Incumbent Behaviour and Disruptive Innovation in The Norwegian Aquaculture Industry

Thomas Walker

Dissertation written under the supervision of Peter Rajsingh

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Abstract

Title: Incumbent Behaviour and Disruptive Innovation in The Norwegian Aquaculture Industry

Author: Thomas Hilding Valstad Walker

Since the early days of salmon farming, it has only been possible to cultivate Atlantic salmon at particular locations. Salmon farming requires certain specific ecological conditions such as water temperatures between 0-20 °C and the flow of currents to let the salmon roam freely. (MOWI, 2019).These conditions usually occur in waters with the protection of fjords and archipelagos and are generally found in parts of the northern or southern hemisphere (MOWI, 2019). The combined coastline of mainland Norway with its various islands stretches over 102 936 km across the northern hemisphere. Fulfilling necessary conditions, Norway has established itself as the biggest producer of salmon in the world (Kartverket [Norwegian Mapping Authority], 19; Hoel & IBM, 2018). Therefore, the Norwegian coastline possesses a significant competitive advantage. However, advances in land-based aquaculture technology could disrupt the industry and render this competitive advantage less relevant.

This study investigates what strategic actions are being taken by the Norwegian Aquaculture Industry (NAI) with regards to Land-Based Salmon farming (LBSF) and seeks to understand how incumbents view LBSF. The working hypothesis posits that LBSF is a potentially disruptive technology and that the industry has fallen victim to *The Innovator's Dilemma* (TID).

The findings in this dissertation demonstrate that risk averse behaviour as Christensen (1997) pointed out, can stymie corporate strategy and this appears to be true for decision makers in the NAI. The findings further indicate that the incumbents in the NAI will only make strategic moves when LSBSF have validated and scaled their methods of production. LSBSF may not need an urgent response in the short term, but it is a development that needs to be closely monitored by incumbent firms.

Keywords: Disruptive innovation; sustaining innovation; the innovator´s dilemma; land-based aquaculture; farmed Atlantic salmon.

Resumo

Title: Comportamento Inquieto e Inovação Perturbadora na Indústria Aquícola Norueguesa

Author: Thomas Hilding Valstad Walker

Desde os primeiros dias da pecuária de salmão em cativeiro, só tem sido possível cultivar salmão Atlântico em localizações específicas. A pecuária de salmão em cativeiro requere certas condições ecológicas específicas, tal como temperatura da água entre os 0 e os 20ºC, e o fluxo de corrente para que os salmões nadem livremente (MOWI, 2019). Estas condições normalmente verificam-se em águas protegidas por fjords e arquipélagos e são geralmente encontradas em partes do hemisfério norte ou sul (MOWI, 2019). A linha costeira da Noruega com as suas várias ilhas alonga-se por mais de 102 936 km no hemisfério norte. Cumprindo com as condições necessárias, a Noruega estabeleceu-se como o maior produtor de salmão no mundo (Kartverket [Norwegian Mapping Authority], 19; Hoel & IBM, 2018). Por isso, a linha costeira norueguesa possui uma significativa vantagem competitiva. No entanto, avanços na tecnologia de aquacultura terrestre podem perturbar a indústria e tornar esta vantagem competitiva menos relevante.

Este estudo investiga que ações estratégicas estão a ser tomadas pela Indústria Norueguesa de Aquacultura (NAI) em relação à Pecuária Terrestre de Salmão (LBSF), e procura entender como é que as empresas incumbentes veem a LBSF. A hipótese de trabalho propõe que a LBSF é uma tecnologia potencialmente disruptiva e que a indústria é vítima do *Dilema do Inovador* (TID).

As descobertas desta dissertação demonstram que o comportamento de aversão ao risco como o Christensen (1997) indicou, pode entravar a estratégia corporativa e isto parece ser verdade para decisores na NAI. As descobertas indicam ainda que as incumbentes na NAI apenas farão decisões estratégicas quando a LBSF tiver validado e escalado os seus métodos de produção. A LSBSF pode não precisar de uma resposta urgente no curto-prazo, mas é um desenvolvimento que precisa de ser monitorizado de perto pelas empresas incumbentes.

Palavras-chave: Inovação disruptiva; inovação sustentável; o dilema do inovador; aquicultura em terra; salmão do Atlântico de viveiro.

Acknowledgments

I would never have imagined one year ago that when writing these bittersweet words – the world would be experiencing the pandemic of COVID – 19 and I have been limited to my boyhood room instead of walking through the streets of Bairro Alto. Yet it is the culmination of my academic life and here I stand, ready to disembark on a new journey of uncertainty.

I want to express gratitude to my dissertation supervisor and mentor Peter Rajsingh, a man I have great respect for. I thank him for not only the significant amount of time he has dedicated to guide and help me through this endeavour, but also for him teaching the value of language. Words should be connected with meticulously precession and I apologize for all the elliptical sentences I have put him through.

To all those I have shared valuable time, through group-work, lectures, debates, late night studies (and parties) I thank you and say, our adventure has just begun and I look forwards to this next chapter in life. Not as students facing the struggles of mid-terms and dissertation deadlines but as professionals. For my time in Portugal, I must give homage to the *"Tequila squad"* whom I travelled with across the country and cheered on Benfica as they won the league. In Brazil, it's my flat mates who I shared the majestic apartment of Rua Do Russel with that I am indebted for all the great memories. My academic life would not have been the same without all of you and there some who deserve special recognition. The decision to study at Catolica Lisbon School of Business & Economics would probably never have happened had it not been for my best of friends Thomas Evensen, and finally I would like to thank my family who I have been extremely fortunate to have in my life, for the eternal support and guidance I am truly grateful.

TABLE OF CONTENTS

Table of Figures

Table of Tables

LIST OF ABBREVIATIONS

CA – Competitive Advantage

DI – Disruptive Innovation

ESG – Environmental, Social and Governance

FAO – Food and Agriculture Organization of the United Nations

FTS – Flow-Through Systems

HTME – High-Technology Manufacturing Environments

IBM – International Business Machine

ISFA – International Salmon Farmers Association

LBA – Land-Based Aquaculture

LBSF – Land-Based Salmon Farming

MAB – Maximum Allowed Biomass

NAI – Norwegian Aquaculture Industry

OE – Operational Efficiency

PE – Private Equity

PS – Problem Statement

RAS – Recirculating Aquaculture Systems

RBV – Resource-Based View

RQ – Research Questions

SCA – Sustainable Competitive Advantage

SDG – Sustainable Development Goals

SI – Sustaining Innovation

TID – The Innovators Dilemma

UN – United Nations

Chapter 1.0: Introduction

We are currently facing two major challenges in the world: we must feed a growing world population and simultaneously reduce our carbon footprint (United Nations [UN], 2019). According to the UN, by 2050, there will be 9.7 BN people on this planet (UN, 2019). Not only is the Earth becoming more populated, but the average lifespan is also increasing (UN, 2019). Thus, we must increase our levels of food production on a planet already experiencing a scarcity of resources (UN, 2019).

Oceans cover seventy percent of the earth's surface, however, approximately only 17% of proteins that are consumed by humans derive from fish (MOWI, 2019). This ratio could change in the future, and the UN estimates that we must double our protein production in order to meet future demand (FAO, 2013). The majority of wild fish stocks are fished closed to capacity, so the growth in much needed animal protein cannot solely stem from this source (FA0, 2018). Therefore, harnessing aquaculture could close the gap between supply and demand of animal protein in the future (FA0, 2018). Atlantic farmed salmon is a solution. Nevertheless, there are many challenges such as sea lice, diseases, escaped farmed salmon and the inefficient usage of fishmeal, associated with the practice of aquaculture today (FA0, 2018). Throughout this paper, whenever salmon is mentioned, the term refers to Atlantic salmon.

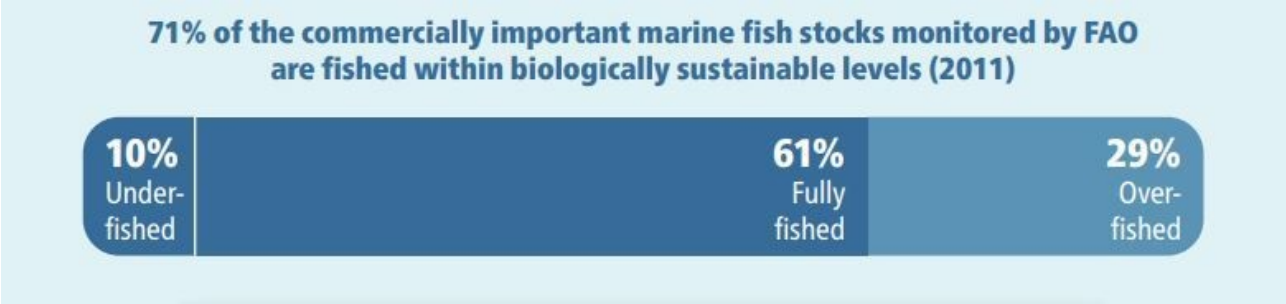

Figure 1**:** *An overview of the utilization of world fish stocks (FAO; State of The World Fisheries & Aquaculture, 2018).*

"Nearly 90% of the worlds marine fish stocks are now fully exploited, overexploited or depleted"
Food and Agriculture Organisations of the United Nations 2018

1.1 Background

The salmon farming industry plays a vital role in the world. In 2017, it contributed 17.5 Bn in protein-rich meals, employed 132,600 people and had a production value of $15.4 Bn USD (ISFA, 2018). Of this the Norwegian Aquaculture Industry (NAI) produced in 2018 1,28 M tons of salmon, equalling roughly 50% of the world's production, of which 95% was exported for a value of 7 Bn Euro (Statistisk Sentralbyrå [Statistics Norway], 2019; Hoel & IBM, 2018).

The Norwegian government has an ambition of becoming the world's leading seafood nation aiming to produce 5 M tons of sustainable aquaculture by 2050. (Fiskeri - og Kystdepartment [The Norwegian Ministry of Fisheries], 2013). This means quadrupling current production levels. However, since reaching the production levels of 2012 at 1,23 M tons, the industry has not been able to continue its steady growth. The NAI faces challenges such as sea lice and diseases outbreaks along the coast. With fish welfare being a priority, the Norwegian Minister of Fisheries stated in 2017 that no further growth in biomass would be allowed until the industry can handle its biological challenges. To this end, a governmental traffic light policy was introduced to control industry growth where an environmental indicator determines regions allowed to grow or made to decrease production (P, Sandberg, 2017).

In the era of climate change, farmed salmon is a climate-friendly rich protein source (Ernst & Young, 2019). In light of the Paris agreement 2016 and the UN´s sustainable development goals (SDG's), the NAI has pledged that it will contribute towards achieving eight of the seventeen SDG´s, even going as far as stating *"The Norwegian aquaculture industry will represent Norway´s most important contribution to achieving the UN´s SDG´s"* (The Norwegian Seafood Federation, 2019). Salmon farming satisfies several criteria for being more environmentally friendly; high utilization of resources, highest protein retention compared to chicken, pork and cattle (see table 1), carbon friendly (see table 1) and requires little space to be farmed (MOWI, 2018).

Table 1: *Comparison of carbon emissions between farmed salmon and other meat industries (MOWI, 2018).*

				
Protein Retention	31 %	21 %	18 %	15 %
Energy Retention	23 %	10 %	14 %	27 %
Edible Yield	68 %	46 %	52 %	41 %
Feed Convertion Ratio (FCR)	1.1	2.2	3.0	4-10
Edible Meat pr 100 kg fed	61 kg	21 kg	17 kg	4-10 kg
Carbon Footprint kg CO2/kg edible meat	2.9 kg	2.7 kg	5.9 kg	30 kg
Water Consumption litre/kg edible meat	2,000 litre (1)	4,300 litre	6,000 litre	15,400 litre

Furthermore, the above graph by the Coller FAIRR Initiative have established a protein producer index. The index assesses the environmental, social and governance (ESG) impact, and only includes meat, dairy and aquaculture producers. From the Coller FAIRR Protein Producer report (2019), five out of the top ten companies operate solely within aquaculture, where four are from the NAI, thus illustrating the ESG contribution from aquaculture (Coller FAIRR Initiative , 2019).

1.2 The Norwegian Aquaculture Industry

Fisheries have played an essential role in the development of Norwegian society. Exports of Norwegian seafood date back to the 12-century through the Hanseatic League, and today fisheries and aquaculture are one of the largest export sectors within Norway (Store Norske Leksikon [The Norwegian Encyclopaedia], 2020; Nærings - og fiskerdeprtementet[Norwegian Ministry of Fishery], 2011). Fisheries were for a long time the largest value creator in Norway, however, in recent years, the aquaculture industry surpassed fisheries with roughly 72% of export coming from farmed salmon (Norwegian Seafood Council, 2020).

1.2.1 A Brief History of salmon farming in Norway

The first salmon smolt (baby salmon), were released into sea pens in the late '60s by the brothers Grøntvedt, and in 1971 the first Norwegian farmed salmon was filleted (Store Norske Leksikon[The Norwegian Encyclopaedia], 2020). The brothers developed the first modern sea pens and laid the foundation for the modern salmon farming in Norway (The Norwegian Encyclopaedia, 2020). In 1972 a total of 146 tons of salmon where farmed, twenty years later the volume of farmed salmon stood at 123,138 tons. Since then, the industry has developed significantly, in 2016 farmed salmon stood for 16% of the export value from Norway (Statistisk sentralbyrå, 2017).

1.2.2 The Norwegian Aquaculture Industry Structure

Most farmed salmon on a world-wide basis comes from a few significant players, whereby the three largest producers are all Norwegian. Mowi is the industry leader harvesting 230,000 tons, followed by Salmar at 142,000 tons and Lerøy at 137,000 tons (MOWI, 2019). The consolidation of the industry into merely a few major players, happened in a short period, as data confirms. One hundred and forty-two companies reported harvests of farmed salmon in Norway in 2018, whereby the ten largest companies stood for 67,5%, compared to 32,8% in 2000 (Fiskerdirektoratet [Ministry of Fisheries], 2019).

Table 2: *Overview of the largest producers of farmed salmon worldwide, excluding Bakkafrost. Figures in geometric weight tons (MOWI, 2019).*

	Top 10 - Norway	H.Q.	Top 5 - United Kingdom	H.Q.	Top 5 - North America	H.Q.	Top 10 - Chile	H.Q.
1	Mowi	230,400	Mowi	38,400	Cooke Aquaculture	60,800	"New Aquachile" (Agrosuper)	109,000
2	Salmar	142,500	The Scottish Salmon Co.	29,900	Mowi	39,300	Mitsubishi / Cermaq	66,000
3	Lerøy Seafood	137,800	Scottish Seafarms	27,500	Mitsubishi / Cermaq	21,800	Salmones Multiexport	64,800
4	Mitsubishi / Cermaq	57,400	Cooke Aquaculture	21,600	Grieg Seafood	16,600	Mowi	53,200
5	Grieg Seafood	46,100	Grieg Seafood	11,900	*		Blumar	47,600
6	Nova Sea	37,900	*				Camanchaca	43,600
7	Nordlaks	36,100					Australis Seafood	34,500
8	Norway Royal Salmon	36,000					Ventisqueros	30,300
9	Sinkaberg-Hansen	27,500					Invermar	20,000
10	Alsaker Fjordbruk	26,000					Marine Farm	19,800
	Top 10	777,700	Top 5	129,300	Top 5	138,500	Top 10	449,000
	Others	350,400	Others	8,900	Others	10,200	Others	160,700
	Total	1,128,100	Total	138,200	Total	148,700	Total	609,700

1.2.3 Governmental Regulation of Salmon Farming in Norway

A commercial license is required, a process that is administered by the Ministry of Fisheries. The licenses are rarely allocated and were last allotted in 1985, 1989, 2002, 2003, and 2009 (Fiskedirektoratet [Ministry of Fisheries], 2019). There is a total of 1,041 licenses for salmon and trout, each license granting a firm four farming sites or if connected, six. Furthermore, each license costs around 15M Euro (MOWI, 2019). The standard maximal allowed biomass (MAB) per license

for a farming site is 780 tons, however, in the counties of Troms and Finnmark 945 tons are allowed (MOWI, 2019).

The Ministry of Fisheries promotes sustainability and fish welfare through "Green Licenses" (2013), development licenses (2015) and the traffic light system (2017) (MOWI, 2019; Fiskerdirektoratet [Norwegian Ministry of Fisheries], 2019). Forty-five green licenses were handed out in 2013, all with requirements of implementing new technology that contributes to a reduction of escaped salmon and sea lice. In 2015, development licenses were introduced to facilitate innovation. Temporary permits could be awarded for free too projects that involved substantial technological breakthroughs in solving environmental challenges. Eighteen projects have been approved (Norwegian Ministry of Fisheries, 2020). The traffic light system divides the coastline into 13 regions of production sites, where the level of sea lice determines if the MAB can be increased or decreased through designating each region with a colour; green, yellow, or red. Green areas can increase MAB by 6%. Yellow areas remain stable, and the red areas must decrease MAB by 6% (Norwegian Ministry of Fisheries, 2019). Every two years, a region is reassessed; in 2020, nine regions were given green zones, two yellow and two red (Norwegian Ministry of Fisheries, 2020).

In 2016 the Ministry of Fisheries removed the license fee from LBSF to decrease barriers to entry and stimulate investment. (Norwegian Ministry of Fisheries, 2016). The costs and risk of investing in LBSF are significantly higher than traditional sea pen farming, and the additional cost of a license would have hampered development of the industry and its ability to compete (Holm et al., 2015). LBSF can potentially solve problems related to sea lice, escaped salmon, and limited coastal waters (Holm et al., 2015).

1.2.4 Production cycle

The production cycle of salmon consists of four main phases: phase one , breeding eggs into fry in freshwater tanks and lasts up to 7 months, phase two, the fry goes through a process known as "smoltification", whereby the fish transforms into being suitable for saltwater, the smolt weighs 100-250 grams and takes up to 12 months from the egg was hatched (MOWI, 2019). Phase three post-smolt fish grows to around 250-1000 grams in a safe environment and phase four, post-smolt are transferred into sea pens until it reaches harvest size – generally around 4-6 kg (MOWI, 2019). The terminology used when the fish enter the grow out face is defined as "food fish". The entire process can take up to 18 months and after harvest, the site must be fallowed between 2-6 months, before a

new generation of post-smolt can be released into the sea pen (MOWI, 2019). It is important to highlight that the NAI utilizes land-based technology in the first parts of the production, however, there are currently no high-volume producers in the last stage that produce on land. This thesis focuses on this particular stage and the potentially disruptive technology that is available.

1.2.5 Challenges pertaining to the NAI

The salmon farming industry faces a variety of biological challenges; algae, diseases, organic waste, escaped salmon and sea lice. The annual fish health report (2019) issued by the Norwegian veterinary institute stated that 52,8 M salmon died and never reached the market, this equals to 16,2% of the total biomass, whereby the institute blamed sea lice for 83% of the mortality (Norwegian Veterinary Institutte, 2019).

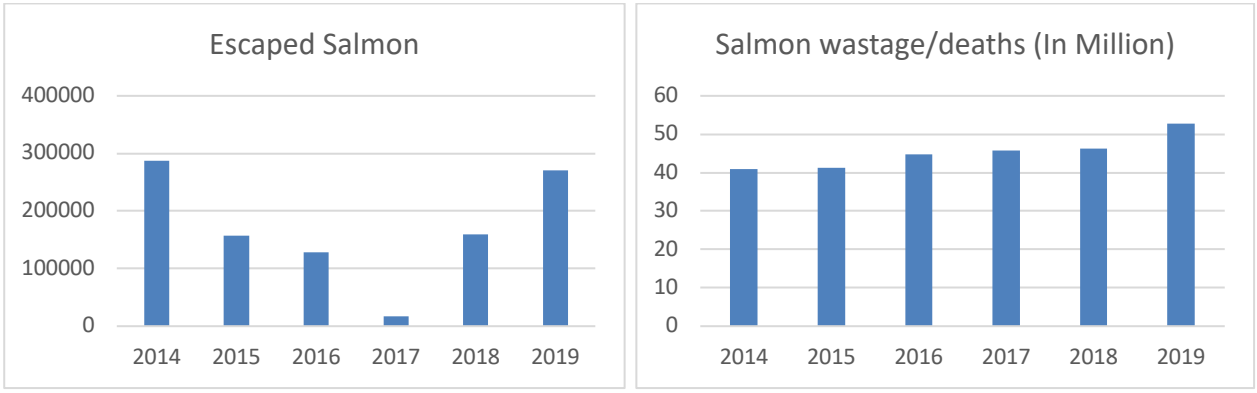

Figure 2: *Yearly overview of total escaped salmon and biomass that never reached the market (Statistics Norway, 2020; Norwegian Veterinary Institute, fish health report 2019).*

"*The greatest environmental challenges within the NAI are sea lice and escaped farmed salmon*"

Norwegian institute of Marine research – Risk report for Norwegian Aquaculture 2018

1.2.6 Sea lice

Sea lice are a natural parasite that attach to and feed off salmon when large enough numbers accumulate in sea pens. They cause wounds, weaken the salmons' immune systems and spread various diseases (Veterinærinstituttet [Norwegian Veterinary Institute], 2020). Costs related to sea lice are estimated at 5 Billion NOK (Nofima, 2019).

1.2.7 Escaped Salmon

Escaped farmed salmon pose two primary threats for wild salmon -- interbreeding and the spread of sea lice (Institute of Marine Research, 2018). Interbreeding over time can lead to genetic changes, thereby weakening the wild salmon stocks capability of adapting to environmental changes (Institute

of Marine Research, 2019). Genetic interference has been detected among 115 of 175 wild salmon stocks in Norway (Institute of Marine Research, 2018). Kevin Glover, the head of research at the Marine Institute, stated in 2019 that there is no doubt that escaped farmed salmon negatively impacts wild salmon stocks and that farmed salmon must be moved to closed pens (Dagens Næringsliv [Todays Business], 2017). Until the NAI can deal the salmon lice and escaped salmon problems, the government will not allow increasing production. Therefore, finding solutions towards such problems have substantial financial incentives.

"It cost the NAI 18 Billion NOK more in 2018 to produce virtually the same amount of biomass as compared to 2012, due to deceases, escaped salmon and salmon lice."

Lars Daniel Garshol (Todays Business, 2020).

1.3 Relevance

Sunday the 1st of March 2020 was a significant day for LBSF. A technical failure at one of Atlantic Sapphire's facilities led to an increased hydrogen sulphide in the water and consequently, 227 000 thousand salmon died within minutes. Although the salmon were insured, the negative press for Atlantic Sapphire, a leading LBSF company, was significant (Atlantic Sapphire AS, 2020).

Despite the global economy "Roaring Into Recession" as stated in a recent Goldman Sachs report, (Goldman Sachs, 2020), Salmon Evolution released in a press statement on the 23, March 2020 that they raised 258 million NOK for a land-based production site capable of producing 36 000 tons of salmon annually (Salmon Evolution, 2020).

1.4 Threat of entry

Porter (1979) describes five forces for understanding the competitive structure of an industry. (Porter M. , 1979). LBSF is a threat of new entrants for the NAI. Porter (2008) highlights that there are seven major barriers to entry which are supply-side economies of scale, demand-side benefits of scale, customer switching costs, capital requirements, incumbency advantages independent of size, unequal access to distribution channels and government restrictions.

Companies producing on a large scale can benefit from spreading fixed costs over a large amount of produced volume thus achieving *supply-side economies of scale* (Porter M. E., 2008). This is evident in the NAI, whereby the ten largest incumbents harvest, roughly 68% of the total output (MOWI,

2019). Furthermore, the salmon farming is capital intensive (MOWI, 2019), and capital investment in the NAI increased from 32 Billion NOK in 2009 to 83 billion NOK in 2017 (Nofima, 2019). Significant upfront investments are required to pay for licenses, production facilities and operating equipment combined with a production cycle that on average takes up to three years (MOWI, 2019). The industry being so capital intensive creates barriers to entry.

Companies in the NAI have *incumbency advantages independent of size.* Porter (2008) highlights how geographical location can create advantages that are not available for outsiders. As previously mentioned, the salmon farming industry is highly regulated and licenses are needed. However, land-based aquaculture (LBA) in Norway benefits from special licenses approved by local authorities and the Ministry of Fisheries (Ministry of Fisheries , 2015). Furthermore, *restrictive government policies* play an important role within the broader NAI, and, as previously mentioned, licenses are rarely allocated.

In sum, it is reasonable to state that there are high barriers to entry in the NAI and the threat of new entrants has been limited. But there are still incentives to enter the salmon farming industry. Compared to other meat products, the price of salmon has steadily increased over the years, becoming significantly higher than lamb, pork, beef or chicken (MOWI, 2018). Furthermore, the industry has high margins. In 2020 salmon prices were at 75 NOK per KG, roughly an 80% increase from the average price in 2013 (Fishpool, 2020).

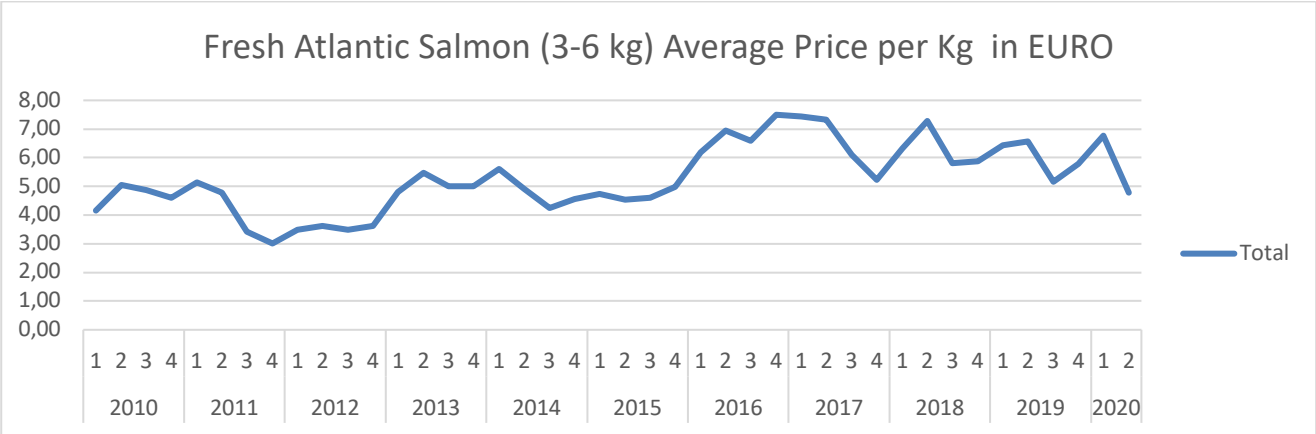

Figure 3: *Overview of the Atlantic Salmon price development* (Fishpool, 2020).

Despite challenges with sea lice, escaped salmon and production limitations from the government through the traffic light system, the NAI is still highly profitable.

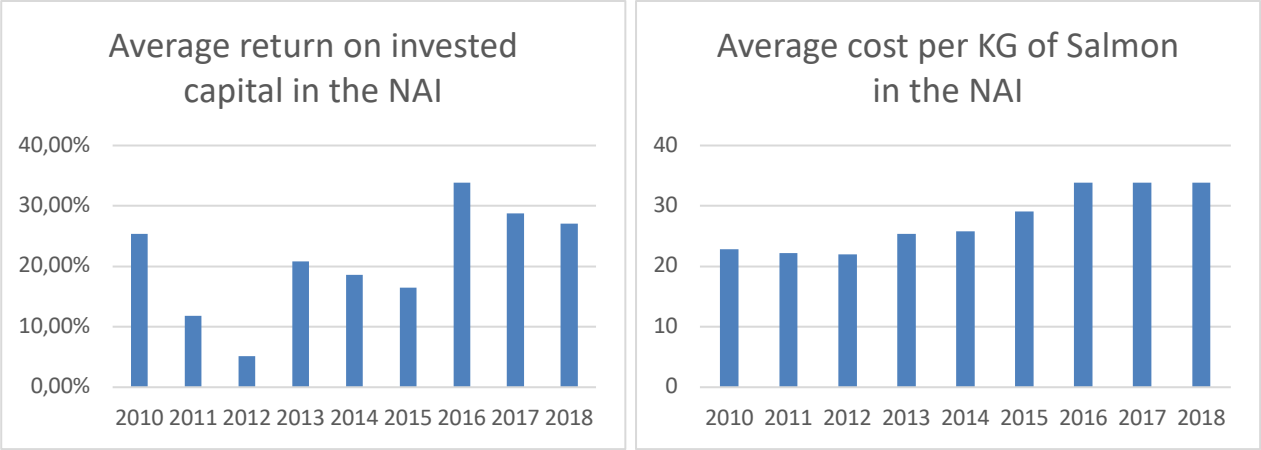

Figure 4: *An overview of profitability and cost development in the NAI since 2010. Costs are in NOK* (Norwegian Minstry of Fisheries, 2019).

It is of interest to test Christensen (1997) *"The Innovators Dilemma"* (TID) concept vis-à-vis the NAI. Given the barriers to entry, incumbents may well have become complacent with the status quo, downplaying the new threat of LBSF and thus not seeing the need for innovation. Atlantic Sapphire may have suffered a minor blow, but they are still pushing forward with their technology.

1.5 Problem statement

The purpose of this paper is to investigate how the Norwegian Aquaculture Industry views the phenomenon of land-based salmon farming. Do incumbents consider it a potential disruptive technology and threat, and if so, what strategic actions are being undertaken by major players in the NAI with regards to LBSF?

To facilitate in answering the above problem statement (PS), these research questions (RQ) have been developed to function as a guideline:

RQ1: Have decision makers in the NAI fallen victims of TID, investing in sustaining innovation and not the needed disruptive innovation?

RQ2: If the NAI acknowledge LBSF as a threat, then what strategic reactions are being undertaken in response?

RQ3: Who are the main drivers of LBSF and from where are the investments coming?

1.6 Research Methods

This thesis addresses the research questions conducting primary and secondary research. Primary research was sixteen qualitative interviews to understand how the NAI view LBSF, and to acquire insights into strategic actions being taken regarding LBSF.

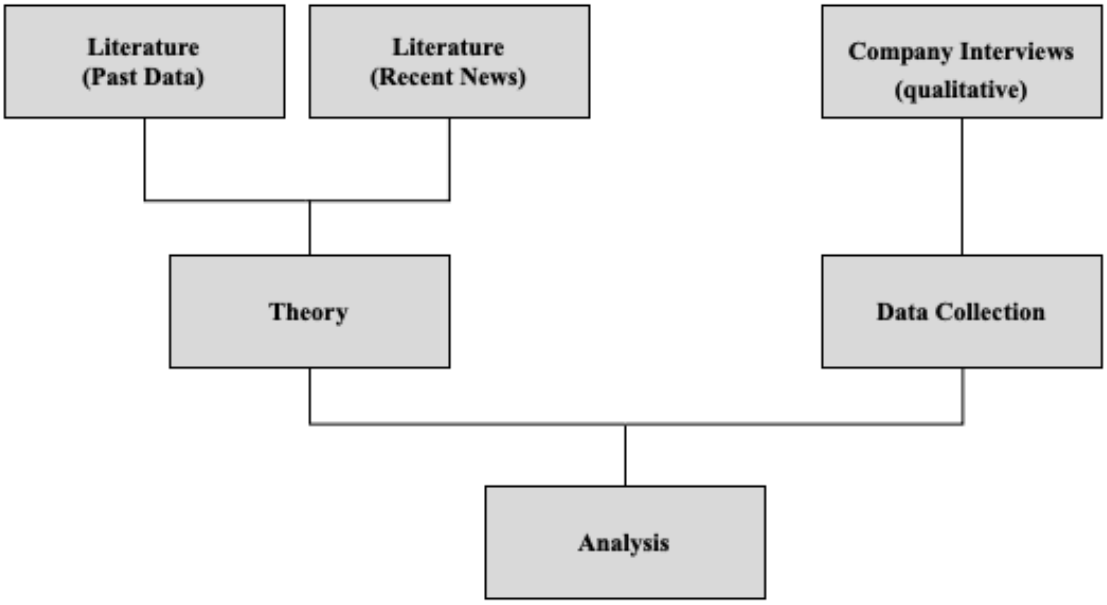

Figure 5*: Conceptual model of this dissertation.*

1.7 Dissertation Outline

This dissertation consists of six chapters. Chapter one: background and the context of the research questions, followed by a literary review that covers the important themes of this dissertation. Chapter three illustrates the research methodology undertaken before the data is analysed in Chapter four. Chapters five and six present the insights, results, conclusions, limitations and suggestions of further research.

Chapter 2.0: Literature review

Numerous articles deal with strategy, uncertainty and why companies either thrive or go under in the face of changing environments (Porter, 1985; Barney, 1991; Courtney et al., 1997). This review will cover the themes of Innovation, Organisational culture, TID, Strategy under Uncertainty, and LBSF technology. The primary focus will be on TID and strategy under uncertainty as these most bear upon the research questions.

The essence of TID is that sound logical decisions can also lead to the downfall of incumbent firms because they tend to privilege sustaining innovation (SI) which have greater visibility and profitability over disruptive innovation (DI). In 1998 Nobel Prize-winning Economist Paul Krugman stated, *"By 2005 or so, it will become clear the internet´s impact on the economy has been no greater than the fax machine´s"* (Paul Krugman, 1998). In hindsight, he could not have been more mistaken, and the point is that even experts cannot predict the future.

2.1 Management theory:

2.1.1 Innovation

There are a variety of different definitions for the word "innovation". One of the earliest definitions comes from Schumpeter in the 1920s who described innovation as *"doing things differently"* (Hanson & Tushman, 1997). The term has evolved and been ascribed many definitions such by Drucker (1985) *"innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service"* (Drucker, 1985, P. 49).

In this thesis, the focus is on a change of production methods (LBSF), combining new technology, whereas the products (salmon) remain unchanged. Therefore, the focus will be on *"process innovation"*. Within innovation, there is a distinction between product and process innovation. Product innovation relates to the development of new goods or services, in contrast to process innovation which serves to improve or create new ways of production and can be achieved through utilizing new or existing technology in different ways (Kazanchi, Lewis, & Boyer, 2006). Tushman & Anderson (1986) introduced the innovation term *"competence – destroying process breakthrough"*. The term involves altering or combining new technology creating a new process of

doing things. This applies when significant changes in production processes are related to major changes in the distribution of power within an industry (Tushman & Anderson, 1986).

Innovation is often classified as either radical or incremental (Tushman & Anderson, 1986). Tushman and O`Reilly (2008) state that *"incremental innovation is when an existing product or service is made better, faster or cheaper"* (p.194). Radical innovation, on the other hand, can be explained as "the development of new business or product lines – based on new ideas or technological or substantial cost reductions – that transform the economics of a business" (Leifer et al., 2000, p. 5). Both definitions are applicable. However, in this thesis, the focus will be on Christensen´s (1997) definitions of sustaining (SI) and disruptive innovation (DI).

2.1.2 The Innovators Dilemma

Christensen (1997) introduced "*The Innovator´s Dilemma*" describing how great companies with top managers who listen to their customers and are industry leaders fail to innovate, thereby falling victim to TID and losing their competitive advantage (Marvel & Lumpkin, 2007).

The framework consists of three parts, the first part being Christensen´s (1997) view on SI and DI. Sustaining innovations are improvements in established products or services that are based on feedback from customers (Christensen, 1997). These improvements could be enhanced battery life on your smartwatch, greater storage on your computer or a better camera on your smartphone. It increases the value of an existing product but does not create new markets in contrast to disruptive innovation (Christensen, Raynor, & Mcdonald, 2015). Disruptive innovation introduces a different value proposition to customers through new products and services, resulting in the creation of new markets (Christensen & Overdorf, 2000). When DI converts non-customers into customers, Christensen (2015) describes this as a *"new-market foothold"*.

Disruptive innovation is also about paradigm shifts such as Netflix causing Blockbuster´s bankruptcy, or Apple redefined the smartphone reducing the need for a personal computer (Christensen, Raynor, & Mcdonald, 2015). Through his analysis of the disk drive industry, Christensen (1997) states how "*many of these technologies were radically new and difficult, but they were not disruptive"* (Christensen, 1997, p. 34).

Incumbents pursuing SI, combined with the pace of technological advances, end up offering products that surpass customer's needs (Christensen, 1997). In doing so, incumbents often serve the higher segment with higher margins, resulting in a vacuum for new entrants to exploit (Christensen, Raynor, & Mcdonald, 2015). DI is often derived from incumbent's overlooking the lower segments; Christensen (2015) defines these DI as *"low-end footholds"*.

According to Christensen & Overdorf (2000), most SI comes from industry leaders, however, the same industry leaders never tend to introduce DI. It generally takes time introducing DI and very often, they deliver lower returns at the outset. Therefore, industry leaders favour SI as it offers the most promising financial returns (Christensen & Overdorf, 2000). However, when successively implemented, DI outperforms SI and end ups generating greater value creation (Christensen, Raynor, & Mcdonald, 2015; Christensen, 1997).

Christensen (1997) concluded that when incumbents are faced with TID, they are vulnerable to threats from new entrants. O´Reilly & Tushman (2008) propose ambidextrous organisations as a solution for TID, suggesting that organisations simultaneously can exploit and explore SI and DI under appropriate conditions. This solution challenges the assumption that there must be a trade-off between innovation and efficiency (O´Reilly & Tushman, 2008). Furthermore, O´Reilly & Tushman (2011) propose ambidexterity as a necessity for incumbents to survive when faced with changing environments.

2.2 Strategy

Michael Porter (1985) introduced the term "competitive advantage" (CA) and stated that strategy is about making choices and trade-offs and is not operational efficiency (OE). OE is easily copied, and if all firms apply best practice production/process methods, companies become similar (Porter, 1985; Porter, 1996). Making trade-offs are important so that companies don't get caught between different generic strategies not leading to CA (Porter, 1996). In short, Porter (1996) describes strategic positioning as key to achieving sustainable competitive advantage through performing distinct activities different from competitors. Kaplan (2008) also highlights that a strategy that is not linked to operational efficiency (OE) cannot alone lead to a sustainable competitive advantage (SCA) (Kaplan & Norton, 2008).

Rumelt (1980) argues that competitive advantages usually derive from having either superior resources, skills or position and that strategy is an art of exploiting these resources. Once a firm has established a position, it can defend this through two mechanisms as long as the underlying environment is unchanged. First, by continually delivering returns and secondly by making market share costly for entrants to capture (Rumelt, 1980). Rumelt (1980) further states "*when a shifting environment allows position to be gained by a new entrant or innovator, the results can be spectacular*." (p. 5)

Barney (1991) introduced the term resource-based view (RBV), whereby firms devise strategies that exploit their internal resources. This makes internal resources the basis of SCA (Foss & Knudsen, 2003). Furthermore, for a resource to potentially create SCA, Barney (1991) explained that the resource must contain four elements: it must have value, it must be rare among competitors, it must be imperfectly imitable and finally, there cannot be substitutes for the resource that are valuable nor rare, or imperfectly immobile (Barney, 1991). The difference between CA and SCA is that CA can be achieved if a firm has a resource that is valuable and rare. However, SCA can be achieved when the same resource cannot be imitated or substituted, or there is a very high cost for a firm to imitate or substitute (Foss & Knudsen, 2003). RBV research has often focused upon the latter, thereby identifying the non-imitability and no equivalent substitute resource, because those barriers can lead to SCA (Foss & Knudsen, 2003).

2.2.1 Strategy under uncertainty

Strategic decisions are predicated on managers' belief that they can predict future outcomes. This is problematic if it underestimates the role of uncertainty (Courtney, Kirkland, & Viguerie, 2000). Raynor (2007) highlights the problem when the future plays out differently than expected in his concept of "the strategy paradox" where the same strategy that brings about success can also conduce failure. This view is supported by Courtney et al. (1997) regarding the binary nature of strategy and where not considering alternative possibilities creates a weakness towards threats and is not dynamic enough to seize opportunities presented by uncertainty.

Courtney et al. (1997) (see Figure 6) present a framework with four levels of residual uncertainty that remain after a thorough analysis has been conducted. This framework can then be applied when mapping a firm's strategy when dealing with uncertainty.

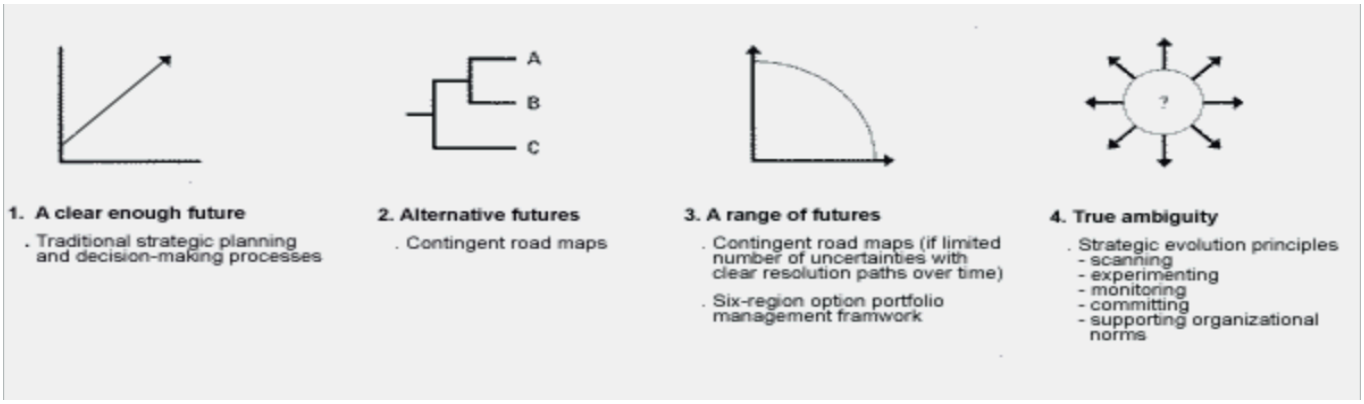

Figure 6: Four levels of uncertainty (Courtney, Jane, & Viguerie, 1997).

2.2.2 Success and Failure

Incumbents need to understand the mechanisms behind paradigm shifts, creating new markets or the maintaining an established position (Christensen, 1997; Rumelt, 1980). Christensen (1997) highlights that "*good management itself was the root cause of failure*". Seemingly sound decision making based on listening to customers, paying close attention to competition and investing in improving products and services ultimately contributes to failure because it pivots the firm away from DI. This goes along with the famous quote "*if I had asked people what they wanted, they would have said faster horses*" (Henry Ford, 1916).

Both Christensen (1997) and Raynor (2007) offer insights into why companies fail. Ironically both are a paradox, failure through rational decisions or a variable such as luck. However, a key take way must be, that in order to be lucky one must be willing to take risks.

2.2.3 Organisational Structure

Tushman & O´Reilly (1996) highlight how innovation is a critical factor for the creation of CA in today's constantly changing environment, or as stated even more boldly by Freeman (1985) "*not to innovate is to die*" (Freeman & Soete, 1985). According to Ahmed (1998), innovation is not about allocating resources, rather it comes from an organizational culture that constantly seeks to innovate in an environment that allows creativity. For Tushman & O´Reilly (1996) innovation lies at the heart of organizational culture. Therefore, it is crucial for organizations to facilitate innovation. This is

especially important in industries that are high-tech manufacturing environments (HTME), where according to Jayanthi & Sinha (1998) the pace of innovation moves faster. HTME is defined as; an environment in which demand, competitors, technology and regulations are in constant change (Jayanthi & Sinha, 1998). The NAI can be classified as operating within an HTME.

Underlying factors that facilitate innovative cultures are empowered employees, communication, sense of community and company aligned goals (Martins & Terblache, 2003; Lawson & Samson, 2001). Meanwhile, there is no 'one solution' for creating innovative cultures; it is important that management are aware of their impact and how to choose a suitable structure for their organization (Christensen & Overdorf, 2000; Trott, 2017). Trott (2017) points out that organisations follow a "*technology-dependent path*" that is linear in development and, as a result, this constrains opportunities. Thus, organisations struggle to adapt as new technology appears. Fostering a culture of sustaining innovation does have some benefits. However, it is something managers must be wary of as it embodies the challenges of the TID (Trott, 2017). Path dependent culture can become the "*Achilles heel*" of incumbents if norms and values restrain creative, technologically competent employees from pursuing disruptive innovation (Marvel & Lumpkin, 2007). This relates to Christensen (1997) value networks*" the context within a firm identifies and responds to customer's needs, solves problems, procures input, reacts to competitors, and strives for profit*" (P. 32). The value networks within an incumbent firm are influenced by past decisions, thus impacting how incumbents measure the economic value of new technology. Future orientation tends to favour SI as it previously has delivered economic value, and the value networks continue allocating resources in this manner (Christensen, The Innovators Dilemma, 1997).

2.3 Land-Based Salmon Farming

There are records of land-based aquaculture dating back around 2000 years, both in China and Japan through the usage of ditches and ponds (FAO, 2006), and roughly 70% of all aquaculture still comes from inland pond culture in China (FAO, 2006). However, it was the Danes who started recirculating aquaculture systems (RAS), a technology that is not landlocked to coastlines, in contrast to flow through systems (FTS), (FAO, 2006; Ernst & Young, 2019). RAS and FTS are both methods of land-based aquaculture that can be utilized to farm salmon (Ernst & Young, 2019). There is a shifting trend towards RAS technology, driven by concerns from European countries about the sustainability of FTS. Their efforts to promote RAS, combined with higher geographical scalability, has led to it

becoming the preferred alternative technology (Badiola, Mendiola, & Bostock, 2012; Ernst & Young, 2019). Therefore, RAS will be the focus in this thesis.

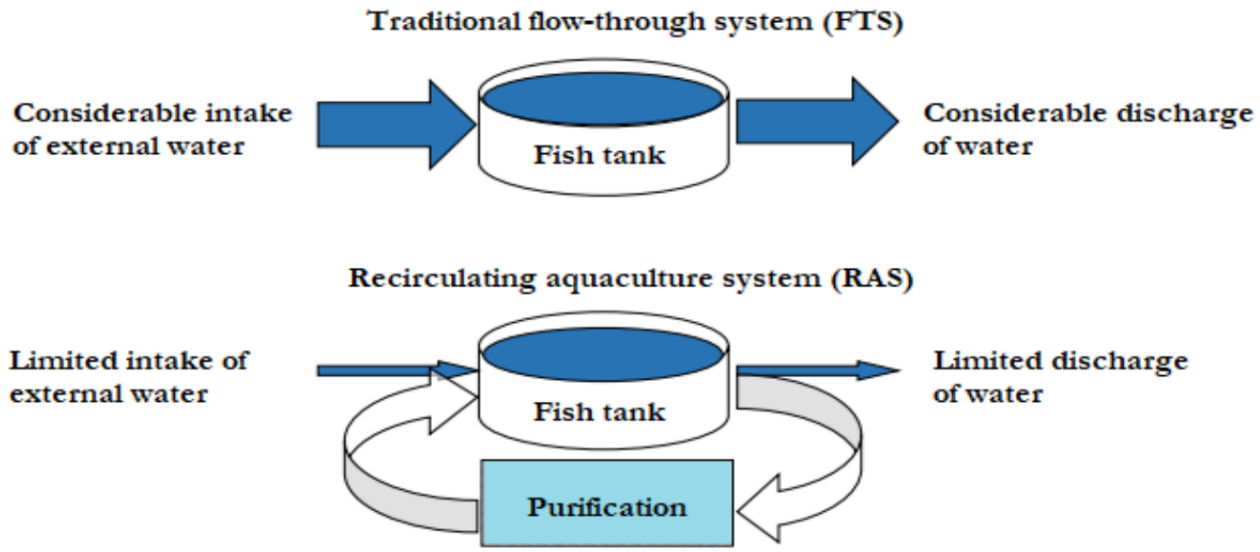

Figure 7: *Comparison between FTS and RAS technology (Terjesen, 2017)*

2.3.1 Recirculating Aquaculture Systems

RAS is essentially a technology that involves reusing water during production (FAO, 2015). In a RAS, the producer/operator decides what parameters production should be at, such as water temperature, salinity, oxygen levels, cleanliness of the water and daylight (FAO, 2015). Through the mechanical removal of particles and the usage of biofilters, RAS are able to recycle up to 95-99% of the water (Holm, et al., 2015).

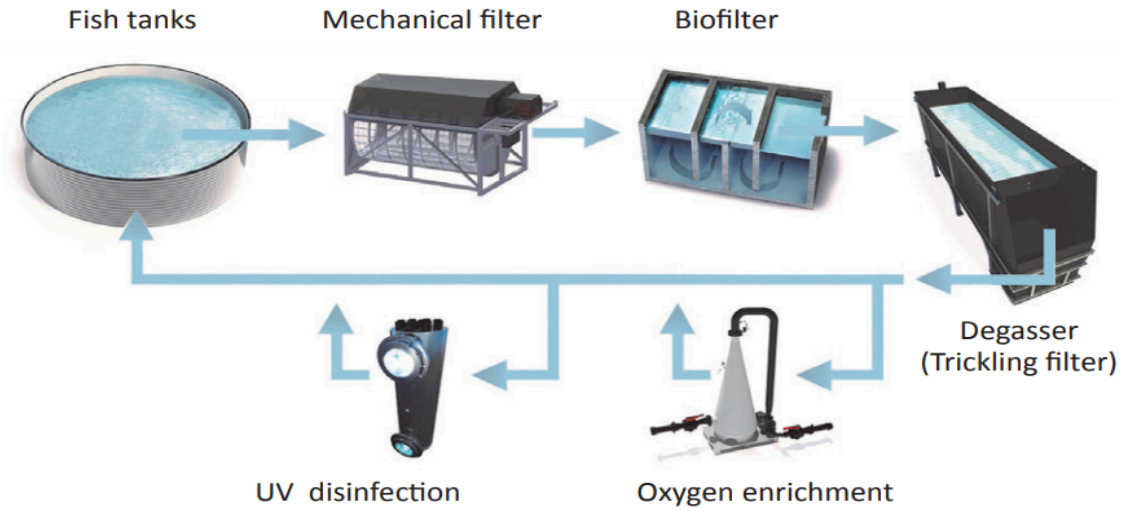

Figure 8: *Simple overview of a RAS, consisting of the basic components (FA0, 2015).*

The NAI are familiar with RAS technology and the majority of salmon smolt are produced in land-based systems (MOWI, 2018). On a global scale, RAS are used to farm a wide range of different species (International Salmon Farmers Association, 2018).

2.3.2 Advantages with Recirculating Aquaculture systems

RAS eliminates problems related to sea lice, escaped salmon and greatly reduces the probability of the spread of diseases due to separated tanks (FAO, 2015; Ernst & Young, 2019). Having access to good water quality is essential in aquaculture, as it greatly impacts the welfare of the fish and thereby the entire operational aspect. Through RAS facility design this is a parameter that can be controlled (Bjørndal & Tusvik, 2017). RAS enables optimal environments for the species, resulting in stable growth patterns and greater predictability for production cycles and harvesting, in contrary to farming in sea pens whereby growth patterns are impacted through environmental changes (FAO, 2015). It is possible that the production cycle can be reduced through RAS; although it is yet to be confirmed.

Further, RAS can enable improved food conversation ratios, fish welfare and reduce the usage of therapeutants (Bjørndal & Tusvik, 2017). Liu et al. (2016) highlight how RAS can have a positive impact on the environment through the reusage of water, turning waste into compost and how the carbon footprint can be decreased due to production closer to end consumers thus reducing logistics.

In theory, it is possible to farm salmon at any location in the world with RAS (Rabobank , 2019). According to Rabobank´s aquaculture 2:0 (2019) strategic choice of location is a critical element due to three factors; The first is *"Hi-tech hub"* encompassing access to competent people on aquaculture, existing networks, logistics and cold-chain systems. The second factor is *"Market size"* and the need to build in regions of high demand or close to metropolitan cities. Air freight to markets in the US and Asia cost between 13-18 NOK per kg from Norway, a potential area of savings for LBSF (Bjørndal & Tusvik, 2017). The third factor is *"Operational attributes"* which pertains to legislative and regulatory matters, and access to water and cheap energy.

2.3.3 Challenges with Recirculating Aquaculture Systems

There are still many challenges related to RAS technology. There has been no large-scale production and the technology is still in its infancy (Bjørndal & Tusvik, 2017). Pathogens can materialise in the biofilter, and it can take up to six months cleaning the filters with no production (Bjørndal, Hilmarsen, Tusvik, & Holte, 2018). An FAO (2015) report highlights that surveillance is critical and that

technical failure can lead to significant loss of biomass. An example of such a scenario outplayed earlier this year at Atlantic Sapphire's facility in Denmark, as previously stated.

According to the international salmon farmers association (ISFA) *"The evolution of land-based Atlantic salmon farms"* (2016) report, for RAS systems to be profitable the density of the biomass must be significantly higher than in sea pen farming (ISFA, 2018). The suggested density is around 50-80 kg of fish per cubic metre at their peak size, compared to a traditional density of 15-25 kg per cubic metre (ISFA, 2018). In sea pen farming in Norway, the highest density allowed per cubic metre is 25 kg of fish. However, with regards to land-based farming, the Norwegian aquaculture law has no density limit. The aquaculture law § 25 states the density must be adequately suited for the fish´s physiological and behavioural needs (Fiskeri - og kystdepartementet [Royal Ministry of Fisheries], 2018). This high density may compromise fish welfare; however, before drawing a conclusion, we must wait for more empirical evidence (Holm, et al., 2015).

Farming salmon is a time-sensitive process. In traditional sea pen farming, the total production cycle can take up to 3 years and includes the period from egg to harvest (MOWI, 2019). The time between investments and returns can cause problems for financing (Rabobank , 2019). There are still challenges related to achieving the expected biomass size, the desired production cycle and quality of salmon (Bjørndal, Hilmarsen, Tusvik, & Holte, 2018). There have been instances of the salmon filet having a "mud-taste" due to the particles that flow in RAS. There are solutions to this but it is an excellent example of unforeseen problems that can occur with RAS (Bjørndal, Hilmarsen, Tusvik, & Holte, 2018).

A study conducted in 2018 by Sintef, NTNU and SNF comparing LBSF and traditional sea pen farming concluded that LBSF requires a lot of land. If the Norwegian output of farmed salmon from sea pens were to be replaced by LBSF, there would be a need for 130 LBSF facilities. With the current technology this would require 11,7 km^2 land area (Bjørndal, Hilmarsen, Tusvik, & Holte, 2018). The facilities would naturally be located along the coastline, and it is questionable if communities along the coast would accept such facilities (Bjørndal, Hilmarsen, Tusvik, & Holte, 2018).

2.3.4 The economics or RAS

The same comparative study in 2018 by Sintef, NTNU and SNF concluded that with today's technology the average cost of production in LBSF-RAS would be 43,60 NOK per kg, compared to

30,60 NOK per kg in sea pens (Bjørndal, Hilmarsen, Tusvik, & Holte, 2018) This study was based on a comparison of production at 6000 metric tons. The findings are somewhat different than Liu et al. (2016) that cited production of 3300 metric tons[1]. Liu et al. (2016) state the average production cost from RAS as 39,27 NOK per kg compared to 35,37 NOK per kg in sea pens. Due to the large capital investment needed, Liu et al. (2016) conclude that traditional sea pens are the superior alternative, ending up with a positive net present value of USD 3.5 million compared to a negative USD -120.2 million for the RAS alternative. However, when excluding depreciation and interest, the operational costs are virtually the same (Liu, et al., 2016). With regards to operational costs there is no clear consensus as to what form of production is the most efficient. Boulet et al. (2010) and Iversen et al. (2013) estimate traditional farming being the better alternative. However, a report from Rosten et al. (2016) points towards RAS delivering the better solution.

It is estimated that the RAS investment would be $54 million compared to $30 million for sea pens (Liu, et al., 2016). Both reports are based on assumptions due to the lack of data (Liu et al., 2016; Bjørndal et al. 2018). Bjørndal & Tusvik (2017), state that there is limited academic literature on the economics of land-based aquaculture. Liu et al. (2016) concluded that land-based farmed salmon at this scale is dependent on selling at a premium price to be a financially viable. However, different reports expect the technology to improve and overall costs to decline when economies of scale can be achieved (Liu et al., 2016; Bjørndal & Tusvik, 2017; Rabobank, 2019).

There are a number of variables that impact the profitability of aquaculture, such as biological factors, capital investments, operational costs, logistical costs and sales price (Bjørndal & Tusvik, 2017). Firms must decide what degree of vertical integration to pursue. Large incumbents in the NAI like MOWI operate across the entire value chain (MOWI, 2019). Land-based salmon farmers who pursue a complete vertical integration strategy naturally require higher capital investment. Operators can outsource the initial faces of production, and only focus on the final production.

[1]The difference in production costs come from the sampling of data relating to different years. From Liu et al. (2016), the sea pen production cost was based on an average between 2009-2013 with data from the directory of fisheries, whereby the Sintef (2018) report used the average from 2016 again from the directory of fisheries.

Table 3*: Overview of investments costs into RAS with different production metrics.*

Study	*USD millions*	*Tons*	*RAS cost per kg compared to Sea Pen farming*
Liu et al. (2016)	53	3300	*10% Disadvantage*
Boulet et al. (2010)	22,6	2500	*18% Disadvantage*
Bjørndal et al. (2018)	93,6	5000	*42% Disadvantage*

2.3.5 Examples of RAS producing salmon

The NAI are familiar with the technology behind RAS and have been using RAS to produce smolt. However, so far there has been no production of salmon at large volumes in the final stage of the production cycle (Bjørndal & Tusvik, 2017). Nordic Aquafarms operating out of Fredrikstad, Norway stated they would be harvesting their first land-based farmed salmon in June 2020, thus becoming the first Norwegian company to do so. The production capacity of the facility upon completion will be 6000 tons (Nordic Aquafarms, 2020). Atlantic Sapphire is the company that has invested the heaviest into land-based salmon farming, aimed at producing 220 000 tons by 2031. However, their current production output is at 1000 tons from their facilities located in Hvide Sande, Denmark (Atlantic Sapphire, 2019). It is essential to highlight that at the time of writing, there is no larger production of LBSF than the 1000 tons from Atlantic Sapphire.

Table 4: *Planned land-based salmon farming capacity in Norway (Norsk Fiskerinæring [Norwegian Fishing Industry], 2019).*
** Important notice, governmental approval not yet granted.*

Company	*Country*	*Planned Capacity*
Ecofisk AS	Norway	40.000 tons
Salmon Evolution AS	Norway	28.800 tons
OFS Andenes AS	Norway	20.000 tons
**OFS Nordkapp*	Norway	20.000 tons
OFS Måløy AS	Norway	15.000 tons
Andfjord Salmon AS	Norway	10.000 tons
Havlandet RAS pilot AS	Norway	10.000 tons
Tomren Fish AS	Norway	10.000 tons
Gigante Salmon AS	Norway	10.000 tons
Aquaculture Innovation AS	Norway	10.000 tons
Kobbervik og Furholmen AS	Norway	10.000 tons
Salmofarms AS	Norway	8.500 tons

Salmo Terra AS	Norway	8.000 tons
Gaia Salmon AS	Norway	7.500 tons
Vadheim Akvapark AS	Norway	6.000 tons
Fredrikstad Seafood AS	Norway	5.500 tons
Bulandet Miljøfisk AS	Norway	5.500 tons
Smart Salmon AS	Norway	5.000 tons
Bulaandet Miljøfisk AS	Norway	5.000 tons
Driva Aquaculture AS	Norway	3.250 tons
Lofoten Salmon AS	Norway	3.100 tons
Hjelvik Matfisk AS	Norway	2.000 tons
Ecomarin Seafarm AS	Norway	2.000 tons
	Sum	245.150 tons

Table 4 depicts an overview of current planned LBSF facilities in Norway. Should all planed LBSF facilities become successful, according to Rabobank´s (2019) by 2030 production volumes from RAS will be at 622, 800 tons. If RAS were a country, then at current production levels RAS would be the second-largest producer in the world.

Figure 9: *Overview of global planned salmon production through RAS.* (Rabobank , 2019).

It is important, however, to have a realistic outlook. There are significant challenges associated with producing salmon through RAS and many projects are expected to fail, either due to financial challenges, wrong choice of location, lack of "know-how "or if there were a rapid decline of the salmon price. The uncertainties pertaining to LBSF are high with regard to consumer acceptance, production costs and volumes (Rabobank , 2019). But it is still believed that LBSF will be successful over time and according to Rabobank (2019), ushering in a new era of land-based salmon farming.

Chapter 3.0: Methodology

This thesis incorporates a holistic perspective to understand how incumbents of the NAI view this innovative technology and to test if Christensen´s (1997) TID is relevant. The following chapter elaborates the approach taken towards research and data collection.

3.1 Research Approach

There are several methods to gather data and design the research with regards to research questions (Bryman, Bell, & Harley, 2019). In this paper, the primary form of information gathering was through qualitative method. Qualitative research is an umbrella term for methods and techniques that can be used to interpret how human beings perceive reality (Mason, 1996). In-depth interviews are a qualitative method that can provide valuable information on how people behave and make decisions (Belk & Kozinets, 2012). Hill & Rothaermel (2003) suggest that the best way of measuring an incumbent's response to radical innovation is by conducting qualitative research and combining it with secondary data (Hill & Rothaermel, 2003). Therefore, in-depth interviews were carried out with experts, and secondary data was analysed to obtain relevant data about the NAI.

3.2 Research Design

Reviewing journals, articles and books provided a theoretical framework for this thesis. It became evident that the literature on LBSF is minimal which equates with lack of knowledge and uncertainty. The research approach a deductive method to draw conclusions about the NAI and TID. Interviews focused on decision-makers within the NAI representing both large-cap and smaller incumbents. It was important also to interview entrepreneurs driving LBSF, as well as leading scientists from governmental organisations. Additionally, to mitigate biases consultants following the NAI were interviewed, providing an additional perspective. The interviews were carried out in a semi-structured manner to allow the interviewees to elaborate and speak freely without being confined to a set of prescribed questions.

3.3 Data Collection

Researching incumbents' homepages and articles published on LBSF produced names of potential interviewees. Fifty-three people were approached through LinkedIn, cold calling and emails, resulting in a total of 16 positive replies. The data set was five incumbents from the NAI, three entrepreneurs of LBSF, four scientists, three consultants and finally the president of the ISFA.

Ten interviews were conducted over the phone, five through Microsoft Teams and one participant only found the time to answer the questions through email. The coronavirus pandemic required social distancing so there were no face-to-face interviews. The interviews varied between 20 minutes to around the hour mark. Before the interviews, a thematic questionnaire was crafted (see Appendix II). Slight adjustments were made tailored to the candidate's background. Naturally, the consultants had limited competence on the technology behind LBSF. Yet, the consultant from Kepler Cheuvreux had visited Atlantic Sapphire's facility in Miami, Florida and tasted their salmon. This interviewee had further participated in investor calls with incumbents in the NAI and could provide valuable insights.

Before the interviews took place, the five p´s were implemented in order to reduce poor performance. (Saunders, Lewis, & Thornhill, 2016). Extensive background reading concerning RAS technology was conducted and each company was researched. Every effort was made to ensure neutrality and avoid response bias (Saunders, Lewis, & Thornhill, 2016). Every interview began with a brief description of the topic. However, no information pertaining to the research questions and hypothesis were provided (Saunders, Lewis, & Thornhill, 2016). The questions asked were predominantly open-ended, seeking to understand the perspectives of the candidates on the different themes. Interviewees spoke freely, elaborating in-depth and providing answers to questions not yet asked so discussions took the form of a conversation and were very relaxed and informal.

All interviewees had the choice of remaining anonymous about identity or company affiliation to reduce potential participant bias and allow the subjects to speak freely (Saunders, Lewis, & Thornhill, 2016). None of the interviews were recorded and notes were taken during the interview and transcribed immediately afterwards. Four international LBSF companies were contacted but no interviews were able to be scheduled. Conversation via email were given less weight due to the brevity of answers provided. The interviews are categorized into the NAI, LBSF and Organisations. There is an overview of the participants in Appendix I.

Table 5: *Data collection overview, divided into primary and secondary research.*

Primary research			Secondary research
Semi-structured interviews			Documents and reports
The NAI	LBSF	Organisations	• Salmon Farming Industry Handbook • (Mowi, 2018/2019) • The Norwegian Aquaculture Analysis 2019 (Ernst & Young, 2019) • Aquaculture 2:0 RAS Is Driving the Change (Rabobank, 2019) • Seafood Barometer 2019 (PWC, 2019) • A Guide to Recirculation Aquaculture (FAO, 2015)
• Grieg Seafood AS • Norwegian Royal Salmon AS • Anonymous actor within the NAI top 10 firms • Pure Norwegian Seafood AS • Nordøy Sea AS	• Salmo Terra AS • Andfjord Salmon AS • Nordic Aquafarms AS	• CtrlAqua • Sintef • Norwegian College of Fishery Science • Norwegian School of Economics • ISFA • PWC • Rabobank • Kepler Cheuvreux	

3.4 Methods of analysis

After the interviews, transcripts were analysed and categorized into themes. This allowed enabled drawing relationships between the theory and data. The process followed Saunders et al. (2016) thematic approach, searching for themes and patterns that would occur in the data. This method following these five steps:

1. Comprehend the qualitative data.
2. Integrate data from transcripts and notes.
3. Identify key themes or patterns for further exploration.
4. Develop and test theories based on apparent thematic patterns
5. Draw and verify conclusions

Chapter 4.0: Results

The overall findings are shown in Table 7 and display the main questions and common answers given. The themes in this chapter follow the structure of the interview questions.

4.1 Interview objects

The interviewees from the NAI were all top tier management, four of whom represented companies that are top 10 in terms of market capitalization, and the remaining were more minor players. Three of the interviewees choose to remain anonymous, two allowed the company name to be referenced. When cited, they will be referred to as ANONYMOUS NAI, ANONYMOUS NRS and ANONYMOUS PWC. The LBSF participants were either cofounders or CEO´s and represented two of the companies that are market leaders in Norway. The scientists interviewed came from four different governmental organisations and have all published reports on LBSF. Two of the consultants co-authored reports on the aquaculture industry and one had visited LBSF facilities. The sum of the interviews reflects different aspects of salmon farming and provides a solid foundation for analysis.

4.2 Future production growth in the NAI

As described in the section 1.1 background, the NAI has not been able to increase production volumes since 2012. When questioned on where growth will come from in the future, the interviewees were clear that without innovation there would be limited growth.

4.2.1 Category I: Growth from sea pen farming

There was clear consensus among the interviewees about lack of growth from NAI sea pen farming within the next ten years. Virtually all interviewees highlighted how salmon lice is a significant challenge and that new solutions are needed to increase production sustainably in ways that pass muster for the government. The subjects did, however, believe the licensing regime for sea pen farming will be improved and that new technology will reduce mortality and shorten production cycles resulting in higher production volumes.

"There will be no growth until we can solve the current biological challenges"
(Åsa Espmark, Appendix XI).

"I honestly don't think there will be growth, there has virtually been no growth in recent years, and the current challenges are still significant. It's possible offshore farming can become a reality, but traditional farming in the fjords will yield limited growth"
(Trond Davidsen, ISFA, Appendix XV).

4.2.2 Category II: Growth from offshore farming

Offshore farming was brought up in fourteen of the interviews as a possible way of achieving growth. But there were mixed feelings about this new production method. Both Knut Utheim and ANONYMOUS NRS consider this opportunity significant for the NAI to take advantage of existing technology from the oil/gas industry and become a leading offshore farming nation (Appendix VII & X). The largest incumbents have invested heavily and there are a few projects at the testing stage. Conversely, it was pointed out by smaller NAI incumbents that offshore farming requires significant investment and is only an option for large companies in the NAI. Fredrik Nordøy and Harald Fiksdal had a negative perspective on this technology, pointing out that it is possible in theory but voicing concerns over farming salmon under extreme conditions (Appendix VIII). Knut Utheim further stated how successful operations from offshore farming in Norway, can be a catalyst for Asian countries to venture into salmon farming in the Yellow Sea (Appendix VII). There was a noteworthy statement by ANONYMOUS NAI, pointing out that his company and other NAI incumbents have invested billions into existing offshore technology and these sunk costs weigh heavily on future decision making about changing to other production methods (Appendix VI).

"*I don't see offshore farming contributing significant volumes, for that to happen we need a technological revolution" (Fredrik Nordøy, Appendix VII).*

"Norway will be the best at offshore development, if the government allows it. Just like we have been at the forefront in the offshore oil/gas industry" (Knut Utheim, Appendix VII).

"The drivers behind offshore farming are the large salmon farmers"
(Beyhan de Jong, Appendix XVIII).

4.2.3 Category III: Growth from LBSF in Norway

Every candidate suggested LBSF could contribute to growth of the NAI. None of the LBSF entrepreneurs considered that land pens will displace the volume of sea pen farming in Norway. They looked upon it as a niche production that could help relieve some of the environmental pressures on the fjords of Norway. Harald Fiksdal and Roy Pettersen were both LBSF entrepreneurs with a strong focus on sustainability and emphasised how their salmon would be a premium product (Appendix III, IV). It was not mentioned if selling LBSF at a premium was necessary for profitability. Still, one

cannot exclude point as it was brought up by Liu et al. (2016). The scientists supported the LBSF entrepreneurs' of LBSF as a niche product and questioned the scalability of the technology.

The determinant factors for LBSF in Norway according to Fredrik Nordøy, Anders Marthinussen and Christian Nordby are the limited licenses, established infrastructure, access to research hubs and the risk variables (Appendix VII, IX, XVI). Should the LBSF facilities incur excessively high operational costs or not achieve the expected salmon size, then the facilities can be transformed into smolt-facilities and function as support infrastructure for the NAI. In addition, there was the question of whether LBSF entrepreneurs can outsource the fileting process and egg-production to limit the need for vertical integration. As every interviewee pointed out, access to people with expertise in aquaculture is critical for success, and Norway is the right locale for this. This limits execution risk when investing in LBSF in Norway. Fredrik Nordøy suggested that if it could be predicted that LBSF will be successful, then they would invest in facilities closer to end consumers. However, there is too much uncertainty pertaining to the technology it also makes more sense to build facilities in Norway (Appendix VII). Overall, the candidates viewed LBSF in Norway as a niche production method and providing supporting functions for the NAI.

"LBSF will be a supplementary form of production and not a competitor"
(Bernt Olav Røttingsnes, Appendix V).

4.2.4 Category IV: Governmental impact on growth

Three participants from the NAI cited government regulation as a concern for the future development of the salmon farming industry in Norway. Through regulating permissible growth and not issuing new licenses, the government was inadvertently stimulating investments into LBSF and perhaps creating an inefficiency. ANONYMOUS NAI even stated that the government should be careful where they step (Appendix VI). Through its sustainability measures and traffic light system, the government broadly impacts the industry. Knut Utheim did add that NAI growth can occur if it is deemed sustainable by the government (Appendix VII).

"The government must be wary of how they stimulate investments into LBSF. Why would you produce salmon on land in Norway, when the market is somewhere else? It would only help facilitate the development of LBSF closer to the markets"
(Knut Utheim, Appendix VII).

"The governments strict regulation of the NAI, inhibiting growth, is the catalysator behind the investments into lBSF"(Anonymous NRS, Appendix X).

4.3 Risk and Opportunities

The candidates pointed out the same challenges as highlighted in section 1.2.5, however salmon escaping pens was not deemed a significant issue. Furthermore, the NAI interviewees considered that this would be solved in the near future. It was further highlighted that there will be new biological challenges in the future, which is to be expected when dealing with biomass. Overall, the candidates pointed to innovation within sea pen farming, LBSF and offshore farming as the greatest industry opportunities.

4.3.1 Category V: Salmon Lice

In all sixteen interviews, salmon lice were presented as the key hurdle for the NAI to overcome. Two of the LBSF entrepreneurs frequently mentioned how their salmon would be cultivated in a lice-free environment and none of the LBSF entrepreneurs believed the NAI can solve the problem in the near future. Only ANONYMOUS NAI and Kjell Maroni considered that the NAI will find a solution within the next ten years (Appendix VI, XII). The candidates all came up with different potential solutions for salmon lice, but had nothing tangible to point to as all were projects in the making.

ANONYMOUS NAI, ANONYMOUS NRS and Christian Nordby pointed out how increasing operational costs over the last several years (see Figure 4) have been related to the salmon lice and how finding a solution would strengthen the competitive advantage of sea pen farming (Appendix VI, X, XVI). The candidates from the NAI all agreed that solving the lice problem is the greatest opportunity for increasing production, profitability and as a way of deterring increasing investments into LBSF.

"For growth to occur, the industry must display it's sustainable, thus finding a solution for the salmon lice" (Anders Marthinussen, Appendix IX).

4.4 Land-Based Salmon Farming

When asked how they viewed LBSF with regards to it being a disruptive technology, no clear consensus could be drawn. There were differing perspectives the NAI and LBSF entrepreneurs. The latter did not see LBSD as a disruptive technology and could not foresee it altering the current status quo, yet the two anonymous candidates from the NAI expressed a clear concern and defined it as potentially disruptive, and voiced frustration towards the government.

Table 6: *Overview of different stakeholders' perspective on LBSF (Appendix).*

Disruptive	***No clear position***	***Not disruptive***
ANONYMOUS NAI	Christian Nordby - Consultant	Bernt Røttingsnes - LBSF
ANONYMOUS NRS	Trond Bjørdal - Scientist	Roy Bernt Pettersen - LBSF
Fredrik Nordøy - NAI	Kjell Maroni - Scientist	Harald Fiksdal - LBSF
Beyhan De Jong - Consultant		Anders Marthinussen - NAI
ANONYMOUS PWC		Trond Davidsen - ISFA
Ulf Winther - Scientist		Åsa Espermark - Scientist
		Knut Utheim - NAI

4.4.1 Category VI: Is LBSF disruptive?

It came as no surprise that when discussing a technology in its infancy there will be a wide array of perspectives. As mentioned in the literature review, there is no significant body of work on LBSF, something pointed out also by the interviewees. Åsa Espemark stated she would only believe research if she were to see it with her own two eyes (Appendix XI). This perspective was similar among many of the interviewees who did not consider LBSF disruptive (see Table 6) and who constantly emphasized that it is incapable of reaching volumes needed to compete with sea pen farming.

Among the candidates from the NAI, Knut Utheim did not directly look upon LBSF as a threat and believed it would have a niche function (Appendix VII). He stated, *"Every day I read the news about what's going on with Atlantic Sapphire "*, or *"How the government should be wary of how they stimulate investments into LBSF"* (Appendix VII). Even though not explicitly posing LBSF as a threat, his statements could be interpreted as acknowledging the potential danger. Fredrik Nordøy, ANONYMOUS NAI and ANONYMOUS NRS all recognized LBSF as a potentially disruptive technology, whereas ANONYMOUS NAI even stated: "LBSF is a threat towards the Norwegian value proposition and job creation" (Appendix VI, VII, X).

Throughout the interviews, there were several different factors the interviewees emphasized as to why LBSF would not become disruptive. Reasons included the fact that LBSF demands land area, substantial investment costs, has uncertain production capacity, operational complexity and there are significant operational costs.

Even though Trond Davidsen did not foresee LBSF becoming a competitor, he said it was just a matter of time before they overcome the challenges related to operational complexity (Appendix XV).

This view was shared by Roy Pettersen, Ulf Winther and Trond Bjørdal (Appendix IV, XII, XIV). Anders Marthinussen did not consider LBSF a threat but did state that it is possible that LBSF could overtake sea pens in terms of production volumes in the future (Appendix IX).

"If LBSF becomes disruptive, its man many years away, probably closer to 20 then 10 years" (Trond Bjørdal, Appendix XII).

"The biggest competitor for the NAI is LBSF. It's their biggest fear" (Fredrik Nordøy, Appendix VII).

4.5 Land-Based Salmon Farming in the NAI

When discussing the topic of LBSF with the candidates from the NAI, there was a red thread running through their responses concerning why the NAI were not investing in LBSF. Interviewee brought up the investor perspective, risk and uncertainty around LBSF.

4.5.1 Category VII: Book value of licenses

When discussing why large NAI incumbents are not investing in LBSF Knut Utheim, Fredrik Nordøy, ANONYMOUS NRS and Christian Nordby all stated that for larger incumbents, LBSF capex could negatively impact the book value for their current licenses (Appendix VII, VIII, X, XVI).

"The licenses have a book value and if you start to invest in lBSF, then what happens to the value of your licenses?" (Knut Utheim, Appendix VII).

"If Mowi invested into LBSF, they are inadvertently devaluing their licenses" (Fredrik Nordøy (Appendix VII).

4.5.2 Category VIII: Economic value from LBSF for the NAI

The fact that no LBSF entrepreneur has been able to produce salmon at large volumes correlates with the interviewee's perspectives surrounding uncertainty in terms of LBSF delivering profits. Christian Nordby highlighted that should LBSF deliver value, then capital will follow; "*However, we don't have the knowledge yet*". Many of these questions should be answered when Atlantic Sapphire begins producing in Florida (Appendix XVI).

The candidates from the NAI all viewed LBSF as a highly risky investment. Trond Bjørndal underlined the importance of distinguishing risk and uncertainty. The lack of knowledge surrounding LBSF is too great, and it is, therefore, impossible to quantify the risk related to LBSF. Hence, it would not make sense for the larger incumbents to invest in LBSF (Appendix XII).

ANONYMOUS NRS viewed the risk of investing in LBSF as too great and could not justify such investments to shareholders, especially considering there are alternate projects available with lower risks (Appendix X). Fredrik Nordøy shared a similar view pointing out how the NAI have sold their salmon to investors as the finest product which might not be true for LBSF (Appendix VII). From Anders Marthinussen´s point of view, LBSF technology has not adequately developed and the salmon price is too volatile to model the risks of investing in LBSF (Appendix IX).

"The whole move to LBSF will be driven by its capability of delivering profits, and if it delivers, it will gain momentum. At this time, there is much uncertainty; nobody has succeeded with large volumes" (Knut Utheim, Appendix VII).

"The larger companies don't see the value of taking the risk and can invest into projects with significantly lower risk" (Christian Nordby, Appendix XVI).

4.5.3 Category VIII: Strategic choice in not investing in LBSF

Not investing in LBSF was also couched as a strategic choice. Knut Utheim, Fredrik Nordøy, ANONYMOUS NRS and Christian Nordby shared the view that the NAI was not interested in disrupting their competitive advantage associated with the Norwegian coastline and thus would not be the driving force behind LBSF. The candidates pointed to Atlantic Sapphire´s success as a pivotal moment for the development of LBSF and that a strategic response might only come when the company shows significant volumes. Fredrik Nordøy and Christian Nordby suggested that the largest salmon farming company in the world, Mowi, would rather let smaller entrepreneurs pave the way and then they would later consider an acquisition (Appendix VIII, XVI).

Kjell Maroni, Harald Fiksdal and ANONYMOUS NRS highlighted how there are only a few locations in the world where one can farm salmon, and that LBSF could change this completely (Appendix III, X, XIII). ANONYMOUS NRS stated the rhetorical question *"Why would we invest in a technology that could remove our greatest competitive advantage?" (*Appendix X).

Ulf Winter, Roy Pettersen and Christian Nordby further emphasized how incumbents have the capabilities required for LBSF should they to move forward and could swiftly make this transition. The challenge was more the financing of projects rather than know-how (Appendix IV, XIV, XVI).

"*For LBSF to become a success, it is alpha and omega that the first projects succeed. It is so capital intensive and technologically demanding, so should the current projects not live up to the anticipations in becoming profitable, then it will slow down the development"*
(Knut Utheim, Appendix VII).

4.5.4 Category IX: Consumer acceptance & Branding

When discussing LBSF as a competitor, every subject from the NAI pointed out that there is considerable uncertainty pertaining to consumer acceptance. Fredrik Nordøy, ANONYMOUS PWC and Christian Nordby highlighted how Norwegian salmon is a quality product sold at a premium (Appendix VIII, XVII, XVI). Christian Nordby further pointed how salmon from LBSF might end up becoming a commoditized product serving a lower segment. Christian Nordby and ANONYMOUS NRS mentioned how Marine Harvest had changed their name to MOWI, to build a brand that can withstand competition from LBSF (Appendix X, XVI).

"It's possible that LBSF will become a commodity product and not competing with salmon from the NAI that's is considered a premium product. However, this is uncertain"
(Christian Nordby De, Appendix XVI).

4.5.5 Category X: Consumer preference & logistics

Future consumer trends were brought up as a topic when discussing LBSF as a threat. The candidates stated that the moment consumers accept imported frozen salmon, the logistical costs for the NAI would decrease drastically. It was also mentioned that there is new freezing technology that makes defrosted salmon virtually indistinguishable from fresh salmon.

"there is new technology that allows us to transport the salmon frozen by ships, and when it is defrosted you cannot taste any difference. A change in consumer preference will be in the favour of the NAI" (Knut Utheim, Appendix VII).

4.5.6 Category XI: Capital investments into LBSF

When questioned about investment sources funding LBSF it was clear that the NAI was not the driving factor. None of the candidates stated that the NAI had invested into LBSF, and the majority said investments are from PE.

"The big salmon farming companies are not the drivers behind lBSF"
(Beyhan De Jong, Appendix XVII).

Fredrik Nordøy noted the difference in investor perspectives between incumbents and PE. Investors outside the NAI see the growth potential. However, in the eyes of the NAI there is too much risk

associated with LBSF. Fredrik Nordøy further pointed out how listed companies such as Atlantic Sapphire and Andøya Salmon have unrealistic valuations considering neither of the companies have production methods optimized nor are they profitable (Appendix VIII).

"I think that if LBSF entrepreneurs could choose between LBSF, or having a license to farm in the sea, they would choose the sea" (Fredrik Nordøy, Appendix VII).

Table 7: *Overview of general answers given in the interviews (Appendix).*

#	Questions	Key Mesages	Respondents
1	*Where will we se the growth in production in the NAI?*	• There will be limited growth due to the challenges of sea lice • The industry is investing in offshore farming and this might yield growth • LBSF will become a niche form of production in Norway • The NAI will yield greater output from the current licenses	• All • All • 1, 6, 7, 8, 9 • 1, 4, 5
2	*What are your general thoughts surrounding LBSF?*	• There is a very high risk of operational failure in LBSF • There is much uncertainty pertaining to OPEX • There is much uncertainty surrounding the scalability of production	• All • All • All
3	*Would you consider LBSF a disruptive innovation?*	• LBSF can become disruptive, but closer to 20 years • No, I dont think its possible to scale up the production volumes • Its possible, but I think the majority of the first movers will become a failure • No, its probably going to be a niche form of production	• 4, 11, 12, 13 • 1, 5, 6, 7, 8, 9 • 3, 5, 7, 10, 16 • 1, 5, 6, 7, 8, 9
4	*Why do you think the NAI are not investing in LBSF?*	• The NAI does not want to disrupt their competitive advantage • The NAI are aware of the risk pertaining to LBSF • The NAI have other investment projects with lower risk • Investing in LBSF could devalue the book value of their licenses	• 2, 3, 4 • 1,2,3,4,6,7,8,9 • 2,3,4,11,13,14 • 1, 2, 4, 14
5	*What are the strategic reactions from the NAI as a response towards LBSF?*	• Finding a solution towards the sea lice would yield increased growth and lowered OPEX • Transporting frozen salmon by ship - significantly lowered logistical costs • Larger incumbents have invested heavy into offshore farming • Investments in post-smolt production can reduce the production cycle	• 2, 3, 14 • 1, 2, 3, 4,10,14 • 2, 3, 4, • 3, 4, 5,14,
(1) Knut Utheim, (2) ANONYMOUS NRS, (3) ANONYMOUS NAI, (4) Fredrik Nordøy, (5) Anders Marthinussen, (6) Harald Fiksdal, (7) Roy Pettersen, (8) Bernt Røttingsnes, (9) Åsa Espmark, (10) Kjell Maroni, (11) Ulf Winther, (12) Trond Davidsen, (13) Trond Bjørndal, (14) Christian Nordby, (15) ANONYMOUS PWC, (16) Beyhan De Jong			

Chapter 5.0: Discussion

This chapter combines the results in Chapter four and the literature review in Chapter two.

5.1 Innovation

Category I, II, III, V, X

Innovation and the challenges the NAI are currently facing was a much-discussed topic throughout the interviews. All interviewees from the NAI stressed how there would be limited growth without innovation taking place and it was clear that the industry was focused on innovation in all aspects of the value chain. Furthermore, innovation in dealing with salmon lice was highlighted as a significant opportunity for competing with the new threat of LBSF.

The innovation term *"competence – destroying process breakthrough"* proposed by Tushman & Anderson (1986) seemed to apply for LBSF. Six candidates expressed how this new method could potentially alter the current paradigm within the salmon industry, thereby also being DI according to Christensen's (1997) definition.

5.2 The Innovators Dilemma

Category VII, VII, VII, XI

The findings in this study uphold characteristics of Christensen's (1997) TID. While it became obvious that the NAI are investing into innovation, the investments are of an SI character and not DI – in this case LBSF. The candidates from the NAI associated LBSF with high risk and uncertainty and saw investments into LBSF as potentially negatively impacting the book value of incumbent's licences. Thus, the responsibility to deliver shareholder value impacts their decision making and they allocate resources accordingly towards SI where the ROIs are easier quantifiable. Fredrik Nordøy, Ulf Winther and Trond Bjørndal all pointed out that for LBSF to become disruptive, it would take upwards of 20 years, something that is in line with Christensen's (1997) *low-end footholds* thesis. LBSF may not serve the luxury/premium segment of customers, instead offering retail salmon to consumers in the lower segment. Christensen (1997) stated how established incumbents rarely introduced DI, and we see how no NAI incumbents have invested into LBSF. It also appears rational for decision-makers not to invest in LBSF for the simple reason that the latter could make one of the NAI ´s greatest competitive advantages redundant. Yet again, this is exactly what Christensen (1997) points out, "*good management itself was the root cause of failure*". The reluctance to invest in LBSF may well be the undoing of the NAI.

5.3 Strategy & Uncertainty

Category VII, VIII, VIIII, IX, X, XI

Prior to the emergence of LBSF there were significant barriers to entry for the NAI due to rationing of licenses as regulated by the government. Even though LBSF requires significant capital, many projects have been able to secure financing and one can conclude that LBSF is a new entrant threat for the NAI. Rumelt (1980) pointed out that companies could defend their position as long as the underlying environment is unchanged. Licenses have functioned as protective moat and as a source of CA, combined with the aquaculture expertise. However, with the emergence of LBSF, the environment is changing and decision-makers in the NAI must be wary of how this may lead to radical change (Rumelt, 1980). Taking Barney´s (1991) RBV, it becomes evident that licenses have been a source of SCA, however as candidates stated, investing in LBSF would devalue their licenses. And with LBSF the licenses no longer being inimitable this erodes SCA. This accords with interviewees pointing out that the NAI might not be so dominant in the future.

It became obvious that the risk and uncertainty attached to LBSF, were the key factors why the NAI were not investing in LBSF. There is also a general belief that the majority of LBSF entrepreneurs would fail. It was further stated that through investments in LBSF the NAI would be digging its own grave. Within the NAI incumbents, none were willing to take the risk and as Raynor (2007) points out the difference between mediocrity and greatness is the willingness to take risk. Certain candidates did suggest that MOWI might acquire Atlantic Sapphire once they have validated their production methods which could be considered a mitigating notion for the TID which Christensen (1997) also would acknowledge.

Uncertainty surrounding LBSF was portrayed as unquantifiable. However, in terms of outcomes the candidates did not doubt LBSF as method. The uncertainty pertained to production volumes, OPEX and consumer acceptance. Utilizing THE Courtney et al. (1997) framework to sketch outcomes, it becomes clear that the uncertainty in terms of outcomes is at level two as Figure ten depicts. Therefore, one must question the interviewee's strategic actions in line with their future predictions.

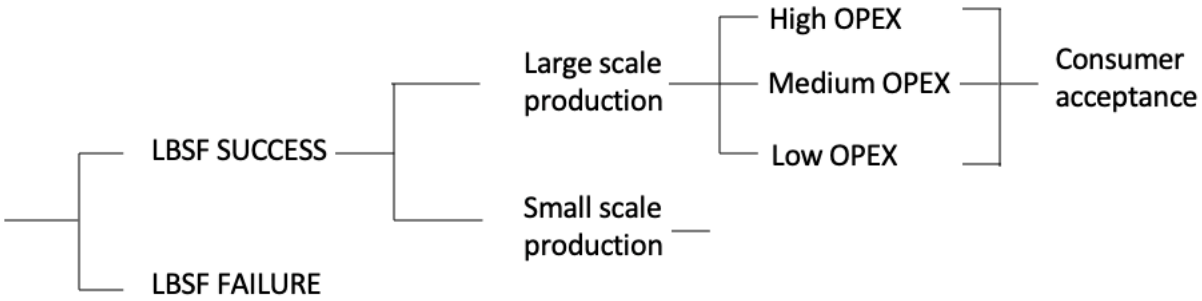

Figure 10: *Alternate outcomes related to the success of LBSF based on the data gathered in this dissertation.*

No clear measures were presented as a strategic response to LBSF. The incumbents mentioned consumer preference as a critical factor, however, if consumer preference changes towards frozen salmon then the transportation costs for the NAI would decrease significantly. It was further suggested that Marine Harvest changed name to MOWI as a strategic manoeuvre to build a brand name as a defensive move towards LBSF. However, this was only speculation from the interviewees. Risk averse behaviour, as Christensen (1997) outlined, is inherent within the business practices of established incumbents and this is apparent also in the NAI. The findings in this dissertation indicate that NAI incumbents will only make strategic moves when LBSF has become validated as a method for producing salmon at a large scale.

Chapter 6.0: Conclusions

6.1 Main Findings

RQ1: Have decision makers in the NAI fallen victims of TID, investing in sustaining innovation and not the needed disruptive innovation?

This study´s findings vindicate Christensen´s (1997) TID. The NAI is not investing into LBSF, perceiving the risks associated with LBSF as too great. The value networks within the NAI favour SI that offer measurable ROI.

RQ2: If the NAI acknowledge LBSF as a threat, then what strategic reactions are being undertaken in response?

Uncertainty surrounding LBSF seemed too great to obtain a clear consensus on whether or not LBSF can be disruptive and thus a threat. However, three of the candidates from the NAI clearly identified LBSF as a threat, yet there is no clear strategic response. The general response among the candidates entailed finding a solution for the salmon lice. In the eventuality of consumers accepting more frozen salmon, transportation costs for the NAI would decrease significantly and thus the benefits from building LBSF closer to end-consumers would be reduced.

RQ3: Who are the main drivers of LBSF and from where are the investments coming?

The difficulty of obtaining licenses is the catalyst for entrepreneurs pursuing LBSF as it is the only viable option for entering this profitable industry. No single candidate stated that the NAI are investing in LBSF and it was clear that the investments are coming from PE. The NAI are currently sitting on the side-lines watching as the technology develops.

6.2 Managerial Implications

Decisionmakers in the NAI constantly questioned the scalability of LBSF. However, their assumptions about significant limitations for achieving scale are contradicted by Atlantic Sapphire´s target of achieving production volumes of 220,000 tons by the year 2031 (Atlantic Sapphire, 2019). The conclusion that the NAI have fallen victim to the TID does not necessarily indicate the need for urgent measures as it will take a significant amount of time for the technology to mature. It is, however, an innovation that the NAI should follow closely as a potential threat.

The difference between LBSF entrepreneurs and incumbents is the former's willingness to take risk. PE firms are investing which has facilitated the emergence of SMB. With advancements in technology come new opportunities. Decisionmakers in the NAI must ask themselves if the potential opportunities of investing into LBSF outweigh the uncertainties associated with not taking an active role in developing LBSF.

6.3 Limitations & Further Research

This study was subject to several limitations. Naturally, time constraints prevented in depth-research that is important when dealing with such an intricate topic. The thesis revolves around farming biological animals, a subject that is very complex and technical. Lack of specific bio-engineering knowledge on aquaculture might have limited the ability to engage with the interviewees in a dynamic manner that could have provided additional insights. However, the greatest limitation in this thesis concerns the significant uncertainty surrounding LBSF. There is no current large scale-producer of LBSF and there are limited academic articles on this topic.

Another limitation comes from not interviewing international LBSF players. Numerous attempts were made to reach LBSF entrepreneurs operating outside of Norway such as Atlantic Sapphire, Salmon Evolution, Swiss Salmon, Pure Salmon and Kuterra. Unfortunately, no such interviews could be scheduled. It is possible that international entrepreneurs could have had a different perspective on LBSF as disruptive technology and provided additional insights. A wider scope of data gathering would have provided a better data foundation for analysis. However, the inclusion of scientists and consultants closely following the industry provides a substantive and coherent representation of the NAI.

The findings in this dissertation present opportunities for further research. Consumer acceptance of salmon from LBA was posited as a significant uncertainty. However, Christian Nordby who had tried salmon from LBA stated that he tasted no difference (Appendix XVI). Conducting further research around consumer preferences with blind tastings would be of interested. New technologies that enable freezing and defrosting salmon without significant implications on taste and quality could be a game changer for the NAI, but this is dependent upon additional validation. There are companies pursuing new production methods for salmon through lab-cloning. This is another potential substitute and it will be interesting see how the NAI views this threat and to what degree consumers will accept lab-produced salmon.

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Appendices

Appendix I: Overview of Interviewees

The table below provides an overview of the interviewees that participated in this thesis.

Company	Position	Name	Mean	Duration	Permission
Top 10 incumbents of the NAI					
Grieg Seafood AS	COO	Knut Utheim	Phone call	21 m	Granted
Norwegian Royal Salmon AS	Anonymous	Anonymous NRS	Phone call	30 m	Not granted
Anonymous	R&D Manager	Anonymous NAI	Phone call	20 m	Not granted
Small incumbents of the NAI					
Nordøy Sea AS	CEO	Fredrik Nordøy	Phone call	50 m	Granted
Pure Norwegian Seafood AS	Business Developer	Anders Marthinussen	Phone call	30 m	Granted
LBSF Entrepreneurs					
Salmo Terra AS	CEO	Harald Fiksdal	Teams	50 m	Granted
Andfjord Salmon AS	Founder	Roy Pettersen	Teams	53 m	Granted
Nordiq Aquafarms AS	CEO	Bernt Røttingsnes	EMAIL		Granted
Organizations					
CtrlAqua	Director	Åsa Espmark	Teams	37 m	Granted
Norwegian College of Fishery Science	Aquaculture Manager	Kjell Maroni	Teams	35 m	Granted
Sintef	Special Advisor	Ulf Winther	Teams	25 m	Granted
ISFA	Director	Trond Davidsen	Phone call	25 m	Granted
Norwegian School of Economics	Senior Researcher	Trond Bjørndal	Phone call	29 m	Granted
Consultants					
Kepler Chevreux	Seafood Analyst	Christian Nordby	Phone Call	18 m	Granted
PWC	Consultant	Anonymous PWC	Phone Call	19 m	Not Granted
Rabobank	Analyst – Animal Protein	Beyhan De Jong	Teams	50 m	Granted

Appendix II: Interview Questions

Below are the general questions used during the semi-structured interviews. Not all questions were asked during each conversation.

- Where do you think the growth in production volumes will come from in the NAI?
- What will be major differences in terms of production methods in the NAI in 10 years' time?
- Where do you see the greatest opportunities in the NAI?
- What threats are pertaining to the NAI?
- How do you think the production volumes will evolve internationally?
- What are your general thoughts surrounding LBSF?
- How would you explain why there is so much interest domestically and internationally surrounding LBSF?
- What role do you think LBSF will play in the NAI?
- Are there strategic reactions from the NAI towards LBSF?
- Have you considered investing into LBSF?
- How would you explain why the large incumbents of the NAI are not investing into lBSF?
- What are your thoughts on the risk associated with investing into LBSF?
- Do you consider LBSF as a threat to traditional sea pen farming?
- Should all current planned LBSF become a success, then we are looking at production volumes of 800,000 tons of salmon a year. Would that not be threat to the NAI?
- Is there much uncertainty in LBSF becoming successful method of producing salmon?

Appendix III: Interview LBSF – Harald Fiksdal

Company: Salmo Terra AS **Role:** CEO

Date: 07-05-2020 **Name:** Harald Fiksdal

Questions regarding growth in the NAI

For us to be able to get better control of what is in the Ocean we need better technology, and we need to give our natural resources time to recover, and not over exploit what we currently have. LBSF can relieve the pressure from the natural resources and compensate. Thus, this can lead to increased production volumes. This will give us more time to work with the sea pen farming. It gives you time

to collect the waste, treat diseases and create more space for the fish in the sea pens.

I believe it will be later than 2050 before we achieve the production goal of 5 million tons produced in the NAI. It is due to the current challenges we currently face and there simply is not enough space in the ocean for this to be a realistic goal at the moment.

View on different production methods in the NAI
I don't believe in offshore farming, it can work in theory, but I don't have faith in it. Further as we show that we can treat the fish in better ways, reduce waste, this technology will eventually be transferred into traditional farming. We absolutely don't think that LBSF will overtake the industry. LBSF and offshore farming will contribute and help relieve some of the pressure from the fjords

Questions pertaining to opportunities in the NAI
I think one of the very big differences is that there will be more people that are educated and specialized rather than being self-taught as many are today. People today are skilful, but I think people are schooled in different areas will solve problems in a different way, coming with a greater academic perspective.

The biggest opportunity we have at the moment is understanding the current trends, and salmon generally is a product that has a decent quality stamp associated with it, however, we need to be careful in how we safeguard it. I think one of the most important aspects are maintaining animal welfare thus preserving the quality stamp. The younger generations will have greater focus on sustainability and be aware of how animals are treated. If someone living in central Europe was to take a dive down in one of the fish farms that was full of lice, we would have a problem selling that fish in Europe.

Working in line with customer demand can be achieved through LBSF. I can tell you now that when we come out to sell our fish, I can guarantee you that we will come out and say that they have been in a specialized facility that has not used any pesticides, and that they have been free of lice and plenty of space. Every single fish from our facility will have a certificate of quality stamp.

Questions pertaining threats to the NAI
If we want to be a leading nation within aquaculture, then we have to be good at utilizing technology, we can't fall behind and simply accept that because we are good at farming fish now, and making a lot of money, this will sustain. If do not adapt and educate our self and apply new
methods, we will eventually fall behind.

It is starting to get better in Norway, but we are still behind other countries like Denmark. They are very good at what they do.

Views on LBSF as disruptive
We don't think LBSF will take over and compete with sea pen farming. We think it will be a supplement and relieve the pressure on sea pen farming.

View on LBSF internationally
If you take Atlantic Sapphire as an example, the only reason that they are capable of producing in Miami, Florida, is because they have drilled down to a water supply and are utilising new technology. LBSF is critical of access to fresh quality water of the right temperature.

To LBSF in Europe you need a source of good cold water and there currently are not a lot of areas where you could make this work. There was an attempt in the Mediterranean Sea, but it is not going very well. You need a proper balance of good water and other factors such as infrastructure to make it work. They can make some fish in Saudi Arabia, but these are small niche markets.

View on the development of LBSF
You cannot stop the development of LBSF if Norway decides they will not partake then Sweden and Denmark will laugh at us. Just half a year ago there was no talk about LBSF in Sweden and now there are 2 massive ones.

Appendix VIII: Interview LBSF – Roy Pettersen

Company: Andøya Salmon AS **Role:** Founder

Date: 18-05-2020 **Name:** Roy Pettersen

Questions regarding growth in the NAI
In the near future, I believe the growth will come from LBSF and offshore farming. The industry has not proven to be capable of dealing with the lice issues, and I don't see any immediate solutions. What I can say as, we can produce salmon, and it's going to be lice free.

Views on LBSF as disruptive
People in the industry often ask me "why are you doing this Roy, you are cutting off our leg?" And I do understand why they ask this question, but the thing is I believe in this technology. The industry is having problems in producing sustainable salmon, and I think through our facility we can produce high quality Atlantic salmon. The entire process at our facility evolves around sustainability. However, I don't think LBSF will be disruptive, I don't think they can achieve the volumes many projects are aiming at.

In order to operate LBSF, you need to have the "know how". Too many private equities are investing into this technology, without truly understanding the complexity of LBSF. Many projects will fail, but there will be those that succeed. This is probably what the NAI are seeing. They are aware of how complex LBSF is, and should LBSF become a viable option, they have the know-how needed for transition. Farming salmon through RAS system is very complex.

Views on the development of LBSF internationally

The technology is in its infancy, it will take time in reaching significant volumes. We will probably see a rise of LBSF entrepreneurs abroad, however many will fail. They lack the know-how. I'm not uncertain about LBSF becoming a success or not, but it depends how you define it. Atlantic Sapphire is paving the way, and much depends on them, the NAI are paying close attention. I think LBSF will become more niche orientated, but I can't say for sure.

Appendix V: Interview LBSF – Bernt Olav Røttingsnes

Company: Nordiq Aquafarms AS **Role:** CEO

Date: 18-05-2020 **Name:** Bernt Olav Røttingsnes

Questions regarding growth in the NAI
Should the industry be able to solve the lice problems, then their opportunities are vast. However, I see that as very unlikely. The current challenges surrounding lice, will be the future challenges. This will drive the development of closed sea pens.

Views on the changes in the NAI in the future
I think the government will have greater demands for sustainability. I think LBSF in Norway will predominately focusing on smolt production thus facilitating in improving efficiency from sea pens. I think offshore farming will become a reality.

Views on LBSF as disruptive
LBSF will be a supplement, and not a direct competitor of sea pen farming. We can't achieve the growth from sea pen farming to satisfy consumer demand, however, we are not able to produce close to consumers either. LBSF can help fill some of the demand.

There challenges with LBSF are large CAPEX and very complicated in operating. We do think the majority of LBSF abroad will be in ASIA and the US.

View on future consumer demand
I think that in the future consumers will not accept salmon transported through airplanes. Export towards Asia and the US will be of frozen salmon.

Appendix VI: Interview with top 10 incumbent of the NAI – ANONYMOUS NAI

Company: Anonymous **Role:** R&D Manager

Date: 18-05-2020 **Name:** ANONYMOUS NAI

Questions regarding growth in the NAI
It is obvious that the current biological issues and escaping salmon have to be solved for growth to come, and there is no discussion we are working very hard in finding solutions. Every day we work hard on this current challenge. We are working on open pen farming; however, the technology needs to be improved. But with new knowledge this can be improved. Further we have several projects where we are trying to improve the traditional sea pens, through reducing waste from feces, improving water quality and working with closed and semi closed sea pens. We have a project called the "preline farm" which is a closed facility out in open water, and we think this might solve the current challenges.

Questions pertaining challenges and opportunities in the NAI and
We must solve the lice problem, there is no discussion, and we are really working hard on this.

Most likely we will have solved the salmon lice problem and other current issues within 10 years. What is uncertain is if it will be biological solution or a technological solution, however I think it will be combination. The salmon will become more resilient towards the salmon lice, although it will still be able to contract the salmon lice, it will cause less pressure on the salmon. It's possible that we can farm through offshore farming and place the facility deeper in the sea exposed to colder water. It would reduce the amount of salmon lice; however colder water would impact the salmon growth negatively. It's not a quick fix, but offshore farming is a new method and I think it's exciting.

Questions pertaining to LBSF
The LBSF will require massive amounts of land, and should we build all of them along the Norwegian coast they will become very intrusive. Further they would require large amounts of energy and building a LBSF facility requires significantly amount of more resources then traditional farming, you need pipes, tanks, cement, glass fibre etc...

Certain aspects of LBSF are beneficial, problems with salmon lice and escaped salmon are non-existent. However, insofar there has been to land-based fish farming at large quantity that has not experienced mass mortality due to technical and biological challenges. The operational complexity induces high degrees of risk, not only are we dealing with biological animals that are taken out of their environment into a tank, you are also dealing with the micro biological production that take place in RAS. The challenge of microbiology requires different tools of analysis, and insofar we know very little about this in LBSF. We also have the third factor that pertains to the technical design of the pipes, filters and pools, and so far, there has been large challenges with the oxygen level, nitrogen and toxic gasses that causes mortality. Challenges that are greater than anticipated. Further there can a rise of new diseases we are not aware of yet and should sickness occur in a RAS then it can spread very fast.

Questions pertaining to LBSF and the NAI
If you ask yourself why the large companies like Lerøy, Mowi, Salmar and Grieg Seafood have not invested into LBSF? Then the answer might, they have invested billions into existing and offshore technology, and that changing now would hurt.

Questions pertaining LBSF as disruptive technology and a threat to the NAI
Atlantic Sapphire are building a massive plant in Florida, because they have no license fees like we have in Norway. The plant is closer to market and has a lot of advantages, and it means it poses a threat towards the NAI. Someone will succeed with LBSF and crack the code, producing without major problems. If this happens it could make the Norwegian coastal production unfavourable. We don't know about the operational costs yet.

If you say that Norway ends up with a concession policy that limits the production, whilst in countries like the USA or France where they have a free policy, that will be unfortunate and make it challenging competing globally. The government needs to facilitate the polices so that Norwegian aquaculture remains competitive.

There are pros and cons with sea pen farming and LBSF. Through sea pen farming the energy costs are at a minimal, we take advantage of the existing conditions in the water. However, in LBSF, you are recirculating vast amounts of water and it will induce large energy costs.

It is clear that when the day comes, and they figure out how to consistently make LBSF work we will be but in a we will be put in a very bad position competitively in the market.

I think 80% of the LBSF entrepreneurs will fail and go bankrupt, but 20% will succeed. and from there on its copy paste. LBSF is a threat towards Norwegian jobs and value creation.

Questions pertaining a strategic response from the NAI towards LBSF
Well, in the end it's a game of producing quality salmon at the lowest operational cost. The NAI as mentioned have invested large sums of money into improving sea pen farming and projects like offshore farming. Through increased production at a hopefully lower cost we are becoming more competitive. The NAI are aiming at achieving greater output from the licenses at a lower cost. Post-Smolt facilities is something that will be interesting follow as it could reduce the production cycle.

Appendix VII: Interview with top 10 incumbent of the NAI – Knut Utheim

Company: Grieg Seafood AS **Role:** Chief Operating Officer

Date: 13-05-2020 **Name:** Knut Utheim

Questions regarding growth in the NAI
There are so many bureaucratic challenges in Norway, that increasing the volumes will be challenge. However, offshore farming might potentially contribute. In the US they might start to invest into offshore farming, and Atlantic Sapphire might contribute with volumes from the US. For LBSF to become a success it is alpha and omega that the first projects succeed. It is so capital intensive and technological demanding, so should the current projects not live up to the anticipations in becoming profitable, then it will slow down the development. We are in uncertain corona-times and LBSF needs capital to survive, there have been projects cancelled due to capital being withdrawn due to corona in

China. With regards to offshore, it's possible the Asian markets will try to harvest Atlantic salmon. It's not something they have ventured into yet, but it's possible they will try in the yellow sea.

If we can produce in a way that the Norwegian governments deems sustainable, then we might be able to increase production.

In general, we will see grater diversification in terms of production forms. I think offshore and lBSF will be a niche from of production. I think traditional farming will have the greatest output of production in the future. However, the government can greatly impact the industry through its regulations.

View on Innovation
Norway will be the best at offshore development, if the government allows it. Just like we have been at the forefront of offshore oil/gas industry, so will we be within farming offshore.

Questions regarding LBSF
The government must be wary of how they stimulate investments into LBSF. Why would you produce salmon in land in Norway, when the market is somewhere else? LBSF benefits from logistical savings.

Questions regarding LBSF as a competitor
We can't sit here in Norway on our high horse and believe that we will dominate the Atlantic salmon industry. If the biological environment is there, and they have the technology then lBSF can work.

However, we don't see it as a threat. The biggest benefit comes from the logistical savings, both financially and environmentally. There are many challenges with LBSF, finding adequate locations, access to water, waste solutions etc...

Questions regarding investments into LBSF
Currently none of the major salmon farming companies have invested into LBSF. The majority of LBSF projects are coming from entrepreneurs with external financing.

Questions pertaining a strategic response from the NAI towards LBSF
The NAI are sceptical of the technology and that LBSF may become a competitor. It can be a strategic choice; people might start to question the value of the licenses. The licenses have a "book value", and if you start to buy up land-based facilities then what happens to the value of sea licenses. The whole move to LSBF will be driven by its capability of delivering profits, and if it delivers it will gain momentum. At this time there is much uncertainty, nobody has succeeded with large volumes. Should Atlantic Sapphire succeed, deliver profits, then the capital will follow. We will see the establishment of more LBSF in different markets. Further, there is new technology that allows us to transport the salmon frozen by ships, and when it is defrosted you cannot taste any difference. A change in consumer preference will be in the favour of the NAI. Further, are consumers going to accept salmon from the LBA?

The CEO of Salmar stated last year that the NAI could live with a salmon price of 30 NOK per kg, something that would kill of LBSF.

Appendix VIII: Interview with smaller incumbent of the NAI – Fredrik Nordøy

Company: Nordøy Sea AS **Role:** CEO

Date: 28-05-2020 **Name:** Fredrik Nordøy

Questions regarding growth in the NAI
The growth we see that is coming in the next 5 years, is from more efficient production. There are coming no new licenses in the short or long term, so growth must come from improved efficiency. So, growth form LBSF is a great opportunity, however, there is much dilemma there.

On a long-term perspective, I think the NAI will stagnate, and fall into these dilemmas of investing into LBSF or not. I don't think there will be significant growth, but it's about becoming more efficient, that's it. I don't see offshore contributing significant volumes, it would have been some technological revolutions. The investments are significant offshore. There is much uncertainty to offshore farming. We know it's possible to farm salmon further out, but they are pushing into extreme conditions.

Questions regarding LBSF
When dealing with biological animals, you're dealing with a ticking bomb. The longer the production cycle, the greater the risk. We are calculating every day the viability of LBSF, it's a question of the salmon price and production volume. We don't want to have a greater density of 50 kg per cubic metre in density. It's possible, but a greater density increases the probability of diseases and it weakens the fish.

It is the market that deems the future of salmon farming. What does the end consumer prefer? If its lBSF then we invest there, if not we don't. Much depends on the size that we are able to bring the salmon up to. There is no answer to what production is possible, but there is a reason why there are such significant investments into LBSF.

LBSF may bring new biological challenges that we are not aware of, new diseases that we don't know how to treat. We are aware of the diseases that come from sea pen farming, we have learned how to treat over time and are aware of them. There is no doubt there will be new biological challenges, insofar we know very little about it. But it's about having control over production.

LBSF in Norway does not make much sense. It would make sense to invest into production closer to consumers. The reasons for why they invest in LBSF in Norway is because of the access to the know-how. The energy required to operate a LBSF is significant and is a cost you should not underestimate.

I do think there will be solutions for LBSF, I just think it will take a long time. We are dealing with biological animals, they need to a healthy environment and creating this environment will take a long time. There is no doubt there will be high mortality in the beginning, and maybe even generations of salmon wiped out because of failures.

Questions regarding the NAI and investing into LBSF

I think that the NAI don't want to take the risk. The companies that are investing into LBSF are smaller players, I think they have raised money, been listed on the stock market and priced very very high. Atlantic Sapphire lost an entire generation in Denmark, a facility that is the foundation for their major facility in Miami, Florida. Yet for some reason their stock price is up, there are some drivers in the financial markets that are crazy. They are gearing up their position

The NAI have sold their salmon to investors and costumers and the finest product. It might not look great from an investor perspective. If MOWI were to invest into LBSF, the production cost would increase, and it would be hard to defend to investors. They don't want to take the risk, and if the LBSF companies make it work, then they will either invest into own lBSF or acquire other LBSF companies. There is too much risk for the major companies. Once they see it's a viable option, then they might invest.

The biggest competitor for the NAI is LBSF. It's their biggest fear, it's for sure one of them.
The salmon price is very volatile, just taking the salmon price three weeks ago at 35 KR per kg, would mean significant problems for LBSF.

Vies towards LBSF entrepreneurs

I think that if LBSF entrepreneurs could choose between LBSF farming or having a license to farm in the sea. They would choose the sea, no doubt. The lack of licenses is the driving factor behind entrepreneurs investing into LBSF. In order to succeed you need people with the expertise, and I think there are many projects out there without sufficient expertise.

It's an investor case, and investors see the growth potential. There are no limits, and that's why you can create so many great investor prospects.

Consumers decide

What salmon do we prefer? The one that is sustainably produced, the one with the lower carbon footprint. In the end its the consumers that decide how the salmon is farmed through their consumer preference.

Questions pertaining a strategic response from the NAI towards LBSF

We can transport frozen salmon through ships. But as long as consumers demand fresh salmon, then that's how we transport them. If I could produce salmon in Korea where I sell, I would definitely do that. But for the investment to come, we have to be certain that there is demand for a land based produced salmon.

I think we don't want to take the industry out of Norway, it's about keeping the production and jobs local. The Norwegian salmon can be produced here, and that's the current preferred way.

It's possible that in 20 years the NAI don't have the same competitive advantage. The technology will develop. Its why I don't think the large incumbents are investing into, by paving the way, investing into LBSF, they are also digging their own grave.

If Mowi invested into LBSF, they are inadvertently devaluing their licenses. The 200 million book value suddenly is ⅓ because they have invested into LBSF. They would rather allow smaller entrepreneurs to pave the way, and later consider acquiring them or invest into their own LBSF.

Appendix IX: Interview with smaller incumbent of the NAI – Anders Marthinussen

Company: Pure Norwegian Seafood **Role:** Business Developer

Date: 29-05-2020 **Name:** Anders Marthinussen

Questions regarding growth in the NAI
I don't think there will be much growth, without change. For growth to happen, the industry must display its sustainable, thus finding a solution for the lice. There is development licenses LBSF and offshore will be the biggest contributes. The industry will become increasingly efficient. Reduced production cycles. Better technology. Further the NAI are investing post-smolt production. Currently only 10% are utilizing this technology, and if the current projects work. Then we will be able to reduce the production cycle.

Questions regarding LBSF
I don't see LBSF as a threat. There are many initiatives, but I don't see the large volumes. I think there will be equilibrium between demand and supply. LBSF will provide a slow increase of production and not a "ketch-up effect". I'm not worried about LBSF.

The technology is not good enough, we have seen incidents of failures causing mortality. There are many biological challenges. Further, the investments costs are significant, and you are dependent on a high salmon price. There is very high risk related to the salmon price.
The benefits are obviously that you build closer to end consumer, which is a major advantage. Building LBSF in Norway comes with less risk, should they solve the lice problem, the facilities can change to smolt production.

Questions regarding investments into LBSF
There will be first movers who pave the way, and I think you need to see evidence of stable production before the large investments come. But, in Norway it's a cheaper option due to there being no license fee. As long as the salmon price is so high, then the risk is lower for LBSF.

We are to small; we don't have the financial strengths to consider this. The movement is coming from outsiders, groups who currently don't farm salmon in the sea. There is a belief in LBSF and increased over time. There are many good concepts present.

Questions regarding the NAI investing into LBSF
I don't think they will invest LBSF in Norway, but rather go abroad. In Norway the large incumbents are focusing on smolt production, rather the LBSF.

I think there is a lot of scepticism from the banking sector, there has been no visible evidence of production and profitability. But investors are willing to risk more in order to take part of the industry. The ones who are good at marketing, with good projects have gotten the financing.

Questions regarding a strategic response from the NAI
I think the production will come slowly over a longer time. Which is one of the reasons why the industry is not too worried. There will always be first movers, and I think the NAI don't see the need to be the first ones. There will be projects that fail, and the NAI don't see the need to drive the technology from the beginning, but rather pick up the relay pin at a later stage. There will be challenges abroad, I don't think they have the know how that the NAI has built up over time.

The probability of success with LBSF is greater now than five years ago to put it that way. But I can't say what probability of success I would give. On paper it should be viable production method, and the challenges are well known. The consequence of a technological failure can however be disastrous.

Appendix X: Interview with smaller incumbent of the NAI – ANONYMOUS NRS

Company: Norway Royal Salmon **Role:** Anonymous

Date: 10-05-2020 **Name:** Anonymous NRS

Questions regarding growth in the NAI

I don't expect to see significant growth from the NAI in the short-term future, the current challenges with lice are inhibiting growth from sea pens. Not only are the salmon lice inhibiting growth, it is also increasing the operational costs significantly. For growth to come it will be through LBSF or offshore farming. We have an opportunity to take advantage of existing technology in oil/gas industry and transfer to our own.

Questions regarding LBSF
We are worried about this development, should companies be able to produce salmon closer to end-consumers at a competitive price, well there is no doubt that is a scary development for the NAI. It is why we are not too happy with the Norwegian government. It is the governments strict regulation of the NAI, inhibiting growth, that is the catalysator behind the investments into lBSF in Norway.

It is obvious to me that LBSF can be a disruptive technology, but with the current technology, investing into LBSF is very risky.

Questions regarding the NAI investing into LBSF
For the moment LBSF is too risky. We have a duty towards shareholders in creating value, it makes no sense for us at this current time to invest into LBSF when we have other projects ongoing. Further, what signal are we sending if we start investing into LBSF, not only to mention how this would negatively impact our book values.

Questions pertaining a strategic response from the NAI towards LBSF
You have to understand, not investing into LBSF is also a strategic choice. We need to protect our competitive advantage, should Atlantic Sapphire become a failure then we might have already succeeded. There is so much risk and uncertainty related to LBSF, and we consider the probability of failure for LBSF entrepreneurs very great. Why would we invest into a technology that could remove our greatest competitive advantage?

The industry is currently testing out projects, whereby increasing the post-smolt size before realising into the sea pens. This could lead to a shortened production and a salmon that is more resistant towards the lice.

We are also very unsure how consumers will perceive salmon from LBSF, salmon from the NAI is perceived as high quality and don't believe LBSF will be able to compete with our premium product.

Appendix IX: Interview with organisations – Åsa Espmark

Company: CtrlAqua **Role:** Director

Date: 19-05-2020 **Name:** Åsa Espmark

Questions regarding growth in the NAI
There are large problems with lice escaped salmon, and it will take a long time before we find a solution. There will be no growth until we can solve these problems.

I think the diversity of production forms will become increasingly important, even the large incumbents of the NAI will diversify. However, to diversify it will become important to have the financial stability in order to invest into new technology. The development will favour capital strong companies. I think there will be big change in how we farm salmon in the future.

Questions regarding LBSF
LBSF exploded last year in Norway, there are many companies that are eager to start with LBSF, however, acquiring financing is a big challenge because LBSF is very capital intensive.

I think companies can raise salmon LBSF without the greatest challenges, however scaling up the production will be very difficult. Therefore, I think it will be a niche and not disruptive. I think it's important to have a realistic perspective on the production volumes.

I think many in the NAI are paying close attention to the development with Atlantic Sapphire. We are very uncertain about their production costs, it's expected to be expensive, but we don't know.

Questions regarding investments into LBSF
I don't think the NAI are investing into LBSF, and I don't think the Norwegian banks are supporting LBSF projects.

Questions the development of LBSF
We will see the greatest development of LBSF abroad. You will save importing from countries like Norway and Chile. Countries will become greater self-supplied, but the total volume will still be low.

There are challenges building lBSF abroad, you are missing out of infrastructure that exists in Norway. Such as egg and smolt production. The surrounding infrastructure is critical for success.

The world is screaming after people with RAS expertise, and there are very few with this competence.

Questions regarding LBSF as disruptive
I don't believe the numbers until I see them, I don't think it will happen and I can't image that it's going to take off. Should Atlantic Sapphire succeed, then many others will too. But very few have succeeded and look at the current production volume, it's very low.

Appendix XII: Interview with organisations – Trond Bjørndal

Company: Norwegian School of Economics **Role:** Senior Researcher

Date: 29-05-2020 **Name:** Trond Bjørndal

Questions regarding growth in the NAI
The current challenges with lice are significant, and we don't have any current solutions towards it. There will be limited growth from sea pen farming, and growth must come from other production methods like offshore farming and LBSF.

Questions regarding LBSF and uncertainty
We must distinguish risk and uncertainty. The risk pertaining to farming lBSF at large scale can´t be quantified. Insofar, it has never been done. We don't have the foundational knowledge in predicting such things. For incumbents in the NAI, they are aware of challenges farming salmon, and the risk pertaining to LBSF does not make much sense. Further, the volatile salmon price adds risk when

investing into LBSF. The current market price, that is potentially needed to defend an investment in LBSF may be lower/higher in three years' time. We just don't know.

Today Norwegian banks are not willing to invest into LBSF, for entrepreneurs it is not easy in sorting out the finance. Much of the capital is coming from outside of Norway.

Questions regarding LBSF as disruptive
It is a possible scenario taking a long-term view. However, it will take a long time for LBSF to reach significant volumes. LBSF does have the potential of reducing the production cycle, but again, we cannot say for sure. I might quote on this in the future, I don't think it will overtake traditional farming. However, in theory it is possible. There are so many factors that impact the development of LBSF, I just don't believe everything will work out. If LBSF becomes disruptive its many many years away, probably closer to 20 then 10 years.

Appendix XIII: Interview with organisations – Kjell Maroni

Company: Norwegian Research Fund **Role:** Chief Advisor on Aquaculture

Date: 11-05-2020 **Name:** Kjell Maroni

Questions regarding growth in the NAI
It is very hard to predict; we have been shocked in this industry before in how rapid the technology progress. But I don't think there will substantial amount of increase in production from the NAI.

I think LBSF can contribute as supplement on the smolt production side, and thus increase production through reduced production cycles.

I am not that concerned with escaped salmon anymore. The big problem is salmon lice, and if you don't take action when dealing with it in the beginning it can rapidly become ugly. I don't think salmon lice will be a problem in 10 years' time, I am more concerned with fish sickness from bacteria.

Questions regarding LBSF
There will be LBSF plants built outside of Norway, some will succeed. But I am convinced the majority will fail due to the lack of expertise on aquaculture. There are also problems with the salmon having a mud taste, at Atlantic Sapphire they taste the fish very often to make sure it has the correct quality. I doubt LBSF will have a premium price to it.
I think it was Mowi who made a graph of where you can farm salmon in the world. Well LBSF would change that map.

Questions regarding strategic response from the NAI

We have the technology to transport the salmon without shipping it by plane. The salmon can be frozen and defrosted at arrival without any noticeable difference in taste. Transport by boat will greatly reduce logistical costs.

Appendix XIV: Interview with organisations – Ulf Winther

Company: Sintef **Role:** Special advisor

Date: 27-05-2020 **Name:** Ulf Winther

Questions regarding growth in the NAI
It's doubtful there will be growth. Looking at the current development its going very slow. The traffic lights regulate for maximum of 3% growth a year. It's evident we need new solutions.

There are different methods of production that will complement the increase of production. Offshore farming will be very interesting to follow, there are many projects being tested as we speak.
I see four current technology movements, LBSF, floating/closed sea pens, offshore and the development of sea pens. In sum these technologies can increase the growth, but we need heavy investments from the NAI.

Questions regarding LBSF
I think many will encounter problems with LBSF in the first few years, but with a long-term perspective they might succeed. I think there are many challenges that need to be overcome. There is so much uncertainty about the technology.

Questions regarding LBSF and the NAI
I am very surprised by how easy it is to get financing from PE, because the risk is so great. It seems like investors are not incorporating the risk. What is noticeable is that the investments are not coming from the NAI, and I think there are good reasons for that.
The NAI see the risk and are not willing to take it, nor do they want to be the first movers. I think they will prefer to sit on the side-line and pay attention before investing.

I think there are mixed feeling about lBSF, I have heard top management in the NAI expressing concerns over why we are conducting research on this technology in Norway. Something they don't like, because we are giving away our advantages. But there are also top managers that are not that worried. But very few from the large incumbents have expressed optimism about LBSF.

I don't think the NAI has much option, should LBSF become a success then they will have to invest. It's just about time before it happens, I think. However, it's not a problem for the major actors in the NAI to make the transition, the have the knowledge to build and can easily acquire.

Questions regarding LBSF as disruptive
With a long time, horizon, it can become a competitor. I think 20 years is a more realistic timeline. The first movers will encounter challenges they did not foresee. I'm uncertain, but in 20 years' time there might significant volumes coming from LBSF.

Should China produce good quality salmon from LBSF, then it will definitely compete with Norwegian salmon.

You have big and small companies in the NAI, and they probably have very different perspectives on LBSF as a threat. The big ones can invest internationally something the smaller actors can't.

It's possible in theory that LBSF might overtake sea pens in terms of production volumes.

Appendix XV: Interview with organisations – Trond Davidsen

Company: ISFA **Role:** Director

Date: 27-05-2020 **Name:** Trond Davidsen

Questions regarding growth in the NAI
I honestly don't think there will be growth, there has virtually been no growth in recent years, and the current challenges are still significant. It's possible offshore farming can become a reality, but traditional farming in the fjords will yield limited growth. Most likely the large volumes will come from offshore farming, some volumes from LBSF.

We already see 2/3 incumbents moving towards offshore farming, and this technology benefits the ones with financial flexibility. The operations will become similar to oil industry whereby utilizing helicopters to transport personnel.

I think all the small investments made into different technology will maintain Norway's position as the world's largest salmon producer.

Questions regarding LBSF
None of the major incumbents are investing into LBSF. However, they are looking into RAS and smolt production. The incumbents are aware of the biological challenges that come with salmon farming and are aware of how rapid things can go south. Their knowledge of risk is an important factor.

LBSF will come, the question is at what capacity. Taking a historical perspective, it's only a question of time before they overcome the biological challenges.

Questions regarding LBSF as disruptive

The first operator who can overcome the biological challenges and establish facilities nearby end consumers will be a very interesting development to follow. We are witnessing investments in the US and ASIAN markets; however, nobody has been able to solve the riddle of LBSF at commercial scale. I do believe that they will succeed and that the volumes will come.

A critical factor will the logistical savings, LBSF will be competing with salmon that is currently transport by planes. However, the day consumer preference changes to frozen salmon. The transportation costs from Norway will be dramatically reduced.

There is so much uncertainty related to LBSF, we have no idea about the production costs. Currently we can say that sea pen farming is the better solution even thou costs have increased drastically in recent years to due to the salmon lice. But in the future LBSF might be the better production method. At one point in time, LBSF will be successfully both operationally and commercially. We expect the demand for salmon to increase, and LBSF can help fill this void.

Appendix XVI: Interview with consultants – Christian Nordby

Company: Kepler Chevreux **Role:** Seafood Analyst

Date: 22-05-2020 **Name:** Christian Nordby

Questions regarding growth in the NAI
I think a combination of LBSF, and offshore farming will contribute, and it seems the industry will become even more capital intensive. The greatest uncertainty is the salmon lice, should they find a solution towards the salmon lice. Then suddenly lBSF farming no longer is very attractive.

Questions regarding LBSF
The solutions related to lice will be pivotal for the development of lBSF. The development of LBSF depends on two factors: the cost of production and the salmon price. It is very hard to say at the moment, there is much uncertainty related to the cost of production. Figures from Atlantic Sapphire point towards 4 USD per kg. It all depends on the scalability and cost of production.

Questions regarding LBSF in the NAI
If there is a solution towards the lice, the industry will focus on sea pen farming. We don't know what most cost-efficient way of production will be, it could be from LBSF or sea pens. However, it does not look like the major players in the NAI are very interested in investing LBSF. Naturally this slows down the development, and its private equity that is the driver. I do think that traditional farmers can make the transition into LBSF rapid, they have the know-how. The challenge is the financial aspect. Mowi can could a facility with no problems, or could easily acquire a company, for example Atlantic Sapphire.

Currently the NAI are heavily invested in projects in the Norwegian sector, and post-smolt is a development the industry is moving towards. Post-smolt can reduce production costs and production cycle.

Questions regarding investments in LBSF

There are two reasons why PE is the driving force. First of all, it's a high risk. The larger companies don't see the value in taking the risk and have other projects to invest in with lower risk. Secondly, I don't think the industry likes talking about LBSF. Should the major players invest in LBSF, the technology development will be rapid, consequently devaluing their licenses. When you speak to managers, they are no to fond of LBSF. However, they are salmon farmers, and should LBSF be the better method, they will move in that direction. But the main reason is the risk adjusted return.

LBSF comes with uncertainty, and the smaller farmers are looking for projects that are less capital intensive.

Due to the scarcity of licenses, LBSF is one of the few ways we increase production in Norway. Should transportation costs decline, then building in Norway makes sense. Further facilities can be transformed into smolt-production. Thus, becoming a supplement and not a competitor.

It's virtually impossible to get financing from banks in Norway.

Questions regarding LBSF as disruptive

There are mixed views within the NAI, some are disregarding Atlantic Sapphire focusing on "mud-taste" from the salmon and other biological factors, other believe they will fail. However, I have tasted their salmon and it tastes great.

The NAI are unsure of how consumers will accept salmon produced on land. Salmon is sold at different retailing price, there is a big difference in salmon from Chile and Norway. Chile sells at 14 USD per kg and Norwegian salmon from Mowi is sold at 50 USD per kg. Branding is very important. So LBSF might become a success in terms of production, but there is uncertainty pertaining to the consumer value of this salmon. It's believed salmon from sea pens is a premium product. It's possible that LBSF will become a commodity product and not competing with salmon from the NAI that's is considered a premium product. However, this is uncertain.

There is no uncertainty in being able to farm salmon on land. The uncertainty is if it can deliver economic value, and at this point in time we don't know. We will get information soon from Atlantic Sapphire. I think Marine Harvest changed names to build a moat against LBSF.

Over time LBSF will compete with the commodity salmon, and consequently the price of salmon will decline.

Appendix XVII: Interview with organisations – ANONYMOUS PWC

Company: PWC **Role:** Consultant

Date: 25-05-2020 **Name:** ANONYMOUS PWC

Questions regarding growth in the NAI

We don't think there will be growth, there are too many challenges with the sea lice and biological issues. For growth to come there must be new legislation. Growth will come from complimentary production forms such as LBSF and offshore farming. Norway will probably not be so dominant in the years to come.

Questions regarding investments in LBSF

The NAI are very confident in the Norwegian salmon. They are probably hoping many LBSF entrepreneurs will fail. It will be a game of marketing. What is the better product and how will consumer perceive the difference in salmon.

The driving force is from PE and American investors. Currently the NAI are sitting on the fence and watching.

Questions regarding LBSF as disruptive

I think LBSF can become a competitor with the NAI. However, the time perspective is uncertain. The growth in US production will be significant if Atlantic Sapphire achieves their goals.

Appendix XVIII: Interview with organisations – Beyhan De Jong

Company: Rabobank **Role:** Analyst – Animal Protein

Date: 15-05-2020 **Name:** Beyhan De Jong

Questions regarding LBSF

The big salmon farming companies are not the drivers behind LBSF. The capital comes from niche investors. Norway is the innovation hub of aquaculture, and has the expertise, so building LBSF in Norway makes sense. The drivers behind offshore farming are the large salmon farmers.

Questions regarding investments into LBSF

Investing in LBSF is very risky, and for banks financing LBSF five years ago was no-go. Most of the projects were failing due to biological reasons or delivering products with an off flavour. Those challenges have been overcome. From a financier perspective, it's been mostly PE and venture capital that as invested in LBSF. Rabobank receives many proposals to finance, and we have a screener

towards these proposals Its important to look at each project separately. Building LBSF in Europe does not make too much sense, but in the US, JAPAN and China it does.

Questions regarding LBSF as disruptive

The biggest advantage with LBSF is the proximity to end consumers, resulting lower transportation costs and carbon footprint.

The planned projects are 800,000 tons; however, the realistic capacity might be closer to 300/400 thousand tons. Don't forget many will fail. However, you must look at where the production will come from. In 2018, the US imported around 500,000 tons, and the target production from LBSF in the US is close to 400,000 tons. With that perspective LBSF can be disruptive. Look at China, they import around 100,000 tons of salmon, and planned capacity from LBSF is around 150,00 tons.
LBSF might disrupt the exports of the NAI towards certain markets and must not underestimate LBSF. But we won't know until we see the volumes. The production capacity is only at 1000 tons. For it to become disruptive there are many factors that need to fall in place. Operational costs, volumes, profitability and consumer acceptance are still uncertain factors.

There is a swiss LBSF company that sells salmon at a higher price then organic salmon. So LBSF is risky, but It can be done.