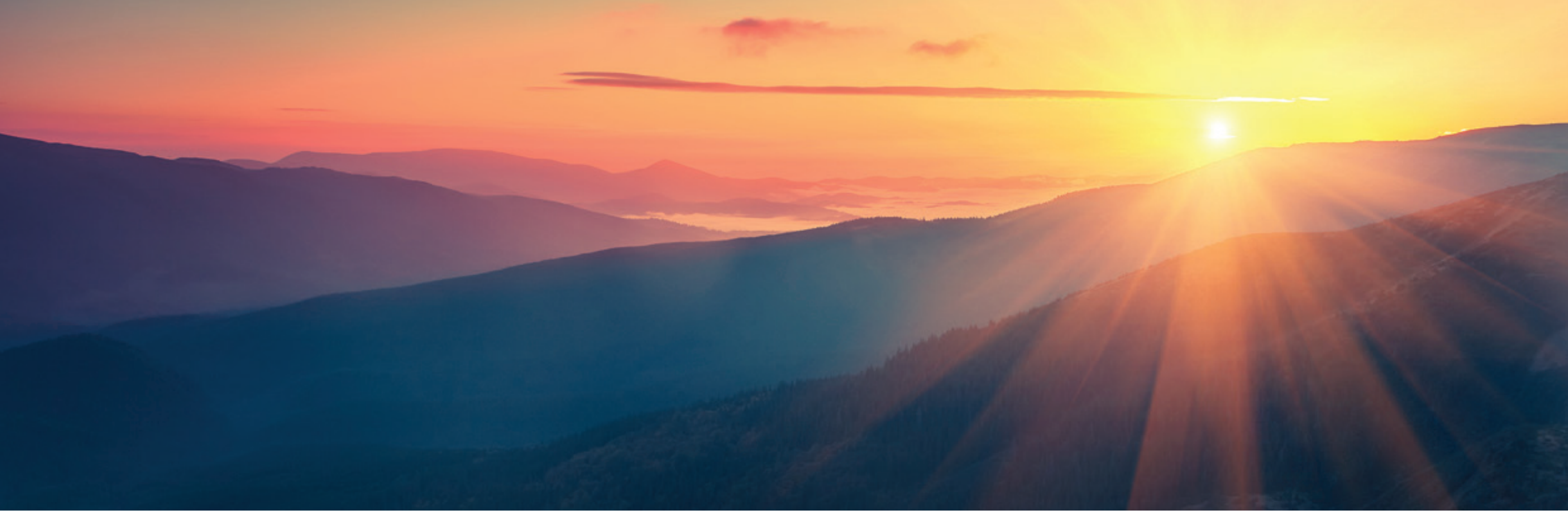
LOCH-ED PROFITS

FORECAST FARMED SALMON INDUSTRY GROWTH NOT CONVERTING TO STABLE PROFIT MARGINS

REPORT MAY 2020

Planet Tracker

CONTENTS



ABOUT PLANET TRACKER

Planet Tracker is a non-profit financial think tank aligning capital markets with planetary limits. It was launched in 2018 by the Investor Watch Group whose founders, Mark Campanale and Nick Robins, created the Carbon Tracker Initiative.

Planet Tracker was created to investigate the risk of market failure related to ecological limits. This investigation is for the investor community where other ecological limits, in contrast to climate change, are poorly understood and even more poorly communicated and not aligned with investor capital.

SEAFOOD TRACKER

Seafood Tracker investigates the impact that financial institutions can have on sustainable corporate practices through their funding of publicly listed wild-catch and aquaculture companies.

Our aim is to align capital markets with the sustainable management of ocean and coastal marine resources.

This report focuses on financial risks to salmon aquaculture expansion. As the aquaculture sector is forecast to experience double digit growth through to 2030, capital markets should be thinking about key sustainability issues in their investments.

Seafood Tracker is a part of the wider Planet Tracker Group of Initiatives.

ACKNOWLEDGEMENTS

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FOREWORD

As we publish more reports investigating the financial and environmental stability of food systems, there is a very familiar pattern emerging which does not bode well for investors.

Food production sectors which, at first glance, appear robust and expanding, upon closer scrutiny often prove to be beset by environment-related challenges which are not priced into existing company and market valuations. This report looks in depth at the farmed Atlantic salmon industry, a highly concentrated sector, which has seen dramatic growth since 2005 and is predicted to continue growing for the foreseeable future (to 2030).

A look behind the broad forecasts shows a very different picture which investors should be taking into account. As this report, 'Loch-ed Profits', clearly shows, the farmed salmon industry has reached a critical point in its development.

On the positive side, medium to long term demand for fish proteins is buoyant and, given the world population predictions, salmon undoubtedly has an important role to play in supplying necessary dietary protein. Having reviewed industry growth estimates from sources such as PwC and the OECD, Planet Tracker has found that most estimates project stable mid-term growth in coastal production of farmed Atlantic salmon.

Loch-ed Profits

On the negative side, salmon is fast approaching the practical physical limits permitted by current coastal farming methods and is still some way from moving to more sustainable and profitable methods at scale.

Planet Tracker posits that, unless coastal land and marine ecological health around salmon farms is improved, total production of farmed salmon will be lower than the current estimates, with supply of salmon from coastal sites declining due to worsening environmental factors such as build-up of effluent, disease and warming seas due to climate change.

Both large- and small- scale producers in the farmed salmon sector face significant environmental challenges such as climate change, disease, sea lice, harmful algal blooms and salmon escapes, compounded by feed-driven issues such as collapsing wild-catch feedstock fisheries or feed substitution with environmentally harmful plant-based feed such as soy.

Put together, these challenges create financial risks for the concentrated group of investors in the industry, especially for those invested in smaller companies which may lack funding or commercial incentives to finance and support transition to more sustainable farming models.

These financial risks have been compounded by the impact of the 2020 COVID-19 pandemic. As people struggle to obtain basic necessities, are restricted in their travel and with lower demand from the restaurant and hospitality industries, immediate demand for salmon has been reduced and the price per kg has dropped sharply. The longer the crisis continues the more farmed salmon margins will suffer, making it less viable for producers to invest in new technologies.

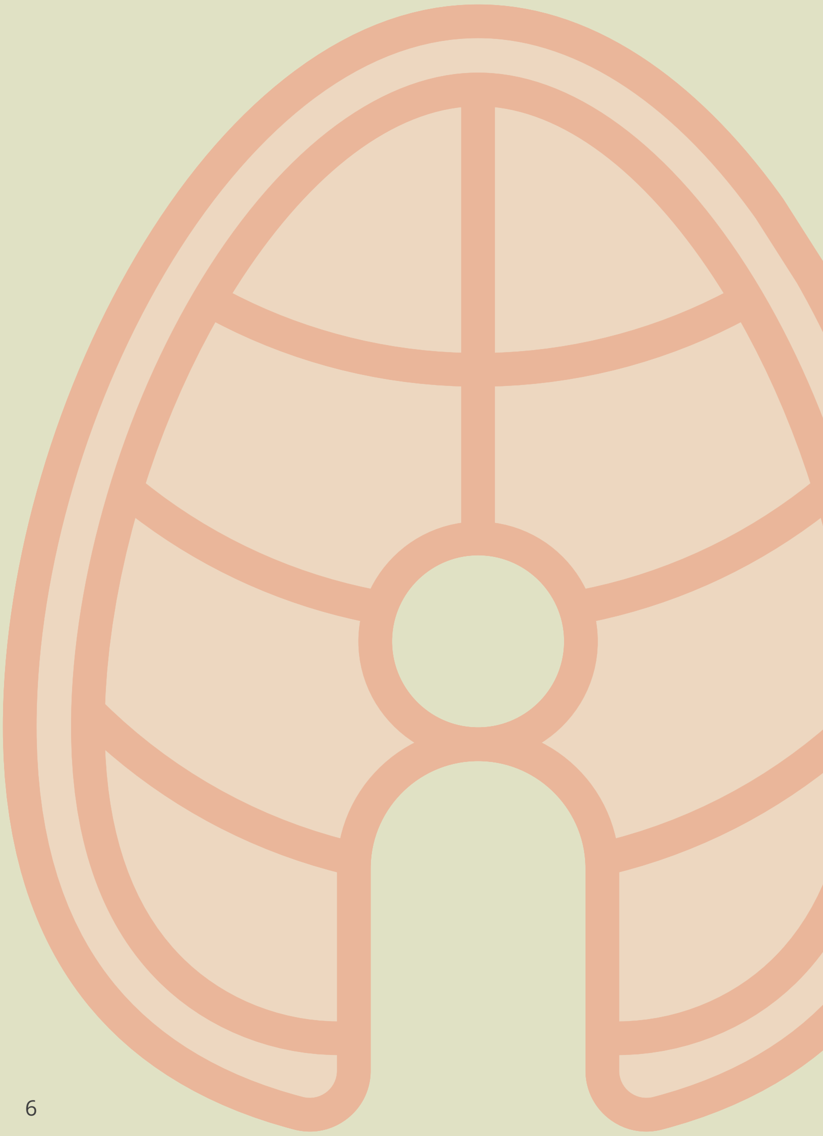
Nevertheless, the future seems clear – salmon farms will eventually need to expand beyond intensive coastal farms, either to off-shore closed containment systems where the biological constraints are reduced, or to high-tech inland recirculating aquaculture systems which are still in the experimental stage. Either option will entail substantial investment. Financing and operating the more expensive closed containment systems and recirculating aquaculture systems farms is one reason why salmon prices per kg are forecast to increase through to 2030.

So, while positive mid-term demand and higher prices may give the impression of a stable and profitable sector, the salmon farming industry will have to overcome some significant barriers in the medium term to transition from current coastal farms to innovative technological solutions, such as offshore farming, if it is to continue to increase production supply through to 2030.

Loch-ed Profits seeks to demonstrate to investors that investing now in making the industry more sustainable will stabilise mid-term operating cost margins enabling profitable growth to continue whilst mitigating environmental risks as the industry is looking to expand beyond coastal operations to install more onshore and offshore-farming capacity.

Mark Campanale – Founder, Planet Tracker

Loch-ed Profits seeks to demonstrate to investors that investing now in making the industry more sustainable will stabilise mid-term operating cost margins enabling profitable growth to continue whilst mitigating environmental risks as the industry is looking to expand beyond coastal operations to install more onshore and offshore-farming capacity.



Caution Required Over Coastal Global Growth Estimates

For over a decade the global farmed salmon industry has experienced significant sector and value growth. In 2018, industry production of farmed Atlantic salmon generated $18 billion in gross sales. Between 2009 and 2018, total global production volumes of Atlantic salmon increased by 64% at a compound annual growth rate (CAGR) of 5%. Converting this production into monetary terms, the economic value of the market grew during this period by 182% at a CAGR of 12%.[i]

This growth has not, however, been stable. Farmed salmon is a highly cyclical commodity industry with short-run elasticity of supply.[ii] This typically results in short term seasonal profits which have historically also been influenced by market price volatility and variable production losses.

Prior to the impact of COVID-19, forecast aggregated growth for the farmed Atlantic salmon industry was expected to continue at a CAGR of 2.2% through to 2028, according to the OECD, FAO and the World Bank.[iii]

By April 2020, as a result of the COVID-19 pandemic, reduced demand for farmed Atlantic salmon primarily from the restaurant and leisure industry resulted in a 14% decline in spot prices to under NOK60/kg on the NASDAQ Salmon Index year-to-date.[iv]

However, even before the effects of COVID-19, the upward trajectory in total industry revenue and production volume of farmed salmon was far from assured. Despite market demand outstripping supply from 2016 to 2019, prices during that period did not rise above NOK80 per kg - see Figure 1 and Figure 2.

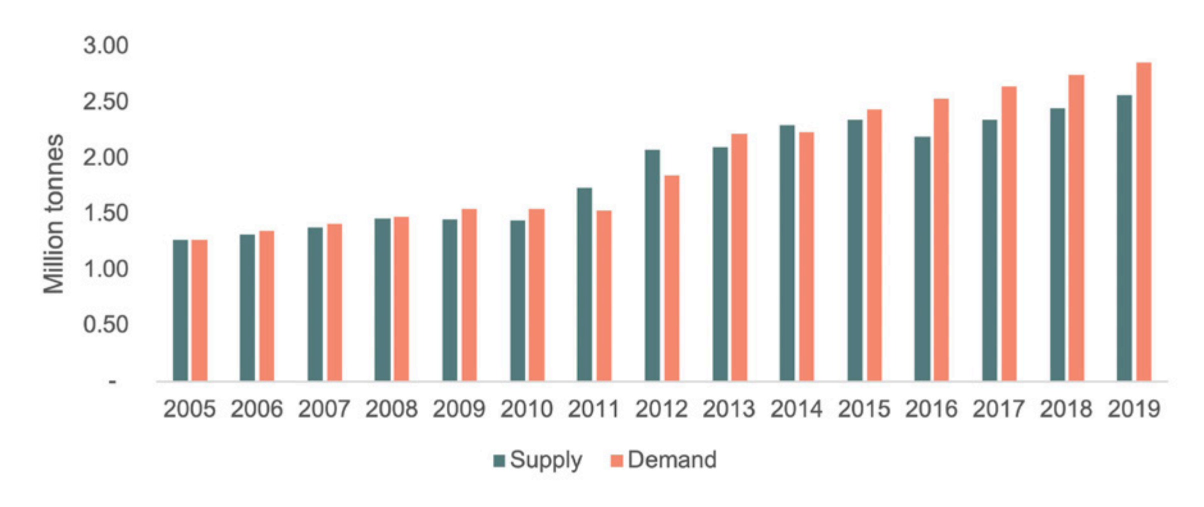


Figure 1: Market Supply and Demand, 2005 to 2019 [v]

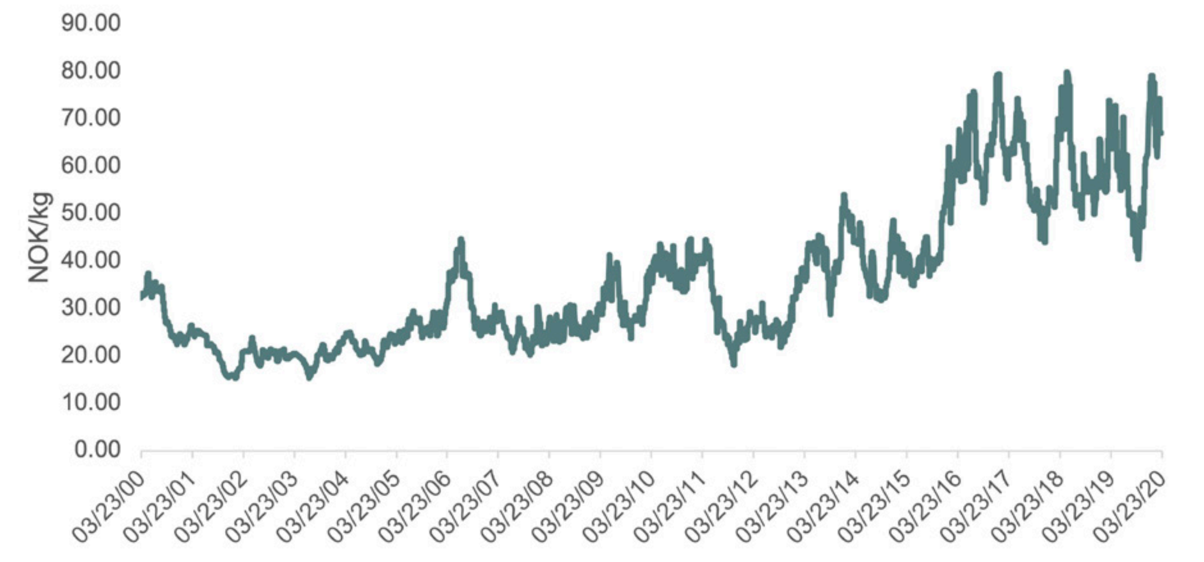


Figure 2: Daily NOK Spot Price Farmed Atlantic Salmon per Kg, March 2000 to March 2020 [vi]

Assuming a post COVID-19 market recovery in the short term, positive mid-term demand and higher prices may give the impression of a stable and profitable sector. The salmon farming industry will, however, have to overcome significant barriers in the medium term to maintain and potentially grow production from existing and new coastal sites.

Coastal open net pen (ONP) production of farmed Atlantic salmon in particular is under pressure. In 2016, over 95% of farmed Atlantic salmon production took place in ONP. ONP farms are found in coastal waters, including fjords and coastal lochs, and rely on the surrounding water currents to remove waste and provide oxygen. ONP siting means that waste, chemicals, parasites and disease from farming operations are freely dispersed into surrounding natural environments.

The increasing concentration of coastal ONP farms has increased the exposure of the salmon farming industry to growth-limiting factors including:

- Availability and suitability of coastal sites
- Environmental shocks (such as algal blooms, sea lice and disease)
- Biological problems resulting from intensive production
- Cost of developing innovative technologies

Short Term Implications of COVID-19

As a result of the 2009/10 global financial crisis, demand for salmon declined in 2010 and 2011 following consistent demand growth from 2005 to 2009 - see Figure 1. As a result spot prices fell in correlation from NOK45 to under NOK20 per kg in 2011 - see Figure 2.

The demand and supply trend inverted in 2011 and 2012 as supply exceeded demand, suppressing market prices. Companies were unable to reduce supply as smolts and salmon were already being farmed.

The same pattern is emerging in Q1 2020, where prices are falling as global farmed Atlantic salmon demand drops. Depending on recovery time post COVID-19, markets could see over supply in the short term (12-24 months), resulting in suppressed market prices for salmon, until demand recovers.

Environmental Shock-related Losses Correlate with Price Volatility

Farmed Atlantic salmon spot prices in NOK per kilogram have generally increased since 2015, when reported environmental constraint-based losses began to increase. Annualised spot price volatility, measured using standard deviation, more than doubled from 4.0 in 2015 to 9.0 in 2019 – see Figure 3.[vii]

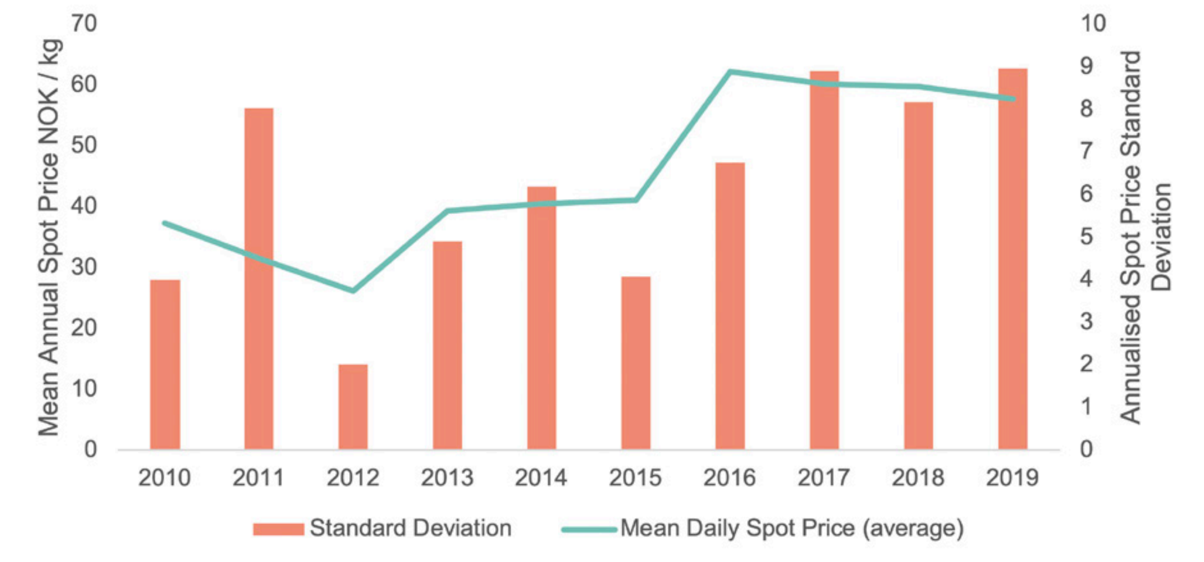


Figure 3: Mean Daily NOK Spot Price Farmed Atlantic Salmon Per Kg 2000 To March 2020[viii] & Annual Standard Deviation Daily NOK Spot Price Farmed Atlantic Salmon per Kg 2010 to March 2020 [ix]

Planet Tracker believes one factor driving increasing volatility is the rise in environmental constraints resulting in salmon losses. Based on data available in annual reports from the world's 10 largest publicly listed salmon producers, the volume and frequency of upstream production losses of farmed Atlantic salmon as a result of environmental shocks has increased post-2015. This data could be indicative of improved reporting, but strongly indicates that both the type and frequency of environmental constraint-based related losses is increasing – see Figure 4.

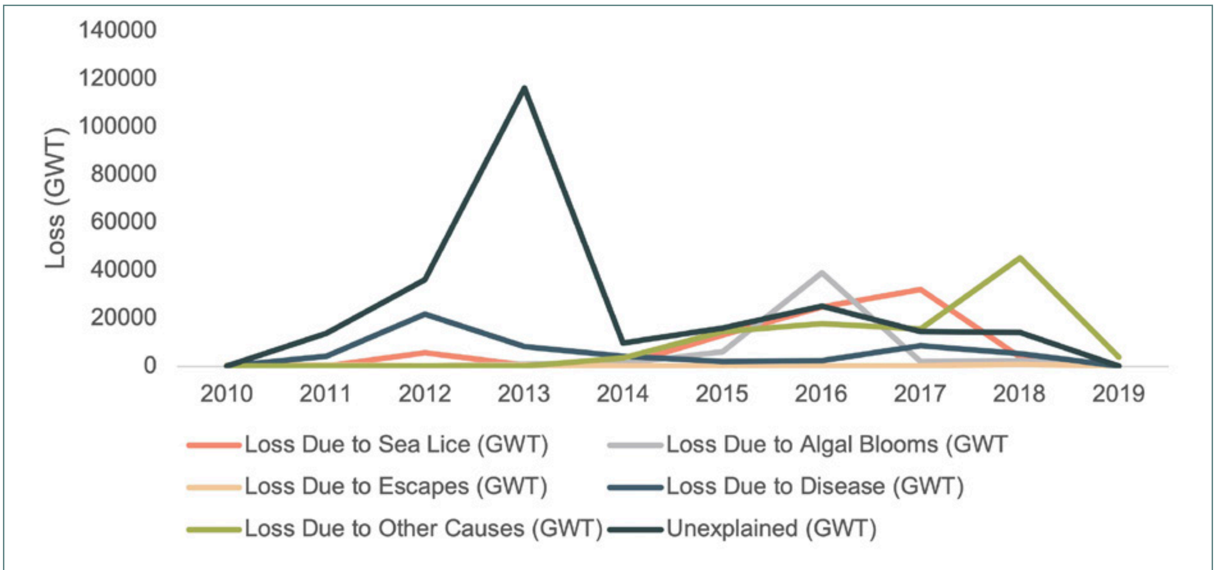


Figure 4: Reported Volume and Cited Cause of Farmed Atlantic Salmon Losses by 10 Leading Publicly Traded Salmon Companies 2009 to 2019 [x]

From 2010 to 2018, approximately 255,000 tonnes of reported farmed Atlantic salmon losses were listed as 'unexplained' or 'no reason given' in the annual accounts of the top 10 listed salmon producers globally. In 2013, where unexplained losses spiked (Figure 4) were primarily from Mowi (58,000 GWT) and Blumar (17,500 GWT). Planet Tracker urges 100% transparency in reporting and citing reasons for these losses by 2022.

Farmed salmon intensification is directly linked to increased incidences and severity of disease outbreaks, which is known as the monocultural effect.[xi] There are more than a dozen varieties of disease and parasites which have a material impact on salmon farming.[xii]

Research shows that as farmed fish densities increase, so does the rate of infectious diseases.[xiii] This means that disease in farmed salmon is a density-dependent constraint to population growth[xiv] and therefore acts as another limiting factor to coastal salmon aquaculture production.

Increasing production volatility due to disease, coupled with rising prices, is both a supply-side and demand-side risk. Producers are uncertain when to harvest farmed salmon due to seasonal harvest cycles, while consumers want consistent supply and pricing of salmon throughout the year.

Thus, these economic factors in the salmon market are being driven by the consolidation of upstream supply into fewer operating companies and the availability of suitable farming sites. This concentration restricts potential mitigation options within the industry to changing demand and spot pricing patterns.

In Chile, local socio-economic issues can arise as a result of salmon losses.[xv] Unemployment, loss of income and rising community debt within the farmed Atlantic salmon industry have been cited as contributing factors in the rise of community level exploitation of coastal fisheries, pollution and food insecurity. If salmon losses are concentrated to a small number of companies, the resultant relative unemployment rate can be significant for salmon farming communities.

Highly Concentrated Sector

The responsibility for delivering stable and sustainable production growth rests with a limited group of stakeholders. Atlantic salmon production is a highly concentrated industry. Just four countries - Canada, Chile, the United Kingdom and Norway - accounted for over 90% of all global farmed salmon production in 2017. Atlantic salmon, the focus of this report, is by far the dominant farmed species, accounting for over 92% of total production.

The top ten publicly traded farmed salmon companies, who together produce almost 50% of global farmed salmon, had an aggregated market capitalisation of $28 billion with more than $12 billion in revenue in 2018.[xiv]

Both the financial performance of these companies and, by extension, the significant environmental challenges they face such as climate change, disease, sea lice, harmful algal blooms and salmon escapes, have a material impact on the income and capital growth of their shareholders' investments.

Reflective of the concentrated group of public companies in the Atlantic salmon production industry, a relatively small number of private and institutional investors are considerably exposed to financial and environmental constraints.

The top 20 investors in the sector account for over $15 billion in holdings[xvii]

The importance of a concentrated investor group cannot be overlooked. Institutional asset managers in particular have a responsibility to their investors, including asset owners such as pension funds, to work with companies in ensuring long term sustainable industry growth that addresses issues such as disease resilience, site selection, technology type and operational resilience to climate change.

Due to fixed harvesting schedules to meet forecast demand and policies that restrict expanding production, companies are neither easily nor rapidly able to respond to changing market dynamics without regulator intervention relaxing industry restrictions such as maximum allowable biomass (MAB – the permitted volume of salmon production within a licensed farming concession).[xviii] This has occurred in Norway & Canada, for example, where MAB thresholds have been increased for 2020 in response to the COVID-19 pandemic.

The medium-term trend has shown that as prices increase and supply struggles to keep up, a "race to raise" and harvest salmon has occurred. When prices are volatile, farmers harvest salmon in fear that price volatility may continue – or drop – which is called a "race to raise".

By harvesting their production early, companies are unable to harvest this same production at a later date, which creates price volatility. For example, the average harvest weight of farmed salmon decreased by 4% between 2013 and 2016 compared to the period between 2005 and 2012. Similarly, the average growth cycle decreased from over 20 months to about 18 months over the same period for the same species of farmed salmon.[xix]

In other words, producers were harvesting salmon sooner as price volatility over the same time frame doubled.

To mitigate short-run price volatility and increase supply to satisfy growing demand (pre COVID-19) companies are looking to diversify production through rapidly developing alternative technologies.

Environmental Constraints are Driving Production Onshore and Offshore as Coastal Supply Stagnates and Demand Grows

The salmon industry is responding to strong market demand and coastal farming supply constraints by expanding global production through innovations in offshore, closed containment systems (CCS) and onshore recirculating aquaculture systems (RAS).

Utilising new technology, these systems are more expensive relative to current ONP and require higher capital and operating expenditure commitments.

In 2019, the Canadian Government issued cost-based data on the farmed Atlantic salmon aquaculture sector in British Colombia. The study assessed the capital and operating costs per kg of farmed Atlantic salmon comparing RAS and CCS technology. The analysis priced the total capital and operating cost per kg at a spread of NOK80 to NOK133 for RAS, and, NOK63 to NOK136 for CCS[1] – see Figure 5.

[1]FX Rate CAD NOK 6.65

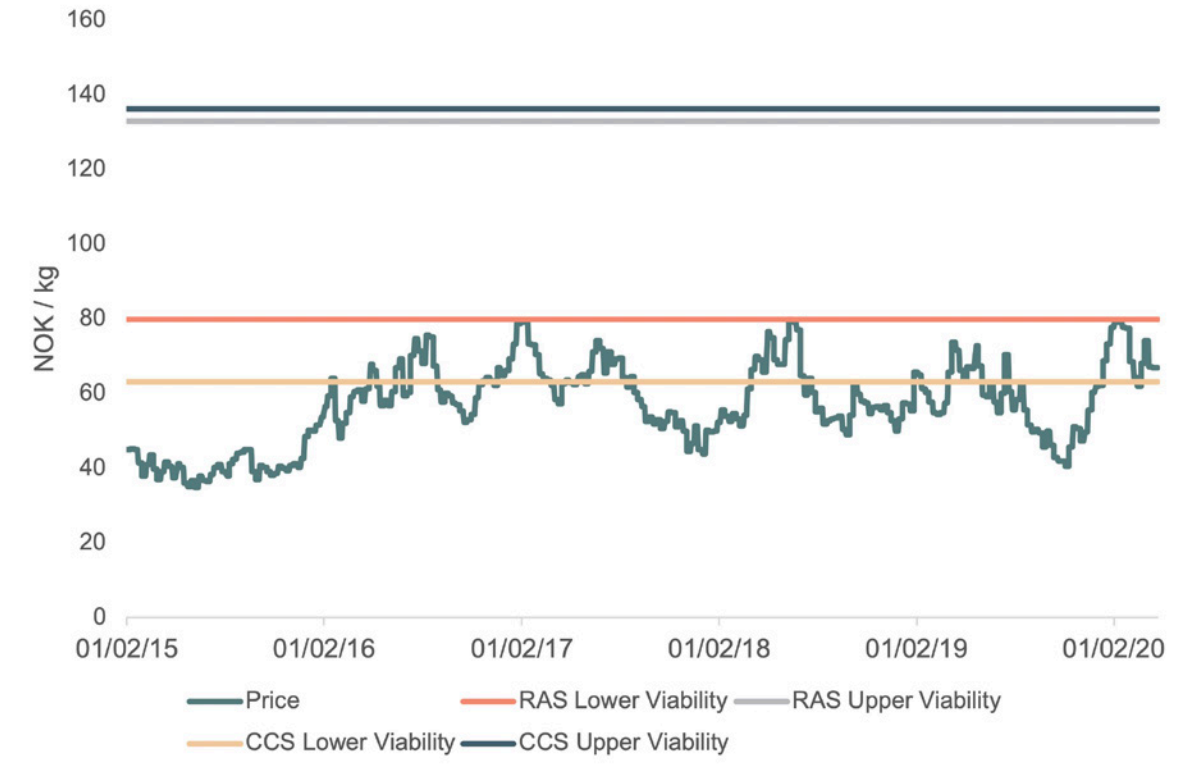


Figure 5: Canadian Government Capital and Operating Cost Estimates per Kg Farmed Atlantic Salmon in British Colombia 2019 [xx]

In the British Colombia context, this data suggests that in order for RAS to achieve a breakeven operating state, salmon prices need to stabilise at a lower estimate of NOK91 per kg. For CCS, the lower breakeven estimate price is NOK72 per kg.

Average farmed Atlantic salmon prices in 2019 were NOK58 per kg.

Despite market price pressures and early stage development challenges, particularly in scaling the technology, PwC projects that by 2050, 50% of all salmon production will take place inland using RAS or offshore in closed CCS systems – see Figure 6.[xxi]

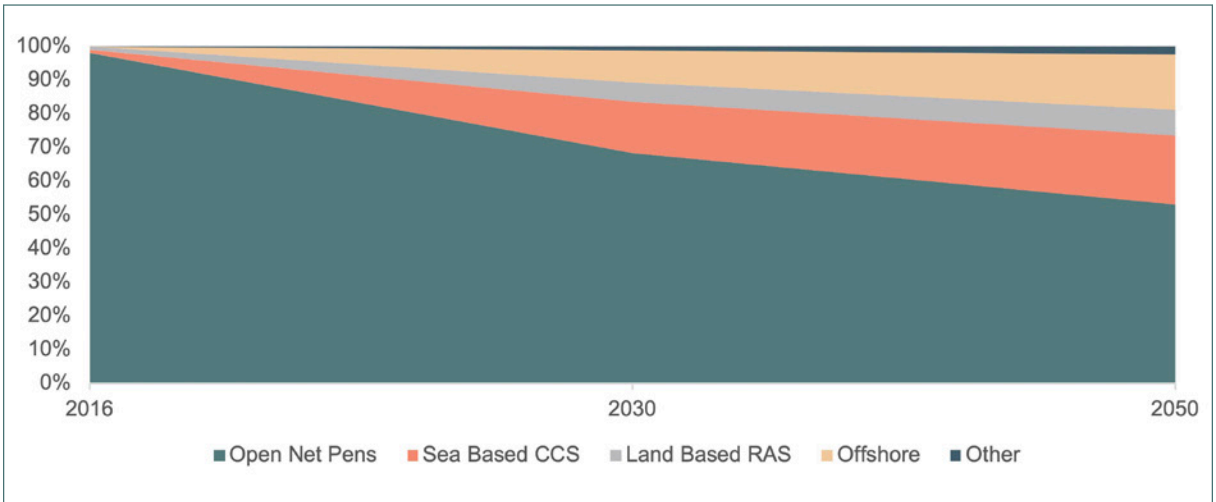


Figure 6: Projection of Salmon Production by Type to 2050 [xxii]

Financing and operating the more expensive CCS and RAS systems is one reason why salmon prices per kg are forecast to increase to 2030.

Unless the costs of production using these systems decrease, profit margins per kg produced using many CCS and RAS systems are simply not commercially viable at scale at current salmon prices.[xxiii]

Atlantic farmed salmon producers and their shareholders should therefore recognise that, at least in the short term, Atlantic salmon market spot and future prices do not support the rapid uptake of CCS and RAS technology by larger scale publicly listed producers.

As a result, ONP production will continue and will likely intensify. Norway, the United Kingdom and Canada have already loosened maximum allowable biomass restrictions as a result of Covid-19 related price pressures and worker travel restrictions allowing for greater intensification.

Investors should therefore price and monitor the potential increased environmental pressures these sites will come under and the related impact on production.

Satisfying Global Demand Requires CCS and RAS but Investors and Companies Should Remain Focused on Maintaining Stable Coastal Production Models

To ensure Atlantic salmon supply can meet demand from 2030 to 2050 the industry must achieve two basic targets. First, stabilise and aim to increase sustainable production on the finite coastal production sites that are available. Second, expand production capacity by building onshore RAS and offshore CCS systems.

Both of these targets will require the effective management not only of commercial costs and margins, but also of natural environments where farms are located. The medium-term commercial viability of both coastal and offshore sites will largely depend on the quality and effectiveness of such environmental risk management.

This paper highlights that, if environmental risks continue unmitigated, the production rates achieved at existing coastal sites may also fall relative to forecasts, in some cases negating the effect of new offshore production capacity coming on stream.

Investors should weigh the higher capital and operating expenditure and risks of offshore farming against the environmental risk mitigation benefits that new offshore technology can bring in reducing production losses. Conversely, these two risks – financial and environmental risks – when mitigated, may enable increases in capital value and earnings per share.

Company and Investor Recommendations

Farmed salmon companies by the end of 2020 should:

- **Industry guidelines:** Report on compliance with environmental regulations and industry guidelines such as the IFC's Aquaculture Environmental, Health and Safety Guidelines to highlight their environmental commitments to investors making them more attractive for investment.
- **Environmental and Social Management Systems (ESMS):** Maintain and report on an effective ESMS. Frameworks include the CDC ESMS Toolkit which also provides advice for investors to engage companies on integrating an ESMS. These frameworks should be auditable and published. ESMS reports should provide 100% citing of reasons for salmon losses. By improving audited environmental reporting companies can improve both risk management and mitigation and engage investors targeting the most sustainable companies in the industry.
- **Real-time reporting:** Deploy remote electronic monitoring systems with live data feeds accessible by investors. Transparent data monitoring may cover core environmental metrics such as water temperature, water quality, sea lice and disease, dissolved oxygen content and effluent control.
- **Research and Development:** Increase research and development spending on environmental risk mitigation such as disease and sea lice control measures. Investors have shown willingness to support research and development spend as highlighted by Mowi's 2020 Blue Revolution Plan.[xxiv]
- **Environmental Auditing:** Strengthen control of third-party independent audited transparency and traceability reporting for all feed sources.

Investors can by 2021:

- **ESMS improvements:** Require companies to present and publish effective ESMS which assesses factors such as reasons citing salmon losses, stocking rates, antibiotic use, effluent management including benthic recovery periods, feed components and water quality. Details within these reports can support investors in analysing company valuation, financial performance and risk exposure.
- **Environmental policies:** Push for assessments detailing chemical and antibiotic inputs into waterways and their origins to mitigate the incidence rates of harmful algal blooms and other problems. These assessments should relate to detailed company policies governing the use of inputs such as antibiotics and feed. Without this knowledge, investors are less able to forecast potential salmon losses resulting from these events, creating performance uncertainty.
- **Marine Spatial Planning:** Advocate for marine spatial planning to maximise sustainable farmed salmon production so as to mitigate environmental risks. This process may require companies to set science-based targets around environmental externality thresholds such as water quality, feed components, sea lice and Scope 1, 2 and 3 emission reporting. Investing in operations that adhere to scientifically-supported spatial planning are less susceptible to production loss risks highlighted in this report.
- **Standardised reporting:** Apply consistent methodologies, accounting standards (such as IAS 41) and reporting descriptions for both materialised environment related losses and stocking values. Standardised reporting would enable investors to better compare and benchmark the financial and operational performance of companies within their portfolios.
- **Loss logs:** Provide an update log of all salmon losses and account for the related financial costs.
- **Monitor environmental constraint losses:** Follow revised maximum MAB thresholds for 2020 post COVID-19.

SALMON PRODUCTION AND SHAREHOLDER OWNERSHIP HIGHLY CONCENTRATED

Country Concentration

In the global aquaculture market, Atlantic salmon is the second most commercially valuable farmed aquatic species after Whiteleg shrimp.[xxv] In 2018, over 2.4 million tonnes of farmed Atlantic salmon products were produced representing a market value of $18 billion, based on NASDAQ Salmon Index prices – see Figure 7.[xxvi]

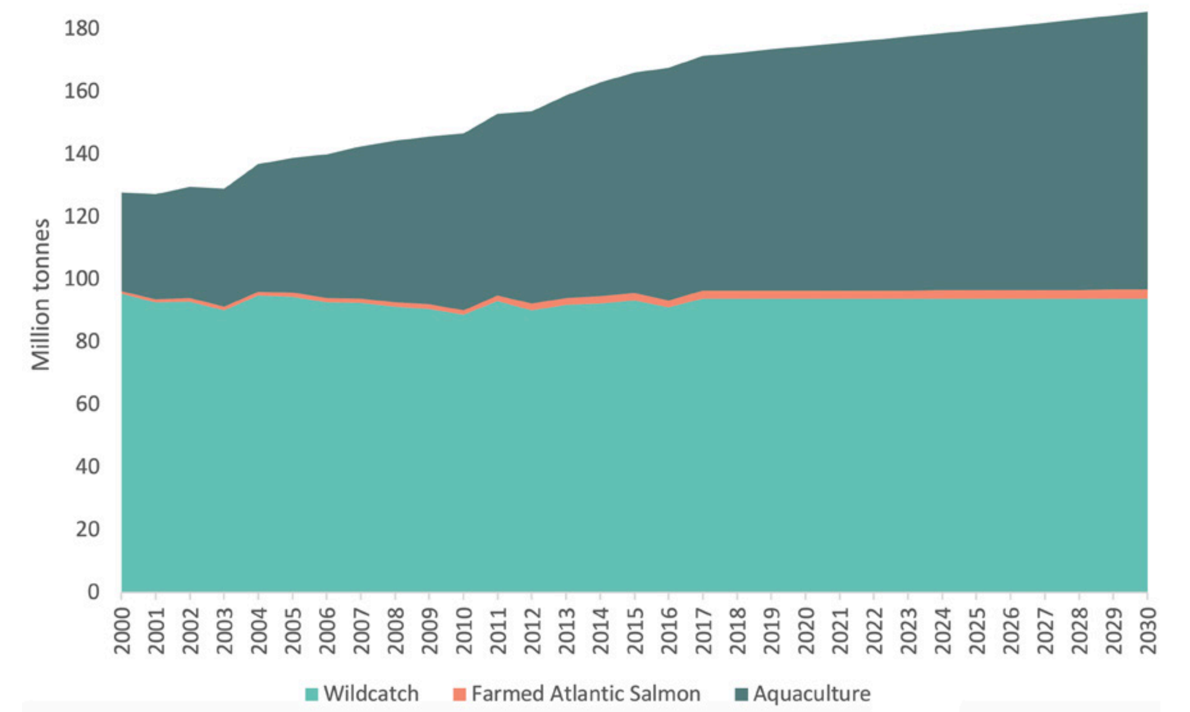


Figure 7: Production of Farmed Atlantic Salmon against Aquaculture and Wild Capture Fish for Human Consumption 2000 to 2025 [xxvii]

While farmed salmon can be sold fresh, frozen, filleted, smoked or cured, fresh whole farmed salmon accounts for 75% of global exports by value.[xxviii] Atlantic salmon is the most produced salmonid species by volume[xxix] and represented 4% of global aquaculture production in 2016.[xxix] Due to biological constraints, seawater temperature requirements and other natural constraints, farmed salmon is predominately produced in Norway, Chile, the United Kingdom (specifically Scotland) and Canada.[xxxi]

Farmed Atlantic salmon production is forecast to remain in line with global aquaculture industry growth until 2030.[xxxii] According to the FAO, Norway, Chile, the United Kingdom and Canada accounted for 92% of global farmed Atlantic Salmon production in 2017 – see Figure 8.[xxxiii]

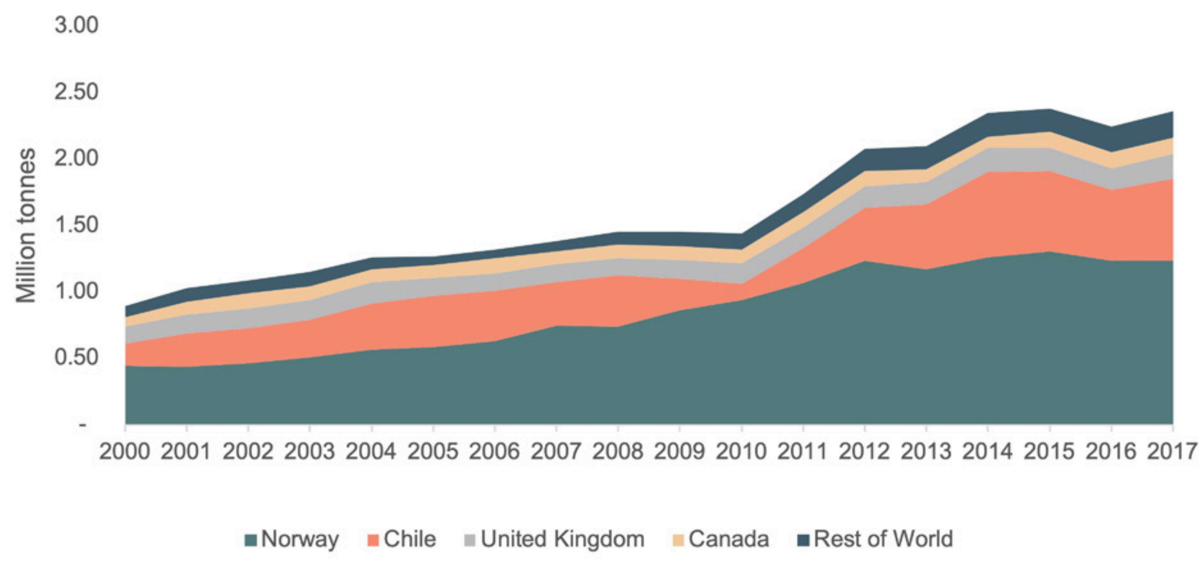


Figure 8: Farmed Atlantic Salmon Production, 2000 to 2017 [xxxiv]

Production Company Concentration

Atlantic salmon production is highly consolidated and mainly controlled by a small number of companies. Planet Tracker has assessed 21 public and private companies accounting for 74% of global farmed salmon production in 2018 – see Table 1.

The United Kingdom's farmed salmon industry is the most highly consolidated, with over 99% of production represented by only 5 companies, as reported by Mowi in 2019.

Table 1: Salmon Farming Companies [xxxv]

Company	% of Total	Company Type	Top 10 Producer in Country
Mowi	17.5	Public	Norway, Chile, United Kingdom, Canada
Cermaq	7.0	Private	Norway
SalMar	6.9	Public	Norway
Lerøy Seafood	6.7	Public	Norway
Grieg Seafood	3.6	Public	Norway, United Kingdom
Nova Sea	1.8	Private	Norway
Nordlaks	1.8	Private	Norway
Norway Royal Salmon	1.7	Public	Norway
Sinkaberg-Hansen	1.3	Private	Norway
Alsaker Fjordbruk	1.3	Private	Norway
Cooke Aquaculture	4.0	Private	United Kingdom
The Scottish Salmon Co.	1.5	Private	United Kingdom
Scottish Seafarms	1.3	Private	United Kingdom
"New Aquachile" (Agrosuper)	5.3	Public	Chile
Salmones Multiexport	3.1	Private	Chile
Blumar	2.3	Public	Chile

Company	% of Total	Company Type	Top 10 Producer in Country
Camanchaca	17.5	Public	Chile
Australis Seafood	7.0	Public	Chile
Ventisqueros	6.9	Private	Chile
Invermar	6.7	Public	Chile
Marine Farm	3.6	Private	Chile
Others (Norway)	1.8	Private	n/a
Others (Chile)	1.8	Private	n/a
Others (United Kingdom)	1.7	Private	n/a
Others (North America)	1.3	Private	n/a
Total	**100**		

Ten publicly traded farmed salmon companies with a total market capitalisation of $28 billion and combined 2018 revenue of $12 billion accounted for nearly 50% of salmon production in Norway, The United Kingdom, Chile and Canada.[xxxvi] These ten farmed salmon companies' market-weighted P/E in 2018 was 14.5x compared to their International Food and Beverage peer group, who had a P/E of 19.5x [xxxvii] – see Table 2.

Table 2: Top Ten Farmed Salmon Equities 2018 Financial Performance.[xxxviii]
**EV/EBIDTA and P/E ratio totals are weighted by market capitalisation*

Company	2018 Revenue (USD Million)	2018 Market Capitalisation (USD Million)	EV/EBITDA	2018 P/E Ratio
Mowi	4,502	12,859	9.2	15.9
SalMar	1,395	5,173	10.4	13.5
Lerøy Seafood	2,783	1,931	7.3	9.4
Grieg Seafood	922	1,683	8.5	11.6
Norway Royal Salmon	625	1,096	12.7	11.7
Bakkafrost	504	3,901	11.6	16.0
Blumar	503	410	4.8	7.5
Camanchaca	332	432	8.4	13.9
Australis Seafood	361	827	11.7	18.8
Invermar	230	253	4.2	10.4
Total	**12,157**	**28,566**	**9.6***	**14.5***

**See Appendix A for ISIN and Bloomberg identification codes; and, Appendix B for detailed company finance performance*

Investor Concentration

Shareholder ownership in these companies is also highly concentrated. The top 20 investors in the sector account for over $15 billion in holdings – see Table 3.

Table 3: Top 20 Investors in Salmon Farming Equities Presented as of 6th February 2020[xxxix]

Investor	Market Value (USD Million)
Gustav Witzoe	2,934
Folketrygdfondet	2,128
Austevoll Seafood	2,026
John Fredriksen	1,786
Grieg Family	857
Legend Holdings	805
DNB Asset Management	607
Vanguard	543
Compania Pesquera Camanchaca	384
Storebrand Asset Management	370
BlackRock	351
Johan Regin Jacobsen	337
Handelsbanken Fonder	336
Oddvor Jacobsen	336
KLP Kapitalforvaltning	333
Canada Pension Plan Investment Board	277
Alfred Berg Kapitalforvaltning	265
APG Asset Management	253
Henderson Global Investors	252
NNIP Advisors	214
	15,396

The top 10 publicly traded companies display high investor concentration risk as they are majority owned by a small number of private individuals and companies. 45% of share ownership across these companies is held by private individuals or private equity, with only 31% controlled by institutional investors – see Figure 9

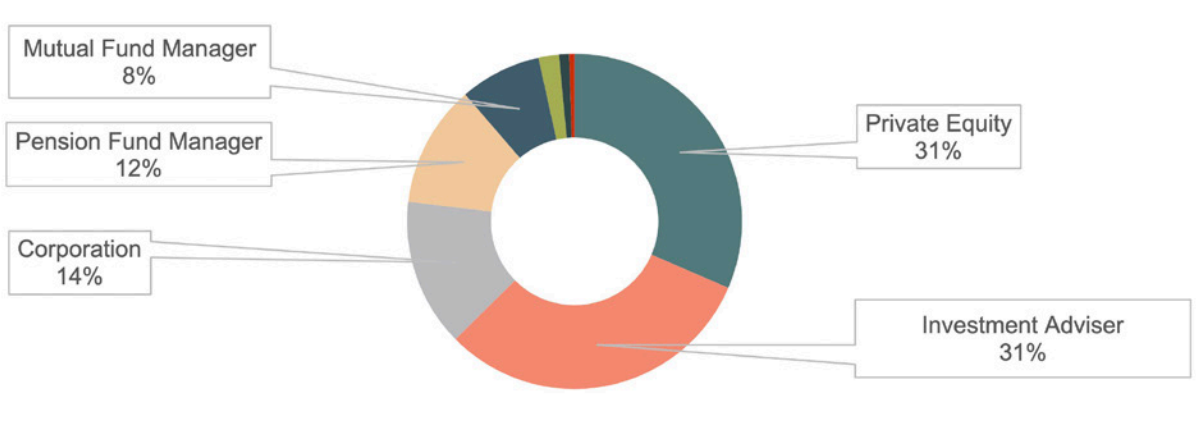


Figure 9: Top Ten Farmed Salmon Equities' Shareholder Categories [xl]

Private investors have large ownership positions in farmed salmon. This means that they are highly exposed to farmed salmon production shocks, price and operating margin volatility – see Table 4.

Table 4: $5 Billion Concentration Risk in Three of Ten Farmed Salmon Companies, February 2020 [xli]

Company	Investor	Shareholder Concentration	Total (USD Millions)
Salmar	Gustav Witzoe	52%	2,934
Lerøy Seafood	Austevoll Seafood	53%	2,026
Grieg Seafood	Legend Holdings Corporation	95%	805
			5,765

FARMED SALMON PRICE VOLATILITY AND ELASTICITY

An analysis of the farmed Atlantic salmon market, using Norwegian production and pricing and export data together with the Fish Pool Index™ (FPI)[3], shows a market with a short-run elasticity of supply (how quickly producers can harvest in response to changing demand) dominated by growing price volatility.[xlii]

While both salmon prices in NOK per kilogram and salmon's annualized price volatility, described as the standard deviation of price log-returns, have increased since 2010 (see Figure 10 showing the trends since 2010), salmon's annualised price volatility has more than doubled from 15% to 35% from the mid-2000s to the present day.[xliii]

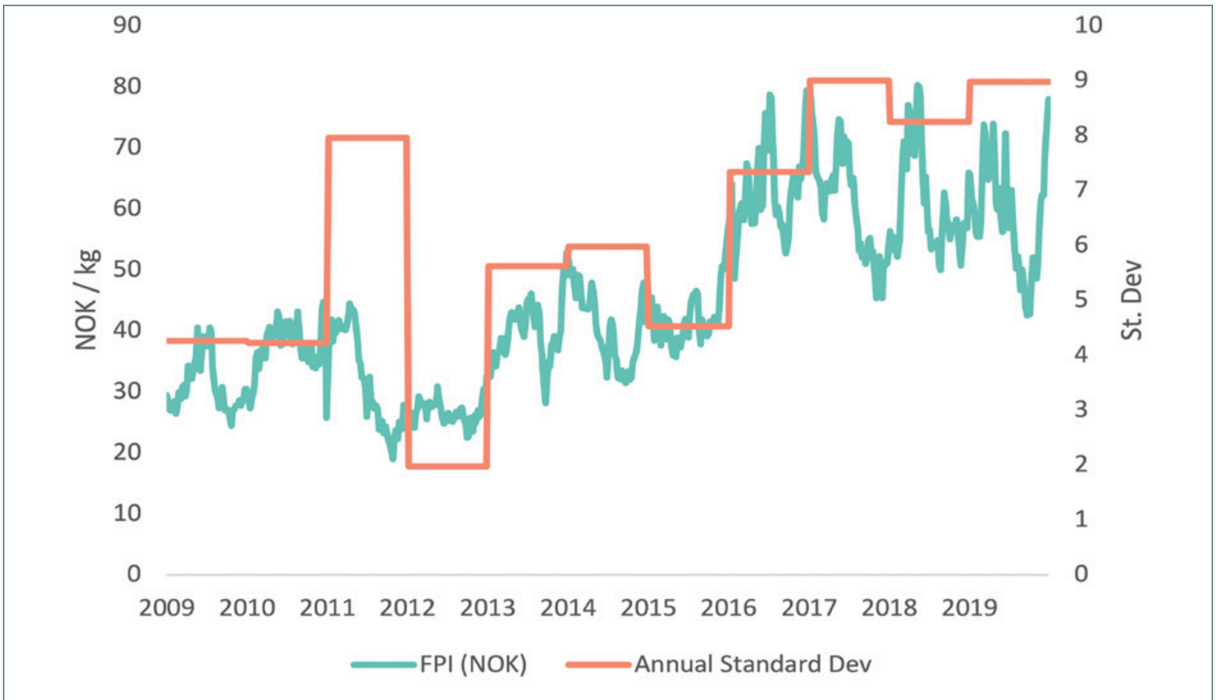


Figure 10: Daily Spot Price farmed Atlantic Salmon

Increasing prices coupled with simultaneously increasing volatility presents both a supply-side and demand-side risk. Driving factors behind these risks, rising volatility and short-run elasticity include:

Industry Company Consolidation

Just four countries - Canada, Chile, the United Kingdom and Norway - accounted for over 90% of all global farmed salmon production in 2017. Within these markets the top ten publicly traded farmed salmon companies collectively produce almost 50% of global farmed Atlantic salmon.

Farmed Atlantic salmon at commercial scales is an industry characterised by a limited number of farming regions within which are a concentrated group of major producers operating at near full capacity.

[3] The FPI is the index used to create The Monthly Settlement Price (MSP) which is the benchmark for all financial contracts traded at Fish Pool, as Fish Pool on the Oslo Børs does not trade physical fish.

Without more diversity in terms of farming regions, methods of production and number of producers, any demand, price or supply volatility in the market is therefore concentrated to a relatively small group of producers which increases systemic risk – events with a market wide impact. This dynamic also works to concentrate investor capital risk to systemic events impacting these limited number of producers and regions.

Limited Number of Farming Licences and Maximum Allowable Biomass Thresholds

Strict industry regulations, such as MAB and the limited number of available farming licences, means that producers are not able to respond rapidly to changing short term market dynamics such as the 2008/9 financial crisis or 2020 Covid-19 demand declines.[xliv]

With only a limited number of producers concentrated in a few countries and at licensed MAB restricted sites, supply risks are high. Simply, producers are not able to rapidly cut short term production when demand falls as the salmon are already in the pens, nor increase production when demand spikes as MAB limits apply. Current salmon production models are not able to adapt rapidly in the short term resulting in low short-run elasticity.

Across the mid- to long- term, production expansion by building new capacity is a limited option for addressing demand increases. For example, from 2011 to 2016, Norway added no new salmon farming licences due to environmental policies with all existing licenses fully subscribed. This acts as a barrier to entry for new companies to access the market at scale exacerbating company consolidation within the Norwegian industry.

These factors support short-run elasticity of supply as, with salmon already in pens, producers cannot withhold supply from the market across extended periods. Firstly, salmon weights increase and the feed, antibiotic and operating costs of keeping salmon in pens reduces profit margins if market prices are low. Secondly, salmon producers risk breaching MAB thresholds if salmon are held in pens for too long gaining weight.

Therefore, whilst demand and price volatility driven by markets can be high, short-run supply elasticity for the industry is low. The result is that companies are less nimble and are therefore more financially and operationally at risk to short term demand and spot price fluctuations. One option for producers to mitigate these risks is to harvest salmon earlier in the growing cycle as described below.

Fixed Seasonal Harvesting Schedules

The farmed salmon industry is supercyclical. One reason is the fixed harvesting schedules where producers have a limited period to harvest farmed salmon due to seasonal harvest conditions. While consumers want consistent supply and pricing of salmon throughout the year, production limitations create spikes and troughs in supply between harvesting schedules.

The FPI, used by farmed salmon producers to forecast future demand, is based on aggregated neutral and verifiable prices that accurately reflect sentiment in the spot and futures market alongside prices and volatility.[xlv] FPI prices have increased from a daily average of NOK 26 in 2012 to NOK 58 in 2019, while volatility has also increased – see Figure 11

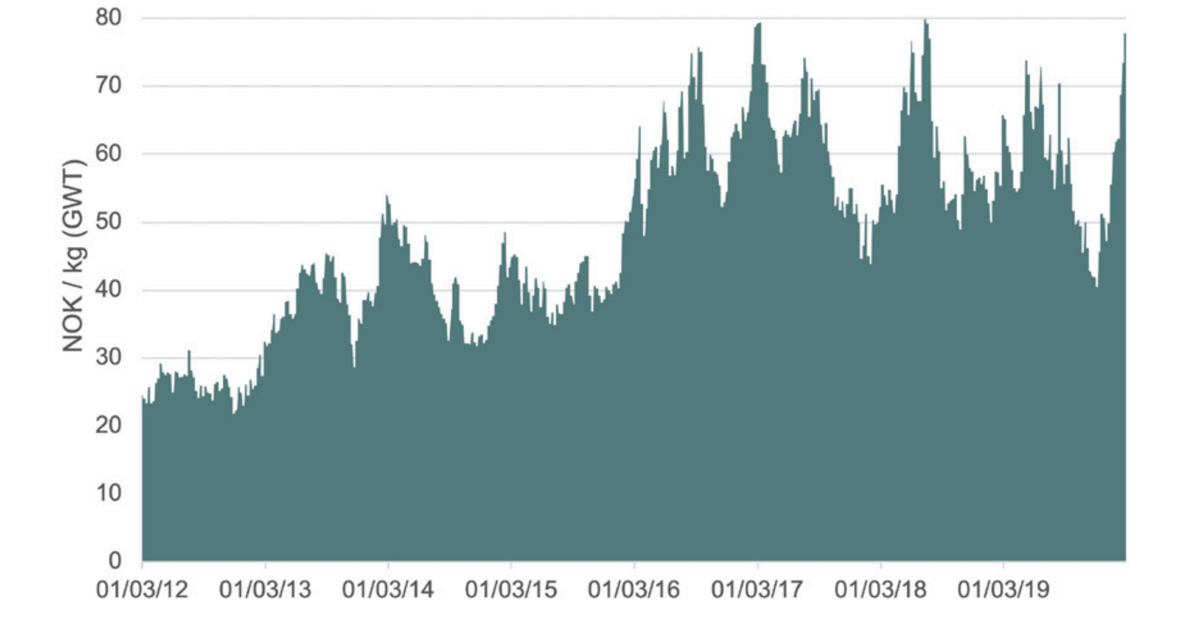


Figure 11: Daily Fish Price Index Spot Price in NOK, January to December 2012 and 2019 [xlvii]

Between 2016 and 2019, as annual average farmed Atlantic salmon prices have increased, supply has struggled to keep up with demand especially outside of the harvesting season, particularly when forecast supply requirements coincide with large scale losses in the industry, for example as a result of algal blooms or water temperature related losses.

When farmed Atlantic salmon prices are volatile, farmers harvest salmon in fear that price volatility may continue – or drop – which is called a "race to raise" [xlvi] – see Figure 12. This often occurs in supercyclical commodity markets where producers do not expect high prices to stay constant so they maximize profits by harvesting as quickly as they can.

Figure 12: Average Spot Price Difference for Variable Harvest GWT [xlviii]

One production response has been to harvest salmon earlier in the growing cycle. The average harvest weight of farmed salmon was 4.85 kilograms between 2013 and 2016, a decrease of 4% from 5.05 kilograms between 2005 and 2012 – see Figure 13. Similarly, the average growth cycle decreased from over 20 months to about 18 months over the same period for the same species of farmed salmon.

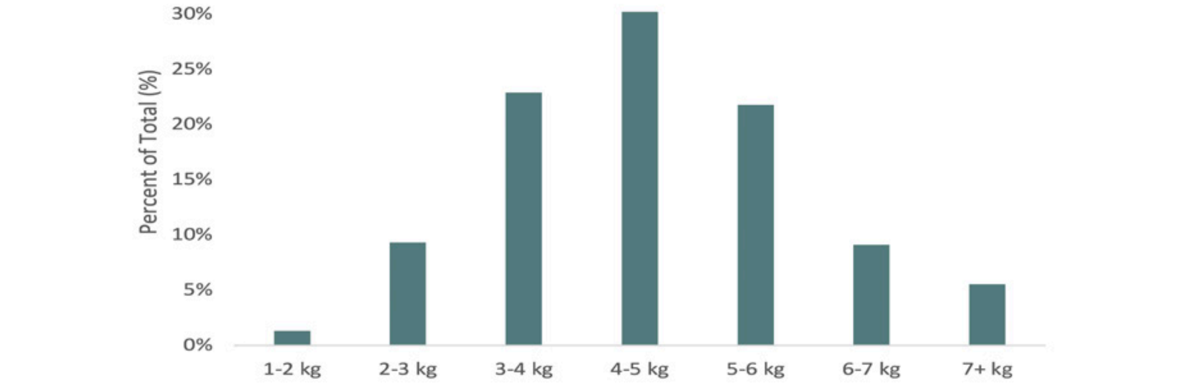


Figure 13: Norwegian Harvest Distribution 2012 to 2018 [xlix]

By harvesting earlier, producers are able to partially address the risks of breaching MAB thresholds. If they harvest later, they face being forced to harvest larger weight salmon when market prices could be lower. Shorter production cycles mean lower weight harvested salmon, again resulting in short-run elasticity of supply which drives increasing price volatility.

As currently constituted, the farmed salmon industry is too consolidated both in terms of the number of producers and MAB permitted under existing licences across the major producing countries. Increasing production capacity for the industry as a whole would alleviate some demand and price elasticity volatility in this supercyclical market. However, for reasons explained in this report, such as the current commercial viability of new technologies, new large-scale capacity is not forecast to be available in the short term.

According to Asche, Misund and Oglend, compared to a basket of agriculture commodity spot prices, using the Goldman Sachs Commodity Spot Index (GSCI)[l] as a benchmark, salmon price volatility has outpaced global agriculture price volatility, which has decreased from 23% between 2000 and 2003 to 19% between 2013 and 2016, while in the same period farmed salmon price volatility has doubled as the market is supercyclical [li,lii] - see Figure 14.

Figure 14 : Volatility of GSCI Sub-indices – Agricultural Products – SPGSAG (wheat, red wheat, corn, soybeans, cotton, sugar, coffee, cocoa; Livestock – SPGSAL (live cattle, feeder cattle, lean hogs); and Salmon – SALM-FDS [liii]

The impact on an increasingly consolidated farmed salmon industry is that volatility in prices is increasing, while agriculture commodities overall see price volatility decreasing.

EXPECTATIONS FOR INDUSTRY GROWTH

Supply of Atlantic salmon increased by 64% between 2009 and 2018 at a CAGR of 5%. Continued aggregated global industry growth is expected, but at more modest rates than before, with separate research from Mowi and Kontali Analyse, a global research reference on aquaculture & seafood, forecasting a CAGR of 4% for the industry from 2018 to 2022 – see Figure 15.

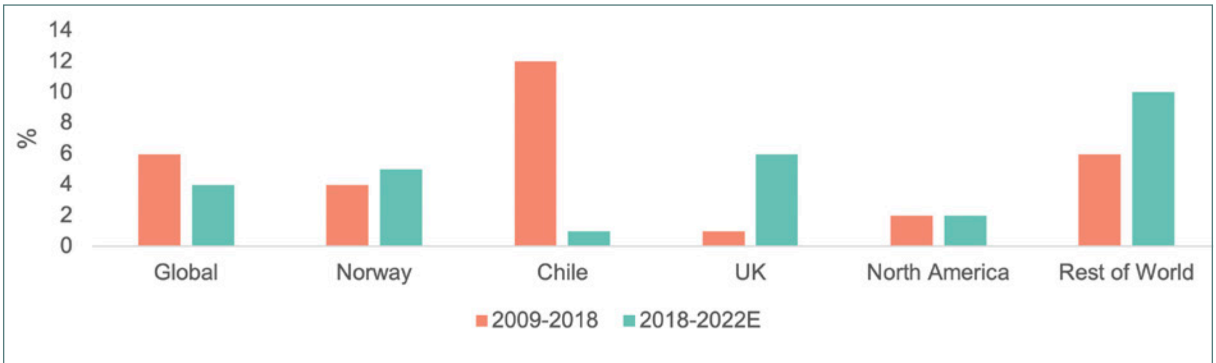


Figure 15: Expected Change in Salmon Supply, 2009 to 2022 [liv]

Atlantic salmon production reached approximately 2.6 million tonnes by the end of 2019, up 7% year-on-year, with a further 3.5% increase expected in 2020.[lv]

In China, Cermaq (owned by Mitsubishi Corporation) expects demand for up to 200,000 to 400,000 tonnes of salmon annually by 2025.[lvi]

These growth expectations may, however, be lower in reality, as they are dependent on securing availability of supply and stable global salmon prices. Securing stable supply has been an issue for the industry over the past decade where the top 10 publicly traded salmon farming companies have cited environmental risks as direct causes of earnings and production losses. Collectively, they experienced environmental shocks between 2010 and 2019, resulting in aggregated production losses of 291,000 tonnes with a market value of $1.8 billion – see Figure 16.

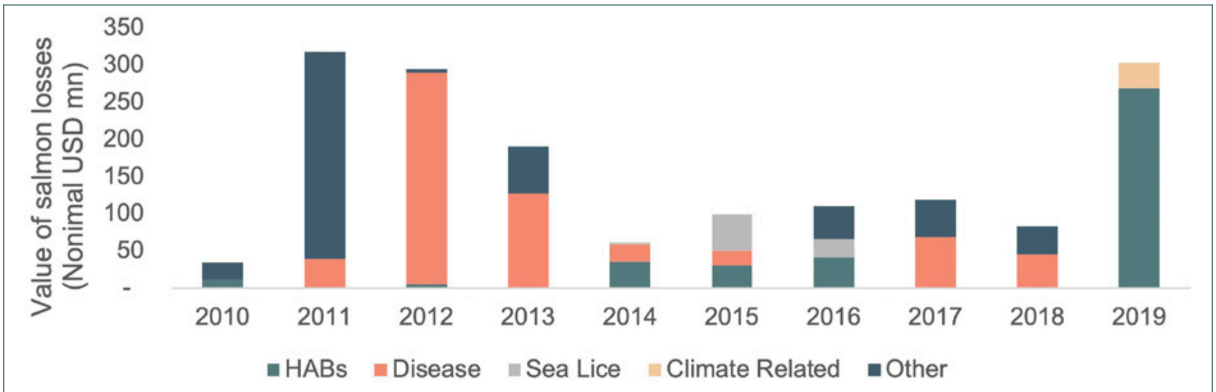


Figure 16: Farmed Salmon Companies' Earnings Losses from Environmental Risks, 2010 to 2019* [lvii]

**As of December 2019, effects of the 2019 El Niño had not yet been reported by these publicly listed companies.*

The cases of Mowi (see Figure 17), Norway Royal Salmon (see Figure 18) and Grieg Seafood (see Figure 19) illustrate how companies are underperforming in terms of year end actual versus year start forecast production partially as a result of these constraints:

MOWI ASA

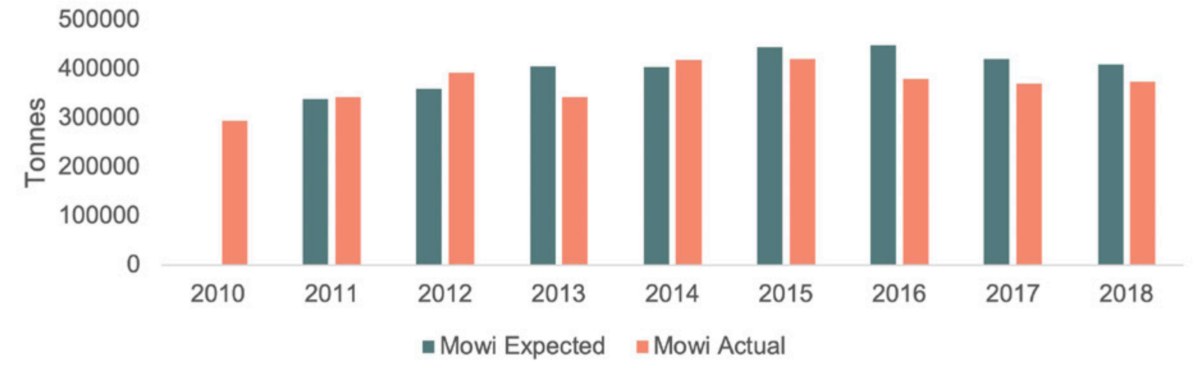


Figure 17: Mowi ASA Actual Versus Forecast Production 2010 to 2018

NORWAY ROYAL SALMON

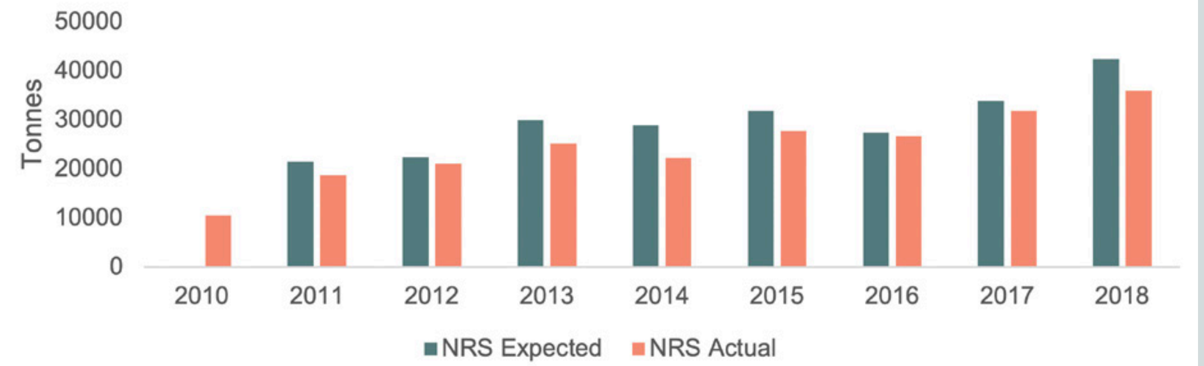


Figure 18: Norway Royal Salmon Actual Versus Forecast Production 2010 to 2018

GRIEG SEAFOOD

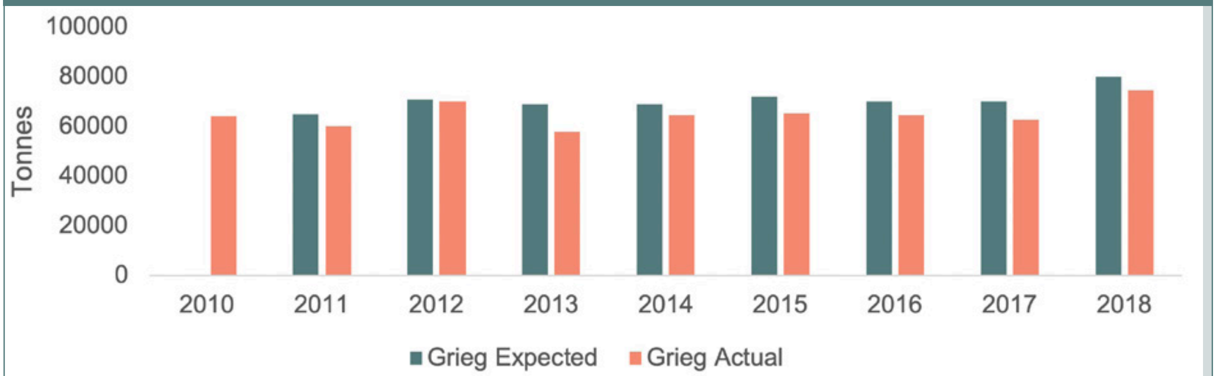


Figure 19: Grieg Seafood Actual Versus Forecast Production 2010 to 2018

The environmental and other factors are likely to limit any dramatic expansion of coastal aquaculture capacity in the near to medium term are presented in Table 5 below – See Appendix C for detailed descriptions of these environmental constraints.

Table 5: Environmental Factors Influencing Ffarmed Atlantic Salmon Production

Production Constraint	
Maximum Allowable Biomass	The total coastal area suitable for salmon farming is constrained by abiotic factors, such as temperature, while maximum yield is constrained by biotic factors, such as effluent discharge. To address this, industry regulators have set defined production thresholds. Maximum Allowable Biomass is a regulation applied by governments and enforced by fisheries' regulators to salmon farming, limiting the total maximum mass of fish allowed on a farm at any one time. Currently, total farmed Atlantic salmon production is close to reaching existing MAB limits in Norway. In 2018, maximum biomass observed in Norwegian salmon farms was utilising 91% of the regulated limit and averaged 85% usage of allocated biomass throughout the year.
Limited Suitable Coastal Land	Identifying new coastal sites with correct conditions for farming salmon and which have not yet been farmed remains a barrier to significant growth in production capacity for coastal open pen systems. Condition factors include water temperature, consistent water flow, biological parameters and political willingness.
Regulatory Pressure	By 2030, it is expected that the regulatory pressure on salmon farming will increase. A list of the current regulations affecting salmon farming can be found in Appendix D.
Climate Change	The optimal temperature range for farmed salmon is 8ºC to 14ºC. Climate-related biological limits are expected to become more restrictive through to 2050 due to warmer seas. Warmer seas reduce the suitability of current aquaculture sites and lead to increased incidences of disease, sea lice and harmful algal blooms. Water temperature increases are therefore material to investors.
Disease	Farmed salmon intensification is directly linked to increased incidences and severity of disease outbreaks, which is known as the monocultural effect.[lviii] Research shows that as farmed fish densities increase, so does the rate of infectious diseases.[lix] This means that disease in farmed salmon is a density-dependent constraint to population growth [lx] and therefore acts as another limiting factor to coastal salmon aquaculture production. Disease and parasite transfer from farmed to wild fish together with the negative effects of genetic introgression between escaped fish and wild, can also reduce the health of wild salmon populations.

Production Constraint	
Sea Lice	Sea lice are the most damaging parasite in the farmed salmon industry.[lxi] In the United Kingdom, the annual costs associated with treating sea lice are about $31 million. Globally, the annual cost is more than $290 million.[lxii] Sea lice are also a density-dependent constraint to salmon farming.[lxiii] Current technological practices dictate the ability to control sea lice infestations and therefore create a maximum production ceiling for coastal salmon farming.
Harmful Algal Blooms	Salmon farms contribute to the organic matter deposits in waterways.[lxiv] Higher organic matter concentrations are correlated with more intense and frequent harmful algal blooms (HABs).[lxv] In 2016, an algal bloom in Chile caused the worst case of mass mortality of fish and shellfish recorded in the coastal waters of western Patagonia. This die-off reduced Chilean salmon production by 12% and caused $800 million in economic losses.[lxvi] By Q2 2019, HABs in Norway killed 11,600 tonnes of salmon with kill estimates of 40,000 to 45,000 tonnes for 2019 – equal to approximately $223 million of lost revenue. [lxvii]
Feedstock Transition	The salmon farming industry is still reliant on essential fish-based proteins which threaten to reduce the profitability of the salmon industry as wild stocks collapse and wild fish prices rise. In 2018, salmon feed accounted for 10% of the global aquaculture feed market. Feed is the largest cost component in farmed salmon production. In 2017, for example, feed constituted 43% of Mowi Norway's total production costs.[lxviii] Feed supply and price volatility can therefore have a significant impact on the financial performance of farmed Atlantic salmon producers. For example, wild fishery collapses lead to low forage fish harvests causing the price of fish oil to increase.[lxix]

Planet Tracker estimates, as highlighted in our 2019 paper Salmon Feels the Heat, that if historic trends continue and coastal ecological health continues declining, total production forecasts for coastal farmed Atlantic salmon to 2025 may be 6% to 8% lower than predicted, equivalent to $4.1 billion, due to worsening environmental factors and constraints listed in this report.[lxx]

PRODUCTION EXPANSION TO OFFSHORE AND ONSHORE SYSTEMS

A study by PwC projects that by 2050 half of all farmed salmon production will occur offshore or in closed systems [lxxi] – see Figure 20.

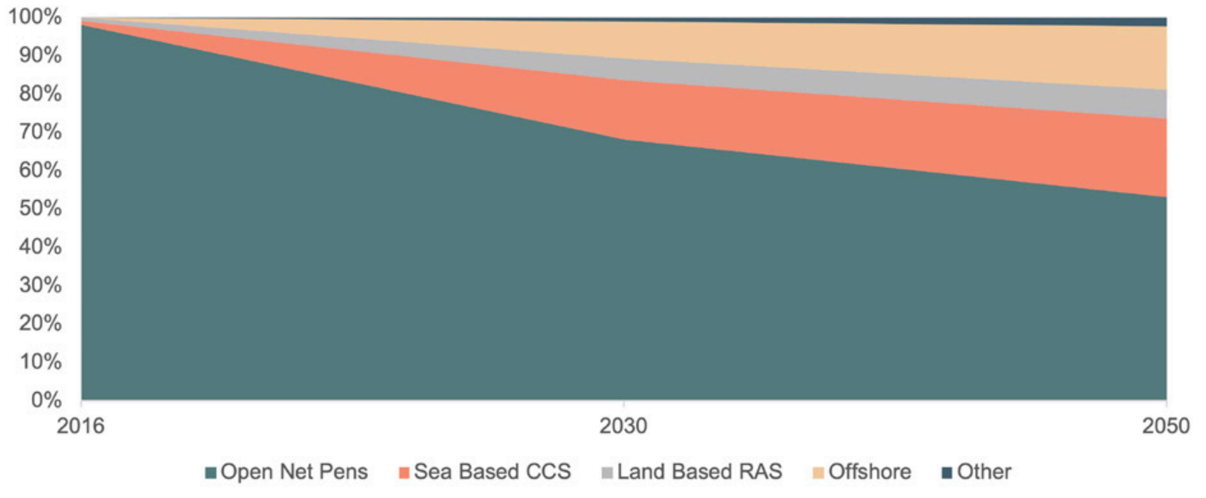


Figure 20: Projection of Salmon Production by Type to 2050 [lxxii]

There are currently three distinct technologies being developed supporting expanded onshore and offshore production - *s*ee Appendix E comparing the operating, production and economic performance of these systems:

Offshore salmon farming involves relocating cages into open ocean, known as exposed sites. SalMar owns the world's first offshore farm with a total estimated overall investment cost of $233 million.[lxxiii] Due to isolation and fast currents, offshore farms can sustain much higher MAB tolerances than sheltered farms.

Sea-based Closed Containment Systems (CCS) are floating, enclosed farms within the open sea rather than coastal areas. They are designed to be "escape proof" as well as preventing sea lice, by using water at depths in which the parasite cannot survive. Mowi has received licences to develop the concept but it is proving difficult to develop at scale.[lxxiv]

While exposed sea-based sites disperse effluent and decrease sea lice risk, they are more exposed to higher kinetic energy from waves and currents, putting farming equipment and salmon stocks at risk. Greater wave action and salinity levels generally increase the rate of wear on salmon farm equipment resulting in higher maintenance and replacement costs relative to sheltered coastal sites. Climate change can increase tidal flows and velocities, increasing the likelihood of equipment failure leading to fish escapes.

Recirculating Aquaculture Systems (RAS) are land-based farms. Benefits include siting production in dense human population areas, such as cities, reducing transport costs. Grieg Seafood has backed the first RAS system for Atlantic salmon in Japan.[lxxv]

Salmon farm fish escapes decrease profitability as less salmon are harvestable, while escapes are accompanied by fines as a result of increased regulatory reviews. In 2018, 680,000 fish escaped from Mowi's Chilean Punta Redonda farm resulting in Mowi being fined $7 million.[lxxvi] A 6% recapture rate, well below the industry 10% threshold, led to speculation that Mowi could lose its concession.[lxxvii, lxxviii] Relocating production to RAS and closed containment systems offers similar benefits to offshore farming, with lower risk of escapes. However, higher capital expenditure is required to build and maintain RAS and closed containment systems. If compromised, these sites incur similar disease risks to coastal sites.

Historically there has been a strong correlation between supply and price for farmed salmon sourced from coastal farms. As supply increases, prices have tended to decrease – see Figure 21.

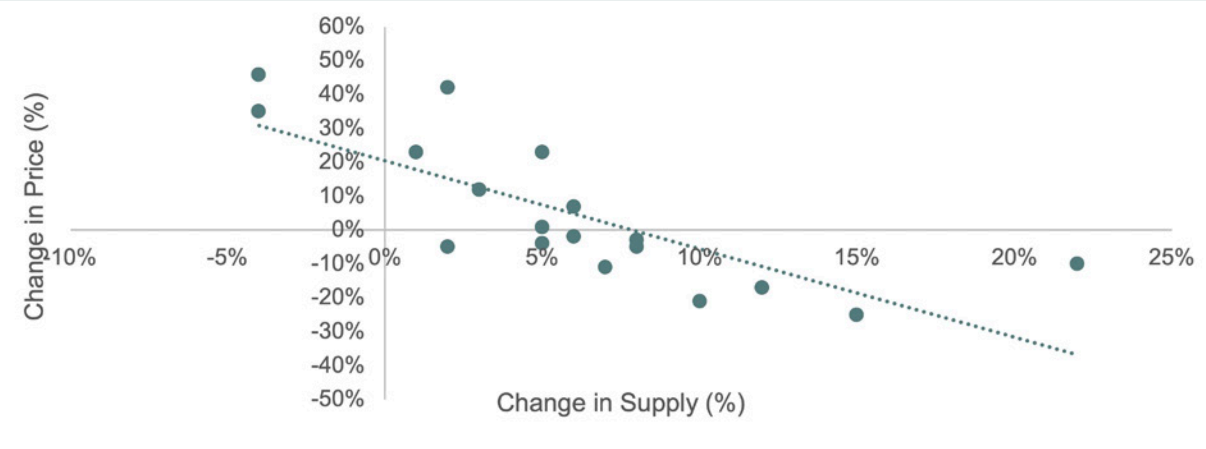


Figure 21: Supply Influences Price, 2000 to 2018 [lxxix]

Planet Tracker analysis suggests this correlation will not be as apparent in the short to medium term with expansion into RAS and CCS.

The main rationale for this is the impact of these more expensive production models on company operating margin. Higher capital expenditure and operating costs of RAS and CCS farms, maintenance of sheltered farms and escalating feed costs are expected to increase company level capital and operating expenditure across the industry.

Based on current market prices, the effect of tightening operating margins and the currently high capital expense of these systems simply make them commercially unviable at scale. In the majority of cases, salmon market prices must therefore increase to make the capital and operating costs of new RAS and CCS capacity commercially profitable.

Even from 2010 to 2018, when the majority of production has been from coastal open pen systems, escalating production costs outpaced harvest growth in percentage terms. Costs of the ten publicly traded farmed salmon companies analysed in this report increased by 74% in real terms from 2010 to 2018. Meanwhile, during the same period harvests only increased by 66% - see Figure 22.

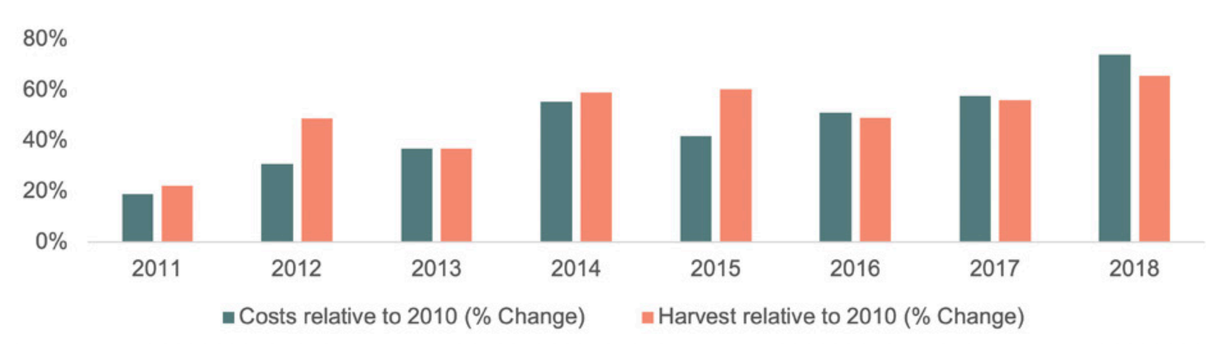


Figure 22: Costs and Harvest Change Relative to 2010 [lxxx]

Industry investors should carefully analyse company production costs versus achieved harvest across blended coastal, RAS and CCS models.

This report encourages investors to also take into consideration supply issues impacting all three of these production systems.

CONCLUSION: LOWER RISKS MEAN HIGHER MARGINS

The farmed salmon industry continues to forecast year-on-year growth, however at a slower rate than in the last ten years. An example of this deceleration is Bakkafrost's September 2019 purchase of 69% of Scottish Salmon's equity for $440 million valued at 7.2x EBITDA, which is below the industry's market-weighted EBITDA of 8.9x. This purchase further consolidates the market, increasing concentration risk in the industry.

Medium-term commercial viability of both coastal and offshore sites will largely depend on environmental risk management. Environmental risks impact companies, as highlighted above in the example about Mowi, as salmon losses twinned with higher operating and production costs are expected to reduce profit margins and EBITDA.

As highlighted in this paper, if environmental risks continue unmitigated, the production rates achieved at existing coastal sites may also fall relative to forecasts, in some cases negating the effect of new offshore production capacity coming on stream.

Investing now in making controlled factors such as stocking rates and recovery periods within the industry more sustainable should enable profitable growth to continue whilst mitigating environmental risks. Uncontrolled risks such as water temperature fluctuations should be monitored by investors, although direct investor options to influence these impacts at existing ONP sites are limited.

With an industry whose shareholder ownership is increasingly concentrated among a few key investors, institutional investors in particular should demand long term sustainable industry growth addressing disease resilience, site selection, technology type and operational resilience to climate change.

Companies and investors failing to implement effective sustainability strategies, which will require short term capital commitments, might face medium term production, operating margin and EBITDA pressure. Without an overall sustainability policy in place that integrates environmental and financial risks, investors might face declining EBITDA and increasing environmental risks driven by companies acting to push MAB limits and intensify production to meet demand which, post the Covid-19 demand declines, is expected to recover in the mid- to long- term.

Simply put, high demand recovery to pre-Covid-19 levels in the mid- to long- term twinned with shareholder ownership concentration and consistent environmental risks may cause the salmon aquaculture industry to underperform financially compared to other food and beverage sectors. Conversely, successfully mitigating financial and environmental risks may enable increases in share price, closing the gap between the salmon sector and its international food and beverage peers and improving returns for both majority and minority investors.

Investors may positively impact the industry by championing the development of sustainable management regimes and also supporting technical innovations that work to mitigate environmental risks such as RAS, CCS together with improved spatial planning.

COMPANY AND INVESTOR RECOMMENDATIONS

Farmed salmon companies by the end of 2020 should:

- **Industry guidelines:** Report on compliance with environmental regulations and industry guidelines such as the IFC's Aquaculture Environmental, Health and Safety Guidelines to highlight their environmental commitments to investors making them more attractive for investment.
- **Environmental and Social Management Systems (ESMS):** Maintain and report on an effective ESMS. Frameworks include the CDC ESMS Toolkit which also provides advice for investors to engage companies on integrating an ESMS. These frameworks should be auditable and published. ESMS reports should provide 100% citing of reasons for salmon losses. By improving audited environmental reporting companies can improve both risk management and mitigation and engage investors targeting the most sustainable companies in the industry.
- **Real-time reporting:** Deploy remote electronic monitoring systems with live data feeds accessible by investors. Transparent data monitoring may cover core environmental metrics such as water temperature, water quality, sea lice and disease, dissolved oxygen content and effluent control.
- **Research and Development:** Increase research and development spending on environmental risk mitigation such as disease and sea lice control measures. Investors have shown willingness to support research and development spend as highlighted by Mowi's 2020 Blue Revolution Plan.[lxxxi]
- **Environmental Auditing:** Strengthen control of third-party independent audited transparency and traceability reporting for all feed sources.

Investors can by 2021:

- **ESMS improvements:** Require companies to present and publish effective ESMS which assesses factors such as reasons citing salmon losses, stocking rates, antibiotic use, effluent management including benthic recovery periods, feed components and water quality. Details within these reports can support investors in analysing company valuation, financial performance and risk exposure.
- **Environmental policies:** Push for assessments detailing chemical and antibiotic inputs into waterways and their origins to mitigate the incidence rates of harmful algal blooms and other problems. These assessments should relate to detailed company policies governing the use of inputs such as antibiotics and feed. Without this knowledge, investors are less able to forecast potential salmon losses resulting from these events, creating performance uncertainty.
- **Marine Spatial Planning:** Advocate for marine spatial planning to maximise sustainable farmed salmon production so as to mitigate environmental risks. This process may require companies to set science-based targets around environmental externality thresholds such as water quality, feed components, sea lice and Scope 1, 2 and 3 emission reporting. Investing in operations that adhere to scientifically-supported spatial planning are less susceptible to production loss risks highlighted in this report.
- **Standardised reporting:** Apply consistent methodologies, accounting standards (such as IAS 41) and reporting descriptions for both materialised environment related losses and stocking values. Standardised reporting would enable investors to better compare and benchmark the financial and operational performance of companies within their portfolios.
- **Loss logs:** Provide an update log of all salmon losses and account for the related financial costs.
- **Monitor environmental constraint losses:** Follow revised maximum MAB thresholds for 2020 post COVID-19.

APPENDIX A - PLANET TRACKER UNIVERSE OF SALMON EQUITY IDENTIFIERS

Table 6: Planet Tracker Farmed Salmon Universe [lxxxii]		
Company Name	Bloomberg Ticker	ISIN
Mowi	MOWI NO Equity	NO0003054108
SalMar	SALM NO Equity	NO0010310956
Lerøy Seafood	LSG NO Equity	NO0003096208
Grieg Seafood	GSF NO Equity	NO0010365521
Norway Royal Salmon	NRS NO Equity	NO0010331838
Bakkafrost	BAKKA NO Equity	FO0000000179
Blumar	BLUMAR CI Equity	CL0001820167
Salmones Camanchaca	SALMOCAM CI Equity	CL0002409135
Australis Seafoods	AUSTRALI CI Equity	CL0001772897
Invermar	INVERMAR CI Equity	CL0000001439

Mowi

Mowi offers farmed salmon, processed seafood, ready-to-eat meals, finger food and smoked seafood. It operates through three business segments: Feed, Farming and Sales and Marketing. Mowi was founded in 1964. It is headquartered in Bergen, Norway.

Table 7: Mowi's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	7.1	8.3	46.5	11.0	55.0	37.1	14.0	15.4	16.6
Enterprise Value/ EBITDA	7.1	4.7	14.5	9.4	10.0	14.9	9.6	6.8	11.6
Dividend Yield	13%	0%	0%	2%	3%	5%	6%	9%	6%
Gross Margin	31%	30%	17%	29%	28%	24%	36%	39%	36%
Operating Margin	21%	17%	6%	17%	16%	11%	22%	29%	21%
Harvest (Tonnes)	295,683	342,820	392,306	343,772	418,873	420,148	380,621	370,346	375,237

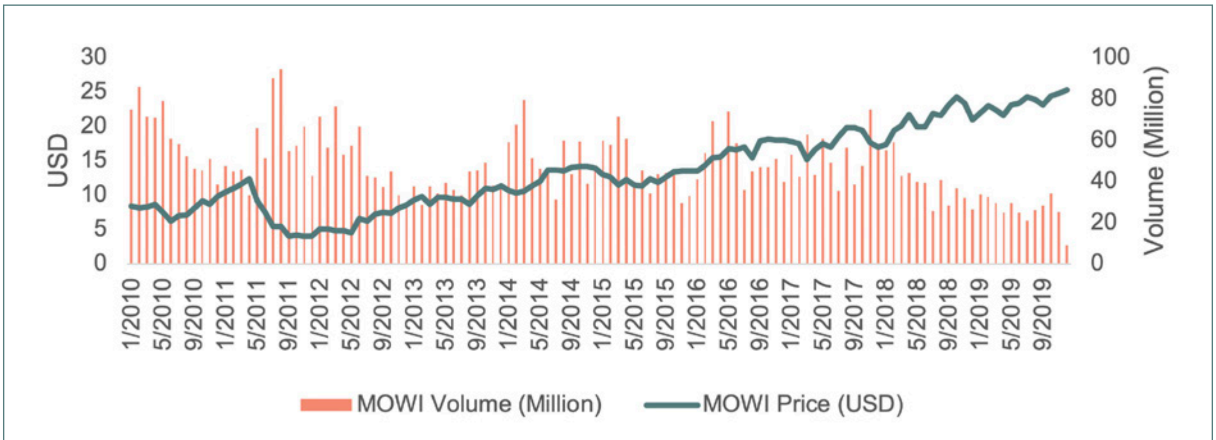


Figure 23: Mowi's Share Price (in USD), 2010 to 2019 [lxxxiii]

Figure 24: Mowi's M&A Activity, 2000 to 2019 [lxxxiv]

SalMar

SalMar engages in processing and trading of fish and shellfish and other related financial activities. It operates the following business segments: Fish Farming Central Norway, Fish Farming Northern Norway and Sales and Processing. The company was founded in 1991. It is headquartered in Kverva, Norway.

Table 8: SalMar's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	6.7	21.3	10.6	4.6	12.0	15.7	11.0	12.2	13.5
Enterprise Value/ EBITDA	6.5	6.2	9.4	6.0	7.4	11.0	12.4	6.8	12.6
Dividend Yield	7%	0%	0%	11%	8%	6%	5%	8%	5%
Gross Margin	40%	33%	29%	37%	42%	36%	41%	44%	44%
Operating Margin	33%	21%	16%	26%	28%	21%	25%	36%	31%
Harvest (Tonnes)	78,500	103,900	116,200	128,350	154,700	149,900	129,600	151,700	159,000

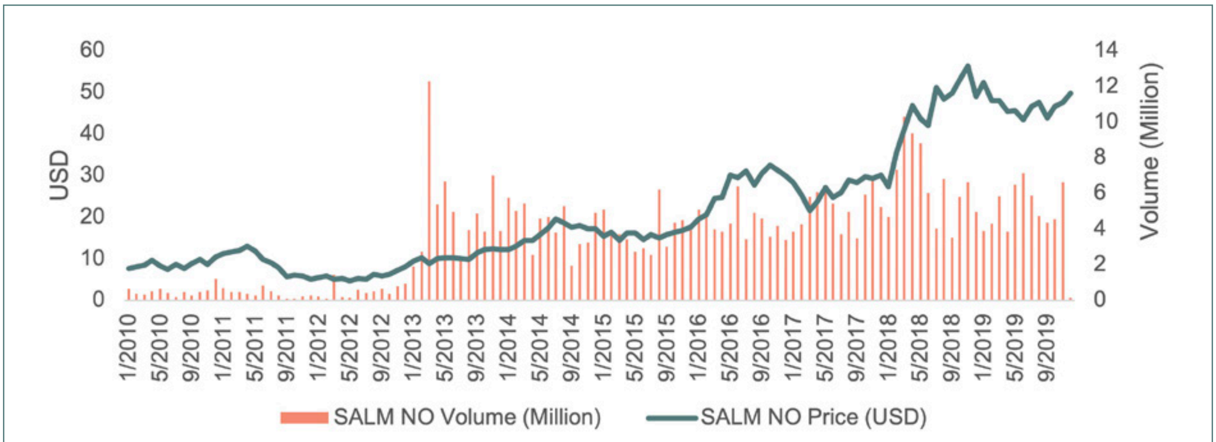


Figure 25: SalMar's Share Price (in USD), 2010 to 2019 [lxxxv]

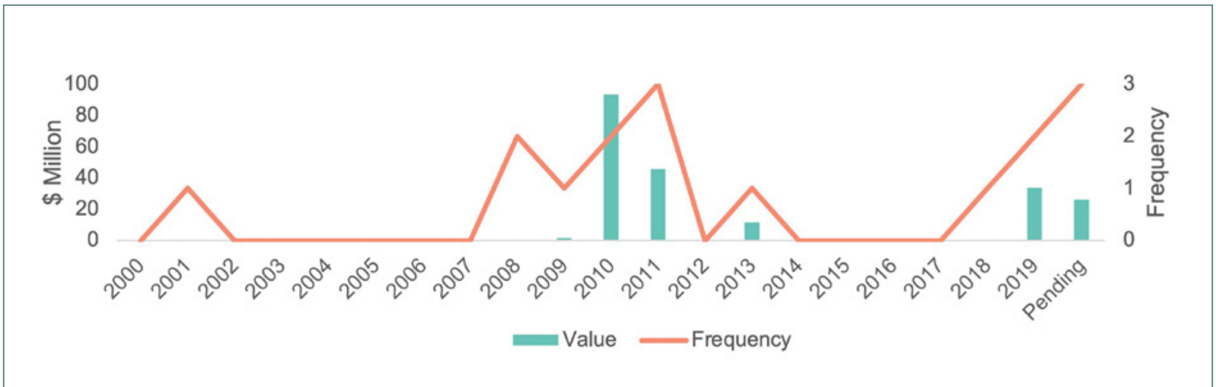


Figure 26: SalMar's M&A Activity, 2000 to 2019 [lxxxvi]

Salmones Camanchaca

Salmones Camanchaca engages in fish farming. It breeds, produces, markets and farms salmon, trout and other species. Salmones Camanchaca was founded in 2009. It is headquartered in Las Condes, Chile.

Table 9: Salmones Camanchaca's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.1
Enterprise Value/ EBITDA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6
Dividend Yield	0	0	0	0	0	0	0	0	4%
Gross Margin	0	0	0	0	15%	5%	18%	29%	28%
Operating Margin	0	0	0	0	8%	-4%	11%	21%	22%
Harvest (Tonnes)	0	5,876	31,120	33,090	39,347	43,330	32,600	36,788	48,496

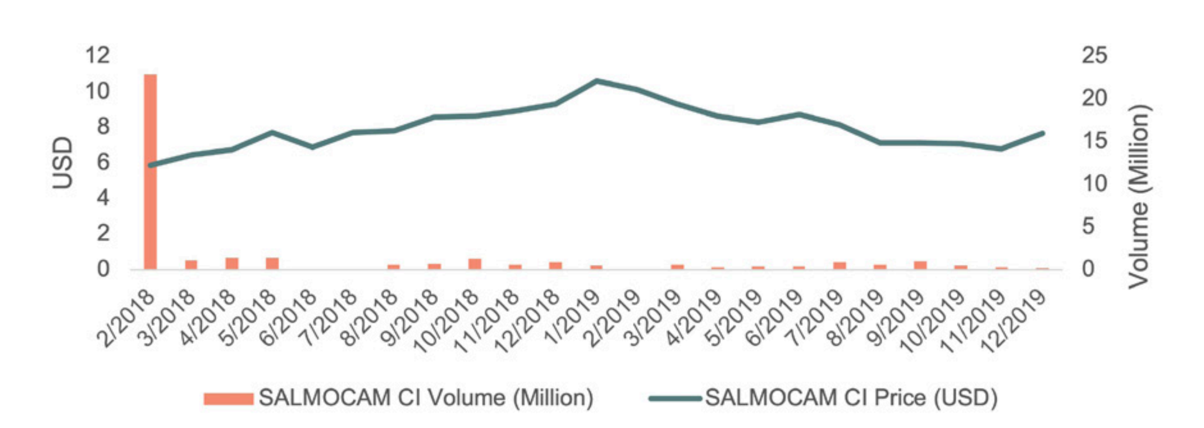


Figure 27: Salmones Camanchaca's Share Price (in USD), 2010 to 2019 [lxxxvii]

*Salmones Camanchaca was Listed in 2018.

Lerøy Seafood Group

Lerøy Seafood Group engages in the distribution, sale and marketing of seafood products. Its business segments include: Wild-catch, Farming and Value-added Processing, Sales and Distribution. The company was founded in 1995. It is headquartered in Bergen, Norway.

Table 10: Lerøy's Seafood Group's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	7.6	12.0	14.7	5.6	14.0	15.2	8.5	15.0	11.4
Enterprise Value/ EBITDA	6.6	4.6	12.8	6.7	8.8	12.2	9.9	6.8	10.5
Dividend Yield	5%	8%	5%	6%	4%	4%	3%	3%	3%
Gross Margin	26%	22%	15%	24%	23%	21%	27%	32%	30%
Operating Margin	18%	13%	5%	14%	13%	10%	16%	20%	17%
Harvest (Tonnes)	130,300	147,500	167,000	158,200	178,100	171,200	164,200	173,200	175,800

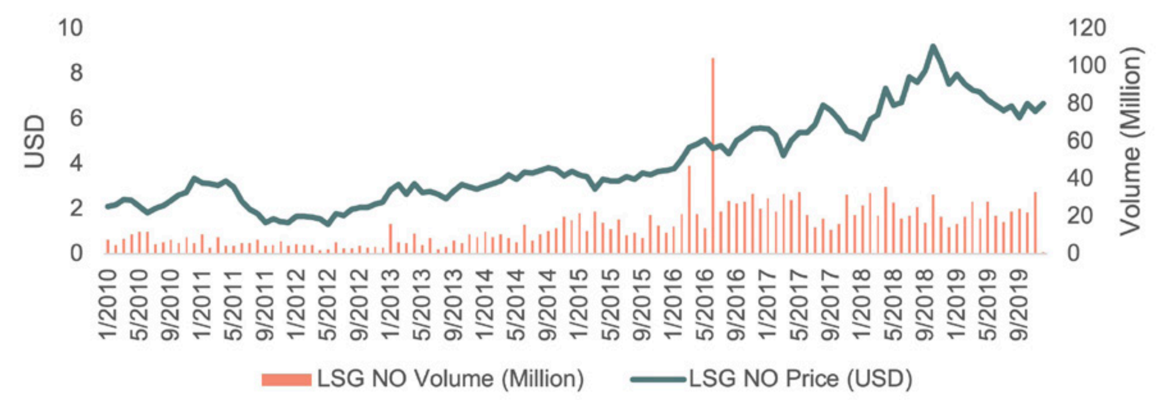


Figure 28: Lerøy's Seafood Group Share Price (in USD), 2010 to 2019 [lxxxviii]

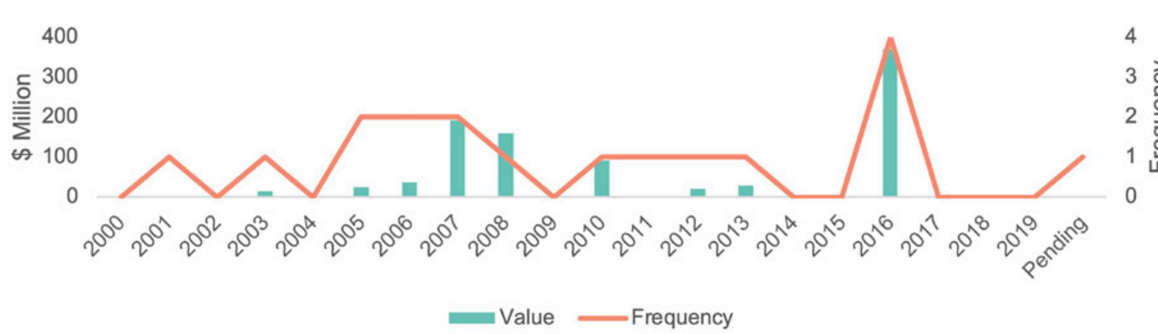


Figure 29: Lerøy's Seafood Group M&A activity, 2000 to 2019 [lxxxix]

Blumar

Blumar engages in the provision of manufactured fish meal and fish oil products. It operates Fishing and Aquaculture segments. The company was founded in 2011. It is headquartered in Las Condes, Chile.

Table 11: Blumar's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	25.5	0.0	0.0	0.0	12.5	0.0	7.4	16.5	8.0
Enterprise Value/ EBITDA	10.1	20.8	27.1	61.0	5.4	9.8	7.9	7.0	5.5
Dividend Yield	2%	0%	0%	0%	5%	0%	2%	3%	5%
Gross Margin	19%	9%	7%	5%	22%	11%	15%	23%	29%
Operating Margin	14%	2%	-3%	-6%	15%	2%	6%	12%	21%
Harvest (Tonnes)	14,395	19,718	44,218	37,645	44,319	28,708	31,617	29,996	55,518

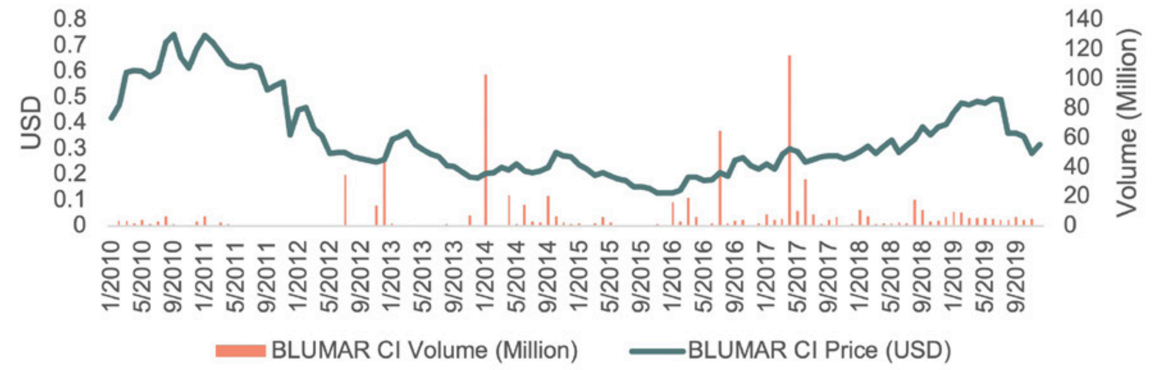


Figure 30: Blumar's Share Price (in USD), 2010 to 2019

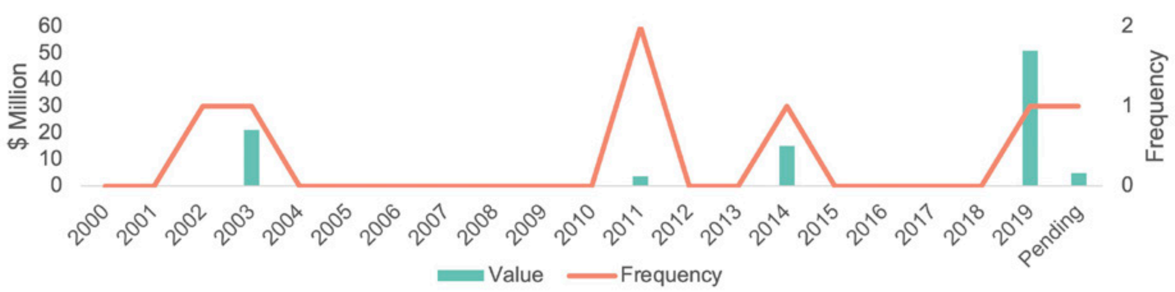


Figure 31: Blumar's M&A Activity, 2000 to 2019 [xc]

Bakkafrost

Bakkafrost engages in production and sale of a wide range of salmon products. It operates through the following segments: Farming, Value Added Products and Fishmeal, Oil and Feed. The company was founded in 1968. It is headquartered in Glyvrar, Faroe Islands.

Table 12: Bakkafrost's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	8.5	5.3	10.4	7.5	11.3	13.0	10.0	26.4	16.5
Enterprise Value/ EBITDA	8.4	6.3	10.3	8.0	7.1	9.5	11.2	9.1	13.8
Dividend Yield	8%	3%	3%	5%	4%	4%	3%	4%	3%
Gross Margin	53%	50%	43%	48%	54%	57%	55%	34%	32%
Operating Margin	29%	25%	15%	23%	36%	36%	36%	36%	32%
Harvest (Tonnes)	21,626	36,343	44,341	41,268	44,013	50,565	47,542	54,615	44,591

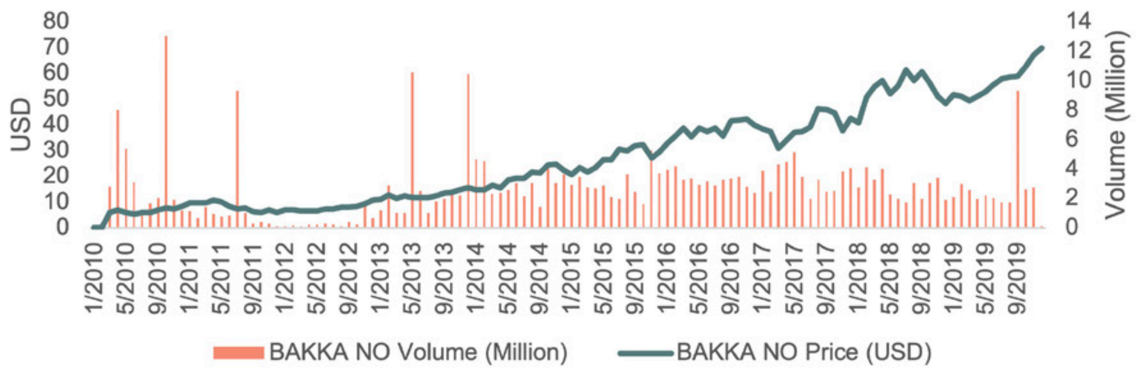


Figure 32: Bakkafrost's Share Price (in USD), 2000 to 2019 [xci]

Figure 33: Bakkafrost's M&A Activity, 2000 to 2019 [xcii]

Grieg Seafood

Grieg Seafood engages in salmon and trout farming. It has the following geographical segments: Rogaland, Norway; Finnmark, Norway; British Columbia, Canada; and Shetland, United Kingdom. The company was founded in 1992. It is headquartered in Bergen, Norway.

Table 13: Grieg Seafood's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	3.3	0.0	0.0	6.3	22.8	0.0	7.6	14.0	11.6
Enterprise Value/ EBITDA	4.7	6.2	0.0	8.8	11.4	23.2	7.6	9.0	10.2
Dividend Yield	7%	0%	0%	0%	2%	3%	4%	3%	2%
Gross Margin	47%	38%	20%	38%	37%	27%	31%	28%	19%
Operating Margin	23%	9%	-11%	13%	10%	1%	18%	13%	14%
Harvest (Tonnes)	64,214	60,084	70,000	58,061	64,736	65,398	64,726	62,598	74,623

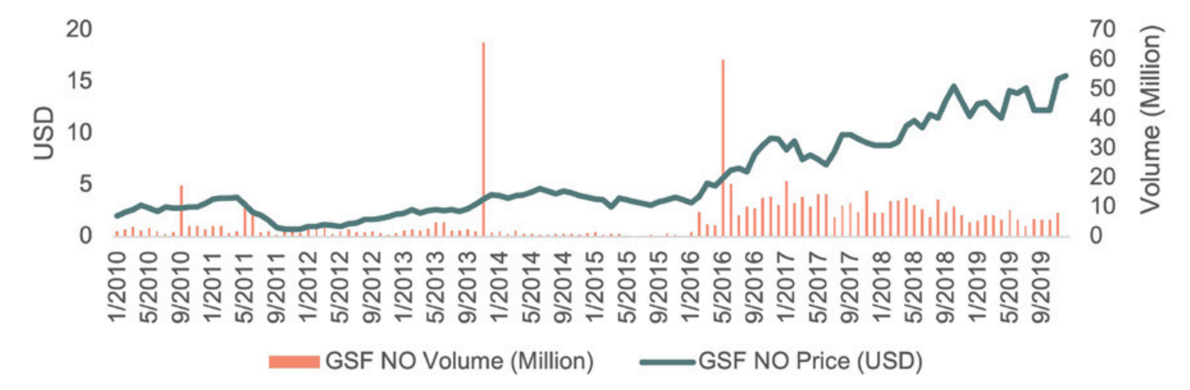


Figure 34: Grieg Seafood's Share Price (in USD), 2000 to 2019 xciii

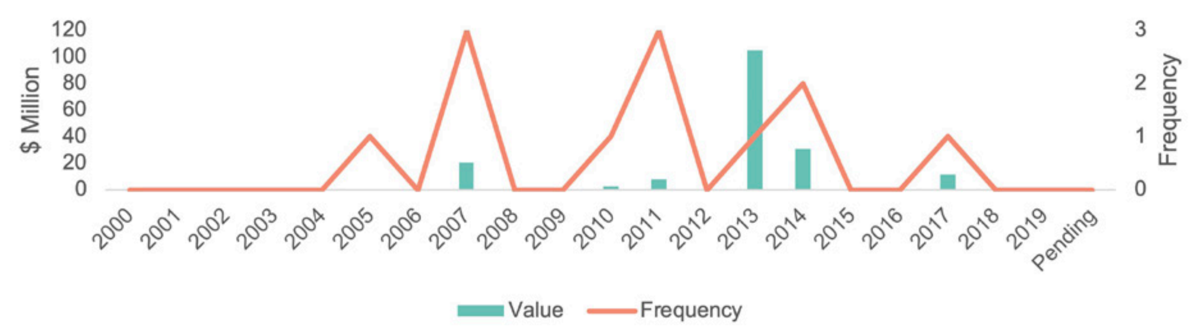


Figure 35: Grieg Seafood's M&A activity, 2000 to 2019 xciv

Norway Royal Salmon

Norway Royal Salmon engages in salmon farming and smolt production. It operates through the Sales and Fish Farming segments. The company was founded in 1992. It is headquartered in Trondheim, Norway.

Table 14: Norway Royal Salmon's Financial Results 2010 to 2018									
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	0.0	124.7	23.2	5.3	11.1	15.2	9.1	25.5	11.0
Enterprise Value/ EBITDA	0.0	11.7	16.1	7.0	14.6	15.5	13.5	7.3	11.5
Dividend Yield	0%	0%	0%	3%	1%	2%	4%	3%	2%
Gross Margin	9%	6%	6%	13%	12%	11%	19%	18%	17%
Operating Margin	7%	3%	2%	10%	7%	7%	15%	17%	13%
Harvest (Tonnes)	10,700	18,781	21,162	25,191	22,356	27,903	26,819	31,918	35,970

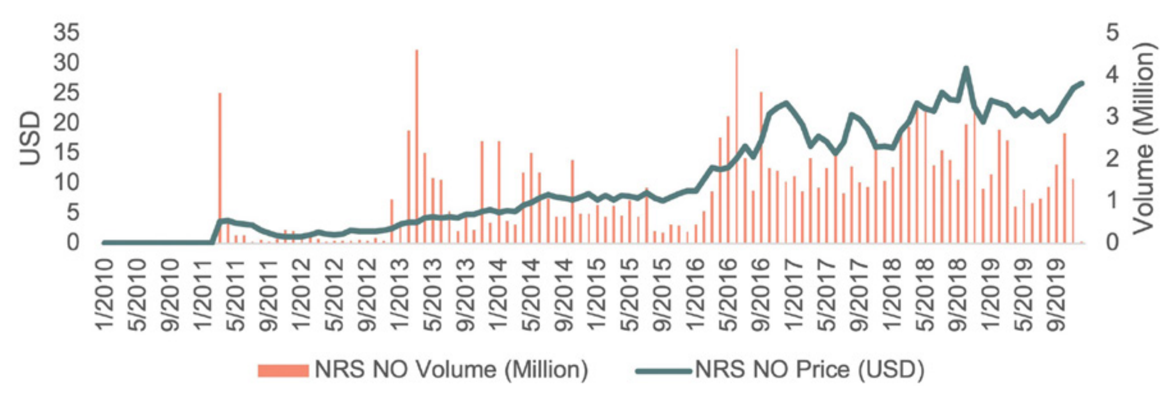


Figure 36: Norway Royal Salmon's Share Price (in USD), 2010 to 2019 [xcv]

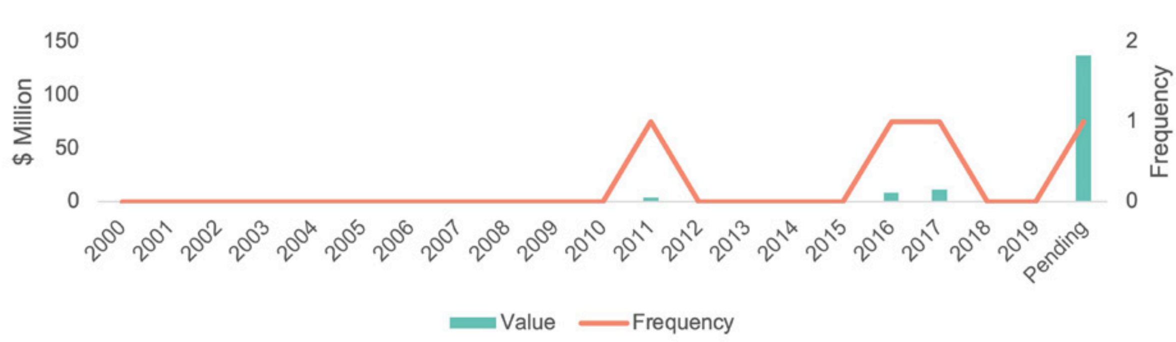


Figure 37: Norway Royal Salmon's M&A Activity, 2000 to 2019 [xcvi]

Invermar

Invermar engages in the farming and culture of seafood. It operates Salmon and Oyster segments. The company's products include Atlantic salmon, Coho salmon and trout. The company was founded in 1988. It is headquartered in Santiago, Chile.

Table 15: Invermar's Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	11.2	4.9	0.0	3.9	0.0	0.3	13.3	6.6	13.1
Enterprise Value/ EBITDA	18.5	14.5	0.0	17.3	31.1	171.6	9.4	4.6	5.8
Dividend Yield	0%	0%	0%	0%	0%	0%	0%	0%	1%
Gross Margin	46%	13%	-13%	9%	1%	-5%	11%	25%	21%
Operating Margin	31%	6%	-25%	-1%	-6%	-14%	7	21	16
Harvest (Tonnes)	10,284	21,367	31,360	22,118	14,820	11,043	23,873	30,232	33,611

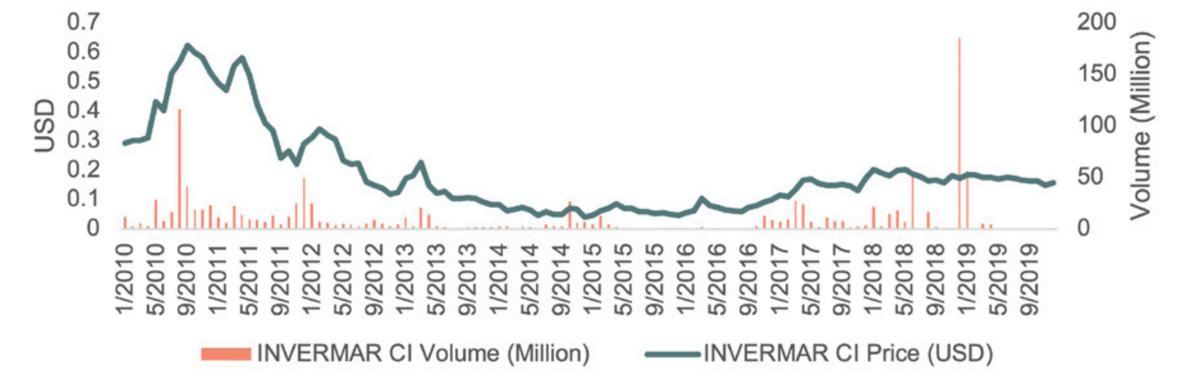


Figure 38: Invermar's Share Price (in USD), 2010 to 2019 [xcvii]

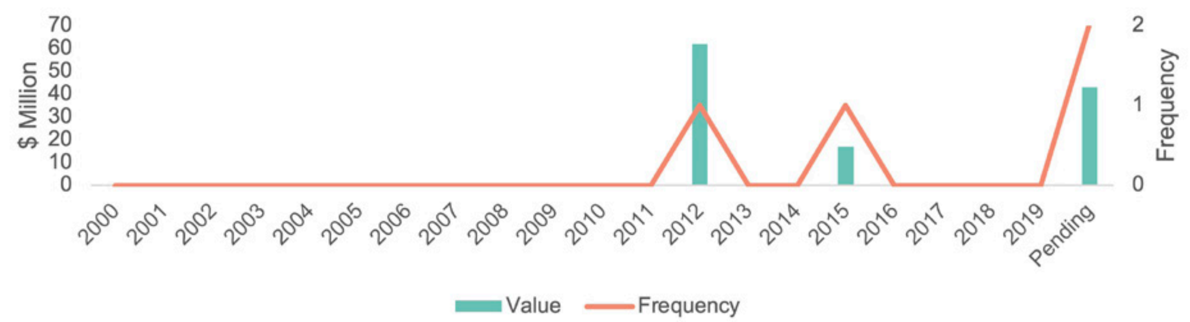


Figure 39: Invermar's M&A Activity, 2010 to 2019 [xcviii]

Australis Seafoods

Australis Seafoods engages in the production and marketing of freshwater and saltwater stage salmonids. Its products include Atlantic salmon, Pacific salmon and trout. The company was founded in 2003. It is headquartered in Santiago, Chile.

Table 16: Australis Seafoods' Financial Results 2010 to 2018

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Price/Earnings	0.0	15.3	0.0	0.0	0.0	0.0	6.7	7.3	20.4
Enterprise Value/ EBITDA	0.0	11.2	0.0	0.0	0.0	0.0	11.3	4.5	11.5
Dividend Yield	0%	2%	0%	0%	0%	0%	0%	0%	0%
Gross Margin	33%	27%	-29%	-11%	-12%	-27%	12%	35%	25%
Operating Margin	23%	23%	-40%	-29%	-29%	-40%	7%	31%	19%
Harvest (Tonnes)	14,881	26,001	35,202	30,167	28,126	60,081	53,754	60,016	59,843

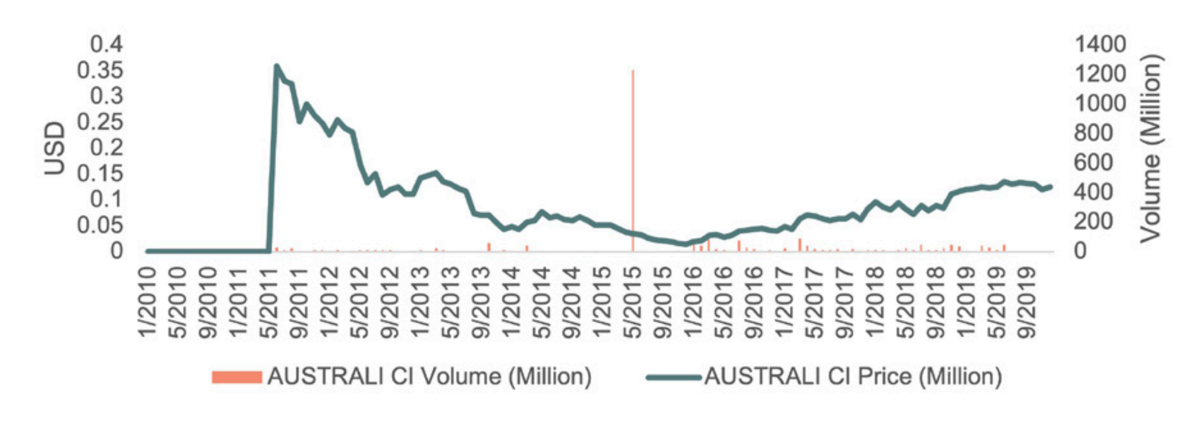


Figure 40: Australis Seafoods' Share Price (in USD), 2010 to 2019

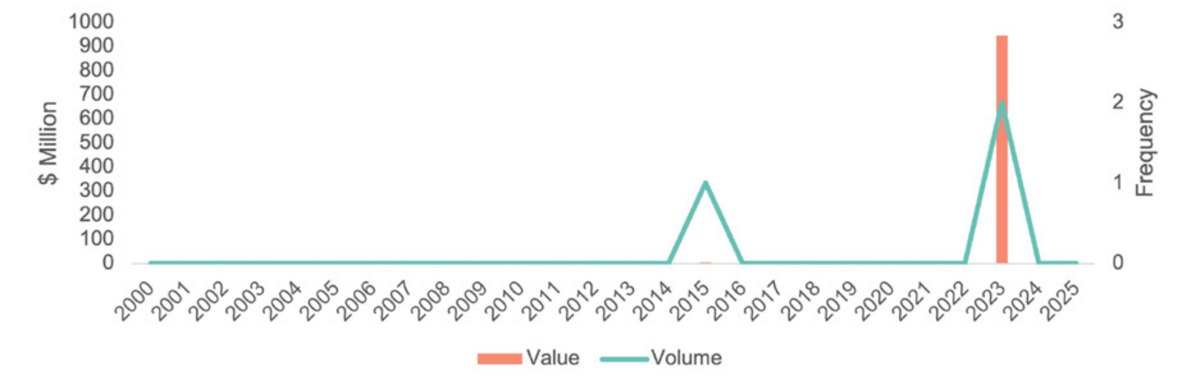


Figure 41: Australis Seafoods' M&A Activity, 2010 to 2019 [xcix]

1 Maximum Allowable Biomass

The carrying capacity for coastal salmon aquaculture is determined by physical and ecological constraints which in turn affect the economic and social appeal of salmon farming assets.

The total coastal area suitable for salmon farming is constrained by abiotic factors, such as temperature, while maximum yield is constrained by biotic factors, such as effluent discharge. To address this, industry regulators have set defined production thresholds. Maximum Allowable Biomass (MAB) is a regulation applied by governments and enforced by fisheries' regulators to salmon farming, limiting the total maximum mass of fish allowed on a farm at any one time.

Currently, total farmed Atlantic salmon production is close to reaching existing MAB limits in Norway and the United Kingdom, and some farms have exceeded their MAB levels during some parts of the year. In 2018, maximum biomass observed in Norwegian salmon farms was utilising 91% of the regulated limit and averaged 85% usage of allocated biomass throughout the year – see Figure 42.

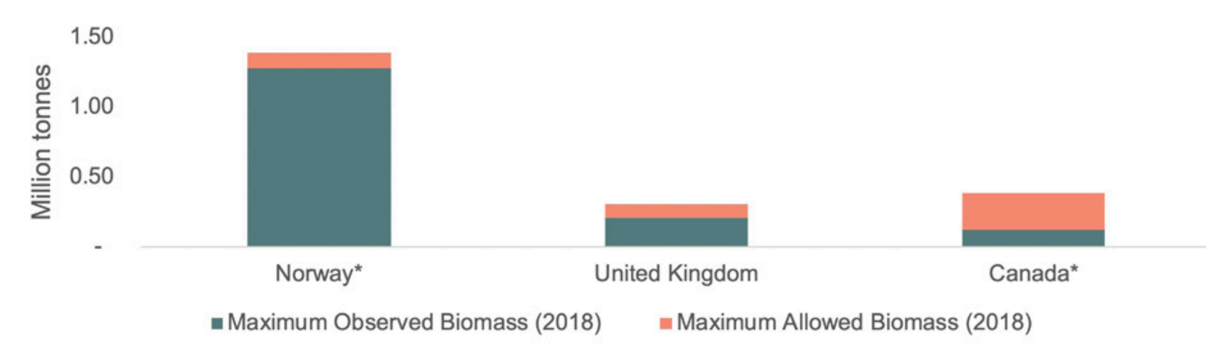


*Figure 42: Estimated Total Observed Biomass vs. Maximum Allowable Biomass in Norway, United Kingdom and Canada, 2018. *Canadian and Norwegian estimates include other salmonids, and so are slightly exaggerated*

In Chile, researchers suggest there is currently no tool available that establishes MAB.[c] Low projections of growth to 2022 in Chile and discussions of farm-level biomass reductions through the implementation of a MAB system in 2019[ci] indicate that coastal salmon farms may already be operating near maximum carrying capacity.

Maximum sustainable yield per m^3 is calculated as carrying capacity. Carrying capacity is defined as "*the maximum number of individuals of a given species that an area's resources can sustain indefinitely without significantly depleting or degrading those resources*".[cii] For coastal salmon farming, this creates a limit on the maximum stocking rate achievable within those farms. Stocking density above 22 kg per m^3 has an incrementally negative effect on salmon welfare.[ciii]

2 Limited Suitable Coastal Land

The main coastal areas used for salmon farming are as shown in the map below:

Mowi, the largest publicly traded farmed salmon company, defines the conditions required for salmon farming as:[civ]

- **Water temperature** must range between <0-20ºC, with the optimal temperature range ranging between 8-14ºC.
- **Consistent, low speed flow regimes** are required to allow a flow of water through the farm. The current must be slow enough to allow the fish to move freely around in the sites. These conditions are typically found in waters protected by archipelagos and fjords and so rule out several coastlines.
- **Certain biological parameters** are also required to allow efficient production. The biological conditions vary significantly within the farming areas and are prohibitive for certain other areas.
- **Political willingness** to permit salmon farming and to regulate the industry is required. Licence systems have been adopted in all areas where salmon farming is carried out.

Identifying new coastal sites satisfying these conditions and which have not yet been farmed remains a barrier to significant growth in production capacity for coastal open pen systems.

3 Regulatory Pressure in the Blue Economy

By 2030, it is expected that the regulatory pressure on salmon farming will increase. A list of the current regulations affecting salmon farming can be found in Appendix D.

As an illustration, in 2018 the US State of Washington passed a bill to phase out all non-native fish farming by 2022 (including Atlantic salmon).[cv] Competition for areas zoned for commercial use will become more intense as marine spatial planning becomes a larger element in the Blue Economy, a concept describing the sustainable use of ocean resources for economic growth.

Marine spatial planning is a framework allowing for the effective co-ordination of marine space. Use of tools such as satellite imaging, Geographic Information System (GIS) mapping and site surveys reduce conflicts between transport, commercial and conservation methods through the optimal allocation of space.

Areas zoned for commercial use in Exclusive Economic Zones[4] are not all equally viable for salmon farming. This creates a bottleneck on space in which salmon farming can develop.[cvi] This has led to reports of illegal salmon aquaculture expansion into marine protected areas. Examples include Nova Austral into Chile's Beagle Channel in 2019, which in turn led to civil action against the company,[cvii] resulting in the suspension of its salmon concessions by the Chilean Army.[cviii]

4 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathway 6.0 report forecasts, between 2000 and 2050, an average coastal seawater temperature increase of 1.6ºC for Norway and United Kingdom and 1.1ºC for Chile.

The optimal temperature range for farmed salmon is 8ºC to 14ºC. Water temperature increases are material to investors.

For example, in Norway, monthly coastal seawater temperatures were higher than 14ºC from June to September 2018 – see Figure 43.[cix]

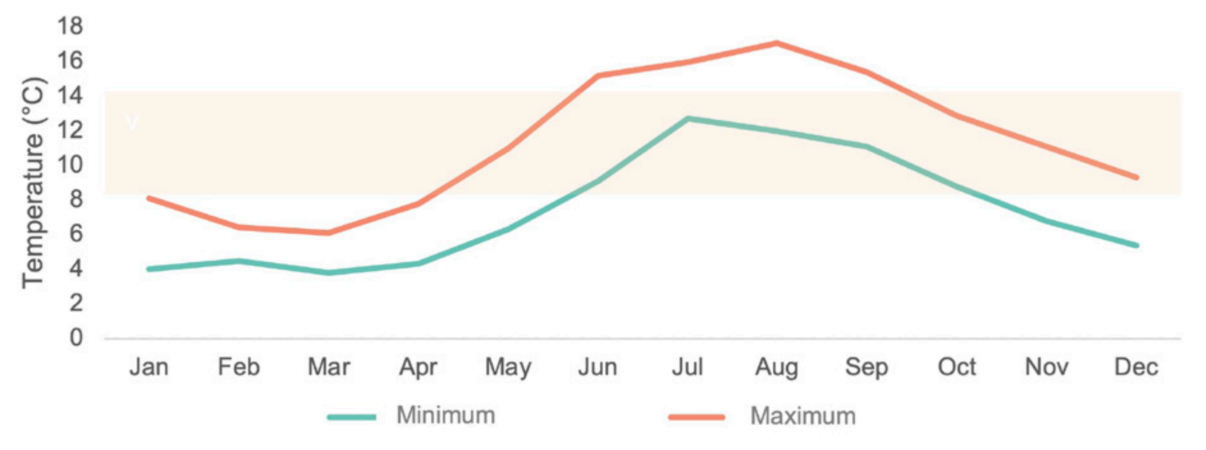


Figure 43: Norwegian High and Low Monthly Sea Temperatures, 2018.[cx]
**Yellow-coloured area indicates the optimum temperature range for salmon growth*

Climate-related biological limits will also become more restrictive through to 2050 due to warmer seas, which reduce the suitability of current aquaculture sites and lead to increased incidences of disease, sea lice and harmful algal blooms.

Coastal farmed salmon assets, such as pens, processing, storage and refrigeration equipment could become commercially unviable for longer periods of the year as sea temperatures increase, or due to increased costs of moving the pens to cooler waters.

If physical assets remain unused or operate below commercial capacity, they risk becoming stranded. Stranded assets increase credit default risk on loans secured to purchase equipment and impact the value of booked balance sheet assets.

[4] An Exclusive Economic Zone (EEZ) is a sea zone prescribed by the 1982 United Nations Convention on the Law of the Sea over which a state has special rights regarding the use of marine resources.

5 Disease

Substantial intensification of salmon farming has taken place in Norway since 1980, where production per farm licence increased from 26 tonnes in 1980 to 1,130 tonnes in 2010.[cxi]

In the United Kingdom, the industry has been consolidating towards larger farms. Farms with annual production over 2,000 tonnes now constitute 50% of all licences in the United Kingdom and 99% of all salmon produced, up from 16% of licences in 2000[cxii] – see Figure 44.

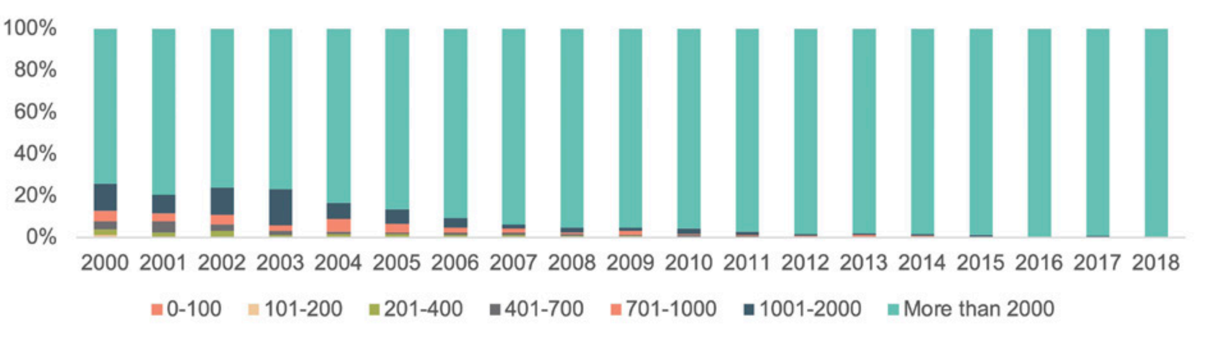


Figure 44: Farmed Atlantic Salmon Production by Licence Production (Tonnes) in the United Kingdom, 2000 to 2017[cxiii]

Farmed salmon intensification is directly linked to increased incidences and severity of disease outbreaks, which is known as the monocultural effect.[cxiv] There are more than a dozen varieties of disease and parasites which have a material impact on salmon farming.[cxv]

Research shows that as farmed fish densities increase, so does the rate of infectious diseases.[cxvi] This means that disease in farmed salmon is a density-dependent constraint to population growth[cxvii] and therefore acts as another limiting factor to coastal salmon aquaculture production.

In Q3 2019, Scottish Sea Farms, owned by Lerøy Seafood and SalMar, reported a loss of $11.5 million due to gill health issues requiring earlier than expected harvests.[cxviii]

6 Sea Lice

Sea lice are the most damaging parasite in the farmed salmon industry.[cxix] In the United Kingdom, the annual costs associated with treating sea lice are about $31 million. Globally, the annual cost is more than $290 million.[cxx]

Sea lice are also a density-dependent constraint to salmon farming.[cxxi] Current technological practices dictate the ability to control sea lice infestations and therefore create a maximum production ceiling for coastal salmon farming.

Coastal salmon farms are disproportionate contributors to sea lice compared to wild stocks.[cxxii] There is an association between stocking rates and sea lice concentrations.[cxxiii] Sea lice were one of the causes of the 19% mortality rate in farmed salmon in Norway from 2015 to 2016.[cxxiv]

This led to Norway, in 2017, setting in place regulation to mandate growth depending on the condition of lice infestations using a traffic light system. Green areas can increase their biomass (by 6%), yellow must freeze growth and red areas will in future reduce growth (by 6%) in order to lower the incidence of sea lice[cxxv] – see Figure 45.

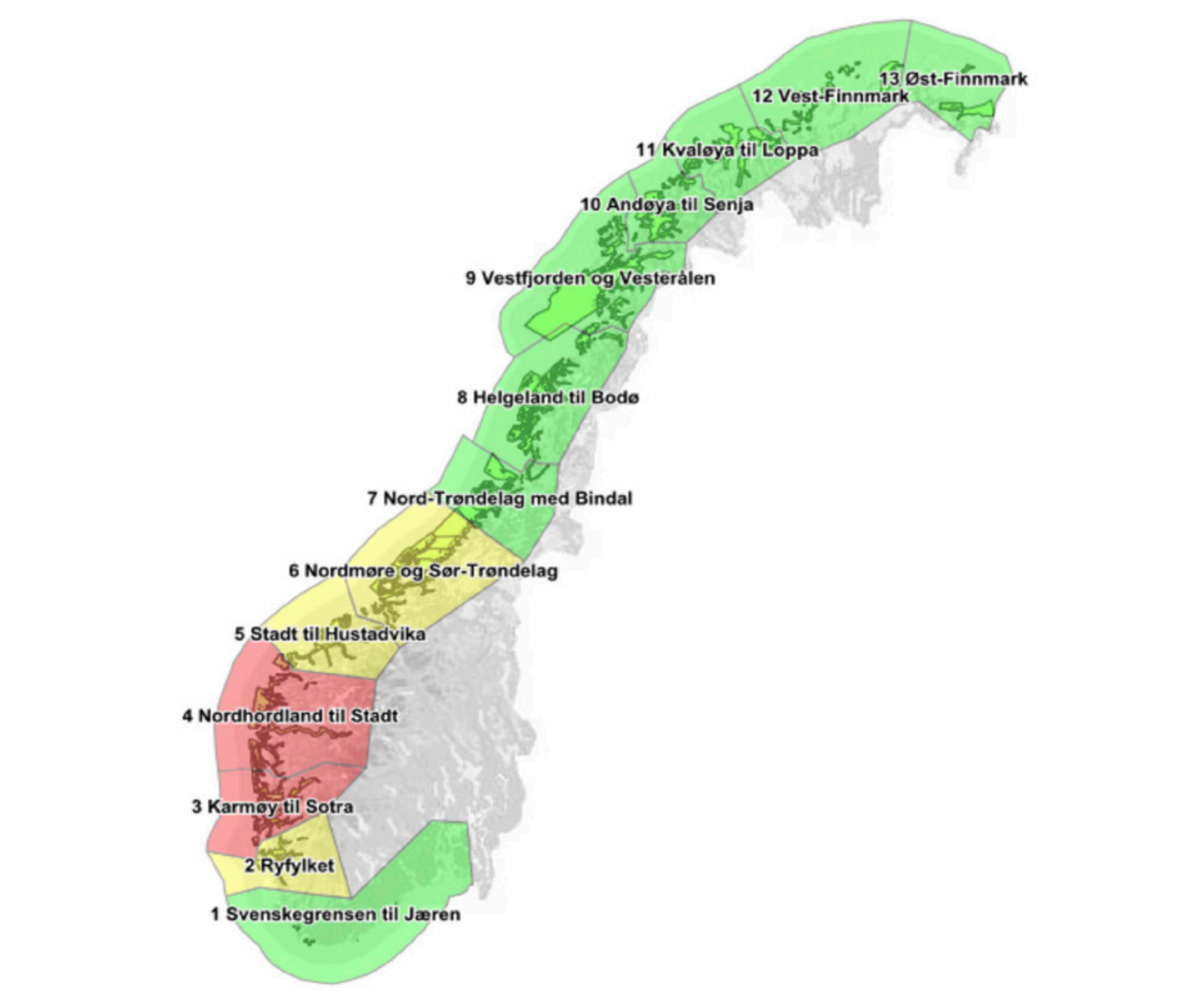


Figure 45: Norway Sea Lice Traffic Light System [cxxvi]

The epidemic potential of sea lice increases with temperature due to a faster generation time and increasing net reproduction.[cxxvii] Sea lice populations grow proportionally to the concentration of salmon in an area and therefore have increasingly become an issue as the industry expands.

7 Harmful Algal Blooms

Salmon farms contribute to the organic matter deposits in waterways.[cxxiii] Higher organic matter concentrations are correlated with more intense and frequent HABS.[cxxix] Eutrophication of Patagonian channels and fjords from farmed salmon has been recognized as an environmental risk since the early stages of development of the industry in Chile.[cxxx]

In 2016, an algal bloom in Chile caused the worst case of mass mortality of fish and shellfish recorded in the coastal waters of western Patagonia. This die-off reduced Chilean salmon production by 12% and caused $800 million in economic losses.[cxxxi]

By Q2 2019, HABs in Norway killed 11,600 tonnes of salmon with kill estimates of 40,000 to 45,000 tonnes for 2019 – equal to approximately $223 million of lost revenue.[cxxxii]

Climate change will increase the severity of stalled high-pressure weather systems. Greater rainfall increases the exposure of farmed salmon to land-based agriculture farm run-off, which can have negative impacts on water quality and farm productivity. HABs are intensifying in parallel with climate change.[cxxxiii] Canada has experienced annual occurrences of hypoxia since 2002.[cxxxiv] Increased nitrogen run-offs from agricultural farmland are expected to increase incidence rates of HABs by 2050.[cxxxv]

Along with HABs, build-up of faecal matter and uneaten food can render a salmon farm and its surrounding area toxic, negatively impacting profitability. Eutrophication, high biomass and decaying algae can lower the oxygen content in water.

Young salmon are particularly vulnerable to temperature increases and lower oxygen levels. Rearing smolt at low oxygen levels reduces hatching success and in warmer waters hatching success is even lower.[cxxxvi]

8 Feedstock Transition

a. Wild-catch fish-based feeds

Feed has been a limiting factor to salmon farming growth due to the reliance on wild-catch fisheries. Historically, salmon feed protein came from small pelagic fisheries, harvesting forage fish such as anchovies and sardines.[cxxxvii] In 2016, anchovies and sardines comprised 12% of global wild-catch fisheries and were primarily used for salmon feed.[cxxxviii] Anchovy and sardine fisheries in major production regions, including Peru, periodically collapse due to impacts from El Niño[cxxxix] while these fisheries also suffer negative impacts from climate change and overfishing.

Despite recent innovations, first in plant-based proteins and now in insect protein such as black soldier fly larvae, which promise sustainable growth at cost-effective rates, the salmon farming industry is still reliant on essential fish-based proteins which threaten to reduce the profitability of the salmon industry as wild stocks collapse and wild fish prices rise.

Wild-catch fish-based feed production, which is a protein source used in salmon feed, peaked in 1994 at 30 million tonnes. By 2016, fishmeal production had declined to 15 million tonnes due to reduced catches of anchovies. Fish oil, which is produced from fishmeal, is a key nutritional component in farmed salmon diets as it provides essential polyunsaturated fatty acids which assist growth and health in salmon.[cxl]

In 2018, salmon feed accounted for 10% of the global aquaculture feed market. Feed is the largest cost component in farmed salmon production. In 2017 for example, feed constituted 43% of Mowi Norway's total production costs.[cxli] This is consistent across geographies – see Figure 46.

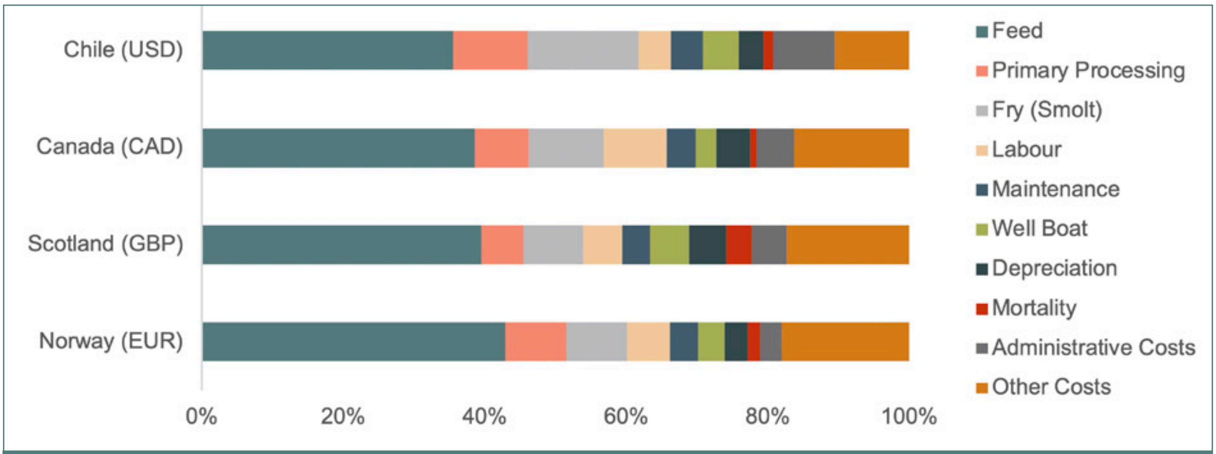


Figure 46: Salmon Farming Cost Structure by Nation [cxlii]

Fishery collapses lead to low forage fish harvests. These collapses cause the price of fish oil to increase.[cxliii] Anchovy and sardine fisheries' health and output link production volume to costs in farmed salmon.[cxliv] For example, the Pacific sardine fisheries declined by 95% between 2006 and 2017, from 1.8 million tonnes to 27,000 tonnes.[cxlv] This forced salmon farmers to look to other protein sources for feedstock and increase farm efficiencies.

Feedstock efficiency in salmon farming is measured using fish in/fish out ratios (FIFO), the ratio of feed required to grow 1kg of salmon. In 1990, 4.4 kg of feed was required to produce 1.0 kg salmon.[cxlvi] Since the 1990s, the Norwegian farmed salmon industry has improved its feedstock efficiency. By 2015, Norwegian FIFO ratios had declined by 87% to 0.8 kg of feed to produce 1.0 kg salmon.[cxlvii] Overall marine protein content in Norwegian salmon feed decreased from 90% in 1990 to less than 30% in 2013 – see Figure 47.

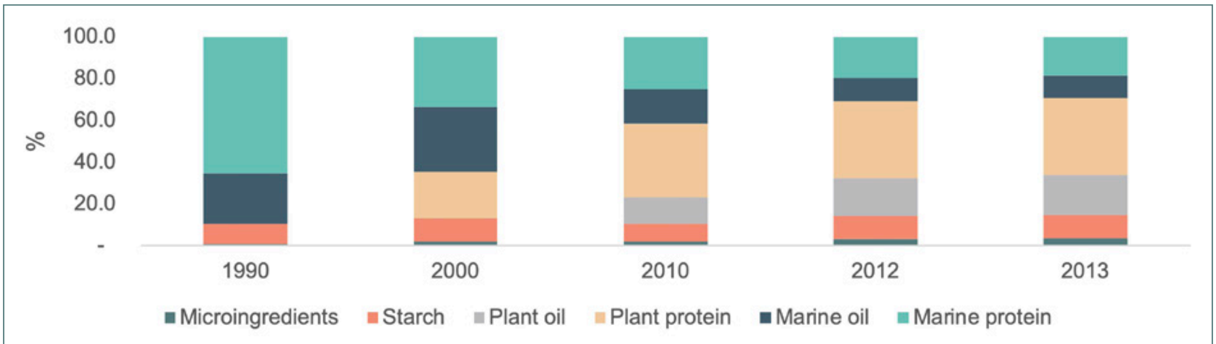


Figure 47: Relative Ingredient Sources in Feed 1990 to 2013 [cxlix]

The **fish in/fish out ratio (FIFO)** measures the amount of fish meal and fish oil that is used to produce one weight equivalent of farmed fish back to wild fish weight equivalents. The **forage fish dependency ratio (FFDR)** is the amount of wild-caught fish used to produce the amount of fish meal and fish oil required to produce 1 kg of salmon.[cl]

Pressure exists to decrease FIFO and FFDR ratios to lower farmed salmon's impacts on wild-catch fisheries since fish protein sourcing is a limiting factor for growth in the salmon industry. Planet Tracker assessed the populations of forage fish against their use in fish feed. 60% of biomass used comes from anchovy and blue whiting species.[cli] These two populations decreased by 49% between 2000 and 2017[clii] due in part to overfishing, which threatens the long term viability of the farmed salmon industry.

The price of fish oil and fishmeal is expected to continue to climb in response to decreasing supply. The World Bank has projected that prices for fish oil and fishmeal will increase by 72% and 92% respectively by 2030, relative to 2010 prices, compared to an estimated salmon price increase of 8%[cliii] – see Figure 48.

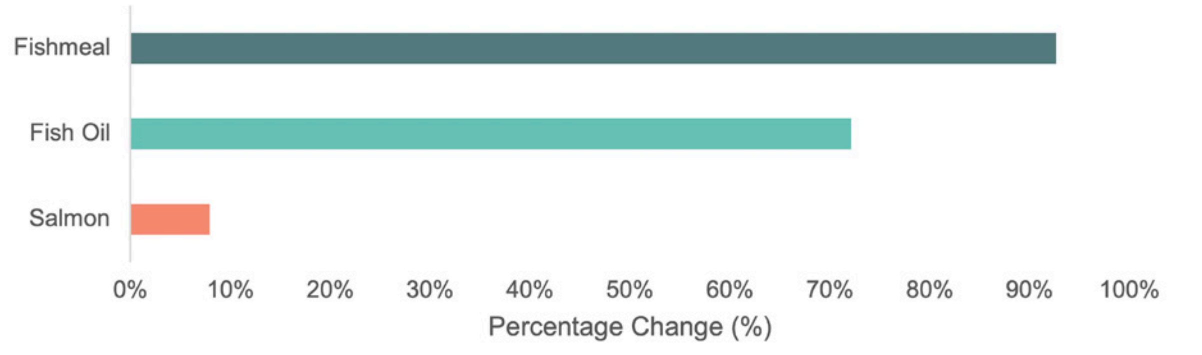


Figure 48: Projected Change in Real Prices of Seafood 2010 to 2030[cliv]

Demand for fishmeal and fish oil is projected to continue to increase as the demand for farmed salmon grows.[clv] To counteract the high cost of fish protein, feedstock efficiency in salmon farms has improved.[clvi] Industry-level feeder fish fishmeal (FFDRm) and fish oil (FFDRo) requirements have decreased by 3% and 47% respectively between 2000 and 2015. Global farmed salmon production has increased by 166% over the same period[clvii] – see Figure 49

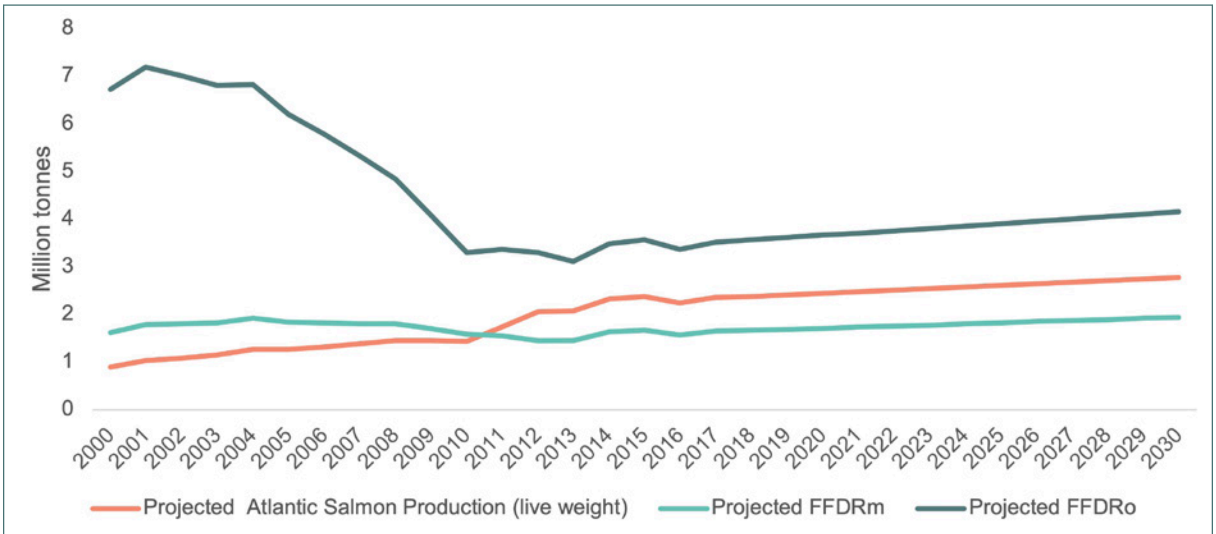


Figure 49: Projected Farmed Salmon Production vs Forage Fish Requirement to 2030[clvii]

Historically, rising costs have led to decreased fish oil use in favour of land-based substitutes, such as soy protein concentrate. Because these substitutes lack nutritional fatty acids, the level of omega-3, a key measure of nutrition, in Scottish farmed salmon has dropped by 50% over the last 10 years.[clviii] Overcoming historic boundaries, such as restricted fish oil supply, has allowed for growth at the expense of one of salmon's key consumer benefits – high nutritional value.

b. Soy Protein Presents Other Environmental Issues

Marine content has been replaced primarily by the plant-based material, soy protein concentrate. In 2016, 70% of Norway's total imported soy was used for fish feed.[clix] The Norwegian salmon industry is dependent primarily on Brazilian soy cultivation. In 2017, the Norwegian farmed salmon industry imported 282,448 tonnes of soy protein concentrate.[clx] To grow the soy needed for that year alone, 2,258 km2 of cropland was required.[clxi]

To feed its salmon industry, Norway's imported soy protein concentrate land-use footprint is equal to the size of the country of Luxembourg.

In 2018, firms representing 67% and 74% of Norway's and Chile's farmed salmon farming production made statements regarding the use of sustainable soy protein concentrate.[clxii]

Norway's Salmon Group, representing 12% of the country's farmed salmon production, removed Brazilian soy from use in feeds from 24 September 2019 due to record Amazonian deforestation rates.[clxiii] As of December 2019, Grieg Seafood, Lerøy Seafood and Mowi have signed the Amazon Soy Moratorium.[clxiv]

The companies with public statements regarding sustainable soy protein concentrate are:

- Mowi
- SalMar
- Lerøy Seafood
- Cermaq
- Grieg Seafood
- Nova Sea
- Nordlaks
- Norway Royal Salmon
- Alsaker Fjordbruk
- Bremnes Seashore
- Salmones Multiexport
- Empresas Aquachile
- Pesquera Los Fiordos
- Australis Seafood
- Camanchaca
- Blumar
- Nova Austral
- Invermar

Nonetheless, BioMar, the top Norwegian feedstock producer controlling 26% of the salmon feed market in 2017, noted concerns with 'pirate soy' in which deforestation-linked soy pollutes certified supply chains.[clxv] Pirate soy protein concentrate degrades zero-deforestation and sustainable soy commitments and is a reputation risk for the companies listed above who have publicly supported sustainable soy protein concentrate.

The farmed salmon industry needs rigorous control of feedstock transparency and traceability. Both require independent third-party audit to ensure accuracy for each company's zero-deforestation commitments.

There is a material risk of both deforestation-linked soy and pirate soy entering into supply chains as land under cultivation increases, primarily in the Brazilian Amazon and Cerrado, and the Argentinian and Paraguayan Gran Chaco regions. The Amazon, Cerrado and Gran Chaco are all key biodiverse regions at risk from fires, drought, land conversion and climate change.[clxvi]

Failure to transition to sustainable feed supply is fiscally inefficient for salmon farmers and their investors. At current feed conversion rates, Planet Tracker estimates the requirement for fishmeal and fish oil will increase by 17% between 2015 and 2030, compounding the effect of increasing fishmeal and oil prices on farm-level costs and may increase the price of salmon above previously projected levels.

However, transition to soy alone creates the potential for reputational risk through deforestation exposure or 'pirate soy', as well as lowering the nutritional content of the product. The salmon industry has displayed strong momentum in adapting its feed supply, but financial risk remains prevalent until a sustainable supply of fish oil alternatives can be created and scaled at a cost-effective rate.

To protect investor capital, investors in the farmed salmon sector must act to protect wild-catch fisheries to conserve protein supply chains - see Planet Tracker's report "Perfect Storm" for the impact of declining wild-catch fisheries.

While it is important to recognise how the industry is attempting to address the issue of feedstock costs and sourcing, feed costs will remain a limiting factor for growth in farmed salmon until technological innovation enables cost-effective sustainable production of the protein volumes needed, as well as maintaining acceptable levels of key nutritional elements, such as omega-3.

Industry needs to address the environmental risks it faces from the collapse of forage fisheries and the reputational risks arising from deforestation and degradation in soy protein concentrate production to ensure long term industry viability and growth while minimizing industry's reputation and financial risks.

Table 17: Relevant Legislation for Salmon Concessions [clxvii]

Country	Policy	Description
Canada	Fisheries Act (1985)	Covers multiple fishery and fishery-related issues.
	Pacific Aquaculture Regulations (2010)	Applies to aquaculture in fresh and marine waters in British Columbia.
	Aquaculture Activities Regulations (2015)	Clarifies conditions under which aquaculture operators may maintain an aquaculture facility, treat their fish for disease, as well as deposit organic matter.
	Food and Drugs Act (1985)	Covers food, drugs, cosmetics and therapeutic devices.
	Pest Control Products Act (2002)	Protects human health and safety and the environment by regulating products used for the control of pests.
	Health of Animals Act (1990)	Covers diseases and toxic substances that may affect animals or that may be transmitted by animals to persons and respecting the protection of animals.
	Canadian Environmental Assessment Act (2012)	Describes responsibilities of the federal government in relation to the environmental assessment of projects, but not including aquaculture projects.
	Ministry for Environment Finfish Aquaculture Waste Control Regulations (2004) amended (2010)	Applies to all farms' provisions for registration, waste discharge standards, pre-stocking requirements, domestic sewage requirements, best management practices, monitoring and reporting, remediation, fees, offences and penalties.
	Navigable Waters Protection Act (1985)	Covers the protection of navigable waters.

Country	Policy	Description
Norway	Aquaculture Act (2006)	Licenses the transfer, mortgaging and registration of aquaculture licences, environmental surveys.
	Regulations on production areas for aquaculture of fish in the sea of salmon, trout,and trout (2017)	Establishes production areas for commercial aquaculture of fish of salmon, trout and rainbow trout, and the regulation of the production capacity within these areas.
	Food Safety Act (2003)	Regulates animal health, food safety and quality.
	Animal Welfare Act (2009)	Regulates animal welfare and respect for animals.
	Pollution Control Act (1981)	Protects against pollution, promotes waste management.
	Fish Disease Act (1997)	Addresses diseases in fish and other aquatic animals.
	Natural Diversity Act (2009)	Protects biological and geological diversity and ecological processes through sustainable use.
	Planning and Building Act (2008)	Promotes sustainable development and co-ordinated planning between the central government and regional and municipal bodies to provide a basis for administrative decision-making regarding the sustainable use of resources.
	FOR-2014-12-19-1726 (2014)	Regulates environmental impact assessments.
	FOR 2012-12-05 nr 1140 (2012)	Controls the incidence of sea lice on farmed and wild salmonids.
	FOR-2008-06-17-822 (2008)	Promotes the health and welfare of farmed fish and the sustainable economic development of the industry.
	FOR-2013-06-24-754 (2013)	Regulates licensing.
	FOR-2009-08-18-1095 (2009)	Reduces the incidence and harmful effects of sea lice and combats the development of drug resistance in lice.
	European Economic Agreement (EEA) Council Regulation (EC) (2009)	Concerns pharmacologically active substances.
	EC Regulation No. 37 (2010)	Lists prohibited and allowable pharmacological active substances.

Country	Policy	Description
Chile	General Law on Fisheries and Aquaculture (GLFA) (Law No.18.892)	Regulates Chilean aquaculture, including establishing of licensing and area-based management systems.
	GLFA Law No. 20.434, Modifies the General Law of Fisheries and Aquaculture, in the Matter of Aquaculture	Creates the Aquaculture Subdivision in SERNAPESCA and reinforced SUBPESCA's National Direction of Aquaculture. Strengthens the government's role in inspection and enforcement and distinguishes aquaculture activities from fisheries activities.
	Regulation on Concessions and Authorizations for Aquaculture (1993)	Licenses farms.
	National Environmental Framework Law (1994)	Regulates environmental impact assessments and monitoring
	Environmental regulations for aquaculture (2001)	Regulates environmental requirements for approval of aquaculture activities, avoiding and assessing sediment anoxia. Establishes site characteristics for inland and marine sites. Establishes annual environmental monitoring as part of the environmental information programme.
	Sanitary regulations for aquaculture (2001)	Prevents and controls high risk diseases in aquatic species.
	Resolución Exenta No. 1141 (2012)	Creates sanitary program for monitoring and control of caligidosis
	Resolución Exenta No. 1741 (2013)	Classifies high-risk diseases.
	EC Regulation No. 37 (2010)	Lists prohibited and allowable pharmacological active substances.

Country	Policy	Description
United Kingdom (Scotland)	Town and Country Planning (Marine Fish Farming) (2011)	Supports local authorities and statutory consultees: SEPA, SNH, MSS, District Salmon Fishery Boards – planning permission.
	Marine Act (2010)	Supports marine planning and marine licensing including well boat discharges, seal control, marine installations.
	Aquaculture and Fisheries Act (2013)	Manages interactions between farmed and wild salmonids e.g. sea lice control, escapes; well boat control and monitoring. Establishes Farm Management Areas and Farm Management Agreements that support co-ordination between producers.
	Water Environment (Controlled Activities) Regulations (2011)	Licenses and monitors aquaculture activities having an impact on the environment.
	Crown Estate Act (1961)	Manages and supports leasing of the seabed.
	Town and Country Planning (Environmental Impact Assessment) Regulations (2011, 2017)	Frames environmental impact assessments prior to development.
	Aquatic Animal Health Regulations (2009)	Authorises aquaculture production businesses, disease monitoring and control, health certification.

APPENDIX E – STRENGTHS AND WEAKNESSES OF NEW FARM TYPES

The Canadian Government assessed three distinct production methods (RAS, CCS, Offshore), alongside hybrid systems, across 7 environmental criteria and 7 economic criteria for suitability in the Canadian Province of British Columbia (referred to as B.C. in the following table).

Table 18: Environmental and Economic Considerations of Novel Salmon Aquaculture Solutions in Canada. Adapted from Canadian Government (2020) 'State of Salmon Aquaculture Technologies' [clxviii]

Factor	Land RAS	Floating CCS	Offshore
Marine Escapes	Not considered an issue for Land RAS.	There have been historical escape events from floating CCS systems due to structural failures during storm events. The risk for escapes persists, especially during transfer of salmon to and from the site.	The risk of escapes is relatively low since these systems are built for very harsh conditions and the integrity of the containment system for salmon is extremely high. There have been issues with earlier systems and it will be important for next generation systems to demonstrate their integrity.
Wild salmon / Disease Impacts	Not considered an issue for Land RAS.	Sea lice risk is significantly reduced but risk of disease remains if untreated water is used in the system – treatment and filtering of outflows has not been developed at economical stages yet. Using water from underneath the structures significantly reduces risk of sea lice introduction.	Offshore systems are open pens so disease transfer within farms is still high. System offers protection of wild salmon from sea lice and potentially other diseases, as well as protecting wild salmon migratory routes. Sea lice risk is significantly reduced if cages are submerged below water depths where sea lice are prevalent. There will be more space offshore to separate growing sites so the transfer of sea lice between sites and resulting build-up will be lowered.
Waste Effluent	Waste will be handled on land with advanced access to disposal including composting, soil amendments for energy generation using biodigesters. Discharge of saltwater does present a risk if freshwater or marine resources become contaminated. Land-based RAS offers the best potential waste management of the new technologies.)	Advanced designs assume waste will be extracted and processed on land. However, this does not capture all dissolved nutrients and waste particles and difficulties exist processing saltwater waste materials.	Offshore systems will produce high amounts of waste due to high fish biomass, but the issues of this will be less pronounced due to faster currents and deeper waters. Impacts to benthic communities are likely to be minimal. Assuming the resources used on-site are biodegradable, waste build-up in the surrounding area is not expected to pose risks - some waste collection for land-based processing is possible, but this raises costs.

Factor	Land RAS	Floating CCS	Offshore
Wildlife Inter-actions	Not considered an issue for Land RAS.	Interactions with wildlife are reduced by solid-wall tanks, but not eliminated altogether. Mooring lines and anchoring systems could be a concern for marine mammals, but there is no scientific consensus on this as yet.	Since these systems will be built with stronger materials for security and integrity, this should improve performance. As for floating CCS, offshore system use of mooring lines and anchoring systems could be a concern for marine mammals, but this requires further research with implementation of these systems.
Chemical Release	Pathogenic microbial infections are the main concern in these systems, but standard anti-microbial treatments are avoided since they harm the beneficial bacteria used in the bio-filters (denitrifying bacteria). These systems employ some antibiotics for bacteria, formalin for gill parasites and alternatives such as low dose ozone.	Reduction in sea lice and other diseases minimizes or eliminates therapeutants and treatments that are released in marine waters.	Disease pressures including sea lice are expected to be lower therefore use of treatments and therapeutants will be minimized. Where anti-fouling agents (e.g. copper) are used, there is some concern that these will be more common on large metal structures, and once they fall to the seafloor it would be a challenge to recover them in deep waters.
Water Usage	This is minimal in state of the art re-circulation systems. RAS Salmon facilities are already operational in desert environments. There is a caution regarding exceptionally large developments and sites with water limitations or sensitive environments (e.g. aquifers). Requirements for a depuration stage to deal with off-flavours before sale to market may also use more water than the rest of the production scale.	Since the water usage is not derived from limited sources (e.g. aquifers), this issue is not associated with these systems.	This is not considered an issue for offshore systems.
Energy Usage	System design and location dependant - In general, these systems use more energy in construction and operation than other systems. Use of solar panels, wind turbines, energy generation through biodigestion of waste material and other low carbon electricity sources can alleviate climate change concerns.	Energy usage is greater than for open pens, but lower than land-based RAS requirements. Grid connected electricity is best, but not always possible, so self-sufficiency with solar and wind energy is being developed to avoid the need for diesel generators. Some energy is used in the service and supply activities to the structure, but this is not substantial over the production cycle or life of the system.	Offshore systems require substantial energy in construction, although not as much as land-based RAS. Operational energy requirements will be low since currents will move water through the system. Renewable energy such as solar panels and wind turbines can be incorporated into offshore systems, and this will be used to run automatic feed systems, remote operated vehicles or cage movements. Transport of goods and personnel to and from the offshore sites will add to energy requirements, although the frequency of ship movements will be relatively low. For developments in Canada (specifically in BritishColumbia) short distances to existing feed supplies is an advantage, but farms are still distant from major consumer markets.

Factor	Land RAS	Floating CCS	Offshore
Profit-ability	Announcements of secured funding for numerous large-scale projects has proven that investors are ready to move this system forward even with relatively high risk. There is a concern that failures of these large projects to deliver on promises to investors could hamper the momentum that exists. Given the need to monitor the success in the next few years for the large systems being built, there is still some caution before declaring these are profitable.	Signs of financial attractiveness and feasibility are emerging as companies are investing in this technology. Increased costs of sea lice treatments coupled with operational advantages of this approach are making floating CCS more commercially viable reducing the relative costs of the system. There is no surge in development yet, but proof of commercial viability will grow in the next few years.	The financial attractiveness and feasibility are least evident with this system, as the largest investments in offshore salmon aquaculture have only recently begun and most are concentrated in China. The drivers for investment in China are different, but some salmon production companies in Europe are also deploying offshore systems. The next 3 to 5 years will confirm profitability at commercial scales.
Capital Costs	The capital costs have dropped substantially over the last ten years and are now in the range of $10 CAD to $14 CAD per kg of salmon capacity for systems with 5,000 tonnes capacity. The largest proposed projects today (over 10,000 tonnes) are in the $7 CAD to $10 CAD per kg range. These figures do not account for production not always meeting capacity, so actual capital costs per kg of salmon produced will be important to confirm going forward. Capital costs include site preparation, buildings, electrical, concrete work, RAS equipment and other installations (excluding land). The time required for permitting is related to capital costs. Any complexity and delay of permitting and approvals is a deterrent to development of land-based RAS systems, since financial capital is tied up longer. The locations where large projects are going forward took many years to meet all regulatory requirements. This ultimately represents a cost to operate, risk to investors and a challenge to achieve returns on projects.	Capital costs range from $5 CAD to $15 CAD per kg of salmon capacity and this wide range reflects the variety of designs still being considered. There are fewer opportunities to gain economies of scale and bring unit capital costs down as for large offshore or land-based technologies.	This is lower than for full grow-out in land-based RAS. Approvals and permitting processes have not been fully elaborated so this extends the wait for investors. Once this is resolved, the long-run prospect for permits and approvals will be superior to other alternatives owing to the space available and uniformity of offshore locations. The unit capital cost of 5,000-6,000 tonnes capacity offshore systems in Norway and China are just over $20 CAD per kg of growing capacity. Annual capital maintenance and depreciation is about 2% of capital costs. The increased costs relate to the large solid structures required to maintain the system in high energy environments. Larger vessels for deployment and servicing are costly, anchoring systems and advanced automation and controls add to the total. The amount of fish produced in the system is the partially offsetting factor that keeps unit capital costs within a reasonable range, but further research is required since multiple designs could emerge successfully.

Factor	Land RAS	Floating CCS	Offshore
Operat-ional cost	The operational costs are competitive with other systems, especially where optimal growing conditions and system advantages can reduce costs and reduced transportation exists in ideal locations. The expected production costs per kg of salmon from land-based RAS are now about $5 CAD to $6 CAD. Considering production challenges such as growing salmon to full size and avoiding any system failures, the actual long term operational cost will be confirmed going forward. In Canada (specifically British Columbia), transport to the U.S. is economical, but shipping to Asian markets may be a competitive challenge with this system, especially as local Atlantic salmon production capacity in Asia is growing rapidly.	The operational costs are lower than for land-based RAS, but higher than for hybrid systems. Costs in the range of $4.5 CAD to $5.5 CAD are likely, but research is needed.	The operational costs are very competitive since these systems make the best use of automation and natural resources. A 10-15% additional cost compared to conventional pens is expected in the near-term for offshore systems. This is competitive with land-based RAS and floating closed containment system costs and has the potential to be more economical in the long-run. Feeding and salmon growth is currently not as efficient in offshore environments; insurance costs and transport to and from shore are key drivers of operational costs.
Financial Risk	Pathogen control, biosecurity and system component failures are key concerns for investors as mortality incidents can be severe. High rates of early salmon maturation, poor feeding response to husbandry practices and stocking density issues can also impact growth, quality and ultimately revenues. Although recent financing success is a strong indicator that risks are being addressed in new systems, along with a considerable amount of research to advance the above noted concerns, this is ultimately confirmed through successful operations over a number of years. The current environment is favourable, with salmon prices above $9 CAD per kg over the last two years, but in 2011 and 2012 prices fell below $7 CAD per kg (22% lower). These systems must demonstrate financial resilience through price volatility and also in a global production growth environment. As more land-based capacity develops, along with other emerging technologies, a higher proportion of product will be able to meet high consumer expectations, and this could erode any premiums that are possible.	The financial risks associated with system component failures or market fluctuations are much lower than for land-based RAS or offshore systems.	There is currently a financial risk given this is the newest technology among the alternatives and several years of operation are needed to confirm its reliability. Since there is a relatively high capital investment, it is important to demonstrate that the system is resilient to component failures and market fluctuations (e.g. lower salmon prices).

Factor	Land RAS	Floating CCS	Offshore
Supply-chain	Most of the supply-chain elements required for this system are available, but land-based RAS does not have the best supply-chain advantages amongst the technologies considered. System-specific managers must be trained and the expertise for construction and maintenance are being primarily developed in Europe. As large-scale land-based systems are being developed particularly in the U.S., the advantages in British Colombia are not sufficient to have already attracted large developments and supply-chains will now be developing elsewhere.	Canadian companies offer some designs but use of systems and components from other countries is likely since leading manufacturers are positioned in Europe. Feed production is already well established in Canada, so this is one reason for Canada's economy to perform well with this system.	Leading offshore system designers and manufacturers are located outside of Canada; however, it is possible to bring modules to Canada for domestic assembly and customization. As for other systems, the other primary input is feed supply, which is well-established in Canada.
Economy	Advanced skills and expertise are required for most positions in RAS facilities so locations with excellent training and aquaculture industry presence are in a good position. Given the advanced labour requirements, the salaries and wages are attractive for salmon farm workers. The location of these systems is very flexible so coastal employment opportunities may be lost as production moves closer to consumer markets and distribution centres. There are fewer jobs per tonne of salmon produced than most other alternative technologies. The most significant consideration is where these jobs are located in B.C. or elsewhere – land-based RAS systems operating at commercial scale in B.C. are expected to generate about 26-30 direct jobs per 1,000 tonnes of capacity. This is only a small decline compared to hybrid or floating CCS and a bit more than anticipated for offshore systems. The nature of the jobs will be more technical and average salaries will be higher.	Some labour requirements will include more advanced technical training and higher salaries, but the existing workforce can adapt easily to this system. The number of jobs required is comparable to current industry operations and the use of B.C. marine sites will keep employment in coastal communities. More jobs per tonne of salmon will be retained than with full RAS systems. Floating CCS operating at commercial scale in B.C. is expected to generate about 30-35 direct jobs per 1,000 tonnes of capacity. This is closely related to pen labour requirements with more technical management and maintenance offset by reduced treatment and fish health activities. The mix of occupations will command slightly higher average salaries. These jobs are likely to remain where they are currently located in B.C. since marine grow-out sites will be important.	The main consideration is that the location of jobs, especially those tied to the offshore site activities will shift in B.C.

Factor	Land RAS	Floating CCS	Offshore
Expansion	Sites already selected for existing, under-construction and proposed land-based RAS facilities around the world demonstrate the flexibility in siting this technology. Although there are many considerations for meeting system requirements and optimizing performance, British Columbia offers options for suitable sites. Based on the size of land parcels secured for recent large-scale farms in Maine and Florida, about 32,000 tonnes of salmon can be produced on about 20 hectares of land (50 acres). Subject to water source availability, all of the current farmed salmon production in B.C. could be accommodated in a combined space of about 60 hectares (150 acres). This does not mean it is a simple matter to identify the best location(s) and a couple years may be required for site selection considering the substantial investments involved.	Some growth of production could occur as a result of this approach, however there are anticipated limits to marine expansion. The environmental performance advantages, once fully proven, would offer suitability in a wider range of sheltered in-shore environments, but the issue of marine spatial conflicts will place limits on this. As the systems become more robust for submersible and in-shore exposed applications, there will be more expansion potential.	There are very few limitations to expansion of offshore systems, therefore substantial growth could proceed once this technology is fully proven. B.C. offers extensive offshore waters that are suitable for salmon production. It will likely be a decade before significant commercial operation occurs in Canada or the United States.

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