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The Norwegian Live Fish Carrier Fleet

Is there a mismatch between capacity, utilization & investments?

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Master thesis in Finance & Energy, Natural Resources and the Environment.

NORWEGIAN SCHOOL OF ECONOMICS

Preface

This thesis is written as part of our Master of Science in Economics and Business Administration within our majors in Finance and Energy, Natural Resources and the Environment.

As part of the aquaculture value chain, Live Fish Carriers (LFC) have gone through a significant growth phase over the last decade. However, little attention has been drawn towards the industry of live transportation and live processing of salmon in academia. We consider it to be an emerging shipping market in Norway. This allows us to be, perhaps, the first to do academic research to analyze the market for Live Fish Carriers and their services in an economic perspective.

Taking on this task, we acknowledge that the access to reliable data was challenging. There is a considerable difference between academia and the industry. In our research approach we try to satisfy the practicality of the industry while maintaining a theoretical approach. We used considerable time to be present in different market settings, to get first hand insight on the market dynamics and the people making the decisions in the industry. In order to simplify the dynamics, we have made a number of reasonable assumptions. We are confident that our findings are contributing to valuable insight for the industry stakeholders and for further analysis by academia.

We are very thankful to the shipowners, and other participants, in the industry who participated in our interviews and meetings, and the interest they have expressed for our work. Without their willingness to share information, we would not have been able to write the thesis. We would also like to thank our supervisor, Gunnar S. Eskeland, for his insights, guidance and inspiring talks throughout the semester. His feedback and perspectives have been highly valued, and challenged us to improve the quality of our work in ways we would not have thought of ourselves.

Sindre Flak Stovner

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Abstract

The Live Fish Carrier Industry is a specialized shipping segment in Norway, transporting and processing live salmon. The underlying driver for the segment is the production of salmon in aquaculture. With an absence of academic research on the topic, this thesis will try to fuse the attention from the academic society.

By modeling the supply and demand of LFC operations, we observe a surplus on the demand side of the market. A turning point occurred in 2013 when the supply increased more than the demand. New, large and expensive vessels entered the market, and substantial capacity will enter in 2017. This will eliminate the demand surplus, and create a movement towards market balance.

The operations of the vessels are managed by the salmon producers. Our positional tracking analysis indicates that the vessels are not utilized efficiently. The vessels are operating across a large range of regions, within a six-month period. The analysis provides grounds for an argument that large vessels, individually, are covering fewer regions than the smaller vessels. The smaller vessels are unlikely to capture long charter contracts, and consequently have to move more between regions. This operational pattern is a reason for concern, when the risk of spreading diseases is high.

There are several reasons to operate in the LFC industry. From a salmon producer's perspective, we believe that the supplied services can be looked upon as an insurance from random shocks of lice and diseases on the biomass. The value of an average cage has increased with 400% the last ten years, which consequently will increase the value of having excess LFC-capacity. From our analysis based on the Return on Shipping Investments model, the average financial return is 12.6%. We conducted a freight rate sensitivity analysis to assess the effect on NPV of a new LFC investments. The findings show that LFC owners are investing in a profitable asset, despite considerable changes in the market.

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1. Introduction

The Life Fish Carrier (LFC), or the Well Boat, industry in Norway has experienced a tremendous growth the last decade, as an essential part of the aquaculture value chain. LFCs represents a cost-efficient way of transporting live Atlantic salmon (*Salmo Salar*).

Over the last decades, the vessels have developed from basic fishing boats to highly advanced transporting vessels, with an individual cost of about 300 million NOK. The highly specialized vessels have increased in both number and size. Long contracts and non-transparency characterize the market for transport and processing services provided by the LFCs.

The aquaculture industry and the physical production of salmon are the underlying drivers for the demand for LFC operations. Hence, the value of production will be reflected in the LFC market. In Norway, the total sales of fish and shellfish were 1.39 million tons in 2015 (SSB, 2016). This accumulates to a value of 47.6 billion NOK. Salmon accounts for 95% of the produced volumes of fish and shellfish in Norway, and every single one of the salmon has to be carried by an LFC at least twice.

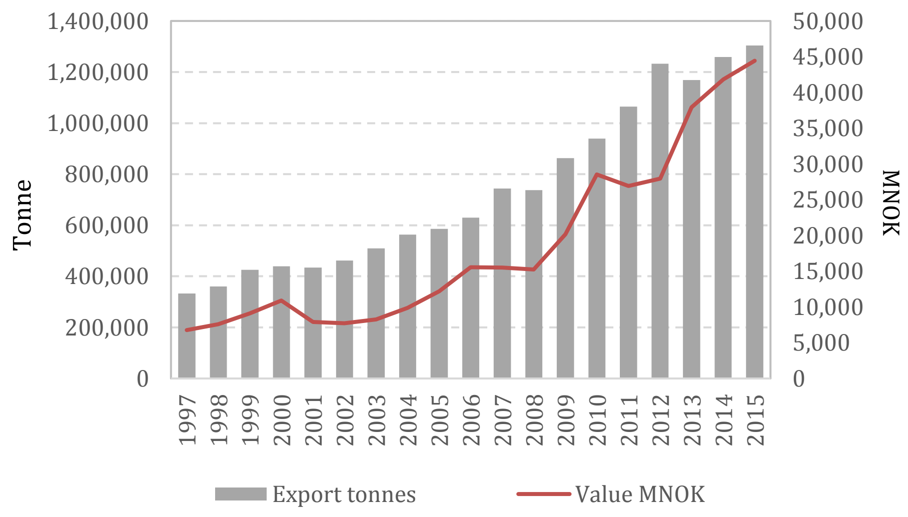


Chart 1*: Exported volumes and values from aquaculture (SSB, 2016)*

Major investments in new and advanced vessels are stacking up the orderbooks at the Norwegian shipyards (Kleven Verft, 2016). The shipowners are making more money than ever. Some argue that there is going to be an overcapacity in the LFC market. Others say that the problem with lice is a driver for the demand of more highly specialized vessels.

1.1 Mission and motivation

In this thesis we will investigate the Norwegian LFC industry, with the research question:

"Is there a mismatch between capacity, utilization and investments?"

The paper will investigate the capacity, utilization and investments separately, to jointly draw a conclusion of whether or not there is an unhealthy mismatch in the market. Further the thesis will evaluate the possible consequences of this development. The size and growth of the LFC market is a key motivator to get a greater understanding of the segment. Salmon is one of the largest export commodities from Norway and depends heavily on the services from LFCs (Norges Sjømatråd, 2016).

1.2 Perspective

When analyzing the LFC market and the vessels services, our scope is at the industry as a whole and not on individual companies. The focus will be on the development and present state, to contribute to the understanding of future development. This is done with the intention of creating valuable insight that could contribute to a healthy and sustainable growth in the LFC industry.

We will not thoroughly discuss the design of policies, nor discuss R&D and the possibilities of increased salmon production due to new technologies. These factors will rather be looked upon as constants and constraints for the analysis. The identification of the vessels will not be present when the goal of this analysis is not to characterize companies, but rather the dynamics of the industry as a whole.

1.3 Context

In our opinion, the offshore industry and the LFC have developed with a similar pattern. The demand for the shipping services from the oil and aquaculture industry, in times of high revenues, are resulting in increased costs and investments in the respective value chains. An optimism in the market for LFCs, where newbuilding rates are increasing is a reason for concern. In the event of a turning point in the upswing of aquaculture, a drop in the salmon price, the prerequisites for the market will change. The effects of such a change will consequently affect participants in the value chain and other stakeholders.

To get the opinions on the present state of the market, we approached different market participants and did a survey to investigate the market expectations. The results indicate that the salmon producers have a more optimistic view on the future than the shipowners. What they do have in common is the opinion that freight rates tend to be higher. This survey was done simply to categorize information that we have obtained in more informal settings, and should not be looked upon as empirical evidence.

With this insight and the historical tendency of volatility in the shipping markets, the investigation of the market will contribute to a greater understanding of the capacity, utilization and investment drivers in the LFC market.

1.4 Methodology

To answer the research question the paper provide key insight in the production process of salmon, and the LFC integration in the aquaculture value chain. This insight will create the foundation for the further research of the capacity, utilization and investments in the LFC industry.

In section 2, *Aquaculture,* we will briefly introduce the Aquaculture industry with technological and biological technicalities of the production, price and value development, cost structure and market. The LFC's function in the value chain of aquaculture is introduced in section 3, *The Live Fish Carriers.* This section provides insight on the function of the vessel, risks, contract structure, financials and the market for the services provided by the LFCs. The introduction, in sections 2 and 3, determines the prerequisites for the further analysis of the LFC industry in light of data and theories from sections 4 and 5.

In section 6, *Modelling the Supply and Demand*, we are thoroughly analyzing the capacity through calculating a proxy for both the supply and the demand side of the market for LFC services. The model is based on historical numbers, and will give insights on the development in the mismatch between supply and demand over an eleven-years period.

We investigate the actual utilization of the fleet in section 7, *Fleet Utilization.* Positional tracking of vessels over a half year period, gives insight on the operational patterns of the fleet and the geographical distribution. The output will be evaluated in light of theories from operational research. The insight will contribute to the argumentation of the development of the mismatch of supply and demand from section 6.

The technical analysis in sections 6 and 7, are not sufficient to evaluate the health of the LFC market. In section 8, *Investment Drivers*, we assess the financial drivers for the utilization and management of the fleet, and the incentives for further investments in the LFC is mapped.

In a joint discussion of the mentioned sections, we form arguments in light of current and future challenges in the industry, in section 9. New regulations and trends in the market will be discussed as for how it will affect the future capacity, utilization and investments in the LFC industry.

The methodology used, is covering different aspects of the market in an untraditional way. To answer the research question this is necessary when the transparency of the market, and sources of information are scarce. The approach will capture the practicality of the industry in a theoretical academic approach, and contribute to the conclusion if there is a mismatch in the market.

2. Aquaculture

Aquaculture in Norway has been a development frontier for the global market development since the humble beginning in the 1960s. A licensing system for practicing fish farming was established when the first aquaculture law was introduced in 1973 (Bratberg, 1974), to stimulate a balanced and sustainable development and become a profitable and sustainable rural industry.

After twenty years of continuous growth, the industry experienced their first downturn at the end of the 1980s, when it became exposed to international competition. The export industry experienced a significant fall in prices, and first large-scale problems with diseases. This crisis triggered a new set of regulations that caused reductions in production through the feed-quota regulations (Jakobsen & Aarset, 2007). From 1973 one of the main goals was to reach specific regional and district policy goals. The new regime regulated the industry in a way that has stimulated growth since the 1990´s.

Today the aquaculture industry is a highly technological and dynamic industry, which employs 6570 people at sea, in costal and urban areas (SSB, 2016).

2.1 Salmon production

The physical production of salmon happens in different stages, which replicates the natural lifecycle of a salmon. Different stakeholders are involved in the stages of production, and insight is therefore necessary to create an understanding of the market drivers and dynamics. The production is categorized into four phases; Fish Egg (roe) production, smolt hatcheries, grow-out centers and processing plants. Transportation of the smolt and salmon is performed by LFCs.

2.1.1 Biology

The natural lifecycle of an Atlantic salmon starts in fresh water. After the roe are hatched upstream rivers, the salmon juvenile spends the first months of their lives in fresh water (Store norske leksikon, 2015). The juvenile develops into smolt, and migrates to sea. In sea water the smolt grows into salmon, where they spend the majority of their lives. Only in breeding season the salmon migrates back to freshwater.

The production process of salmon follows the same pattern. The roe is kept in fresh water hatcheries (Marine Harvest, 2016). When hatched the salmon juvenile is transported to freshwater tanks. After 10-16 months in the freshwater tanks, the smolt has grown to a size of 60-140 grams and is ready for transportation by LFCs to the cages at the grow-out centers. At the centers the salmon is fed in saltwater for 14-22 months, to a size of 4-6 kilos. Then the salmon is transported, by LFCs, to processing plants on shore.

The aquaculture industry has defined the Norwegian coastline. At the end of august 2016, 3616 cages distributed on 598 grow-out centers held 395 million salmon (Fiskeridirektoratet, 2016). The fjords in Norway provides perfect conditions for the production of Atlantic salmon.

Production of Atlantic salmon is restricted geographically to coast areas where the biological conditions for breeding is present. The natural habitat of the Atlantic Salmon is in the Atlantic Sea. Regions with a sea temperature between of zero to 20 degrees Celsius, with an optimal temperature of 8-14 degrees Celsius (Marine Harvest, 2016). Temperatures and other factors such as the level of oxygen and throughput of water are restricting the present major production of salmon to facilities in the Atlantic Ocean, The Pacific and the Tasmania, with the present production technologies.

Map 1*: Geographical distribution of Salmon Production (Marine Harvest, 2016)*

2.1.2 The grow-out phase

Depending on when the salmon are released into cages at the grow-out centers in the different geographical locations, several factors determine the growth of the salmon, and consequently the time when it is ready for transportation to the processing facilities (Bravo, et al., 2013). Such factors are hours of light during the day, the number of salmon in the cage, feeding, seasonal trends, sea temperatures and weather conditions, as well as downstream market demand.

Environmental regulations are necessary to keep a healthy development in salmon production. This restricts the total allowance of cages and locations throughout the coastline. Even though the number of locations and cages are steady over time, the number of salmon in the cages are rising. This is due to more effective production and larger nets. Throughout the grow out phase the salmon is exposed to risks in regards to diseases and lice.

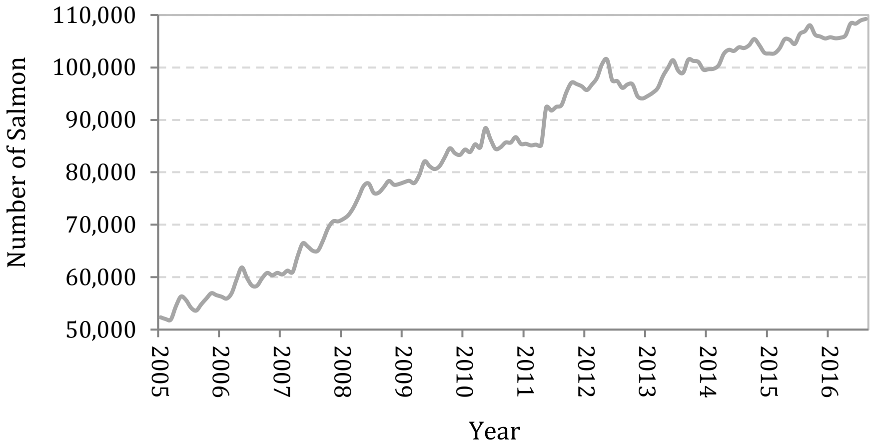


Chart 2: *Total livestock divided on total number of cages (Fiskeridirektoratet, 2016)*

2.1.3 Diseases, lice, stress and mortality

There are several types of diseases occurring in Norwegian coast line. The most severe diseases are Pancreas Disease (PD) and Infectious Salmon Anaemia (ISA). PD is a severe virus-disease which can give salmon producers enormous economic losses due to low growth and reduced quality of their biomass (Norwegian Veterinary Institute (a), 2016). ISA is a serious, contagious viral disease (Norwegian Veterinary Institute (b), 2016). If there is suspicion of ISA a severe investigation is set in motion. Positive findings of PD at a location can consequently result in a complete harvest of the specific location. Since 1993 there has been on average registered 10 ISA outbreaks annually while there has been on average 20 PD outbreaks annually.

Sea Lice (*Lepeophtheirus Salmonis)* is a natural parasite on salmon in saltwater in the northern hemisphere. The lice are eating skin, mucus and blood of the salmon and can create large wounds and harm the quality of the salmon.

The density of hosts influences the danger of infection of sea lice. It is shown that the greatest incidences of lice is in regions with high density of salmon (Norwegian Veterinary Institute (c), 2016). More hosts imply greater infection pressure not only for the farmed salmon, but also the wild salmon stocks. The development of lice is dependent of temperature, and high sea temperatures makes the proliferation escalate.

The Norwegian Food Safety Authority have set a maximum limit for sea lice in salmon farms (Norwegian Veterinary Institute (c), 2016).The law states that there must always be not more than 0.5 adult female lice on average per salmon in the facility, with some regional differentiations. Farmers are responsible for ensuring that the number of sea lice is not over the limit. If they fail to control the population, the salmon producer is forced to complete harvest of that location. Numbers of female lice on salmon is counted by picking 20 random salmon from a cage, and manually counting the number of lice on the salmon (Forskrift om lakselusbekjempelse, 2012).

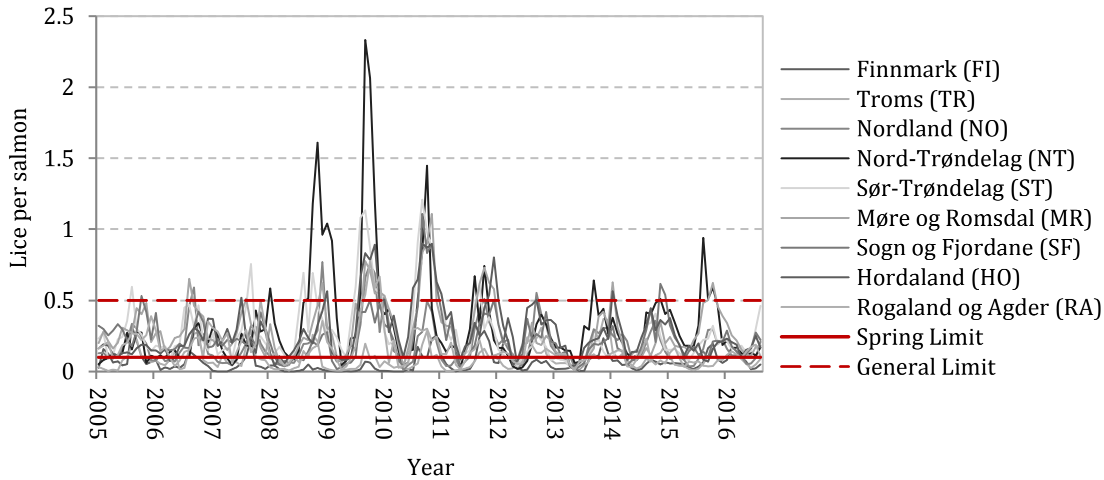


Chart 3*: Lice observations (grown females) and limits (Lusedata, 2016)*

2.1.4 Development and drivers

Farming Atlantic salmon was pioneered in Norway in the late 1970´s, in the shadow of the Norwegian Oil Industry. Aquaculture has grown to be one of the most important industries in Norway. After the oil price drop in 2014-2015 more attention has been drawn towards the aquaculture industry both in the media and by academia.

In the present state of salmon production, we are moving towards a roof of production under the current political, technological and environmental restrictions. In recent years’ large investments have been made in research and development (R&D) of new technologies. The goal has been to reduce the footprint of the production which in the long run can scale up the production to new levels. This includes on- and offshore grow-out centers and different closed sea cages. In the short run, this will not have a significant impact on the salmon production. In the long run, however, more R&D, investments and political will can facilitate a significant change in the production of salmon.

2.2 Salmon Production Market

In Norway, ten independent companies control 70% of the harvested volume. Consequently, these companies have strong positions in the market. Marine Harvest, as the market leader in both the Norwegian and the UK market, is the most dominant market force with approximately twice the harvesting volumes compared to their largest competitor in the respective markets in 2015.

Norway	Harvested tonnes
Marine Harvest	254 800
Salmar	136 400
Lerøy Seafood	135 000
Mitsubishi (Cermaq)	58 000
Nordlaks	39 000
Nova Sea	37 400
Midt-Norsk / Bjørøya	32 000
Grieg Seafood	31 700
Norway Royal Salmon	27 900
Alsaker Fjordbruk	27 000
Top 10 harvest	779 200
Total Harvest	1 110 800
% of Total	70 %

UK	Harvested tonnes
Marine Harvest	50 100
Scottish Seafarms	27 000
The Scottish Salmon Co.	25 600
Cooke Aquaculture	19 000
Greig Seafood	16 400
Top 5 harvest	138 100
Total Harvest	149 700
% of Total	92 %

Table 1: *Top producers of salmon. (Marine Harvest, 2016)*

2.3 Pricing of salmon

Several factors determine the price development of salmon. The short-term driver is the expected production volumes, which determines the expected supply (Øglend, 2010). This supply is affected by a set of variables such as diseases, logistics and political matters. On the demand side, consumption patterns concerning annual seasonality and longer consumption trends are important.

The market for salmon has expanded globally, and national trade makes the price sensitive to global market trends, such as currency swings and transportation costs.

From the early days of production, when the pioneers of aquaculture produced small volumes of salmon, the salmon have followed a price development pattern from an exclusive good to a more normalized good in the Norwegian market. The industry has been subject to economies of scale, technological development and market expansions. From the total harvest approximately 95% is exported to mainly EU, North-America, Japan, Asia and Russia (Marine Harvest, 2016).

The Norwegian salmon industry has over the period invested heavily in a collective marketing strategy, both in domestic and foreign markets (Norwegian Ministry of Fisheries and Costal Affairs, 2008). Salmon partly due to this still priced as an exclusive good in most foreign markets.

Chart 4: *Salmon price NOK, Free Carrier (Fishpool, 2016)*

The development of the salmon price[1] in the period 2014 to 2016 the price is significantly higher than at the end of the period. In week two of 2016, the salmon was traded at 65 NOK, which indicates that a 4.5 kilos salmon was worth 292 NOK. The same week one barrel of Brent Crude was traded at 276 NOK. The Oil Crisis and an algal bloom in Chile resulted in relatively low export prices and a supply shortage in the salmon market. Chile accounts for approximately one-third of the salmon production (Marine Harvest, 2016). This particular case was extraordinary. However, such deterministic occurrences will impact the price of salmon and effectively the marginal return for the salmon producers, as well as other operators in the value chain.

[1] Weekly averaged, of sizes between three to six kilos of superior quality head-on gutted

2.4 Cost structure

The costs of salmon production are commonly stated as the cost of producing one kilo of salmon. These costs are divided into different categories and are at the moment adding up to the sum of 28.55 NOK/kilo on a national average (Marine Harvest, 2016). This includes *feed*, *processing*, *smolt*, *salary*, *maintenance*, *well boat* (LFC), *sales and marketing*, *mortality* and *other costs*. In 2011 the costs of producing the one kilo of salmon, measured on the same variables accumulated to 24.09 NOK, adjusted for inflation. The change in total cost for one kilo of salmon have in other words changed with 19 % over four years.

Cost	2011*	2015	Change
Feed	11.96	13.34	12 %
Processing	2.45	2.67	9 %
Smolt	2.21	2.67	21 %
Salary	1.39	1.67	20 %
Maintennance	0.74	0.94	26 %
Well Boat (LFC)	0.98	0.95	-3 %
Depreciation	0.66	0.78	18 %
Sales and Marketing	0.47	0.62	32 %
Mortality	0.50	0.44	-12 %
Other	2.72	4.47	64 %
Total	**24.09**	**28.55**	**19 %**

Table 2: *Cost development of Production (in 2015 NOK) (Marine Harvest, 2012,2016)*

Overlooking the cost development from 2011 to 2015, "other" costs has increased by 64% over the period. This cost includes "*direct and indirect costs, administration, insurance, biological costs (excluding mortality), etc*.". The only accounts that have not had an increase over the period is mortality and Well Boat (LFC). The loss of biomass has had a negative trend during the period which sends a positive signal. The reduction in the LFC-costs per kilo, indicates that the relative use of LFCs have been stable in over the four-year period.

One would assume that the increased volumes would result in the economics of scale on a business level, hence reduce the unit costs. Talking to industry participants, the reasoning behind the cost development is related to the problems regarding lice. This perception is brought forward by media and forums, which are distressing the topic. However, one has to acknowledge that the cost development is distributed throughout the cost drivers in the industry and that the cost development is driven not only by the lice problems.

3. The Live Fish Carrier

A Live Fish Carrier, or a Well Boat, is a purpose built vessel for transportation and processing of live fish. These operations are essential for the production of salmon. The vessels can intervene with the production chain at five stages,

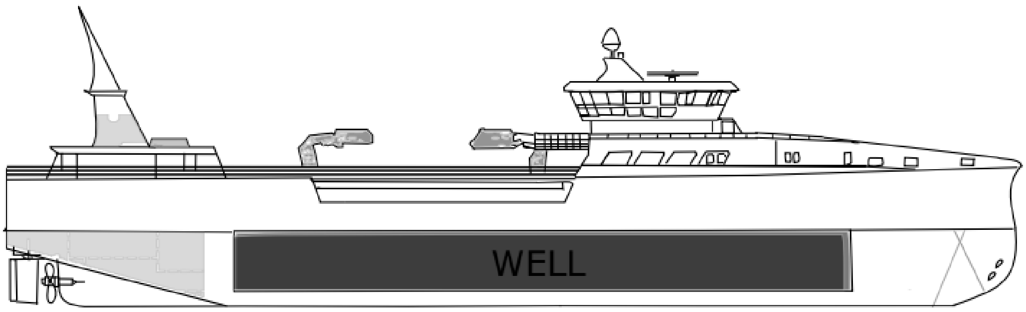
i) Smolt transportation*, smolt hatcheries to grow-out center,*

ii) Harvest transportation*, grow-out center to processing facility,*

iii) Delicing processes*, on site at grow-out centers,*

iv) Size sorting of salmon*, on site at grow-out centers,*

v) Handling of diseases*, on site at grow-out centers.*



Picture 1: *Drawing of a modern LFC (Rosbach, 2015)*

3.1 The function

The LFCs differ in size, age and onboard equipment. What the vessels have in common is a cargo room, which is designed for circulation of salt seawater. This allows the vessels to contain the salmon alive for transport while the salmon swims inside the well. The well can be designed with an open or a closed system. The open system allows circulation of water from the sea into the well. In a closed system the water is captured, recycled and supplemented with oxygen. Newer vessels typically has a closed system with the option to operate with open system, which minimizes risk during transportation (Forskrift om transport av akvakulturdyr, 2008). The risk is related to the welfare of the salmon in the well and the potential of transporting diseases from one region or facility to the next.

In addition to the physical transportation of live salmon, the vessels have gained a central role in the treatment of diseases and parasites. The salmon is treated inside the vessels, and such additional services constitute a significant proportion of the vessels operations. There are different ways of treating the salmon for diseases and parasites. Filters, brushes, freshwater, hydrogen peroxide ($H2O2$) and other techniques are used. Increased demands for new and specialized on-board equipment for effective treatment is becoming a large cost for the LFC owner. The charterers, salmon producers, are demanding more advanced technology as a prerequisite for chartering the vessels.

3.2 Physical transportation and risks

The loading of the salmon is executed by pumping the salmon into the LFC with onboard installed pumps and pipes. This operation is not risk-free (Epsmark, 2015). The salmon is hurdled in the cage to stimulate a more efficient pumping process. If the salmon is too dense, this will increase the stress and decrease the amount of oxygen in the seawater. This can potentially cause loss of biomass. The physical pumping process is also related to collective stress and physical harm, which can result in loss of biomass or quality.

Loading the salmon into the well, the crew have access to live video from the well (Forskrift om transport av akvakulturdyr, 2008). There are a range of different tracking devices, which ensures the welfare of the salmon. If the salmon is treated in the LFC, the risk of death is always present while conducting the treatment. Further, the salmon will be exposed to damage as a consequence of the design of the wells. Weather conditions impose another risk factor that the vessel is exposed to under operation. It is highly important that the wells are cleaned and disinfected, after operations. The disinfection process is today highly modern and automated, and controlled from the bridge (Solvtrans, 2016).

The period the salmon is on board depends on what kind of assignment the LFC is executing. On a transport assignment, this will solely depend on the distance and speed the salmon is transported. Additional services such as delicing will take around two to four hours per load. When unloading the salmon is headed to one side of the well using a sliding bulkhead inside the well, pushing the salmon and water out. The danger and risk related to loading is also present during this process.

3.3 Contracts in the LFC industry

There are three types of contracts in the market for LFC operations, Time Charter (TC), Volume Charter (VC) and Spot. The market for freight and operations of salmon is relatively new, and not regulated. The business of ingoing contracts is consequently to a large extent based on acquaintances and relations.

The most common contract form, is to charter a vessel for a specific period of time referred to as a TC. This contract form gives the charterer operational control of the vessel carrying his cargo, while leaving the ownership and management of the vessel in the hands of the shipowner (Stopford, 2009). The length of the charter may be the time to complete a voyage or periods of months and years.

In the LFC industry, it is common to agree on a charter period of four to seven years. During the time period of the contract, the shipowner is accountable for the operating expenses of the vessel, crew, maintenance and repairs. The charter directs the commercial operations of the vessel and accounts for the variable expenses related to the operations, which includes bunkers, port charges and cargo handling costs. The cargo handling costs refers to the variable costs of delicing and processing operations.

For the shipowners, a TC reduces the financial risk. The TC provides a clear basis for preparing the budget for the individual vessel for the time period of the contract. For the charterers, the salmon producers, the TC reduces their operational risk, when they are assured LFC capacity throughout the period.

VC contracts provides the salmon producer with an option to execute transport or processing of a total volume in a specified time period. The fact that the contract contains both a time element and a volume element, will restrict the charterer more during the contract period than a TC (Gorton, 2010). The time period is relative to the volume of transported and processed, and would consequently need a higher degree of operational planning for the charter. The VC gives a steady cash flow for the shipowner in the time period of the contract. However, the time period is generally lower than for a TC.

The third contract market is the Spot market. Clarksons defines the spot market as the “short term contracts for voyage, trip or short term charters, normally no longer than three months in duration” (Clarksons, 2016). In the LFC market, there is not a regulated spot market. A spot contract covers a short period of time, which gives the shipowner more risk related to the cash flow and the salmon producer more flexibility.

	Time Charter	Volume Charter	Spot
Time	Long	Medium	Short
Revenue	Steady	Steady	Variable
Risk	Low	Medium	High

Table 3*: Overview of Charter Contracts*

Time Charters are today the dominant choice of contract in the LFC industry in Norway. On average, 79.6% of the fleet are in TC contracts in the present state of the market. The shipowners consequently face less uncertainty when the average TC in the LFC market today is 4.2 years. These findings are obtained through interviews with market participants. Due to the sample size these are not accurate numbers, but indications.

3.4 LFC market

A qualitative framework for analyzing the LFC market is Porter’s Five Forces model. Porter's five forces is a framework developed by Michael Porter to analyze the profitability and attractiveness of an industry (Porter, 2008). The industry will through the five forces be assessed based on the level of internal rivalry among competitors, entry barriers to the industry, threats from substitutes in the market, customers bargaining power and suppliers negotiating power.

A large degree of competitive pressure in the factors determining the model indicates difficulties in obtaining profits in the market (Johnson, et al., 2005). The advantage of Porter's framework is its simplicity and transparency. Furthermore, it is effective to expand the understanding of the competitive forces in the market. The weakness of the framework is that it is static. It presupposes a stable environment and changes in market conditions will alter the structure of the industry accordingly.

3.4.1 Threat of new entry

Barriers to entry are, according to Johnson, Whittington & Scholes (2011), obstacles that future competitors must overcome to establish themselves in the industry. High barriers will thus be suitable for existing industry players. There are several types of barriers depending on the kind of industry they operate in (Johnson, et al., 2005).

The LFC industry is a capital intensive industry, similar to the general shipping industry. A new and advanced LFC costs approximately 300 MNOK in the current market (Skår Hosteland, 2016). A new entry is capital intensive, and investments would consequently need security in terms of a capital and a TC contract at the end of the building period. The agreements between a shipowner and a salmon producer typically cover a relatively long time period of four to seven years. Throughout the value chain personal connections between operators are present, which creates another barrier for entrants.

3.4.2 Bargaining power

Factors affecting customers bargaining power concerns if the industry has a concentrated or spread customer base, low transaction costs, or whether there may be a situation where the customer can cover the product needs themselves (Johnson, et al., 2005).

In recent years there has been a movement towards fewer and larger salmon producers. In 2015 there were 22 salmon farming companies in Norway, where the top 10 companies controlled 70 % of the total harvest volume (Marine Harvest, 2016). Of the smaller firms many have come together in collaborations, where umbrella organizations are established. The organization controls the delivery of the LFC services to the production facilities of the included parts. In this way, smaller salmon producers increase their barging power when negotiating the term structure of contracts with LFC owners.

3.4.3 Threat of substitution

Substitutes are products or services that have the same or similar function, but meets customer needs in a different way (Porter, 2008). LFCs provide safe marine transportation of salmon. Historically tank trucks have been used as a mean of transportation. However, the logistics and volume of the trucks make this alternative not cost efficient in regards to the LFCs. The latest years there has been introduced new technology regarding additional service to the salmon producer. The frequent occurrences of lice have led to several inventions which cope with the delicing in alternative ways. Since a significant portion of the LFC operation consists of lice treatment, the new technology makes the salmon producers less dependent of LFC vessels.

3.4.4 Supplier power

Suppliers source companies with the input the respective company needs to produce their product or service. Supplier bargaining power depends on the number of suppliers in the market, whether there are high costs associated with switching supplier or whether the company can obtain the resource itself (Johnson, et al., 2005).

The supplier power in the LFC industry is low since there are several shipbuilding companies in Norway and in foreign countries. The shipyards have high competence and deliver state of the art vessels. Since several shipyards are providing the same product, the barging power is assigned the ship owners. There are differences in the ship design and technical solutions, but these factors are chosen by the preferences by the shipowner.

The need for chemicals is always present in LFC operations when the vessels are required to disinfect after operations. In Norway, there are several providers of chemicals which make the barging power strong for shipowners.

3.4.5 Competitors

Competing rivals in an industry are organizations with similar products or services aimed at the same customer group. How big the internal rivalry in the industry depends on the size of companies that compete, the growth rate in the industry, as well as degree of differentiation of products (Johnson, et al., 2005).

The LFC industry has similarities to an oligopoly. Six large companies controls 85% of the total available capacity in the market; Sølvtrans, Bømlo, Rostein, Norsk Fisketransport, Seistar Holdning and Frøy Aquaservice. There are several smaller holding companies that own one or two vessels. Throughout the short history of the LFC industry, there has been some minor mergers and acquisitions. In December 2015 Sølvtrans acquired five vessels from Bømlo Brønnbåtservice and became the largest company in the LFC industry in regards to capacity, measured in cubic meters of volume (M3).

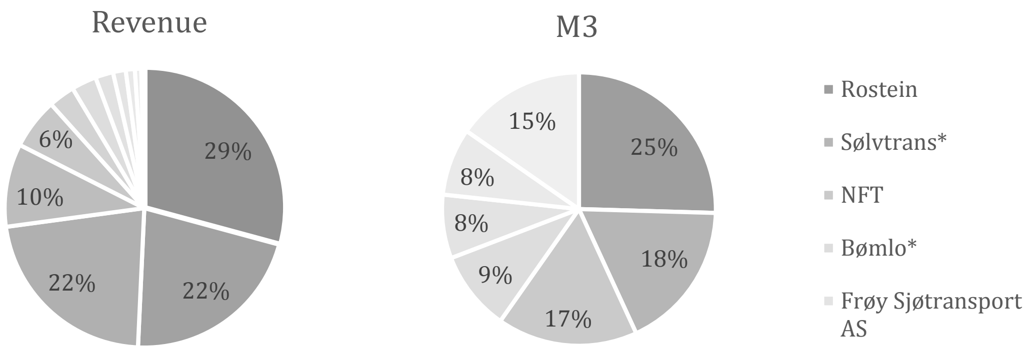


Chart 5: *Capacity (M3) and Revenue distribution (Brønnbåteiernes Forbund, 2016)*

It occurs that the largest owner of capacity also has the largest share of revenues. However, the utilization of the M3 cannot singlehandedly be described through this comparison.

3.5 Financial

Key multiples from the market leaders in the LFC industry are useful indicators of the financial health of the segment, and the development of the profitability of the shipowners.

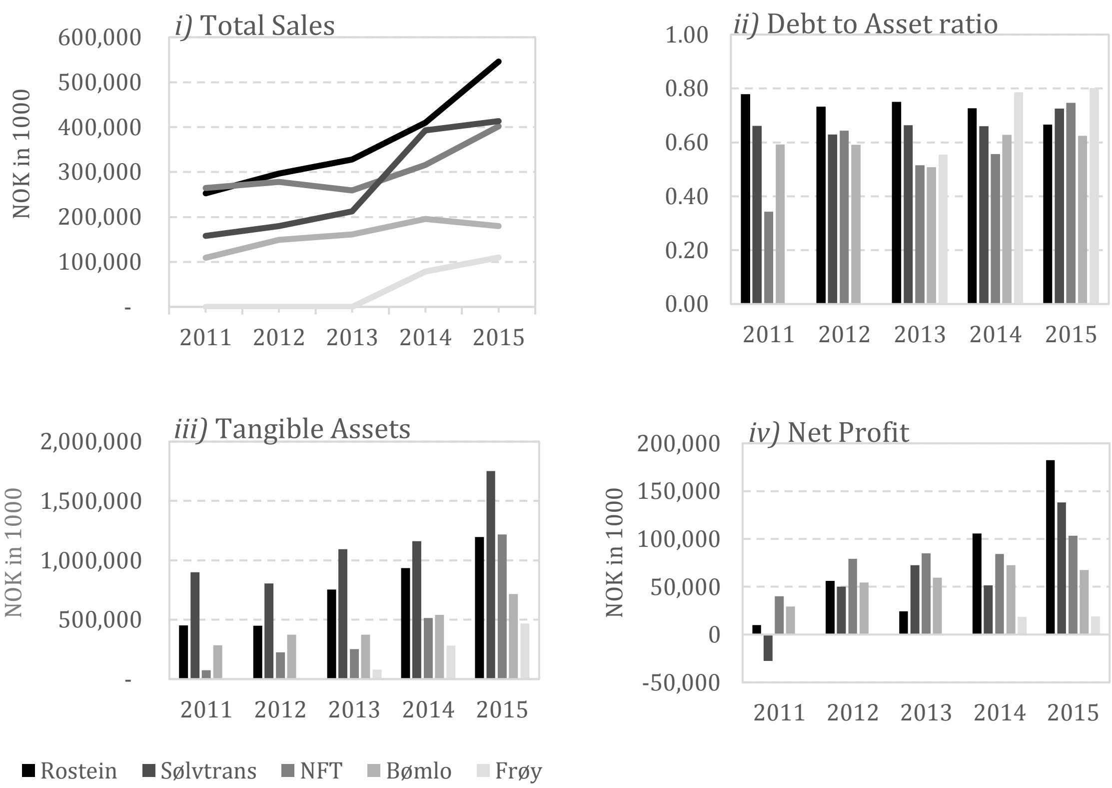


Chart 6: *Financial Key Multiples Development (Proff.no, 2016)*

The top five LFC participants have over the last years experienced high margins on their operations, which has contributed to a very good financial results. These margins and results are naturally making the market attractive for entrants. Some salmon producers are considering to operate their own vessels and the market leader, Marine Harvest, have already ordered two LFCs.

The development of total sales (i), shows an increase in the sales for all the five major companies. This includes profits and losses from asset sales and other revenues. On an average, the four majors, excluding Frøy, over the period from 2011 to 2015 have experienced a growth in sales of 99%. All of the majors in the industry are operating with a high share of debt. The debt to asset ratio (ii) illustrates the development, and indicate that the five largest companies in the LFC industry are financed with a range of 62-80% of debt. However, this is not unusual for ship owning companies (Drobetz, et al., 2013).

Tangible assets in the companies include buildings, machinery, equipment, vessels, operating movable property, furniture, tools and more. From the development of tangible assets (iii) of the five majors, it is noticeable that the development of Sølvtrans is worth 1.75 billion NOK in 2015 and their total sales are 413 million NOK. The sales are 120 million NOK less than the sales of Rostein which have tangible assets worth 1.2 billion NOK.

Profit after tax (iv) in 2015 shows a that Rostein AS, Sølvtrans AS, Norsk Fisketransport AS and Bømlo Brønnbåtservice AS stands out. In late December 2015, Sølvtrans AS bought Bømlo Brønnbåtservice AS which made Sølvtrans the largest company terms of number of vessels and profit after tax. These four companies had in 2015 a profit margin between 42.18% and 52.48% which is extraordinarily high.

A common multiple to analyze and compare the salmon producers is EBIT/kg which adjusts their income to the kilos produced. In a similar way, one could estimate of how profitable the LFC companies are by dividing the EBIT on M3 which gives the income adjusted to the size of the company’s fleet. This multiple will be reasonable for comparison among the major participants in the LFC-industry when they all own several vessels.

The interpretation of this multiple, in regards to the findings in Chart 5, shows that Sølvtrans is utilizing its capacity in terms of financial return better than its peers. There are differences in regards to the management of the respective company’s M3 capacity. The differences in size, equipment and the term structure of the contracts will effectively give different returns on the capacity.

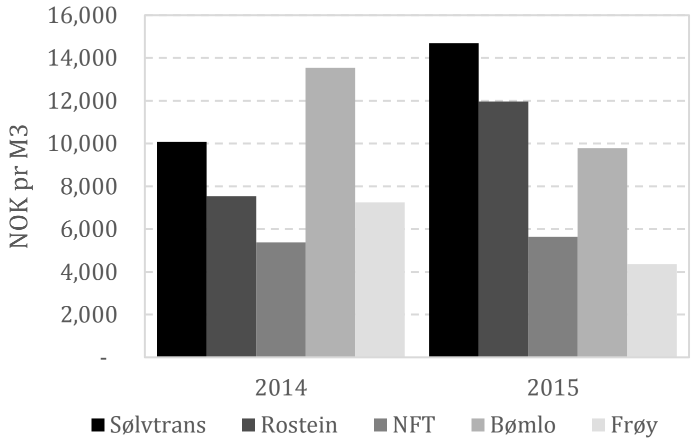


Chart 7: *EBIT/M3 in 2014 and 2015*

The chart indicates large differences between the companies. A surprising difference of 238 % between Sølvtrans and Frøy in 2015 suggest that the utilization of capacity is managed differently. This paper will not investigate differences between companies, but this aspect should be analyzed by academia in further research.

4. Research Design

This chapter will explain the choice of research design and methods of approaching the research question. To determine if there is a mismatch between capacity, utilization and investments in the LFC industry we will need an innovative approach as the subject is not researched by the academia and there are lack of extensive data from the shipowners. The research design is an overall plan for how one would go about addressing the research question (Ghauri & Gronhaug, 2010). Research design includes an overview of the goals one has and the methods he will use to collect, interpret and analyze data.

To weigh the quality of the data and the different aspects of the analysis, we have to evaluate the gathering of data and consequently the analysis (Sounders, et al., 2012). To acknowledge the strengths and weaknesses of the data we reduce the chance of misinterpreting the output in the joint conclusion, the *validity* and *reliability* is weighted.

The validity refers to the relevance and strength of the study in regards to the topic which it is intended to investigate (Ghauri & Gronhaug, 2010). Internal validity is to what extent the causal conclusion can describe the actual specific situation. The external validity is to what extent the results can be generalized and applied in other situations.

Reliability is the stability in the observations, moreover if the observations would give the same results if the analysis where done multiple times (Ghauri & Gronhaug, 2010). The intention is to minimize the risk of biases in the measurements.

4.1 Data collection

To conduct the case, have we gathered data from a variety of sources. Primary data was obtained from positional tracking, personal communication, a survey and interviews. Secondary data has been collected from the public sources; Directory of Fisheries, Brønnøysund Register, Seafood Norway, The LFC owners' association and news articles.

4.1.1 Preparations

In August, we joined the Nor-Fishing 2016 exhibition to get an insight in the industry. By talking to LFC industry participants, we got a good understanding of the market dynamics. We also had central positions on the board of Bergen Shipping Conference 2016, which was held at the Norwegian School of Economics in September. At the conference, we got the opportunity to discuss the topic with profiled shipping leaders and analytics. Through this work we came in contact with a location intelligence service provider[2] located in Spain, which contributed with a free license to their analyzing platform.

4.1.2 Primary data

When collecting primary data, we conducted interviews and surveys with the players in the industry. As the market is non-transparent, we made a precaution that all our data collected was to be made averages of. The companies should not be referred to as a source of information, if not it already was public information. That is why we always operate with averages and not reference any information back to the source.

When conducting the survey, we asked ten salmon producers and four shipowners our questions. The questions are found in *Appendix 1*. The reason why so few observations, is the lack of contact information, especially regarding the shipowners. The survey has not been attached much importance to since the low degree of reliability, but it was interesting to see who the correspondents were similar in their marked outlook.

Anteo AS collected primary AIS data from a number of LFC vessels, with the purpose of our thesis. Some vessels were extracted from the data because of lack of relevance or inconsistency of data. This made it possible for us to be the first academicals research group that analyzed the movements of the LFC fleet.

The main advantage of obtaining such primary data is that it is collected in terms of the specific case study (Ghauri & Gronhaug, 2010). The updated information has not yet been published and helps to strengthen any findings since the high degree of validity.

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[2] CARTO.com

4.1.3 Secondary data

Ghauri & Grønhaug describes secondary data as data previously collected information from others (Ghauri & Gronhaug, 2010). The authors show that the available information could have been collected for a different purpose and that the first step should be to assess the relevance of such information to the report's focus.

“Brønnbåteiernes forening” provided us with the latest fleet overview with additional data of fleet and ship specifications. From The Directory of Fisheries, got access to a public dataset of the number of outgoing and ingoing salmon in nine geographical regions and number of active cages and locations in these regions. This data has a time horizon starting January 2005, with monthly intervals. From Lusedata.no published by Seafood Norway, based on reports from Norwegian Food Safety reports, we have gathered data on the occurrences of treatment processes done in each of the regions in the respective time periods. The data represents to a total of 140 time periods and 9 regions.

The data from Brønnbåteiernes Forening and The Directory of Fisheries are assumed to have a high degree of validity and reliability. The data on the occurrences of treatment processes is not reliable before 2012. In 2012 there was a change in the Aquaculture laws, where the reporting system changed (Forskrift om lakselusbekjempelse, 2012). *Total Treatments* are computed by the number of reports with treatments over the total number of reports. When the frequency of the reporting is equal across grow-out centers, and the reporting is mandatory, the computation will effectively be adequate to say something about the treatments of an average center in a region. However, before 2012 this is not the case and the reporting was not done with the same frequency. Therefore, we put more weight on the latter years of observations but keep the pre-2012 numbers in our analysis.

5. Theory

5.1 Shipping Cycle Theory

There are three different types of shipping cycles, which can occur simultaneously. Long cycles, short cycles, and seasonal cycles. Technical, regional and economic change is the driver for the long-term cycles. Short cycles have the same characteristics as the long cycles, except from the time horizon. Seasonal cycles are often occurring in shipping. These are driven by seasonal patterns of demand for sea transport (Stopford, 2009).

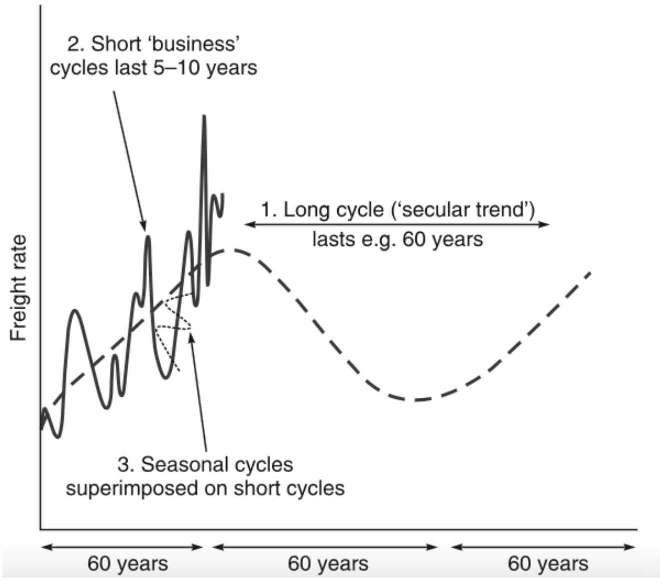


Figure 1*: Shipping Cycles (Stopford, 2009)*

Shipping cycles follow classic crisis theory, which was developed by Hyman Minsky and Charles Kindleberger. In every cycle there are four stages: Trough, Recovery, Peak/Plateau and Collapse (Stopford, 2009).

• *Stage 1* is called a Trough. In a trough there are clear signs of surplus of capacity where the vessels are slow-steaming to save fuel. The freight rates fall to OPEX of the least efficient ships, which increase the lay-up rate. Because of the low freight rates and the tight credit from lenders, the shipowners get negative cash flow and the financial pressure builds up.

• *Stage 2* is called a recovery. As the supply and demand move toward balance, the freight rates rise above OPEX and the laid up tonnage falls. The confident in the market is still uncertain, but growing. As the liquidity improves, the second hand prices increases.

• *Stage 3* is called peak or plateau. In this part of a cycle, there is under capacity in the market, where the vessels are fully employed. Only untradeable ships are laid up and the operating fleet operates at full speed. Freight rates rise, often multiplied as much as 2-4 times. The time horizon of a peak is uncertain, it may last a few weeks or several years. High freight rates also give incentives to shipowner to capture more deadweight so they can utilize the high prices. A lot of newbuilds are set in motion, and in rare cases the second hand prices exceed the newbuilding prices. Lending is easy accessed and the investors are happy.

• *Stage 4* is called collapse. As the supply overtakes demand the market moved into the collapse phase and the freight rates fall. The reason why supply overtakes demand can be many, but usually it is the new deadweight entering the market which results in an overinvestment and overcapacity in the market. The liquidity is still high and there is few ship for sale since the owners are unwilling to sell their ship at a discount.

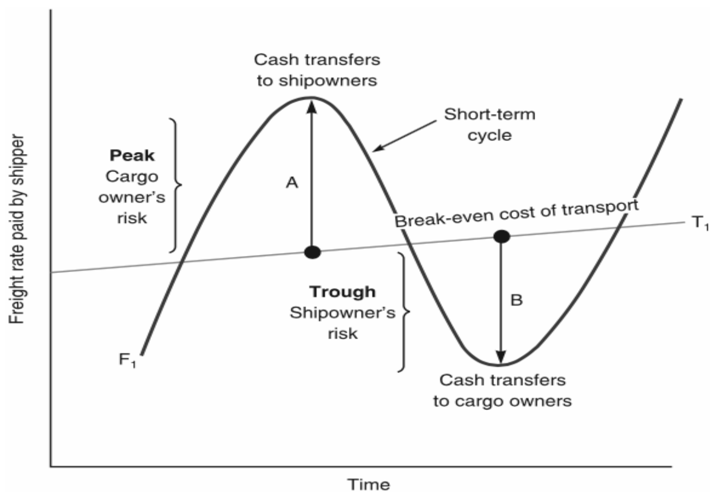


Figure 2: *The four stages of a cycle (Stopford, 2009)*

5.2 Automatic Indentification System

Automatic Identification System (AIS) was initially intended to prevent collisions and assist port authorities to control sea traffic. December 2004, the International Maritime Organization (IMO) required all vessels with more than 299 gross tonnages to carry an AIS transponder on board. The transmitter communicates the speed, position, course and other factors such as the vessels identification number (MMSI) dimensions and other voyage details.

The AIS-transponder includes a GPS receiver and a VHF transmitter, which respectively collects the position and transmits the information periodically through two VHF channels. This data is publically available to the public domain (Marine Traffic, 2016). There are mainly two types of AIS transponders which are used to collect the data. Both methods can be used combined to get maximum coverage (IMO, 2016). Terrestrial AIS (T-AIS) is received by an external antenna placed 15 meters above sea level and will receive signals with a radius of 15-20 nautical miles. Base stations at higher grounds may extend the range to 40-50 nautical miles. Satellite AIS (S-AIS) transceivers are transponding much further vertically than horizontally, with a reach of up to 400 kilometers.

Our AIS-dataset contains nine gigabytes of .csv which corresponds to 800 million cells of information. The dataset obtained for the fleet contains available AIS-tracking from 44 vessels in the Norwegian LFC fleet. Some of the vessels AIS-tracking are only partial, which can be a consequence of their time of entry into the market or other technical faults. The operations in the Norwegian fjords, can be challenging if they are only transmitting T-AIS. To compensate for these errors, only 34 vessels have sufficient data in the set, diversified in size and age.

5.3 Return on Shipping Investments

The Return on shipping investment model shows how profitable an investment is, in each company within a shipping segment. The ROSI model can be split into four components where NAV is the net asset value of the fleet at the end of accounting period and EVA is the economic value added.

$$ROSI_t = \frac{EVA_t}{NAV_t} = \frac{EBID_t - DEP_t + CAPP_t}{NAV_t} * 100$$

To calculate the economic value added (EVA), we take the earnings before interest (EBID), subtract depreciation (DEP) to reflect the fact that during the year the company's ship age reducing their value, and add capital appreciation (CAPP) (Stopford, 2009). EBID is the cash flow earned trading on the spot market or TC market after deducting operating expenses. CAPP is the change in the company's asset value during the year.

5.4 Free cash flow & NPV

Free Cash Flow (FCF) represents the excess cash that a company have to disposal to invest with, after they have done their initial investments and costs. This implies that FCF is the incremental effect of a project on the firm's available cash is the project's free cash flow (Berk & DeMarzo, 2014). FCF is important because it allows a company to pursue opportunities that enhance shareholder value and increase the revenues. The following formula give the FCF of a project for a company:

$$Free\ cash\ flow = (revenues - costs) * (1 - \tau_c) - CapEx - \Delta NWC + \tau_c * Depreciation$$

The last term, $\tau_c * Depreciation$, is the depreciation tax shield. It is the tax savings that results from the ability to deduct depreciation. As a consequence, depreciation expenses have a positive impact on FCF. To have the ability to compare among alternatives, the Net Present Value (NPV) is useful. The NPV covert the cash flows into present values, and make the alternatives comparable. One should always choose the project with the highest NPV but also critically evaluate internal rate of return (IRR).

$$PV(FCF_t) = \frac{FCF_t}{(1+r)^t} = FCF_t * \frac{1}{(1+r)^t}$$

A disadvantage with the NPV approach is that the sensitivity to the discount rate. The longer time horizon on the project, the more sensitive the NPV gets in regards to the discount rate (Berk & DeMarzo, 2014). Risk related to the project will in reality fluctuate throughout the period, which is not accounted for in the model.

The selected cost of capital has large impact on the NPV analysis. The weighted cost of capital (WACC) is the effective after-tax cost of capital to a firm. The WACC is taken into account that a firm is financed by both equity and debt. Because interest expense is tax deductible, the WACC is less than the expected return of the firm’s assets.

$$r_{wacc} = \frac{E}{E+D} r_E + \frac{D}{E+D} r_D (1 + \tau_c)$$

When using WACC as the cost of capital, one assumes a constant cost of capital for all future cash flows, which indicates the same risk in all future. This is not the case in most industries and both the cost of capital and the capital structure is changing continuously.

6. Modelling Supply and Demand

Forecast of future supply and demand is necessary to aid planning and decision making in the LFC sector. However, the future is uncertain. From historical observations, we can get insight into the drivers for the market for Live Fish Carriers. This will contribute to the understanding of the present market situation and consequently add value to future predictions. The different variables determining the market is many and inter-correlated. The first step is to single out the factors of importance. This is not to suggest that detail should be ignored, but rather to accept that too much detail can blur an analysis.

Martin Stopford presents "The Shipping Market Supply and Demand Model" (Stopford, 2009). In this framework. He proposes a model which simplifies the complexity of the maritime economy. Adjustment of the model to match the LFC market Norway is done to get a simplified way of communicating the results of our findings. The model for the LFC market contains the following variables.

On the demand side, five variables determine the quantity. Underlying is the economic development, which is assumed to be exogenous. However, it is crucial to acknowledge the impact of the economic state of the export regions in regards to the Norwegian economy. Salmon production is affected by the economic development. Political and biological conditions regulate the production under the present economic state. The number of salmon transported and the distance which it is transported effectively gives the demand for the transportation. Random shocks, such as unexpected occurrences of lice and illness will have short-term impacts on the demand.

Four markets determine the supply side. New building, phasing out or scrapping and sales and purchase markets determine the volumes which are available in the freight market. The number of vessels, their loading capacity in M3 and utilization determines the supply side. To interpret the development of the supply and demand equilibrium over time, economic incentives, collaborative forces, and management decisions are crucial for the understanding.

The dynamics of the LFC market is described in Figure 3, *The LFC Market Model*, on the following page.

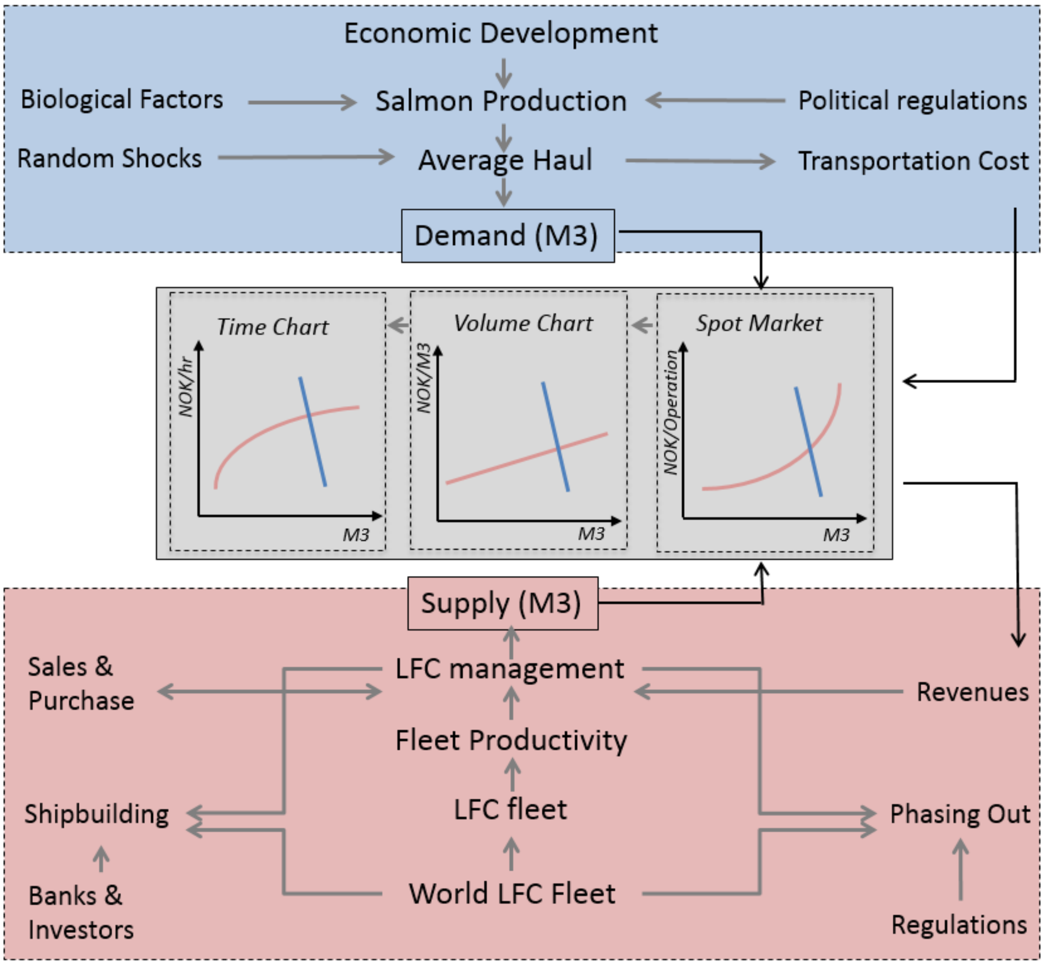


Figure 3: *The LFC Market Model*

In traditional shipping theory, the common measure of quantity in the freight market is tonnemile, which is the tonne capacity times the distance transported. In the model for LFCs, tonnes will be the equivalent of the M3, hence the volume. However, there is no data on the distances the vessels have sailed during the time period from 2005 to today.

To solve this, our data is categorized in time periods of one month. During one month we have obtained information, through interviews, on how many operations one LFC on average could perform in a month. Hence, the three markets for freight are in NOK/hour dependent on the size of the vessel (TC), the NOK per M3 and NOK/operation in regards to the volume.

One cubic meter, M3, can hold different volumes of biomass, in regards to the size of the salmon transported. Larger salmon demands more water in a M3, and smaller less. The density of salmon in a cubic meter dictates the biomass the M3 is able to contain.

6.1 Demand for LFCs

When analyzing the demand, we focus on three main drivers the salmon production: (1) Transportation of smolt to grow-out centers, (2) transportation of grown salmon from centers and (3) operations related to treatment of lice. Random shocks such as occurrences of deceases, are left out of the model due to lack of data.

The dataset of the number of outgoing and ingoing salmon in nine geographical regions, *r*, and number of active cages and locations in these regions. This data has a time horizon starting January 2005, with monthly intervals, *t*. The occurrences of female sea lice and sea lice treatment processes done in each of the regions in the respective time periods. The data represents a total of 140 time periods and nine regions.

The nine regions, r, are respectivly Finnmark (FI), Troms (TR), Nordland (NL), Nord-Trøndelag (NT), Sør-Trøndelag (ST) Møre og Romsdal (MR), Sogn og Fjordane (SF), Hordaland (HO) and Rogaland and Agder (RA).

6.1.1 Demand Drivers

Transportation of smolt to grow-out centers are determined by the number of salmon that are transported to the locations in each region in every time period. In the model the smolt are averaged to be 100 grams *(S)* (Fiskeridirektoratet, 2015). One M3 is able to carry different volumes of smolt in regards to the total size and the shape of the on board tanks at the respective LFC carrier. On average we assume the transporting capacity of one generalized M3 to be 50 kilos, which accounts for approximately 500 averaged sized smolt. However, we assume the capacity not to be maximized, and only 90% of the actual capacity is utilized on an average trip over the time period.

$$D_{r,t}^{smolt} = \frac{I_{rt} * S}{Cs * 0.9} \qquad (1)$$

From the output in Chart 8 we observe a highly recognizable trend in the demand for M3 transportation, from the output of smolt. Monthly averages of the M3 equivalent over a ten-year period, clearly states that the demand for these operations are peaking in May and September. Regionally the demand differs, which reflects the regional differences in production levels, but also the difference in the regional demand for transportation and consequently LFCs.

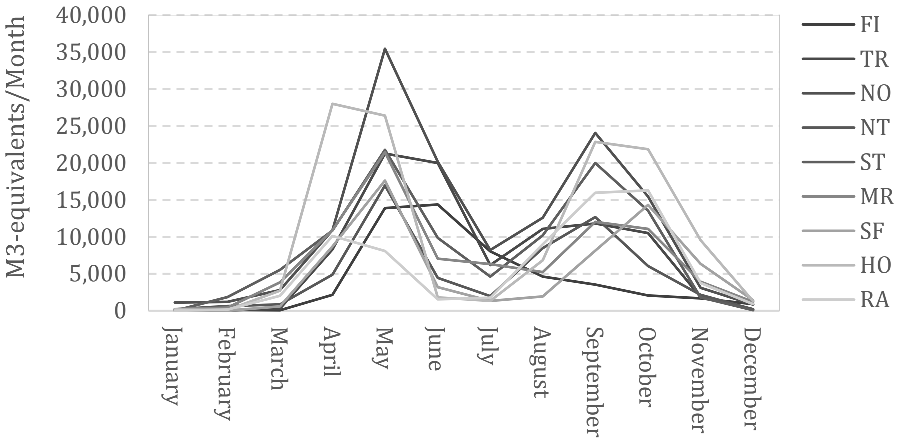


Chart 8: *Monthly averaged M3-equivalent Smolt demand*

Nordland and Hordaland are the two regions which over the time period have the highest average demand of transportation over the time period. There are also differences between seasons regarding to the demand. Biological restrictions determines for example that it is not profitable to move smolts to the growout centers in Finnamrk during fall, due to the temperatures.

The transportation of grown salmon to the processing facilities, is the main operation of a LFC. All the salmon that is transported to the growout centers, will consequently need to be transported from the centers. This is typicaly after 14-22 months, and when the salmon have grown to an average size of 4.5 kilos *(G)* (Marine Harvest, 2016). The size of the salmon determines the dencity of salmon in one M3. This is also subject to the total size of the tank and the shape of it. On average we assume one M3 to be able to carry 40 average sized salmon, which accumulates to a total of 180 kilos of salmon (*Cg*). The number of salmon from each region in every time period is expressed by O_{rt}.

$$D_{r,t}^{salmon} = \frac{O_{rt} * G}{Cg} \qquad (2)$$

The demand for M3 from the harvest of salmon from the growout centers is more evenly destributed over a year. However, averaged monthly over a ten year period there is a tendency towards more harvest in the last six months of the year. The transportation demand from the harvest of salmon is significantly different from region to region. The transportation demand from Nordland accounts for the demand from Nord-Trøndelag, Sogn og Fjordane and Finnmark combined, averaged monthly over the ten-year period.

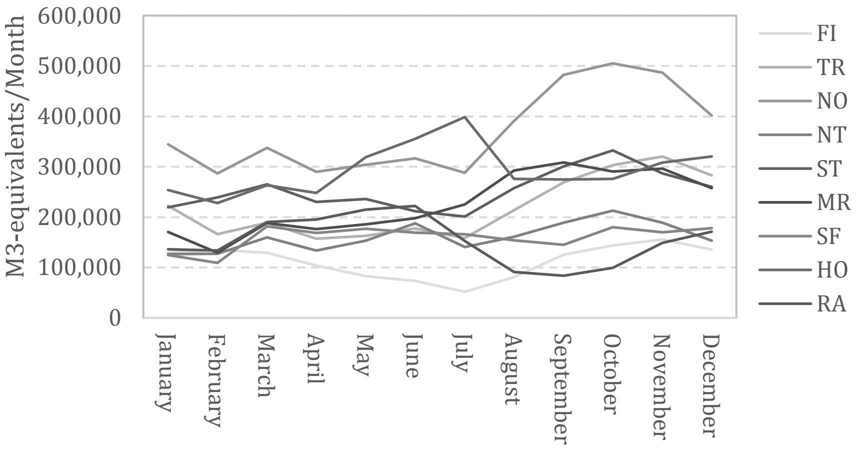


Chart 9: *Monthly averaged M3-equivalent Harvest demand*

The total M3 demand volumes from the Harvest are much larger than the volumes from the smolt transportation. Naturally the capacity in terms of number of salmon dictates this difference, when one M3 is able to hold 500 averaged sized smolt and 40 average sized grown salmon. There is also some loss of biomass during the grow out period, which is not affecting our model.

To account for the transport capacity related to delicing and processing of the salmon, carried out by the LFCs, we need to translate the volumes into M3-equivalents demand drivers. From the Norwegian Food Safety reports, the percentage of reports of lice where the location has undergone a treatment over the total number of reports in period t in region r (R_{rt}). With the average outgoing stock of ($S_{r,t}$), and the number of locations. This percentage number will effectively give insight on the treated salmon over time in the different regions.

To convert the number of treated salmon into an M3 equivalent, the salmon of is assumed to be 2.3 kilos at in an average location, and one M3 is able to hold 97 kilos. This amounts to a total of 42 salmon in a M3. The interpretation of the M3-equivalent in this demand driver is however slightly different, from the transportation drivers. When interpreting the demand in a month there is a lot of uncertainty. We do not know the actual time period of the treatment process within the month, or the type of processing preformed on the salmon. In addition, the treatment can happen in different forms. To account for the uncertainty, the constant *e* is added with the value of 0.8.

$$D_{r,t}^{treatment} = \left(\frac{S_{rt} * \ R_{rt} * A * e}{Ca} \right) \qquad (3)$$

The average of the demand from the treatment in every month over the same time period shows an observed peak during April. This is due to the spring cleaning, where farmers want to enter the summer months with low numbers of lice. The reduction of the lice in April will consequently give a less demand in the following month. However, when the sea temperatures rise delicing operations will increase.

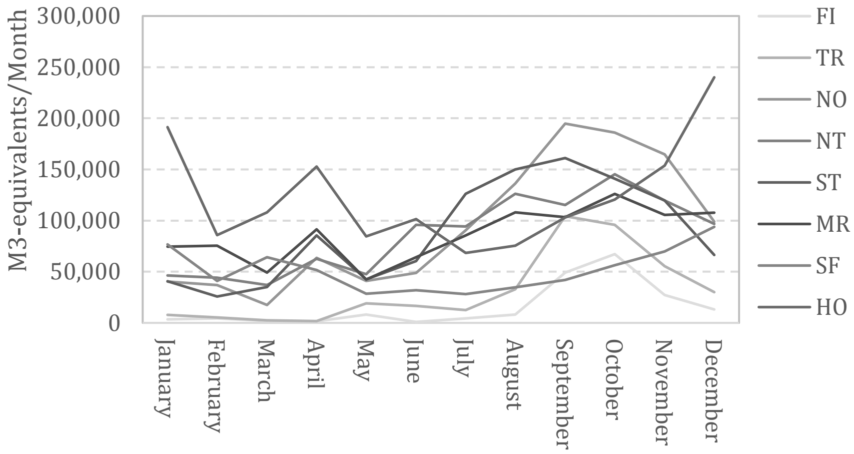


Chart 10*: Monthly averaged M3-equivalents lice treatment*

There is major year to year changes in the occurrences of lice which contributes to more uncertainty regarding the seasonal trends graphed in the above chart.

6.1.2 Total Demand

The total demand is the sum of the three demand drivers in M3-equivalents. This proxy indicates the development on the technical demand side of the market. There are observed regional differences in the seasonal trends, which also are observed over time. Summarizing the demands in every region, r, in each time period, t, across the three drivers, the sum will give insight on the demand side of the market as whole (4). This does not account for the regional differences, but the state and development on a national level.

$$D_t^{total} = \sum_{r \in R} (D_{r,t}^{smolt} + D_{r,t}^{salmon} + D_{r,t}^{treatment}) \qquad (4)$$

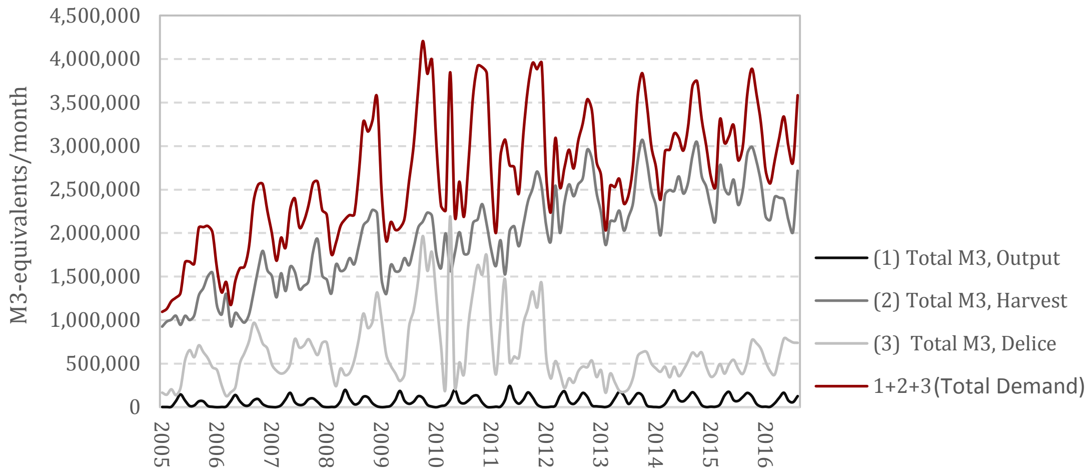


Chart 11: *Total demand over time in M3-equivalents per month*

We observe that about 10% of the demand is assigned the output of smolt, 70% is assigned harvesting of grown salmon and 20% is assigned the processes related to delicing. This is in line with the opinion from participants in the industry. However, this relation is varying within annual seasonality. The total demand for M3-equivalents have been relatively stable since the latest years.

Since 2012 the average monthly demand for M3-equivalents have been steady averaged annually at 3.000.000. However, the relation in the two underlying drivers have changed. The demand for transportation of smolt have been steady and low, with the seasonal swings. In the period from 2009 to 2012 delicing operations was significantly higher than the rest of the period, which is aligned with the observations from chart 3, *Lice Observations.* This contributes to the observed a steady demand for M3-equivalents from 2010 until today. However, the errors in the lice processing operations gives more uncertainty to the calculations before 2012.

6.1.3 Regional Differences

The demand is differing depending on the region, r, and time, t. The regional differences will consequently give insights on the regional LFC fleet distribution. In the different regions there are different underlying drivers for the demand, such as optimal time of harvest and output as well individual patterns in terms of lice occurrences. Furthermore, there are different number of locations and cages in the regions.

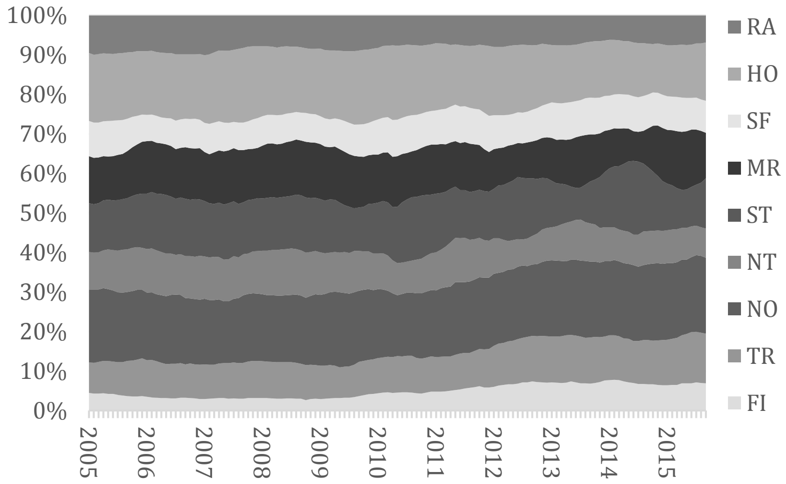


Chart 12: *Geographical distribution of Demand*

The chart shows the relative regional distribution of demand for LFC services over time, with a moving average. Nordland has had the largest proportion of demand throughout the time period. Troms is increasing their demand. The most volatile region in terms of M3-eqivalent demand, is Sør Trøndelag. There could be several reasons for this, but lice and diseases is part of the answer. The distribution changes over the period. More demand for M3-equivalents are coming from the northern regions relative to the others.

6.1.4 Random shocks

Occurrences of deceases is the main contributor to the random shocks observed on the demand for M3-equvalents. There are some observable trends in the occurrences of the random shocks. We choose not to convert this into M3-equivalents due to the relative size of the volume of transport. If ILA is found on the livestock the biomass is transported to a slaughter immediately. If there is an outbreak of PD, this is handled differently depending on the region of observation (Holm, 2007). South of Hustavika PD will result in slaughter transportation and north of Hustavika treatment processes sufficient to cope with the problem.

6.2 Supply of LFC capacity

To determine the supply of LFC vessels, ship production, scrapping or phasing out and productivity of LFC vessels is necessary to investigate. In this chapter this thesis investigates these factors under three different utilization scenarios of the current LFC-fleet.

6.2.1 Shipbuilding in Norway

The latest years there has been a severe change in the shipbuilding production in Norway. From being offshore supply manufacturers, the shipbuilding companies are now mainly producing other types of vessels. The change in production of LFCs is observed in the Norwegian shipbuilding cluster, from 4% in January 2015 to 16% in September 2016 (Kleven Verft, 2016). Sletta Verft, have historically built 10 LFCs but due to the increasing sizes of the newbuilds they had to stop their manufacturing of LFC when their equipment no longer could handle the size development of the fleet. Aas Mekanske Verksted have through many years build LFCs, and are still producing in a large scale. The technological development has affected the LFC industry in such matter that a 3000 – 3500 M3 vessel on 90 meter costs of aproximately 300 million NOK.

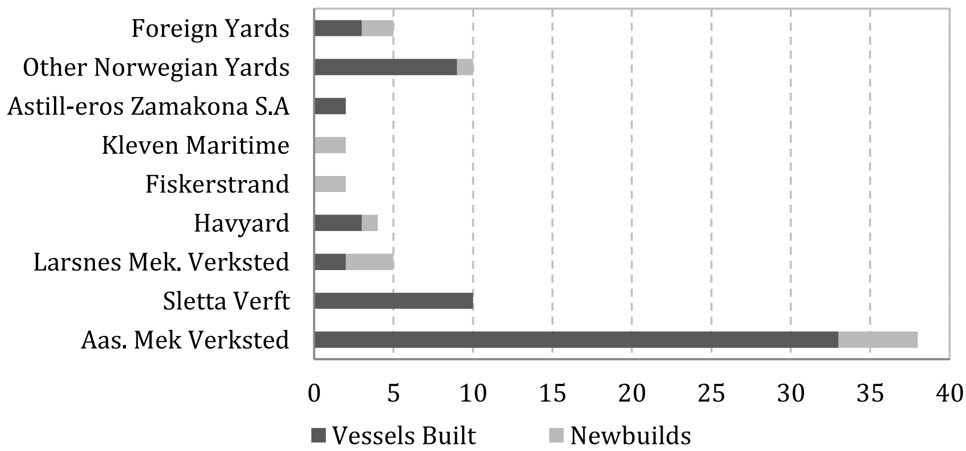


Chart 13*: LFC Production (Brønnbåteiernes Forbund, 2016)*

6.2.2 Phasing Out and Scrapping

There is no registered scrapping in the LFC industry in the Atlantic. The most common way to allocate an old vessel from the fleet is to sell it to other LFC markets or to other industries. Several vessels have been sold to Scotland or the Faroe Islands. The possibility of phasing out is in other words present, but not a frequently used decision to take in the current market.

6.2.3 Norwegian LFC fleet

When focusing on the Norwegian LFC fleet, we exclude the vessels operating in other areas than Norway. Norwegian owned vessels operating in the UK and Faroe Island is included because the short distance between UK and Faroe Island and Norway, which implies that a vessel can operate in the Norwegian coast if needed. The Norwegian LFC fleet owned by Norwegian owner consist of 61 vessels, and represent a total volume of 85.851 M3. On average the age on a vessel is 12,5 years and the average volume is 1407 M3 (Brønnbåteiernes Forbund, 2016). Since there is no scrapping in this segment, we assume that the old tonnage is still available in the market since the costume is to sell off old ship to small companies in nearby countries. Plotting the age and size of the fleet one can observe a clear tendency that older vessels are smaller and newer vessels are larger. Newer vessels naturally also have more advanced on-board technologies, such as closed systems.

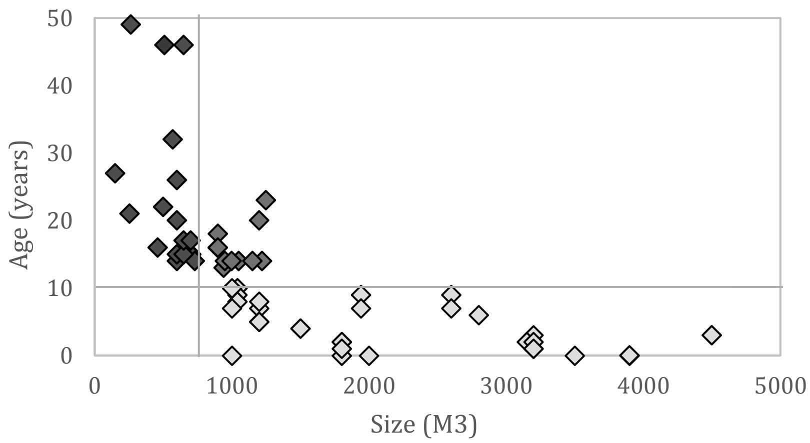


Chart 14: *LFC Distribution between age and size* (Brønnbåteiernes Forbund, 2016)

All of the supplied M3 which is built after 2006, and are 10 years or less of age, have closed systems (G1). Vessels with capacities under 750 M3 does not have closed systems (G3). From the group of vessels that are of are more than ten years of age and have a capacity of more than 750 M3, only one vessel has closed systems (G2).

The five largest LFC companies, control 85% of the total fleet, and all of the G1 vessels. Of the 16 G3 vessels only four are owned by the top five companies. This characterize the market as an oligopoly where the market control is centered between the top five. After the merger between Sølvtrans and Bømlo Brønnbåtservice, this company controls 27 % of the fleet, being the largest company in the industry.

Recent years, larger vessels have entered the market, but also a significant number of medium size vessels with a capacity range of 1000-2000 M3. In 2017, 10 new vessels are entering the market with a total volume of 32.000 M3. Consequently, there will be a 38% increase of total M3 capacity next year. Nine of the ten vessels are owned by the top five companies and will contribute to the G1 group of large and technological vessels.

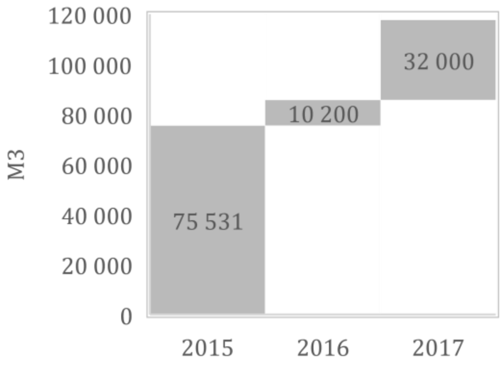


Chart 15: Total M3 capacity

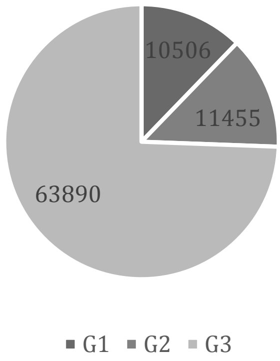


Chart 16: Operating M3 in classes

6.2.4 Fleet productivity

Analyzing the fleet productivity, a number of reasonable assumptions are made. To analyze the productivity, three scenarios makes the basis for computing different utilization of the fleet. The scenarios are computed through upscaling the time use of a vessel such that the available capacity in a month can be obtained. These numbers are cross referenced with statements from industry survey.

Scenario (x)	Utilization	Trips per month
1	Max	50
2	Average	39
3	Min	30

Table 4*: Outline of Scenarios*

The assumptions are subject to a number of possible errors. E.g. maintenance and repairs are natural time consuming activities which are not taken into account. These three utilization alternatives are made as a base for the analysis, and will be crucial to the understanding of the freight market equilibrium in the model. The errors will however be further discussed, when interpreting the positional tracking of a number of vessels in in Section 7, *Fleet Utilization*..

6.2.5 Total Supply

To model the supply of LFC, we have has made a mathematical model to explain the supply drivers (5) in the three utilization scenarios. The total supply of LFC M3-equivalents, C_{tw}, is the capacity of each carrier, w, in time perod, t. The utilization, U_t^x, of the vessels in time period, t, is done in regards to the scenario $x = \{1,2,3\}$. The computation is less accurate the further back in time it is calculated, when we know less about the structure of operations.

$$S_t^x = \sum_w C_{tw} * U_t^x \qquad (5)$$

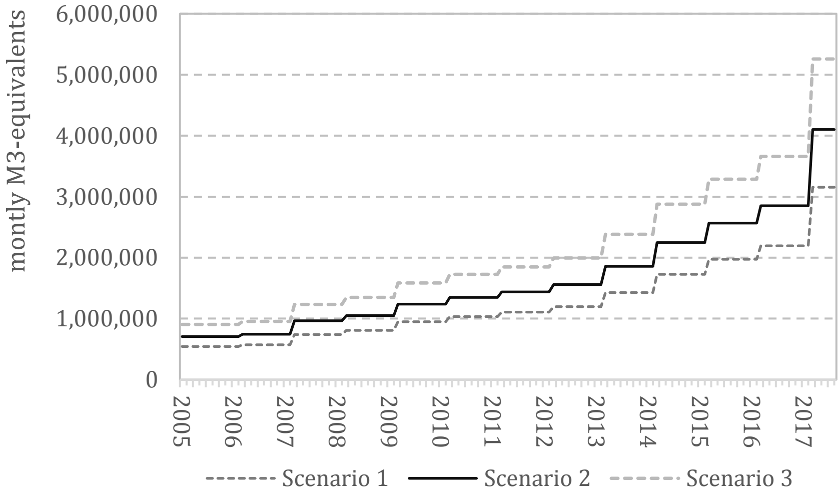


Chart 17: Supply Utilization Scenarios

The different scenarios capture the reasonable range of M3 utilization. From the output of the demand side where 3.000.000 M3 equivalents have been the average level the past six years, this indicates that an observed overcapacity will occur in the time period between 2015 and 2017. However, to evaluate the mismatch it is necessary to look at the mismatch of the supplied and demanded M3-equivalents over time.

6.3 Equalibrium

By matching the supply and demand in every time period, t, the model will give insight of the development the relation between supply and demand. We are combining the two formulas, and adding a mismatch factor, Y_t^x, to the equation (6). It is important to distress the fact that the further back in time the model goes the more uncertainty it contains. We do know more about the operations today, than ten years ago.

$$\sum_{r \in R} D_{r,t}^{total} = S_t^x + Y_t^x \tag{6}$$

Interpreting the relation between the supply we want to smooth the trends to reduce noise. A twelve month moving average captures the yearly trends in the development in the mismatch between supply and demand over time. This method creates a time lag of one year, but captures the annual trend in the mismatch. The simplicity of the calculation is that we add a mismatch factor Y_t^x which captures the mismatch of the supply and demand in every t for each scenario, x. Rearranging the equation (7), we want to isolate the mismatch factor, and create a twelve month moving average (8).

$$Y_t^x = S_t^x - \sum_{r \in R} D_{r,t}^{total} \tag{7}$$

$$\hat{Y}_{t-1}^x = \frac{Y_t^x \quad Y_{t-1}^x \ + \cdots + \ Y_{t-m+1}^x}{m} \qquad where\ m = 12 \tag{8}$$

To account for future demand in 2017, the production in the 2016 is duplicated to the respective months in the going forward. It is not expected that the production will increase significantly in 2017 with the present regulations.

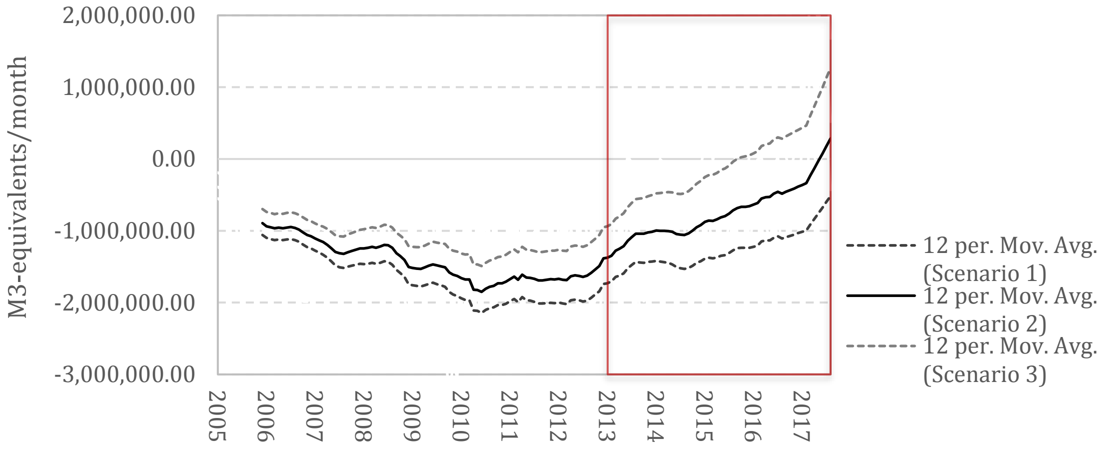


Chart 18: *Moving Average of Supply and Demand mismatch*

The results show a demand surplus of more than 1.000.000 M3-equivalents per month throughout the period until mid-2014. It also shows that the market will balance in 2017 at an equilibrium where the supply matches the demand. As observed, the market is moving towards a stable position, with indication of a small overcapacity. There is no data on newbuilds in 2018, which gives the impression of a stable allocation around 300 000 M3-equivalents. This is the same as a surplus of 0.6 average sized vessels per region.

There are two concerns regarding this interpretation. Firstly, the data before 2012 have to uncertainties related to the treatment processes performed by the LFCs. Secondly, the size distribution of the vessels has changed over the period.

From the secure data, 2012 and onwards, there is a positive trend, in the mismatch. In this period larger vessels entered the market, who could effectively carry more M3 per trip. In other words, a more efficient fleet. In the model above it is assumed that a M3 could move freely and independently, which is not the case. What is important is that the relationship between supply and demand have experienced a dramatic change over the past four years, while the demand has not changed significantly.

A demand surplus of 1.000.000 M3-equivalents is the same as an undercapacity of two averaged size vessels in every region. This undercapacity could potentially be the reason for the high revenues of the shipowners.

It is reasonable to assume that the entry of new capacity will follow the demand for LFCs with a lag due to the production process. *Chart 18* shows that the pattern is not recognized in any time period.

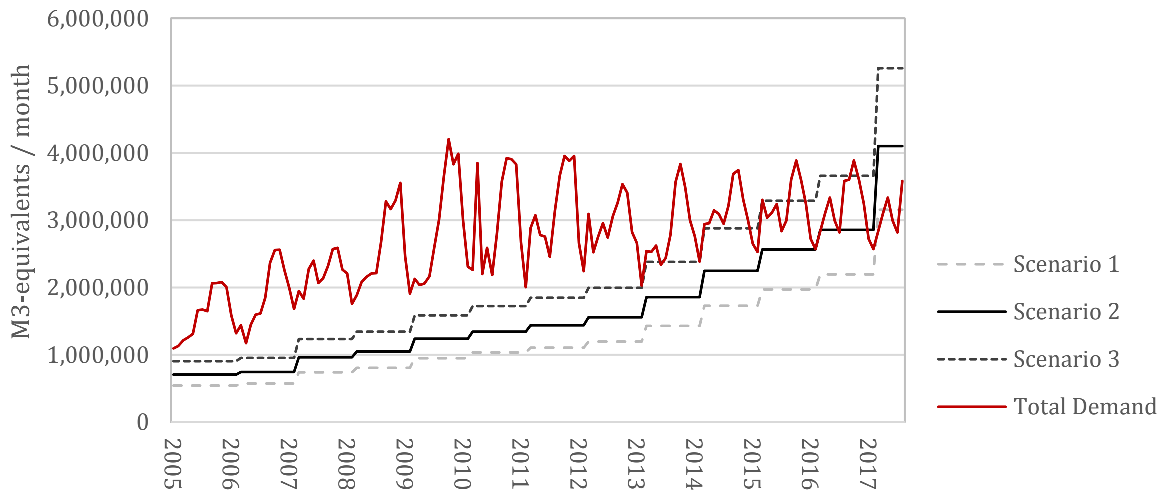


Chart 19: *Supply and demand*

The development of the supply and the demand does not follow the same pattern. With perfect information one would assume the development of the supply to follow the development of the demand, with a lag representing the time it takes to build a vessel. The demand is based on the sum of the development in three categories. By isolating the main driver for demand, the harvest transportation, we observe that the supply follows the demand until 2014.

The harvesting patterns are recognizable over time and a salmon producer would be able to forecast their harvest transportation demand 14-22 months into the future, when this is the time a salmon to grow to its full size at the grow-out centers. Consequently, this information could be transmitted through the value chain such that the different stakeholders could adjust their operations.

These observations are based on ten years of data. The interpretation is highly dependent on the utilization of the fleet, reflected in the three different utilization scenarios. In the following sections we will investigate which of the three scenarios is best suited to explain the weighting of the scenarios, and further why the shipowners still are expanding the total fleet.

7. Fleet Utilization

To obtain greater accuracy on the utilization of the fleet under the present market conditions, we interpret positional and operational tracking of a number of vessels in the LFC fleet. Measuring the utilization of the capacity of the fleet, we have to take into account the way the fleet is managed. The positional tracking will contribute to a greater understanding of the actual utilization and the dynamics of the market in the present state, which will contribute to the model.

7.1 Operational Research

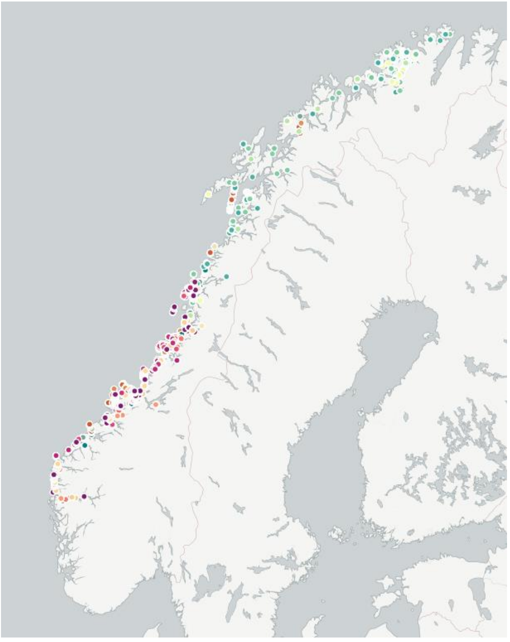
Operational research is playing a gradually more significant role in the natural resource sector. Moreover, how to harvest optimally under environmental restrictions and policies, to maximize profits and reduce the footprint on the environment. The decision making in aquaculture is mainly with the focus of optimally harvesting the right amounts of biomass at the right time for the downstream markets. To be able to make the optimal decisions, it is crucial to obtain as much information as possible on behavior, capacity utilization and efficiency. This is to some extent done at the salmon producing plants isolated, but not transmitted and used through the entire value chain.

The harvesting and output patterns of salmon production are highly recognizable, and individual salmon producers pay close attention to the development of their stock. This information can be used as forecasts for the operational planning of the LFCs. At a 100% utilization of the fleet, vessels would be able to move between contracts to utilize their capacity in regards to distances and volumes, to minimize risks and costs. However, this is unlikely due to financial drivers and competition in the segment.

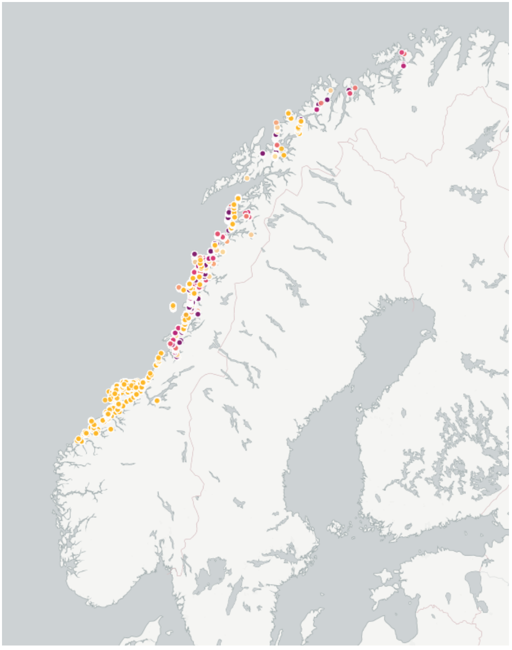
The general increasing environmental concern, makes is important to improve transportation planning. Moreover, the environmental concern drives more efficient decision making, which consequently in most cases would decrease variable costs for the reliable company.

7.1.1 Mapping the AIS

In order to get insight on the actual operations, the first step is to map out the operations of the vessels. Operations occur at speeds less than two knots, and we use this as a filter for identifying the locations for operations in the dataset. From two shipowners three vessels are chosen to get an overview on the geographical extent of the operations. Individual ships have individual colors.



Map 3*: Operations company one*



Map 2*: Operations company two*

The geographical spread in operations for vessels is large and overlapping. Vessels from the same companies are operating across regions and consequently uses a lot of the chartered time on sailing between operations. Naturally this occurs when vessels from a company are chartered from different salmon producers. Further analysis of the AIS tracking data is done by categorizing the vessels into classes dependent on their size (M3) and the year the vessels age in the classifications G1, G2 and G3. To get insight on the vessels actual operations, dummy variables are created to identify the region of operations for each vessel in the dataset. Nine regions are categorized by latitudes defining their southern and northern border. For every vessel, categorized by their identification number (MMSI) one dummy variable is created for each region.

	Latitude (La)		
Region	North (NO)	South (SO)	r
Finnmark	71.39472	70.12947	FI
Troms	70.12946	68.37098	TR
Norland	68.37097	65.09246	NL
Nord Trønderlag	65.09245	64.25507	NT
Sør Trønderlag	64.25506	63.21797	ST
Møre	63.21796	62.14416	MO
Sogn og Fjordane	62.14415	60.52152	SF
Hordaland	60.52151	59.30476	HO
Rogaland og Agder	59.30475	57.53457	RA

Table 5*: Definition of regions in Latitudes*

With the dummy variable it is possible to identify the region where the vessel has operated in the time period. In addition, the reported speed at the specific time in the dataset can give insight on what the vessel is doing at the reported time, in the specific region.

$$Region_r^{MMSI} = \begin{cases} 1 & if \ \ NO_r > La \ > SO_r \\ 0 & if \ else \end{cases}$$

We assume that all speeds below two knots are related to operations. On the other hand, speeds above two knots are assumed to be transport time. Within a region the number of observations of speeds of operational matter will be marked as 1 and the speeds of transportation matters be marked 0 in a dummy variable.

$$Speed^{MMSI} = \begin{cases} 1 & if \ \ Operational\ speed \\ 0 & if \ \ Transportation\ speed \end{cases}$$

The average of the dummy speed observations within a region, will consequently be the number of transmitted observations of operations over transport which can indicate the efficiency of the respective vessel in the region. More observations of low speeds in regards to transportation speeds will indicate that the vessel is assigning relatively less time to the sailing. The efficiency index will range between one and zero, where a higher number reflects higher efficiency and less distance travelled.

The density of the transmitted signal is however varying between vessels and time. The efficiency index is therefore not comparable across vessels, but will give insight on what regions the vessels are operating in and their relative intensity on the operations performed.

With the categorization of the vessels size and age we are able to draw some bold conclusions from the output of this model. Large vessels are often operating in smaller geographical areas, and are more efficient when they are there. Smaller and older vessels are often operating over larger geographical areas, and are less efficient when in the regions they operate.

Class	FM	TR	NL	NT	ST	MO	SO	HO	RA	Sum(r)
G3	0.0	0.2	0.4	0.0		0.1				5
G3	0.0	0.0	0.2	0.0	0.5	0.0	0.0	0.0		8
G3	0.0	0.0	0.0	0.0	0.4	0.1				6
G3	0.0	0.9								2
G3						0.2	0.1	0.3	0.1	4
G3	0.0	0.4	0.2			0.1				4
G3								0.8	0.0	2
G3	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.0		8
G3	0.0	0.8	0.0							3
G3	0.2	0.3	0.0							3
G3								0.1	0.6	2
G3	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	9
G2	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0		8
G2	0.1	0.1	0.2							3
G2	0.0	0.0	0.3	0.0	0.0	0.0				6
G2		0.0	0.0	0.0	0.5	0.1				5
G2	0.0	0.0	0.0	0.0	0.4	0.1				6
G2	0.0	0.0	0.4	0.0						4
G2	0.0	0.0	0.3	0.1						4
G2						0.3	0.1	0.0	0.0	4
G2		0.5	0.1							2
G2		0.0	0.0	0.4	0.0					4
G2	0.4	0.0	0.1							3
G2		0.0	0.0	0.2	0.5	0.1				5
G2		0.3	0.0	0.0	0.4	0.2				5
G2		0.0	0.0		0.0	0.0	0.0	0.3	0.1	7
G2				0.0	0.0	0.0	0.0	0.2	0.4	6
G2		0.0	0.1	0.3	0.3	0.0				5
G2			0.0	0.5	0.1	0.1	0.0			5
G2					0.4	0.3		0.0		3
G1						0.6	0.2	0.0		3
G1						0.9	0.0			2
G1							0.5			1

Chart 20: *Fleet utilization*

This provides indications that the average number of trips per month for a vessel is not fully utilized, which will give less weight to the “max utilization” scenario in the supply and demand model in section 6. Furthermore, the characteristics of a vessel could determine the contract structure. Small vessels are on shorter contracts and would consequently have to move more in order to maintain a backlog, while larger vessels are assigned longer contracts and can operate more efficiently. As new vessels are often acquired based on a contract smaller vessels have a higher probability of shorter and less profitable contracts. When the market is indicating undercapacity, it is noteworthy that the vessels are not used optimally in with in a technical perspective.

7.2 Incentives for maximizing utlization

It is possible to plan the operations of the LFC fleet in regards to the transportation and operational demand for from the grow-out centers going forward. The operational planning of aquaculture value chain is divided into two main parts. Biological optimization focus on the growth of the salmon population in a facility to maximize the biomass output over time. Topics such as feeding and diseases (Cho & Bureau, 1998), cultivation band growth and mortality (Bjørndal, et al., 2011) are widely researched in academic literature.

On the other hand, the operational approach focuses on the operating conditions of the production. Effectively this is the incorporation of economic variables that affect profitability and environment. Other studies have researched the long-term harvesting patterns to optimize the profits. However, in all of these papers the incorporation of transport is left out or only looked upon as a single static cost, not subject to the variable costs on fuel in regards to distances and other operating expenses that are accumulating in the operations of LFCs.

A simple explanation to this is the marginal costs the LFC operations actually accounts for when producing one kilo of salmon. From *the cost structure of salmon production* that of the total cost of producing one kilo of salmon, the LFCs are only responsible for 3.5% of the total costs, about 1 NOK/kilo. The cost of the fuel on the vessels is on the accounts of the salmon producer, not the vessel owner. At the marginal level, the incentive for more efficient operations is not present. Rather the opposite. The LFCs function as an insurance for the biomass is weighted higher than the cost of chartering and fueling a vessel that is not in operation.

Fernanda Bravo et al presents two integrated models in the paper "Mathematical models for optimizing production chain planning in salmon farming". They present a model for the *freshwater* (smolt) and *seawater (*grow-out phase) phase which are coordinated through the quantity of salmon transferred between the respective phases (Bravo, et al., 2013). The results are numerical and presents improvements to the current manual approach to decision making. The study is covering 46 seawater grow-out centers with the total of 944 cages.

With the growth rate as the underlying driver, the model optimizes the output from a region. The results are increasing the productivity of the grow-out centers with 3% more biomass, where the normal distribution of the harvested salmon is narrowed from 1.5-6 kilos to 3.2-5.3 kilos. However, the transportation of the smolt and salmon is only measured through the flow variables y_t and h_t.

Over the five year planning horizon this leaves a trail of 60 individual transportation demands for every grow-out center. The model assumes that the transport is available at a static price in every time period, *t*.

This demand could optimally be used as input for a transportation model, where DS_{tp} is the demanded transport of smolt to facility, *p*, in time period, *t*, and DG_{tp}. At an optimal level, the transportation would be at a technical demand equilibrium. The structure of the market would have some slack in regards to the competition between companies and the willingness to pay for "insurance" in terms of overcapacity such that a salmon farmer would want to be able to cope with random shocks to the biomass.

8. Investment Drivers

From our, more capacity is entering the market. The new tonnage will contribute to more supply in the market, which potentially will decrease the freight rates. The following chapter will try to investigate these following questions:

i) What is the value of the operations?

ii) Why is the shipowners still investing in new tonnage?

iii) How sensitive are the shipowners to changes in freight rates?

8.1 Valuating the operations

From a salmon producer’s perspective, the processing operations from the LFC can be looked upon as an insurance. The static operations in regards to transport, can be forecasted in regards to harvest planning and is not assigned to much uncertainty. The occurrences of lice and diseases, will appear with more uncertainty, and can potentially cause loss of biomass and consequently profits. With the increase in number of salmon per cage (*Chart 2*) and the positive development in prices (*Chart 4*), the value of a cage or location have increased drastically. The potential economic loss experienced in an early harvest of a cage will increase.

The probability of an outbreak of disease and a more rapid growth of lice, is by logic higher when the density of farmed salmon in an area is higher. Over the ten-year period the density of salmon, in the regions have increased.

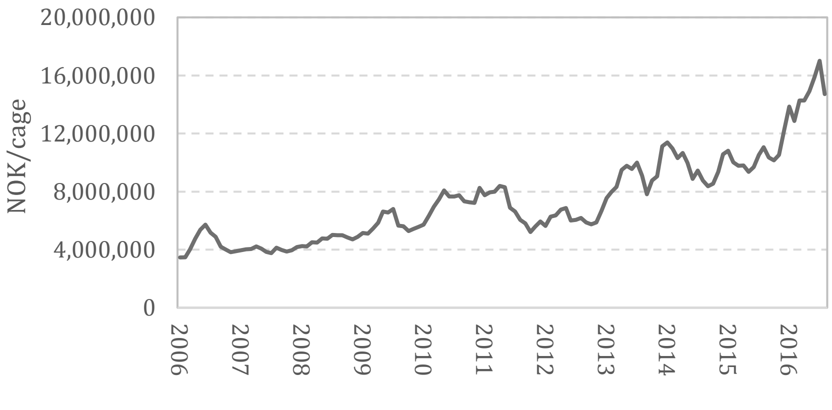


Chart 21*: Development in average cage value*

When both the value of the insured good and the probability of the loss of the good is increasing, naturally the price of the *insurance* will rise. An average cage in 2016 is valued at 15 million NOK. This value has increased with 400% from 2006. It is unlikely that the portion of the charter prices are related to processing have followed the same pattern, but it is reasonable to believe that the increase in value will to a large extent be reflected in the contracts.

The charter contracts in the LFC market typically covers several years, the salmon producers are reducing the physical risk to their biomass. Shipowners are on the other hand reducing their financial risk. The pricing of a TC will reflect the present state of the market and future expectations. Today the average TC price is 4.400 NOK/hour. The average price will contain elements from different times of contract engagement, and consequently contain a lag. Approximately 80% of the present operating fleet is on TC contracts, which are engaged in a time span of up to seven years back in time.

8.2 Return on Shipping Investment Model

On a corporate level, the ROSI-model is adequate to answer the question (ii) of why shipowners are investing in new tonnage. As observed there are differences in the operational returns, and consequently the way the capacity is managed will affect the profitability of a ship owning company. The output from the ROSI model shows the return on the financial investment in the fleet. In the calculations Norsk Fisketransport is left out, because of inconsistent data.

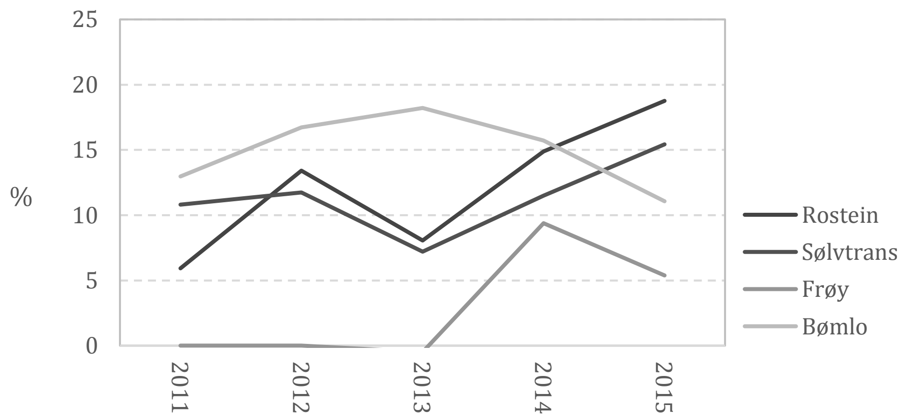


Chart 22*: Return on Shipping Investments*

The return in the investments for the LFC companies have accumulated high financial profits over the latest years. On average the return among the four companies over the period is 12.6%. With high barriers of entry to the sector, there are only a small number of companies who are providing the transporting and processing services. With the operating profit margin of 43% on average among the top five companies, one would assume that the ROSI would be higher. However, the interest and depreciation costs are devouring the profit from the investments.

There are several weaknesses with the data. The net asset value obtains more than only the value of the vessels. Properties is eliminated, but other fixed assets will occur in the calculation due to the accounting standards from non-public companies.

In 2006 McKinsey analysed the return on invested capital (ROIC) on 7.000 publicly listed non-financial companies in the US from 1963 to 2004. The revenues of the companies where more than $200 million in 2003 dollars, adjusted for inflation. (McKinsey, 2011). Their result shows the average ROIC in the respective time period was 9.9% excluding goodwill and 9.4% including goodwill.

A thorough analysis done by Aswath Damodaran at NYU Stern School of Business collected data from several industries, including data from 11 “Shipbuilding & Marine” and 21 “transportation” companies (Damodaran, 2007). This analysis shows that the average ROIC for “Shipbuilding & Marine” was 6,42% while in “transportation” the ROIC was 20,14 %.

Comparing the ROSI with the ROIC from these studies, indicates that the LFC owning companies have relatively high margins. However, not as high as one should suspect from the profit margins. According to the shipowners this is due to increased salaries, financial costs and increased operating expenses. Due to the high profit margins and the relative high return on shipping investments, the LFC market is attractive for both shipowners and investors.

8.3 Freight Rate Sencitivity

In this section we will analyze the effect of different scenarios of price levels on the NPV of a new invested LFC. From our findings the players are making both relatively high operating and financial returns. The information on freight rate is limited, and the only reference point is the average price of 4400 NOK/hour in 2016. To investigate the different price levels and the impact on the financial returns, we can get a further insight in why the shipowners are investing heavily in new capacity. This analysis is an exertion of the ROSI model.

The average of the three largest LFC companies, gives the basis of the cost structure to the free cash-flow (FCF). When estimating the revenues from operations, a price range of 2000 NOK/hour to 4500 NOK/hour is used. This gives us six different scenarios. We expect a lifespan of a vessel to be 25 years, with a linear depreciation. As the assumed new vessel costs 300 MNOK, the depreciation is 12 MNOK a year. The scrap value is assumed to be 15 MNOK. The tax rate is 27% (Regjeringen, 2016).

Step one is to calculate the WACC. The average of the total equity debt in 2015 of the five largest LFC companies are the bases for the equity and debt. The estimated equity to total assets is 21.45 % and the estimated debt to total assets is 78.55 %. Assuming high expecting shareholders and relative low interest rates on newly issued corporate bonds, we assume the return of equity to be 15% and the return of debt to be 5%. These estimates are only a guideline, which are to be analyzed. This gives a WACC with tax on 6.08%.

Before calculating the FCF, a sensitivity analysis of the WACC is preformed to analyze the sensitivity regarding changes in the return of equity (Re) and the return of debt (Rd). Table 7 show how sensitive the WACC is to change.

		Re									
	6.0842 %	2 %	4 %	6 %	8 %	10 %	12 %	14 %	16 %	18 %	20 %
	2 %	1.6 %	2.0 %	2.4 %	2.9 %	3.3 %	3.7 %	4.1 %	4.6 %	5.0 %	5.4 %
	4 %	2.7 %	3.2 %	3.6 %	4.0 %	4.4 %	4.9 %	**5.3 %**	**5.7 %**	6.2 %	6.6 %
	6 %	3.9 %	4.3 %	4.7 %	5.2 %	5.6 %	6.0 %	**6.4 %**	**6.9 %**	7.3 %	7.7 %
	8 %	5.0 %	5.4 %	5.9 %	6.3 %	6.7 %	7.2 %	7.6 %	8.0 %	8.4 %	8.9 %
Rd	10 %	6.2 %	6.6 %	7.0 %	7.5 %	7.9 %	8.3 %	8.7 %	9.2 %	9.6 %	10.0 %
	12 %	7.3 %	7.7 %	8.2 %	8.6 %	9.0 %	9.5 %	9.9 %	10.3 %	10.7 %	11.2 %
	14 %	8.5 %	8.9 %	9.3 %	9.7 %	10.2 %	10.6 %	11.0 %	11.5 %	11.9 %	12.3 %
	16 %	9.6 %	10.0 %	10.5 %	10.9 %	11.3 %	11.7 %	12.2 %	12.6 %	13.0 %	13.5 %
	18 %	10.8 %	11.2 %	11.6 %	12.0 %	12.5 %	12.9 %	13.3 %	13.8 %	14.2 %	14.6 %
	20 %	11.9 %	12.3 %	12.8 %	13.2 %	13.6 %	14.0 %	14.5 %	14.9 %	15.3 %	15.8 %

Table 6*: WACC sensitivity*

To investigate the impact of the effect of different price levels on the NPV, the FCF is first calculated within the price range. We exclude growth in our model because of the LFC market seems to have matured and there is assumed no growth in the salmon production in the future. To find the development of the investment in a new LFC, the investment cost is summarized with the sum of yearly FCF (*Appendix 2 – Figure 7*). *Chart 16* shows a NPV break even analysis. In the end of year seven the investment with a freight rate of 4500 NOK/hour exceeds zero, every year after this the investment will give economic value added (EVA)

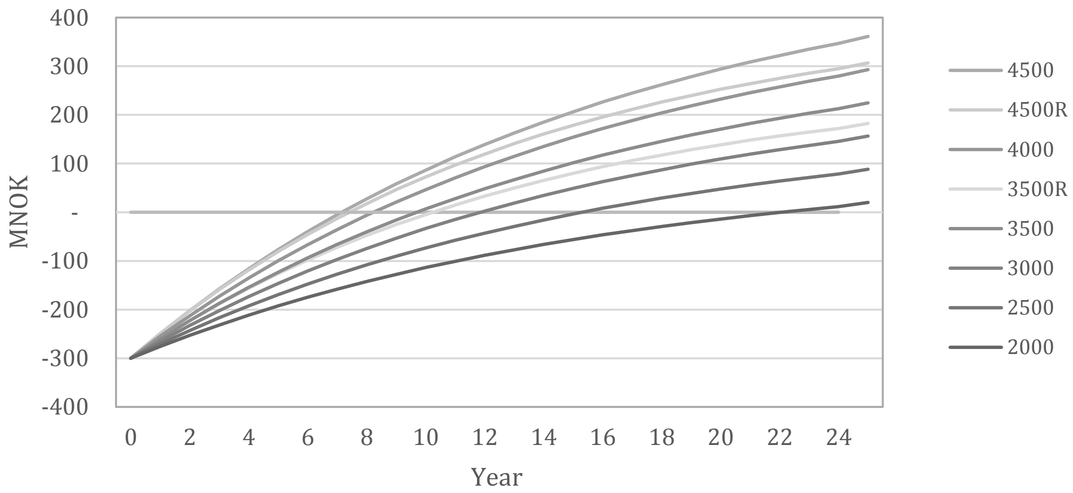


Chart 23: *NPV of Ship investment in regards to TC prices*

The model shows that a price of 3000 NOK throughout the lifespan gives a NPV of zero in year 12, which indicates that the vessel providing EVA. A price of 2000 NOK gives a NPV of zero in year 20. An extreme case is with a price of 4000 or 4500 NOK, which gives a NPV of zero in year 8 and 7. The most reasonable conclusion is that a vessel will obtain a high price in the start of its lifespan, and the price is slowly decreasing throughout the time period. Line 4500R and 3500R shows a such relationship. It is assumed that the freight rate is decreasing with 1 % each year, so the freight rate in year 25 with 4500 NOK in year 1 result in a rate of 3420 NOK/Hour.

The internal rate of return (IRR) shows the discount rate that makes the NPV equal to zero. The freight rate 3000 NOK/hour have an IRR of 11,5 % while 4500 NOK/hour have 17,6%. This indicates that with a freight rate of 3000 NOK/hour, the project will have a NPV of zero if the WACC is 11,5 %. Since the WACC is 6,08 % the project can increase its cost of capital without making the project undesirable.

A weakness with the model is two folded. First we assume that the freight hour rate is constant throughout the time period, which is unrealistic. The second weakness is the assumption of a constant WACC. To analyse these two weaknesses, a sensitivity analysis of freight rates and WACC is assessed. The respective base case for the freight rate is 3000 NOK/hour, because the freight rate should reflect 25 years of operations where the price range will decrease over time.

		Change in price										
	156.6	-10 %	-5 %	**0 %**	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %
Change in WACC	-10 %	142.0	163.8	**185.5**	207.3	229.0	250.8	272.5	294.3	316.0	337.8	359.6
	-5 %	128.5	149.6	**170.7**	191.8	212.9	234.0	255.1	276.2	297.3	318.4	339.5
	0 %	**115.6**	**136.1**	**156.6**	**177.1**	**197.5**	**218.0**	**238.5**	**258.9**	**279.4**	**299.9**	**320.3**
	5 %	103.4	123.2	**143.1**	163.0	182.9	202.7	222.6	242.5	262.3	282.2	302.1
	10 %	91.7	111.0	**130.3**	149.6	168.9	188.2	207.5	226.8	246.1	265.4	284.7
	15 %	80.5	99.2	**118.0**	136.8	155.5	174.3	193.0	211.8	230.5	249.3	268.1
	20 %	69.8	88.1	**106.3**	124.5	142.8	161.0	179.2	197.5	215.7	233.9	252.2
	25 %	59.6	77.4	**95.1**	112.8	130.6	148.3	166.1	183.8	201.5	219.3	237.0
	30 %	49.9	67.1	**84.4**	101.7	118.9	136.2	153.5	170.7	188.0	205.2	222.5
	35 %	40.6	57.4	**74.2**	91.0	107.8	124.6	141.4	158.2	175.0	191.8	208.6
	40 %	31.6	48.0	**64.4**	80.7	97.1	113.5	129.9	146.2	162.6	179.0	195.3

Table 7: *Net Present Value Sensitivity, in million NOK*

The case study indicates that with a price of 3000 NOK per hour, there will not give a negative NPV in either of these scenarios. The study indicates that a 40 % increase in the WACC, ergo a WACC of 8,5 %, will give a much lower NPV. An increase in the price level should give an exponential increase in the NPV. An increase in price of 40 %, ergo 4200 NOK per hour, will give a 98,3 % increase in the NPV.

The financial analysis indicates that with a reasonable WACC level as assumed, an investment in a new LFC gives a positive NPV in either case where the price level is above 2000 NOK per hour. The different scenarios give an indication of where a shipowner should allocate within the price range to get a positive return of its investments.

An interesting area for future academic research is to value a real option with the option to wait or abandon a new investment. A such analysis would give a greater understanding of why shipowners are investing heavily today. The problem with a real option today, is the lack of information about the probabilities for over-and undercapacity in the future.

9. Discussion

9.1 The LFC status today

Modelling the historical supply and demand, our analysis indicates that the LFC market is undergoing a change, as more capacity is brought into the market. In 2017 it is reason to believe that the market dynamics will change, when ten new vessels are entering the market and the demand for M3-equivalents seems to be at a stable level going forward.

The modelling of the supply and demand shows a tendency towards a small excess capacity in the market. The utilization analysis shows that the vessels are not operating optimally, and contributes to the argument that there will be more capacity available. However, the financial state of the ship owning companies and the salmon producers is not contributing an incentive for maximal utilization.

From a shipping cycle perspective, the state of the market could be argued to be between the *recovery stage* and the *peak stage*. The industry has experienced an undercapacity for several years, and in 2017 we expect a balance in the supply and demand. According to our research, the utilization and management of the fleet is not optimal. From a financial perspective, the high investment returns and profit margin indicates a movement of the industry towards the peak stage of the shipping cycle. The experienced undercapacity in the market would according to theory result in relatively high freight rates. The observations of a change towards a balanced market could result in lower freight rates in the future.

It can be argued that the market is experiencing a price lag due to the long contracts in the market. Approximately 80% of the Norwegian LFC fleet is on relatively long TC contracts. The lag could be reflected in the experienced freight rates, when the engagement of the contracts is reflecting a different market situation with an undercapacity. In addition, it could be argued that the freight rates also will reflect the increase of the value of the *insurance* of having excess LFC.

The increased capacity and prices in the market, may result in several outcomes. Salmon producers and shipowners might not experience the change as drastic. If the oversupply leads to a *collapse* in the market is uncertain, it may not happen at all. The market can adjust by not investing in new tonnage and experience high freight rates and good markets in the years to come. As we shall discuss, there is several factors in the future which will determine the future LFC market.

9.2 Possible Regulatory Meassures

Interregional LFC operations could be a source of the spread of decease and lice from one location or region to the next. As shown in the AIS tracking, the LFCs operates at a large number of geographically spread locations. More locations visited by one LFC are effectively increasing the risk of biomass loss and stresses the environmental concern. There are two ways of handling this risk. One is technical requirements to the vessels, and second is regional restrictions which constrains the geographical area the vessels are allowed to operate.

9.2.1 Technical Reqirements

There are several ways of reducing the risk, in regards to the vessel technicalities. From January 2016 all vessels have to register valve positions of the well (Regjeringen, 2014). This data will track and monitor the vessels positions and status, when discharging and loading the wells. The measure is done to increase the attention regarding the danger of spreading the deceases from the LFC operations.

Different regulatory measures have been discussed to cope with this risk (Regjeringen, 2014). In 2021 a requirement that ensures that the loaded transport water is disinfected. Most new and large G1 vessels already have this technology. These are the vessels that are operating in the fewest regions and are imposing a small risk of infection of biomass. Consequently, these measures will affect the owners of the smaller and older G3 vessels. The G3 vessels impose larger risk of interregional spread of diseases and lice.

To rebuilt these vessels to meet the possible requirements, will be highly costly and therefore unlikely. In consequence these vessels have a high probability of being pushed out of the market. This threat is not only from the regulatory measures, but also the substantial capacity entering the market in 2017.

9.2.2 Regional Restrictions

The risk of interregional spread of deceases and lice is increased by the number of regions the LFCs operate. From our sample of AIS tracked vessels, it clearly shows that an average vessel is operating in multiple areas during a relatively short period of time.

Suggestions have been made to restrict geographical areas in the Norwegian coast line (Regjeringen, 2015). The regulatory measure builds on the principle of a traffic light. Green light allows salmon production to grow in the respective region, yellow in no movement, and the consequence of red will be to stop or reduce production. The regulation may affect the LFC market in a negatively way when the vessels movements may be constrained and the salmon production may be reduced.

There have been extensive research trying to map the ocean currents and spread of deceases and lice, which indicates that the vessels geographical spread in operations could be the cause of some outbreaks. The small and old G3 vessels are the ones that would feel the effects of such a restriction, when their operations are covering the largest geographical area relative to the larger ones.

9.2.3 Ownership Strucure Impact

The operational pattern of the smaller vessels, might be the effect of the shipowners are operating in the spot market. The vessels would then have to move between locations, regions and salmon producers. If the new regulations are set in motion, the structure of the market will change towards a more centralized oligopoly. The larger companies are mostly operating the largest vessels, and the smaller companies are operating the smaller ones. This will result in a few large players with fears competition among the rivals.

An increased interest in the LFCs are observed from the salmon producers. Marine Harvest has contracted one newbuild and Nova Sea has ordered one vessel which will enter the market in 2017 (Ilaks, 2016). This may indicate that the salmon producers in the industry wants to gain control of the value chain to save costs. As the largest obstacles to enter the market is the capital, the salmon producers pose a great threat against the market leaders. The impact of the entry of salmon producers in the LFC industry will be a decrease in the contract available to the original shipowners. The competition will increase and the need for tonnage will decrease.

9.3 Collaboratives

To minimize the risk of biomass loss, regional co-operatives (collaborative) could be an option. If the supplied, or chartered, transportation and processing on the vessels in a region is substitutes, the incentive for collaborates is present if the regional shared cost for each company is less than the cost of operating by itself. In a cooperative the total costs are distributed among the involved players. It would be rational for every participant that reduces the individual cost by entering such a collaborative.

In a geographically bound collaborative, the respective salmon producers who charter in M3 capacity would be the players in the game. In one region, there are several independent companies present, who in theory could charter M3 from the same provider.

By restricting a geographical region, the salmon producers would effectively also reduce the risk of loss of biomass and through a more effective allocation of the LFC the variable costs related to the operations would be minimized. Such a solution will not be present under the current market conditions when there are no regulations, in terms of the areas the LFCs can operate. In a *regional restricted* scenario, the incentive would be present.

9.4 Stabilizing the LFC Market

To achieve a healthy and sustainable development in the LFC market, the knowledge of previous shipping downturns should be kept in mind. There is a common dynamic in the shipping industry that the shipowners and financial institutes are creating overcapacity and downturns because of overinvestments. As previously mentioned, the survey we did is statistically weak but gives some insight on the perception on the market conditions.

9.4.1 Market Condition Perceptions

The shipowners have a perception of the freight rates to be relatively lower than what the perception of the salmon producers, at respectively 3.3 and 4 on a one to five scale. The salmon producers are in general satisfied by the services provided by the shipowners. However, the shipowners on average believes that the salmon producers are not fully utilizing the hired capacity, with a score of 3.3 out of five. The majority of the salmon producers experience that the capacity available is sufficient to meet their demand.

Salmon producers are in general very optimistic about the future, while the shipowners are more pessimistic. On the 1th of the December, the owner of Sølvtrans AS expressed concerns about the probability of oversupply in the LFC industry (Kyst.no, 2016). A concern is the fact that the salmon producers are dictating the need for LFC which impose the shipowners for major investments.

9.4.2 Phasing out

In the future, there will be need for phasing out or scrapping of some old vessels if the technical regulations are initiated in 2021. Today there are 16 vessels without closed systems and with a size below 750 M3. A majority of these vessels are also owned by small, independent companies without the financial strength to reinvest in new equipment and extension of the vessel.

This will lead to a reduction of the fleet size, which will especially gain the larger shipowners. To what extent the effect this will have on the technical overcapacity is uncertain, but it will lead to a change of the current situation.

9.4.3 Newbuilds

The future fleet must adapt to the changes in the aquaculture industry. Several projects, with the intention of coping with the lice-problems, are initiated. Such projects are Hydrolicer, Termolicer, fresh water treatment, SkaMik, wrasse and The Egg. These are all trying to reduce the lice problems in different ways. There is also an increase in service vessels that can perform treatment on the salmon. The newest contributions to the LFC fleet are purpose built to handle delicing processes effectively. It could be argued that the newbuilds are too technical and expensive, when their main purpose is to transport live salmon. This could reduce the investment costs and financial risk for the shipowners, as well as the freight rates.

Marine Harvest have showed interest in in a new type of vessel. Slaughter-vessel is a new concept which will not only transport the grown salmon to shore but slaughter the salmon during the trip. This would consequently increase the efficiency of the salmon production value chain, and impose a threat to the operations of LFCs. The in-house capacity can be used as a bargaining power when negotiating the freight rates of charter contracts with external shipowners. How efficient these vessels will be is still uncertain. However, it represents a willingness for change and innovation.

A new possibility for salmon production is to locate the grow-out centers in the ocean, instead of along the coastline. Ocean farms will require new types of LFC, with bigger and more robust hull and with dynamic position systems. The increase in size to the present fleet may be a preparation for these new trends.

In the Paris-agreement, the shipping industry was excluded from the emission reduction (OECD Insight, 2016). The propulsion of a LFC vessel today is mostly driven by diesel oil. In the future, there is several alternatives to the traditional fuel. LNG or hydrogen is commercial solutions available today, but the lack of infrastructure is setting a constraint for the LFC fleet. There is likely that the LFC fleet will be driven by alternative energy sources, such as LNG or hybrid solutions in the future.

9.4.4 Market Transparency

In the LFC industry the information flow is limited, with freight rates traded under the table and limited information regarding customers and operations. Market transparency can be divided into three parts, operational, financial and environmental transparency.

Operational transparency refers to the openness regarding operations the LFC preform on a daily basis. In 2016 all the LFC was regulated by Norwegian authorities to transmit their position (AIS) and status on the valve on board the vessel. This will automatically introduce more transparency to other stakeholders. Regulatory demands of AIS data could be used to analyze the market and make a better basis for decision making.

Financial transparency refers to the openness regarding the costs and revenues for the shipowners. Since the companies are non-listed, limited financial information is available to the public.

With an increased environmental focus both form the government but also the aquaculture industry, the pressure increase regarding openness of the environmental effects of using a LFC. As the LFC has reduced the use of H_2O_2, they have already taken action towards a more environmental friendly approach. The information flow regarding their actions is non present, and may be a strategy for the shipowners.

10. Conclusion

The purpose of this thesis has been to investigate the Norwegian LFC fleet in regards to capacity, utilization and investments. After an introduction of the relevant dynamics of aquaculture and the LFC industry, we start the concluding remarks of the thesis in the respective order.

An observed demand surplus in the LFC market is present from 2005 to 2016. The M3-capacity of the fleet has increased exponentially starting in 2013. The demand of LFC services, in M3-equivalents, have been relatively stable since 2011. The market seems to stabilize with the substantial capacity entering the market in 2017.

The LFC fleet is not efficiently operated from a theoretical view. Utilization of vessels differs in regards to age, size and ownership. G3 classed vessel’s operational patterns and technicalities are imposing a biological risk.

It is rational to operate and invest in the LFC market. Shipowners financial returns are high, while the term structure of the contracts imposes little risk. The NPV of ship investments are not to a large degree sensitive to freight rate changes.

It seems that the relative capacity change does not impose a concern for the shipowners in the short run. The investments in vessels are secured with long term contracts with salmon producers. In the long run, more efficient utilization, market transparency and more capacity in the market could impose increased competition among the participants. This could potentially change the market structure.

We believe that there not a mismatch between the capacity, utilization and investments, in the present market state. However, future regulations of the industry, market and the environment may challenge the financial incentives and create a mismatch.

There are some noteworthy limitations in our analysis. We experienced that the LFC market is a challenging segment to analyze, due to lack of information and market transparency. Modelling the supply and demand, we were unable to convert diseases into M3-equivalents due to inconsistency of data. The supply side of the model could be biased due to limited information regarding phased out vessels. The AIS data does not cover the entire fleet, and the financial data is standardized.

Finally, we acknowledge that further research from academia could be performed on three specific aspects. First, the factors affecting the supply of LFC carriers. Second, further operational research on the fleet, when labelled positional data is available in line with regulations. Third, a real option approach on the investment decision of a new vessel. With this paper, we hope to lay the foundation for further analysis.

11. Appendix 1: Survey Question

11.1 Appendix 1: Survey Question to Salmon Producers

Question	**Answer form**
What do you think about the level of LFC freight rates?	Range (1 – 5)
How satisfied are you with the services provided by the LFC companies?	Range (1 – 5)
Is there available capacity to yours demand?	Range (1 – 5)
Assess **price** at your LFC provider	Range (1 – 5)
Assess **capacity** at your LFC provider	Range (1 – 5)
Assess **treatment of biomass** at your LFC provider	Range (1 – 5)
Assess **operation knowledge** at your LFC provider	Range (1 – 5)
Assess **technological services** at your LFC provider	Range (1 – 5)
Assess **environmental treatment** at your LFC provider	Range (1 – 5)
How does the future look of the aquaculture sector?	Range (1 – 5)

11.2 Appendix 1: Survey Question to Shipowners

Question	**Answer form**
What do you think about the level of LFC freight rates?	Range (1 – 5)
Is your fleet being optimally used by the salmon producer?	Range (1 – 5)
How does the future look of the LFC industry?	Range (1 – 5)
What is your biggest cost driver?	Short answer
How many operations/trips have 1 vessel a month?	Short answer

12. Appendix 2 – FCF & NPV

Figure 5 shows an example of the FCF calculation with a freight rate of 3000 NOK in 25 years. This exercise is done for 5 price-cases. Figure 5 only shows five years, but the calculation is performed in 25 years.

NPV - Rate = 3000 NOK	3000					
	0 %					
	3 000	1	2	3	4	5
Sales		26 280 000	26 280 000	26 280 000	26 280 000	26 280 000
Cost of goods sold		10 379 774	10 379 774	10 379 774	10 379 774	10 379 774
Gross profit		**15 900 226**	**15 900 226**	**15 900 226**	**15 900 226**	**15 900 226**
Selling, general and admistrative		- 8 241 097	- 8 241 097	- 8 241 097	- 8 241 097	- 8 241 097
Research and development		-	-	-	-	-
Depreciation		-12 000 000	-12 000 000	-12 000 000	-12 000 000	-12 000 000
EBIT		**19 659 129**	**19 659 129**	**19 659 129**	**19 659 129**	**19 659 129**
Income tax at 27%		- 5 307 965	- 5 307 965	- 5 307 965	- 5 307 965	- 5 307 965
Unlevered net income		**24 967 094**	**24 967 094**	**24 967 094**	**24 967 094**	**24 967 094**
Depreciation		12 000 000	12 000 000	12 000 000	12 000 000	12 000 000
FCF		**36 967 094**	**36 967 094**	**36 967 094**	**36 967 094**	**36 967 094**
PV of FCF	**456 585 322**	34 730 453	32 629 136	30 654 957	28 800 223	27 057 706
Scrap Value	**3 151 154**					
NPV	**156 585 322**					

Figure *4: FCF calculation for different price range*

Figure 6 shows the calculation of the accumulated FCF. The first matrix shows the calculated FCF in each year, while the second matrix shows the increase in the FCF. 3500/4500R is the freight rate with an 1 % decrease each year.

Freigth rate	**0**	**1**	**2**	**3**	**4**	**5**
2000		24 278 367	22 809 439	21 429 387	20 132 832	18 914 724
2500		29 504 410	27 719 288	26 042 172	24 466 528	22 986 215
3000		34 730 453	32 629 136	30 654 957	28 800 223	27 057 706
3500		39 956 496	37 538 985	35 267 742	33 133 918	31 129 198
4000		45 182 538	42 448 834	39 880 528	37 467 613	35 200 689
4500		50 408 581	47 358 682	44 493 313	41 801 309	39 272 180
4500R		50 408 581	46 916 796	43 663 011	40 631 211	37 806 443
3500R		39 956 496	37 195 296	34 621 952	32 223 842	29 989 180
SUM						
2000		24 278 367	47 087 806	68 517 193	88 650 025	107 564 749
2500		29 504 410	57 223 698	83 265 869	107 732 397	130 718 612
3000		34 730 453	67 359 589	98 014 546	126 814 769	153 872 475
3500		39 956 496	77 495 480	112 763 223	145 897 141	177 026 338
4000		45 182 538	87 631 372	127 511 899	164 979 513	200 180 202
4500		50 408 581	97 767 263	142 260 576	184 061 885	223 334 065
4500R		50 408 581	97 325 377	140 988 388	181 619 599	219 426 042
3500R		39 956 496	77 151 791	111 773 743	143 997 585	173 986 766

Figure 5: *Calculation of the accumulated FCF*

Figure 7 shows the NPV calculation for all the price ranges and continues for 25 years.

Year	0	1	2	3	4	5
Investment cost						
2000	- 300 000 000	- 275 721 633	- 252 912 194	- 231 482 807	- 211 349 975	- 192 435 251
2500	- 300 000 000	- 270 495 590	- 242 776 302	- 216 734 131	- 192 267 603	- 169 281 388
3000	- 300 000 000	- 265 269 547	- 232 640 411	- 201 985 454	- 173 185 231	- 146 127 525
3500	- 300 000 000	- 260 043 504	- 222 504 520	- 187 236 777	- 154 102 859	- 122 973 662
4000	- 300 000 000	- 254 817 462	- 212 368 628	- 172 488 101	- 135 020 487	- 99 819 798
4500	- 300 000 000	- 249 591 419	- 202 232 737	- 157 739 424	- 115 938 115	- 76 665 935
Zero		0	0	0	0	0
4500R	- 300 000 000	- 249 591 419	- 202 674 623	- 159 011 612	- 118 380 401	- 80 573 958
3500R	- 300 000 000	- 260 043 504	- 222 848 209	- 188 226 257	- 156 002 415	- 126 013 234

Figure 6*: Development of the NPV with different price range*

13. References

Adland, R., Cariou, P. & Francois-Charles, W., 2016. The Influence of charterers and owners on bulk shipping freight rates. pp. 69-82.

Adland, R. & Jia, H., 2014. *Shipping market inegration: The case of sticky newbuilding prices,* s.l.: Norwegian School of Economics (NHH).

Berk, J. & DeMarzo, P., 2014. *Corporate Finance.* Third Edition ed. s.l.:Pearson Education Limited.

Bjørndal, T. et al., 2011. Operation research in the natural resource industry. *International transactions in operational research,* 19(1-2), pp. 1-24.

Bratberg, E., 1974. *Lover og forskrifter av betydning for oppdrettsnæringen,* Bergen: Fiskeridirektoratets Havforskningsinstitutt.

Bravo, F. et al., 2013. Mathematical models for optimizating production chain planning in salmon farming. *International transactions in operational research,* 20(5), pp. 731-766.

Brønnbåteiernes Forbund, 2016. *Oversikt over Norsk Brønnbåt flåte,* Trondheim: Jan Harald Hauvik.

Cho, C. & Bureau, D., 1998. Development of bioenergetic models and the fish-prfeq sofeware to estimate production, feeding ration and waste output in aquaculture. *Aquatic Living Resources,* 11(4), pp. 199-210.

Clarksons, 2016. *Glossary Spot market.* [Online]
Available at: http://www.clarksons.com/glossary/
[Accessed 20 10 2016].

Damodaran, A., 2007. *Return on Capital (ROC), Return on Invested Capital (ROIC) and Return on Equity (ROE): Measurement and Implications.* [Online]
Available at: http://people.stern.nyu.edu/adamodar/pdfiles/papers/returnmeasures.pdf
[Accessed 23 10 2016].

Drobetz, W., Gounopoulos, D., Merikas, A. & Schröder, H., 2013. Capital structure decisions of globally-listed shipping companies. *Transportation research*, Issue Part E 52, pp. 49 - 76.

Epsmark, Å. M., 2015. *Smoltpumping og storfiskpumping - med fokus på velferd,* Sundalsøra: Nofima.

Fishpool, 2016. *FPI weekly details.* [Online]
Available at: http://fishpool.eu/price-information/spot-prices/weekly-details/
[Accessed 4 10 2016].

Fiskeridirektoratet, 2012. *For stor merd eller for mange fisk?,* s.l.: Fiskeridirektoratet & Mattilsynet.

Fiskeridirektoratet, 2015. *Settefisk.* [Online]
Available at: http://www.fiskeridir.no/Akvakultur/Tildeling-og-tillatelser/Kommersielle-tillatelser/Laks-oerret-og-regnbueoerret/Settefisk
[Accessed 29 11 2016].

Fiskeridirektoratet, 2016. *Akvakulturstatistikk (tidsserier).* [Online]
Available at: http://www.fiskeridir.no/Akvakultur/Statistikk-akvakultur/Akvakulturstatistikk-tidsserier
[Accessed 29 11 2016].

Forskrift om lakselusbekjempelse, 2012. *Forskrift om bekjempelse av lakselus i akvakulturanlegg.* [Online]
Available at: https://lovdata.no/dokument/SF/forskrift/2012-12-05-1140#KAPITTEL_1
[Accessed 4 12 2016].

Forskrift om transport av akvakulturdyr, 2008. *Forskrift om transport av akvakulturdyr.* [Online]
Available at: https://lovdata.no/dokument/SF/forskrift/2008-06-17-820
[Accessed 04 09 2016].

Ghauri , P. & Gronhaug, K., 2010. *Research Methods in Business Studies.* Foruth Edition ed. s.l.:Finanical Times Prentice Hall.

Gorton, L., 2010. *Volume Contracts of Affreightment – Some Features and Principles.* [Online]
Available at: http://www.scandinavianlaw.se/pdf/46-3.pdf
[Accessed 5 11 2016].

Harvard Business Review, 2008. The Five Competitive Forces That Shape Strategy. *Harvard Business Review*, 01.

Hegnar, 2016. *Børs og finans/ anslår enda flere døde laks i Chile.* [Online]
Available at: http://www.hegnar.no/Nyheter/Boers-finans/2016/03/Anslaar-enda-flere-doede-laks-i-Chile
[Accessed 10 10 2016].

Holm, J. C., 2007. *Fiskeridirektoratets anbefalinger vedrørende områder,* s.l.: Fiskeridirektoratet.

Ilaks, 2016. *Nykontrahert Marine Harvest-båt slakter 100 tonn i timen.* [Online]
Available at: http://ilaks.no/ny-kontrahert-marine-harvest-bat-slakter-100-tonn-i-timen/
[Accessed 15 11 2016].

IMO, 2016. *AIS Transponders.* [Online]
Available at: http://www.imo.org/en/OurWork/safety/navigation/pages/ais.aspx
[Accessed 7 11 2016].

Investopeida, 2016. *Terms/Real Options.* [Online]
Available at: http://www.investopedia.com/terms/r/realoption.asp
[Accessed 23 11 2016].

Jakobsen, S. & Aarset, B., 2007. *På en skyfri dag kan du se helt til Brussel. Om EUs innflytelse på norsk akvakulturpolitikk.* Bergen: Fagbokforlaget.

Johnson, G., Scholes, K. & Whittington, R., 2005. *Exploring Corporate Strategy.* Seventh ed. Essex: Prentice Hall.

Kleven Verft, 2016. *Kleven Verft - Foretningsmodell,* Bergen: Kjersti Kleven.

Kyst.no, 2016. *Kyst.no/fartøy.* [Online]
Available at: http://kyst.no/nyheter/tror-det-raskt-voksende-servicebat-segmentet-kan-fore-til-overkapasitet/
[Accessed 03 12 2016].

Laksefakta, 2016. *HAR LAKSEN DET BRA I OPPDRETTSANLEGGENE?.* [Online]
Available at: https://laksefakta.no/lakseoppdrett-i-norge/har-laksen-det-bra-i-oppdrettsanleggene/
[Accessed 20 November 2016].

Lusedata, 2016. *Lusedata i Excel.* [Online]
Available at: http://lusedata.no/statistikk/excel/

Marine Harvest, 2012. *Salmon Farming Industry Handbook 2012,* Bergen: Marine Harvest.

Marine Harvest, 2016. *Marine Harvest Industry Handbook 2016.* [Online]
Available at: http://hugin.info/209/R/2023118/751659.pdf
[Accessed 23 08 2016].

Marine Traffic, 2016. *Marinetraffic/What is AIS.* [Online]
Available at: https://shop.marinetraffic.com/what-is-ais
[Accessed 7 11 2016].

McKinsey, 2011. *Report McKinsey Global Institute.* [Online]
Available at: http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/big-data-the-next-frontier-for-innovation
[Accessed 7 11 2016].

Norges Sjømatråd, 2016. *Laks og ørret for 50 milliarder i 2015.* [Online]
Available at: http://www.seafood.no/Nyheter-og-media/Nyhetsarkiv/Pressemeldinger/Laks-og-%C3%B8rret-for-50-milliarder-i-2015
[Accessed 02 10 2016].

Norman, V. D., 1980. Organization of the Tanker Market. *Supply and Demand of Water transport*.

Norwegian Ministry of Fisheries and Costal Affairs, 2008. *Strategy for a Competitive Norwegian aquaculture industry,* Oslo: Ministry of Fisheries and Coastal Affairs.

Norwegian Veterinary Institute (a), 2016. *Pankreassykdom.* [Online]
Available at: http://www.vetinst.no/sykdom-og-agens/pankreassykdom-pd
[Accessed 10 10 2016].

Norwegian Veterinary Institute (b), 2016. *Infeksiøs Lakseanemi - utbrudd og statestikk.* [Online]
Available at: http://www.vetinst.no/oppdrettsfisk/infeksis-lakseanemi-ila
[Accessed 10 10 2016].

Norwegian Veterinary Institute (c), 2016. *Lakselus.* [Online]
Available at: http://www.vetinst.no/sykdom-og-agens/lakselus
[Accessed 10 10 2016].

OECD Insight, 2016. *OECD Insight / discussion.* [Online]
Available at: http://oecdinsights.org/2016/05/04/carbon-emissions-all-at-sea-why-was-shipping-left-out-of-the-paris-climate-agreement/
[Accessed 3 12 2016].

Øglend, A., 2010. *An Analysis of Commodity Price Dynamics with Focus on the Price of Salmon,* Stavanger: University of Stavanger.

one, d. t., n.d. s.l.: s.n.

Proff.no, 2016. *The business finder/Search.* [Online]
Available at: http://www.proff.no
[Accessed 15 08 2016].

Regjeringen, 2014. *Fastsetter krav til fremtidens brønnbåter.* [Online]
Available at: https://www.regjeringen.no/no/aktuelt/Fastsetter-krav-til-fremtidens-bronnbatflate/id757376/
[Accessed 01 11 2016].

Regjeringen, 2015. *Bærekraftig og forutsigbar vekst for laks.* [Online]
Available at: https://www.regjeringen.no/no/aktuelt/barekraftig-og-forutsigbar-vekst-for-laks/id2401801/
[Accessed 05 11 2016].

Regjeringen, 2016. *Regjeringen.no - Skattesatser 2016.* [Online]
Available at: https://www.regjeringen.no/no/tema/okonomi-og-budsjett/skatter-og-avgifter/skattesatser-fradrag-og-belopsgrenser-i-2016/id2457143/
[Accessed 23 11 2016].

Rosbach, M., 2015. *Sundmørsposten / Sølvtrans bygger ny brønnbåt lokalt.* [Online]
Available at: http://www.smp.no/naeringsliv/article11620804.ece
[Accessed 20 11 2016].

Skår Hosteland, L. T., 2016. *Kyst.no / Nyheter.* [Online]
Available at: http://kyst.no/nyheter/norsk-fisketransport-kontraherer-ny-bronnbat/
[Accessed 30 08 2016].

Solvtrans, 2016. *solvtrans - about - technology.* [Online]
Available at: http://www.solvtrans.no/about/technology
[Accessed 12 11 2016].

Sounders, M., Lewis, P. & Thornhill, A., 2012. *Research Methods For Business Students.* 6th ed. Essex: Pearson Education Limited.

Sparebank 1 Markets, 2016. *Investing in Wellboats,* s.l.: Sparebank 1 Markets.

SSB, 2016. *Akvakultur.* [Online]
Available at: www.ssb.no/fiskeoppdrett
[Accessed 08 10 2016].

SSB, 2016. *Eksport av laks, uke 43 2016.* [Online]
Available at: https://www.ssb.no/utenriksokonomi/statistikker/laks
[Accessed 4 11 2016].

Stopford, M., 2009. *Maritime Economics.* 3rd ed. London: Routledge.

Store norske leksikon, 2009. *Brønnbåt.* [Online]
Available at: https://snl.no/br%C3%B8nnb%C3%A5t

Store norske leksikon, 2015. *Laks.* [Online]
Available at: https://snl.no/laks
[Accessed 20 09 2016].

Sysla, 2015. *Sysla Maritim.* [Online]
Available at: http://maritime.no/marked/solvtrans-kjoper-bomlo-bronnbatservice/
[Accessed 25 08 2016].

Sysla, 2016. *Nå er en laks verdt mer enn et fat olje.* [Online]
Available at: http://sysla.no/2016/01/12/havbruk/na-er-en-laks-verdt-mer-enn-et-fat-olje_73418/
[Accessed 05 10 2016].

SYSLA, 2016. *SYSLA.* [Online]
Available at: http://sysla.no/2016/09/09/havbruk/tror-det-blir-for-mange-bronnbater-i-2017_150952/
[Accessed september 2016].

The Norwegian Food Safety Authority, 2016. *Fakta om lakselus og lakselusbekjempelse.* [Online]
Available at:
http://www.mattilsynet.no/fisk_og_akvakultur/fiskehelse/fiske_og_skjellsykdommer/lakselus/fakta_om_lakselus_og_lakselusbekjempelse.23766
[Accessed 10 10 2016].