton trailer	number of trailers	Total emission
Paris	2291	5743.54	37.00	212510.98
Madrid	3539	8872.27	8.00	70978.16
Ruhr area	1752	4392.26	31.00	136160.06
London	2315	5803.71	12.00	69644.52
Brussels	1595	3998.67	12.00	47984.04
			Sum up	537277.76

Table 6.12: Emission of road mode (100 semi-trailers)

The overall emission for this alternative is 903355 kg, carbon footprint emission from both road mode (537278) and intermodal mode (366077). The ship is fully loaded for 200 semi-trailers, with weight of 4600 tons and sailing distance 2134 km. The emission from maritime shipping is 1664916 kg at sailing speed 19 knot. (emission coefficient 0.0168)

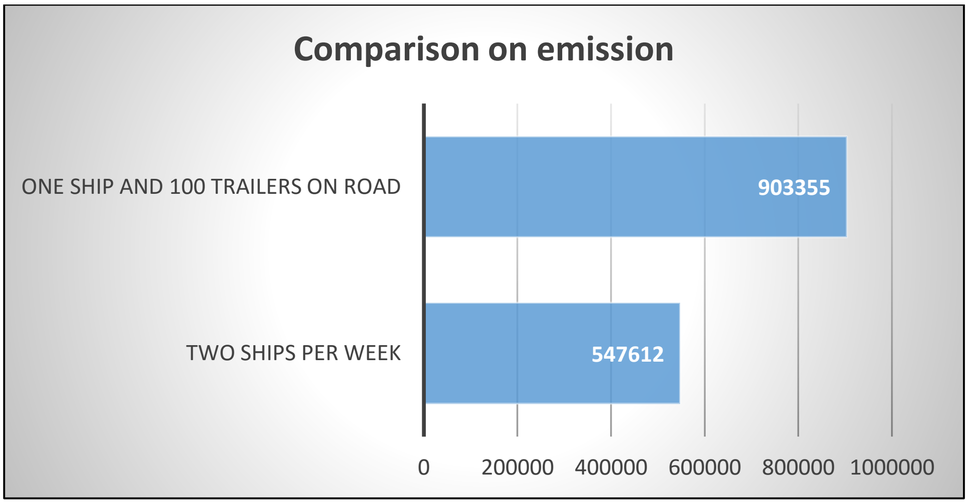


Figure 6.4: Comparison on emission for two alternatives (300 semi-trailers)

In terms of economic saving and emission reduction, it seems like that utilize two ships per week is superior that another one. In addition, it will also drop down the probability of serious accidents on road.

However, we should also consider the investment on vessels. Initial investment on facilities and port construction are costly. It also takes a lot of time to ensure the shipping route under operation. The maintenance cost for old ships also account for high proportion of total operation cost.

6.3 Conclusion

We can conclude that the intermodal mode is superior choice for sea food freight in Mid-Norway. This mode cuts down at least 60% of transportation cost, which is beneficial for all actors in the supply chain. Further more, it efficiently controls the carbon footprint emission from transport section. The concept of green corridor will be presented more entirely by adopting the intermodal shipping route.

We also observed that the relevant cost is much lower when the ship is fully loaded, comparing with the one with surplus capacity. In order to obtain maximum utilization of ship capacity, it will be critical for operators to set up a reasonable shipping schedule.

7 Limitation

The shipping corridor cost structure and its further development has not been presented in the thesis. This is explained by the fact that the information on vessel purchases and the costs of port area construction are kept confidential. The relevant information can neither be found on the website nor obtained from other sources. Therefore, we have made several assumptions at the beginning of the calculations part.

Likewise, the assessment of intermodal transportation exhibits a risk of calculation error since the exact data on fuel consumption have not been obtained. Though this lack of evidence does not affect the main conclusion of the superiority of the intermodal mode, it may affect the choice of sailing speed which depends on fuel consumption and transit time.

8 Future investigations and questions to be answered

The key challenges in the realization of the project that must be addressed as soon as possible are:

- Logistics performance:

It is necessary to work out an integrated logistics concept involving both road and sea transport modes. Return cargo markets are important and must be built up gradually. The price of the sea transport alternative depends on the number of return cargo flows. The balance of freight flows has not yet been achieved.

- Use of innovative technologies:

Implementation of innovative methods of transportation and new packaging solutions

- Government support:

Fee reductions required during the launching of the project - 'infant industry argument' Possible government influence on fish farmers' incentives

Effective collaboration between logistics providers and producers. Ships and port facilities are now in place, but the carrier will require certain guarantees with regards to volume to start the transportation. Practice sailings are very costly because the transport aids will only be in place for a given short period. The Government support and subsidies are the essential factors for the realization of the project.

Even though we have proven that intermodal transportation is the superior mode for sea food freight from the perspective of economic and environmental concern, challenges for the new shipping corridors are obvious and inevitable.

Intermodal transport requires high carriage volume of sea food from external market. Ships, cargo base and port facilities are now in place, but the carrier will require certain volume guarantees to start the transportation. If the volume is too small, the superiority of shipping will not emerge for the reason of not reach economics of scale. Achieving the goal of full utilization on vessel capacity is hard due to the external demand on fish delivery varies from month to month. Seasonal fluctuation for fish production is also significant at different seasons (60% at autumn and 40% at spring). Synthetizing above reasons, it is difficult to achieve the goal of full utilization and profit maximization.

In the calculation part, we only compare the transportation cost per trip between road mode and intermodal mode. Since we have not obtained further information on investment on facilities at port area and vessels which used for carriage. As we can estimate that the initial capital input will be huge in building such new transport corridor, and unpredicted risk and changes will occur afterwards. It will be a great challenge for project participants to raise financial support. The project will be suspended due to lack of financial foundation from local governments.

It will be another challenge to reach the high degree of flexibility for transportation. The application of intermodal mode requires accurate forecast on demand and then ship cargo to end users weekly. The weekly shipping schedule is stable, so it will not possible to cater changes on demand from customers in time. In contrast, road transport allows low volume of cargo distribution, therefore it is more possible to provide high level of logistics service.

Empty return is very costly so the authorities have proposed the solutions of ship return. Imbalance on cargo flow in both directions will become obstacle of the project if it can not be solved appropriately. Loading capacity which has not been used is the waste and lower the efficiency of the whole supply chain.

The initial plan for the shipping is that it delivers the fresh fish to the end destinations in EU and return with fruits and vegetables back to Norway. In fact, it will increase the waiting time and loading time at discharge port. Long waiting for return cargo is not allow for the reason of catching the shipping schedule per week.

However, we should also consider the investment in vessels. Initial investments in facilities and port construction are costly. It also takes a lot of time to ensure the shipping route under operation. The maintenance cost for old ships also account for high proportion of total operation cost.

9 Conclusion

In our study we have completed an analysis of the perspectives of the “Sustainable transport solutions for fresh fish from Central Norway to the Continent” project. The project focuses on a "from-road-to-sea" solution that has a national and an international interest. The overall objective of our research was to prove the viability of sea transport as the alternative to road transportation. To achieve this, we have stated 4 research questions to which we gave answers in our study.

At the moment the aquaculture is the industry where the delivery of the end product to the end customer is dominated by road transport in all stages of transportation.

The analytics we have provided in the thesis indicate significant environmental benefits from the use of maritime transport.

The most serious challenges in the realization of the project are the organization of the transport and opportunities for return cargo flows.

The expected production increase will involve a new transport solution which will supplement the road transportation one in the StartUp phase and has the potential for becoming a reliable transportation alternative in the future.

Today Norway has no specific port hubs for the fish farming industry and the seafood exports. Most ports are multipurpose and handle both fish and other types of commodities. There is a dominating approach in transportation: either sea, road, air or rail. The need for collaboration between sectors, a tighter coordination of activities and the introduction of intermodal concepts are all urgent tasks. Effective collaboration between ports of the Coastal Harbour Alliance will lead to great development opportunities for those participants who have already settled in the ports and the potential sea transport newcomers. The establishment of an effective harbor/terminal solutions at Hitra and Krakøya under the Coastal Harbour Alliance will lead to many goods being transported by sea along the coast from Mid Norway to the continent. The collaboration between producers of fresh fish located in the Hitra-Frøya region will improve the cargo flow sustainability. Considerable and regular flows of fresh fish transported by sea will provide profitability and sea transport efficiency. Decisions about return cargo flows will significantly contribute to the development of export/import supply chain network.

Comprehensive transport planning and the integration of the coastal port into the regional infrastructure are of great importance for the development of sustainable marine and land transport solutions.

Most of all, the realization of the project of fish freight flows reallocation from road to sea in Hitra and Frøya regions will considerably reduce the number of vehicles on Norwegian roads and as a result, reduce CO_2 emissions, the cost of road maintenance and the number of road accidents.

Reference list

A logistics hub for the future - at the main shipping fairway between Trondheim and Kristiansund. Available from http://www.hitra.kommune.no/ (Accessed 20.12.2015)

Ahumada, O. and Villalobos, J.R. 2009. Application of planning models in the agri-food supply chain: a review. *European Journal of Operational Research*, 196(1):1-20.

Baccarach, S.B. 1989. Organisational theories: some criteria for evaluation, *Academy of Management Review* 14(4): 496-515

Boske, L. B. (1998). MULTIMODAL/INTERMODAL TRANSPORTATION IN THE UNITED STATES, WESTERN EUROPE, AND LATIN AMERICA-GOVERNMENT PLANS, POLICIES, AND PROGRAMS. Austin: LBJ School.

Crawford, I. (1997). Agricultural and food marketing management, FAO Rome, Italy, P.210.

Combi Lift. 2016.

http://www.combi-lift.net/home.html/ (Accessed 12.02.2016)

Container Handbook. 2016. Container-carrying vessels, part 2.

https://www.containerhandbuch.de/chb_e/stra/index.html?/chb_e/stra/stra_01_03_01_02.html/ (Accessed 10.02.2016)

C.Macharis, Y.M. Bontekoning. 2004. Opportunities for OR in intermodal freight transport research: a review, *European Journal of Operational Research*. 153: 400-416.

Dekker, R., et al. (2012). "Operations Research for green logistics–An overview of aspects, issues, contributions and challenges." European Journal of Operational Research 219(3): 671-679.

DSV. 2015. Global transport and logistics. EU Environmental Low. Sulphur directive (SECA).

http://www.ie.dsv.com/about-dsv/press/News/2014/11/EU-Environmental-Low-Sulphur-Directive/ (Accessed 05.05.2015)

Ellram, L. 1996. The use of the case study method in logistics research, *Journal of Business Logistics*, 17(2): 93-138.

EU Commission. 2009. Strategic Goals and Recommendations for the EU`s Maritime Transport Policy until 2018 [Com (2009) 008 final]. Brussels: Commission of the European Communities. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Atr0015/ (Accessed 23.01.2015)

FAO. 2010. Food and Agriculture Organization of the United Nations. Fisheries and aquaculture department. Norway. National Aquaculture sector overview.

http://www.fao.org/fishery/countrysector/naso_norway/en (Accessed 18.01.2016)

Food and Agriculture Organization of the United Nations. 2016. National Aquaculture Sector Overview. Norway. Market and Trade. http://www.fao.org/fishery/countrysector/naso_norway/en#tcN7010C/ (Accessed 02.04.2016)

Food Port. 2013. Hitra Case: set up of an intermodal corridor Hitra-Zeebrugge.

http://www.foodport.eu/sites/default/files/Corridor%205%20-%20Hitra%20Case%20-%20set%20up%20of%20an%20intermodal%20food%20corridor%20betweens%20Hitra%20and%20Zeebrugge.pdf/ (Accessed 04.02.2016)

Global Secuirity. 2016.

http://www.globalsecurity.org/military/systems/ship/lo-lo.htm/ (Accessed 14.04.2016)

Halldorsson, A. and Aastrup, J. 2003. Quality criteria for qualitative inquiries in logistics. *European Journal of Operational research*, 144(2): 321-32.

Hitra-Frøya. 2014.

a.Utvider industriparken for 46 millioner. http://www.hitra-froya.no/nyheter/article9829710.ece/

b.BEWi etablerer ny fabrikk på Jøstenøya. http://www.hitra-froya.no/nyheter/article9787857.ece/

c.Sundegruppen bygger ny fiskekasse-fabrikk. http://www.hitra-froya.no/nyheter/article9567355.ece/ (Accessed 25.02.2016)

d.Sikrer seg fabrikktomt for framtida. 2014.

http://www.hitra-froya.no/naeringsliv/article9774586.ece/ (Accessed 25.02.2016)

Huon Tasmania. 2016.

https://www.huonaqua.com.au/about/farm/well-boat/ (Accessed 29.03.2016)

Intergovernmental panel on climate change IPCC. 2007. Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available from URL: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf/ (Accessed 10.02.2016)

"IPCC AR4 SYR Appendix Glossary"/ Kaipia, Riikka, Dukovska-Popovska, Iskra and Lauri Loikkanen. 2011.Creating sustainable fresh food supply chain through waste reduction. *International Journal of Physycal Distribution & Logistics Management*, 43(3)262-276.

Kittipanya-ngam, P., Shi, Y. and Gregory, M.J. 2010. Food Supply Chain (FSC) in manufacturing companies –an exploratory study on product and configuration, Proceedings of 17th EurOMA Conference, Porto, Portugal.

Kristiansund and Nordmøre harbor. 2016. Hitra kysthavn.

http://knhavn.no/ (Accessed 15.12.2015)

Koufteros, X., et al. (2005). "Internal and external integration for product development: the contingency effects of uncertainty, equivocality, and platform strategy." Decision Sciences 36(1): 97-133.

Lakseeksporten øker kraftig: 130 vogntog fylles daglig-press på veger og ferjer. Samferdsel. NR 9-NOVEMBER 2014: 6-7.

Lerøy Seafood Group. 2016. Sustainability. Sustainable value chain. Environmental policy. Distribution and transport solutions. https://www.leroyseafood.com/en/ (Accessed 03.03.2016)

Liljestrand, Kristina. Chalmers University of Technology. 2012. Food Logistics Centre at Hitra/Frøya.

MacGregor. Shortsea RoRo ships. 2016. http://www.macgregor.com/en-global/macgregor/merchant-ships/shortsea-roro-ships/Pages/default.aspx/ (Accessed 14.03.2016)

Marine Harvest. 2016. Product range. Seafood value chain. http://marineharvest.com/product/seafood-value-chain/ (Accessed 08.03.2016)

Medda, Francesca and Lourdes Trujillo. 2010. Short-sea shipping: an analysis of its determinants, Maritime Policy & Management, 37(3): 285-303.

Meredith, J. 1998. Building operation management theory through case and field research, *Journal of Operations Management*, 16 (4): 441-54.

Mora, Camilo, Abby G.Frazier, Ryan J.Longman, Rachell S. Dacks, Maya M.Walton, Eric J.Tong, Joseph J. Sanchez, Lauren R.Kaiser, Yuko O.Stender, James M.Anderson, Christine M.Ambrosino, Iria Fernandez-Silva, Louise M.Giuseffi and Thomas W.Giambelluca. 2013."The project timing of climate departure from recent variability": 183-184. doi: http://10.1038/nature12540

Netter, J.E. 2013. Sustainable transport solutions for fresh fish from Central Norway to the Continent. Final Report. Hitra Municipality. Enova supported project.

1. Nord-Trøndelag Havn Rørvik IKS. http://nthr.no/ (Accessed 03.01.2016)
2. Norwegian Government`s official web-site. 2013. National Transport Plan 2014-2023. https://www.regjeringen.no/no/dokumenter/meld-st-26-20122013/id722102/ (Accessed 19.01.2015)
3. Norwegian Seafood Council (NSC). 2015. Norwegian salmon and trout exports worth NOK 50 billion in 2015. http://en.seafood.no/News-and-media/News-archive/Press-releases/Norwegian-salmon-and-trout-exports-worth-NOK-50-billion-in-2015/ (Accessed 20.03.2016)
4. Posts Tagged 'mobile reefer service'. 2010. Fix on road: Reefers Explained. http://fixonroad.com/blog/tag/mobile-reefer-service/ (Accessed 14.03.2016)
5. Port of Hirtshals. 2016. http://www.portofhirtshals.com/The-port/Map-and-geographical-location/ (Accessed 11.01.2016)
6. Port of Zeebrugge. 2016. http://www.portofzeebrugge.be/ (Accessed 17.03.2016)
7. OTTS Transport. 2016. http://otts-as.no/ (Accessed 19.03.2016)
8. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available from URL: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf "IPCC AR4 SYR Appendix Glossary"/ (Accessed 20.12.2015)

Papalexi, M., et al. (2015). "A case study of kanban implementation within the pharmaceutical supply chain." International Journal of Logistics Research and Applications: 1-17.

Perols, J., et al. (2013). "On the relationship between supplier integration and time-to-market." Journal of Operations Management 31(3): 153-167.

Rodrigue, J.-P., et al. (2001). "Green logistics (the paradoxes of)." The Handbook of Logistics and Supply-Chain Management 2.

Rondinelli, D. and M. Berry (2000). "Multimodal transportation, logistics, and the environment: managing interactions in a global economy." European Management Journal 18(4): 398-410.

Rørvik Harbor. 2016. A safe harbor for all.

Available from URL: http://nthr.no/wp-content/uploads/2015/11/Presentasjon-av-Rørvik-havn.pdf/ (Accessed 230.01.2016)

SalMar. 2016. About SalMar. Strategy&Vision. http://salmar.no/ (Accessed 12.03.2016)

State Highways Authority.2016. Fv. 714. Salmon road.

http://www.vegvesen.no/Fylkesveg/fv714laksevegen/fv.714-laksevegen/ (Accesssed 27.03.2016)

Statistics Norway. 2014. Emissions of greenhouse gases, preliminary figures.

http://www.ssb.no/en/natur-og-miljo/statistikker/klimagassn/aar-forelopige /(Accessed 22.01.2016)

Statistics Norway SSB. 2015. Aquaculture, 2014, Final figures. Continued growth in aquaculture, figure 1. http://ssb.no/fiskeoppdrett/ (Accessed 12.03.2016)

Simina, D., et al. (2012). "Economic Benefits Of Developing Intermodal Transport In The European Union." Annals of Faculty of Economics 1(2): 81-87.

Stevenson, S. and R. Pirog (2008). Values-based food supply chains: strategies for agri-food enterprises-of-the-middle. Annual Meeting of the Rural Sociological Society. Manchester, New Hampshire,(July 28, 2008), http://www. allacademic. com/meta/p244246_index. html,(May 5, 2010).

Taylor, D.H. and Fearne, A. 2009. Demand management in fresh food value chains: a framework for analysis and improvement. *Supply Chain Management*, 14(5): 379-392.

Tidens Krav. 2015.Closer salmon keel. http://www.tk.no/nyheter/nordmore/transportnaringen/narmere-laks-pa-kjol/s/5-51-119132/ (Accessed 01.12.2015)

The Center for Sustainable Transportation and vision of sustainable transportation, the University of Winnipeg. 2002. Definition and vision of sustainable transportation.

http://cst.uwinnipeg.ca/documents/Definition_Vision_E.pdf/(Accessed 25.03.2016)

Thomaeus, B (2011). "The European Concept of Green Corridors in Sustainable Transport Systems: Case of East-West Transport Corridor in the Baltic Sea Region."

United Nations Framework Convention on Climate Change. Kyoto protocol. 1998.

http://unfccc.int/kyoto protocol/items/2830.php/ (Accessed 25.03.2016)

United States Environmental Protection Agency. 2014. Sources of Greenhouse Gas Emissions.

https://www3.epa.gov/climatechange/ghgemissions/sources/transportation.html/(Accessed 19.12.2015)

Wacker, J.G. 1998. A definition of theory. Research guidelines for different theory building research methods in operations management. *Journal of Operations Management*, 16: 361-85.

Workshop Hitra. 2012.

A) Behrmann, K., Jantzen, K., Lukas, W. Milde, P. and W. Zeits. FOOD PORT. Connecting food port regions. Between and beyond. Fish/Seafood and B2B Workshop. Hitra, April 17th 2012.

B) OTTS AS a part of the Transport Chain

Woo, J.-K. and D. S.-H. Moon (2014). "The effects of slow steaming on the environmental performance in liner shipping." Maritime Policy & Management 41(2): 176-191.

Wu, H.-J. and S. C. Dunn (1995). "Environmentally responsible logistics systems." International Journal of Physical Distribution & Logistics Management 25(2): 20-38.

Yevdokimov, Y. V. (2000). "Measuring economic benefits of intermodal transportation." Transp. LJ 27: 439.

Appendix I: Salmon export volume from year 2011 to year 2015
Source: Statistics Norway

Export of salmon, fish-farm bred, by commodity group, time and contents										
	2011		2012		2013		2014		2015	
	Fish-farm bred salmon, fresh or chilled									
Week	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**
1	9309	38.43	11785	25.65	10364	33.57	9341	50.34	9466	45.57
2	11133	39.96	12528	24.95	15684	33.35	15118	48.75	15622	45.77
3	11853	40.44	13994	26.71	15135	34.76	14505	49.27	15946	46.28
4	11570	38.82	12990	25.26	14010	36.51	13699	49.72	16444	44.31
5	10320	39.98	13226	25.31	13732	35.27	13784	46.8	14810	39.78
6	10817	39.71	12883	27.51	13631	34.84	13053	45.62	14693	43.43
7	10982	40.81	13613	28.49	14332	36.13	13190	49.41	14634	44.78
8	10585	41.61	14382	29.84	13163	37.03	14324	48.76	15864	41.76
9	10941	40.89	15829	28.77	13550	38.97	15963	46.68	16173	39.1
10	12801	40.56	15525	28.64	14576	38.9	15949	44.13	15920	41.14
11	12165	40.44	16395	29.07	15892	37.7	15975	44.07	17767	42.47
12	11899	40.79	17175	28.27	18376	36.02	16449	43.63	19019	41.79
13	10941	40.94	18334	26.64	10986	37.93	16159	43.83	20283	40.32
14	12729	42.2	9286	29.61	11291	39.85	17313	44.01	12240	42.3
15	13763	43.61	15530	29.34	13550	42.27	19722	44.35	15764	42.24
16	8130	43.08	16510	28.7	13438	43.23	12057	47.4	17988	39.35
17	9888	42.71	15370	29.11	14289	42	14614	46.29	16066	37.62
18	11889	42.21	13019	29.11	13265	42.41	14590	44.62	16206	39.25
19	13036	40.05	16526	29.06	14217	42.31	15636	42.03	17602	36.99
20	10413	38.75	14425	31.27	14132	43.51	15695	40.28	15948	39.96
21	12609	36.67	16542	29.51	14456	43.81	16593	39.37	18209	38.65
22	10992	36.08	15328	28.3	15171	40.77	14444	38.83	16364	37.92
23	13201	34.11	16993	26.42	14847	40.22	16919	37.65	16613	38.77
24	11833	33.37	17607	25.92	14940	39.22	15355	37.51	17313	41.51
25	13159	31.61	16734	27.59	13330	41.19	17308	36.47	16036	42.69
26	12880	28.54	15826	26.9	13309	43.4	17145	33.6	16383	40.94
27	12160	31.2	16555	27.7	14217	45.15	15108	37.6	15214	39.76
28	13277	33.21	16064	26.9	14102	44.26	15256	41.66	15205	42.26
29	12758	30.11	14412	26.4	14098	45.12	14452	42.26	14930	44.81
30	10897	30.62	14355	26.56	13509	43.01	14297	42.23	15267	46.23
31	11197	29.35	15238	27.17	12572	40.14	15439	37.7	13878	45.63
32	12169	29.59	15064	28.31	13734	39.92	15634	37.48	14226	46.68
33	12639	28.91	15317	27.36	13675	43.43	15710	35.82	15798	46.63
34	13788	26.55	15533	27.67	15530	42.03	16726	34.95	16971	41.74
35	13819	27.27	16542	29.1	16403	38.16	16287	34.87	17353	39.06
36	14804	27.47	16474	28.6	16791	37.31	17045	35.71	17227	43.03
37	14613	25.97	17354	26.92	18020	33.73	17009	34.43	17706	43.18
38	14992	26.59	18359	26.02	18859	30.04	17405	34.05	19057	41.54

39	16079	25.23	18459	23.99	18487	32.82	17142	35.43	18914	40.39
40	16648	24.55	17312	24.28	18727	35.87	17134	35.59	18598	40.07
41	16376	24.2	17499	26.66	18442	35.68	17554	34.4	18604	43.09
42	16207	23.01	18298	26.24	18051	38.32	17925	34.44	18992	42.43
43	15906	21.63	17301	25.1	18068	38.74	17091	36.51	20108	41.06
44	15301	24.18	17795	27.02	18734	39.7	17873	37.06	19201	41.86
45	16194	25.23	17867	26.59	17751	38.5	16848	37.61	18118	42.98
46	17327	24.16	18453	27.73	18020	36.98	17877	39.95	18705	42.52
47	18890	26.15	19372	26.63	17907	39.94	17687	41.76	18125	44.51
48	18710	26.06	19394	27.15	18384	40.17	18451	43.38	18889	48.79
49	19953	25.9	21897	29.16	21121	45.65	20184	45.29	19802	50.06
50	22369	28.49	23674	30.78	23617	48.61	21210	46.84	20949	49.05
51	16499	26.9	23219	29.56	22644	48.52	18822	42.36	20207	51.3
52	9721	26.4	7356	33.11	7100	50.58	8305	47.2	10494	53.26
53	0	0	0	0	0	0	0	0	9593	55.06
Total or Average	693131	32.99	837518	27.67	802229	39.76	829371	41.35	881504	43.05

a= Weight (tons)

b = Price per kilo (NOK)

The table above is the weekly weight and price from week 1 to week 52 for each year. Year 2015 has 53 weeks, as shown in the table.

At the last row of table, the number for column of weight is sum, and the number for column of price is average.

Appendix II: Interview Guide

General section

1. What kind of issues you want to solve in current operation? (research questions) It can be more than one issue
2. Why do you consider it so significant?
3. What goals do you have in the project? Profitability, efficiency, social responsibility
4. Do you have some ideas how to achieve?
5. What challenges do you suppose will have in processing? Is it solvable or not?
6. How the project processes are carried out?
    -Implementation of the plan worked out in 2014
    -Timing of the construction works of the port in Hitra
7. Which one of 3 potential scenarios of the structural solution we are going to investigate?

-1A: Intermodal SSS Kristiansund-Zeebrugge-Start-Up scenario

-1B: Intermodal SSS West-Coast Norway (Hitra-Risavika)-Zeebrugge

-2A: Intermodal SSS Hitra-Zeebrugge-Kristiansund-Hitra-based on long term basis.

Detail section

8. Is it road transportation the main transport mode?
9. Do you have plan to change it into intermodal (road and sea)?
10. What are advantages and disadvantages of road transport? (accidents, emissions)
11. The main shipping routes among ports currently (from Hitra to EU)
12. The reason to choose sea transport?
    -Competitiveness of transportation by sea in terms of cost and time
13. Is it some evidence of improvement on sea transport? (saving money, utilize productivity)
14. Which shipping companies are contracted with the port?

Shipping companies which will provide services:

-Company Blue water.

-AB Transatlantic Short Sea- is it only one in the scope at the moment?

-Deep Sea: Intercontinental reefer container services: Maersk, UASC, CMA/ CGM

-Leroy

Contact information:

15. What type of vessel they use to deliver the seafood?

-Details about the vessels, technical characteristics, capacity, sailing speed, fuel consumption.

-Coastal and shortsea traffic frequency.

16. How to evaluate the shipping performance?

17. How about the customer service?

-Service time at the port

-Possibility of storage

18. The main markets the flows are oriented to (future / current situation):

-Mid-Norway

-Northern Norway

Semitrailer transport (road haulage) of fresh salmon goes towards the main markets in:

-Benelux/France (mainly via Boulogne-sur-Mer and Paris)

-Spain (Barselona and Madrid)

-Germany (mainly via Bremerhaven, Hamburg, Frankfurt)

19. Main carriers at the moment: DB Shenker, Bring, Otts Collaboration between them?

Car flow: approx. 80 semitrailers per day (20 tones per load) Routing

Contact information

20. Future:

-Transportation by sea/road:

-detailed routes

- details about transportation: Lead times for transportation of products by sea.

Possible structural and multimodal sustainable alternatives to door-to-door road transport.

What is preferable intermodal solution we are going to investigate?

Combined sea/road freight, preferable intermodal solution-initial freight collection and final distribution by track with preference of RO/Ro trailers (Short Sea Shipping)

21. Producers of Sea Food, production volumes:

Statistical data on production and consumption Is there a collaboration willingness?

Marine Harvest Lerøy

Frøya municipality:SalMar, Contact information: Frøya+Hitra: Salmon region

Cost of transportation for producers of sea food: Vessel and truck

22. Volumes of fresh salmon: Other products:

-crabs

-cod

-bakalao

What are the lead times for transportation products by sea? Special product handling on a short and long term bases.

23. Seasonality:

- balance of flows all year around

24. Return cargo: Fruit, vegetables, cars

25. Collaborating Ports: Zeebrugge, Port of Esbjerg Risavika?

26. In period from September 2011 to April 2012 by a work group (Zeebrugge Havn v/Emmanuel Van Damme, POM v/Kevin Lyen and Alexander Demon and KNH representative v/ Jan Erik Netter) was made a significant data collection and mapping with the participation of farming companies.

May this information be available for our research?

Appendix III: Shipping route of maritime transport

The information is provided by marketing manager of Kristiansund and Nordmøre Harbor (Jan Erik Netter)

Site from / Site to	Hitra	Kristiansund	Risavika	Zeebrugge
Kristiansund	Distance: 90 km; Transit time: 0.08 days; Trailers: 3868 #			
Risavika		Distance: 594 km; Transit time: 0.13 days; Trailers: 3868 #		
Zeebrugge			Distance: 1450 km; Transit time: 0.13 days; Trailers: 3868 #	
Paris				Distance: 310 km; Transit time: 0.17 days; Trailers: 1420 #
Madrid				Distance: 1550 km; Transit time: 3.60 days; Trailers: 319 #
Ruhr area				Distance: 350 km; Transit time: 0.21 days; Trailers: 1183 #
London				Distance: 290 km; Transit time: 0.25 days; Trailers: 473 #
Brussels				Distance: 110 km; Transit time: 0.04 days; Trailers: 473 #

The columns in the table are the places of departure, the rows are the places of arrival.

If the cell is empty, it means that two sites are not connected.

The number of trailers are yearly demand.

Appendix IV: The basic parameters of road transport

The information is provided by marketing manager of Kristiansund and Nordmøre Harbor (Jan Erik Netter)

Site from / Site to	Hitra		Stavanger	
	Km	Days	Km	Days
Pairs	2291	3.82	1771	2.95
Madrid	3539	5.90	3020	5.03
Ruhr Area	1752	2.92	1233	2.06
London	2315	3.86	1796	2.99
Brussels	1595	2.66	1475	2.46

Hitra and Stavanger are two places of departure.

Five end destinations are Paris, Madrid, Ruhr Area, London and Brussels.

The distance unit is km.

Appendix V: The general input

The information is provided by marketing manager of Kristiansund and Nordmøre Harbor (Jan Erik Netter)

Maritime Handling Cost (based on 2000 LM)		
T/C	11500	Euro / Day
IF 380 (1%)	538.46154	Euro / mt
MDO	769.23077	Euro / mt
Port dues/charges	15000	Euro / Call
Stevedoring	150	Euro / Trailer
Other	1000	Euro / Voy
Consumption MGO	2.50	mt / Day
Rental Cost Trailer	100	Euro / Day
Basic price		
Fuel price (diesel)	2948 DKK/Ton	
Km price (road)	1.916 Euro per km	
Sailing speed and fuel consumption		
Speed	Consumption diesel	
17 kn	45	Ton / Day
18 kn	51	Ton / Day
19 kn	57	Ton / Day
20 kn	62	Ton / Day
21 kn	74	Ton / Day
22 kn	87	Ton / Day
Carbon Footprint Emission		
Speed	Emission coefficient	
Road	0.1090	Kg / Ton * Km
Shortsea 17kn	0.0132	Kg / Ton * Km
Shortsea 18kn	0.0150	Kg / Ton * Km
Shortsea 19kn	0.0168	Kg / Ton * Km
Shortsea 20kn	0.0182	Kg / Ton * Km
Shortsea 21kn	0.0218	Kg / Ton * Km
Shortsea 22kn	0.0256	Kg / Ton * Km