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Profitability of land-based farming of Altantic salmon

What are the key profit drivers for land-based farming of Atlantic salmon?

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Abstract

Several factors suggest that global production of seafood will have to increase in the future from a demand perspective. In principle, this growth must come from aquaculture as global fisheries are to a large extent fully exploited. However, the growth potential of aquaculture in the sea is limited due to environmental and biological issues. As a consequence, this master thesis attempts to answer the following problem statement:

What are the key profit drivers for land-based farming of Atlantic salmon?

A conceptual theoretical framework for the relation between strategic decisions and profit drivers is established based on the theory and perspectives about strategic management accounting. In light of this framework, a comprehensive literature review on the profitability of land-based salmon farming is performed. Unfortunately, most of the reviewed literature lacks a systematic discussion of the key strategical choices for the industry's profitability. The previous literature concentrates solely on the profitability of imaginary and fictional RAS facilities, disregarding the profitability of the other two technology types.

For this reason, we have further divided the problem statement into three research questions to examine what strategic choices are the most important in the emerging industry, and how these choices drive costs and revenues, respectively. In connection, we perform a case study of three existing land-based farming facilities soon producing on land in Norway and Japan. Our selection represents the three main technology types one can utilise in the industry.

An important implication of our analysis is that we find that land-based salmon farming is not just a cost game regarding competitive strategy. There is also a differentiating potential, particularly if product quality is related to the branding of animal welfare and sustainability in the marketing, which could result in a price premium for land-based salmon.

However, our main finding is that the examined industry is very complex with respect to business strategy. Strategic choices such as technology and location influence each other and could drive both capital expenditures and operational costs. At the same time, these choices impact subsequential operational choices like facility layout and capacity utilisation, which all drive costs. Moreover, we argue that some economies of scale and scope exist in land-based salmon farming. However, quality management and strategic partnerships are considered more important for the profitability as the production methods are not plug-and-play. Considering that our conclusion is based on uncertain company estimates, further research should strive to validate our conclusion with reliable data when the industry is more mature.

Acknowledgements

This thesis was written in the spring of 2022 at the Norwegian School of Economics as an integral part of our Master of Science degree in Economics and Business Administration, majoring in Business Analysis and Performance Management. Therefore, it was in our interest to study the relationship between strategy and profit drivers in land-based farming of Atlantic salmon. The economic research of the emerging industry discusses this subject merely, which has sparked our interest in the subject and encouraged us to provide such information.

We would like to express our sincerest gratitude to our supervisor, Trond Bjørnenak, for providing constructive feedback, valuable insights, and always a brilliant mood throughout the process of writing this thesis. He has been an indispensable mentor, and the thesis would not have been possible without his support and help.

We would also sincerely thank the executives we have been in contact with on behalf of the three land-based salmon farming companies we have analysed, as well as researchers and industry experts for providing us with data and valuable hands-on insights from the industry. We especially appreciate the time the land-based salmon farmers have set aside to respond to our questions and inquiries in a very hectic and demanding phase of their operation.

Finally, we would like to extend our gratitude to our families, fellow students, and friends for the love and support they have provided us throughout this project and our years at NHH. Realising that our time at NHH has come to an end brings up mixed emotions. However, we are grateful and excited to embark on a new chapter of our lives.

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Terminology and ratios for Atlantic Salmon

FCR: Feed Conversion Rate. Measures the productivity of fish feed utilised within aquaculture. FCR is often expressed in biological terms, meaning the amount of feed that is needed for the fish to grow one kg of body weight (Great Norwegian Encyclopedia, 2019)

FTS: Flow-Through Systems. Land-based salmon farming technology that lets fresh and new water flow into the system regularly. Usually, the water is filtered before flowing into the tanks and when disposed (Pareto Securities, 2020).

HFS: Hybrid Flow-Through Systems. Land-based salmon farming technology that is a combination of RAS and FTS, where a share of the water is continuously recirculated while the other part is added and removed over time (Pareto Securities, 2020).

HOG: Head-On-Gutted. Fish weight after being bled and gutted with head on (Mowi, 2021)

ONP: Open-net pen farming. The conventional and most widespread way of farming Atlantic salmon in the sea (Moe, Skage, & Helsengreen, 2022)

MAB: Maximum allowed biomass. This is an absolute limit of biomass that a holder of an aquaculture permit could have present in nets in the sea or fish tanks on land at any time. The Norwegian Directorate of Fisheries regulates the MAB regime in Norway at the locality and company levels. A standard MAB permit for aquaculture of salmon, trout, or rainbow trout in Norway is 780 tonnes (Norwegian Directorate of Fisheries, 2022)

RAS: Recirculating Aquaculture Systems. Land-based farming technology that is based on the reuse of water through continuous recirculating through mechanical and biological filters. Typically, the degree of recirculation of water is above 90% (Pareto Securities, 2020).

TGC: Terminal Growth Coefficient. Measures for the average growth rate of salmon by accounting for fish size (grams) and temperature (Celsius) (Bjørndal & Tusvik, 2018).

WFE: Whole Fish Equivalent. Harvest weight of the fish (Mowi, 2021).

Terminology	Conversion ratios
Live fish	100,0%
Loss of blood/starving	7,0%
Harvest weight (WFE)	93,0%
Offal	9,0%
Gutted fish (HOG)	84,0%

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1. Introduction

1.1 Background of the thesis

Global fisheries are, to a large extent, fully exploited, according to the Food and Agriculture Organisation of the United Nations (FAO). FAO reports in *The State of World Fisheries and Aquaculture* (2020) that 34.2% of the global fishery was overfished at an unsustainable biological level in 2017, comprising 21.3% of global seafood. This implies that the supply of wild fish has limited growth potential going forward. Consequently, growth in global seafood must in principle come from aquaculture, which could explain why the demand for farmed salmon has been increasing in the last couple of years (Egeness & Dahl, 2022). Several factors suggest that seafood production in the world will have to increase in the future from a demand perspective (Moe et al., 2022).

Firstly, the world's population is estimated to grow to ~10 billion in 2050 (UN, 2019). All else equal, this suggests that more food must be produced, including seafood. Today, large parts of the world population are too reliant on red meat and starchy vegetables in their diets. This is neither healthy nor sustainable (Willett et al., 2019). Therefore, eating more fish could be part of the solution to the sustainability problem, thus enforcing the need for more seafood. According to OECD-FAO (2020), yearly consumption of fish per capita is estimated to increase from 20.4 kg in 2017-2019 to 21.4 kg in 2029, in other words, 0.5% yearly.

Secondly, there are demographic and social trends causing a transition toward the consumption of seafood because of expected health benefits (Bjørndal, 2014). For example, an aging population has put healthy eating on the agenda, and a growing middle class has increased purchasing power to eat more nutritious (Hupkens, 2000; Moe et al., 2022; UN, 2019). On top of that, consumers are generally becoming more aware of sustainable food production (Moe et al., 2022). For example, farmed Atlantic salmon is considered one of the most efficient and environmentally friendly forms of animal husbandry and has a carbon footprint of 7.9 kg CO_2 equivalents per kg edible product compared to 6.2 kg for chicken, 12.2 kg for port, and 39.0 kg for cattle (Mowi, 2021; Winther, Hognes, Jafarzadeh, & Ziegler, 2020). This could also partly explain the push toward increased salmon production and consumption in the future (Hoegh-Guldberg et al., 2019). In this regard, global macro trends have increased the interest in the aquaculture industry, especially land-based salmon farming.

However, several factors limit the growth of conventional salmon farming, which has raised questions about how the aquaculture of salmon could become more sustainable (FAO, 2020). For instance, natural constraints limit conventional salmon farming. Multiple conditions must be met for a location to be suitable for salmon farming. For example, the water temperature must be within a specific interval, and the sea currents must be within given limits (Mowi, 2021). As a result, only a few coastal areas worldwide are suitable for salmon farming, which has caused increased interest in land-based salmon farming.

Furthermore, most conventional salmon farming locations in the sea face several biological challenges that limit growth possibilities. Over time sea lice and other diseases have become some of the most crucial challenges to overcome in traditional salmon farming. Mitigating these challenges have resulted in higher industry costs, stricter regulations, and reduced availability of water and suitable production localities (Bjørndal & Tusvik, 2019). For example, sea lice alone account for a yearly loss of more than NOK 5 billion for the Norwegian salmon industry and have led to strict industry regulations, thus limiting growth in Norway (Jensen, 2020). The so-called "*Traffic Light System*" allows a maximum of 6% growth every two years for the current issued licence paid at a fixed feed of NOK 156 000 per tonne to the Norwegian government (Norwegian Directorate of Fisheries, 2020b). Chile has also experienced challenges with the ISA diseases, resulting in stricter regulation of fish density in net pens from 2018 and onwards (Asche, Hansen, Tveteras, & Tveterås, 2009; Evans, 2018).

On top of biological challenges and stricter regulation, conventional salmon farmers are expected to reduce its overall environmental impact. This makes it challenging to grow sustainably to meet the increased demand for farmed salmon (FAO, 2020). Consequently, the possibility of a shorter and more sustainable value chain and increased control of the biological growth conditions for the fish has sparked significant attention for land-based salmon farming.

Furthermore, the technological development in recent years within major areas like biofiltration and solids capture has led to land-based facilities becoming larger and more robust (Espinal & Matulić, 2019). Larger facilities achieving economies of scale could be an important step to making land-based salmon farming profitable (Bjørndal & Tusvik, 2019).

Along with technological development, land-based salmon farming is in many countries subject to less strict regulations and favourable license schemes compared to conventional salmon farming (e.g., Holm et al. (2015)). For example, commercial licenses to farm salmon on land are free of charge in Norway if one disregards case processing fees paid to involved parties. Licences for farming in the sea are conversely costly. The last time the Norwegian

Ministry of Trade, Industry and Fisheries held an auction of new licenses for conventional farming of salmon, trout, and rainbow trout in the sea, they were sold on average for NOK 219 757 per tonne. This implies that a salmon license with a MAB capacity of 780 tonnes was, on average, sold for 171 million at the auction (Norwegian Directorate of Fisheries, 2020a).

Given all of these circumstances, it may not be surprising that more capital is being allocated to land-based salmon farming to facilitate growth within aquaculture. In 2021, 109 companies planned to farm salmon on land in 21 countries (iLaks & Business, 2021). These facilities have a total planned capacity of 2.5 million tonnes head-on-gutted salmon (HOG), equal to 93% of the world's production in 2021 (Statista, 2022). This demonstrates the scope and potential of the emerging new sector, even though it should be mentioned that the majority of the projects are at a very early stage.

Existing literature highlights several important characteristics of the land-based salmon farming industry. Firstly, land-based salmon farming is known for having significant up-front investments (e.g., Bjørndal and Tusvik (2017); Boulet, Struthers, and Gilbert (2010); Espinal and Matulić (2019); Iversen, Andreassen, Hermansen, Larsen, and Terjesen (2013); Liu et al. (2016); Summerfelt et al. (2013)). Generally, land-based facilities are complex and specialised, making them costly to build. Furthermore, a certain size is needed to achieve economies of scale, leading to higher investments (Bjørndal & Tusvik, 2019).

Secondly, the land-based salmon farming industry has a short and simple value chain in terms of controllable input factors (The Conservation The Convervation Fund, 2019). For instance, by using procedures such as filtration and close monitoring of relevant parameters, ideal production conditions could be achieved and controlled (Winther et al., 2020).

Thirdly, the land-based salmon farming industry is recognised for its unique ability to locate facilities almost anywhere in the world. This characteristic does enable land-based salmon farms to be located in or close to the largest markets for salmon (Bjørndal & Tusvik, 2017). There are several advantages of being located near the market. Most importantly, costs associated with transportation can be minimised for the benefit of both overall costs and carbon footprint (Liu et al., 2016). Additionally, it is possible to deliver products to the market in fresher condition, which can lead to a higher price paid by consumers (ibid.).

Lastly, due to more control over the production process, land-based salmon farming is characterised as a potential sustainable industry (Bjørndal & Tusvik, 2017). The high degree of control indicates that all input factors are controllable going in and out of the facility. The result is, for instance, less or ideally no discharge of biological waste from the facilities. Some technologies also limit the need for water by recirculating, resulting in a reduced need for this scarce input factor (Espinal & Matulić, 2019).

This thesis seeks to provide reliable, comprehensive, and up-to-date information about the profitability of land-based salmon farming. There exists a lot of information on this topic already in the literature. However, from our literature review, it is evident that most of the published research primarily concentrates on the profitability of RAS. The literature takes this strategic choice of technology for granted. To our knowledge, a comprehensive analysis of the profitability of strategic choices regarding the whole technological spectrum, i.e., RAS, FTS, and HFS, has not yet been carried out and is needed.

Furthermore, the second contribution of this thesis is that three main technology types in land-based salmon farming are analysed evenly in a case study. By interviewing the management of a range of actual land-based facilities, this thesis systematically explores how important strategic choices regarding product characteristics, technology, and configuration in the value chain are important for the profitability of land-based salmon farming. Previous literature has only analysed imaginary or research facilities.

Overall, we believe the combination of theory and empiricism in this thesis could contribute to the literature and help develop land-based salmon farming.

1.2 Problem statement

With reference to the background of this thesis, we have formulated the following problem statement:

What are the key profit drivers for land-based farming of Atlantic salmon?

To provide a timely answer to the problem statement, we formulate three research questions and clarify the methodology for addressing these questions in chapter 4. The specification of the problem statement is a consequence of the conceptual theoretical framework for profit drivers in chapter 2, and the literature review on profit drivers in land-based salmon farming in chapter 3. Together, these two sections lay the basis for the research of this thesis and illustrate that further research about the profitability of strategic choices regarding product characteristics and production technology is necessary.

Boundaries and empirical delimitations

In order to narrow the scope of the thesis, we have chosen to delimit the empirical analysis to Norwegian companies operating either in Norway or outside of the country. This is a practical delimitation given the timeframe of our thesis. Furthermore, the boundary will most likely increase data access and the reliability of the conclusion as the companies in our sample are listed, close to the end of planning or even producing Atlantic salmon on land.

Furthermore, Norway is a pioneer in aquaculture and the country's biological, environmental, and commercial competence have provided beneficial conditions for further growth and sustainable development within aquaculture (PwC Norway, 2017, 2021). Considering this, Norway is a reasonable place to start examining how various circumstances impact the profitability of land-based salmon farming. Nevertheless, Norway is not a major market for salmon consumption. That is why we include a Norwegian listed companies operating in Japan to discuss possible advantages and disadvantages of locations in proximity to the market.

1.3 Outline of the thesis

In this introductory chapter, we have clarified the thesis's background, purpose, and problem statement. Furthermore, we have presented boundaries and empirical delimitations briefly. Finally, the outline of the thesis is summarised in Figure 1.1:

Chapter 1: Introduction	Presents the background, purpose and the problem statement of the thesis. Bounderies and the outline of the thesis is also elaborated
Chapter 2: Conceptual theoretical framework	Introduce the conceptual framework applied to addresss the problem statement. This framework is based on litterature about project profitability, strategy and profit drivers
Chapter 3: Studies of the profitability of land-based salmon farming	Reviews litterature on land-based salmon farming based on a profit driver framework that is fundamental for our analysis. Clarifies what has not yet been studied, and thus motivate the thesis
Chapter 4: Methodology	Specifies the problem statement in three research questions and describes the methodological framework for the thesis. Moreover, strenghts and weaknesses as well as validity and realibility of the method are discussed
Chapter 5: Business strategy and cost drivers in land-based farming of Atlantic salmon	Describes business strategy of three land-based farmers of Atlantic salmon in relation to the conceptual theoretical framework. Furthermore, an indicative cost of production estimate presented by the firms is validated and adjusted where sensitivy analysis illustrate estimate uncertainty
Chapter 6: Discussion and implications of the findings	Compare the case analysis in relation to theory about business strategy, revenue drivers and cost drivers from the conceptual theoretical framework. Implications of this discussion are thereafter structured and synthesised in accordance with the research questions of this thesis
Chapter 7: Limitations and further research	Clarifies the limitations of the thesis and suggest areas for further research on the topic of land-based salmon farming
Chapter 8: Conclusion	Summaries and provides the conclusion of the thesis

Figure 1.1 - Outline of the thesis

2. Conceptual theoretical framework

This chapter presents the conceptual theoretical framework which discloses how we intend to address the problem statement of this thesis. Firstly, we present a framework for analysing project profitability as an overall structure for our land-based salmon farming industry analysis. This framework is divided into three distinct phases (Bjørnenak, 2019). The first phase is *the creative phase* which regards the profitability of the company's possible strategic decisions given the business environment. This lays the foundation for the second phase, called *the technical phase,* where expected profitability for possible decision alternatives is estimated. The third phase is *the communicative phase* which communicates the profitability and tests its robustness by altering fundamental assumptions and parameters (ibid.).

Secondly, to explore how strategic decisions will impact the most significant revenue and cost drivers within land-based salmon farming, we apply the *Cost and Profit Driver Research* by Banker and Johnston (2006). This framework demonstrates the fundamental assumptions for analysing the strategic decisions incorporated by the land-based salmon farmers.

Finally, we attempt to measure the profitability of strategic decisions in the case study. Moreover, we communicate the uncertainty related to significant parameters and assumptions and how they impact the profitability of various land-based salmon farmers. Technical techniques, like sensitivity, are applied to indicate which parameters account for the most significant variation in profitability. Based on our judgement and assessment of the literature, we present the following conceptual theoretical framework in Figure 2.1 below:

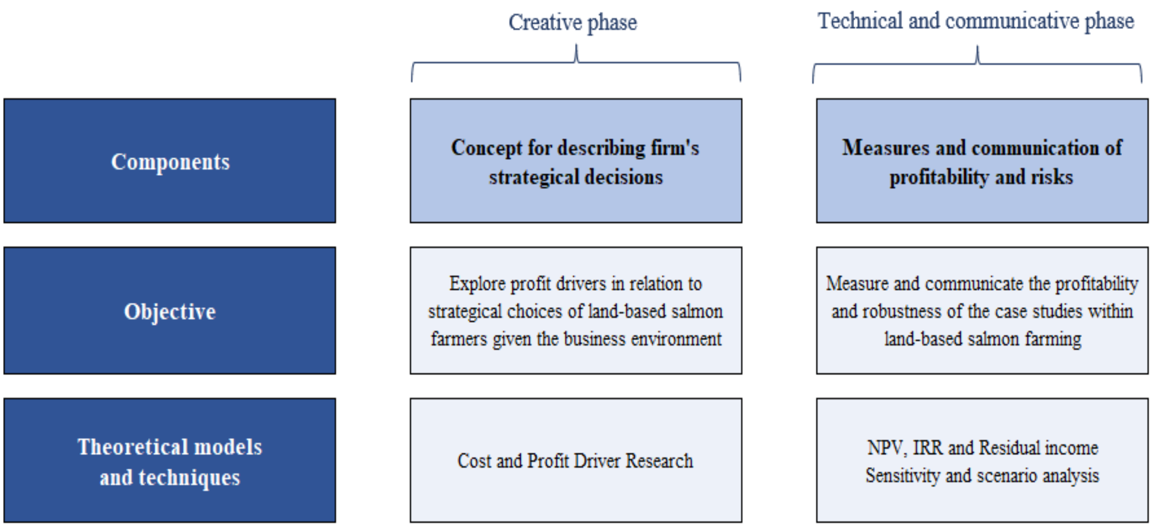

Figure 2.1 - Project profitability framework (Bjørnenak, 2019)

2.1 Concepts for describing a business strategy

In this section, we present *Cost and Profit Driver Research* by Banker and Johnston (2006). This framework is applied for analysing the relation between strategic choices and profit drivers in industries given the business environment. Strategic choices are decomposed into three different levels, and the relation to profitability for each level will be explained.

2.1.1 Cost and Profit Driver Research

Until the 1980s, production volume was assumed to be the primary cost and revenue driver and hence one of the most important strategic variables. Kaplan (1983) was one of the first to challenge this idea. He argued that other variables than production volume could affect costs, revenues, and long-term profits. Since then, many researchers like Porter (1985) and Riley (1987) have explored profitability drivers other than production volumes in a strategic context elaborated in section 2.1.3 below.

Banker and Johnston (2006) exemplify that the empirical research is particularly focused on cost drivers (e.g., Anderson (2001); Datar, Kekre, Mukhopadhyay, and Srinivasan (1993); Foster and Gupta (1990)). Nevertheless, some empirical research has explored the relationship between cost drivers, customer value, revenues, and thereby profits (e.g., Ittner, Larcker, and Taylor (1997); Kekre and Srinivasan (1990)).

Accordingly, *the Cost and Profit Driver Research* framework aims to synthesise empirical evidence that manifests how strategic choice can cause both costs, revenues, and profits. The framework assumes that an analysis of profit drivers is a linear process initiated by a company's choice of competitive strategy. This strategic choice has again implications regarding which market strategy and operational strategy are feasible. All these choices, in turn, make up the overall business strategy and give direction to decision variables such as product design, technology, and process design in the value chain. A comprehensive understanding of the causal relationships between strategic choices and the decision variables in Figure 2.2 below could help management to make more informed decisions. This is because the framework demonstrates how various strategical decision variables could drive both cost, revenue, and thereby profits (Banker & Johnston, 2006).

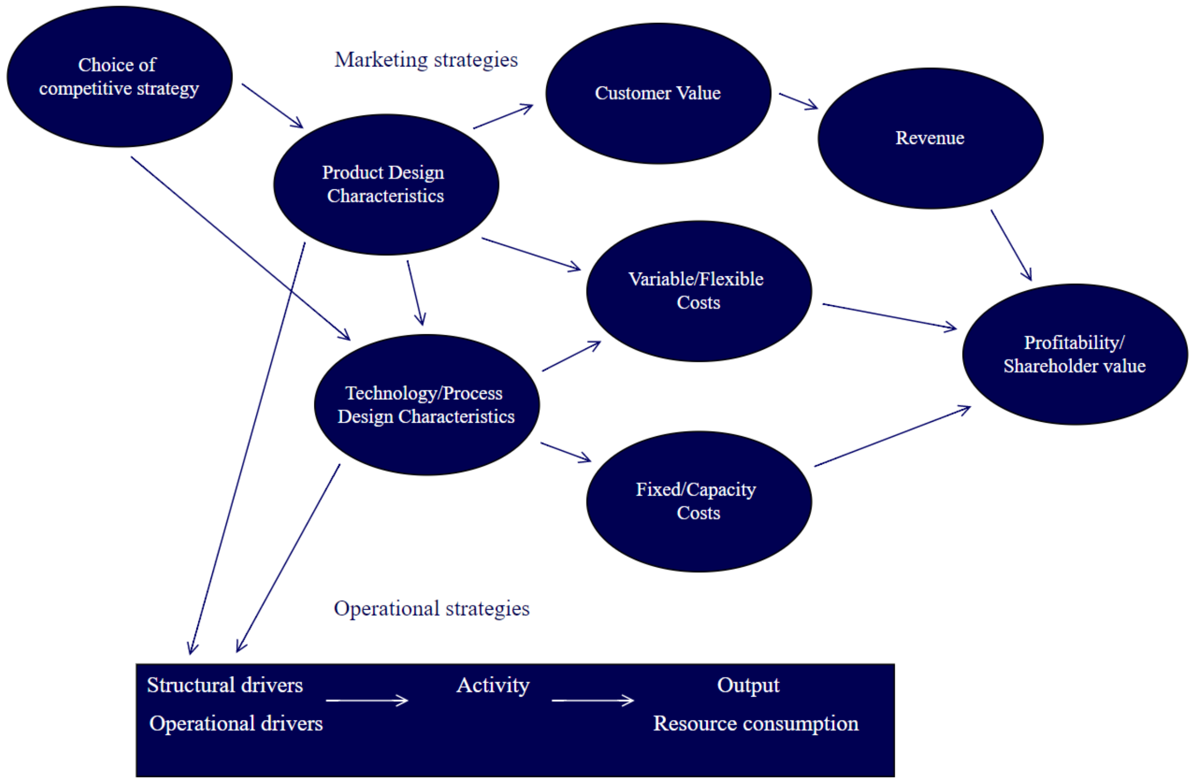

Figure 2.2 - Cost and Profit Driver Research framework (Banker & Johnston, 2006)

Competitive strategy

According to Porter (1985), there are two basic types of competitive advantages, namely *low cost* and *differentiation*. Figure 2.3 shows three generic *competitive strategies* when combining competitive advantage and scope. Together, they describe how a company could position itself to compete in the market (Besanko, Dranove, Shanley, & Schaefer, 2017).

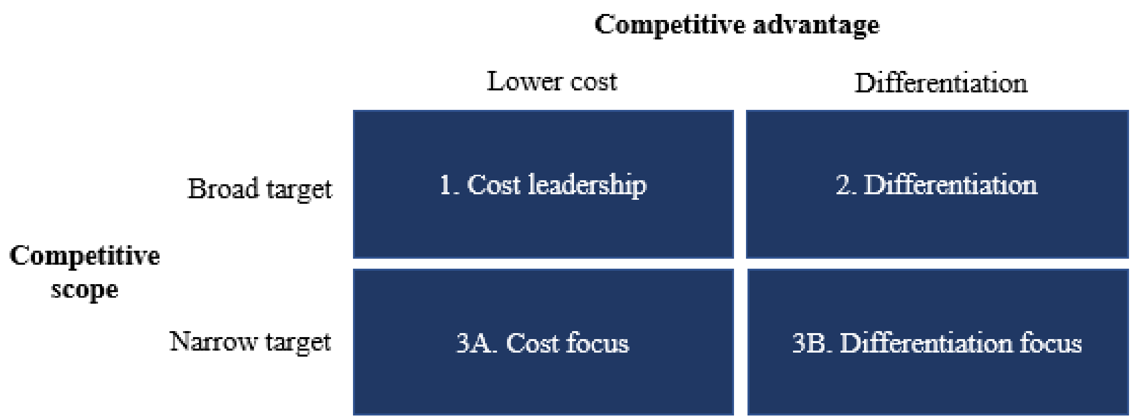

Figure 2.3 - Generic competitive strategies (Porter, 1985)

Cost leadership requires a cost advantage in terms of resource access or activities in the values chain, meaning it is possible to have a broad scope of customer segments or related industries (Porter, 1985). For this reason, it is a typical strategy for commodities. Value is created mainly by reducing product cost without necessarily decreasing product quality. This requires companies to be both productive and efficient, something *total quality management* or *lean production* could contribute towards (Lien, Knudsen, & Baardsen, 2016). These two concepts could ensure compatibility between company production and customer demands, facilitate teamwork as well as improving production activities (Dean Jr & Bowen, 1994).

In contrast, companies pursuing *differentiation* have an advantage in terms of brand or product characteristics. This means that their brand or products create more value for the customer than their rivals. For this reason, customers are willing to pay a price premium for its uniqueness (Porter, 1985). The magnitude of this price premium depends on the price elasticity of demand (Besanko et al., 2017). Osterwalder and Pigneur (2010) discuss how companies could increase customers' willingness to pay by positioning products differently from rivals. For example, companies could try to deliver differently than rivals on product-related attributes like performance, design, or accessibility. Moreover, companies could also differentiate in terms of non-product-related attributes such as status and user image.

Focus, the third generic strategy concentrate either on differentiation or low costs in a niche market. This means the competitive scope is narrower than the other two competitive strategies, but the fundamental competitive advantages are the same (Porter, 1985).

Lien et al. (2016) explain that there are trade-offs between positions because activities are incompatible. Accordingly, companies usually have to perform several activities that drive up the cost to deliver differentiated products that increase customers' willingness to pay. The *production possibility curve* (PPC) below illustrates the trade-offs between strategic choices. Figure 2.4 shows that the competitive strategy lays the basis for a company's optimal market position on the PPC. Also, it demonstrates how the operating strategy could influence productivity and efficiency, meaning how close to the PPC a company is able to position itself. Consequently, Banker and Johnston (2006) claim that selecting the *competitive strategy* is the most fundamental choice for a company seems reasonable. This choice influences what marketing and operating strategies are appropriate, and thus, their cost, revenue, and profits.

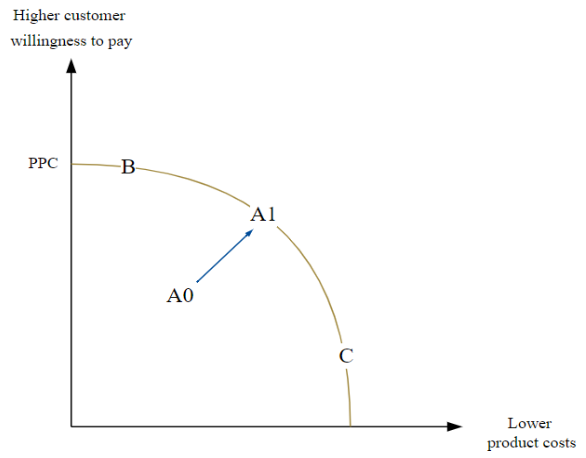

Figure 2.4 - Production possibility curve (Lien et al., 2016)

Marketing strategy

Selection of competitive strategy will subsequently affect an organisation's appropriate choice of *marketing strategy* (Banker & Johnston, 2006). This involves establishing a competitive value proposition for target customer segments that drive revenues, but also requires input from areas like sales, manufacturing, and finance that drives cost (Kotler & Keller, 2016). In addition, the marketing strategy is closely linked to the choice of *product design characteristics,* including quality, design, and product mix. These characteristics will again impact a company's revenues and costs through perceived *customer value*, especially with differentiation as a competitive strategy. Customer value is the difference between willingness-to-pay and market price, in other words, consumer surplus (Besanko et al., 2017). According to Banker and Johnston (2006), decisions regarding product characteristics in the marketing strategy also drive revenues and not just costs.

Operating strategy

The selection of competitive strategy and marketing strategy also impact strategic choices regarding the *operational strategy*. This regards *technology* and *process design characteristics*. These two terms are broadly defined and comprise the organisational structure, activity design, and resource utilisation (Banker & Johnston, 2006). The objective of the operational strategy is to ensure consistency between a company's value proposition and how they intend to create and capture this value. In short, operational strategies is about designing a profitable business model (Christensen, Johnson, McGrath, & Blank, 2019).

In sections 2.1.3 and 2.1.4, a comprehensive overview of the relationship between business strategy and profit drivers is carried out.

2.1.2 Limitations of the Cost and Profit Driver Research

The *Cost and Profit Driver Research* could be an appropriate framework to apply when addressing the problem statement of this thesis. The reason for this is that it systematically synthesises empirical evidence on how strategic choices can drive both costs, revenues, and profits. However, the framework also has its limitations which must be addressed.

Firstly, a limitation with *the Cost and Profit Driver Research* is that the framework is simple and conceptual. A linear process of strategic choices related to competitive, marketing, and operating strategy is assumed to initiate the causality between cost, revenue, and profit drivers. In reality, the relationship between profit drivers and strategic choices may be more complex.

Secondly, it has been shown that the framework focuses more on cost than revenue drivers. Banker and Johnston (2006) argue that this is a challenge for the management accounting literature and thus motivates future research to expand the scope of profit drivers to include value and revenue drivers.

Thirdly, the *Cost and Profit Driver Research* do not indicate if the various strategical decision variables drive costs and revenues primarily through unit price, production volume, or both.

Given these limitations, it is timely to define profit and its relation to profit drivers. Banker and Johnston (2006) demonstrate that profit is the difference between revenue and costs:

1) $\text{Profit} = \text{Revenues} - \text{Costs}$

This could be further decomposed into the following:

2) $\text{Profit} = (\text{Price per unit} - \text{Average cost per unit}) * \text{Production volume}$

3) $\text{Profit} = (\text{Price per unit} - \text{Average cost per unit}) * \text{Capacity} * \text{Capacity utilisation}$

From equation 2, it is evident that *production volume* could drive both revenues and costs. However, the *Cost and Profit Driver Research* does not define this dual relationship clearly. Revenue appears to be mainly driven by *perceived customer value* which in turn is influenced by *product design characteristics* that companies decide on in their marketing strategy. The framework does not state whether these two decision variables drive revenue mainly in terms of *price per unit* or *production volume*. To be willing to pay, a customer must perceive value from product attributes (Lien et al., 2016). For that reason, we find it most appropriate to present revenue drivers in relation to unit price instead of production volume.

On the other hand, Banker and Johnston (2006) categorise costs into variable and fixed types. Equation 3 demonstrates that production volume links these two costs through *structural* and *operational* cost drivers like *capacity* and *capacity utilisation,* respectively. Therefore, production volume could influence the average cost per unit either by driving up total variable costs or driving down a product's fixed unit cost.

In light of this, cost drivers presented down below in section 2.1.3 are connected to production volume, while revenue drivers presented in section 2.1.4 are mainly related to unit price.

2.1.3 Cost drivers

The intuition of Banker and Johnston (2006) is that a company's choice of competitive, marketing, and operational strategy make up its overall strategy. These strategic decisions, in turn, drive revenue, costs, and profits. For this reason, we believe a definition of cost drivers is timely for addressing the problem statement of this thesis.

Until the 1980s, production volume was assumed to be the primary cost and revenue driver and hence one of the most important strategical variables. Kaplan (1983) was one of the first to challenge this idea. This initiated the "Relevance lost"-debate, where several researchers have reviewed and tried to classify cost drivers other than production volume (Ax & Ask, 1995; Shank, 1989; Shank & Govindarajan, 1989). All of them take Porter (1985) and Riley (1987) as a point of departure, and try to describe how cost drivers other than production volume could be managed in a strategic context.

Porter (1985) defined a cost driver as a structural factor that influences the resource utilisation of an activity and thereby the origin of the cost. He divided them into ten different categories. As an alternative, Riley (1987) divided cost drivers into *structural* and *executional cost drivers,* as Appendix A1illustrates. However, he does not include *geographic location* and *institutional factors* as structural cost drivers like Porter. Moreover, Porter does not recognise *product line complexity* as an individual structural cost driver like Riley (Blindheim, 2010).

Building on the "Relevance Lost"-debate, Cooper and Kaplan (1988b) introduced *ABC*. They argued that all organisational activities that impact the value delivery should be considered a production cost. According to Cooper (1990) activities drive costs directly or indirectly through resource consumption in a *cost hierarchy*. This hierarchy has different levels, which is outlined in Appendix A1.

In this thesis, cost drivers are defined as either *structural* or *operational*. The classification in Table 2.1 below is based on various sources (e.g., Ax and Ask (1995); Porter (1985); Riley (1987); Shank and Govindarajan (1989)).

Structural cost drivers	Operational cost drivers
• Economics of scale and scope	• Competence
• Product mix and complexity	• Capacity utilisation
• Timing (first/late movers)	• Facility layout efficiency
• Learning and spillover effects	• Product design
• Technology	• Quality management
• Location	• Employee engagement
• Institutional factors	• Process and linkage utilisation

Table 2.1 - Cost drivers (Ax and Ask, 1995; Porter, 1985; Riley, 1987; Shank and Govindarajan, 1989)

Structural cost drivers

Structural cost drivers regard underlying economic structures that invoke decisions in the competitive, marketing, and operational strategy. These structural decisions will drive a company's costs and could both be within or beyond its control (Blindheim, 2010; Shank, 1989). The conceptual theoretical framework of this thesis includes ten structural cost drivers.

Economics of scale arises from the ability to perform activities at full capacity more efficiently at larger volumes (Porter, 1985). For this reason, scale illustrates how production volume might drive costs directly or indirectly. Whether scale is an advantage or a disadvantage, depends on whether the industry is capital or labour intensive. Moreover, it depends on the company's configurations of marketing and operational activities in the value chain like R&D, purchasing, manufacturing, brand development, and customer service (Besanko et al., 2017).

Porter (1985) discusses *scale* in relation to *product mix* and *complexity* which he defined as a policy choice driving cost. Riley (1987) treated *complexity* as a separate cost driver. However, both agree that a diverse and advanced product mix can increase the complexity of operating activities such as set-ups, inspection, material handling, and scheduling. According to Cooper and Kaplan (1988a), the strategic decision about product mix and complexity could drive costs. This is especially true if several low-volume products are in the product mix. If overhead costs are allocated traditionally based on total production volume, high-volume products would normally subsidise the low-volume products in the production mix. On this basis, scale is a driver that could both positively and negatively affect profits. Therefore, a part of the causality depends on product mix and complexity (Anderson, 2001; Foster & Gupta, 1990).

Economics of scope regards how vertical integration might affect costs at various production stages (Shank, 1989). For example, Porter (1985) explains that the integration of activities in the value chain can be a resource providing a competitive advantage, especially in markets with powerful suppliers or customers. Moreover, Riley (1987) and Besanko et al. (2017) extend the concept of scope to consider revenue increase and cost savings a company achieves by offering a wider variety of products or services. However, research has displayed that breath in products and services could drive costs disadvantageously in terms of profitability (e.g., MacArthur and Stranahan (1998)). This illustrates that *product mix* and *complexity* are important operational decision variables when evaluating if vertical and horizontal opportunities of scope are beneficial or not for a company's profit.

Timing of business cycles and market conditions could impact the cost of marketing and operational activities in the short-term or long-term by having favourable competitive conditions being the first mover. However, late movers could reap the benefits of newer equipment and industry maturation, causing lower development costs (Porter, 1985). Furthermore, the timing of the move impact when *learning* starts. Learning could enhance knowledge, increase employee skills, and reduce production unit costs over time due to better resource utilisation (ibid.). Moreover, the economics of learning may be substantial even when the economics of scale is minimal. This might be the case for labour-intensive industries, and the opposite is usually true for capital-intensive industries. Managers who do not correctly distinguish between the economics of scale and learning might draw incorrect interference about the benefits and cost of adjusting production volumes (Besanko et al., 2017). Learning could as well cause *spillover effects*. The spillover rate determines if learning creates a cost advantage for a specific company in the industry, or the overall industry (Porter, 1985).

Porter (1985) defines *technology* as one of many strategical policy choices that drive cost, but Riley (1987) regards technology as a separate structural element related to production. We will consider technology as a factor that impacts activity configuration and resource utilisation in the value chain. Technology is closely linked to operational strategical choices and whether the company wants to be a leader or a follower in the market. The former involves high development costs and risks. Greer Jr and Moses (1992) reveal that technological complexity explains little of the variation in development cost but has a significant effect on development time. This implies that there could be cost savings by dividing up the development phase.

Choice of technology could be analysed in relation to *location.* This is another structural cost driver that might influence demand, but also cost related to input factors such as labour, raw material, transportation, and energy (Besanko et al., 2017). Moreover, location is closely linked with *institutional factors* like local rules and norms, governmental tax, tariffs, and other financial incentives. These factors involve advantages and disadvantages that are mostly beyond companies' scope of control (Porter, 1985).

Operational cost drivers

Operational cost drivers reflect a company's operational ability, which again determines the level of costs consumed by its activities. Consequently, operational cost drivers are possibly more oriented towards activities than structural cost drivers (Blindheim, 2010).

As opposed to structural cost drivers, more is better for operational cost drivers since the concept is closely connected to competitive advantage. For example, increased *employee engagement, facility layout efficiency,* and *capacity utilisation* are beneficial (Besanko et al., 2017). These factors could reduce downtime, bottle-necks, and improve unit profitability by spreading fixed capacity costs over a larger production volume (Shank, 1989).

Moreover, MacArthur and Stranahan (1998) found that economics of scope is positively related to capacity utilisation. However, research has also shown that increased product mix and complexity might have a negative impact on efficiency and capacity utilisation (Anderson, 1995, 2001; Foster & Gupta, 1990). This again illustrates trade-offs in economics of scope.

Additionally, *product design characteristics,* mainly product-related attributes, are a cost driver that could improve profitability and create a competitive advantage. For example, Datar et al. (1993) and Nagar and Rajan (2001) demonstrate how the interplay between product design, product price, and product quality in operating and marketing strategy drive revenue and production costs. Moreover, (Banker, Datar, Kekre, & Mukhopadhyay, 1990) reveals that product design positively correlates with life cycle costs, even though a large proportion of these costs are locked in before production begins.

Finally, *process and linkage utilisation* with customers and suppliers is a cost driver that an organisation can exploit to improve their value creation, delivery, and capture and thus create a competitive advantage (Lien et al., 2016; Porter, 1985). This is also the case for *quality management,* where the basic idea is that success depends on good internal and external processes rather than on technical solutions and innovations (Feigenbaum, 2002).

2.1.4 Empirical research on revenue drivers

Researchers have developed several profit driver models over the last 40 years (Cooper and Kaplan (1988b); Ittner and Larcker (2001); Kaplan and Norton (1996); Porter (1985); Riley (1987)). However, most models put significantly more emphasis on cost than revenue drivers. Shields and Shields (2005) display that empirical research on revenue drivers is fragmented and can be discussed at the customer, product, and organisation level. However, based on their empirical research, it is not necessarily clear whether the drivers influence variation in revenues primarily through unit price, production volume, or both at the same time.

As there is no recognized, comprehensive theoretical framework for revenue drivers, we choose to shed light on this topic by presenting theories about *product design characteristics* and *customer value*. According to Banker and Johnston (2006), revenues are determined by whether a company manages to provide products with material and non-material attributes that customers value. This impacts their willingness to pay, meaning that revenues in terms of unit price are a function of competitive, marketing, and operational strategical choices.

Product design characteristics

In the following, we will define product design characteristics and how these could influence the unit price. In general, the terms product characteristics and product attributes are used interchangeably. Keller (1998) divides product attributes into *product-related* and *non-product-related attributes*. This division is relevant for the conceptual theoretical framework of this thesis since it influences perceived customer value and thus drives unit price.

Product-related attributes regard the physical composition and functionality of a product. This includes, for instance, colour, taste, weight, product design, and condition of the product. Some product-related attributes are necessary for the product to perform at a minimum level. Others are applied to differentiate, illustrating marketing strategy trade-offs (Keller, 1998).

Non-product-related attributes are symbolic benefits that customers associate with the purchase or consumption of a product. This could be price, packaging, brand personality, and user image (Keller, 1998). Non-product-related attributes do not directly influence the product’s functionality but indirectly affect perceived customer value through emotional benefits and costs. *Country origin* is an example of a non-product-related attribute. According to Bertoli and Resciniti (2013), consumers with a high ethnocentrism are willing to pay a price premium for domestic products. This is particularly true for food products since they symbolise social and cultural connotations and associations.

Customer value

Banker and Johnston (2006) explain that a company's decisions about product design characteristics are driven by its anticipation and understanding of customer needs and wants. These marketing choices generate costs in operations and revenues through new and retained customers. This is because customers choose the offerings they perceive will deliver the most value, given their material and non-material product attributes.

With this in mind, it is clear that product design characteristics have an effect on unit price through *perceived customer value*. This is illustrated by Banker and Johnston (2006). According to Kotler and Keller (2016), customer perceived value of a product is the difference between all perceived *customer benefits* and *customer costs*. Total *customer benefits* are the perceived monetary value in terms of economic, functional, and psychosocial benefits that a customer expects from a market offering. These benefits are related to the product itself, as well as the service, personnel, and image. On the other hand, total *customer costs* are the perceived bundle of costs customers expect to incur when evaluating, obtaining, using, and disposing a market offering. Figure 2.5 illustrates that these costs could be divided into monetary, time, energy, and psychological costs.

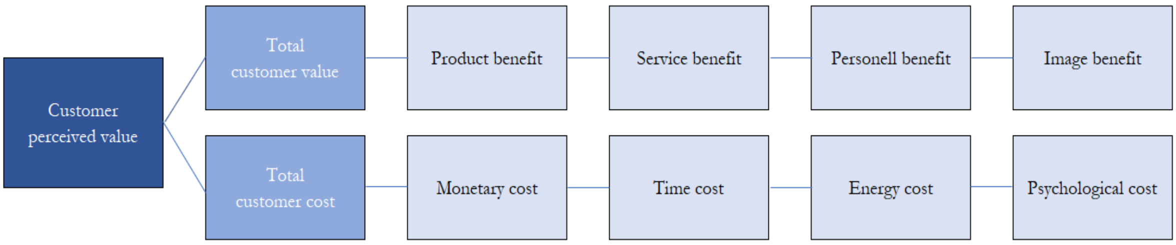

Figure 2.5 - Customer perceived value (Kotler and Keller, 2016)

On this basis, companies can increase customer perceived value of an offering, and thus revenue, by improving the correspondence between product specifications and delivered quality. This is called *conformance quality* and is mainly related to material product attributes. However, a company can increase customer value through *design quality*. This concerns initiatives that improve the correspondence between product-related and non-product-related characteristics and customers' desires (Datar, Rajan, & Horngren, 2020). In short, a company can increase the value of an offering by raising customer benefits or reducing its costs related to economic, functional, psychological, or emotional product traits (Kotler & Keller, 2016).

2.2 Measures and communication of profitability and risk

2.2.1 Measures of profitability

Profitability is the ability to make financial gains and there are numerous ways of measuring the profitability of projects within an industry like land-based salmon farming. A possible way is to examine accounting results such as *operating margin*, *net profit margin*, *return-on-investments*, *pay-back period, break-even-production,* and *price.* However, a significant disadvantage is that accounting results do not necessarily reflect the opportunity costs. This is not the case for the net present value (NPV) and internal rate of return (IRR), which is probably why the profitability measures are widely used (Brealey, Myers, & Marcus, 2020).

Net Present Value

Brealey et al. (2020) define NPV as the difference between the present value of cash inflows and outflows over a period of time. Present value is the current value of a future cash flow considering a discount factor determined by a specific rate of return. The discount factor represents the opportunity cost and time value of money and compensates investors for inflation, risk, and postponed consumption. The NPV rule says that a project is, by all means, profitable if it generates a positive NPV. With this in mind, NPV has the following formula:

$$4)\ NPV = \sum_{t=1}^{T} \frac{NCF_t}{(1+r)^t}$$

NCF = Net cash flow, r = Required rate of return, T = Number of periods, t = Period

Internal rate of return

The internal rate of returns could complement the NPV rule. Brealey et al. (2020) explain that IRR is the discount rate that makes the NPV of a project equal to zero. The internal rate of return rule says that a project is profitable if the required rate of return is less than IRR.

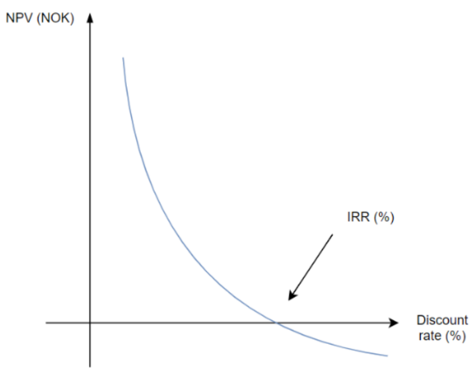

Figure 2.6 - NPV and IRR relation

Residual income

When measuring a project's profitability, it is essential to assess capital employed from an investor perspective. The reason for this is that investors' capital could have been applied to alternative purposes, thus representing an opportunity cost of capital (Brealey et al., 2020)

There are various ways of accounting for the cost of capital. NPV and IRR estimate capital costs through the required rate of return. However, only NPV can be applied consistently to evaluate which project is most profitable if projects are mutually exclusive. Managers should then choose the project with the highest NPV and not IRR, as this can result in a sub-optimal decision overall when projects are mutually exclusive (Brealey et al., 2020).

However, in this thesis, project profitability is being measured by residual income. Kaldestad and Møller (2016) define residual income as company or project income after accounting for the cost of capital. If residual income is positive, then a project is profitable. Equations 5-7 specify how we define residual income:

$$5)\ \text{Residual income} = \text{Net Operating Income} - \text{Capital costs}$$

$$6)\ \text{Residual income} = \text{EBITDA} - \text{Depreciation} - \text{Imputed interest}$$

$$7)\ \text{Residual income} = \text{EBITDA} - \text{Depreciation} - \text{Capital employed} * \text{Required rate of return}$$

As equations 5 and 6 display, capital cost will be accounted for separately as a production cost in our measurement of project profitability and consist of depreciations and imputed interest.

In relation to depreciations, the objective of strategic project profitability analysis is to connect and relate capital costs with revenues over the economic lifetime of assets. For this reason, the choice of depreciation plan and capital base impact the magnitude of capital costs. At the same time, equation 7 displays that the imputed interest represents the opportunity cost of capital as a function of capital employed and the required rate of return (Bjørnenak, 2019).

It is possible to estimate total capital costs as a yearly annuity, or a linearly, where depreciation is held constant as part of the capital base and imputed interest is reduced over the economic lifetime of assets. At the same time, total capital costs could be measured in nominal or real terms, where the general or specific development of prices is reflected in the required rate of return or depreciation, respectively (Bjørnenak, 2019).

Together, the two choices mentioned above create five different methods of calculating total capital costs: (1) *nominal linear*, (2) *real linear*, (3) *nominal annuity,* (4) *real annuity with a general price increase,* and (5) *real annuity with a specific price increase* (Bjørnenak, 2019).

2.2.2 Measure of risks

A single formal definition of risk does not exist. However, Roggi, Damodaran, and Garvey (2012) explain that risk is something that offsets the upside of an opportunity. According to them, an appropriate risk classification could be the following: (1) *Operational risk*, (2) *Financial risk*, and (3) *Market-based risk*. Operational risk regards biological, technical, and other daily processes that can distort business operations. Financial risks comprise investors' possibility of losing money on their investment. This could be due to internal risks like failed control systems or external risks due to inflation and interest rates. Finally, market-based risks include natural disasters, political turmoil, and recessions that affect markets overall (ibid.).

The required rate of return

One way of measuring the risk of a project is through the required rate of return. This measure reflects investors' opportunity cost of capital and the risk of accepting the project. When evaluating the risk of projects, it is typically assumed that investors are well diversified because of good diversification opportunities. This implies that a project's required rate of return only accounts for systematic risk in terms of market fluctuations. Unsystematic risks related to operational and financial events are instead accounted for through scenarios in the expected cash flows (Kaldestad & Møller, 2016; Koller, Goedhart, & Wessels, 2020).

Having said that, the estimation of the required rate of return is distorted by human judgement, representing a fundamental weakness. For this reason, the market and its premium might fail due to human behaviour and asymmetric information, causing inefficient capital allocation. On top of that, premiums might exist other than the market premium due to liquidity or country risk that the *Capital Asset Pricing Model* does not reflect (Kaldestad & Møller, 2016). As a result, there is unlikely a consensus on what required rate of return is suitable for a project. Accordingly, the choice of the required rate of return is one of many input factors that could affect the profitability of a specific project. Sensitivity and scenario analysis are appropriate techniques to apply to establish an understanding of this matter in the communication of projects' profitability and risks.

2.2.3 Communication of profitability and risks

Sensitivity analysis

Sensitivity analysis is a "what if" technique that demonstrates how, for example, profitability is affected by changing specific variables like price one at a time (Bøhren & Gjærum, 2020). The greater the marginal change, the more sensitive the profitability is to change in the given parameter. Thus, sensitivity analysis helps decision-makers visualising the consequences of possible outcomes that might occur, before committing to a project (Datar et al., 2020).

On the other hand, sensitivity analysis has its weaknesses. Firstly, the method does not indicate the probability of a specific change occurring. Secondly, dependencies between variables such as price and volume are disregarded (Bøhren & Gjærum, 2020). Nevertheless, it is possible to apply scenario analysis as a complement to sensitivity analysis to address these limitations.

Scenario analysis

Scenario analysis is a more advanced sensitivity analysis to manage dependencies and the possibility of change in multiple variables simultaneously (Bøhren & Gjærum, 2020). Bourmistrov, Helle, and Kaarbøe (2017) argue that studying scenarios could be beneficial when evaluating a project's profitability. This is because it encourages strategic thinking and establishes a potential picture of the future given uncertainty. The authors distinguish between two approaches of scenario analysis: *the intelligent machine* and *the creative ideas.* The intelligent approach studies the future by discussing and modelling causal relationships. Contrarily, the creative approach considers the process of creating scenarios as valuable. This makes an organization more robust and prepared for what is to come. For this reason, the creative method is often more used as a planning tool by companies that have considerable influence on their environment (Bourmistrov et al., 2017).

2.3 Summary of the conceptual theoretical framework

In this chapter, we have clarified the conceptual theoretical framework of this thesis that will be applied to address the problem statement of this thesis.

Firstly, the presentation of the *Cost and Profit Driver Research* framework has illustrated that the strategic choices could drive profits in terms of revenues and costs on three overall levels: *competitive, marketing,* and *operational*.

Secondly, the review of the conceptual theoretical framework has demonstrated that cost drivers could be analysed *structurally* and *operationally*. These decision variables are related to both *production volume* and *unit price*. It has also been brought to attention that cost drivers will be analysed mainly in relation to production volume since this variable is linked to structural and operational cost drivers like *capacity* and *capacity utilisation*.

Thirdly, it has been explained that empirical evidence on revenue drivers is fragmented. It is not necessarily clear whether such decision variables cause variation in revenue through unit price, production volume, or both. Considering that Banker and Johnston (2006) illustrate that customers' willingness to pay is influenced by the *perceived customer value* and *product design characteristics*, revenue drivers will be analysed with respect to unit price.

Finally, the review of the conceptual theoretical framework has demonstrated that the exploration of the problem statement will be structured based on the three phases in the *Project profitability* framework by Bjørnenak (2019). The discussion of strategic choices in our case study and how they influence profit drivers accord with the *creative phase*. Furthermore, measurement and communication of the profitability in the case study concur with the *technical* and *communicative phase*. *Sensitivity* and *scenario analysis* are theoretical techniques applied in this part of the analysis.

Before specifying the problem statement of this thesis with respect to the conceptual theoretical framework, we believe it necessary to review previous studies of the profitability of land-based salmon farming in chapter 3. Such an approach allows us to formulate adequate research questions to explore and contribute to uncovered areas in the existing literature.

3. Studies of the profitability of land-based salmon farming

This chapter will give a brief review of previous studies of the profitability of land-based salmon farming. The studies have been selected and sorted based on how they fit, relate to, and utilise the framework of Banker and Johnston (2006). The land-based salmon farming industry has been an area of interest in recent times, resulting in several interesting studies. We have used some key articles as a starting point for the review. These are Bjørndal and Tusvik (2019); King, Elliott, James, MacLeod, and Bjorndal (2018); Liu et al. (2016); Solheim and Trovatn (2019). Relevant studies mentioned in these articles have been evaluated and, in turn, lead us to other studies. The review has been additionally accompanied by searches in the Google Scholar database using keywords such as "land-based salmon farming" and "profitability of land-based salmon farming". Therefore, we find it reasonable to assume the review covers a broad part of studies regarding the profitability of land-based salmon farming.

In order to uphold the scope of the thesis, reports and papers have been evaluated qualitatively based on whether there is a direct use of the framework or discussion of parts of the framework. Therefore, the review excludes studies mainly focusing on the biological and environmental side of land-based salmon farming. Despite these being interesting studies and material for the profitability, the studies lack a direct use or discussion of the central elements of the framework of Banker and Johnston (2006).

3.1 Strategic choices

3.1.1 Competitive strategies

There is, to our knowledge, no previous research that discusses the alternative competitive strategies thoroughly from a land-based salmon farming industry perspective. This can probably be explained by farmed salmon being normally seen as a commodity (Asche & Oglend, 2016). Commodities are often associated with low-cost competitive strategies, meaning competition is a cost game (Porter, 1985). However, some previous studies discuss a differentiation strategy indirectly by examining the possibility of achieving a price premium (Liu et al., 2016; Solheim & Trovatn, 2019). This is discussed further in the following section.

3.1.2 Marketing strategies

When discussing marketing strategies, it is highly relevant to consider what product attributes consumers value and whether these lead to a price premium. Badiola, Gartzia, Basurko, and Mendiola (2017) studied what sensory product qualities consumers perceive valuable when choosing salmon. The sensory qualities of salmon filets from two RAS facilities with different thermal regimes are compared based on aspect, smell, flavour, texture, and global impression. The authors found no significant differences in sensory quality. Furthermore, based on consumers' acceptance and their stated purchasing intention, they conclude that most consumers probably would buy land-based salmon farmed both locally and commercially. However, this assessment only accounts for consumers' intentions based strictly on sensory quality, and hence price is not discussed.

Moreover, Liu et al. (2016) discussed how implementing the RAS technology could lead to a price premium. The rationale behind the price premium is that consumers perceive products with sustainable characteristics as valuable and thereby are willing to pay a premium for sustainable production. Therefore, the price premium could be one of the main motivations for establishing land-based facilities. The authors also argue that a price premium is necessary for making land-based salmon farming profitable because of extensive capital requirements.

Furthermore, Solheim and Trovatn (2019) argue for selling RAS salmon with a price premium. According to them, the price premium can be justified based on fish health, product improvements, and more sustainable production. For example, improved fish health could be achieved through less medical treatment, absence of sea lice and reduced impact on wild salmon due to less escapees. Additionally, creating a more controlled production environment on land may result in salmon with better sensory quality (colour, texture, taste and more).

However, to our knowledge, no one has discussed the possibility of a price premium for Atlantic salmon farmed in proximity to the market due to increased freshness as well as cultural and symbolic connotations of domestic products.

3.1.3 Operating strategies

Most of the previous studies have focused on the choice of technology and how this affects costs. All studies focusing on technology discuss the use of RAS technology, and most of them compare the cost of production with an ONP facility. According to Banker and Johnston (2006), the choice of technology will affect costs. Consequently, it is natural to discuss these two aspects together. Our review does not distinguish between variable and fixed costs like Banker and Johnston (2006). It is more common in the salmon farming industry to sort variable and fixed costs into *capital expenditures* (CAPEX) and *operational expenditures* (OPEX). Most research estimates a cost of production per kg which includes both variable and fixed costs. These estimates are compared in Figure 1.1**,** Table 3.1 and Table 3.2.

Furthermore, in our review, we have found that the previous studies vary in how they account for the cost of capital. Ideally, the cost of capital should consist of depreciations and imputed interest on capital employed. The latter reflects that employing more capital is associated with a higher cost, as the capital could be used for other purposes (Bjørnenak, 2019). All studies include depreciations but differ in their handling of imputed interest.

Summerfelt et al. (2013) conducted growth trails of 2 052 salmons in a research RAS facility in an attempt to examine vital biological factors. Amongst the findings were biological FCR (1.09), mortality (11%) and grow-out cycle (~12 months from post-smolt to harvest). The authors used the results to estimate the cost of production per kg HOG and the investment cost of a RAS facility with a capacity of 4 000 tonnes live weight. The report identifies the most important input factors when choosing RAS. However, it does not compare the cost of production estimate to other production technologies, nor include imputed interest.

Several studies compare the cost of production of RAS and ONP. However, some of them lack the use of techniques such as sensitivity, scenarios, or simulation in order to discuss the precision of their estimates. Iversen et al. (2013) studied several different production technologies, including RAS. The study aimed to examine whether new technologies could threaten the ONP technology's dominance in the industry. Cost of production, including transportation and processing, were calculated for all technologies. Most of the input factors regarding the RAS technology are based on the findings of Summerfelt et al. (2013) and the researchers' rough evaluations, making the estimate unprecise. For example, two different estimates of the RAS technology are presented: one for Norway and one for an "extreme low-cost country". Many input factors are assumed to be 50% cheaper than in Norway without further justification. Moreover, the authors include the imputed interest on both working capital and the facility investment in their estimate.

Furthermore, Liu et al. (2016) compared the economic performance of two facilities using RAS in the USA and ONP in Norway. The purpose was to examine how the technologies affect the cost of production and profitability. Their findings indicate that the ONP facility is superior in all terms from an economic point of view. However, the authors only included the imputed interest on liabilities, not on all capital employed. Additionally, a contingency is included in both the CAPEX and OPEX estimates for the RAS facility. This results in higher estimates in an attempt to capture some uncertainty. The authors also discussed how the choice of technology would impact CO_2 emissions, finding that the RAS facility has a lower carbon footprint when including transportation to the USA. Despite lacking the use of techniques to analyse the precision of the estimates, the authors discussed how the price of feed might significantly affect the cost of production.

Boulet, Struthers, and Gilbert (2011) estimated the cost of production for a RAS facility and compared it to the cost of production for an ONP facility. The two technologies were selected from a sample of nine based on the chances of them being profitable. The authors also studied FTS but concluded that the cost of production would be too high to make it worthwhile. Moreover, the findings indicate that the RAS technology has a higher cost of production than ONP, despite its potential. Note that the authors only included depreciations and not imputed interest in their estimates. Furthermore, a 20% contingency is included when estimating CAPEX for RAS. In other words, the estimate is increased by 20% to account for uncertainty. The RAS facility itself, excluding investments in net working capital, is estimated to cost ~4.5 times more than an ONP facility measured in initial investments. The results indicate that the exchange rate and the feed price are the most influential parameters in the sensitivity analysis.

On the other hand, King et al. (2018) utilised stochastic simulation in order to compare different production technologies on several economic parameters. All technologies, including RAS, were compared to an ONP benchmark located in Tasmania. Based on their simulation, they find that the RAS technology involves a lower biological risk compared to other technologies. Additionally, the RAS facility performed better than the ONP facility in all economic parameters but poorer than other sea-based technologies due to very high initial investments. However, the authors did not include the imputed interest in their estimates.

Moreover, Bjørndal and Tusvik (2017) studied the economic attractiveness of a RAS facility located in Norway. They aimed to estimate the cost of production and calculate the profitability of such a facility. Also, considering the RAS technology as given, the authors sought to answer what advantages such technology has compared to traditional ONP production. The results indicate that investing in a RAS facility will result in a higher cost of production than an ONP facility. However, an important finding is that possible lower transportation costs and no need for sea lice treatment can make RAS a viable option. The estimate does include imputed interest. The authors also used sensitivity analysis to identify what parameters have the most influence on the cost of production, finding that changes in the biological FCR and late-cycle mortality are the most crucial.

The same authors, Bjørndal and Tusvik (2019), performed an economic analysis of a RAS facility, focusing on the consequences the production technology has on the cost of production, profitability, and risk. All parameters are compared to an ONP benchmark. The authors find a cost of production that is ~NOK 13.00 higher compared to ONP. Note that the imputed interest is included in their estimates. When discussing CAPEX for the given facility, the authors argue that it is possible to achieve economies of scale in CAPEX up to capacities of 4 800 tonnes per annum. For larger facilities, there are no significant economies of scale in CAPEX. Additionally, it is discussed how constructing separate fish tanks would lower the biological risk and further affect the cost of production. Not surprisingly, due to higher investments, the cost of production will increase. Finally, capacity utilisation and shrinkage are identified as two parameters that can significantly influence the cost of production.

Solheim and Trovatn (2019) had a different approach and aimed at estimating the break-even production cost for land-based farmed salmon using Monte Carlo simulation. Based on simulations with varying assumptions (e.g., changes in the price of salmon or the timeframe), they find a break-even cost in the interval NOK 42.6-57.1/kg HOG. Their simulation indicates that the price of salmon is the parameter that affects the break-even cost primarily. In the thesis, it was also used a larger facility compared to other studies (10 000 vs [2 500-6 000] tonnes live weight). Their base case result is NOK 50.1/kg HOG, which is higher than most other estimates, indicating that RAS technology can be worthwhile. The authors only included the imputed interest on the working capital in their estimates, thus not including the full imputed interest for all capital employed.

3.2 Estimates

3.2.1 Cost of production

Figure 1.1[1] illustrates the different estimates calculated on the cost of production of land-based farmed salmon per kg HOG[2]. The estimates differ substantially. Furthermore, it should be mentioned that the most optimistic estimates also are the oldest. These studies are seen as less relevant due to, for instance, technology improvements and the increased cost of input factors (Iversen, Hermansen, Nystøyl, & Hess, 2017). The estimates are not suitable for direct comparison due to varying underlying assumptions, input factors and circumstances. Therefore, the difference of NOK 28.18/kg HOG between the minimum and maximum production cost found in previous studies is misleading.

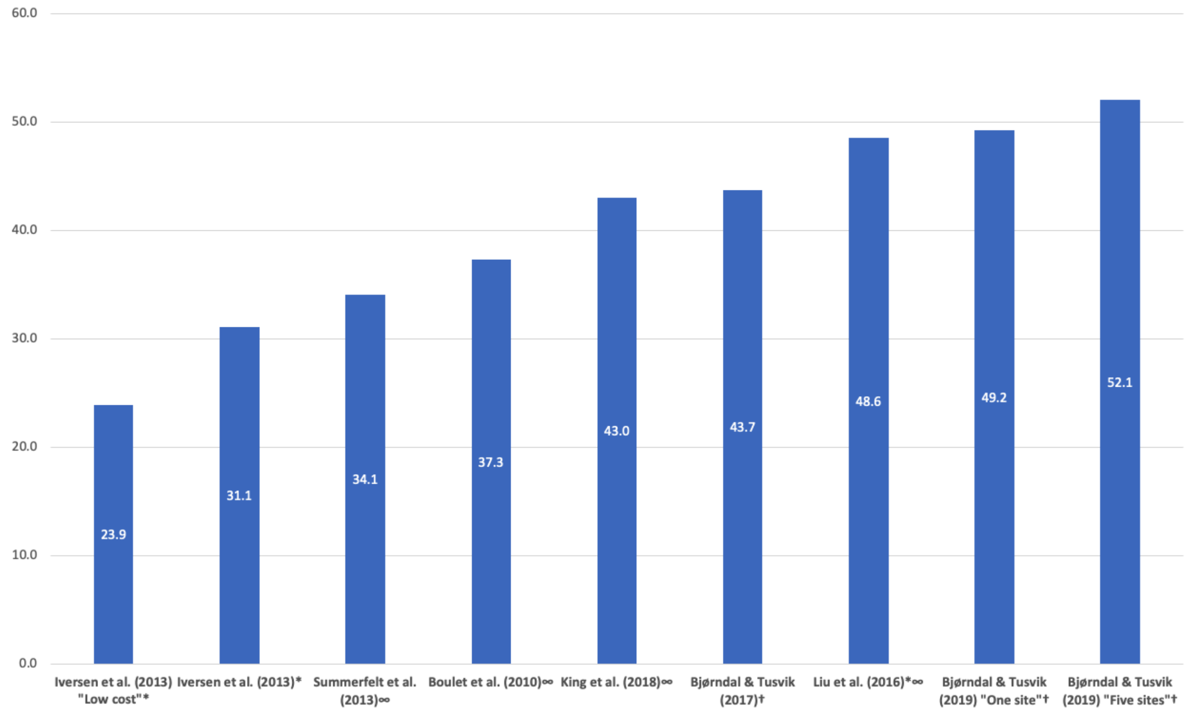

Figure 3.1 - Previous estimates of cost of production

[1] *The estimate includes all costs (transportation, processing, distribution, etc.)

† The original measure was WFE. Calculation from WFE to HOG has been done by multiplying by 1.13.

∞ The estimate was originally stated in USD. Exchange rate used is 8.67

[2] Iversen et al. (2013) does not state whether cost of production is per kg HOG or WFE.

Table 3.1 and Table 3.2 present some of the most important assumptions and how the studies differ. For example, Bjørndal and Tusvik (2019) find that the cost of capital accounts for as much as 21% of the cost of production. This indicates that dissimilar practices of managing the cost of capital are one of the key reasons why the estimates are not comparable. Therefore, excluding the imputed interest can result in misleadingly low estimates.

Additionally, the studies differ regarding what type of costs are included in their estimates. For example, some studies include transportation in their estimates. Traditionally, the transportation of salmon to customers has been relatively expensive (Liu et al., 2016). Whether transportation should be included in the cost of production estimate or not is not straightforward. However, it is evident that to compare estimates, they need to be consistent.

Moreover, the studies differ in their assumptions considering the existence of a hatchery on-site or not. Having an internal smolt production will require transfer pricing. This exercise could shift the profits from the smolt operation to the grow-out operation. In contrast, buying smolt externally would lead to different challenges. Furthermore, the studies differ with respect to biological assumptions such as TGC, biological FCR and mortality.

Altogether, our review of the previous studies of the profitability of land-based salmon farming uncovers several challenges with regard to presenting comparable results. Lastly, a comparison of the different studies is further complicated by the use of different currencies, facility sizes and cost levels in the chosen countries.

Author	Capacity (tonnes live weight/annum)	Measure	Cost of production	Average harvest size (kg)	Cost of capital
Boulet et al. (2011)	2 500	HOG	USD 4.30	5.65	Depreciation
Iversen et al. (2013)	3 300	Unspecified	NOK 31.09	Unspecified	Depreciation + imputed interest
Iversen et al. (2013) "Low cost"	3 300	Unspecified	NOK 23.87	Unspecified	Depreciation + imputed interest
Summerfelt et al. (2013)	3 300	HOG	USD 3.93	4.65	Depreciation
Liu et al. (2016)	4 000	HOG	USD 5.60	Unspecified	Depreciation + interest on liabilities
Bjørndal and Tusvik (2017)	5 000	WFE	NOK 38.7	4.60	Depreciation + imputed interest
Bjørndal and Tusvik (2019) "One site"	6 000	WFE	NOK 43.60	4.90	Depreciation + imputed interest
Bjørndal and Tusvik (2019) "Five sites"	6 000	WFE	NOK 46.10	4.90	Depreciation + imputed interest
King et al. (2018)	7 200	HOG	USD 4.96	4.26	Depreciation

Table 3.1 - Assumptions behind the cost of production estimates of the reviewed studies

Author	Type of estimate:	Facility includes hatchery?	Facility investment per tonne capacity	TGC range	Biological FCR	Mortality (total)
Boulet et al. (2011)	Farm gate	No	USD 9 049	2.7	1.05	7%
Iversen et al. (2013)	All costs included	No	NOK 55 455	N/A	1.1[3]	10%
Iversen et al. (2013) "Low cost"	All costs included	No	Unspecified	N/A	1.1	10%
Summerfelt et al. (2013)	Processing, but not transportation	Yes	USD 9 648	1.68-2.50	1.09	11.9% [4]
Liu et al. (2016)	All costs included	Yes	USD 13 385	1.25-2.30	1.09	11.9%
Bjørndal and Tusvik (2017)	Farm gate	Yes	NOK 85 920	2.20-2.70	0.9-1.10	~7%
Bjørndal and Tusvik (2019) "One site"	Unspecified	Yes	NOK 101 232	2.70	0.9-1.10	~10%
Bjørndal and Tusvik (2019) "Five sites"	Unspecified	Yes	NOK 122 883	2.70	0.9-1.10	~10%
King et al. (2018)	Farm gate	No	USD 5 639	2.30	1.08	~4%

Table 3.2 - Assumptions behind the cost of production estimates of the reviewed studies continued

[3] Iversen et al. 2013 do only report economic FCR.

[4] Summerfelt et al. 2013 do include some culling in the grow-out phase (5.6 %), which is included in their mortality calculations.

3.2.2 Profitability

Table 3.3 demonstrates how the relevant studies vary in terms of assumptions and profitability measures used. Due to these variations in underlying assumptions, the studies are not directly comparable. For example, different costs of production, currencies, timeframes, and price types make any comparison difficult (se section 3.1.1). However, in the following, we comment on some interesting results. Note that the TGC shown in Table 3.2 are used to build production models. None of the previous studies conducted sensitivity analyses on this parameter.

Firstly, it is interesting that three out of four studies finding negative NPV per capacity results also have capacities under 5 000 tonnes per annum. This could support that facilities with a capacity above a given threshold are required in order to become profitable.

Secondly, most previous studies focus on facilities in countries where conventional salmon farming is widespread. Some of these countries are not located in proximity to major salmon markets (e.g., Norway, Tasmania, Canada), and there does not utilise one of the vital advantages of land-based salmon farming. Nevertheless, Liu et al. (2016) reviewed local land-based salmon farmers in the large American market, but the Asian market is still uncovered.

Thirdly, Table 3.3 shows that the previous studies vary in how they discuss the precision of their estimates. Sensitivity analysis is the most used. However, King et al. (2018) and Solheim and Trovatn (2019) differentiate by using Monte Carlo simulation when estimating the profitability of a RAS facility. This technique is different from sensitivity in several aspects. Most importantly, it allows the researchers to simultaneously change several input factors or parameters (King et al., 2018). For this reason, simulation makes it easier to create realistic scenarios as most parameters might have multiple dependencies in reality.

Furthermore, using a Monte Carlo simulation utilises probability curves when running the different scenarios. This typically returns many possible results, each with a distinct probability. For instance, King et al. (2018) report from 25 000 simulations that the difference between the minimum and maximum NPV result is 87.7M USD. Hence, when discussing the precision of estimates, it is common to present the base case or the most likely results in a Monte Carlo simulation. Accordingly, Table 3.3 displays the studies' respective base cases.

Author	Location	Capacity (tonnes live weight/annum)	Timeframe (years)	WACC	Price/kg	Price type	NPV per tonnes capacity	Other profitability measures	Discussion of precision
Boulet et al. (2011)	Canada	2 500	19	7%	USD 5.05 HOG.	Farm gate	- 1 512 (CAD)	IRR, ROE, ROI	Sensitivity
Liu et al. (2016)	USA	4 000	15	7%	USD 5.97-8.11[5] HOG.	Export	- 30 050 (USD)	IRR, ROI, payback, margins	No
Liu et al. (2016) "With price premium"	USA	4 000	15	7%	USD 7.76-10.54 HOG.	Export	- 5 085 (USD)	IRR, ROI, payback, margins	No
King et al. (2018)	Tasmania	7 200	15	7%	USD 7.55 HOG	Farm gate	16 222 (USD)	IRR, payback	Monte Carlo simulation
Bjørndal and Tusvik (2017)	Norway	5 000	20	4% (real)	NOK 49.2 WFE	Farm gate	149 080 (NOK)	IRR	Sensitivity
Bjørndal and Tusvik (2017)	Norway	5 000	Infinite	4% (real)	NOK 49.2 WFE	Farm gate	316 160 (NOK)	IRR	Sensitivity
Solheim and Trovatn (2019)[6]	Norway	10 000	20	7%	NOK 59.0 HOG	Farm gate	- 5 360 (NOK)		Monte Carlo simulation

Table 3.3 - Assumptions and NPV estimates from previous studies

[5] Liu et al. (2016) assume the price to increase 2% yearly the first five years. Then 3% yearly.

[6] Solheim & Trovatn (2019) present several different scenarios. Here their base-case is included. Then their break-even cost is used as a basis for cost of production.

3.3 Limitations and summary

3.3.1 Limitations

Overall, the reviewed studies all utilise parts of the Banker and Johnston (2006) framework. To some degree, all of them discuss relevant strategical choices and profit drivers. However, they do not systematically debate profit drivers on all three strategic levels from the *Cost and Profit Driver Research* framework. Most of the previous studies focus on the operating strategy and how the choice of technology will affect either costs, revenue, and/or profitability. The choice of technology in land-based salmon farming is evidently a significant profit driver, but it is not discussed extensively and broadly in previous studies. For example, factors that can affect the choice of technology such as location, competence, learning, quality management and desirable product attributes are not discussed.

Furthermore, most studies consider RAS the only viable option for land-based salmon farming. This technology is, in turn, compared with ONP. Consequently, the primary focus has been to compare the costs or profitability of a RAS facility with one or more sea-based options and not to examine what actually drives profits in the land-based salmon farming industry. Only focusing on RAS and ONP disregards the complete variety in technology and production choices. Considering there being launched projects with both FTS and HFS technology, it is reasonable to argue that the previous studies handle the choice of technology regarding land-based salmon farms too narrowly.

Additionally, the previous studies use various techniques for the sake of identifying what factors are most important for profitability (e.g., Bjørndal and Tusvik (2017, 2019); King et al. (2018)). These factors could be related to profit drivers, but they are presented as accounting terms. For instance, the effect of changes in salmon and feed prices are emphasised as significant for profitability. Accounting terms are interesting, but they fail to explain the underlying decision variables, such as location, capacity, and linkage utilisation, that drive costs, revenue, and profit. Nevertheless, Bjørndal and Tusvik (2019) mention some operational cost drivers but do not discuss their impact. According to them, shrinkage and capacity utilisation are two essential parameters to control in order to achieve satisfactory profitability in land-based salmon farming.

Profit drivers in the marketing strategy, such as perceived customer value and product attributes, are only merely considered in the literature. Furthermore, there is limited discussion about profit drivers related to the choice of competitive strategy. However, it should be mentioned that some studies are discussing revenue drivers with respect to sustainable product attributes and fish health (e.g., Liu et al. (2016); Solheim and Trovatn (2019)). Nevertheless, these studies only discuss the possibility of a price premium by listing arguments supporting consumers' potential willingness to pay a premium. They do not present any empirical evidence and lack an estimation of the value of such a price premium.

3.3.2 Summary

To summarise, previous studies vary substantially in terms of what extent they utilise the framework of Banker and Johnston (2006). Much of the research draws on some parts of the framework, for instance, regarding operating strategies and the choice of technology. However, despite there being research that partly fits the framework, it is clear that the previous studies possess some limitations. Overall, the previous studies lack a systematic discussion of how different strategical choices affect each other and profit drivers.

Accordingly, this thesis will, in our opinion, bring value to the land-based salmon farming industry by filling the gap through a systematic exploration and discussion of the most important strategical decisions and how these, in turn, affect profit drivers. Additionally, our thesis will analyse all three main technology types with regard to costs and profitability. In other words, technology will be treated as a company-specific strategical choice, not a premise in the analysis of profit drivers. We facilitate this through a deliberate selection of land-based salmon farming facilities, which is explained in chapter 4. Lastly, since the land-based salmon farming industry is relatively new and exposed to rapid technological improvements, previous studies could quickly become outdated. Thus, we bring additional value to the industry by presenting more up-to-date numbers and calculations.

4. Methodology

In this chapter, we introduce methodical choices and methods applied in this thesis. Saunders (2016) define methods as: "*Techniques and procedures used to obtain and analyse data.*". In order to write an interesting and relevant thesis, it is necessary to have a thorough plan and a suitable method. For this reason, this chapter is structured into four parts to comprehensively review the methodology of this thesis.

In section 4.1, we specify the scope of this thesis and the problem statement through three research questions. Furthermore, boundaries and delimitations are provided. Section 4.2 introduces the research design applied to address the research questions by discussing key topics such as research purpose, approach, methods, and techniques. Section 4.3 describes data sources and the data collection procedures. Lastly, section 4.4 discusses the thesis's quality and robustness, focusing on reliability, validity, and ethical concerns.

4.1 Scope of the thesis

4.1.1 Specification of the problem statement

To provide a timely answer to the problem statement of this thesis, we have formulated three research questions. These are based on the conceptual theoretical framework and insights from the literature review of the profitability of land-based salmon farming, as Figure 4.1 demonstrate. Our research questions are the following:

1. *Which competitive, marketing, and operational strategical choices have a significant influence on the profitability of land-based salmon farming?*
2. *What are the most important cost drivers for land-based salmon farming, and how are they related to possible strategical choices?*
3. *What are the most important revenue drivers for land-based salmon farming, and how are they related to possible strategical choices?*

Research question 1 is defined in relation to the three levels of business strategy that are described in chapter 2. On the other hand, research questions 2 and 3 examine the most important cost and revenue drivers in the land-based salmon farming industry. Cost drivers are analysed regarding the classification of structural and operational cost drivers, while revenue drivers are investigated primarily in relation to product-related and non-product related attributes presented in chapter 2. All of the research questions are motivated and actualised by the absence of a comprehensive and systematic review of significant strategical choices and profit drivers in the literature. This was demonstrated in chapter 3, and central insights from the literature review are illustrated in Figure 4.1.

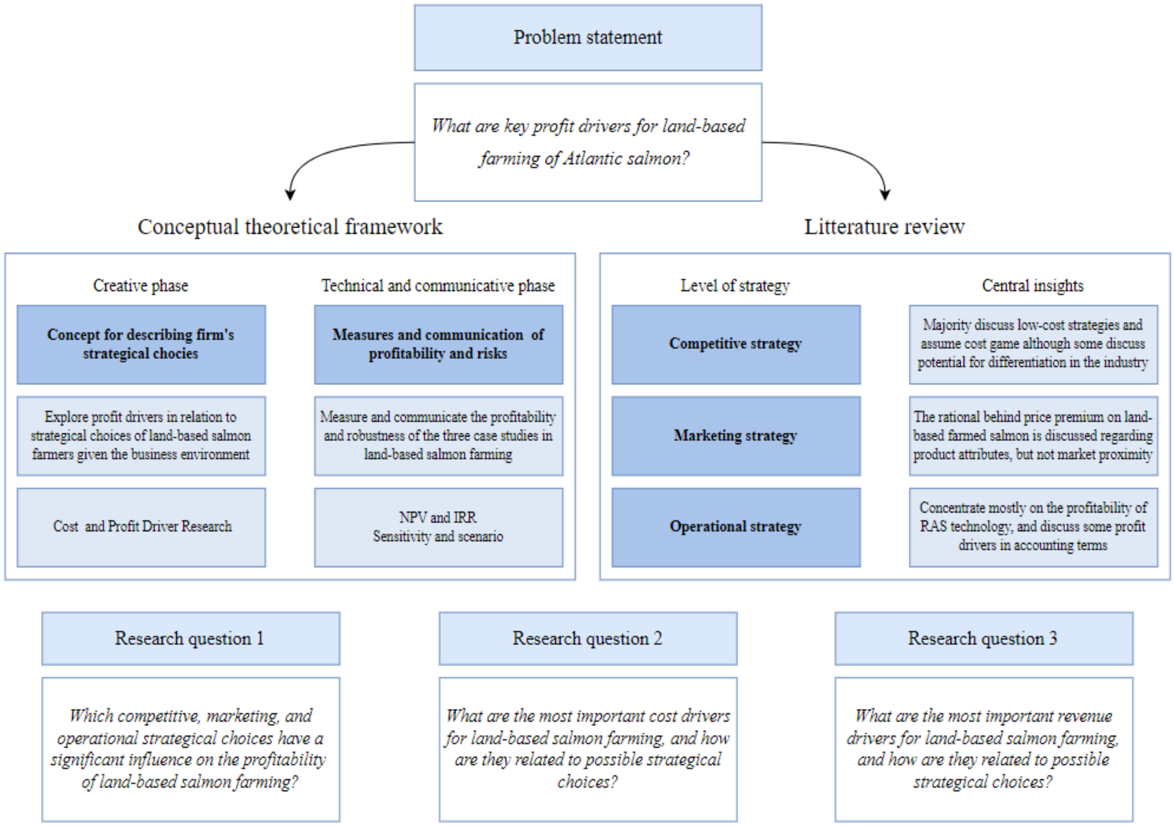

Figure 4.1 - Specification of the problem statement

4.1.2 Delimitations and boundaries

The land-based salmon farming industry is growing fast worldwide. A report published by iLaks and Salmon Business (2021) states that land-based salmon farms of various sizes are planned in 21 countries as of late 2021. Given the timeframe of this thesis, it would be too comprehensive to gather data and interview representatives from all 21 countries. To simplify, we have decided to interview and explore strategic choices and profit drivers of two listed land-based salmon farming companies operating in Norway and one listed company operating in Japan. There are several reasons for such a delimitation.

Firstly, even though we only examine three different land-based farmers through a case study, the sample is diverse as the three main technology types in the industry are included. For this reason, we believe that the most essential strategical choices regarding profit drivers found in our case study could be transferable to other land-based salmon farmers.

Secondly, having a sample with companies located in different parts of the world enables a discussion of the role of location, especially regarding transportation costs. This is suggested as a cost driver in the conceptual theoretical framework. Locating facilities in proximity to large markets are recognised as one of the most important arguments for launching land-based projects (Proximar Seafood, 2022a).

Lastly, only including companies from or connected to Norway is a practical choice. Norway has been the leading actor in the worldwide salmon market for a long time due to its exceptional natural conditions and well-developed expertise. From a business perspective, if land-based salmon farming is profitable in Norway, where input factors are relatively expensive, it should be possible to utilise this experience and knowledge to make it profitable elsewhere. Additionally, Norwegian authorities and companies are well known for their consistency, quality, and openness to sharing data. We are dependent on access to data of high quality and contact with experts from the land-based salmon farming industry in order to give an extensive answer to the problem statement of this thesis.

4.2 Research design

In this section, we will present important choices regarding the thesis research design. In brief, the research design is a general plan for how one intends to answer a problem statement (Saunders, 2016). This consists of several elements that ensure high quality and give clarity for both researchers and readers. Firstly, a clear objective of the research should be presented based on the problem statement. This is usually accomplished by defining the approach and purpose of the research. Secondly, the plan should outline chosen strategies or methods for collecting and analysing data (ibid.). Thirdly, an overview of data sources should be included to ensure high quality. Lastly, for the research to hold high quality, ethical matters, reliability, and validity should be discussed (ibid.).

4.2.1 Research approach

Generally, research approaches can be divided into deductive, inductive, and abductive approaches. These approaches differ in their view on data and theory, logical structure and what techniques and types of data are typically used (Saunders, 2016).

The deductive approach is characterised by being theory-driven, where the objective is to test theory based on collected data (Ghauri, 2020). The researcher takes on a clear theoretical position and defines hypotheses based on the existing theory. These hypotheses are falsified or verified using various tests, often statistical. Hence, quantitative data is typically utilised (Edmonds, 2017). Moreover, the logical structure of deductive research is that the conclusion is valid if all premises are true. Thus, deductive research often lacks the ability to present alternative explanations. Lastly, using a deductive approach, there are requirements with respect to generalisation, typically resulting in large samples (Saunders, 2016).

In contrast, an inductive approach is characterised as data-driven and aims at exploring a topic or phenomenon (Saunders, 2016). The objective is to build a theoretical explanation or refine existing theory through an analysis of data (Ghauri, 2020). Moreover, inductive research is not based on a theoretical position but allows for potential explanations to be developed relying on the data. However, this must not be interpreted as inductive research disregarding existing theory since this is typically used to construct the problem statement. Moreover, the logical structure of inductive research is that known premises are used to develop one of several potential and untested conclusions (ibid.). Also, qualitative data is frequently used, and context is considered important, typically leading to small samples. For this reason, the results are often presented as a conceptual framework. Finally, an inductive approach is usually applied when exploring new topics or topics with limited existing literature (Saunders, 2016).

An abductive approach is considered a combination of the inductive and deductive approaches. The combinations can be configured in many variants, but such research typically involves building new or developing and testing existing theory (Saunders, 2016).

We define the approach of this thesis as inductive based on several aspects. Firstly, land-based salmon farming is an emerging industry, meaning literature on this field is limited. Secondly, the profit drivers we identify will not be tested statistically but instead discussed qualitatively and conceptually. Thus, the conclusion is untested, a typical characteristic of inductive research as mentioned above. Thirdly, using semi-structured interviews and searching for patterns and relationships between the data are typical techniques or procedures used in inductive research (Saunders, 2016). However, the thesis draws on some specific deductive elements. Particularly, we take a theoretical position based on the *Cost and Profit Research* framework by Banker and Johnston (2006). This lays the foundation for identifying the profit drivers that are analysed and discussed. However, the objective of the thesis is not to test the framework of Banker and Johnston (2006) but rather to evolve and adapt to fit a specific industry. For this reason, we argue that an inductive approach is the most suitable description of the research approach applied in this thesis.

4.2.2 Research purpose

Generally, researchers can have four different research purposes. These are *explanatory*, *descriptive*, *exploratory*, and *evaluative*. An *exploratory* purpose is recognised by the research using open questions to study what is happening and thus build a better understanding of an issue, topic, or phenomenon (Saunders, 2016). Furthermore, *descriptive* research aims at creating an accurate account of events, persons, or circumstances (Edmonds, 2017; Saunders, 2016). However, solely descriptive research is often criticised for being of negligible relevance. The description(s) can be interesting and informing but can alone seldom be used to draw conclusions. Moreover, the objective of *explanatory* research is to define causal relationships between two or more variables (Edmonds, 2017; Saunders, 2016). This is accomplished by using different statistical tools to verify correlation and causality. Lastly, *evaluative* research aims at evaluating the functionality of a concept (Saunders, 2016). By defining what works and why this is the case, evaluative research has a dual objective.

Based on our research questions, we argue that this thesis has both a descriptive and exploratory purpose. All research questions have a descriptive element, as we seek to define and describe what strategic choices and profit drivers are most important for land-based salmon farmers. However, research questions 2 and 3 are more explorative since they examine how different strategical choices relate to revenue and cost drivers. Hence, the goal is to clarify the understanding of industry profit and how this is affected by strategic choices. We believe that the dual purpose is a strength and that the purposes should be seen as complements. By both describing and exploring, we argue our thesis will bring value to the land-based salmon farming industry and the management accounting literature.

4.2.3 Qualitative and quantitative: Techniques and strategies

Research differs in what they normally study, what kind of data is being collected, and how it is analysed (Saunders, 2016). Mainly, techniques, strategies, and data are separated into two categories: *qualitative* and *quantitative*. Techniques regard how the data is collected, while strategies refer to how the data is analysed and presented (Ghauri, 2020).

The distinction between qualitative and quantitative data is usually drawn as *non-numeric* and *numeric* data. However, this is a relatively narrow distinction. Today, it is acknowledged that the qualitative data is not limited to only non-numerical since numbers based on meanings can be defined as *qualitative numbers* (Saunders, 2016). Techniques are usually defined as either qualitative or quantitative, based on the collected data type. However, it is accepted that qualitative techniques can collect some quantitative data and vice versa. Two examples of much-used techniques are semi-structured interviews (qualitative) and structured surveys (quantitative). Moreover, strategies are seldom defined as solely qualitative or quantitative but rather a combination. High-quality research often uses both data types and several techniques, meaning the two categories should be perceived as ends on a spectrum. Lastly, the overall research design is defined as either qualitative or quantitative, based on the combination of data, techniques, and strategies (Ghauri, 2020; Saunders, 2016).

A semi-structured interview is characterised by being non-standardised. The interviewer typically has a list of themes and some key questions to be asked. Furthermore, he or she is otherwise free to ask follow-up questions, change the order and add questions based on interview objects and the specific context (Saunders, 2016). The semi-structured interview is thus something between structured and unstructured interviews. Standardised questions are asked to all participants using the former, while the latter involves questions being customised to each participant (Ghauri, 2020).

Qualitative strategies are typically used when the researcher wants to examine the relationship between or the patterns amongst the participant's meanings (Edmonds, 2017). Furthermore, when applying a qualitative strategy, data is typically collected in unstandardised manners with various techniques resulting in unstructured data. Moreover, there are no typical analytical procedures because the data can take many forms (Ghauri, 2020). Therefore, qualitative strategies are much used in an inductive approach, especially when the objective is to give a theoretical contribution or build a conceptual framework (Edmonds, 2017; Saunders, 2016). Some examples are action research, case study and ethnography.

In contrast, quantitative strategies are used when the researcher wants to study the relationship between numerically measured variables (Edmonds, 2017; Ghauri, 2020). The data is typically collected in standardised manners, resulting in structured data. This facilitates the use of different statistical and/or graphical techniques to analyse the data. Using both standardised data and statistical analysis usually give high control of the validity of the data. Furthermore, the use of statistical techniques has resulted in quantitative strategies often being used together with deductive approaches where the objective is to use data to test theory (Saunders, 2016). Some examples are experimental and survey research.

This thesis has a mainly qualitative research design. Firstly, we use qualitative techniques, have an overweight of qualitative data and use a strategy having several qualitative elements. For example, the primary data is mainly qualitative, consisting of words, meanings, and numbers. The numbers are considered qualitative because they are either estimates or based on the interview participants' meanings. Secondly, our primary data is collected through semi-structured interviews, a well-known qualitative technique. This technique is often used when having an exploratory purpose (Saunders, 2016). The semi-structured interview has been preferred in this thesis since it brings flexibility to adapt the interviews to consider each business-specific context while ensuring relatively similar questions being asked. Thirdly, the collection of data is unstandardised. For this reason, it is not guaranteed that the same data is gathered from each participant. Fourthly, the thesis utilises qualitative strategies in the form of a case study. The findings from three cases are used to answer the problem statement. Lastly, the use of sensitivity analyses to examine the uncertainty of the findings is a known quantitative procedure, highlighting that the thesis is not solely qualitative.

4.2.4 Case study

Case studies are, in general, considered a strategy that can draw on both qualitative and quantitative elements (Ghauri, 2020). Case studies are often used when the research has a descriptive or exploratory purpose. Such studies are especially suitable when it is challenging to examine the given phenomenon outside its natural settings and/or there are so many variables that other research strategies are considered inappropriate (Saunders, 2016). Also, case studies are often associated with a relatively low sample size. However, Lillis and Mundy (2005) explain that cases are typically selected based on their richness in information.

Furthermore, distinctions can be made between a simple case study and a multiple case study (Lillis & Mundy, 2005). Multiple case studies are normally well-suited when the objective is to compare a given phenomenon in different contexts. In contrast, a single case study usually studies the given phenomenon in one specific context. However, when increasing the breadth of the study by including more cases, it naturally limits the depth. Thus, the complexity of the studied phenomenon is normally lower when utilising a multiple case study than with a single case study. Lastly, a key consideration when using a multiple case study is to ensure sufficient variation between the selected cases.

We argue that a multiple comparative case study is an appropriate strategy for this thesis. There are several reasons for this. Firstly, a case study, in general, is well suited for our inductive research approach. The industry is emerging, and there are limited discussions on industry profit drivers in relation to our conceptual theoretical framework. Hence, to discuss how the theory can be fitted to the industry, we are dependent on understanding how the industry variables are related. Considering there are several variables, and many of them are interconnected, it would be challenging to systematically discuss the most important strategical choices without studying companies in the specific industry context.

Secondly, utilising a multiple comparative case study has many advantages given our problem statement. By studying more than one company, we can examine how different decisions or combinations of decisions lead to variations in profitability. Also, since the chosen companies possess some differences with regard to potential key strategic decisions, we argue that the sample will provide an improved understanding of strategic decisions' effect on profitability. The three cases in our thesis mainly differ with respect to technology and location. Both could be important structural cost drivers based on the conceptual theoretical framework. Studying different technologies is also supported based on chapter 3, where we argue that previous studies are too focused on the RAS technology. Nevertheless, we believe that selecting three companies is sufficient since it still facilitates a relatively deep exploration of each case.

Lastly, an advantage of using case studies is that it enables the possibility to combine and utilise qualitative data gathered from the semi-structured interviews and quantitative data collected from public reports. Thus, the broad collection of data will make it possible to understand what strategic choices are the most important in the industry.

4.3 Data collection

4.3.1 Primary and secondary data

Saunders (2016) separates data into two categories: *primary* and *secondary data*. *Primary data* is data which is collected in order to answer the given problem statement. *Secondary data* is originally collected for other purposes (Ghauri, 2020; Saunders, 2016).

Our thesis uses both primary and secondary data providing a variety of data which enriches the thesis. We have collected primary data through qualitative interviews with representatives from the companies. Also, some primary data have been gathered by more informal contact with industry suppliers (e.g., phone calls and emails). Moreover, we have collected secondary data from published reports, previous studies, articles, and the companies' websites. Both primary and secondary data have been used to map the most important strategical choices taken by land-based salmon farmers and how they affect the companies' profitability.

4.3.2 Primary data: Interview of representatives from land-based salmon farmers

Using a multiple comparative case study supports the choice of having a rather small sample. In this thesis, we seek to gain a detailed understanding of the most important profit drivers and their connection to strategic choices. We believe this is easier when studying a few cases in depth. However, we are aware that a small sample can reduce the thesis' validity, something we will discuss further in section 4.4.4. Furthermore, an essential part of collecting the primary qualitative data was deciding what companies to interview. Below follows a detailed description of how the participants were identified and contacted.

Selection of land-based salmon farmers

After deciding on the empirical narrowing of the scope, presented in section 4.1.2, The Norwegian Directorate of Fisheries' Aquaculture Register was the starting point for choosing which land-based salmon farmers to interview. The preliminary selection criteria applied as filters in the Aquaculture Register were the following:

1. The farm needs to be placed on land and breed Atlantic salmon
2. The company needs to have a commercial purpose
3. The MAB needs to be above 1.000 tonnes
4. The facility needs to breed edible fish, not smolt or broodstock

Based on these criteria, we identified 18 companies located in Norway. The final evaluation was based on three additional criteria. Firstly, we prioritised companies based on their progress in the building-, financing- and production process. Secondly, to properly discuss the decision of production technology, we wanted the sample to represent RAS, FTS, and HFS. Thirdly, we wanted to include at least one Norwegian company with production abroad, enabling a discussion of transportation costs and the relevance of proximity to the market. Since the Aquaculture Register does not include such companies, we searched the Internet to identify potential candidates outside of Norway.

After assessing all criteria, we sent an inquiry to a total of eight companies. All eight are listed in Appendix A2 Six of these have their production facility located in Norway, while the remaining two are located in Japan or USA/Denmark. Three companies answered the enquiry and were interviewed. Table 4.1 lists these companies.

Company	Technology	Country of production
Andfjord Salmon AS	FTS	Norway
Proximar Seafood	RAS	Japan
Salmon Evolution ASA	HFT	Norway

Table 4.1 - Participating land-based salmon farming companies

The primary qualitative data is the main part of our data material. This has been collected using semi-structured interviews with representatives from the three land-based salmon farming companies. We held interviews to gain an increased understanding of the land-based salmon farming industry and what parameters have the most significant effect on profitability. Table 4.2 presents relevant information about the interview objects.

Fish farmers	Representative	Role
Andfjord Salmon AS	Helge Krøgenes	CCO
Proximar Seafood AS	Joachim Nielsen	CEO
Salmon Evolution ASA	Trond Håkon Schaug-Pettersen	CFO

Table 4.2 - Interview object information

Interview guide

It is common practice to use an interview guide when conducting semi-structured interviews. We made such an interview guide in our preparations which we sent in advance to the selected interview objects. The interview guide is enclosed in Appendix A3

We categorise the interview guide into three parts. The first part can be called an introduction. Here, we present ourselves as interviewers, introduce the purpose of the interview, and clarify formalities such as permission to record the meeting. Moreover, the participant is given time to introduce themself and their role in the company.

The second part of the interview guide consists of themes with the ambition to improve our understanding of the land-based salmon farming industry, the representative’s company, and its value chain. Data collected from these themes are used in order to answer the research questions. This part of the interview guide covers the production facility, the technology used, production factors, production process, product attributes, distributors, and risk factors. In our opinion, these themes cover all relevant aspects of the land-based salmon farming industry and hence will make it possible to identify the most important profit drivers. Also, this part of the interview guide includes some questions to ensure comparability between the companies. For example, we have ensured that all companies define a production cycle in the same terms.

This is because a different definition of production cycles could result in variations in the cost of production of otherwise similar companies.

Furthermore, it is important to emphasise that the questions asked in the second part of the interview guide are selected based on potential profit drivers from the conceptual theoretical framework. Especially, Figure 2.2, retrieved from Banker and Johnston (2006), has been used as an inspiration. A detailed description of this is presented in Appendix A3 When formulating our questions, we focused on uncovering strategic decisions in the companies' business strategies. Moreover, potential follow-up questions focused on understanding the relationship between the strategic choices and profit drivers.

The third part marks the end of the interview. Here we finish the session, allowing the participant to ask us questions and clarify ambiguities. This part of the interview aims to set clear boundaries for the ending and enable the participant to correct or supplement their contribution with new information.

Interview execution

After answering our initial inquiry, we invited the company representatives to an informal meeting. The purpose of such a meeting was to explain the objective of our thesis, how a possible contribution could take place and clarify expectations. All these informal meetings were held on Microsoft Teams. At the end of these meetings, the representatives were again asked to confirm their willingness to participate by agreeing on a time for the formal interview. Hence, we ensured that all participants understood what they were contributing towards. We believe that giving the representatives the chance to withdraw from the project after a more comprehensive description is a proper process.

The actual interviews were conducted in two different manners. We interviewed a representative from Proximar Seafood at their head office, located in Bergen. Such physical interviews were the preferred interview form. The other two interviews were held on Microsoft Teams. This is because Salmon Evolution and Andfjord Salmon have their offices located in Molde and Andøya, respectively. We found it inconvenient to travel far for a physical interview, given our short timeframe. Nevertheless, all interviews were recorded and later transcribed in order to correctly quote the participants.

4.3.3 Primary data: Interview of representatives from technology suppliers

In addition to interviewing representatives from land-based salmon farmers, we interviewed representatives from two technology suppliers listed in Table 4.3. The selected technology suppliers have been identified based on qualitative criteria. Billund Aquaculture has previously contributed to several of the key studies mentioned in the literature review (e.g., Bjørndal and Tusvik (2019); Solheim and Trovatn (2019)). Therefore, it was, in our opinion, probable that they also wanted to contribute to our research. We contacted Artec Aqua because they deliver all three production technologies. The purpose of interviewing technology suppliers was to improve our understanding of alternatives in the three technology types.

Furthermore, we wanted an alternative opinion on some of the key questions asked to the land-based salmon farmers, particularly considering investments and input factors. The purpose of this second opinion is to verify the given answers and discuss their degree of reasonability. We interviewed the technology suppliers using unstructured interviews. The interviews varied regarding what type of information was requested. Due to such differences, the need for an interview guide or semi-structured interviews was considered less important.

Technology suppliers	Representative	Role
Billund Aquaculture	Bjarne Hald Olsen	COO
Artec Aqua	Bjørn Finnøy	CSO

Table 4.3 - Participating technology suppliers

4.3.4 Secondary data

This thesis also uses some secondary data. This includes specific information about the land-based salmon farming industry and general information about the companies. We collected this data from multiple sources such as the companies' websites, prospectuses, annual reports, and press releases. Moreover, published reports, papers, articles, and information from Norwegian authorities have provided essential general information about the land-based salmon farming industry. Finally, we have also utilised equity research published by AGB Sundal Collier and Sparebanken 1 Markets.

4.4 Validity, reliability and ethical concerns

In this section, we will discuss the quality of the thesis through the central concepts of reliability and validity. The term reliability examines the thesis' degree of replication and consistency, while validity treats whether appropriate methods have been used, the accuracy of the analysis and the degree of generalisability of the findings (Ghauri, 2020; Saunders, 2016). Both reliability and validity are divided into an internal and an external part (Saunders, 2016). Validity also refers to measurement validity, but this is considered less relevant with respect to our research design. Thus, the section discusses the different reliability and validity forms in the following four subsections. Also, we present ethical issues and how we have handled them in the last subsection.

4.4.1 Internal reliability

The internal reliability of the research treats the measures taken to ensure consistency from the researchers (Saunders, 2016). There are several ways to achieve this. For example, one can use more than one researcher for a project to ensure consistency. This enables a discussion of the data and analysis (ibid.). Discussing the data, process, or analysis limits the probability of misinterpretations or errors. Other elements are also relevant to evaluate under the term internal reliability, such as researcher biases and errors. Researcher biases account for all factors that affect the recording of answers or interpretation of given answers. In contrast, researcher errors account for any factor that affects the data collection, like not understanding a given answer (ibid.).

We have taken several precautionary measures to ensure high internal reliability. Most importantly, we are two researchers working on the thesis. So, naturally, both of us have been present during all interviews, which have been recorded and later transcribed. Stored recordings and transcripts enable a discussion of collected data lowering the risk of misinterpretations. Furthermore, every part of the thesis is both approved and validated by both researchers. Together, these measures increase the probability that we capture the true meanings of the participants and, at the same time, reduce the probability that our subjective interpretations of the answers affect the thesis.

Moreover, we have introduced several initiatives to minimise research errors and biases. For example, constructing the interview guide in advance enabled us to have similar preparations before each interview, facilitating consistency and reducing the chance of errors during the interview. Also, recording the interviews allowed us to focus on understanding the answers and ask follow-up questions to improve or clarify our understanding instead of taking notes. Besides, recordings allow replaying the interview and discussing answers, situations, and context to ensure we have a correct understanding.

Lastly, to be as prepared as possible and reduce the chances of errors, we always allocated at least thirty minutes before the meeting to prepare together. These thirty minutes come in addition to initial individual preparations by reading the company's latest annual and quarterly reports, press releases and relevant news articles. During these thirty minutes, we divided responsibility and practical assignments between us. In addition, minor adjustments to the interview guide, such as sequence or specific follow-up questions relevant for the given company, were discussed and prepared. Besides, to avoid research biases, we decided that neither of us should have any economic interest in the analysed companies. A financial interest makes it more likely that the collected data is being interpreted and analysed positively in an attempt to support the initial investment decision.

4.4.2 External reliability

The research's external reliability concerns whether the research results, based on data collection techniques and analytic procedures, could be replicated if conducted by other researchers or by the same researchers another time (Golafshani, 2003). When discussing the external reliability of the research, it is relevant to consider both participant errors and biases. This involves factors affecting how the participants perform and factors leading to false responses, respectively. Both can affect the external reliability (Saunders, 2016).

Before discussing the external reliability of the thesis, it should be mentioned that qualitative research with an exploratory purpose and the use of case studies do not necessarily aim at achieving a high degree of external reliability. Saunders (2016) argues that there exists a trade-off between the strengths of this type of research design and external reliability. Given that land-based salmon farming is an emerging industry, the natural environment of the analysed companies is constantly changing. This means that if someone were to replicate this thesis, it is almost guaranteed that the estimates and calculations would be different due to new data. This reduces the external reliability. Nevertheless, the objective of this thesis is not to present an accurate point estimate of the cost of production or profitability of the chosen companies. For this reason, we consider this shortcoming less relevant.

Furthermore, a common practice to improve the chances of replication when utilising a qualitative research design is to present a thorough description of the research design (Saunders, 2016). We have described our research design thoroughly in sections 4.2 and 4.3.

When it comes to participant errors, we have taken several measures in an attempt to collect the correct data. Firstly, all participants received the interview guide with all questions at a minimum of 2.5 weeks before their interview. This enabled the participant to prepare, discuss answers with colleagues or collect necessary material. Secondly, during the interview, all participants were informed of the possibility of a follow-up email if they needed more time to investigate. Lastly, to ensure no participants were misquoted, they have all read and approved their respective cases before we handed in the thesis.

Moreover, our research design, especially the data sources, makes it more challenging to avoid participant biases. Most of our primary and secondary data is collected directly from the studied companies, making the thesis prone to biased information. When using the company itself as a main source, a relevant concern is that the data can be positively biased (Koller et al., 2020). In order to avoid participant biases, we have compared the collected data with other sources. For instance, in chapter 5, the primary data have been compared with secondary data from various sources. This has been done to increase our estimates' accuracy, reasonability, and reliability. Additionally, we have compared the assumptions and estimates of analysed companies with each other and previous literature. This decision gives us warning signs and enables a further examination if the underlying assumptions are significantly varying. At the same time, we have conferred with industry experts such as Bjarne Hald Olsen at Billund Aquaculture, Bjørn Finnøy at Artec Aqua and senior researcher Trond Bjørndal. The latter has published several previous studies of the industry. By comparing and discussing the data with several other sources, we believe that we have gathered a relatively nuanced data material.

In light of this, we believe that the main findings about the key profit drivers of the industry are consistent and replicable. Furthermore, since the findings are supported across several sources, it could be claimed that the thesis has high external reliability. However, it should be mentioned that since the industry is emerging and a limited number of companies are operating at a commercial scale, there are also a limited amount of data. Thus, it could be argued that truly unbiased data is challenging to obtain since more or less all available sources do have some interest in the industry being successful. We acknowledge this challenge and will discuss it further in section 4.4.3.

4.4.3 Internal validity

The internal validity of research concerns whether the research can correctly establish a causal relationship between two variables (Edmonds, 2017). This is not limited to quantitative studies and is just as relevant for qualitative studies. Considering qualitative studies' shared objective of studying a concept or object in-depth, the result is normally that the causal relationships are founded on several data sources (Saunders, 2016). When the research has a high degree of internal validity, the participant's answers and the interpreted meaning match the participant's intended meaning (ibid). Thus, an essential element is to assess the validation of the data and their quality. Triangulation and participant validation is common practices. These involve that the researcher(s) are using several different sources and being transparent by allowing the participant to verify the collected data (ibid).

We have adopted several initiatives to ensure high internal validity. Firstly, we gave the participants the opportunity to read and approve their respective cases before handing in the thesis. All participants used this opportunity and approved our work. Thus, we have made sure that no participants were misquoted or misunderstood when being interviewed. Secondly, during the interviews, all participants agreed to continue having an open line of communication. Thus, it was easy to confer with the participants if we ever were in doubt about how to interpret answers or if we needed more detailed information. Thirdly, we have used triangulation by validating the data with several other sources, as mentioned in section 4.4.2. Moreover, our production models, assumptions, and estimates have been approved by senior researcher Trond Bjørndal, an acknowledged expert in land-based salmon farming.

Nevertheless, it could be argued that the validity of the thesis could be increased by expanding our sample or discussing the data with more critical actors. It is debatable whether the industry suppliers could be acknowledged as critical since they all are interested in the industry's success. Despite this, we argue that a sample of three companies is sufficient considering our research design. By including three companies with some differences, we can both compare and contrast the collected data with similar data from the other companies. This could be viewed as an attempt to validate the data by using a form of triangulation. Moreover, considering the timeframe of the thesis, we argue that it would not be possible to increase the sample without significantly reducing the ability to study each case in depth. For instance, performing and preparing interviews are time-consuming tasks. Consequently, we believe that introducing more cases could reduce the quality of each interview given our timeframe, and thereby reduce the overall quality of the thesis.

Regarding the limited number of critical actors, this is a deliberate choice. Considering our problem statement and the scope of this thesis, it makes sense to limit our contact with critical actors. This thesis focuses on identifying the most important strategical decisions and exploring how these are related to different profit drivers. In other words, we are examining what premises need to be true for land-based salmon farming to be profitable. Suppose we were to discuss the data, assumptions, and models with more critical actors. In that case, we believe that the focus would shift to discussing the probability of land-based salmon farming being profitable. This discussion is certainly interesting but outside the scope of this thesis. We return to this discussion in chapter 7.

Lastly, as discussed previously, most of our data material is qualitative data, consisting of meanings and estimates. Hence, there is a high degree of underlying uncertainty related to our data. Considering the emerging land-based salmon farming industry, this would be true regardless of sources. There are very few companies operating their facilities at a commercial scale. This is a general challenge regarding validity and is further discussed in chapter 7.

4.4.4 External validity

The external validity of the research concerns whether the results can be generalised to other relevant groups or settings (Edmonds, 2017; Ghauri, 2020). Qualitative research has earlier been criticised, due to small samples, for having a low degree of external validity. This is because the samples are usually too small to fulfil specific statistical criteria. However, researchers pointed out that generalisability could take many forms and that qualitative research thus can indeed have a high degree of external validity. One example could be that the learning from one research setting can be used in other settings (Saunders, 2016).

Again, it is critical to underline that research with an explorative purpose and the use of a case study does not aim at being generalisable. The aim is often to understand a phenomenon in a given environment, limiting the ability to generalise to other contexts. However, in our opinion, the thesis does have a relatively high degree of external generalisability as the results are based on a multiple comparative case study, introducing variation in both technology and location. By studying the strategic decisions taken in three companies with some distinct differences, we believe that the results can be generalised to some degree. Based on the different cases, we present the most important strategical decisions for the industry in general. However, we acknowledge that there will be business-specific circumstances which will not necessarily be generalisable.

4.4.5 Ethical concerns

We have identified two major ethical concerns in our work with this thesis. Firstly, and most importantly, there is an ethical aspect related to using, handling and analysing data directly or indirectly from publicly listed companies. The participants have the primary responsibility of not sharing confidential information. However, as researchers, we also have a responsibility when using company-specific data collected from other sources. For instance, when interviewing an industry supplier, with the objective to verify the data collected from the companies, we were offered to see classified information if we promised not to use it. We decided to not see this data in order to maintain an objective point of view.

Secondly, there are some ethical concerns regarding using the companies' own data. Having the chance to interview key players from the industry and having ongoing contact with them is a new experience for us. This could lead to a desire to reciprocate the favour by presenting the companies from an overly optimistic standpoint. Fulfilling this desire would be unethical since our role as researchers is to analyse the data and present the results in an objective, non-biased manner. We have been aware of this challenge since the beginning of the project. However, being two researchers, it is easier to hold each other accountable. Furthermore, to stay objective, we decided not to have any financial interest in any of the analysed companies. Lastly, all participants were informed of the other participants and frequently reminded that the thesis was not written on their behalf.

5. Business strategy and cost drivers in land-based farming of Atlantic salmon

This chapter is structured around three different cases where a land-based farming facility of Atlantic salmon is being built and developed. The various cases all have in common that the land-based farmers are in their first development phase. Hence, they are relatively close to the first harvest compared with other commercial land-based salmon farming projects. Table 5.1 briefly introduce relevant information about the first development phase of the three cases:

	ANDFJORD™	PROXIMAR SEAFOOD	SALMON EVOLUTION
Founded	2014	2015	2017
Location	Andøya, Norway	Oyama, Japan	Indre Harøy, Norway
Technology	FTS	RAS	HFS
Licence (MAB)	10 000 tonnes	N/A	13 300 tonnes
Yearly production	19 000 tonnes HOG	5 300 tonnes HOG	7 900 tonnes HOG
Listed	Euronext Growth	Euronext Growth	Oslo Stock Exchange
First harvest	Q2 2023	Q2 2024	Q4 2022

Table 5.1 - Relevant project information

For each case above, the business strategy is described in relation to the three strategy levels identified in the conceptual theoretical framework. Furthermore, an indicative cost of production breakdown estimate per kg HOG presented by the companies is validated. This validation is based on a simple production model we have customised for each case. Following the validation of the production cost estimates, we present our own adjusted estimates. Furthermore, we perform sensitivity analyses to illustrate the uncertainty regarding the production cost estimates and to get an indication of important profit drivers. Fundamental assumptions in the production model such as FCR, mortality rates and capacity utilisation are altered in this process. After examining all cases, a comparison and discussion of findings regarding business strategy, cost estimates, and profit drivers are presented in chapter 6.

5.1 Case 1: Andfjord Salmon

5.1.1 General description

Andfjord Salmon (hereby: Andfjord) was established in 2014 and is located on the island of Andøya in Northern Norway. In late 2018, the company was granted a licence of 10 000 tonnes (MAB) of salmon for a facility on Kvalnes, Andøya. Development of the site started in February 2019. The initial planned annual capacity is 19 000 and 40 000 tonnes HOG after final expansions. The maximum fish density in Andfjord's facility will be 35-40 kg per m^3 (Rasmussen & Martinsen, 2021).

Figure 5.1 - Andfjord's locations (ABG SC, 2020)

In June 2020, the company got listed on Euronext Growth to facilitate further growth on Kvalnes and expansion on Fiskenes and Breivik located on Andøya as Figure 5.1 demonstrate. These localities have a planned annual capacity of 25 000 tonnes HOG each, and the company has already started the licensing process for these expansions. In total, Andfjord has a planned annual capacity of 90 000 tonnes HOG. Andfjord expects harvest first volumes of Atlantic salmon during Q2 in 2023.

Andfjord's technological solution combines benefits from both conventional and land-based aquaculture, which suggest lower biological risk. Their land-based salmon farming facility will utilise a closed flow-through system that brings a continuous laminar flow of fresh seawater into independent fish pools placed below sea level. This limits the need to lift or pump water into the fish pools, which reduces energy needs (Rasmussen & Martinsen, 2021). Andfjord's flow through laminar current technology is patented and will, together with their location, be discussed in more detail later.

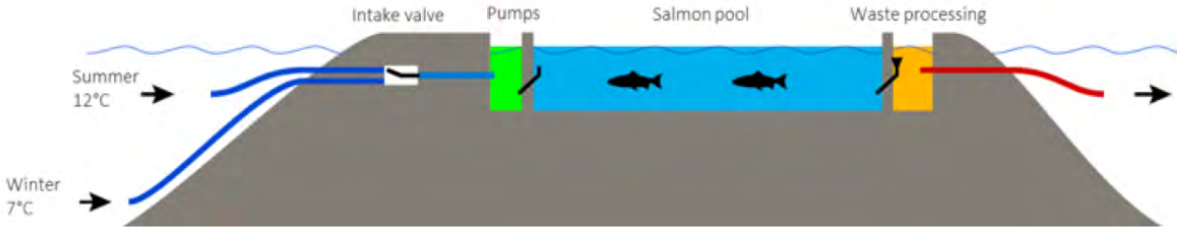

Figure 5.2 - Illustration of Andfjord's pool and pumping solution (ABG SC, 2020)

5.1.2 Description of strategic choices

Competitive and marketing strategy

Andfjord's competitive strategy could be described as cost-leadership since the company aspires to be profitable mainly by delivering Atlantic salmon with desirable quality at a lower cost than the market price. This claim is sustained by findings from our interview with Helge Krøgenes, the COO of the company, and in internal and external reports.

The choice of technology is a fundamental strategical choice that supports cost-leadership. According to Andfjord, their patented FTS technology allegedly gives them a significant cost advantage with respect to OPEX and CAPEX compared to traditional RAS systems (Rasmussen & Martinsen, 2021). There are two reasons for this, and the magnitude of Andfjord's cost advantage is discussed in detail in section 5.1.3.

Firstly, the FTS technology, in general, is less complex compared to traditional land-based RAS facilities (ABG SC, 2020). The extensive use of fresh seawater from great depths limits the need for electronic installations and complex filtration of water. The effect is a lower investment which, all else equal, results in a lower cost of capital and thus production costs.

Secondly, the need for lifting the water is severely decreased due to the company's patented FTS technology, thereby lowering energy costs by 70-80% compared to average RAS systems. Andfjord's technology and their calculations have been verified by SINTEF (Rasmussen & Martinsen, 2021). Energy has traditionally been considered a significant cost component in land-based salmon farming (e.g., Bjørndal and Tusvik (2019)), which was highlighted in our interview: *"The general perception is that it (land-based salmon farming) is not possible because of the high energy costs. We have disproved this."* (Krøgenes, COO, Personal communication, February 17, 2022).

Considering Andfjord’s competitive strategy, it is important for the company to promote that they can produce salmon at a low cost without necessarily reducing the quality of the product. Therefore, marketing could be seen as an instrument to secure sufficient willingness to pay amongst consumers, making their business model financially viable. That is why the company actively promote their farming methodology and location on Kvalnes. For example, Andfjord argues that they will be able to facilitate great conditions and fish welfare in their fish pools on land, resulting in healthy salmon. This is because their location is close to ideal water currents from the Gulf Stream, as illustrated in Figure 5.3 (Rasmussen & Martinsen, 2021).

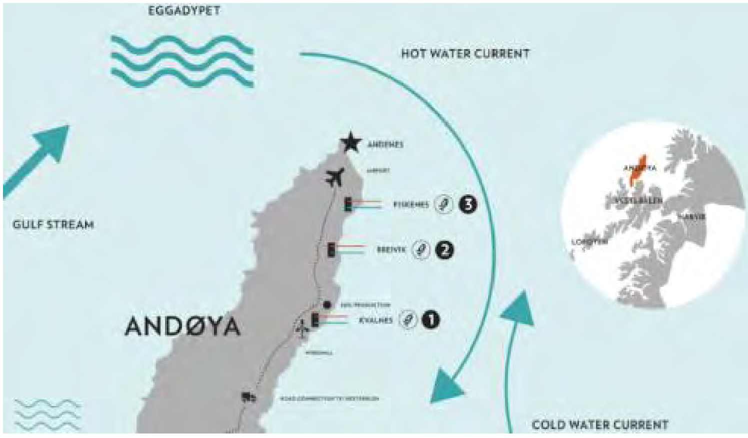

Figure 5.3 - Andfjord's location (Rasmussen & Martinsen, 2021)

In contrast, we also observe that Andfjord, to some extent, try to differentiate their product from other salmon farmers by promoting non-product related attributes such as sustainable production and animal welfare in their marketing. This is to possibly earn a price premium.

Regarding sustainable production, Andfjord communicates in its latest ESG report (2021) that the company aims to have the highest biosecurity resulting in *“the world’s most fish-friendly and sustainable farming facility of its kind”*. Consequently, Andfjord has started to report the carbon footprint and impact on the diversity of various production processes and collaborate with sustainable certification bodies. Also, the company is engaged in external initiatives to create a more sustainable and environmental marine business in Norway.

With reference to animal welfare, Andfjord has decided to promote this in their ESG-report from 2021. For instance, the company disclose that they successfully have verified the laminar water flow technology in their fish pools. This makes it possible to replicate wild salmon’s natural living conditions and ensures optimal fish welfare when production starts. Moreover, Krøgenes (2022) stated that good animal welfare is valued by consumers and could result in a price premium of 10 % for their salmon, but this is not accounted for in Andfjord’s budgets:

"We use spot prices in our budgets, and this is reasonable given our planned production volume. So, a price premium on our salmon is eventually a bonus" (Krøgenes, COO, Personal communication, February 17, 2022).

On this basis, Andfjord's marketing does not appear to be motivated by the possibility of achieving a price premium due to differentiation. Instead, the company has chosen a marketing strategy that promotes product-related and non-product related attributes with the first and foremost objective of securing customers' willingness to pay in the mass market. This support the strategy of earning margins by being a low-cost competitor. Therefore, as demonstrated in Figure 5.4, we classify Andfjord's competitive strategy as having a broad competitive scope.

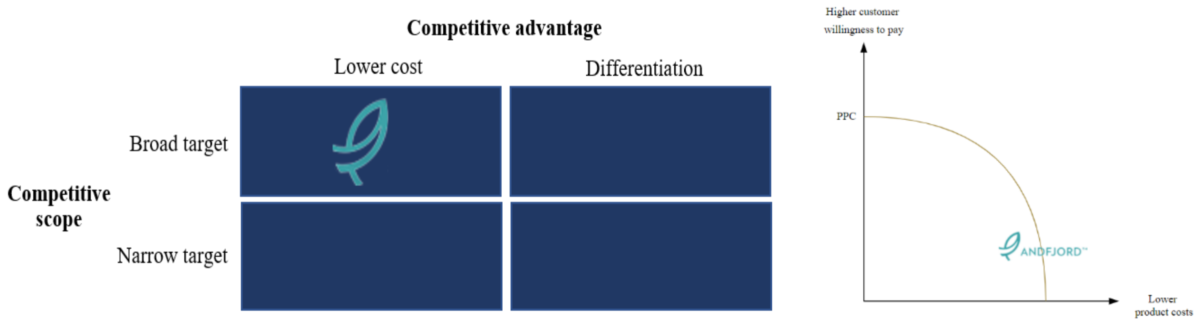

Figure 5.4 - Andfjord's competitive strategy

In the following, we describe how Andfjord's low-cost competitive strategy is materialised in operational strategical choices.

Operational strategy

Andfjord's choice of a low-cost competitive strategy is not just evident in the marketing strategy regarding the extent and way product-related attributes are promoted. Operational strategical decisions related to technology and process design additionally demonstrate that Andfjord has ambitions of realising a cost advantage relative to competitors. Considering that company wants to be a low-cost competitor and farm salmon on Andøya, FTS naturally is the preferred production technology. This is because it is the least complex technology for land-based salmon farming (ABG SC, 2020). The simple FTS production process in Figure 5.2 implies lower capital investments. It further illustrates in relation to the conceptual theoretical framework that technology and its complexity is an important structural cost driver.

On the other hand, it should be noted that Andfjord has less opportunities of controlling the biological environment compared to a RAS facility. However, an advantage compared to RAS facilities is the reduced probability of producing hydrogen sulphide, which could cause mass slaughter. Such incidents could increase production costs substantially. This has been a problem in Atlantic Sapphires' RAS facility, even though human errors have been claimed as part of the fault (Atlantic Sapphire, 2022).

Moreover, Andfjord has taken several sequential strategical decisions regarding the choice of FTS to customise their production technology to facilitate cost-leadership. An example is their patented solution. The concept is simply based on placing the fish tanks below the sea level, thus reducing energy costs in terms of lifting and pumping the water into the fish tanks.

Sea lice are not assumed to be a problem since Andfjord has water intakes from 30 and 160 m depths. Consequently, the company is less reliant on water filtration as well as temperature and oxygen manipulation due to clean and high-quality water flowing into the pool. This will reduce production costs.

Furthermore, Andfjord has decided to have rectangular fish pools instead of the traditional circular form. The rationale is that this gives a laminar water flow through the fish pools, which replicate the natural environment of the salmon. According to company data, this will increase the growth and production volumes of salmon, as well as simplify waste handling, thereby lowering the cost of production (Rasmussen & Martinsen, 2021). In relation, the fish density in Andfjord's FTS facility will be 35-40 kg per m^3 which is lower than average RAS facilities, which usually have a fish density of 70-80 kg per m^3 (ABG SC, 2020). According to Krøgenes (2022), this could improve fish welfare if water quality is maintained.

All in all, the FTS technology is relatively simple and customised to fit the chosen location and ambition of cost-leadership: "*Our facility and how it is developed is unique, making it very similar to conventional salmon farming getting a flow-through of water, but without the problems regarding escapees, sea lice and other pathogens laying at the surface*" (Krøgenes, COO, Personal communication, February 17, 2022).

Besides technology, Andfjord have also implemented parts of their operational strategy to support their marketing strategy, focusing on animal welfare and sustainability. For instance, the company has entered into a strategic partnership with Nutreco, securing a supply of both customised and sustainable feed (Andfjord Salmon, 2022b). In addition, Andfjord is at the moment examining whether it will be possible to make their production facility energy self-sufficient by transforming internal generated biological waste into biogas (Krøgenes, COO, Personal communication, February 17, 2022). This operational process could significantly reduce Andfjord's carbon footprint.

Taking this into account, it seems like Andfjord's choice of competitive strategy has subsequently caused strategic configuration in marketing and operational strategy. However, one could also argue that an operational choice, like location, has provided guidelines that cost leadership is the optimal competitive strategy for Andfjord. Two reasons illustrate this claim.

Firstly, according to Krøgenes (2022), the natural conditions of the location make an FTS facility the most suitable and feasible production technology for Andfjord. This indicates that location could influence what production technology is most optimal.

Secondly, Andøya makes it possible for the company to take advantage of already established infrastructure, suppliers, and unique competence within the value chain of conventional salmon farming. Accordingly, Andfjord could buy input factors such smolt and outsource harvesting, processing, and transportation to external parties. Furthermore, specialising solely in the grow-out of salmon in the value chain could make it easier for Andfjord to be productive. Also, a compact operation makes it possible to capitalise on economics of scale. Moreover, the location provides Andfjord with valuable competence from conventional salmon farming. This is acknowledged as a critical success factor for land-based salmon farmers, according to Bjarne Hald Olsen, COO of Billund Aquaculture, an established supplier of RAS technology (Olsen, COO, Personal communication, March 25, 2022).

Lastly, we observe trade-offs between Andfjord's operational strategical choices. Even though Andfjord's decision of not fully integrating the value chain in the development enables learning, access to industry expertise and lower production costs, the operational choice also makes it more difficult to realise the benefits of economies of scope, at least in the short term. That being said, Andfjord are working on securing their entire value chain. This involves that the company is evaluating strategic partnerships with or investments in existing industrial actors. Investing in new infrastructure, such as a harvesting facility, in relation to the facility at Andøya is also considered (Rasmussen, CEO, Personal communication, May 27, 2022).

5.1.3 Estimated cost of production

In an investor presentation from November 2021, Andfjord presents an indicative cost breakdown (Rasmussen & Martinsen, 2021). They estimate EBIT/kg HOG and CAPEX/kg HOG capacity of NOK 34.2 and 60.0, respectively, for the first three development phases at Kvalnes (Kvalnes 1). The estimates are stated in nominal terms. The license for production is 10 000 tonnes MAB, and the company plan a yearly production of 19 000 tonnes HOG.

Figure 5.5 - Indicative cost breakdown for Andfjord (Rasmussen & Martinsen, 2021)

In the following, we will analyse each item from the cost breakdown. Based on this analysis, we present an adjusted estimate for Andfjord's cost of production. Note that this estimate will be presented in real terms, thus ignoring the effect of inflation. This complies with the method used by Bjørndal and Tusvik (2019). We discuss inflation and how this could affect the analysis in chapter 7. Furthermore, we want to note that CAPEX per HOG capacity is a key figure for how expensive Andfjord's land-based facility is. We use this measure to compare capital expenditures across cases. For this reason, CAPEX per kg HOG capacity is not the same as cost of capital per kg HOG, which is a production cost.

Production model

We have created a simplified production model in order to discuss the validity of Andfjord's estimate. This plan is based on the underlying assumptions presented in Table 5.2, collected from the interview with Helge Krøgenes (Krøgenes, COO, Personal communication, February 17, 2022). The production model in Figure 5.6 illustrates the average development in total biomass per generation. Furthermore, Figure 5.7, we display the sensitivity of the most important parameters in a tornado diagram. The results of the sensitivity analysis lay the foundation for our discussion of strategic decisions and their effect on profit drivers in section 6.1. Moreover, a detailed explanation of the simplified production model and the underlying assumptions is shown in Appendix A4

	Smolt grow-out
Average start weight	300.0 g
Average final weight	4200.0 g
TGC	3.0
Biological FCR	1.1
Average temperature	8.7°C
Production cycle (months)	12
Number of generations	6
Number of smolt per generation	944 822
Total expected mortality	5.0%
Expected mortality first month	2.5%
Expected mortality (evenly from the second month)	0.24%
Weight loss when harvesting (bleeding & gutting)	16.0%
Price of feed (per kg)	NOK 12.75

Table 5.2 - Assumptions behind Andfjord's production model

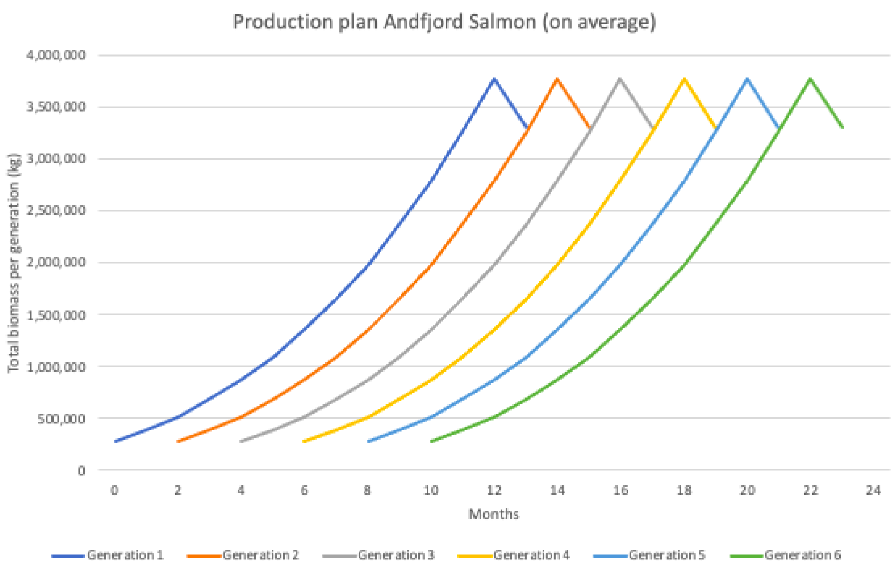

Figure 5.6 - Development in Andfjord's total biomass

Smolt cost

In their indicative cost breakdown, Andfjord estimates a smolt cost of NOK 5.5 per kg HOG. This is somewhat higher than the average cost for Norwegian conventional farmers in 2020 of NOK 4.66 per kg HOG. Several parameters affect this estimate, most notably the price per smolt and the mortality rate. The company itself argue that their cost of smolt is somewhat higher than competitors and conventional farmers due to the use of only high-quality smolt at 300 g (Rasmussen & Martinsen, 2021). Later, it has been specified that Andfjord will use smolt with sizes between 150 and 300 g (Rasmussen, CEO, Personal communication, May 27, 2022). Our calculations are based on a smolt size of 300 g since this is what Andfjord will use in their first batches. Based on the estimate of NOK 5.5 per kg HOG and the underlying assumptions in Table 5.2, we find an implicit price per smolt of NOK 18.43.

This implicit price is significantly lower than the expected market price for a smolt of the given size. We calculate the expected market price based on the following formula, presented by Bjørn Finnøy at Artec Aqua (Finnøy, COS, Personal communication, May 6, 2022). The price of a smolt consists of three parts. Firstly, a fixed component of NOK 8.0 per smolt, independent of size. Secondly, a variable part dependent on the size of the smolt, normally between NOK 0.07 and 0.08 per gram. Thirdly, additional features such as only high-quality roe or extra vaccination can be included, both at NOK 1.0 per smolt. Based on this formula, the price per smolt should be between NOK 30 and 33 when assuming high-quality roe and no additional vaccines.

Consequently, it could be argued that Andfjord’s cost estimate is understated. However, as shown in Figure 5.9 we do not adjust Andfjord’s indicative cost of smolt. To illustrate the uncertainty of this estimate, we conduct a sensitivity analysis on the price of smolt, displayed in Figure 5.7. We note that this effect is somewhat misleading. The sensitivity analysis examines the impact of a 20% change in the implicit price of NOK 18.43 with a resulting change in the cost of production of NOK 1.10 per kg HOG. Increasing the price base per smolt to NOK 30 would have an effect of NOK 3.45 per kg HOG on the cost of production estimate.

Regarding the discussion of mortality in land-based salmon farming and what drives the mortality rate, we acknowledge that it is a very complex parameter to comprehend. Morality can affect several factors and parameters such as smolt cost per kg, feed cost per kg, economical FCR and capacity utilisation. However, it is crucial to distinguish between different terms of mortality. Broadly, we distinguish between culling and mortality. Culling refers to the process of sorting out smolt of low quality. This is more relevant for farmers with their own hatchery operation. By culling, the farmer is more confident that all smolts in the grow-out facility have the best conditions to reach harvestable size. Consequently, by mortality, we refer to deaths occurring during the grow-out phase, which can be divided into *expected* and *realised* mortality.

Based on the design of our production model, the impact on production costs due to changes in *expected* mortality is quite limited, also illustrated in Figure 5.7. The negligible effect is due to the companies' option to compensate by setting out more smolt. Thus, changing the expected mortality rate will impact both smolt and feed cost per kg HOG. For a more detailed explanation of how expected mortality is handled in our production model, see Appendix A4

Realised mortality is more associated with capacity utilisation since the farmers will not be able to compensate by setting out more smolt. When discussing the realised mortality, the impact is dependent on the timing of the deaths. Experiencing mass mortality in the last months before harvesting will have a more considerable impact on production costs than mass mortality shortly after transfer to the grow-out facility because the biomass loss is smaller. Figure 5.8 demonstrate that a 10% biomass loss will increase Andfjord's overall production cost with NOK 4.15 cost per kg HOG, illustrating the significant impact of mass mortality.

Feed cost

Andfjord estimates a feed cost of NOK 15.7 per kg HOG, constituting ~46% of the total EBIT cost per kg HOG. Previous studies estimate this cost in the interval [NOK 17.98-22.14] per kg HOG (Bjørndal & Tusvik, 2017, 2019; Solheim & Trovatn, 2019)**.** It should be mentioned that all previous estimates are based on RAS facilities and thereby not necessarily comparable with Andfjord's facility. We carry out sensitivity analyses on the three of the most influential parameters that affect the cost per kg HOG in Figure 5.7. The parameters are the price of feed, mortality rates and biological FCR.

Based on the assumptions from Table 5.2 and our production model, we have estimated an implicit price per kg feed of NOK 12.75. Similarly, the average price paid by Norwegian conventional farmers in 2020 was NOK 12.55 per kg (Norwegian Directorate of Fisheries, 2021). Thus, Andfjord believes that they will be able to buy their feed at approximately the same prices as conventional salmon farmers. On the other hand, sources from BioMar claim that a price of NOK 16.50 per kg is more reliable as of today (Lother Kjørseng, Personal communication, April 8, 2022). They argue that this is based on the need for higher quality feed for land-based salmon farming and the recent spike in inflation, causing the prices of input factors to increase. As mentioned earlier, we do not account for the inflation effect in our estimates. However, it could still be argued that Andfjord's cost of production estimate is somewhat understated due to higher quality needs. Nevertheless, due to a strategic partnership with Nutreco, it is possible to argue that Andfjord could achieve relatively low feed prices.

Moreover, the biological FCR will affect the cost of feed per kg HOG. Therefore, if Andfjord can reduce the biological FCR, they will be able to produce the same volume of salmon using less feed, thereby lowering their overall costs. Andfjord assumes a biological FCR of 1.1, which is also supported by previous literature (Bjørndal & Tusvik, 2019; Summerfelt et al., 2013). Based on Figure 5.7, it is evident that a 20% change in the biological FCR and feed price do have the same absolute effect of NOK 3.14 per kg HOG on Andfjord's cost of production. Together, these are two of the most influential parameters. This is caused by the design of our production model. However, changes in the two parameters are affected by different mechanisms, and they must therefore not be viewed as identical parameters.

Lastly, the mortality in the grow-out facility is also an important parameter affecting the cost of feed per kg HOG. Earlier, we discussed the complexity of mortality in general associated with land-based salmon farming. Due to the design of our production model, *expected* mortality does not have a significant impact on the cost of feed per kg HOG. With regard to *realised* mortality, we display the overall effect of lower capacity utilisation in Figure 5.8. The effect is shown on the cost of production per kg HOG and could, for instance, be due to mass mortality or sickness late in the production cycle.

Energy cost

Andfjord presents energy costs of NOK 1.0 per kg HOG in their cost breakdown. This estimate is quite challenging to verify since it requires a thorough validation of the complete production facility and processes. However, the estimate is verified by SINTEF, limiting the need for further validation (Rasmussen & Martinsen, 2021). In their investor presentations, annual reports, and other communication, Andfjord argues that their facility has a competitive advantage due to very low energy costs. Lower energy usage was also highlighted during our interview: *"The general perception is that it (land-based salmon farming) is not possible because of the high energy costs. We have disproved this."* (Krøgenes, COO, Personal communication, February 17, 2022).

Conventional ONP facilities have even lower energy costs. Based on data from the Norwegian Directorate of Fisheries (2021) energy is not included as a specific object in the estimates but in other operating costs. However, considering conventional salmon farming does not have any need for pumping and filtration of water, it is limited what other operations are very energy-consuming. Consequently, comparing Andfjord's energy usage with other land-based salmon farmers might be more relevant. According to ABG Sundal Collier (2020) the cost advantage of lower energy usage is estimated to be around NOK 4.0 per kg HOG. This is also supported by Bjørndal and Tusvik (2019), finding an energy cost per kg HOG of NOK 5.71 for a RAS facility. Thus, if the estimate of NOK 1.0 per kg HOG is true, Andfjord could possess a competitive advantage with respect to energy costs.

We see a limited need for sensitivity analysis with regard to Andfjord's energy usage since it is common for larger companies to buy their energy at fixed prices. The limited need is further supported by Andfjord's technology being verified by SINTEF. Nevertheless, this must not be interpreted as energy usage being an unimportant parameter.

Harvesting cost

Andfjord presents a cost of harvesting of NOK 6.1 per kg HOG. This is higher than the average cost of harvesting for Norwegian conventional salmon farmers in 2020, which was NOK 4.55 per kg HOG (Norwegian Directorate of Fisheries, 2021). Furthermore, the cost includes transportation from the grow-out to the harvesting facility, which could explain Andfjord's higher cost. Considering harvesting is a fairly similar operation for all salmon farmers, we argue that a sensitivity analysis is less relevant. Nevertheless, we acknowledge that in the long run, Andfjord could achieve economies of scope in harvesting costs due to lower transaction costs in the value chain. However, this is not relevant for Kvalnes 1.

Personnel cost

Andfjord reports a salary cost per kg HOG of NOK 1.3 for Kvalnes 1. It could be argued that the cost does include more than solely salary and should therefore be called personnel costs. Some examples are taxes, social security costs and insurance. However, we do not know whether the estimate only includes operating personnel or if it also includes administration and management. Moreover, it is reasonable to assume that some parts of the overall personnel costs are variable with the number of salmon in the tanks. In contrast, other parts are fixed and not dependent on production. The lack of a more detailed classification of the personnel costs complicates further analysis.

Furthermore, there exists a trade-off between lower personnel costs and increased cost of capital. By investing in a more automated production process, the need for personnel is reduced, thereby limiting the production cost per kg HOG. However, this is somewhat offset by an increased investment, which results in a higher cost of capital per kg HOG. The net effect of changing the degree of automation is, for this reason, debatable.

Moreover, it is reasonable to assume that there will be some degree of economies of scale associated with personnel costs. For instance, it is natural to assume that there would be a limited need for a larger management group when Andfjord is fully expanded and producing 90 000 tonnes HOG annually. Nevertheless, the magnitude of such economies of scale is rather uncertain. In our interview with Krøgenes, economies of scale regarding personnel were suggested in general terms but not quantified (Krøgenes, COO, Personal communication, February 17, 2022). This is understandable since the company is not yet producing any salmon.

Lastly, due to limited information regarding personnel costs, we do not conduct any sensitivity analyses affecting this cost. Still, we acknowledge that there are most likely economies of scale when increasing the production.

Other operating costs

In their indicative cost breakdown, Andfjord estimates that other operating costs constitute NOK 2.4 per kg HOG. We do not have a detailed classification of all included costs in this collective term. We know that insurance is included, but there are surely many more elements included in this cost type (Rasmussen & Martinsen, 2021). Most likely, Andfjord has included costs regarding waste handling, R&D, transportation, veterinary and maintenance in other operating costs. Without a specific cost classification, it is not very relevant to conduct sensitivity analyses. However, this does not signify the costs being unimportant.

Cost of capital

Andfjord's estimate of NOK 2.2 per kg HOG in depreciations is based on an estimate of NOK 1.14 billion in CAPEX or a CAPEX per kg HOG capacity of NOK 60. This estimate does not include the future plans of building both a smolt and harvesting facility. In their investor presentation, this figure is further decomposed in rich detail (Rasmussen & Martinsen, 2021). However, we will not discuss the reasonability of each item but keep the discussion on a more general level. The size of the total CAPEX is quite uncertain. ABG Sundal Collier (2020) and Sparebanken 1 Markets (2022) estimate NOK 70 and 80 per kg HOG capacity, respectively. Both present inflation as their main argument for higher CAPEX. As mentioned previously, we estimate the cost of production in real terms, thereby not adjusting for inflation. Nevertheless, we conduct a sensitivity analysis on the effect of CAPEX per kg HOG capacity, displayed in Figure 5.7**,** to illustrate the impact of delays, errors or misestimation.

Furthermore, based on a total CAPEX of NOK 1.14 billion and depreciations of NOK 2.2 per kg HOG, we are able to calculate and discuss what implicit assumptions the estimates depend on. We find an implicit assumed average economic lifetime of ~27 years by assuming linear depreciations. From our interview with Krøgenes, an average of 15-20 years is argued, while their investor presentation claims 15-25 years (Krøgenes, COO, Personal communication, February 17, 2022; Rasmussen & Martinsen, 2021). As we do not have detailed assumptions regarding each item of the overall CAPEX and depreciations, we are not able to discuss whether 27 years is reasonable or not. For example, some components in CAPEX are not depreciated (e.g., land), making the discussion challenging.

Moreover, when calculating the total cost of capital, we argue that calculating a real annuity would be more appropriate. This is partly due to uncertainty regarding the specific and general price development going forward. At the same time, a real annuity is consistent with the assumption of a stable cash flow in steady state, which is a fundamental assumption behind Andfjord's indicative cost breakdown for Kvalnes 1. Thus, in real terms, the same cost is charged every year during the economic lifetime. In our calculations of the annuity, we have assumed an average economic lifetime of 20 years and a real WACC of 4%. The latter assumption is equivalent with the assumptions of (Bjørndal & Tusvik, 2019)Note that we have reduced the economic lifetime to be in correspondence with our collected data. Based on these assumptions, we estimate a cost of capital of NOK 4.41 per kg HOG for Andfjord.

Nevertheless, we have conducted two sensitivity analyses to display the effect on the cost of capital per kg HOG by changes in the assumptions regarding the real annuity calculation. Firstly, we examine the impact of changes in the average economic lifetime. Secondly, we alter the assumed real WACC of Andfjord, which again affects the cost of capital per kg HOG. The changes in the average cost of capital are most influential. This is displayed in Figure 5.7.

Lastly, the cost of capital is affected by the realised yearly production or, in other words, the capacity utilisation of Andfjord. When it comes to capacity utilisation, we conduct two sensitivity analyses based on different assumptions. The first is illustrated in Figure 5.7, where we have assumed a constant EBITDA per kg HOG. This demonstrates that regardless of capacity utilisation, Andfjord has to use the same resources of smolt, feed and harvesting.

Differences in TGC could partly explain variations in capacity utilisation. TGC is an expression for how much the salmon is growing. In reality, salmon farmers will try to harvest daily to fully utilise their MAB licences. To maximise the production, salmon farmers usually harvest the net growth in biomass on a daily basis, thus keeping the standing biomass constant at the MAB specified level. All else equal, a higher TGC results in higher growth, making it possible to set in more smolt and harvest more salmon. Therefore, a higher TGC is considered one of the main advantages of land-based salmon farming compared to conventional salmon farming (Bjørndal & Tusvik, 2019).

However, our simplified production model is not created on a daily basis, making it difficult to display the actual effect of changes in TGC. Furthermore, we acknowledge that TGC is a very complex parameter. It is dependent on several variables such as feed quality, biological traits of the salmon, water quality, and the quality of the feeding process. If the TGC is to change, it is possible to argue that minor changes in EBITDA per kg HOG would occur. However, the main effect will be materialised in the cost of capital per kg HOG due to changes in Andfjord's capacity utilisation.

For this reason, the assumption of a constant EBITDA cost per kg HOG might not be entirely realistic, but it is sufficient to illustrate the main effect of changes in TGC on the cost of production. Nevertheless, changes in capacity utilisation could be due to parameters other than TGC, such as smolt quality, feed, technological design, and so forth.

The second sensitivity analysis on capacity utilisation is illustrated in Figure 5.8**.** Here, the assumption is that the total EBITDA is fixed based on a planned production of 19 000 tonnes HOG. Hence, a lower capacity utilisation illustrates the effect of losing parts of the biomass, for instance, due to mass mortality or sickness. We conduct this analysis to show the effect of mortality at a late stage in the production cycle.

Cost of net working capital

The cost of investing in net working capital should also be included when calculating the actual cost of production. Net working capital is included in capital employed, and therefore an imputed interest should be calculated, as mentioned in section 2.2.1. However, the net working capital is not depreciated. Consequently, we handle the imputed interest on net working capital as a separate cost of capital.

Andfjord does not include any estimates of net working capital in their reports. However, by assuming that net working capital is dependent on annual production volume, we find an estimated net working capital of NOK 430 million by upscaling Proximar Seafood's estimates. The result is a cost per kg HOG of NOK 0.91. This is not very different from assuming a working capital of NOK 25 per kg HOG capacity, as done by Sparebanken 1 Markets (2022). They find a net working capital estimate of NOK 470 million. Proximar's estimate measures net working capital up until the first sale. We acknowledge that such an estimate differs from an estimate of net working capital in steady state production. However, since these estimates are not available for Andfjord, and it is unclear what Sparebanken 1 Markets and ABG Sundal Collier have included in their estimate, we use the up till the first sale estimate of net working capital. In relation, we display the underlying uncertainty with a sensitivity analysis. From Figure 5.7, it is evident that a 20% change would lead to an absolute change in the cost of production per kg HOG of NOK 0.18.

Sensitivity

Figure 5.7 illustrates the effect of a 20% change in the most important parameters regarding Andfjord's cost of production. Based on this model, it is clear that controlling the feeding operation and maintaining a high capacity utilisation is the most important for Andfjord.

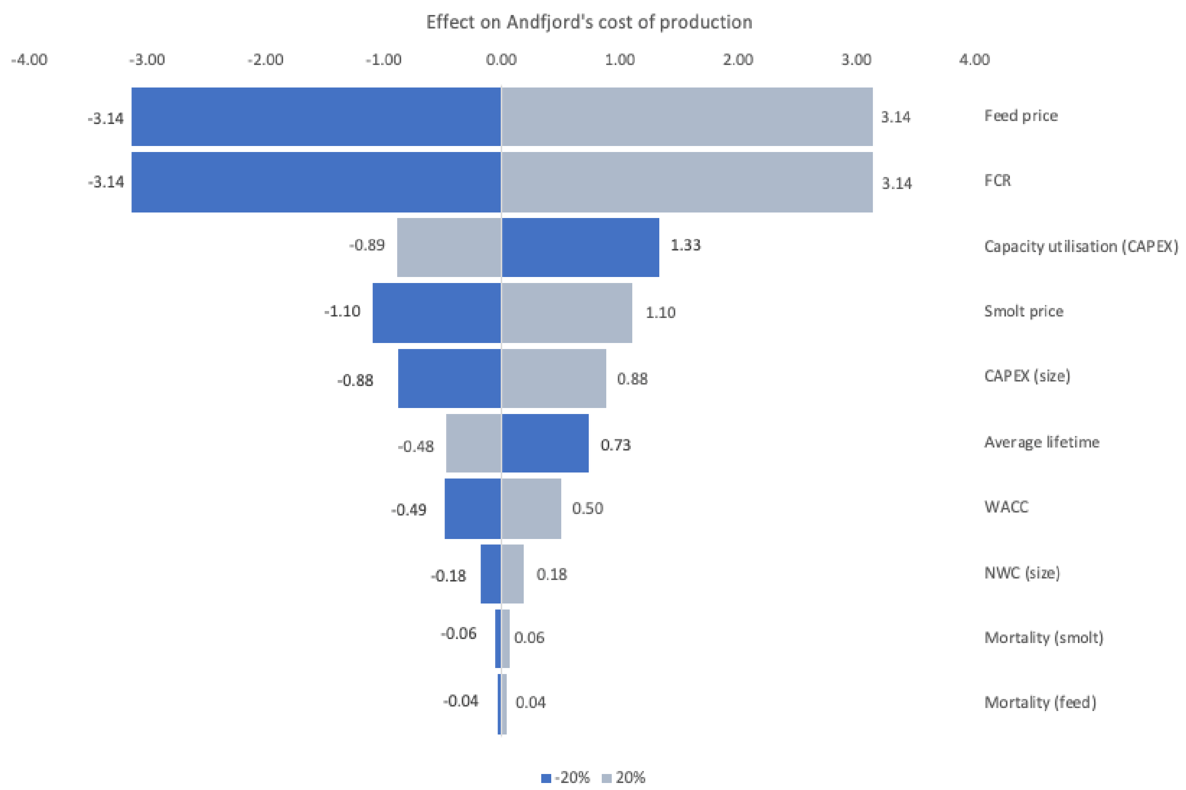

Figure 5.7 - Sensitivity in Andfjord's cost of production estimate

Furthermore, Figure 5.8 displays the effect of losing a given percentage of the biomass at a late stage in the production cycle. As stated earlier, this analysis assumes a fixed overall EBITDA cost, calculated at a production of 19 000 tonnes HOG annually.

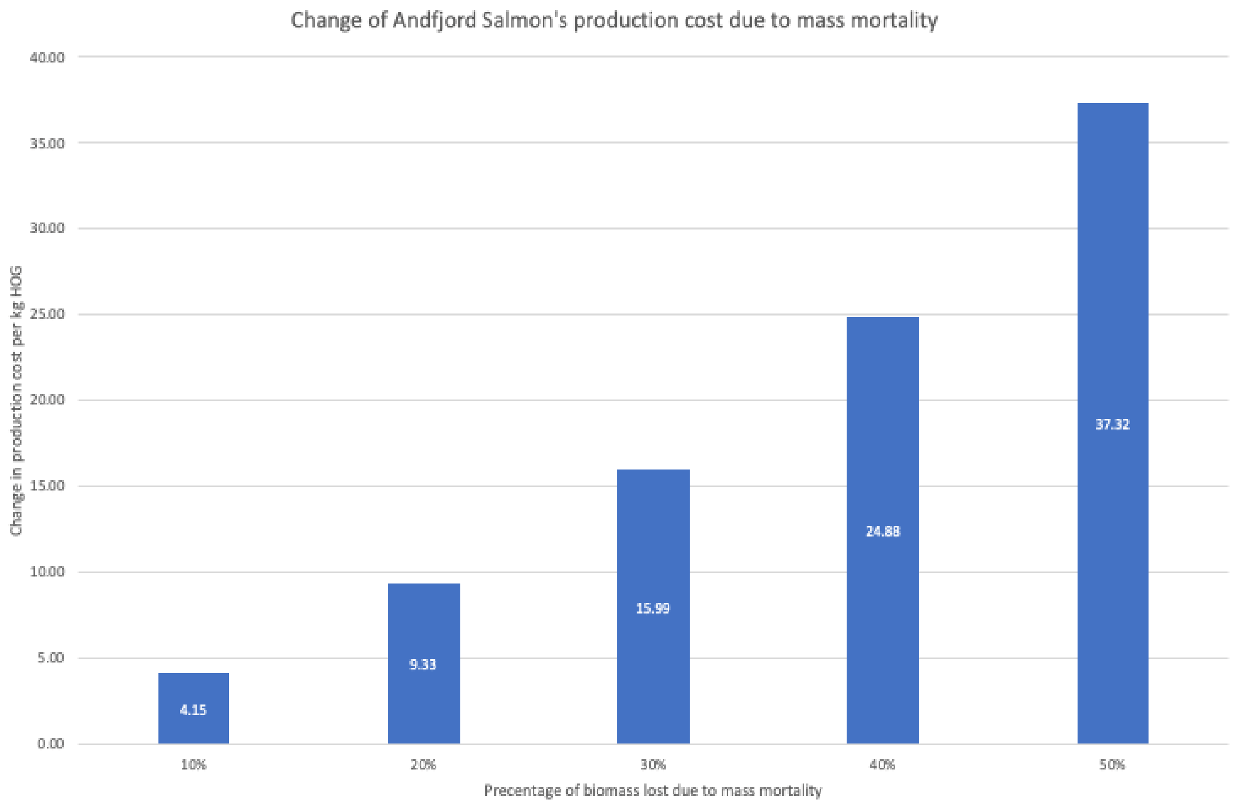

Figure 5.8 - Effect of biomass loss on cost of production for Andfjord

Adjusted cost of production

Based on the discussion of each item of Andfjord's indicative cost breakdown from 2021, we present the following adjusted cost of production as shown in Figure 5.9.

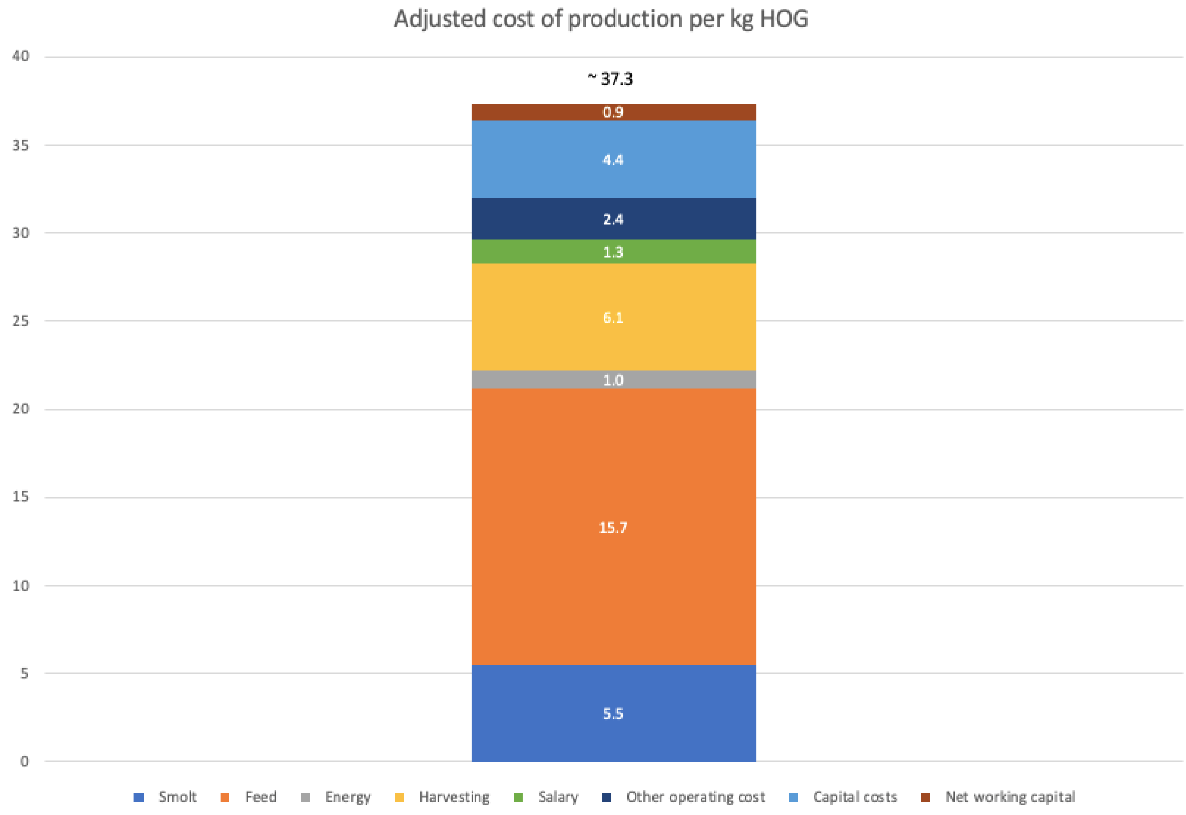

Figure 5.9 - Adjusted cost of production estimate for Andfjord

Considering that we want to estimate a production cost that fully accounts for investors' cost of capital, we have adjusted Andfjord's 2021 cost estimate to include the imputed interest rate on capital employed. Other than that, we have chosen not to adjust other items from the 2021 indicative cost breakdown. There are two reasons for this.

Firstly, as stated previously, we do not account for a general or specific price increase from 2021 to today. This is because we consider that such an exercise would have a limited impact on our conclusion about important profit drivers for Andfjord. For instance, adjusting for inflation would naturally change the magnitude of our sensitivity analysis, but most likely not our findings indicating that choice of technology and capacity utilisation are important cost drivers for Andfjord. For this reason, we have adjusted for capital costs in real terms since a nominal adjustment from 2021 to today would imply that we have to adjust all other cost estimates as well. This would be an arbitrary exercise for some cost types due to limited information regarding unit price and resource utilisation.

Secondly, it is possible to argue that most of Andfjord's cost items we have validated in comparison with other companies and industry experts are estimated at a reasonable level if one ignores variation due to inflation. However, we also have examples that could indicate some forms of underestimation (e.g., smolt). Nevertheless, due to limited information behind Andfjord's estimate, it would be arbitrary to adjust for such underestimations. At the same time, we believe that our sensitivity analysis illustrates that Andfjord's cost of production estimate is prone to uncertainty. Therefore, we consider only adjusting for the cost of capital as sufficient given the purpose of this thesis.

With regard to the adjusted cost of production estimate, it is clear that Andfjord must be able to achieve a price of NOK 37.3 per kg HOG in real terms compared to 2021-levels in order to be profitable from an investor perspective. Note that the company is profitable at even lower prices in accounting terms. Nevertheless, it is important to keep in mind that the estimate is somewhat uncertain and that minor changes in several of the underlying parameters at the same time could increase the cost of production significantly.

5.2 Case 2: Proximar Seafood

5.2.1 General description

Proximar Seafood (hereby Proximar) was founded in 2015 and is in the process of constructing a land-based salmon farming facility in Oyama at the foot of Mount Fuji in Japan as Figure 5.10 illustrate. This facility provides Proximar access to high-quality water and market proximity with only a few hours' driving distance to Tokyo and Yokohama. Proximar has a targeted annual production of 5 300 tonnes HOG after stage 1 of development. The company will start with a fish density of 68 kg per m^3 and gradually increase it to 80 kg per m^3. The amount of standing biomass in the fish tanks (MAB) is currently not regulated in Japan. However, land areas and water access must be approved before construction starts. After stage 2 of development, the annual capacity will be 26 300 tonnes HOG. Additionally, the company has plans for further growth in production, but these expansions is to be determined.

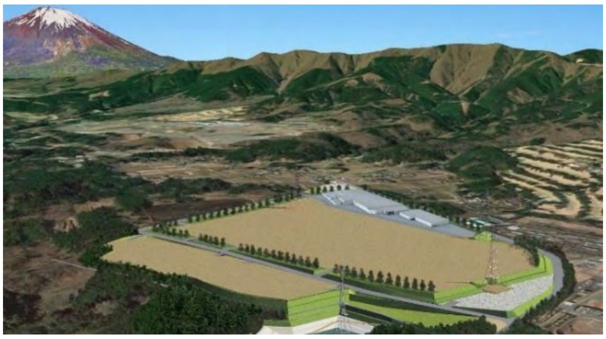

Figure 5.10 - Proximar facility located nearby Mount Fuji (Proximar Seafood, 2021a)

In 2017, the Grieg family joined as shareholders and directors of Proximar. This family is the majority owner of Grieg Seafood, one of the world's leading salmon farmers. The family have provided Proximar with aquaculture expertise. Later, the company established a partnership with Daiwa House for the construction of the facility, with the majority at a fixed price in 2018. After some private placements and the listing on Euronext Growth at the Oslo Stock Exchange, Proximar started construction of phase 1 in Oyama. Proximar expects to finalise this phase in 2023. First harvest volumes and sales are expected in Q2 in 2024.

Proximar will utilise recirculating aquaculture systems from AquaMaof. This technology is proven and has produced salmon to harvest weight since 2017. According to Proximar, the AquaMaof system has several benefits related to filtration, denitrification, water use, and waste handling compared to traditional RAS technologies but has higher capital costs. Proximar Seafood's technical solution will be discussed more in detail later.

5.2.2 Description of strategic choices

Competitive and marketing strategy

Proximar's competitive strategy resembles some degree of differentiation. The company tries to differentiate its produced salmon from imported salmon in Japan to achieve a price premium and thus capitalise on this market position. Insights from our interview with Joachim Nielsen, CEO of the company, as well as information from published reports and different external sources written about Proximar, support this claim.

In the interview, Nielsen stated that proximity to the market has always been a fundamental strategical choice for Proximar since its inception (Nielsen, CEO, Personal communication, March 17, 2022). Given that unprocessed salmon is typically perceived as a commodity, Proximar's selection of location is believed to create a differentiation potential. This could give the company a price advantage in Japan. There are two reasons for this.

Firstly, the choice of location makes it possible for Proximar to promote product-related attributes such as freshness and availability in their marketing. This choice makes it possible to differentiate their processed and non-processed Atlantic salmon in the Japanese mass and niche market. These markets have historically been served by imported salmon from Norway and Chile. As a result of limited local supply nearby and high transport and handling costs, Japan has one of the highest regional prices for Atlantic Salmon (Norwegian Seafood Council, 2022). Given these circumstances, being the first local producer of Atlantic salmon could be a profitable market position for Proximar. By operating within driving distance to two of Japan's biggest cities, Proximar could deliver superior Atlantic salmon in terms of freshness and availability compared to imported salmon. Market studies give indications that 50% of consumers in Japan would be willing to pay a premium of around 10% for fresh and local produced Atlantic salmon (Proximar Seafood, 2022a). Nielsen also highlighted this differentiation potential in the interview:

> *"Our market position is a great advantage because we can differentiate ourselves from the imported fish and not be a substitute, but a separate product ... Japan is probably the market globally that has the highest willingness to pay for fresh produced domestic food ... Consumers in Japan are very quality-oriented and have great interest and focus on food and raw materials"* (Nielsen, CEO, Personal communication, March 17, 2022).

Secondly, Proximar could promote non-product related attributes such as country origin, sustainability, and animal welfare to differentiate their Atlantic salmon in their marketing. Considering that consumers are becoming more aware of sustainable food production, this could give Proximar a competitive advantage due to an ESG price premium (Moe et al., 2022). This is because local production in Japan would provide Proximar with a significantly lower carbon footprint than imported salmon transported on long-haul flights. For example, SINTEF estimated in 2017 that airfreight accounted for over 51% of total emissions for Norwegian fresh Atlantic salmon transported from Oslo to Shanghai in Figure 5.11. This illustrates that Proximar's salmon could be a sustainable alternative to imported salmon.

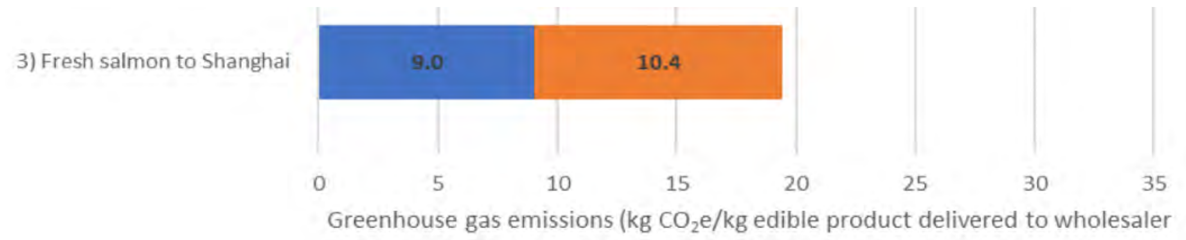

Figure 5.11 - Greenhous gas emissions of salmon transportation to Shanghai (SINTEF, 2017)

Proximar's potential for an ESG price premium is closely linked to the company's Mount-Fuji branding. The reason for this is that the branding gives customers the impression that Proximar's production is in harmony with nature. For this reason, the production could be perceived as sustainable and animal friendly even though it takes place on land. Additionally, Mount Fuji is an iconic national treasure in Japan, which may give Proximar a strong market position due to the local preferences of Japanese consumers. Nielsen explains that Japanese seafood is popular and sought-after in Asia. For this reason, the Mount Fuji-branding also appears to be valuable for Proximar because it will enable some exports of salmon to niche markets outside of Japan (Nielsen, CEO, Personal communication, March 17, 2022).

From this perspective, it appears that Proximar's competitive strategy is partially oriented toward differentiation, where local production is believed to result in a price advantage. However, it is also possible to claim that Proximar's competitive strategy is motivated by cost leadership to some degree. For instance, Nielsen mentioned that being located in a relatively built-up area in Japan has made it easier for the company to recruit personnel with sufficient competence. This is acknowledged as an important cost driver (Nielsen, CEO, Personal communication, March 17, 2022). Moreover, Proximar estimated in 2021 that local production would save transportation and handling costs of around NOK 25-30 per kg HOG compared to Norwegian imported Atlantic salmon (Nielsen, Stigaard & Grimsrud, 2021). This cost advantage is illustrated in Figure 5.12.

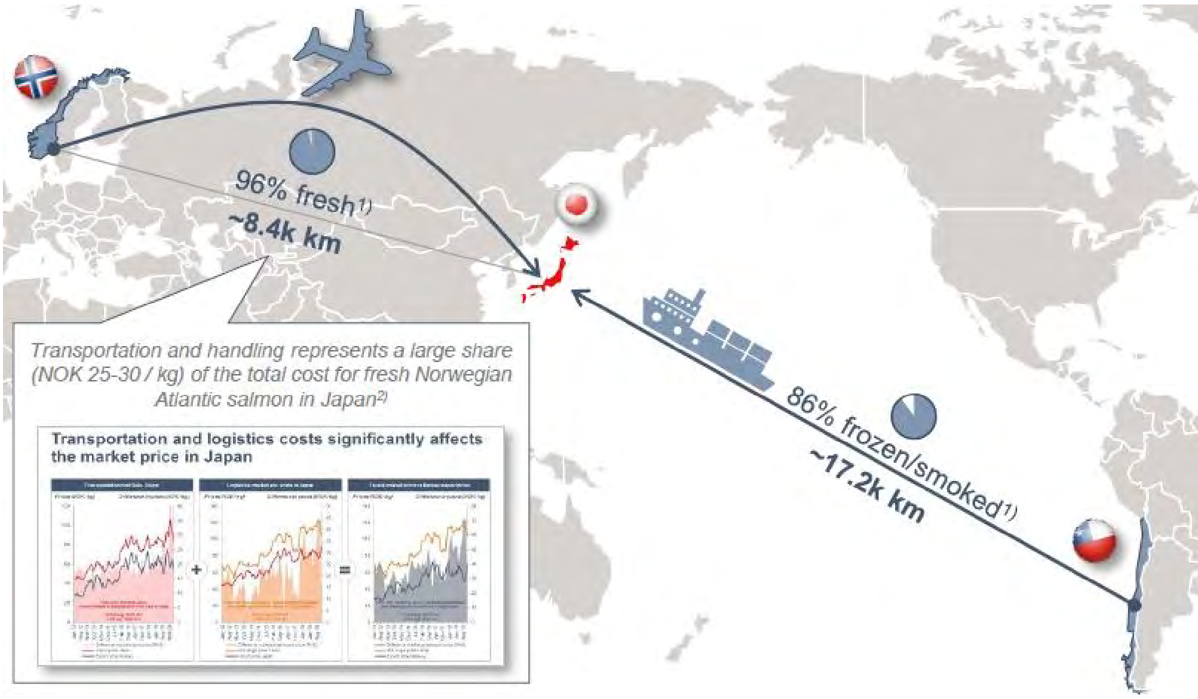

Figure 5.12 - Proximar's cost advantages due to reduced transportation (Nielsen, Stigaard & Grimsrud, 2021)

Overall, it is evident that Proximar's competitive and marketing strategy is motivated by the ambition of achieving a price advantage due to the differentiation of non-processed Atlantic salmon in the mass market in Japan. Consequently, the differentiation scale must be viewed in this context. That is why we have decided to place Proximar to the right in Figure 5.13 with regard to competitive advantage. However, since the company plans to serve niche markets in and outside of Japan with more processed Atlantic salmon, we have decided to position Proximar in the middle in relation to competitive scope.

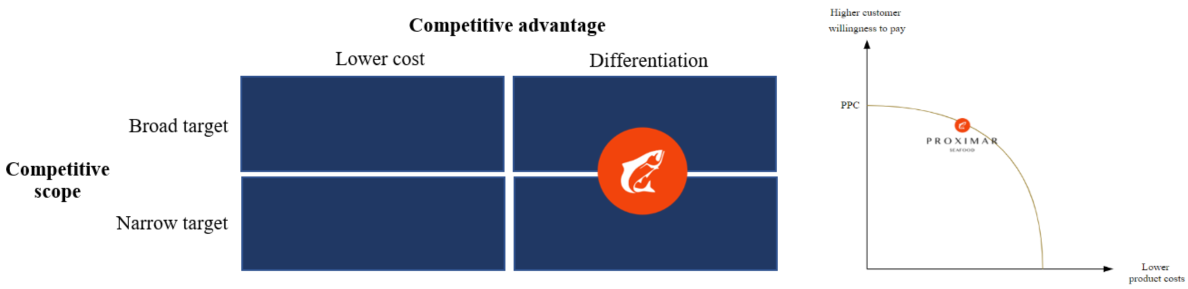

Figure 5.13 - Proximar's competitive strategy

Regardless of this classification, we have mentioned that cost is a motivational factor in Proximar's competitive strategy. Therefore, we will describe operational strategical choices mainly from a cost perspective in the following. Proximar's differentiation potential due to location and Mount Fuji-branding has already been comprehensively covered.

Operational strategy

From our observation, it appears that Proximar's choice of location is not the only operational strategical choice that has been motivated and influenced by costs. The company has also tried to utilise the cost advantage of being a local producer of salmon in Japan when it comes to technology design. Moreover, this is also evident in Proximar's development of the production facility and accumulation of competence due to strategic partnerships in the value chain.

Regarding technology, Nielsen explains that Proximar would have chosen RAS if they had decided to build a facility in Norway. There are two reasons for this:

> *"Firstly, RAS is the only way you can ensure stable water parameters and a good environment for the fish. Secondly, it is preferable to have a closed facility in relation to diseases. When you have to take in large amounts of water, there is always a risk that something goes wrong. This is probably why the majority of land-based salmon farmers use RAS*" (Nielsen, CEO, Personal communication, March 17, 2022).

This observation highlights that location does not necessarily put restrictions on the choice of technology in land-based salmon farming, at least when it comes to RAS.

Speaking of RAS, it is evident that Proximar has selected a RAS solution that has lower complexity compared to other RAS facilities. For example, Proximar will use less equipment and more natural processes as demonstrated in Figure 5.14. In particular, Proximar will not use mechanical filters like traditional RAS systems but instead, have settler tanks that remove particles naturally in a laminar water flow. Together with a trickling filter which is installed in the biofiltration process, this reduces the risk of H2S and mass mortality of the salmon. Moreover, a denitrification system will be applied to reduce the need for new water in the system significantly. Finally, purge tanks will also be installed to control the levels of geosmin in the fish and water, which can give the salmon off-flavour and unpleasant odour.

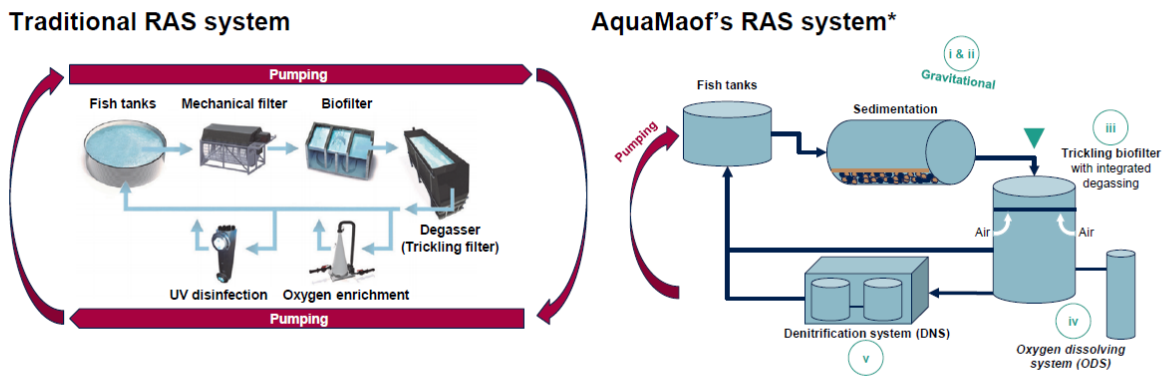

Figure 5.14 - AquaMaof's RAS system compared with a traditional RAS system (ABG SC, 2021)

Moreover, AquaMaof requires Proximar to have 100% backup on all critical equipment and installations as operational safety measures. This includes electricity systems and the self-production of oxygen. Proximar even has a backup on backup generators. In relation, Proximar also will construct and operate their own hatchery, as demonstrated in Figure 5.15. Nielsen explained that this is because AquaMaof does not allow Proximar to use external breed smolt since this will increase biological risks of diseases and mortality:

> *"It is probably cheaper if we had outsourced the smolt production, but then we would have to buy from external sources. This increases the risk of diseases and can quickly become an expensive affair. So, it is a risk and reward trade-off."* (Nielsen, CEO, Personal communication, March 17, 2022).

Altogether, Proximar's technical solution is unusual compared to traditional RAS systems. However, their facility requires more investments per capacity due to a more extensive area usage. This results in higher capital costs due to more capital employed. Nielsen also noted this in the interview (Nielsen, CEO, Personal communication, March 17, 2022).

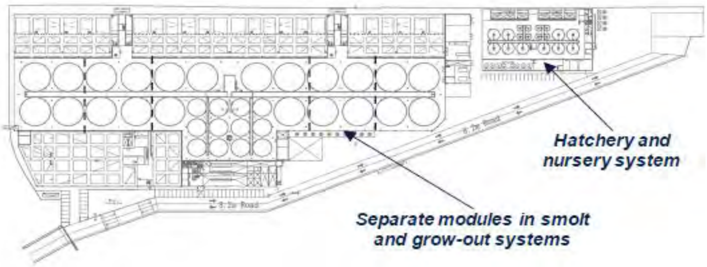

Figure 5.15 - Overview of Proximar's facility (ABG SC, 2021)

With this in mind, Proximar's price and cost advantage due to location have made it possible for the company to invest more in safety measures to mitigate challenges such as disease outbreaks, H2S, off-flavour and system breakdowns. The reasoning for these strategic, operational choices is the belief that this will lead to more healthy and superior salmon due to a sustainable production emphasising good biology and an animal-friendly environment. These plans have been acknowledged in the market as Proximar has been awarded the highest rating on sustainability by a leading credit rating agency in Japan (Proximar Seafood, 2022c).

Furthermore, Proximar's capital investments enable the company to take advantage of economies of scope due to a fully integrated value chain in the early production stages. For example, Proximar's own hatchery of smolt could reduce their production cost of Atlantic salmon due to less transaction costs in the value chain.

Additionally, according to Nielsen, Proximar's capital investment could be beneficial despite strict regulations in Japan:

> "*Japan is regulated, so you must have permission to collect larger amounts of water. Getting these permissions is difficult. This means that extra CAPEX invested in our facility could be justified by the operational cost advantage we get as a local producer in Japan.*" (Nielsen, CEO, Personal communication, March 17, 2022).

Having said that, we notice that higher capital investments make it crucial for Proximar to have high capacity utilisation in their facility to be profitable. Nielsen acknowledges that there are economies of scale, making dimensioning of the production facility in the early development phases an important cost driver. However, he believes economies of scale in CAPEX are limited as many input factors are priced unit wise. This implies that an increased scale is just a quantity adjustment (Nielsen, CEO, Personal communication, March 17, 2022).

In connection to capacity utilisation, Proximar has been very oriented towards accumulating industry competence related to operations since its inception:

> *"Building industrial competence has been our focus since day 1. Bjørn Myrseth, who has been farming salmon in RAS before, has been involved from the start. The Grieg family has guided us with their competence. Moreover, we have the feed company Nutreco on the owner's side and a very close and good relationship with AquaMaof. For this reason, industry competence and experience are in our DNA, which is crucial. Building and operating a land-based salmon farming facility is not just plug and play"* (Nielsen, CEO, Personal communication, March 17, 2022).

Nielsen's quote illustrates that having skilled personnel, good control systems and management of production processes are essential operational features. This could, for instance, contribute to limiting costs without distorting product quality. Proximar's focus on capacity utilisation and how this could be facilitated through quality management and good facility layout are cost-leadership traits (Lien et al., 2016).

Finally, we observe that Proximar has focused on process and linkages in the value chain when designing and developing its operations. For example, Nielsen mentioned that Proximar will buy Atlantic salmon eggs produced in Iceland by Benchmark Genetics. Moreover, the company will purchase salmon feed from Skretting as a part of the strategic partnership with Nutreco. In a recent press release, Proximar also announced that the company will partner with Marubeni as a key distributor in Japan (Proximar Seafood, 2022b).

5.2.3 Estimated production cost

In an investor presentation from 2021, Proximar presents a nominal indicative cost breakdown of NOK 44.5 in EBIT/kg HOG and NOK 192.5 in CAPEX/kg HOG capacity. The estimates in Figure 5.16 cover the first development phase at Oyama (Oyama 1). Planned annual production volumes Oyama 1 are 5 300 tonnes HOG (Nielsen, Stigaard, & Grimsrud, 2021).

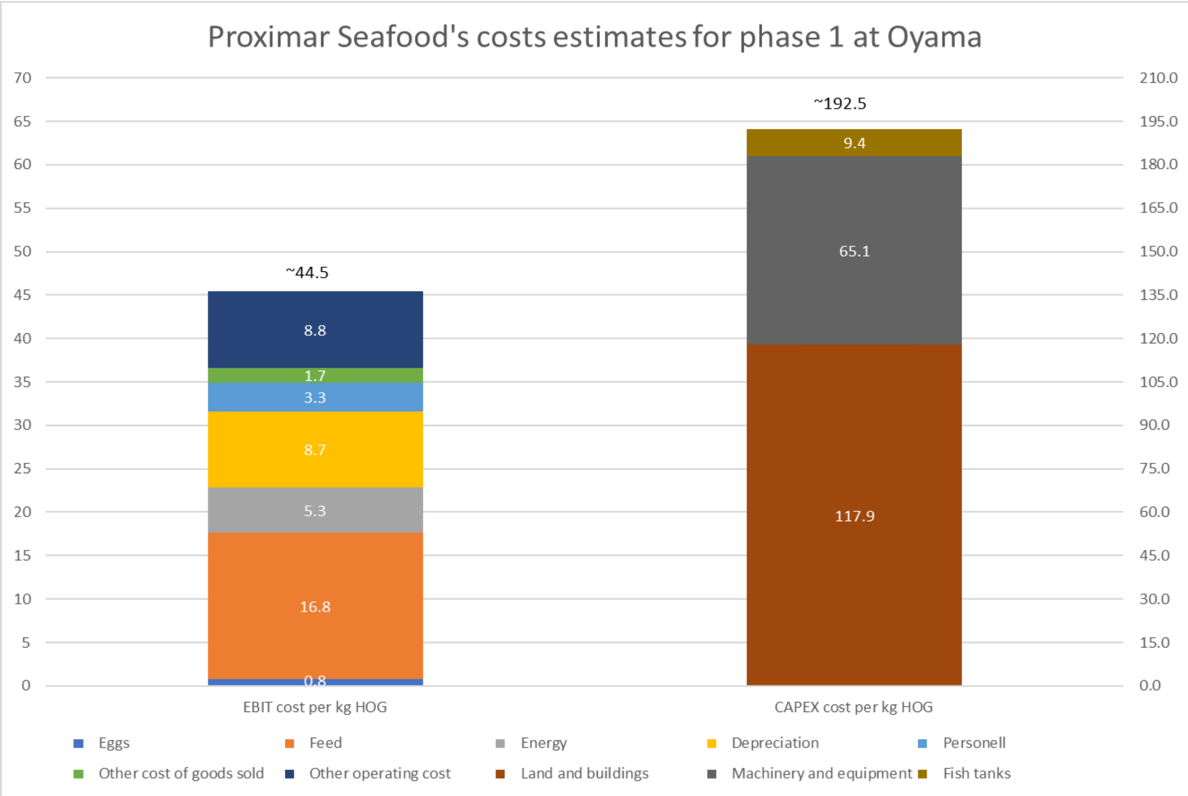

Figure 5.16 - Indicative cost breakdown for Proximar (Nilsen, Stigaard & Grimsrud, 2021)

In the following, we will validate each cost item from the breakdown in order to present an adjusted cost of production for 2022 in real terms. The reasons for this are elaborated in the Andfjord case in section 5.1.3.

Production model

With the purpose of validating Proximar’s indicative cost breakdown, we have created a production model based on the assumption presented in Table 5.3. The production model is rather simplified compared to Proximar’s actual biological plan. For example, all salmon are assumed to be harvested at the end of a production cycle at an average weight of 5000 g. However, Proximar plans to harvest daily. Figure 5.17 shows the average development in total biomass found in the production model. A detailed explanation of Proximar’s assumed production model is provided in Appendix A4

	Hatchery	Smolt grow-out
Average start weight	0.2 g	100.0 g
Average final weight	100.0 g	5000.0 g
TGC	2.0	3.0
Average temperature	8.5°C	13.0°C
Production cycle (months)	10	12
Number of generations	12	12
Number of eggs and smolt per generation	156 000	100 072
Expected mortality and culling (overall)	36.0%	3.0%
Expected mortality (first month)	5.4%	1.5%
Expected mortality (evenly from the second month)	5.4%	0.1%
Purging (months)	0	0.5
Weight loss when purging	N/A	7.0%
Weight loss when purging & gutting	N/A	9.0%
Price of eggs	NOK 2.26	
Price of feed (per kg)	NOK 12.80	NOK 12.80

Table 5.3 - Assumption behind Proximar's production model

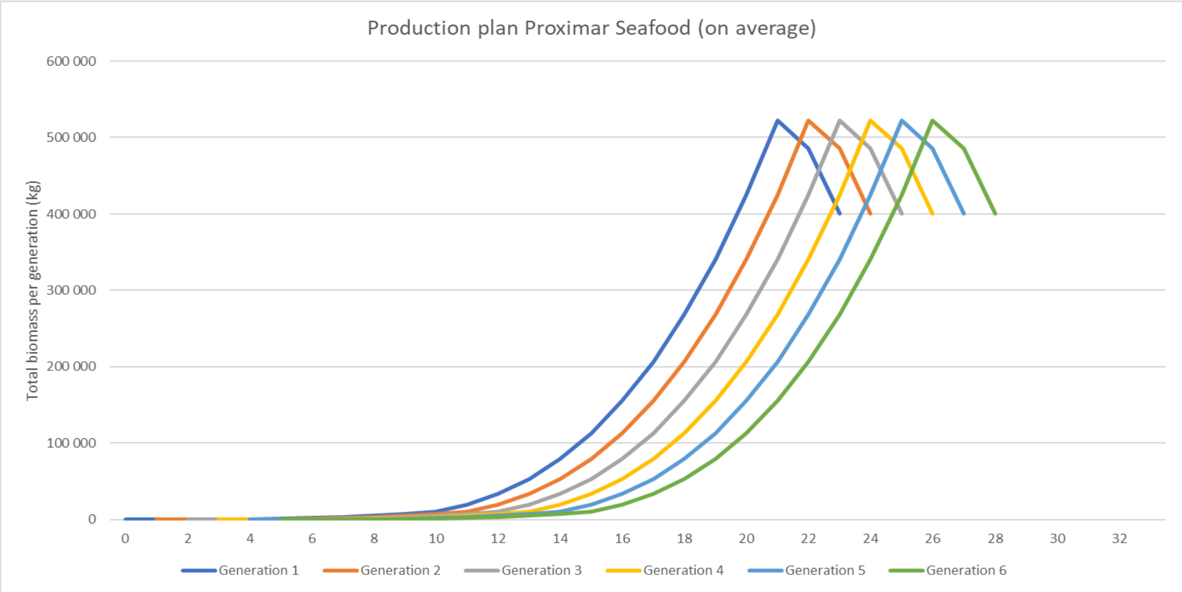

Figure 5.17 - Development of Proximar's total biomass

Egg cost

Proximar estimates a cost of eggs per kg HOG at NOK 0.8 in relation to the operation of their smolt hatchery. This corresponds to 1.8% of the total estimated EBIT cost for Oyama 1. Two parameters that impact the magnitude of this estimate are yearly purchases and the unit price of eggs. In the interview, Nielsen explains that Proximar plans to buy 156 000 Atlantic salmon eggs per month when Oyama 1 is running at full production of 5 300 tonnes HOG (Nielsen, CEO, Personal communication, March 17, 2022). Accordingly, Proximar will buy 1 872 000 eggs annually, indicating a total egg cost of NOK 4,2 million in round numbers. This implies an average unit price of Atlantic salmon eggs of around NOK 2.26.

Data from the Norwegian Directorate of Fisheries (2021) indicate that the average price for Atlantic salmon eggs in the Norwegian aquaculture industry was NOK 1.05 and 1.18 in 2019 and 2020, respectively. Bjørndal and Tusvik (2019) estimate a price of NOK 1.50 per egg, but the authors acknowledge that the price range is between NOK 1.1 to 1.6, depending on genetics. In this regard, Proximar's implicit unit price of NOK 2.26 per egg is comparably higher. The price difference could be explained by transportation costs from Iceland being included in Proximar's implicit egg price. Furthermore, according to Nielsen, Proximar would only buy eggs with good genetics and a 100% disease-free history, which could also explain the higher price (Nielsen, CEO, Personal communication, March 17, 2022). For this reason, we find Proximar's implicit price for eggs as reasonable if one disregards inflation. Nevertheless, the sensitivity analysis in Figure 5.18 shows that a 20% change in the egg price has an overall neglectable absolute impact of NOK 0.16 per kg HOG on the production cost.

Another parameter that impacts egg costs and overall EBIT cost per kg HOG is mortality in the hatchery. Proximar estimate a production cycle of 10 months to breed smolts of 100 g and forecast an expected mortality overall of approximately 33% in the hatchery process, mainly due to culling (Nielsen, CEO, Personal communication, March 17, 2022). With a yearly production of 5 300 tonnes HOG, our production model implies an expected average monthly mortality in the hatchery of 5.4%. This corresponds to an average expected cumulative mortality of around 36 %, which is fairly close to Proximar's forecasts. The deviation is probably due to simplifications in our production model.

The sensitivity analysis in Figure 5.18 illustrates that a 20% increase in expected mortality increases the egg cost per kg HOG by around NOK 0.01. On the other hand, a 20% decrease in mortality reduces the egg cost per kg HOG by approximately NOK 0.12. Changes in expected mortality overall thus have a negligible impact on production costs. This is mainly due to relatively low egg prices, meaning that the resource loss due to mortality in the early production process is limited.

However, we want to clarify that some mortality is desirable in the hatchery due to culling. Without culling, the probability of the smolt not reaching harvestable size increases, which could result in lower capacity utilisation. As illustrated in Figure 5.18**,** reduced capacity utilisation has a significant negative effect on Proximar's production cost per kg HOG. This demonstrates that management early in the production cycle might have a significant impact on Proximar's overall costs during a year of full production.

Feed cost

The cost of feed per kg HOG is estimated to be NOK 16.8 by Proximar. This corresponds to 37% of the total estimated EBIT cost per kg HOG for Oyama 1. Proximar's estimate is slightly lower than the feed cost interval of NOK [17.98-22.14], which previous studies suggest for a RAS facility (Bjørndal & Tusvik, 2017; Solheim & Trovatn, 2019). Data from the Norwegian Directorate of Fisheries (2021) indicate a cost of feed per kg HOG of NOK 18.7 for the Norwegian conventional salmon farmers in 2020, given an economical FCR of 1.32. In this regard, Proximar might underestimate their feed cost. However, the feed cost estimate could be sound since Proximar expects a lower expected economical FCR of around 1.1. Additionally, it should be mentioned that Proximar plan to let their salmon starve in separate purge thanks to improve the texture of the fish and get rid of potential off-flavour due to geosmin in the RAS facility. We assume Proximar purge the salmon for two weeks, resulting in an average weight loss of 7%.

Three key parameters that impact Proximar's feed cost are the unit price of feed, mortality rates in hatchery and grow-out as well as the biological FCR. Naturally, the feed price and FCR correlate positively with the feed cost per kg HOG. The same applies to higher expected mortality because this implies greater economical FCR and lower capacity utilisation. For a more detailed explanation of mortality, see section 5.1.3.

Based on our production model for Proximar, we find an implicit feed price of NOK 12.8 per kg HOG. The average feed price for Norwegian conventional salmon farmers was NOK 12.55 in 2020 (Norwegian Directorate of Fisheries, 2021). Therefore, one could argue that Proximar's cost of feed for 2021 is, to some extent, underestimated. However, according to BioMar, a feed price of NOK 16.50 per kg is more reasonable to assume in 2022 (Lother Kjørseng, Personal communication, April 8, 2022). This is due to both inflation, and that land-based salmon farming generally requires a higher quality of feed. However, it should be mentioned that company could have negotiated a competitive feed price due to a strategic partnership with Skretting, which is owned by Nutreco, one of Proximar's shareholders. Thus, the estimate could be sound if one disregards inflation.

The sensitivity in Figure 5.18 demonstrates that a 20% change in the feed price has an absolute effect of NOK 3.36 on Proximar's production cost per kg HOG. FCR follows the same pattern given the way our production model is constructed. With a total production of 5 300 tonnes HOG, this implies a total cost increase of around NOK 17.8 million.

Interestingly, the sum of egg and feed cost is NOK 18.6 per kg HOG. This is lower than the average smolt and feed cost for the Norwegian conventional farmers, which was NOK 23.4 in 2020. For this reason, Proximar seemingly could capitalise on economies of scope due to less transaction costs by having an in-house hatchery at their facility in Japan.

Overall, the negotiation of the feed price and the biological FCR appears to have the foremost influence on Proximar's feed cost. As illustrated in Figure 5.18, expected mortality has a minor effect on the cost of production. However, as mentioned in section 5.1.3, the timing of the realised mortality is essential. If Proximar, for example, experiences mass mortality at the end of the production cycle, this could have a severe negative impact on the production cost per kg HOG. By illustration, as shown in Figure 5.19, if 10% of Proximar's planned production volume is lost just before harvest due to mass mortality, the production cost will increase by NOK 6.72 per kg HOG. This is, for instance, due to lower capacity utilisation. Note that we assume a constant overall EBITDA cost in this analysis to demonstrate that a lot of resources, such as eggs and feed, are going to waste due to mass mortality.

Energy cost

In Proximar's indicative cost breakdown, the company estimate an energy cost of NOK 2.8 and NOK 2.5 per kg HOG for their RAS facility and other installations, respectively. In total, the company estimate an energy cost of NOK 5.3 per kg HOG. This accounts for 11.7% of the total estimated EBIT cost per kg HOG for Oyama 1. Bjørndal and Tusvik (2019) report an energy cost per kg HOG of NOK 5.71 for a traditional RAS facility, which might indicate that Proximar's RAS technology is energy efficient. However, ABG Sundal Collier (2021) argues that Proximar will face higher energy costs compared to FTS and conventional salmon farming in Norway. This is mainly due to the extent of machinery and equipment in their RAS facility.

Overall, the two main parameters influencing the energy cost are energy price and usage. With reference to energy price, Proximar communicates in their sustainability report that the company will only buy grid-based electricity that has certification of origin and sustainability (Proximar Seafood, 2022a). However, the electricity price is unknown but most likely fixed.

In relation to energy usage, Proximar have communicated that their RAS solution has a more energy efficient design compared to traditional RAS systems. Moreover, Nielsen explains that the company will produce around 15% of the company's energy demand through solar panels (Nielsen, CEO, Personal communication, March 17, 2022).

Proximar forecast an energy consumption of 2.9 kWh per kg HOG, resulting in a total consumption of 15.4 GWh. As a reference, Atlantic Sapphire reports energy usage of 69.8 GWh for their Bluehouse in Miami, which produced 1 385 tonnes HOG in 2021 (Atlantic Sapphire, 2022). This implies that phase 1 of Proximar will be more energy efficient than Atlantic Sapphire. However, it should be mentioned that phase 1 of Atlantic Sapphire has almost twice the production capacity as Oyama 1. The numbers do not reflect steady state production due to several incidents on-site in Miami. Moreover, Proximar has neither produced any salmon yet, making estimates about energy usage uncertain, even though their RAS technology has been proven by AquaMaof in various test facilities.

Given that energy prices are normally fixed in contracts and unknown for Proximar, we do not carry out a sensitivity analysis in this case. However, we acknowledge that both energy price and usage affect Proximar's cost of production per kg HOG.

Personnel cost

Proximar estimates personnel cost of NOK 3.3 per kg HOG, accounting for 7.3% of the total estimated EBIT cost per kg HOG for Oyama 1. This suggests an overall personnel cost of NOK 17.5 million when operating Oyama 1 at full production. The estimation from 2021 assumes 31 employees and excludes related general & administrative expenses.

Based on our collected data, we do not have information about how much of Proximar's personnel cost could be classified as variable or fixed. However, Nielsen explains in the interview that Proximar plans to have 16 employees working in production, 7 in harvesting, and 2 on the technical side. Also, the company plans to have between 8 to 10 employees in administration (Nielsen, CEO, Personal communication, March 17, 2022). This gives an indication about the proportion of variable and fixed personnel costs, but the ratio is uncertain.

Additionally, Nielsen explains that building industrial competence has been part of Proximar's DNA since its inception. This seems to have helped Proximar with recruitment:

> "*We want to reduce the risk by building industrial anchoring and competence from the start. This has given us an advantage in terms of recruitment because we have an industrial setup. For this reason, we have managed to get, I would say, the best and most experienced in the industry for grow-out on salmon*" (Nielsen, CEO, Personal communication, March 17, 2022).

However, Nielsen also explained that land-based salmon farming is not plug-and-play. Consequently, he acknowledged that there are learning effects related to both conventional and land-based salmon farming processes:

> *"It (land-based salmon farming) is not plug-and-play in this way. You can build and get started, but then you do not necessarily operate in an efficient way. It is absolutely crucial to have that competence from day one"* (Nielsen, CEO, Personal communication, March 17, 2022).

Data from the Norwegian Directorate of Fisheries (2021) display that the average personnel cost for the Norwegian aquaculture industry was NOK 3.63 per kg HOG. This indicates that there might be economies of scale or benefits of automation for Proximar. However, the variation could also be due to structural differences between salaries and work hours in Norway and Japan. Therefore, we do not conduct sensitivity analyses on Proximar's personnel cost, given this uncertainty. However, this does not imply that the type of cost is not important but instead that we are unable to examine this relationship due to a lack of precise data.

Other costs of goods sold

In the investor presentation, Proximar estimates other costs of goods sold to be NOK 1.7 per kg HOG. This represents 3.7% of the total estimated EBIT cost per kg HOG for Oyama 1. The estimate includes costs related to harvesting, oxygen usage, and distribution. Accordingly, we have not performed a sensitivity analysis for this cost, considering that the estimate is a pool of production costs. Nevertheless, it should be noted that Proximar could have an operating cost advantage regarding harvesting and distribution since this will be undertaken on-site in Oyama. However, as mentioned, Proximar will have backup on all critical functions and even backup on backup generators and oxygen tanks. These investments suggest higher production costs for Proximar, all else equal, because it increases the cost of capital per kg HOG capacity.

Other operating costs

Similar to other cost of goods sold, Proximar estimates other operating costs as a pool of various production costs. Other operating costs are measured at NOK 8.8 per kg HOG, which is 19.4% of the total estimated EBIT cost per kg HOG for Oyama 1. This involves costs regarding insurance, maintenance, veterinary, R&D, real estate, taxes, as well as waste and water handling. Consequently, we do not conduct a sensitivity analysis. However, this does not mean the various production costs are not interesting for Proximar's profitability. For instance, maintenance could influence the economic life of Proximar's equipment.

Cost of capital

Regarding capital expenditures, Proximar budget a total of NOK 1.02 billion in CAPEX when Oyama 1 is fully developed. NOK 625 million has been assigned to land and buildings, NOK 345 million to machinery and RAS equipment, and NOK 50 million to the fish tanks. Taking full production at Oyama 1 into consideration, this corresponds to a cost of NOK 117.9, NOK 65.1, and NOK 9.4 per kg HOG capacity for the three categories, respectively.

In total, Proximar's CAPEX forecast corresponds to approximately NOK 193 per kg HOG capacity for Oyama 1. The company announced in a recent press release that the estimate is still representable despite today's price development:

> "*The high degree of fixed costs and low impact of the pandemic puts us in a unique position to follow our business plan and finish the project on time and within budget. With a high degree of fixed costs, our estimate of CAPEX around NOK 193/kg (including land) is maintained, and we are therefore well-positioned in terms of our business plan*" (Proximar Seafood, 2022d).

As noted in various reports and the interview, Proximar includes investments in an on-site hatchery and harvest plant as well as a distribution facility in their total CAPEX forecast. Additionally, it has been mentioned that AquaMaof's technical solution requires more area and has overcapacity on several critical equipment. Together with an attractive location near Mount Fuji, this drives investments in land and construction costs. These two corresponds to around 61% of Proximar's total CAPEX estimate of NOK 193 per kg HOG capacity at Oyama 1.

Figure 5.18 demonstrates that a 20% change in total CAPEX will have an absolute impact on Proximar's production cost of NOK 2.83 per kg HOG. This implies a total effect of NOK 15.0 million. Consequently, delays and errors in construction could have a massive impact on Proximar's capital expenditure and, thereby, its production costs.

Based on a total forecasted CAPEX of NOK 1.02 billion, we can calculate and discuss implicit assumptions that Proximar's estimate for Oyama 1 depends on. Proximar estimates depreciations of NOK 8.7 per kg HOG. Assuming linear depreciation, Proximar's CAPEX estimate indicates an average economic lifetime of ~22 years. In our interview, Nielsen explained that Proximar's fish pools probably have an average economic lifetime of 50 years, while buildings and fixed installations average around 25 years. Equipment is estimated to have an average economic lifetime of approximately 10 to 15 years (Nielsen, CEO, Personal communication, March 17, 2022).

Given that Proximar has a lot of backup equipment, we assume an average economic lifetime of ~20 years to be reasonable. Based on the investor presentation, Proximar has estimated the cost of capital for 2021 in nominal terms, but the company only accounts for depreciation. As explained in the Andfjord case in section 5.1.3, we adjust for this measurement error by estimating Proximar's capital cost per kg HOG as a real annuity. We use a real annuity because we do not account for inflation and because this is consistent with the assumption of stable cash flows in steady state production for Oyama 1. Given an assumed real WACC of 4%, we estimate a cost of capital of NOK 14.2 per kg HOG for Proximar in real terms. This estimate includes both depreciation and imputed interest on capital employed, excluding net working capital, which is addressed separately below.

Considering that the assumption of the average economic lifetime and WACC is uncertain and highly debatable, we have performed a sensitivity analysis on the two parameters, illustrated in Figure 5.18. Based on this, a 20% decrease in the average economic lifetime from 20 to 16 years will increase Proximar's production costs by NOK 2.36 per kg HOG. Furthermore, a 20% increase in real WACC from 4.0% to 4.8% will increase Proximar's production costs by NOK 1.20 per kg HOG. Hence, changes in the average economic lifetime and WACC could significantly impact Proximar's production costs, all else equal.

In relation, Proximar's cost of capital is naturally impacted by capacity utilisation. If Proximar, contrary to expectations, are not able to produce 5 300 tonnes HOG, CAPEX per kg HOG will naturally increase. For instance, the sensitivity analysis demonstrates that a 20% decrease in capacity utilisation from 5 300 tonnes HOG to 4 240 tonnes HOG will increase Proximar's production cost by NOK 3.77 per kg HOG. This illustrates that productivity in terms of TGC could be an important cost driver for Proximar. As discussed in section 5.1.3., such an analysis assumes a constant EBITDA per kg HOG. This reflects that Proximar still uses the same proportion of egg, feed and energy per kg HOG, despite not being able to produce the planned annual volume.

Cost of net working capital

In the investor presentation, Proximar measures investments in net working capital of NOK 120 million for Oyama 1 up until the first sale. Ideally, we should have data about net working capital needs for steady state production, and it is fair to assume this number would be different from the initial estimate. However, it would be arbitrary to adjust Proximar's initial estimate for steady state production due to uncertainty about the estimate. For this reason, we use the initial estimate in our calculations. Moreover, the imputed interest on Proximar's net working capital is not included as a cost of capital in their indicative cost of production estimate. For this reason, we calculate an imputed interest on net working capital is NOK 4.8 million, assuming a real WACC of 4%. This implies NOK 0.91 per kg HOG for Oyama 1.

As a reference, based on a financial statement analysis of Atlantic Sapphire's annual report for 2021, the company has a net working capital of ~NOK 83.9 million as per the exchange rate in December 2021. Regarding this number, it should be noted that Atlantic Sapphire harvested 2 374 tonnes HOG in 2021 and that Proximar has only estimated net working capital up until the first sale from Oyama 1. At the same time, the two production facilities are fundamentally different. For this reason, it is difficult to conclude whether Proximar's estimate of net working capital is reasonable.

Sensitivity analysis performed in Figure 5.18 demonstrates that a 20% increase or decrease in net working capital has an absolute effect on Proximar's production cost of NOK 0.32 per kg HOG, and a total effect of around NOK 1.7 million given a full production at Oyama 1.

Sensitivity

The sensitivity analysis in Figure 5.18 demonstrates uncertainty and how sensitive Proximar's production cost estimate is to changes in fundamental assumptions.

Figure 5.18 - Sensitivity in Proximar's cost of production estimate

Moreover, Figure 5.19 demonstrate how sensitive Proximar's production cost per kg HOG is to mass mortality late in the production cycle.

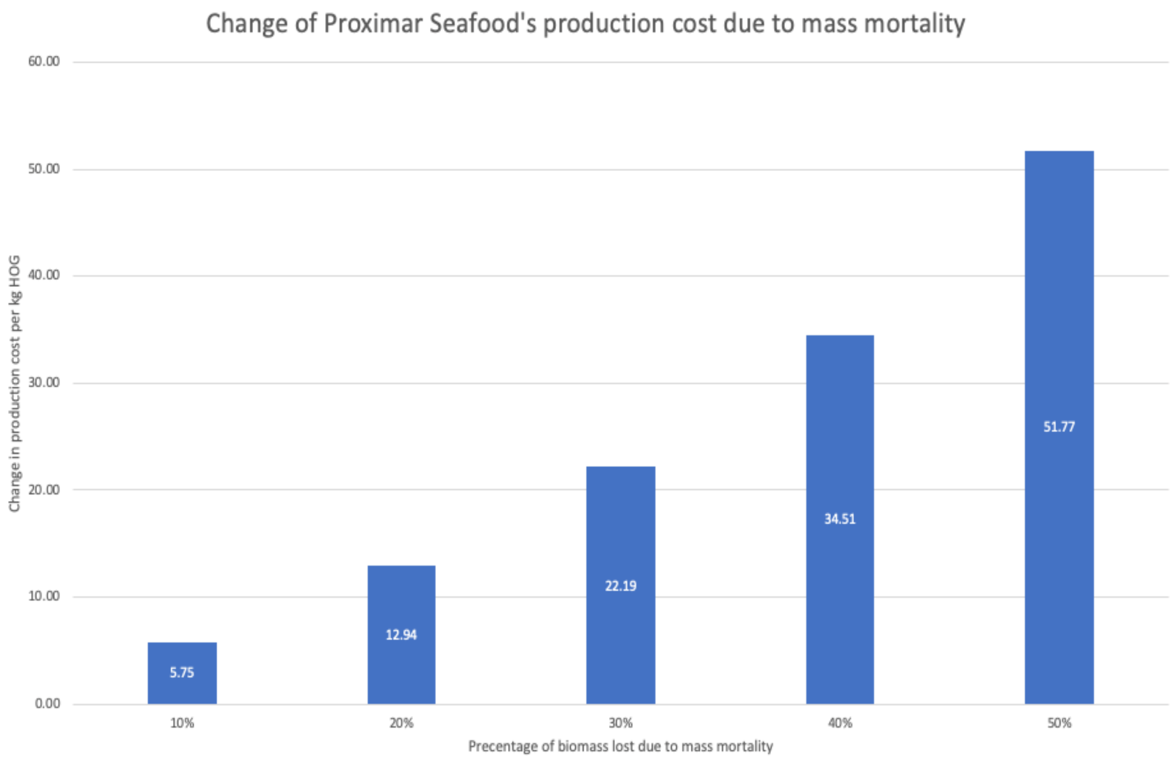

Figure 5.19 - Effect of biomass loss on cost of production for Proximar

Adjusted cost of production

In this section, we present an adjusted cost of production of NOK 51.8 per kg HOG for Proximar. As mentioned before, the estimate in Figure 5.20 fully accounts for the cost of capital as the imputed interest rate is calculated on capital employed. This is because such an adjustment better portrays Proximar's cost of production for Oyama 1 from an investor perspective. Moreover, we have decided not to adjust any of the other costs from the indicative breakdown, even though we have indications that some estimates might be misestimated. This is partly since an adjustment for inflation is beyond the scope of our analysis, as discussed in section 5.1.3. Moreover, adjustments beyond measurement errors in the cost of capital would be arbitrary. This is because the price levels and resource utilisation of Proximar are uncertain, as the company is not expected to harvest salmon before 2024.

Figure 5.20 - Adjusted cost of production estimate for Proximar

Based on our adjusted estimate of Proximar's cost of production, it is evident that the company must be able to achieve a price of above NOK 51.8 per kg HOG in real terms compared to 2021 levels in order to generate positive residual income from an investor perspective. Note that the business is profitable at even lower prices in accounting terms. Nevertheless, it is crucial to keep in mind that the estimate is somewhat uncertain and that minor changes in several of the underlying parameters, at the same time, could increase Proximar's cost of production significantly.

5.3 Case 3: Salmon Evolution

5.3.1 General description

Salmon Evolution was established in 2017 by a group of people motivated to pursue land-based salmon farming in Western Norway. In July 2018, the company was awarded a MAB licence of 13 300 tonnes salmon for the Indre Harøy facility in Hustadvika. The facility's construction is divided into three phases and started in May 2020. Phase 1 has a planned annual capacity of 7 900 tonnes HOG and an average density of salmon in grow-out of 48 kg per m^3. Phases 2 and 3 will increase annual capacity with 7 900 and 15 700 tonnes HOG, respectively. Altogether, the facility at Indre Harøy will have an annual capacity of 31 500 tonnes HOG. Additionally, Salmon Evolution has plans for a further expansion of 20 000 tonnes HOG, resulting in a total potential capacity of 51 500 tonnes HOG in Norway.

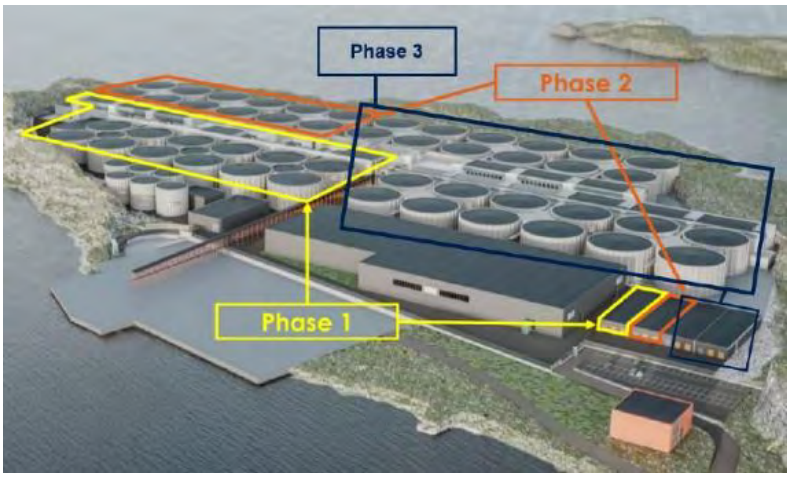

Figure 5.21 - Salmon Evolution's planned phases (ABG SC, 2022)

In July 2020, Salmon Evolution entered a partnership with South Korea's Dongwon Industries, one of the world's leading seafood companies. Together, they founded a joint venture named K Smart Farming to develop, construct and operate a land-based salmon farming facility in South Korea. This facility will have an annual capacity of 16 800 tonnes HOG. To facilitate further growth and secure financing, Salmon Evolution got listed on Euronext Growth on September 18, 2020. In July 2021, the company was transferred to the Oslo Stock Exchange. The company expects the first harvest in Q4 2022 and recently released smolt for the first time in their farming facility at Indre Harøy on March 28, 2022 (Salmon Evolution, 2021b).

Salmon Evolution will utilise a proven hybrid flow-through system in their facility at Indre-Harøy, supplied by Artec Aqua. The system will recirculate 65-70% of water while 30-35% will flow through. This ratio does not require all the filtering features necessary in a traditional RAS system with a recirculation degree above 70% (Salmon Evolution, 2022a). The water temperature is regulated through water intake stations with intake pipes at 25 and 95 metres depth. Salmon Evolution's technical solution and location will be discussed more in detail later in the analysis. This ratio does not require all the filtering features necessary in a traditional RAS system with a recirculation degree above 70% (Salmon Evolution, 2022a). The water temperature is regulated through water intake stations with intake pipes at 25 and 95 metres depth. Salmon Evolution's technical solution and location will be discussed more in detail later in the analysis.

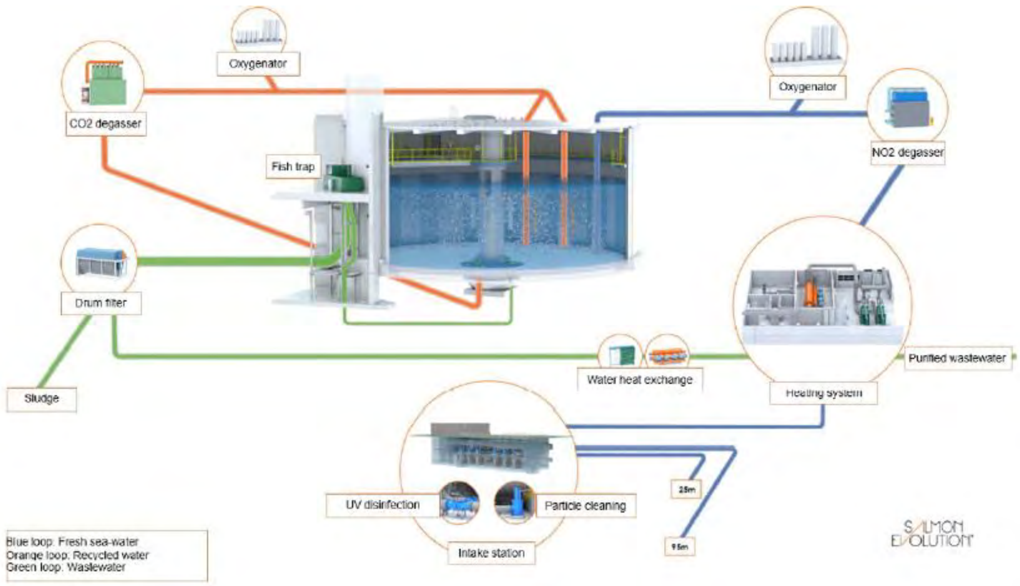

Figure 5.22 - Illustration of Salmon Evolution's HFS technology (ABG SC, 2022)

5.3.2 Description of strategic choices

Competitive and marketing strategy

When assessing Salmon Evolution's decisions regarding their competitive strategy, it is necessary to distinguish between a short- and long-term perspective. Based on our interview with Trond Håkon Schaug Pettersen, CFO of the company, it seems like the company has different objectives, dependent on the given timeframe.

In the short term, it is evident that Salmon Evolution's objective is to develop a land-based farming facility that enables them to farm salmon at low, or at least competitive costs, compared with other salmon farming facilities. This is mainly accomplished with the chosen

HFS technology. A more detailed discussion of how the HFS technology relates to low costs and low risk is carried out when examining Salmon Evolution's operating strategy.

When shifting to a more long-term perspective, we observe, based on the choice of technology, location and plans regarding marketing, that the company also has an ambition of being profitable by differentiating their salmon. The differentiation is based on promoting product-related attributes affecting quality and non-product related attributes like for example biology, animal welfare and sustainability.

Altogether, this illustrates that Salmon Evolution will try to be competitive by balancing both elements from cost-leadership and differentiation depending on the timeframe. This flexibility in the configuration of competitive strategy could be seen as one of the major operating advantages of the HFS technology that Salmon Evolution will utilise. This is supported by findings from our interview with Schaug-Pettersen. In this interview, he stated that good biology is a key priority for Salmon Evolution (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). For this reason, costs were not the only factor that was considered when Salmon Evolution chose their technology type and design. Considering that the company has an ambition of producing salmon at competitive costs but also with low biological risk, their HFS technology was the natural solution given their competitive strategy.

In relation to the differentiation potential, Schaug-Pettersen elaborated the ambition to deliver other products than only HOG salmon. Their ambition of actively managing a larger part of the value chain, especially regarding the harvesting and processing operations, can be seen as a part of Salmon Evolution's differentiation strategy. This strategy enables the company to deliver more customised products to consumers in both the mass and niche market for salmon. However, it is unclear whether Salmon Evolution will fully own harvesting and processing facilities or continue their strategic partnership with VikenCo when fully operational (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Furthermore, it can be argued that superior quality based on biology combined with customised products can result in a higher willingness to pay from consumers. Schaug-Pettersen supported this claim in the interview by arguing that the global market for salmon is highly commoditised. Therefore, to achieve a price premium, either a different product or the same product with better quality must be offered. Nevertheless, Schaug-Pettersen claimed that superior quality needs to be associated with a certain marketing of non-product or product-related attributes. This is because general high quality only receives around NOK 1.0 per kg in premium (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Based on this, it seems like Salmon Evolution has an ambition of obtaining a price premium by differentiating on both product-related and non-product related attributes in their marketing. For example, the company argues that they will be able to achieve a price premium based on a superior texture of the fish, an important product attribute in the market (Badiola et al., 2017). Schaug-Pettersen explained that this superior texture is a result of the company's focus on biology:

> *"What is very exciting about the land-based salmon farming industry is that you have an active fish that exercise its whole life as it continuously swims upstream. This gives the fish fine muscle and a very firm texture. For this reason, land-based farmed salmon should be suitable for raw consumption such as sashimi which is by far the highest paying market for salmon*" (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Consequently, the land-based farmed salmon's texture is a result of both biology and the choice of technology. However, it should be noted that texture is a product-related attribute that could be more or less manageable for all land-based salmon farmers.

Moreover, it could be argued that it is difficult for Salmon Evolution to capitalise on product-related attributes without creating a strong brand and customised products for the end consumer. This is probably why Salmon Evolution aim to get a premium on their salmon by being sustainable in their grow-out facility. In their presentation of Q2 (2022b) Salmon Evolution claim the ambition of having a strong ESG profile and also being a global leading supplier of sustainable and high-quality salmon. We argue that the focus on sustainability must be considered a non-product related attribute.

According to Schaug-Pettersen, sustainability can lead to a price premium in two manners. On the first hand, it is an essential step in achieving an ASC certification, usually resulting in a price premium of NOK 1-3 per kg (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). This kind of certification has criteria related to animal welfare, sustainability, and other factors. On the other hand, and more importantly, the focus on sustainability can be considered important when it comes to the branding of their products. Here, Schaug-Pettersen claims the potential for a price premium to be even larger than the ASC certification. However, the magnitude of and approach for obtaining such a premium is unclear (ibid.).

Additionally, their focus on sustainability is present in other parts of the value chain than the grow-out facility. For example, when entering into a strategic partnership with Cargill, one of the main advantages emphasised was the focus on developing sustainable solutions and customising the feed to fit Salmon Evolution's facility (Salmon Salmon Evolution, 2021c).

All in all, it seems evident that Salmon Evolution aims to be profitable by having a cost-efficient and biologically secure technology. This will enable them to differentiate their salmon on both product- and non-product related attributes in the mass and niche markets, at least in the long-term. As a differentiation focus is paired with a focus on obtaining competitive costs, we place Salmon Evolution in the middle with regard to both competitive advantage and scope.

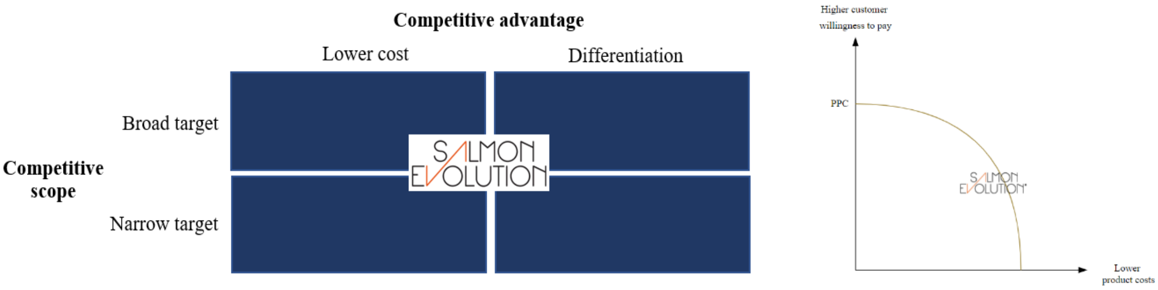

Figure 5.23 - Salmon Evolution's competitive strategy

Operational strategy

Salmon Evolution build their operational strategy around their competitive strategy. By this, we mean that the company has made several operational strategical choices with the objective of creating a viable production facility. For instance, Schaug-Pettersen explained in the interview that in order to be profitable, it is critical to avoid accidents such as mass mortality and production stops (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). Hence, biology is not something that will be given less priority than costs in Salmon Evolution's operational strategy. Moreover, the focus on biology could also be viewed as a result of the company's ambition of differentiating its salmon in the long run.

Choice of technology type and design are operational strategical choices that illustrate Salmon Evolution's combined focus on biology and costs. In their annual report for 2021, their HFS technology is said to be configured in the sweet spot as regards to complexity, costs, and biological risk: "*Utilising hybrid flow-through system ("HFS") with 30%-35% fresh seawater intake, reducing complexity and biological risk and securing optimal growth at low cost*." (Salmon Evolution, 2022a). Recirculating approximately 70% of the water limits the need for costly and complex processes to remove unwanted particles. At the same time, it enables Salmon Evolution to have sufficient control over the production process, which is the most important (ABG SC, 2022).

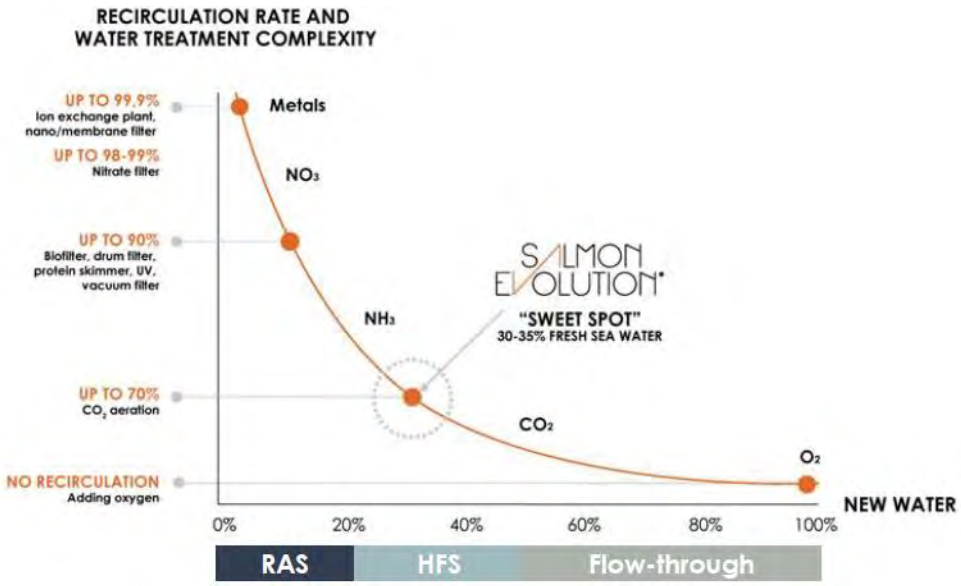

Figure 5.24 - HFS technology compared with RAS and FTS (Salmon Evolution, 2022a)

In relation, ABG Sundal Collier (2022) suggests that the HFS technology offers an attractive combination of better control over the production environment and lower operational costs than an average FTS facility. Additionally, the HFS technology has a relatively low CAPEX compared to an average RAS facility. Hence, the company's HFS technology could be viewed as the best of both worlds. Furthermore, Schaug-Pettersen stated in the interview that:

> "*In our opinion, we have a lot of advantages with our facility. Not only when it comes to biology, but also considering reducing the probability and consequence of negative events by having each tank as an individual biological zone.*"

Hence, Salmon Evolution has designed a facility with the goal of having a limited degree of biological risk. For instance, the facility does possess the opportunity to empty the production tanks between each production cycle, something that is not possible with a traditional RAS facility (ABG SC, 2022). Thereby, the accumulation of unwanted substances is limited.

In the interview, it was also explained that Salmon Evolution has redundancy in all stages of production. By limiting both the probability and consequence of negative events, such as mass mortality, Salmon Evolution is likely to succeed at reaching their desired cost level. This supports their low-cost objective. With respect to costs, Schaug-Pettersen explained that there are significant economies of scale in CAPEX, given that the facility is easy to upscale (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Along with building a facility that has claimed superior biological conditions and low risk, Salmon Evolution has decided to integrate parts of its value chain with both biology and risk in mind. As explained by Schaug-Pettersen in the interview, there are several reasons why Salmon Evolution decided to buy Kraft Laks. This local smolt producer is located within two driving hours from the grow-out facility at Indre-Harøy (Salmon Evolution, 2021a)

Figure 5.25 - Kraft Laks' facility (Salmon Evolution, 2021a)

Firstly, by owning a smolt producer, Salmon Evolution is guaranteed to get the best possible smolt from the producer. According to Schaug-Pettersen, when buying smolt externally, there is often uncertainty regarding its quality (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Secondly, Salmon Evolution can keep a more regular and stable production by having an internal smolt production. In other words, there will most likely be a limited degree of problems related to delayed deliveries. Schaug-Pettersen explained that in order to succeed as a land-based salmon farmer: *"The environment of the fish needs to stable and the production regular. Thus, it is important that you get the smolt you need, when you need it and in the correct size."* (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). The decision to use a standard size of 130 g smolt is based on the possibility of buying this size externally if the internal operation is struggling. Also, Schaug-Pettersen claimed that owning a smolt operation could lead to a lower cost of production by realising economies of scope.

Lastly, Salmon Evolution has taken a deliberate decision to build its facility in Norway. There are several reasons for choosing the location at Indre Harøy. First and foremost, the location supports the desired technology and thereby supports the goal of ideal conditions and low risk. With regard to technology, the natural conditions of the location fulfil the criteria for successfully operating a HFS facility (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). Secondly, being located at Indre Harøy in Norway, Salmon Evolution has access to a full value chain when starting its production:

> "*We are located in the middle of the global aquaculture cluster. We have all parts of the value chain and supplier industry in immediate proximity. We have harvesting facilities only 20 minutes from the site using boats. There are a lot of process- and farming industries nearby. This gives us favourable access to labour and so on. Also, there is a lot on the energy side. Since there is a lot of industry nearby, all infrastructure is very adjusted for what we are going to do.*" (ibid.).

Thus, the company can focus more on the grow-out facility and outsource other operations. Moreover, according to Schaug-Pettersen, having access to vital competence is a crucial consideration for Salmon Evolution: "*In order to be successful outside, you first have to be successful in Norway*" (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). If the company is successful in Norway, the focus shifts to other parts of the world.

Prioritising Norway could also be seen as a risk minimising measure from Salmon Evolution. Focusing on learning the process of land-based salmon farming in a familiar environment can increase the chances of success. Such an argument is also supported by Schaug-Pettersen, who argues that the process of learning the capacities and features of the facility is easier in Norway with the best competence (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Overall, it seems evident that a trade-off between obtaining competitive costs and attaining superior biological conditions, with associated low risk, has been assessed in Salmon Evolution's operational strategical decisions.

5.3.3 Estimated cost of production

Figure 5.26 presents an indicative breakdown of Salmon Evolution's costs for phase 1 of their facility at Indre Harøy. EBIT cost/kg HOG and CAPEX/kg HOG capacity are estimated at NOK 44.1 and 183.5, respectively. Both estimates are stated in nominal terms. The data is collected from an investment report published by ABG Sundal Collier (2022), which is again based on company data. The planned annual production volume is 7 900 tonnes HOG, and the company has a MAB licence of 13 300 tonnes salmon.

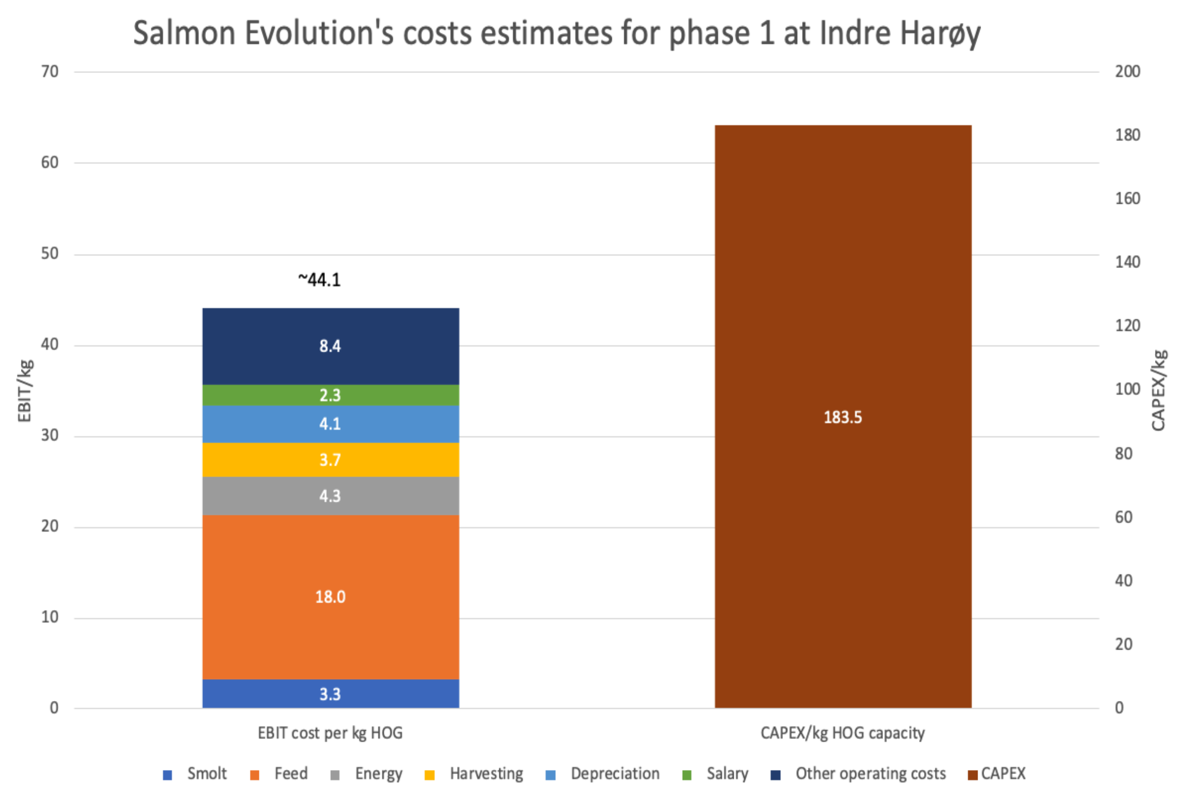

Figure 5.26 - Indicative cost breakdown for Salmon Evolution (ABG SC, 2022)

In the following, we will discuss and validate each item from the indicative cost breakdown. We present an adjusted cost of production estimate in Figure 5.30. Like the cases of Andfjord and Proximar, the adjusted estimate is presented in real terms. For an explanation of why we use real and not nominal terms, see section 5.1.3. Additionally, it should be emphasised that Salmon Evolution's estimate, unlike Andfjord's and Proximar's, is from 2022. Thus, the discussion of an adjustment from the 2021 to 2022 price level is irrelevant.

Production model

Based on the underlying assumptions listed in Table 5.4, we have created a simplified production model in order to discuss the validity of Salmon Evolution's estimate. The assumptions have been collected based on our interview with Trond Håkon Schaug-Pettersen. Building on the production model, the average development in the total biomass per generation is shown in Figure 5.27. Furthermore, the sensitivity of the most influential parameters are displayed in a tornado diagram in Figure 5.28. As for the previous cases, the results of the sensitivity analysis lay the foundation for our discussion of strategic decisions and their effect on profit drivers in section 6.1. For a more detailed explanation of the production model, how it is simplified and what assumptions it depends on, see Appendix A4 .

	Grow-out
Average start weight	130.0 g
Average final weight	5893.7 g
TGC	3.0
Biological FCR	1.05
Average temperature	13.1 °C
Production cycle (months)	11
Number of generations	6
Number of smolt per generation	280 000
Total expected mortality	5.0%
Expected mortality first month	2.5%
Expected mortality (evenly from the second month)	0.26%
Weight loss when harvesting (bleeding & gutting)	16.0%
Price of feed (per kg)	NOK 14.56

Table 5.4 - Assumptions behind Salmon Evolution's production model

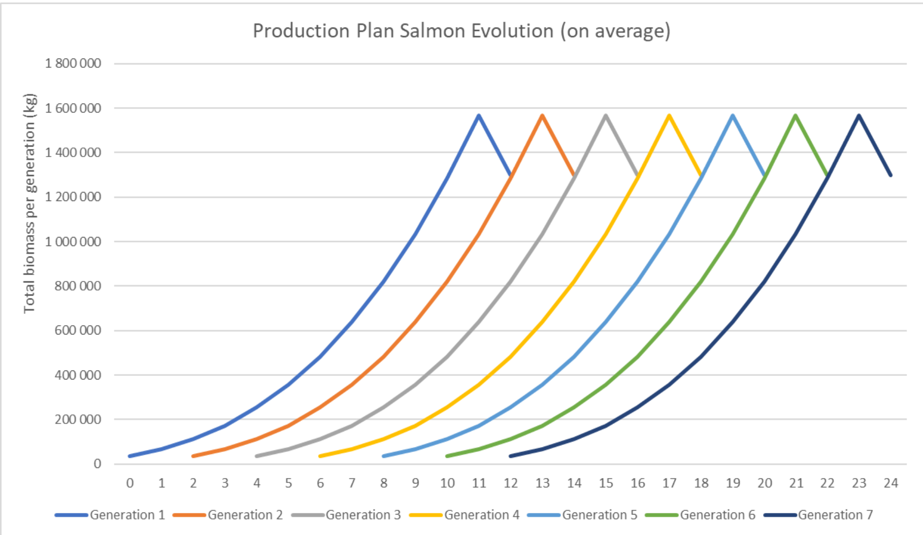

Figure 5.27 - Development of Salmon Evolution's total biomass

Smolt cost

Salmon Evolution estimates a cost of smolt per kg HOG of NOK 3.3. The smolt cost accounts for approximately 7.5% of the EBIT cost per kg HOG. There are mainly two parameters affecting the cost of smolt per kg HOG. These are the mortality rate during the grow-out phase and the purchase price of smolt. Given a yearly production of 7 900 tonnes HOG and a cost of smolt per kg HOG of NOK 3.3, this indicates a total smolt cost of ~NOK 26 million. These numbers imply a price per smolt of NOK 15.52, slightly below the market price of a smolt weighing 130 g. As previously explained under the Andfjord case, the market price is calculated based on a formula presented by Bjørn Finnøy at Artec Aqua (Finnøy, CSO, Personal communication, May 6, 2022). For a detailed explanation, see section 5.1.3. Based on this formula, the market price of a 130 g standard smolt should be between NOK 17.1-18.4.

However, the lower price could be explained by Salmon Evolution owning the smolt facility. Such ownership could result in lower transaction costs. Schaug-Pettersen also emphasised this advantage during our interview (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). Figure 5.28 illustrates the uncertainty considering the price of smolt in a tornado diagram. This analysis shows that a 20% change in the price would result in an absolute change in production costs of NOK 0.66 per kg HOG.

Regarding mortality, the relation to smolt cost is rather complex, which has already been elaborated in section 5.1.3. From Figure 5.28, it is evident that changes in the *expected* mortality are relatively insignificant. On the other hand, Figure 5.29 shows that mass mortality at a late stage in the production cycle has a significant effect on Salmon Evolution's cost of production. This can also be used as an example illustrating that *realised* mortality normally has a larger effect on costs than *expected* mortality. The significance of timing was also emphasised by Schaug-Pettersen in our interview: *"Feeding the fish till 2-3 kg, for then to let it die, is poor economics."* (Schaug-Pettersen, CFO, Personal communication, March 2, 2022).

Feed cost

In their indicative cost breakdown, Salmon Evolutions presents a cost of feed per kg HOG of NOK 18.0. Feed is the largest component in Salmon Evolution's estimate, and it accounts for ~40.2% of the EBIT cost. Therefore, the parameters influencing the feed cost per kg HOG are some of the most dominant, according to our sensitivity analysis presented in Figure 5.28.

The feed cost is also one of the more challenging costs to analyse since it is affected by several underlying parameters. Some of the most important are the price of feed, mortality and the biological FCR. Based on the assumptions presented in Table 5.4 and our simplified production model, we have calculated an implicit price per kg feed to NOK 14.56. The average price paid by Norwegian conventional salmon farmers was NOK 12.55 per kg in 2020 (Norwegian Directorate of Norwegian Directorate of Fisheries, 2021). However, despite a higher price, Salmon Evolution estimates a lower feed cost per kg HOG than conventional farmers (ABG SC, 2022). This could be explained by a lower FCR, less mortality and a higher degree of control in the facility.

Moreover, according to sources in BioMar, a more correct estimate as of today is ~NOK 16.50 per kg (Lothe Kjørseng, Personal communication, April 8, 2022). They argue that land-based salmon farming requires better feed quality, resulting in higher prices. Also, due to inflation, the price should increase. Ignoring this effect, Salmon Evolution's estimate could be sound. Figure 5.28 illustrates that a 20% change in the feed price results in an absolute change of NOK 3.60 per kg HOG. This implies a total change of NOK 28.44 million in production costs.

Furthermore, both the *expected* and the *realised* mortality in the production cycle will also affect the feed cost per kg HOG. The complexity of mortality is explained thoroughly in section 5.1.3. As shown in Figure 5.28, given the design of our production model, it is clear that a change in the *expected* mortality rate results in a negligible change in the overall production cost. However, with regard to the effect of mass mortality or the timing of mortality, we display an overall effect on production costs in Figure 5.29. Based on the figure, it is evident that a 10% loss of the biomass results in increased production costs of NOK 5.68 per kg HOG. Note that we assume a fixed overall EBITDA cost for Salmon Evolution in these calculations to illustrate the loss of resources due to mass mortality.

Lastly, the biological FCR ratio will also affect the feed cost per kg HOG. If Salmon Evolution is able to decrease the biological FCR ratio, it will result in a reduced need for feed since the same production volume can be achieved with a less amount of feed. Salmon Evolution argue that they will reach a biological FCR of 1.0-1.05 (ABG SC, 2022). This is low compared to competitors, both Andfjord and Proximar report 1.10. Salmon Evolution argue that the advantage is related to a low degree of overfeeding and mortality. Figure 5.28 shows that a 20% change in the biological FCR results in an absolute change in the production cost per kg HOG of NOK 3.60. Changing the biological FCR has precisely the same effect as earlier discussed regarding feed price. This is related to how we have designed our production model. Despite them having the same effect, the same mechanisms are not causing the changes.

Energy cost

Concerning energy usage, Salmon Evolution presents an estimated cost per kg HOG of NOK 4.3. This is naturally higher than conventional salmon farming, which has a negligible energy demand (Norwegian Directorate of Fisheries, 2021). Thus, it could be more relevant to compare with other land-based salmon farming facilities. However, according to an equity report published by ABG Sundal Collier (2022), Salmon Evolution is not to obtain a competitive advantage based on energy usage. Nevertheless, the report argues that the choice of technology is related to lower energy consumption than an average FTS facility due to a lower need for pumping of water. The same report state that the energy demand will normally be higher than an average RAS facility.

Furthermore, Salmon Evolution has entered into an agreement with Statkraft, buying their electricity at fixed prices (Salmon Evolution, 2021d). Here it is claimed that the fixed price is in correspondence with the original budget. Moreover, we do not possess detailed data regarding energy usage for the facility, making it challenging to conduct sensitivity analyses on the underlying parameters. Also, we find it less relevant to perform such sensitivity analyses since energy usage most likely is not a source of competitive advantage for Salmon Evolution. However, this does not imply that energy costs are unimportant.

Harvesting cost

In their indicative cost breakdown, Salmon Evolution estimates a cost of harvesting per kg HOG of NOK 3.7. This is slightly lower than NOK 4.55, the average cost per kg HOG for Norwegian conventional farmers in 2020 (Norwegian Directorate of Norwegian Directorate of Fisheries, 2021). The cost advantage could be due to Salmon Evolution's deal with VikenCo, a harvesting and processing facility located near the facility at Indre Harøy (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). This could potentially represent some economies of scope in terms of reducing transaction costs. However, without a more detailed description of the cooperation and why it reduces costs, we are not able to conduct a sensitivity analysis on the underlying parameters.

Personnel cost

Salmon Evolution estimates a salary cost per kg HOG at NOK 2.3, which accounts for a total of 5.2% of the EBIT cost per kg HOG. We argue that other costs such as taxes, social security and insurance are included in salary costs. Hence, personnel cost is a more appropriate classification. Based on the information retrieved from the interview with Schaug-Pettersen, Salmon Evolution aims to have an organisation with approximately 55 employees when phase 1 is fully operating (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). Here, 24-25 employees operate the farming facility, 8-10 work with varying support operations, 6-7 operate the smolt facility and the rest work in the administration and management. This classification gives some indications as to what parts of the personnel costs are fixed and variable. However, it is difficult to define the exact ratio without a more detailed description and, therefore, difficult to analyse the sensitivity of changing the underlying parameters.

Furthermore, according to ABG SC (2022), Salmon Evolution believes that there exist some economies of scale regarding personnel costs when upscaling their operations. When the facility at Indre Harøy is fully developed, Salmon Evolution argues that the personnel cost per kg HOG will be reduced to NOK 2.0. This indicates that Salmon Evolution will produce their salmon more productively. We find this assumption realistic. According to Schaug-Pettersen, Salmon Evolution will have around 100 employees when phase 3 at Indre Harøy is finished (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). In other words, a 300% increase in production is accompanied by an increase in employees of ~82%.

Despite there being a potential for economies of scale when it comes to personnel, it is still difficult to estimate and verify the effect since we do not know the ratio of fixed and variable personnel costs. Therefore, we will not conduct a sensitivity analysis on the underlying parameters. Nevertheless, we acknowledge that personnel is an important success factor for land-based salmon farming.

Other operating costs

Salmon Evolution estimates that other operating costs constitute NOK 8.4 per kg HOG in their indicative cost breakdown. We do not have a detailed classification of costs included in this collective term. It is natural to assume that the collective term includes waste handling, oxygen, transportation, and maintenance costs. However, without a more detailed description, it is not possible to decide the size of each specific cost and thereby impossible to analyse the effect of changes in the underlying parameters. The result is a limited relevance of sensitivity analyses. Nevertheless, despite not conducting sensitivity analyses on the collective term, it must not be interpreted as the different costs are unimportant.

Cost of capital

In their indicative cost breakdown, Salmon Evolution estimates their depreciations to be NOK 4.1 per kg HOG. Total CAPEX is projected to be between NOK 1.3 and 1.4. billion for phase 1 at Indre Harøy (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). In our calculations, we use a total CAPEX of NOK 1.4 billion. Several parameters affect the cost of capital per kg HOG, such as total CAPEX, average economic lifetime, and WACC.

Phase 1 at Indre Harøy has a CAPEX per kg HOG capacity of NOK 177.2. Considering there are, to our knowledge, no comparable facilities with regard to technology and size, it is difficult to discuss the estimate's validity. However, since the overall CAPEX of the facility is still uncertain, we conduct a sensitivity analysis to illustrate the effect of delays, accidents and misestimations of the measure. Figure 5.28 shows that a 20% change in the overall CAPEX will lead to an absolute change of NOK 3.4 per kg HOG or a change of ~NOK 27 million in overall production costs.

Furthermore, by using a CAPEX of NOK 1.4 billion and assuming the estimated depreciations to be linear, we have calculated an implicit average economic lifetime of the facility and its components at ~38.5 years. This is somewhat higher than ABG Sundal Collier's estimate (2022) of 25-30 years. Also, Schaug-Pettersen stated an average economic lifetime of approximately 30 years in the interview. We acknowledge that the estimate could be affected by different adjustments. For example, land is normally not depreciated and will thereby affect the average economic lifetime.

However, we argue that calculating the cost of capital as a real annuity is more appropriate. This is consistent with the method used for both Andfjord and Proximar, as explained in sections 5.1.3 and 5.2.3. In order to calculate the real annuity, we have assumed an average economic lifetime of 30 years, consistent with our sources. Furthermore, a real WACC of 4% is assumed, as suggested in Bjørndal and Tusvik (2019). Based on our calculations, Salmon Evolution's cost of capital is estimated at NOK 10.25 per kg HOG. We acknowledge that the average economic lifetime and the WACC are uncertain parameters. Therefore, we conduct sensitivity analysis on both, as displayed in Figure 5.28. For instance, it is possible to argue that an average economic lifetime of 30 years is somewhat optimistic. Figure 5.28 shows that a 20% decrease in this parameter would increase the cost of production by NOK 1.37 per kg HOG. Furthermore, if we assume an average economic lifetime of 20 years, as for Andfjord and Proximar, the cost of production would increase by NOK 2.79 per kg HOG. Based on our calculations, Salmon Evolution's cost of capital is estimated at NOK 10.25 per kg HOG. We acknowledge that the average economic lifetime and the WACC are uncertain parameters. Therefore, we conduct sensitivity analysis on both, as displayed in Figure **X**. For instance, it is possible to argue that an average economic lifetime of 30 years is somewhat optimistic. Figure **X** shows that a 20% decrease in this parameter would increase the cost of production by NOK 1.37 per kg HOG. Moreover, if we assume an average economic lifetime of 20 years, as for Andfjord and Proximar, cost of production increase by NOK 2.79 per kg HOG.

Lastly, the cost of capital per kg HOG is strongly affected by the realised capacity utilisation. This is also recognised and emphasised by Schaug-Pettersen in the interview (Schaug-Pettersen, CFO, Personal communication, March 2, 2022). Considering the cost of capital is distributed across the realised production volume, it could be very costly for Salmon Evolution not to reach their planned production level. This is illustrated in Figure 5.28, where it is evident that capacity utilisation is vital to control for the company. However, this part of the analysis assumes a constant EBITDA per kg HOG, as explained previously in section 5.1.3. Thus, a change in the capacity utilisation could, for instance, be explained by changes in the TGC.

In contrast, mass mortality or emergency harvesting could also affect realised capacity utilisation. Figure 5.29 illustrates the effect of such circumstances occurring late in the production cycle, resulting in a severe loss of biomass and thus resources. This analysis rest on an assumption of a fixed overall EBITDA cost. According to this figure, it is evident that losing 10% of the biomass late in the production cycle increases Salmon Evolution's cost of production per kg HOG with NOK 5.68.

Cost of net working capital

Consistently with the cases of Andfjord and Proximar, we have included the imputed interest on net working capital should in the adjusted cost of production estimate. Since net working capital represents a part of the capital employed, it should be calculated an imputed interest in order to adjust Salmon Evolution's cost of production estimate correctly from an investor perspective. We estimate the net working capital of Salmon Evolution at ~NOK 179 million. This is found by scaling Proximar's estimate to the planned annual production of Salmon Evolution. On a per kg HOG basis, the imputed interest on net working capital constitutes ~NOK 0.9. On the other hand, ABG Sundal Collier (2022) estimates a net working capital for the first development phase at Indre Harøy of ~NOK 198 million. Therefore, our scaling could be reasonable if inflation is ignored. However, it should be mentioned that our estimate measures the net working capital up till the first sale. Furthermore, it is unclear what timeframe ABG Sundal Collier assumes in their estimate of net working capital.

We acknowledge that net working capital up until the first sale differs from net working capital in steady state production. However, since these estimates are not available for Salmon Evolution, and the adjustment would be arbitrary, we use the up till the first sale estimate and display the underlying uncertainty with a sensitivity analysis. This is displayed in Figure 5.28, where it is evident that a 20% change in the total net working capital would result in an absolute change of NOK 0.18 per kg HOG in production costs. Hence, changes in the net working capital appear to have a minor effect on the total cost of production per kg HOG.

Sensitivity

Based on our simplified production model, we have conducted several sensitivity analyses. Figure 5.28 below presents the effect of changing the underlying parameter by 20%.

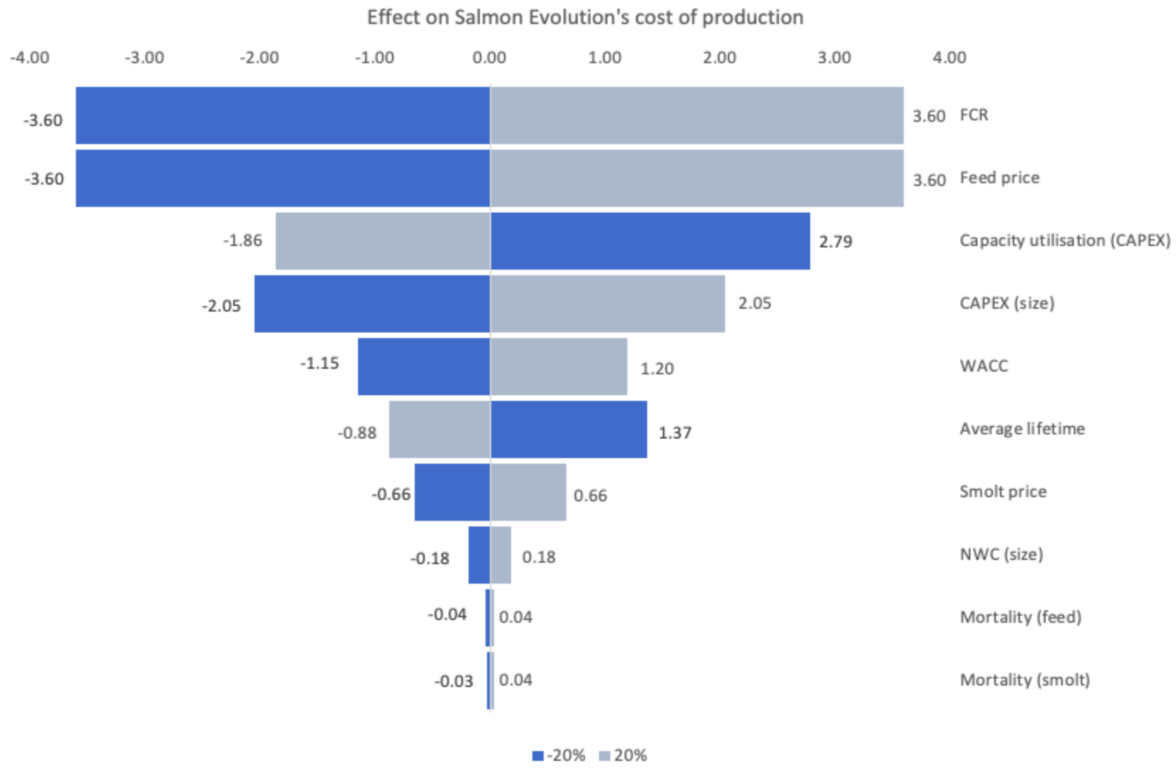

Figure 5.28 - Sensitivity in Salmon Evolution's cost of production estimate

Furthermore, Figure 5.29 below illustrates the effect of losing a given percentage of the biomass at a late stage in the production cycle. Based on the figure, the cost of production per kg HOG will increase significantly if accidents cause events such as mass mortality is to occur.

Figure 5.29 - Effect of biomass loss on cost of production for Salmon Evolution

Adjusted cost of production

Based on the discussion and verification of the different costs in Salmon Evolution's indicative cost breakdown, we present the following adjusted cost of production in Figure 5.30.

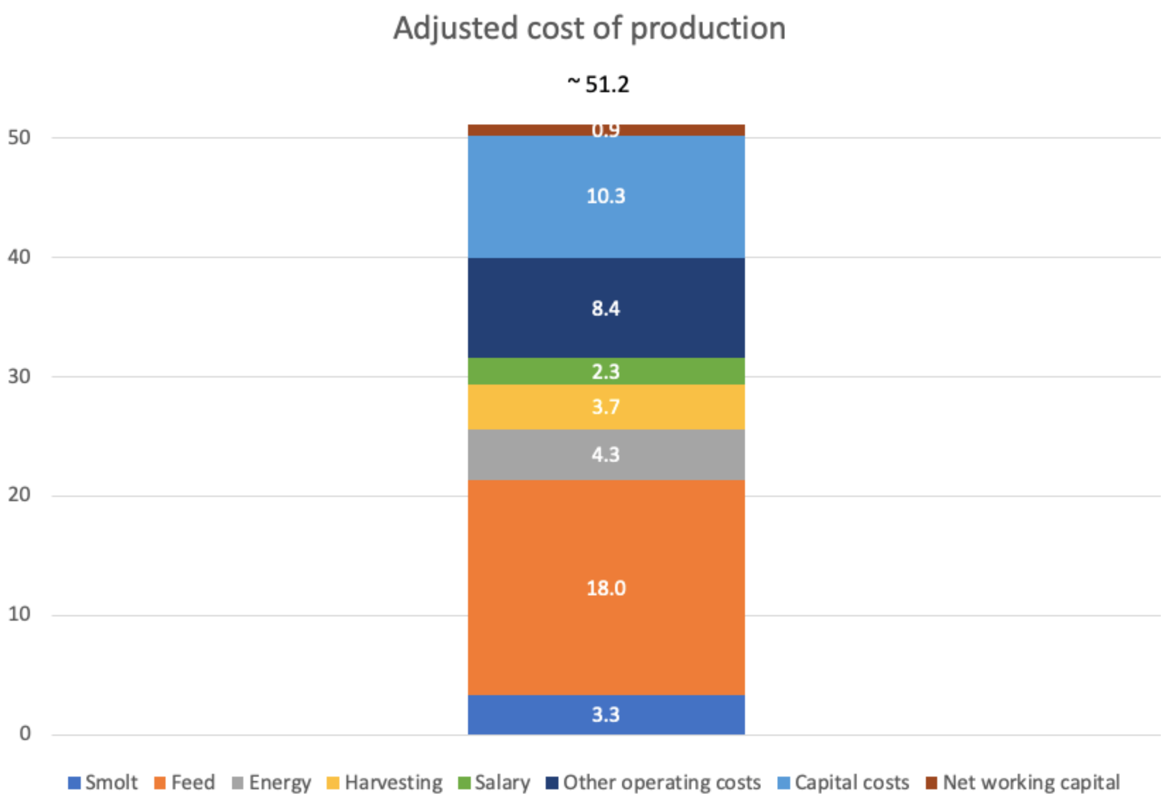

Figure 5.30 - Adjusted cost of production estimate for Salmon Evolution

The adjusted estimate includes the total cost of capital in terms of both depreciations and imputed interest on capital employed. Note that none of the other costs has been adjusted. We explain this decision in section 5.1.3. However, unlike the cases of Andfjord and Proximar, the estimate of Salmon Evolution is presented in 2022 terms. The result is that there would be no need for an adjustment due to inflation. Nevertheless, the interpretation of the result is equal. In order to be profitable from an investor perspective, Salmon Evolution needs to obtain a price of NOK 51.2 per kg HOG in real terms, compared with a 2022 price level. As for the previous cases, it is important to keep in mind that, as shown in Figure 5.28, the estimate is still prone to uncertainty. Minor changes in several underlying parameters simultaneously could significantly impact the profitability of Salmon Evolution.

6. Discussion and implications of the findings

In this chapter, we discuss similarities and differences between the three cases in relation to theory about business strategy and profit drivers from the conceptual theoretical framework. The implications of this discussion are thereafter structured and synthesised in accordance with the three research questions specified in section 4.1.1.

6.1 Comparison of the cases

6.1.1 Business strategy

Based on our case study, we observe similarities and differences between the three land-based salmon farmers in terms of *competitive strategy*. Regarding *competitive scope*, all of the land-based farmers initially concentrate on the mass market of salmon. However, it has been noted that Proximar and Salmon Evolution have plans to engage in further processing of salmon in the future, thereby serving niche markets such as the sashimi market.

In relation to *competitive advantage*, the choice of location demonstrates that Andfjord has the most apparent focus on cost leadership, while Proximar is the company trying to differentiate the most to obtain a price advantage. Andfjord's location at Andøya has enabled the company to take advantage of a cost-efficient FTS technology. Contrarily, Proximar's RAS facility near Mount Fuji provides both a price and cost advantage as local a producer in Japan.

With this in mind, we have decided to position Proximar and Andfjord at each end of the PPC in Figure 6.1. On the other hand, Salmon Evolution is placed somewhat in the middle in terms of competitive advantage. This is justified by the company's choice of HFS technology, where the primary objective and motivation is to balance and minimise biological risk. The reasons for this are that this objective could reduce production costs but also increase the degree of sustainable production, which is an important revenue driver for land-based salmon farmers.

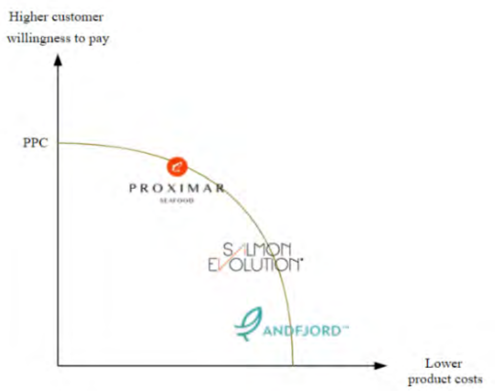

Figure 6.1 - Comparison of competitive strategy

Considering the choice of competitive strategy, Proximar naturally is the company that concentrates the most on differentiation in their *marketing strategy* by promoting various product attributes. For instance, it is evident from the case study that Proximar's market position is built around the Mount Fuji branding. The ambition is that this branding would earn Proximar higher margins since customers would associate their salmon with product-related attributes such as freshness. Additionally, the Mount Fuji branding could help Proximar promote non-product related attributes such as animal welfare, sustainability, and country of origin to customers.

Having said that, this does not mean that Andfjord and Salmon Evolution are not interested in promoting product attributes as part of their business strategy. The case study points out that both companies acknowledge that focusing on animal welfare and sustainable production could provide a price premium in today's salmon market. However, Andfjord and Salmon Evolution seemingly apply marketing less as a differentiation instrument than Proximar and more to ensure customers and other stakeholders that their business model is viable.

Finally, on the subject of *operating strategy*, the case study indicates that structural strategical decisions such as choice of *location* and *type of technology* lay the foundation of several subsequent operational strategical decisions. Some examples are *facility layout*, *technical design,* and *linkages* in the value chain. Moreover, the value chain in land-based salmon farming is generally more controllable in terms of input factors and production process compared to conventional salmon farming. We observe that the three land-based salmon farmers apply *risk management* in their operational strategy. For example, Proximar and Salmon Evolution have decided to have overcapacity on all critical production equipment. This is because the companies believe such risk management could reduce their production costs and thereby improve profitability.

Overall, all the strategic decisions in the business strategy cause variation in the operation of the three land-based salmon farmers, especially with respect to *capital expenditures* and *production costs*. This is elaborated thoroughly in sections 6.1.2 and 6.1.3 below.

6.1.2 Structural cost drivers

Based on the case study, it is evident that choice of *technology* is one of the most influential structural cost drivers in land-based salmon farming, particularly when it comes to capital expenditures. This is consistent with what one would expect based on the *Cost and Profit Driver Research* by Banker and Johnston (2006).

When comparing the three main types of technology, it is clear that RAS facilities require the most investments per production capacity. This is exemplified in Figure 6.2, where Proximar's capital expenditures per capacity are more than three times greater than Andfjord's equivalent investments per capacity in their FTS facility. On the other hand, Salmon Evolution's HFS facility is somewhere in between with regard to capital expenditures per capacity. Overall, this ranking of capital expenditures per capacity is not surprising given the categorisation of the companies' competitive advantage in Figure 6.1.

Figure 6.2 - Comparison of CAPEX per kg HOG capacity

However, what is more interesting is that we observe that the choice of technology again causes a new series of *interconnected strategical choices*. In other words, land-based salmon farmers are not just choosing between RAS, HFS or FTS when it comes to *facility layout*. There are also a vast number of possible configurations within each technology group regarding *design* which drives capital expenditures. For instance, the land-based farmers have to decide on the shape of their fish pool, the density of fish, which equipment and production processes to include or not, as well as the degree of excess capacity in critical functions.

Furthermore, the choice of technology must be considered with respect to *location*. For example, Andfjord's FTS solution would not be as cost-efficient if their location lacked access to fresh seawater with ideal temperatures between 8 to 12°C. The company would then have used a lot of energy to heat the seawater to ideal temperatures.

Additionally, by being located nearby existing infrastructure related to the conventional salmon farming industry, Andfjord and Salmon Evolution could postpone the construction of hatchery and harvesting facilities till later development phases. Such *linkage utilisation* in the value chain makes it possible for the two farmers as *first movers* to solely focus on *learning* and succeeding with the commercial grow-out of edible salmon on land.

Due to requirements from their RAS facility supplier, Proximar, in comparison, decided to fully integrate their value chain from the start. This is not necessarily a disadvantage. Proximar could invest more per capacity in their facility and still be profitable since being a local producer provides the company with a price and cost advantage.

We also observe two other important structural cost drivers based on the three cases. Firstly, it is evident that *economies of scale* could impact both capital expenditures and production costs. Regarding capital expenditures, we observe that the land-based salmon farmers consider the economies of scale as diminishing, especially after the first development phase, which is consistent with previous research (Bjørndal & Tusvik, 2019). In relation to production costs, economies of scale could result in lower purchase prices of, for instance, Atlantic salmon eggs, smolt, or electricity. However, large production volumes are likely required for this cost advantage to materialise. For this reason, we observe that strategic partnerships are an operational cost driver that all three land-based farmers try to take advantage of to keep production costs low in their early development phases.

Secondly, *economies of scope* are recognised as an important structural cost driver, especially in the first development phase of a land-based facility. The reason for this is that there is a trade-off with reference to value chain integration. This is consistent with the theory about structural cost drivers. Building a hatchery and harvest facility like Proximar from the start naturally involves more investments per capacity for the company, which increases capital costs and, thereby, production costs. At the same time, the first development phase could be more demanding for Proximar than Andfjord and Salmon Evolution since the company will have to develop and master several production processes at once.

However, there is also a possible upside since Proximar's vertical integration reduces the company's transaction cost of buying smolt and harvesting their salmon. This could reduce Proximar's overall production costs per kg HOG in the long-term compared to Andfjord and Salmon Evolution. Moreover, Proximar gets greater control of operational and biological risk factors in the value chain from the start than the other two. Hence, Proximar might be better positioned to generate super-profits due to economies of scope in their value chain, at least if one accounts for the long run.

Figure 6.3 illustrates the possible benefit of economies of scope. In this figure, Proximar estimates total egg and feed costs of NOK 17.6 per kg HOG, where all of the grow-out happens in-house. Contrarily, Andfjord and Salmon Evolution estimate NOK 23.2 and NOK 22.3 per kg HOG, respectively, where smolt production is off-site. Moreover, Proximar estimate a harvesting and handling cost of NOK 1.7 per kg HOG, which is substantially lower than Andfjord and Salmon Evolution's estimates of NOK 6.1 and 3.7 per kg HOG, respectively.

One could argue that this illustrates the benefits of having an integrated value chain on-site in early development phases. However, it should be noted that this benefit could be outweighed by increased capital costs. At the same time, the differences in mentioned cost estimates could be due to variations in purchasing price, biological FCR and mortality in production. These operational cost drivers are elaborated more in detail in section 6.1.3 below. After all, the company estimates are uncertain, so it remains to be seen which strategic approach is the most profitable when they all have started production.

Considering all of the structural cost drivers, the case study demonstrates that business strategy in land-based salmon farming is more complex than what one might assume from *Cost and Profit Driver Research* by Banker and Johnston (2006). The causality between strategic choices in the industry is not necessarily *linear* and *one-way*. Instead, we would describe them as *interconnected* and *two-way*. This means that, for instance, land-based farmers' choice of location could also influence technology, not just the other way around. Hence, business strategy in the land-based salmon farming industry is not necessarily a linear process initiated by competitive strategical choices. As noted in three cases, operational and marketing strategical choices could also be initiating and influential factors for the business strategy.

6.1.3 Operational cost drivers

On the subject of operational cost drivers, Figure 6.3 demonstrate that *facility layout* is an influential operational cost driver of not just capital expenditures but also production costs. For example, due to Andfjord's strategic decision of *technology* and *location*, the company has been able to design a facility with superior efficiency when it comes to energy consumption. Therefore, Andfjord estimates a considerably lower energy cost per kg HOG than Salmon Evolution and Proximar. The same applies to personnel, given that Andfjord's FTS facility requires far less personnel in relative terms, as illustrated in Figure 6.3 below.

Figure 6.3 - Comparison of EBITDA per kg HOG

Having said that, the sensitivity analysis from the case study demonstrates that *capacity utilisation* is the most influential operational cost driver with respect to production costs per kg HOG. For example, it has been shown that a lower capacity utilisation of 20% due to the fish not reaching a desirable harvestable weight has an impact of NOK 3.77, 2.79 and 1.33 per kg HOG for Proximar, Salmon Evolution and Andfjord, respectively. Since Proximar's facility is the most capital intensive, it is not surprising that the impact of a lower capacity utilisation is most significant for this facility. Furthermore*, quality management* and *competence* amongst personnel have been identified as important drivers of both *TGC* and biological *FCR*. This again directly impacts productivity in terms of biological gains in the production processes. At the same time, it has been identified that quality management in land-based salmon farming also affects operational risk. This is because *risk management* could reduce production costs since it, for instance, limit the probability of technical failures.

Additionally, the *density of the salmon* and *MAB requirements* could influence capacity utilisation. At the same time, these two could be linked to animal welfare and sustainability. These have been identified as non-product related attributes that could lead to a price premium, especially if combined with branding.

However, the case study also points out that focusing on animal welfare and sustainability could drive costs. This is because it might require land-based farmers to keep fish density to a certain level or make specific investments in water and waste management, which does not necessarily monetise. For this reason, it will be interesting to monitor the actual impact of these mentioned revenue and cost drivers when the land-based farmers start production.

Finally, *mortality* has been identified as a very important and complex operational cost driver for production cost per kg HOG. For example, the Proximar case has illustrated that some degree of *culling* in the early stages of the production cycle is desirable in land-based salmon farming. This is because it could reduce the number of cases where salmon is not reaching harvestable weight, thus improving capacity utilisation. Moreover, all three cases show that *mass mortality*, especially at the end of the production cycle, has a devastating impact on overall production costs. For instance, mass mortality of 30% will increase production cost per kg HOG with NOK 22.2, 21.9 and 16.0 for Proximar, Salmon Evolution and Andfjord, respectively. Mass mortality could be due to *human* or *technical* error, which Atlantic Sapphire unfortunately already has experienced in USA and Denmark.

Overall, the case study of Andfjord, Proximar and Salmon Evolution demonstrates that land-based salmon farming is not just plug-and-play. This results from a vast number of interconnected strategical choices that can drive both revenues, costs and thereby profitability.

6.2 Research questions

In this section, central insights and findings from the case study are synthesised in accordance with research questions 1, 2 and 3. The purpose is to give an indication of the overall answer to the problem statement of this thesis, which we present in chapter 8.

6.2.1 Research question I

Which competitive, marketing, and operational strategical choices have a significant influence on the profitability of land-based salmon farming?

In this thesis, *cost-leadership* appears to be a fundamental *competitive strategical choice* for the profitability of land-based salmon farming. This is primarily a result of salmon generally being perceived as a commodity. For this reason, strategic decisions regarding cost management could have a more significant impact on industry profitability than price management. Consequently, costs are a fundamental competitive factor to consider when deciding which location and technology are most profitable to develop. Furthermore, cost management in later stages when production starts is crucial since land-based salmon farming is not plug-and-play. Hence, it is also essential to have sufficient control systems and skilled personnel to manage risk and production costs. Moreover, we observe that marketing could be used to ensure customers and other stakeholders that land-based salmon farming is viable.

Contrarily, the case study also demonstrates that land-based salmon farming is not just a cost game. *Differentiation* in product-related attributes such as freshness, colour, texture, and odour could be a profitable market position, especially when produced locally. However, such a market position is less likely to generate higher margins if not supported by a specific branding and communication of non-product related attributes in the *marketing strategy*. Considering consumer trends*, sustainability* and *animal welfare* have been mentioned as important elements to include in a profitable marketing strategy for land-based salmon. These two could drive revenues in terms of unit price since they impact *customer perceived value*. However, building awareness of *country origin* could also be a profitable marketing strategy as some customers could be willing to pay a price premium for locally produced salmon. This is discussed more in detail in research question 3.

In terms of *operational strategy*, it is evident from the case study that the choice of *technology* and *location* are important strategical decisions for the profitability of developing and operating a land-based salmon farming facility. The same accounts for *internal resources* such as *human capital*, *control systems* and *organisational capital*.

Based on the case analysis, we have indications that the strategic choices of the land-based farmers regarding marketing and operations could be viewed in relation to their overall competitive strategy. For this reason, there might be a linear one-way causality in business strategy in this particular industry, where the choice of competitive strategy impact what subsequent strategical choices in marketing and operations are profitable.

On the other hand, the case study also suggests that strategic choices in business strategy could be two-way on a strategic level. This means that operational strategical choices could have implications for what competitive strategy is most profitable and not just the other way around. Furthermore, we observe the possibility of two-way causalities between structural cost drivers such as technology and location. At the same time, sustainability is considered a factor that could impact the unit price of salmon through marketing, but also the production cost of land-based farmers through technology and production processes.

Considering all of our findings, we present a modified version of *the Cost and Profit Drivers Research* framework in Figure 6.4 where we have added several red arrows. This illustrates that the relation between profit drivers and strategic choices is more complex in the context of the land-based salmon farming industry than what one might assume based on Banker and Johnston's (2006) presentation of the *Cost and Profit Driver Research* framework.

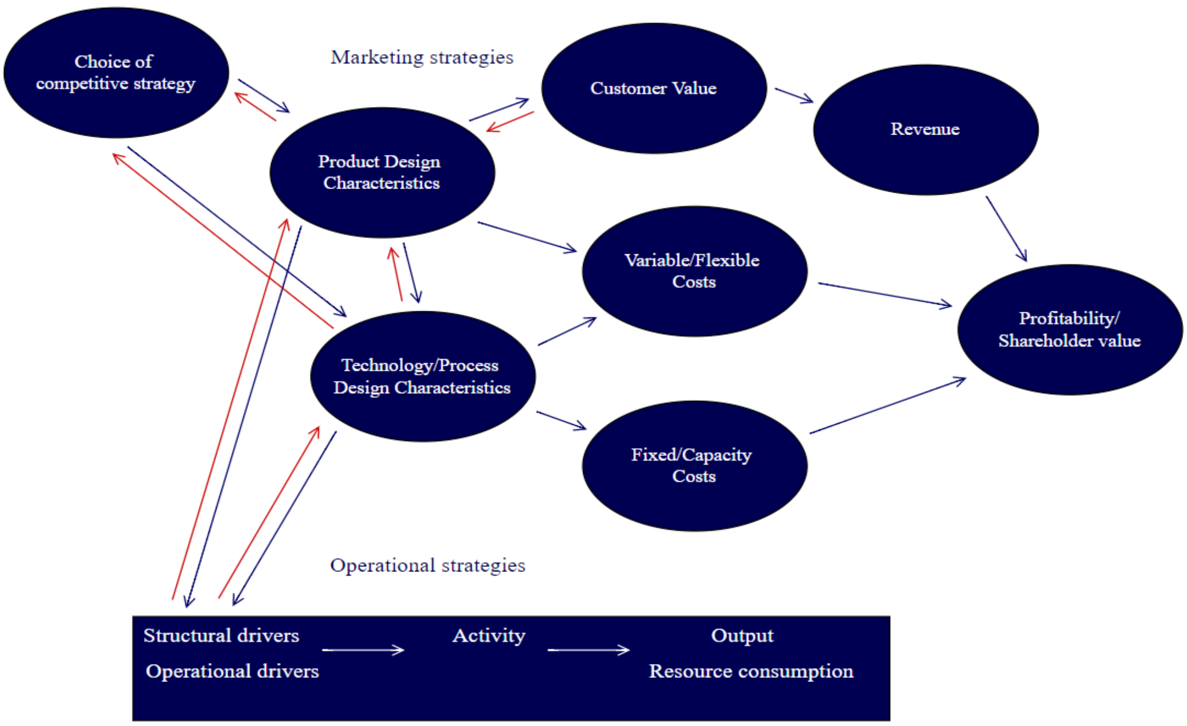

Figure 6.4 - Refined version of Banker & Johnston's (2006) framework

6.2.2 Research question II

What are the most important cost drivers for land-based salmon farming, and how are they related to possible strategical choices?

Based on chapter 5, we find several cost drivers that could significantly influence the profitability of the land-based salmon farming industry, as illustrated in Table 6.1. A common trait of these cost drivers is that they are materialised primarily in the operating strategy. This is in correspondence with the conceptual theoretical framework.

In terms of *structural cost drivers*, we argue that *technology* and *location* are the two of the most important. These two could drive costs directly on their own but also indirectly by laying the foundation for sequential strategical decisions that again will influence costs. Technology, and more specifically the complexity of technology, drives the cost through an increased need for investment. Thus, the choice of technology and its fit with location is very important. For example, different locations will enable different types of technology design. As an illustration, Proximar could not choose FTS or HFS technology, considering their choice of location in the Japanese countryside. In contrast, Andfjord's choice of FTS technology necessitates access to fresh seawater with a particular temperature profile, limiting the number of attractive locations in Norway. This demonstrates the two-way causality in cost drivers and strategic choices indicated in section 6.2.1.

Moreover, we suggest *economies of scale* as an important structural cost driver. As discussed in chapter 5, several of the companies argue that they will achieve economies of scale concerning personnel costs. It is also reasonable to assume that economies of scale will be achievable for other input factors when the companies expand their operations and increase production volumes. Furthermore, we find evidence that *economies of scope* could be an important structural cost driver. This is especially true for Proximar, which has a lower cost of feed and smolt than Salmon Evolution and Andfjord. This could be explained by lower transaction costs since Proximar owns and operate hatchery and grow-out facilities. A similar result can be observed at Salmon Evolution. Based on their ownership of Kraft Laks, they could obtain their smolt at lower prices due to reduced transaction costs.

When it comes to *operational cost drivers*, we suggest *capacity utilisation* as the most important, accompanied by *layout efficiency, quality management* and *competence*. Also, *linkage utilisation* should be acknowledged as important despite having a somewhat different effect. As seen in chapter 5, the ability to reach the planned production volume is one of the critical concerns in the industry. However, layout efficiency, competence, and quality management can be considered three of the most important operational cost drivers. These could affect several important parameters such as biological FCR, TGC and mortality, which again influence the realised capacity utilisation. For instance, possessing the essential competence and control systems could facilitate an efficient production. This could also reduce the operational and biological risk of land-based salmon farming.

Moreover, as seen in all cases, different types of *linkage utilisation* could be an important decision with respect to profitability. By utilising other companies' competence in the value chain, it could be possible to reduce the cost of capital and thereby increase profitability. However, it should be mentioned that vertical integration in the value chain could also reduce production costs due to economies of scope. This illustrates the trade-off when it comes to linkage utilisation in the value chain.

Lastly, we want to emphasise that other cost drivers mentioned in sections 6.1.2 and 6.1.3 could also influence the profitability of land-based salmon farming. We acknowledge that the industry is complex and that strategic decisions related to other cost drivers could potentially increase the profitability of land-based salmon farming.

Structural cost drivers	Operational cost drivers
• Technology • Location • Economic of scale and scope	• Capacity utilisation • Facility layout efficiency • Quality management • Competence • Process and linkage utilisation

Table 6.1 - The most important cost drivers for land-based salmon farming

6.2.3 Research question III

What are the most important revenue drivers for land-based salmon farming, and how are they related to possible strategical choices?

The case study shows that *location* could also be an important revenue driver for land-based farmers and not just necessarily an important strategical choice related to capital expenditure and production costs. This is especially evident in the Proximar case.

Today, Japan imports all of the Atlantic salmon consumed in the country (Norwegian Seafood Council, 2022). As a result, Japan has one of the highest regional prices for salmon since the market price includes the transportation and handling costs of exporting salmon farmers. For this reason, Proximar as a local producer, could be able to sell fresh salmon for NOK 95 per kg HOG in Tokyo, given a Norwegian spot price of NOK 70 per kg HOG for fresh Atlantic salmon. The example is illustrated in Figure 6.5 and is inspired by ABG SC (2021).

Figure 6.5 - Proximar's potential price advantage

In light of this, Proximar could capitalise greatly on being a local producer of Atlantic salmon in Japan because of lower transportation and handling costs. However, the significance of transportation and handling costs will decrease if more local production is established in Japan. Thus, Proximar’s price advantage might not be sustained in the long run.

Nevertheless, considering the amount of time, capital and resources needed to develop a land-based salmon farming facility, Proximar could capitalise by being the first local producer of Atlantic salmon in a growing Japanese market. We believe this price advantage could be obtained in other salmon markets, especially in America and Asia, at least in the short term.

Furthermore, it is evident from the cases that *product-related attributes* naturally are important revenue drivers. The reason for this is that they impact product benefit and cost through salmon quality, performance, and functionality. This again impacts *customer perceived value* and their willingness to pay. Examples of product-related attributes could be *freshness, colour, texture,* and *odour*. In relation to freshness, the Proximar case demonstrates that local suppliers could differentiate their salmon on freshness. For example, due to a location within driving distance from Tokyo, Proximar's salmon could be for sale in the capital only hours after harvesting. However, it can take between 3-5 days for farmers that export the salmon from Norway (ABG SC, 2021). Consequently, the location of land-based salmon farming facilities could also be regarded in relation to differentiation on product-related attributes, and not just structurally in terms of transportation and handling costs.

However, our analysis demonstrates that differentiation on product-related attributes is less likely to generate higher margins on its own. This is because salmon is customarily considered a commodity. Nevertheless, higher margins could be obtained if the differentiation is supported by a certain branding or marketing of *non-product related* attributes such as *sustainability*, *animal welfare* and *country origin*. Proximar and Andfjord Salmon have indicated at least a 10% differentiation potential when it comes to unprocessed Atlantic salmon farmed on land. The potential might be even more considerable for further processed salmon, especially in markets where sashimi and sushi are popular.

Overall, Figure 6.6 exemplifies that the profitability of differentiation is a function of both product-related and non-product related attributes in land-based salmon farming. This suggests that management control is not limited to quality regarding production processes and product-related attributes in the industry. In addition, sustainable communication, branding, price management, and customer relations could also be important for industry profits. Based on this, we argue that the most important revenue drivers are a function of configuration in marketing and operating strategy.

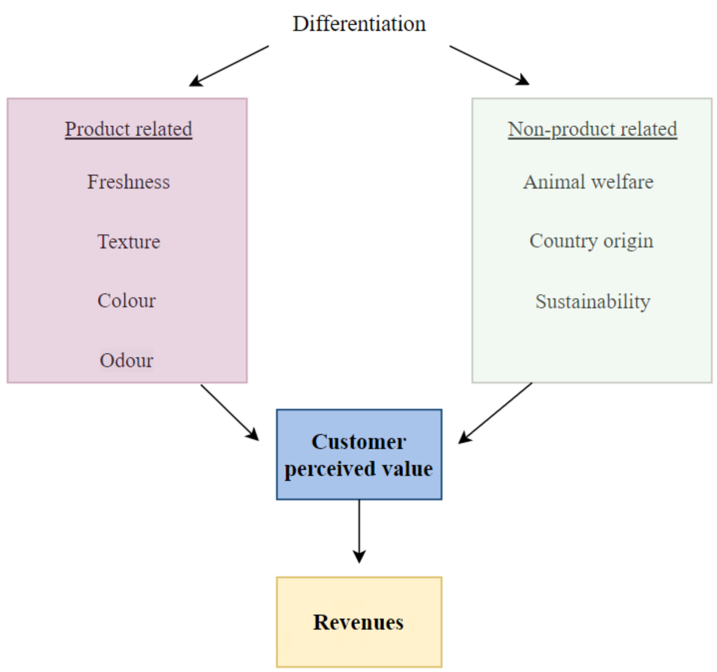

Figure 6.6 - Revenue drivers in land-based salmon farming

7. Limitations and further research

In this chapter, we present and discuss limitations associated with our thesis. We argue that the limitations are mainly related to the quality and accuracy of our data material. However, considering all measures we have taken to ensure high reliability and validity, as discussed in chapter 4, we believe that the limitations have a negligible impact on the key findings of this thesis. Furthermore, we present suggestions for further research on the profitability of the land-based salmon farming industry.

7.1.1 Limitations

We have previously presented the main limitations of our thesis in chapter 4. Firstly, a limitation of the thesis is the extensive use of uncertain estimates. This can be explained by the industry being relatively new, limiting the amount of data from real land-based salmon farming facilities producing at a commercial scale. Thus, most of the available data are estimates, which are difficult to validate since they are by nature uncertain. Hence, it can be argued that the thesis possesses a limited degree of validity. However, this has been handled by discussing the estimates with several sources, ensuring that the estimates are as reasonable as possible. Also, we have conducted sensitivity analyses on the most important parameters for all three cases to display the underlying uncertainty.

Nevertheless, it could be argued that we should have conducted scenarios to illustrate the effect of changing several parameters at once. However, we believe that this exercise would be of small value, given the uncertainty of the data material. This is because we do not know whether the original company estimates represent a base case or not. Consequently, it is difficult to decide how parameters should be changed when creating different scenarios.

Secondly, we have examined all companies from an external perspective as a consequence of having three cases in our multiple comparative case study. This naturally limits the degree of validity since we are restricted to use publicly available information. If we had limited the analysis to only one company, we could potentially get access to confidential information and thereby making the entire thesis confidential. Such confidential information could increase the validity of the data material. However, as discussed in chapter 4, there will be a trade-off between breadth and depth when utilising a multiple comparative case study. Therefore, we believe that having an external perspective and thereby introducing more cases is appropriate with regard to our problem statement. Furthermore, as discussed in chapter 4, several measures have been taken to increase the thesis's validity.

Thirdly, we decided not to account for inflation in our analysis. This is based on a simplified assumption that inflation will affect all prices similarly and thus not influence the analysis. Therefore, adjusting for inflation would only contribute with noise in terms of profit drivers. However, we acknowledge that this assumption is a simplification of the real world. In reality, prices are not affected similarly by inflation. Nevertheless, we claim that adjusting for inflation would not alter our findings and conclusion. With regard to the problem statement, we believe that ignoring inflation is a reasonable decision.

7.1.2 Further research

Based on the thesis and limitations, we suggest several areas for further research. Firstly, the findings of our thesis need further verification. This can be accomplished in several manners. One suggestion is to replicate this thesis when the companies are operating at a steady state in their production. Thereby, the analysis will to a larger extent, be based on objective and observable data and not only assumptions and estimates. This could also facilitate the creation of a more detailed production model, which could further improve the understanding of the industry. Alternatively, it could be possible to take on a more internal perspective by focusing solely on one single company. By accessing more confidential or at least company-specific data, it should be possible to increase the validity of the results. Since both alternatives concern a further validation of operational data, we acknowledge that they are first feasible when the facilities are operating at a fully commercial scale.

Secondly, as mentioned in chapter 4, opinions from critical actors with respect to land-based salmon farming have been discussed to a limited degree. We have earlier explained that such a discussion would focus more on the viability of land-based salmon farming, which is outside the scope of this thesis. The main contribution of this thesis is that it identifies what premises need to be present for land-based salmon farmers to be profitable. With these premises being known, we suggest that further research should discuss the probability of them actually occurring by evaluating a larger sample of land-based salmon farmers.

8. Conclusion

In this thesis, we have tried to address the following problem statement:

What are the key profit drivers for land-based farming of Atlantic salmon?

The problem statement is rather broad and has been further specified into three research questions based on a conceptual theoretical framework and a review of previous studies of the profitability of land-based salmon farming. In order to answer these research questions, we have conducted a multiple comparative case study of three land-based salmon farmers.

Our findings suggest that several profit drivers are key for the industry. However, analysing their importance for a given company is complex since they are related to and dependent on several strategical decisions in the business strategy. With regard to revenue drivers, we conclude that the branding of non-product-related attributes, such as sustainability, and product-related attributes, such as freshness, can be important for the industry. The attributes facilitate differentiation, and the industry should therefore not be viewed solely as a cost game. Moreover, we have observed that marketing is not solely applied for differentiation. It is also used to communicate the viability of land-based salmon farming to stakeholders.

Furthermore, some cost drivers are considered important across the three cases. Regardless of competitive and marketing strategy, the choice of technology and location are key structural cost drivers. This is because they drive costs individually and lay the foundation for further decisions in the operating strategy. For example, all cases highlight that capacity utilisation is a critical operational cost driver. Reaching the planned production volume is complex and a function of technology, location, and several operational cost drivers such as facility layout, competence, and quality management. In addition to capacity utilisation, we observe that economies of scale and scope are affected by the initial choice of technology and location. These two structural cost drivers can reduce production costs due to lower prices on input factors and transaction costs. Nevertheless, economies of scale and scope involve higher investments in the value chain, thus representing a trade-off regarding linkage utilisation.

Based on our case study, we have observed that the key profit drivers are interrelated in a series of strategic decisions. Together, these decisions constitute the business strategy of a company. As suggested in the refined version of *The Cost and Profit Driver Research* in Figure 6.4, these interrelationships illustrate that land-based salmon farming is a complex industry. For this reason, the studied cases account for only three concepts out of many possible variants. Consequently, we argue that it is not reasonable to discuss the profitability in the context of strategic choices of the entire industry. Instead, such discussions should be centred around the profitability of the strategic choices related to a given concept.

Lastly, it should be noted that the conclusion is prone to some limitations. The findings are based on uncertain estimates and untested assumptions. This is due to the studied companies have not yet started their production or are in a very early phase. Therefore, it is, for instance, difficult to examine whether a price premium based on specific attributes is achievable or not. Similarly, it is difficult to truly validate the cost of production estimates. However, several measures have been taken to ensure as high validity as possible. For example, we have compared the collected data across the cases and discussed its implication with industry experts. Nevertheless, further research should focus on improving this validation. Finally, it is important to emphasise that despite some uncertainty, we believe that our findings of key profit drivers should be relatively robust, based on several sensitivity analyses.

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Appendix

A1 Comparison of different cost driver taxonomies

Porter (1985)	Riley (1987)	Cooper and Kaplan (1999)
Scale	*Structural drivers*	*Manufacturing stage of value chain*
Learning and spillovers	Scale	Unit-level
Capacity utilisation	Scope	Batch-level
Linkages between activities across value chain (within company, across extended value chain)	Experience	Product-sustaining
	Production technology	Facilities-sustaining
	Production line complexity	
Linkages with business units within the company		*Rest of company value chain*
Timing (first/late movers)	*Executional drivers*	Customer-sustaining
Policy choices (product design and mix, service levels, investments, delivery times, distribution channels, technology, and material quality)	Workforce commitment	Product-line-sustaining
	Quality management	
	Capacity utilization	Brand-sustaining
	Plant layout efficiency	Channel-sustaining
	Product design configuration	Location-sustaining
Geographical location		Corporate-sustaining
Institutional factors (regulation, tariffs, unionization)	Linkages with suppliers	
		Extended value/supply chain
		Vendor-sustaining

Table A1 - Different cost drivers

A2 Conctacted companies

In this section, we present an overview of the land-based salmon farmers we sent an enquiry. The companies that were not chosen as interview objects did not respond to the enquiry. Note that most land-based salmon farms plan to use RAS technology, explaining the overweight of companies using this particular technology.

Company	Technology	Production country	Interview object
Salmon Evolution ASA	HFS	Norway	Yes
Andfjord Salmon AS	FTS	Norway	Yes
Proximar Seafood	RAS	Japan	Yes
Atlantic Sapphire ASA	RAS	USA/Denmark	No
OFS Måløy AS	RAS	Norway	No
Hjelvik Matfisk AS	FTS	Norway	No
Nordic Aqua Farms AS	RAS	Norway/Denmark/USA	No
Lerøy Årskog AS	RAS	Norway	No

Table A2 - List of companies receiving enquiry

A3 Interview guide – Land-based salmon farming

In the following, we present the interview guide's relation to Banker & Johnston's (2006) *Cost and Profit Driver Research.* An explanation is given for all themes, except *Introduction, About the informant* and *Closing comments*. We have used Figure 2.2 as an inspiration when creating the interview guide.

Production facility: In order to understand the fixed cost of the company, we examined the production facility, and questions regarding location are included to evaluate its importance.

Technology: Based on previous literature, technology is emphasised as an important cost driver. It is also highlighted in Figure 2.2. Therefore, it was natural to have technology as a theme in order to improve our understanding of its importance.

Input factors: This theme was included in an attempt to improve our understanding of the variable costs of the industry. Also, we wanted to understand whether it is common with partnerships and the importance of integrating the value chain.

Production process: In an attempt to improve our understanding of underlying assumptions, we included this theme. This has later been used to create production models, which again have been used to evaluate the importance of different cost drivers. Also, questions regarding some structural cost drivers are included.

Product characteristics: This theme was included in order to improve our understanding of potential revenue drivers and what customers value when buying salmon. In other words, the theme is related to the top branch of Figure 2.2. Here, we also tried to improve our understanding of potential choices regarding competitive and marketing strategies.

Distribution: In order to understand whether integrating the value chain with respect to distribution, this was included as a theme. Moreover, based on the questions, we wanted to understand the potential advantage of reduced need for transportation. This is related to variable costs.

Risk factors: This theme was included in order to improve our understanding of the underlying risk factors of the industry. Risk could affect both variable and fixed costs.

Theme:	Questions:
Introduction	• Brief presentation of ourselves • Short introduction about the purpose of the thesis • Short introduction about the purpose of the interview • Do you consent to recording the interview? • Feel free to ask us questions during the interview
About the informant	• What is your position in the company? • For how long have you been working at the company?
Production facility	• Where is your production facility located? • What is the cost of investment for your facility? • What economic lifespan have you assumed for the different parts of your facility? (Land, buildings, aquaculture systems, production tanks and other installations)
Technology	• What kind of production technology do you use? (RAS, FTS, HFS) • How much biological waste do the facility generate, and how is this handled? (Ammoniac, excrements, etc.)
Input factors	• How many person-years do you need at desirable, steady state yearly production? • What kind of energy sources do you use? • How much oxygen do you add to the water? • Do you have your own hatchery at your production facility? • How many tonnes of feed do you buy during a year with full production?
Production process	• What is the yearly harvesting volume and release of smolt (generations and number) in steady state for the different phases? • How do you define a production cycle, and how long is it? • What Feed Conversion Ratio (FCR) and Thermal Growth Coefficient (TGC) do you expect in your production cycles? • What mortality rates do you expect? • What do you think about first-mover advantages, economies of scale and economies of scope within land-based salmon farming? • What production processes do have the greatest learning potential within land-based salmon farming?
Product characteristics	• What condition is your salmon delivered? (HOG, WFE, fresh or frozen) • What is the size of the salmon you harvest/sell? • What reference price for salmon to you use? What product characteristics do you consider as especially important for the sales price of salmon? (Colour, taste, freshness, country of production).
Distribution	• Do you produce mainly for exports or for domestic sales? • How do you transport your salmon from the production facility to the market?
Risk factors	• What do you consider as the largest technological risk factors for your facility? • What do you consider as the largest biological risk factors for your facility?
Closing comments	• What do you consider as the most important profit drivers in the industry? • Questions? • Thank you for accepting this interview.

Table A3 - Interview guide

A4 Production model

In this thesis, a production model is constructed for each case to validate company production cost estimates such as egg, smolt or feed cost, as well as the effect of mortality given a yearly steady state production. Considering that detailed information about the biological plans of the land-based farmers is unavailable, several simplifications have been made when constructing the different production models.

Firstly, it is assumed in the various production models that the land-based salmon farmers only harvest in the final month of the production cycle at the reported average harvest weight. We know this is not true as the land-based salmon farmers plan to harvest daily growth in biomass to be as productive as possible given MAB regulations. For this reason, some salmon will be harvested at a weight below or over the average harvest weight. Our production model is not able to capture this variation when it comes to feed costs. However, we can still analyse how feed costs are influenced in broader terms by factors such as biological FCR and expected mortality rates.

Secondly, the land-based farmers only report the average monthly TGC as well as the average start and harvest weight of their salmon in a production cycle. Consequently, components in TGC have been implicitly estimated based on the reported average harvest weight. This has, in turn, been used to define an average salmon growth curve ending at the reported average harvest weight at the end of the production cycle. Moreover, average temperatures in the facility and the number of eggs or smolt needed in a production cycle have been implicitly estimated based on this information. In this regard, there is a circularity problem in the various production plans because of our simplifications, average harvest weight has been used to define both components in TGC and input factors in the growth plan. Solving this problem would improve the precision of the cost estimates. On the other hand, it would require more comprehensive data and not necessarily change our conclusion of what are the most important cost drivers in the land-based salmon farming industry. Consequently, we believe this simplification in the production model is adequate given the purpose of the thesis.

Thirdly, the production model treats mortality broadly by distributing the overall expected mortality rates in the hatchery and grow-out process out to each month in the production cycle. Overall expected mortality in the hatchery is distributed evenly across each month in the hatchery cycle. On the other hand, half of the overall expected mortality in the grow-out phase is distributed to the first month, while the other half is distributed evenly over the remaining months. This is inspired by previous profitability studies on land-based salmon farming (e.g., Bjørndal and Tusvik (2017, 2019); Boulet et al. (2010)). The advantage of this solution is that the practice of culling early in the production cycle of both the hatchery and grow-out phase is illustrated. However, due to this distribution in the production model, the impact on production cost due to changes in expected mortality rate is minimal in the sensitivity analysis. Realised mass mortality, especially at the end of the production cycle, will naturally have a significant impact on production cost since a lot of resources such as egg or smolt as well as feed is going to waste. This impact on the production cost has been separately analysed in a sensitivity analysis where capacity utilisation varies, but the overall EBITDA cost is held fixed to illustrate the resource loss of mass mortality in late production cycles.

In the figures below, we present the different production models we have estimated for the land-based salmon farmers we have examined in the three cases.

Production plan Andfjord Salmon										
	Month beginning:	Weight per fish in grams (W_t)	Weight increase (grams): ($W_{t+1} - W_t$)	Survival (%)	Number of fish, given survival rate (N_t):	Biomass increase in kg included mortality (($W_{t+1} - W_t$)*N_t)/1000	Standing biomass in kg beginning of month: B_t = (N_t*W_t)/1000	FCR:	Feed quantity in kg (Biomass increase * FCR)	Feed cost NOK per month:
Smolt into growout -->	0	300	119	97.50%	944,822	112,127	283,447	1.1	123,340	1,572,587
	1	419	146	99.76%	921,202	134,913	385,685	1.1	148,404	1,892,149
	2	565	177	99.76%	919,029	162,807	519,369	1.1	179,087	2,283,365
	3	742	211	99.76%	916,861	193,247	680,567	1.1	212,571	2,710,286
	4	953	247	99.76%	914,699	226,214	871,753	1.1	248,835	3,172,651
	5	1200	287	99.76%	912,541	261,690	1,095,377	1.1	287,859	3,670,202
	6	1487	329	99.76%	910,389	299,657	1,353,866	1.1	329,622	4,202,684
	7	1816	374	99.76%	908,242	340,096	1,649,623	1.1	374,105	4,769,840
	8	2191	423	99.76%	906,100	382,989	1,985,026	1.1	421,288	5,371,417
	9	2613	474	99.76%	903,962	428,318	2,362,429	1.1	471,150	6,007,160
	10	3087	528	99.76%	901,830	476,066	2,784,165	1.1	523,672	6,676,819
	11	3615	585	99.76%	899,703	526,213	3,252,541	1.1	578,835	7,380,142
Harvest -->	12	4200			897,581		3,769,841			

Figure A1 - Production model Andfjord

Production plan Proximar Seafood										
	Month beginning:	Weight per fish in grams (W_t)	Weight increase (grams): ($W_{t+1} - W_t$)	Survival (%)	Number of fish, given survival rate (N_t):	Biomass increase in kg included mortality (($W_{t+1} - W_t$)*N_t)/1000	Standing biomass in kg beginning of month: B_t = (N_t*W_t)/1000	FCR:	Feed quantity in kg (Biomass increase * FCR)	Feed cost NOK per month:
Introduction of eggs -->	2	0.20	1	94.60%	156 000	172	31	1.1	189	2 420
	3	1.30	3	94.60%	147 578	411	192	1.1	452	5 790
	4	4.09	5	94.60%	139 612	733	571	1.1	807	10 327
	5	9.34	9	94.60%	132 075	1 123	1 234	1.1	1 235	15 812
	6	17.84	13	94.60%	124 945	1 566	2 230	1.1	1 723	22 052
	7	30.38	17	94.60%	118 200	2 051	3 591	1.1	2 256	28 873
	8	47.73	23	94.60%	111 819	2 566	5 337	1.1	2 822	36 126
	9	70.68	29	94.60%	105 782	3 102	7 476	1.1	3 412	43 677
Transfer from hatchery to grow-out -->	10	100.00	96	98.50%	100 072	9 642	10 007	1.1	10 606	135 754
	11	196.35	144	99.86%	98 571	14 208	19 354	1.1	15 628	200 043
	12	340.48	202	99.86%	98 433	19 839	33 515	1.1	21 823	279 336
	13	542.03	269	99.86%	98 296	26 401	53 280	1.1	29 041	371 729
	14	810.62	345	99.86%	98 159	33 890	79 570	1.1	37 279	477 167
	15	1155.88	432	99.86%	98 022	42 301	113 301	1.1	46 531	595 594
	16	1587.42	527	99.86%	97 886	51 630	155 385	1.1	56 793	726 955
	17	2114.87	633	99.86%	97 749	61 875	206 727	1.1	68 062	871 196
	18	2747.87	748	99.86%	97 613	73 030	268 227	1.1	80 333	1 028 262
	19	3496.03	873	99.86%	97 477	85 092	340 782	1.1	93 601	1 198 099
	20	4368.98	1007	99.86%	97 341	98 058	425 280	1.1	107 863	1 380 651
	21	5376.34	-376	99.86%	97 205	(36 583)	522 608			
Harvest -->	22	5000.00			97 070		485 348			

Figure A2 - Production model Proximar

Production plan Salmon Evolution										
	Month beginning:	Weight per fish in grams (W_t)	Weight increase (grams): (W_{t+1} - W_t)	Survival (%)	Number of fish, given survival rate (N_t):	Biomass increase in kg included mortality ((W_{t+1} - W_t)*N_t)/1000	Standing biomass in kg beginning of month: B_t = (N_t*W_t)/1000	FCR:	Feed quantity in kg (Biomass increase * FCR)	Feed cost NOK per month:
Smolt into growout -->	0	130	114	97.50%	280,000	31,871	36,400	1.05	33,464	487,237
	1	244	166	99.74%	273,000	45,358	66,564	1.05	47,626	693,440
	2	410	228	99.74%	272,292	62,183	111,632	1.05	65,292	950,652
	3	638	300	99.74%	271,585	81,607	173,364	1.05	85,688	1,247,612
	4	939	382	99.74%	270,881	103,611	254,310	1.05	108,792	1,584,005
	5	1321	474	99.74%	270,178	128,174	356,992	1.05	134,582	1,959,518
	6	1796	576	99.74%	269,477	155,275	483,907	1.05	163,038	2,373,840
	7	2372	688	99.74%	268,778	184,894	637,524	1.05	194,139	2,826,662
	8	3060	810	99.74%	268,081	217,012	820,284	1.05	227,862	3,317,676
	9	3869	941	99.74%	267,385	251,607	1,034,605	1.05	264,188	3,846,574
	10	4810	1082	99.74%	266,692	288,661	1,282,876	1.05	303,094	4,413,052
Harvest -->	11	5893			266,000		1,567,460	1.05		

Figure A3 - Production model Salmon Evolution