

Sustainable Edge

Sector Brief: Aquaculture

Year 2020

Sector definition

NACE code A3.2.1: Marine aquaculture. Geographical scope: Norway.

Value chain activities included: Feed production; Fish farming; Processing; Transport.

Most important connecting activities: Production of agricultural and marine ingredients for feed.

Summary

Norway is the world's largest producer of farmed salmon, 95% of which is exported, 70% to the EU. Seafood is the most valuable Norwegian export after petroleum, and salmon accounts for 66% of this export. The carbon footprint of farmed salmon is substantially lower than that of beef, but higher than that of poultry. The majority of salmon's carbon footprint arises in the production of agricultural and marine inputs for salmon feed. Brazilian soy is a particularly problematic input, as its cultivation is linked to deforestation. In addition, aquaculture causes a range of local environmental problems in Norwegian fjords, including prevalence of sea lice, increased levels of disease, nutrient leaching, and decline in wild salmon stocks. Norwegian Seafood Federation is looking for more volume growth in the future to continue developing the industry.

Main climate and environmental risks¹

- Happening now → ● Limitations in licenses for production due to local environmental problems (particularly sea lice)
- Likely in short term → ● More frequent periods of abnormally high sea temperature
- Likely in medium term → ● Climate policies in Norway and internationally will likely increase the cost and availability of feed and transport

¹ The selection of key risks and categorization of those is based on expert judgement. Short-term refers to impacts that are likely in the next decade.



Physical risk exposure

- Water temperatures >14°C reduces growth health, and welfare. Above 20 °C, growth stops and mortality increases. Projections under RCP 4.5 (mild scenario) shows negative effect on production in southern Norway due to temperature rise already in the 2020s (Falconer et al, 2020).
- Increased freshwater runoff and sea water temperature may facilitate increased spread of sea lice (Berg et al, 2012).
- Increased storm activity can cause damages and fish escapes (Barange & Perry, 2009).
- More frequent algal blooms (Barange & Perry, 2009), as experienced in Northern Norway in 2019.
- Catches and prices of fish for feed depend heavily on weather events that relate to climate change (FAIRR, 2019a).
- Ocean acidification has been hypothesized to affect young salmon growth (Ou et al., 2015) but the effect on salmon is understudied; no conclusion can be reached.

Transition risk exposure

- The government has for the first time instructed a reduction in production in some areas due to sea lice pressure.
- Increased concern with the negative environmental effects of aquaculture may result in further restrictions, limiting growth or increasing costs.
- Stricter climate policies (like higher carbon price) would make product transport more expensive.
- Stricter climate and environmental policies in the agricultural sector may make inputs to feed production more expensive.
- Evolution of plant-based and cell-based meat production may affect demand for seafood (FAIRR, 2019a).

Key statistics & background figures

- Aquaculture has surpassed wild fishing as the main provider of seafood globally. Aquaculture represents 47% of global fish production, 53% if excluding non-food uses (FAO 2018).
- Fish accounts for about 17% of animal protein consumed by the global population. Fish consumption has increased by 3.2% in volume annually over the period 1961-2016, outpacing the growth for meat.
- Salmonoids account for 18% of world trade in fish and fish products by value, more than any other species group (FAO 2018).
- Norway is the world's largest producer of farmed salmon, the second largest when including all farmed finfish, and the seventh largest when including all farmed seafood (FAO 2018). Aquaculture accounts for 72% of Norway's seafood exports (seafood.no).
- The sector accounts for 1.3% of GDP in mainland Norway, counts around 1000 farms², and employs 8000 people. Annual growth in value terms 1995-2017 has been almost 10% (NOU 2019: 18).
- Direct emissions from farms and associated vessels in Norway: 454 000 tonnes CO₂ annually (1% of Norway's territorial emissions) (ABB/Bellona, 2018). These emissions are covered by the Norwegian CO₂ tax (544 NOK/ton CO₂e). Indirect emissions are many times larger. Feed production accounts for ~80% of the carbon footprint.
- No reliable statistics are available for the sector's GHG emissions globally.

² of which 600-700 are typically producing at any point in time while the rest are in fallow periods.

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About this brief

This sector brief was developed by CICERO as a part of the Sustainable Edge research project. The purpose of the brief is to outline the key material climate-related issues for the sector. The audience for the brief is the financial sector, either as potential investors or lenders to the sector. The reader is expected to have background knowledge of the sector and of climate risk assessment. The analysis methodology is rooted in CICERO's climate science and build on CICERO Shades of Green's methodology for green bond frameworks. This brief is to be considered a science-based opinion. CICERO Shades of Green AS is a subsidiary of CICERO established in November 2018.

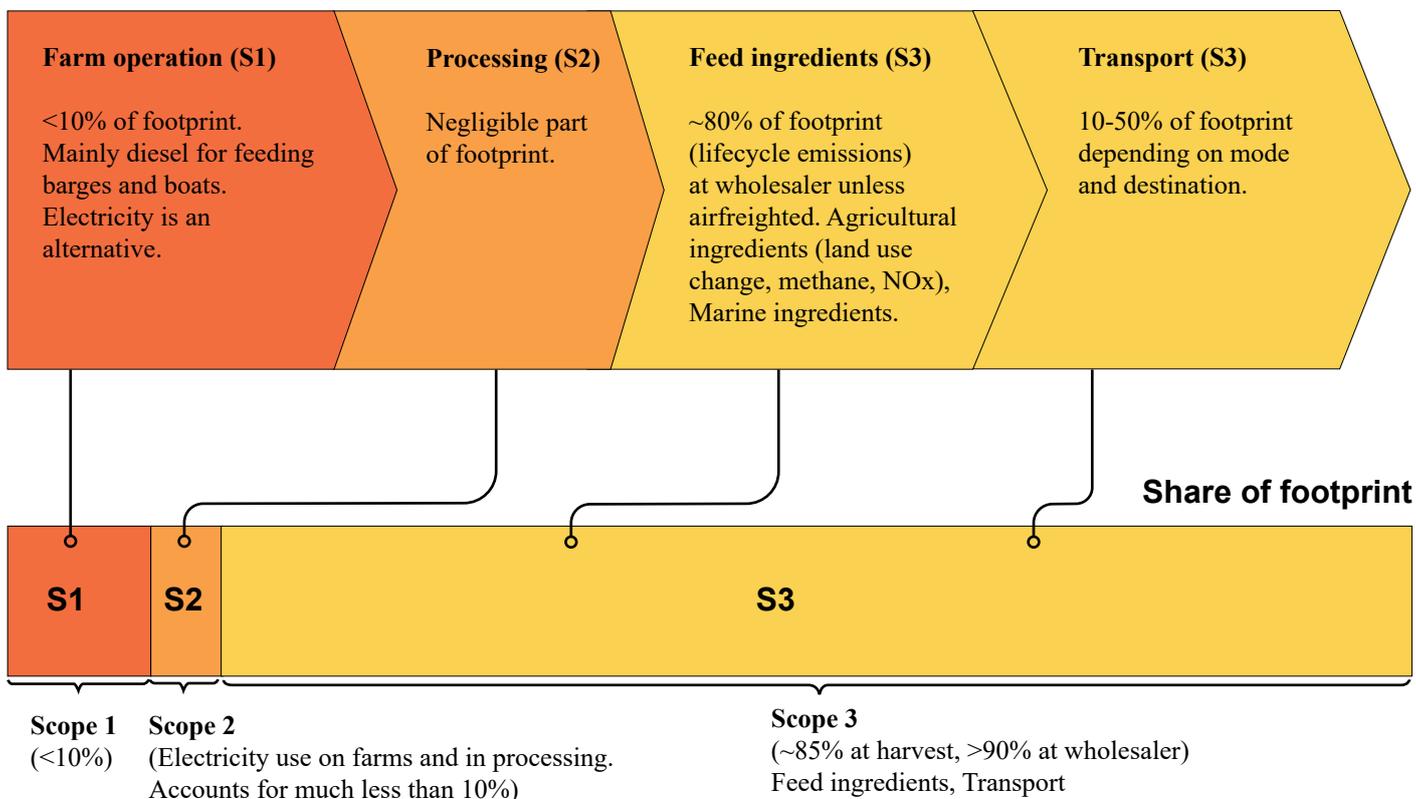
CICERO Shades of Green AS has commercialized a corporate climate risk assessment based partially on the Sustainable Edge research, in addition to their own methodological development. The Sustainable Edge project is financed by ENOVA SF and our financial sector partners: Oslo Pensjonsforsikring, CICERO Shades of Green AS, Nysnø, Sparebank 1 SMN, Sparebank 1 Nord-Norge, SR-Bank, Samspar and Sparebank 1 Østlandet. Thank you also to our partners Finans Norge and Schjødt.

Please note this assessment focuses on climate-related issues and risks. Other environmental and social aspects may be noted, but assessing material social, ethical and governance issues are outside the scope of the assessment. We discuss governance specifically in the context of climate governance, this should not be viewed as a substitute for a full evaluation of the governance of the sector and does not cover, e.g., corruption.

CICERO Center for International Climate Research
P.O. Box 1129 Blindern
N-0318 Oslo, Norway
Phone: +47 22 00 47 00
E-mail: post@cicero.oslo.no
Web: www.cicero.oslo.no

Emissions

Main sources³



Scope 1 (S1)

Definition: Direct emissions from owned or controlled sources, e.g. fuel use by boats and other farm infrastructure, direct emissions from feed factories, and transport fuel.

Status:

- Feeding barges are powered by electricity or diesel generators and are the most energy intensive piece of equipment at farms.
- Vessels used in farm operations currently use diesel, with some hybrid vessels recently added. Fully electric alternatives are under development.

Potential and challenges: to reduce scope 1 emissions

- Around 60% of farms are connected to the electricity grid.
- Connecting more farms and electrifying vessels could reduce Norwegian fish farms' direct emissions by 75% using existing technologies (ABB/Bellona; 2018).
- For remote localities, hybrid diesel generators can improve efficiency. These can later be replaced by on-site electricity generation (ABB/Bellona, 2018).
- See Klimakur 2030 (S09) for more detailed assessments.

No targets set by government or industry organizations. Some companies have set targets (see Table 2).

³ Key source: Winther et al. (2020)

Scope 2 (S2)

Emissions are considered negligible due to Norway's supply of carbon-neutral hydropower.

Scope 3 (S3)

Definition: All indirect emissions that occur in the value chain of the reporting company including up- and downstream emissions, most notably emissions relating to production of inputs to feed.

Status:

- Generally, the amount and type of feed used determines the carbon footprint of farmed salmon, except if the fish is airfreighted (Winther et al., 2020).
- Land-use change alone accounts for around 28% of footprint at slaughter, but estimation is uncertain. These emissions are embodied in soy protein concentrate from Brazil, which may contribute to deforestation (see Pitfalls).
- Like soy, micro ingredients (e.g., amino acids and phosphate) provide a disproportionate contribution to the footprint.
- For marine ingredients, the main emissions source is fuel use in fishing vessels.
- Transport emissions vary greatly by mode and destination. Generally contribute <25% to the final footprint, but air transport to Asia more than doubles the footprint (Winther et al., 2020).
- Ship and rail transport give the lowest emissions (Winther et al., 2020)

Potential and challenges: to reduce scope 3 emissions

- Feed efficiency is an important determinant of scope 3 emissions. Sea lice and diseases cause mortality and reduced growth thus causing reduced efficiency over the last decade (Winther et al., 2020).
- Feed composition is also important. Reducing the share of marine ingredients reduces overexploitation of wild fish stocks but increases emissions from agricultural inputs.
- To reduce risk of deforestation from increased soy demand, conduct dialogue with Brazilian soy suppliers, or source from other countries. E.g. Salmon Group (network for smaller fish farmers) replaced Brazilian soy with European soy in 2019.
- There is potential for reduction in soybean protein concentrate. Currently ranges from 10%-26% across Norwegian feed producers (Regnskogsfondet & FIVH, 2017)
- More sustainable protein sources are under development, based on, e.g., seaweed and insects. Research is needed to assess the carbon footprint of these alternatives.
- There has been a large increase in airfreight of Norwegian seafood in recent years. Farming closer to markets can reduce the need for airfreight (Winter et al., 2020).

No targets set by government or industry organizations. Some companies (Mowi, Grieg) have set voluntary targets that cover scope 3.

Climate risk management



Current risk management

- The major Norwegian feed producers are engaged in a dialogue with their soy suppliers to encourage reduced deforestation. Soy currently imported to Norway is certified not to come from land recently deforested.
- The Collier FAIRR Protein Producer Index analyze the 60 largest global meat, dairy and aquaculture producers across a range of environmental, social and governance risk factors.
- Climate disclosure by the major firms is generally good. This includes reporting according to TCFD recommendations.

Key opportunities

- Demand is expected to increase as global population is projected to grow beyond 9 billion by 2050 (FAO 2018)⁴.
- Capture from fisheries has been stagnant for 30 years and is not projected to increase. One third of fish stocks are fished beyond biological sustainability (FAO 2018).
- Aquaculture has the potential to address the gap between aquatic food demand and supply and to help countries achieve their economic, social, and environmental goals (FAO 20118).
- The potential for emissions reductions from the replacement of red meat with farmed seafood and plant-based diets is estimated at 2.9 million tonnes of CO2 equivalent between 2021-2030. This is almost double any other mitigation measure within the food sector. (Klimakur, 2020).
- Shifting diets from red meat to farmed seafood could spare millions of tonnes of feed crop annually (Froelich et al, 2018).
- The climate footprint of farmed salmon is substantially lower than that of beef, and in between those of pork and poultry. (Winther et al, 2012). Climate policies may therefore make farmed fish more competitive.
- Aquaculture facilities located closer to the shore (60%) are already connected to the grid. The remaining 40% that are located further offshore will be more expensive to electrify but will likely receive subsidies through, e.g., Enova (Klimakur 2030).
- Sea temperature rise in Northern Norway likely beneficial for growth but also likely to increase disease and parasites (Falconer et al, 2020.).
- Climate impacts on agriculture may increase global demand for farmed fish (Mikkelsen & Buanes, n.d.).
- Innovations may significantly reduce the climate and environmental impacts of aquaculture. E.g., closed containment systems (CCS), new alternatives to soy, new delousing technologies. Note that may also pose a risk to the Norwegian industry as it will allow a range of northern countries without fjords to enter the market on the supply side.
- Delaying the transfer of fish from land to sea (post-smolt production) reduces escapes, mortality, sea-lice problems, and the amount of time the fish interacts with the marine environment (NOFIMA, 2019). However, land-based systems require more energy (Klimakur 2030).
- Growth in aquaponics (combining aquaculture with cultivating plants in water) makes the industry more climate resilient, less resource-intensive, and reduces waste. However, it will require considerations like electricity cost, combined risk of aquaculture and hydroponics (NIBIO, 2015)

⁴Note that population scenarios are under revision.

Key pitfalls

- Greater demand for fish will lead to greater risk for environmental impacts from aquaculture, including fish escapes, disease, lice, and mineral leaching (Klimakur 2030).
- Farmed salmon is the Norwegian seafood product with the highest emissions (Winther et al., 2020).
- Demand for soy contributes to demand for tropical deforestation (Regnskogsfondet & FIVH 2017), and thus to GHG emissions and other negative environmental impacts. Soy protein concentrate makes up 10-26% of the feed produced in Norway. Most soy currently imported to Norway is certified not to come from land recently deforested. However, a problem with the certification schemes is that major soy producers currently only certify a small share of their production, while the rest may contribute to deforestation. It is not possible to reliably quantify the emissions difference between certified and non-certified soy (Winther et al, 2020). Demand for marine ingredients in feed puts pressure on wild fish stocks.
- Airfreight over long distances can more than double the product's footprint and there has been a large increase in airfreight of Norwegian salmon in recent years. (Winther et al, 2020).
- Fish escapes pose a serious threat to wild salmon stocks, as the farmed fish modify the gene pool and outcompete local species.
- The high concentration of salmon in farms allow sea lice to thrive, which also pose a threat to wild salmon stocks. Closed containment systems offer a solution to this issue.
- Chemicals used for delousing may negatively affect wild species such as cod and shrimp, and thus coastal fisheries.
- Increasing problems with disease and sea lice have increased the carbon footprint of farmed salmon, through reduced feed efficiency and increased use of service vessels for treatment (Winther et al, 2020).
- Organic matter from open-net pens negatively affect life on the adjacent seabed.
- Medicines have been found to kill shrimp and other crustaceans in laboratory experiments.
- Copper used in antifouling paint for fish farm installations is a toxin polluting the local marine environment.
- Concern about fish welfare is increasing among consumers. Fish disease and mortality also lead to increased emissions through lowering the feed efficiency.

Disclosure and integration of climate risk

Climate disclosure by the major firms is relatively good (see Table 1). Some have also set targets for reducing emissions (see Table 2). However, only one company has set a target for reducing scope 3 emissions, which account for ~80% of total emissions.

Disclosure of climate risk and environmental impact

Norwegian aquaculture companies score well in terms of GHG disclosure compared to other protein producers (Fairr 2019b).

Company	CDP Climate Change 2019	CDP Forests 2019	Completeness of emissions disclosure (scope 1&2) (FAIRR, 2019b)
Mowi	A-	No response	Complete
Salmar	B	Declined to participate	Complete
Lerøy Seafood Group	C	No response	Complete
Bakkafrost	Declined	Declined to participate	Complete
Austevoll Seafood	No response	No response	Company not assessed
Grieg Seafood ⁵	A	Declined to participate	Complete
Norway Royal Salmon	B	Submitted but was not scored	Company not assessed

Table 1. Companies disclosure of climate risk. Companies are listed in order of valuation at Oslo Stock Exchange (NOU, 2019).

⁵ Mowi, followed by Grieg Seafood, recently issued the first green bonds in the aquaculture sector (both rated medium green).

Integration of climate risk in operations / decisions

The Collier FAIRR Protein Producer Index analyses the 60 largest global meat, dairy and aquaculture producers across a range of environmental, social and governance risk factors. Of the seven companies ranked as lowest risk, five are Norwegian aquaculture companies (see Table 2 below). Although scope 3 emissions account for >90% of GHG emissions at wholesaler, most companies lack targets covering scope 3 emissions-reduction.

Company	Fairr (2019b) risk index rank	GHG mitigation target strength (FAIRR, 2019b)	Change in reported emissions 2017-2018 (FAIRR, 2019b)
Mowi	1 (low risk)	Target covers >95% emissions in scope	Large decrease
Salmar	7 (medium risk)	Partial target	Increase
Lerøy Seafood Group	2 (low risk)	Target covers >95% emissions in scope	Increase
Bakkafrost	3 (low risk)	Energy-related target	Increase
Grieg Seafood	5 (medium risk)	Target covers >95% emissions in scope	Increase

Table 2: Companies' engagement with climate risks.

Regulations and scenario information

Policies in Norway

- Production requires a permit, which are issued based on environmental requirements in the Aquaculture act and the Biodiversity act.
- The government introduced the “traffic light system” for sustainable growth in 2017, to determine where production can be expanded (green) and where it must be reduced (red). Two out of 13 zones got a red light in 2020. However, the only environmental indicator relates to sea lice effects on wild salmon (Fauchald, 2017), thus ignoring other environmental issues. Chemical delousing improves the sea lice situation but may cause harm to other species, while treatment with hot water increases salmon stress and mortality.
- Climate considerations are not included in the regulatory system and neither government regulation nor voluntary certification schemes currently address GHG emissions. However, GHG emissions may become a criterion for permit issuances in the future (Klimakur 2030, p. 176).
- Voluntary certification schemes (e.g. ASC, BAP, Global GAP, and particularly organic schemes) set stricter criteria than Norwegian regulation to address non-climate environmental challenges.

EU Taxonomy

Sector is not included in the EU Taxonomy as of November 2020.

Global scenarios

- The FAO (2018) predicts 36.7% growth in global aquaculture production from 2016-2030 (in tonnes). For Norway, the predicted growth is 30% (FAO 2018).
- One report estimated a potential for a fivefold increase in Norwegian aquaculture production 2010 to 2050 (by value) given that challenges around local environmental impact and feed ingredients sourcing were resolved (DKNVS & NTVA, 2012).

CICERO Shades of Green & analyst perspective

CICERO Dark Green for the sector⁶

Considerations for main activities

- Both the site and associated vessels should be electrified, along with a focus on improving energy efficiency.
- Closed containment systems (CCS) onshore greatly reduce local environmental effects and may increase feed efficiency, although energy use increases greatly. CCS opens opportunity to place “catch-crops” e.g., shellfish nearby to filter organic effluents and to use as feed (Rosten et al., 2013). Moving all current aquaculture onshore would increase Norway’s electricity consumption by 7-11 TWh (5-8%) and require upgrading of the grid (Klimakur 2030). CCS farms at sea have succeeded in eliminating escapes and lice, but do not contain the waste. Not yet in commercial production (SFI, 2018).
- Offshore farming reduces contact with wild salmon stocks and facilitates greater dilution of waste (SFI, 2018). However, increased distance to shore makes electrification more difficult, increases transportation, and increases exposure to wind and waves.
- Ensure local coastal communities and stakeholders are involved in decision-making process (FAO, 2017a).
- Incorporate integrated monitoring and information systems to aid in responding to environmental impacts.
- Optimize feeding with alternative (non-soy/fishmeal/fish oil) feeds, to improve fish health and reduce emissions intensity (FAO, 2017b).
- Focus on biodiversity, which improves fish health and resilience to disease. (FAO, 2017a).

Considerations for upstream and downstream factors

- Product transport should not be by air, and preferably by ship or rail.
- Soy from suppliers that do not contribute to deforestation in their operation, for example from countries where agriculture is not expanding.
- Alternatively: soy-free feed. Alternative vegetable protein sources are already used. Potential future alternatives include insects, seaweed, and wood.
- Feed production mill emissions can be reduced by using alternative lower emission fuels.
- Utilize by-products from processing and reduce waste along the value chain. (FAO, 2017a)
- Marine ingredients in feed should comply with the Aquaculture Stewardship Council’s criteria.

Current best practice - activities

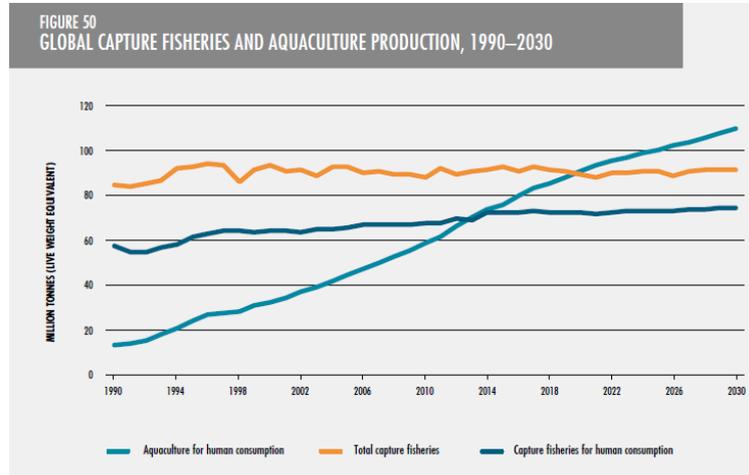
- ★ Since the majority of emissions arise from feed production, there should be a focus on feed sourcing, efficiency, and composition.
- ★ Several voluntary certifications schemes exist but, like Norwegian regulation, the certification schemes do not consider GHG emissions. The Aquaculture Stewardship Council (ASC) is regarded as having the strictest environmental criteria (FIDRA, 2018). In many respects, they are much stricter than the standards set by Norwegian government (Vormedal & Gulbrandsen, 2018). The ASC requires soy to be sustainably sourced (relying on soy certification schemes), from 2022, but its operationalization is relatively weak.
- ★ Most soy imported to Norway for aquaculture feed is certified according to ProTerra, which provides a better safeguard against deforestation than required by the ASC.
- ★ Organic salmon farming uses less soy and has stricter criteria on deforestation and pesticide use (Regnskogsfondet & Framtiden i Våre Hender, 2017).
- ★ 60% of aquaculture facilities in Norway are connected to the electricity grid (Klimakur 2030).
- ★ Closed containment systems reduce fish escapes and prevent sea lice and disease spreading in wild salmon. Post-smolt production involves keeping the young fish in such systems for longer before transfer to open net pen systems. Environmental benefits are less time interacting with the marine environment, lower mortality, and reduction in sea lice problems. However, energy consumption goes up.
- ★ New technologies for monitoring and de-licing can be used to achieve increased growth, improved fish welfare, reduced local environmental impact, and reduced carbon emissions through increased feed efficiency.

Current best practice - Governance

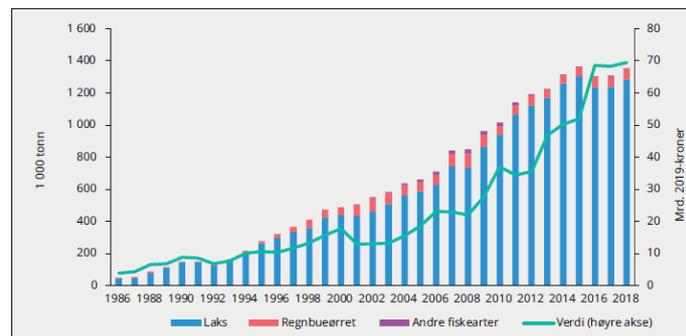
- ★ Norwegian aquaculture companies and feed producers are engaged in a the ‘Aquaculture Dialogue on Sustainable Soy Sourcing from Brazil’ with ProTerra and major soy suppliers, working towards reducing deforestation also in non-certified production.
- ★ Several aquaculture companies and feed producers signed the New York Declaration on Forests at the UN Climate Summit in 2014, setting a goal to eliminate deforestation from the production of agricultural commodities such as soy.
- ★ Several Norwegian companies in the aquaculture supply chain are signatories to the Cerrado Manifesto Signatories of Support, an initiative aiming to halt deforestation in the Cerrado in Brazil, which is currently the world’s largest area of deforestation. Grieg Seafood is in the steering group. Grieg Seafood has also, together with Tesco and Nutreco, launched the Cerrado Funding Coalition, which aims to provide financial incentives for soy farmers in the Cerrado to halt deforestation.

Data and indicators for climate risk disclosure

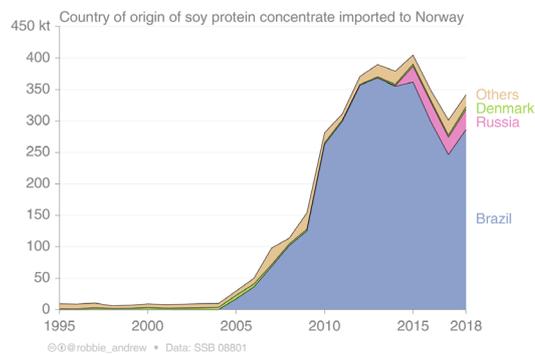
Historic data



1 Global Capture Fisheries and Aquaculture Production. Source: FAO 2018



2 Sale of farmed fish for food consumption in Norway 1986-2018. Note: blue = salmon, red = trout, purple = other, green = value Source: NOU 2019: 18.



3 Import of soybean protein concentrate for use in Norwegian aquaculture feed by country of origin. Imports from Brazil raise concerns about deforestation. Source: SSB (2019).

Climate-relevant data sources

- FAIRR (2019b) finds that the five Norwegian aquaculture companies included in their analysis all provide complete GHG inventories. Data is available to investors at fairr.org.
- Responses to the CDP are available at cdp.net.
- Data on mortality, sea lice, mineral effluent available at Miljøstatus for Fiskeoppdrett.

Potential difficulties in attaining / using existing data

- As >90% of total emissions at wholesaler are scope 3, estimation is complex and uncertain.
- Footprint estimation would be simplified if companies collected the most critical data in a standardized way and ideally made them public (Winther et al, 2020).
- Fish farmers generally do not include energy use of sub-contractors in their GHG accounting (Winther et al., 2020).
- Some exported fish is processed and re-exported, which is not captured in current estimations

Indicators which would improve climate risk disclosure⁷ Transition risk

Preliminary indicator or metric	Benchmark/ typical value/range/ASC limit
GHG emissions per kg salmon at slaughter (incl. from feed inputs)	<i>Avg: 5.75kg (Range: 3.4-6.8kg) (Winther et al, 2020)</i>
Total GHG emissions (scope 1,2 & 3)	
% soy used in feed	<i>Range: 10-26% (Regnskogsfondet & FIVH 2017).</i>
% soy originating from Europe	<i>Typically 0, but Salmon Group has achieved 100% (sal-mongroup.no /internasjonal-interesse-for-vart-nye-for/)</i>
% soy certified by ProTerra or equivalent	<i>Typically 100%</i>
Feed conversion ratio	<i>1.32 for Norwegian aquaculture industry as a whole in 2017</i>
Fish mortality	<i>16.2% in 2019 (Norwegian Veterinary Institute, 2020)</i>
Fishmeal Forage Fish Dependency Ratio	<i>ASC: <1.2</i>
Fish Oil Forage Fish Dependency Ratio	<i>ASC: <2.52</i>
% marine ingredients certified	<i>ASC: 100%</i>
Fish escapes	<i>ASC: ≤300 fish per production cycle</i>
Sea lice concentrations	<i>ASC: ≤0.1 mature female lice per farmed fish</i>
Chemical and therapeutant use	<i>ASC: Cumulative parasiticide treatment index ≤13</i>
Copper levels in sediments	<i>ASC: <34 mg Cu/kg dry sediment weight,</i>
% of sites certified by, e.g., ASC	<i>MOWI: 42% ASC</i>
Proportion of produce transported by air.	<i>20% in 2018 (Bellona)</i>

⁷Please note that these are preliminary indicators and metrics that will be further developed. As the methodology and data availability evolves, we expect adjustments to the list. Also note that within the sector there are many different business models and different indicators and metrics may be more relevant depending on the company under assessment.

Preliminary indicators for physical risk

Water temperature (°C)	Implications for salmon
>20	<i>Growth stops, mortality increases</i>
16-20	<i>Reduced welfare and feed intake, growth slows, stress and mortality increases.</i>
14-16	<i>Sub-optimal growth, higher risk of reduced health and welfare.</i>
11-14	<i>Optimal growth and feed intake.</i>



Key analyst questions for all companies in this sector

1. Does the company have a strategy to reduce GHG emissions? Does the company have or plan to set a science-based target to reduce GHG emissions?
2. Does the company report annually on scope 1, 2 and 3 emissions? Does this include emissions from the sourcing of fish feed?
3. Is the company investing in feed innovations that reduce reliance soy?
4. What measures are taken to encourage reduced deforestation in soy production?
5. What measures are taken to improve feed efficiency?
6. What proportion of sites are certified according to the ASC or other schemes? Does the company have a target to certify additional sites?
7. What measures have been taken to reduce local environmental issues (see Pitfalls)?
8. What proportion of produce is transported by airfreight? Does the company take measures to limit airfreight?

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