BLUE EMPIRE

How the Norwegian salmon industry extracts nutrition and undermines livelihoods in West Africa

CONTENTS

Front cover image: Salmon farm in Norway's Lofoten Islands' Credit: Dieter Meyrl (iStock).

GLOSSARY

Aquaculture – Farming of aquatic organisms, including fish, shellfish, plants, and algae. In this report it is used primarily to refer to the production of fish and shellfish for food.

Aquafeed – Compound feed (i.e., feed made up of several different ingredients) given to aquatic farmed animals.

Atlantic salmon (Salmo salar) – The most common species of farmed salmon[1]. The largest producer of farmed Atlantic salmon is Norway[2]. Approximately 70% of salmon produced worldwide is farmed[3].

ECOWAS – Economic Community of West African States, a political and economic union of states in the West Africa region which comprises Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

FAO – The Food and Agriculture Organization, a specialised agency of the United Nations charged with international efforts to defeat hunger and improve nutrition and food security.

FAO 34 – Eastern Central Atlantic Major Fishing Area 34 as defined by the FAO. It is the area located off the west coast of Africa, which stretches from the Strait of Gibraltar to the mouth of the Zaire River[4].

Fed aquaculture – The farming of aquaculture species which require the use of feed inputs. The growth of fed aquaculture (i.e. of species such as farmed Atlantic salmon and farmed seabass) has consistently outpaced the growth of non-fed aquaculture (i.e. of species such as mussels and oysters) in recent decades.

Feed footprint – A term used in this report to refer to the volume of feed, specifically of feed ingredients obtained from wild-caught fish, used to supply the Norwegian salmon industry.

Fish meal and fish oil (FMFO) – Concentrated sources of protein and micronutrients used for the production of feed for aquaculture and agriculture, produced by processing whole wild-caught fish or trimmings from fish processing.

Food-feed competition – The tension between the use of a finite edible resource, such as wild-caught fish, for direct human consumption versus its use to feed farmed terrestrial and aquatic animals.

Global Roundtable on Marine Ingredients – An industry body whose members include feed producers Skretting, BioMar and Cargill as well as fish oil supplier Olvea and European aquaculture producers.

Global South – A term traditionally used to refer to economically disadvantaged nation-states. In recent years, the term has been increasingly employed to refer to spaces and peoples negatively impacted by contemporary capitalist globalisation[5].

IFFO – IFFO is an international trade organisation that represents the marine ingredients industry, such as fish meal, fish oil and other related industries.

Marine ingredients – Inputs for aquafeed, terrestrial animal feed and consumer products such as nutritional supplements and pet food. Principally sourced from whole wild-caught fish in the form of fish meal and fish oil.

MarinTrust – A certification programme dedicated to marine ingredient production factories, allowing them to gain recognition for their sourcing and production of marine ingredients. The fruit of a rebranding process in 2020, it is the successor to the IFFO Responsible Sourcing (RS) standard, which was created by the marine ingredients trade body, IFFO (see above), in 2008.

Novel ingredients – Unconventional ingredients for aquafeed, marketed as alternatives for current unsustainable dependency on fish meal and fish oil. Include algal oil, insect meal and single-cell proteins.

Small pelagic fish – Forage fish such as anchoveta, mackerel, herring, whiting and sardines that live in the pelagic zone (i.e. not close to the bottom or near the shore) of oceans or lakes. They play a vital role in ecosystems as prey of larger ocean animals. In addition to this, they provide critical nutrition for many vulnerable coastal communities in the Global South. Some species of krill and squid are also considered forage fish because many animals rely on them as a food source[6].

Reduction fisheries – Fisheries which process (or reduce) their catch into fish meal and fish oil.

Salmonids – The family of ray-finned fish which includes salmon and trout.

Sardinella – A genus of small pelagic fish, a key source of protein central to food security and livelihoods of coastal communities in West Africa, also used to make fish meal and fish oil. According to the FAO, the state of the once abundant species in Northwest Africa is alarming, with two stocks of sardinella - the round sardinella (*Sardinella aurita*) and Madeiran sardinella (*S. maderensis)* - decreasing in the region[7].

Trimmings – Co-products from fish processing deemed unsuitable for direct human consumption.

Trophic Level – Term used to describe the position of an organism in the food chain. Mid-trophic fish such as sardines, herring and anchovy account for more than one-third of total global marine catch, with the majority processed for fishmeal, oil, and animal feed[8].

EXECUTIVE SUMMARY

SUMMARY OF REPORT

Norway is the world's biggest salmon farming country, with Norwegian companies occupying eleven out of the top 20 slots in the list of global producers of farmed salmon[9]. From its humble beginnings in the 1970s, the industry has come to be dominated by a handful of powerful companies including the world's largest salmon farmer, MOWI, which had a turnover of nearly €5 billion in 2022[10], and supplies supermarkets all across Europe.

However, what is often presented as an exemplary corporate success story has come at huge costs which remain absent from Norwegian salmon companies' balance sheets. One such cost is the socio-economic harm resulting from the extraction of wild-caught fish to feed Norway's farmed salmon. This fish would otherwise provide valuable livelihoods and nutrition in some of the most food-insecure countries in the world.

This report exposes how the expansion of the Norwegian salmon farming industry has come at the expense of communities and fish populations in the Global South. While salmon producers tout their sustainability credentials, the industry's inefficient and wasteful use of finite natural resources is driving the loss of livelihoods and exacerbating malnutrition in nations including The Gambia, Senegal and Mauritania. We argue that the Norwegian salmon industry is not so much leading a 'blue revolution' as establishing a 'blue empire'.

Based on detailed analysis of corporate and government data as well as the latest academic research, Feedback estimated the volume of wild fish required to feed Norway's huge salmon farming industry. We found that Norwegian salmon farming has a voracious appetite and an enormous feed footprint, driving the extraction of nearly 2 million tonnes of whole fish from the wild every year. What is more, a significant share of its fish oil, a key commodity in salmon farming, is imported from Northwest Africa, a region facing acute food insecurity. Norway's demand for fish oil is depriving up to 4 million people in the region of fish required to meet their annual nutritional needs.

Faced with unfair competition from the global aquaculture industry, including major Norwegian companies, West African communities are mobilising to protect their fish and livelihoods; women, who play a central role in fish processing, are at the forefront of efforts to hold governments and companies to account.

The plundering of African fish stocks by Norwegian companies, and the Norwegian government's uncritical embrace of industrial aquaculture, stand in stark contrast to Norwegian development policy, which has identified food security and the fight against hunger as a priority area, notably in sub-Saharan Africa, as well as highlighting women's central role in food production. This reflects a startling lack of policy coherence.

By revealing the Norwegian salmon industry's enormous feed footprint, this report seeks to highlight the hypocrisy of global aquaculture corporations, who claim to be helping feed a growing world population while taking precious resources from the Global South for export to high-income markets. Shining a spotlight on a critical part of its supply chain, this report exposes how the Norwegian salmon industry relies on extracting nutrition from Northwest African coastal and inland communities, threatening health, food security and nutrition, in direct contradiction with the Norwegian government's stated development goals.

Salmon farm in Trondheim, Norway. Credit: Evgeny Sergeev (iStock).

SUMMARY OF FINDINGS

Based on detailed analysis of corporate and government data as well as the latest academic research, we calculated that:

- In 2020, nearly 2 million tonnes of wild fish were required to produce the fish oil supplied to the Norwegian farmed salmon industry. 75% of these were fish that are otherwise widely eaten, such as anchovy, sardine, sprat and herring, with the remainder made up of fish critical to the marine ecosystem, such as sand eels.

- The volume of fish needed to produce the fish oil fed to Norwegian salmon every year is equivalent to 2.5% of global marine fisheries catch.

- Norway's annual output of farmed salmon is one-quarter (27%) lower than the volume of wild fish required to produce the fish oil used in Norwegian farmed salmon feed.

- In 2020, the Norwegian salmon farming industry sourced fish oil produced from between 123,000 to 144,000 tonnes of fish from FAO 34, the Major Fishing Area located off the coast of West Africa.

- The volume of fish sourced from FAO 34 to supply fish oil to the Norwegian salmon farming industry in 2020 could have provided between 2.5 million and 4 million people in the region with a year's supply of fish sufficient to meet their nutritional needs[a].

- Four big feed producers, MOWI[b], Skretting, Cargill and BioMar supply close to 100% of the feed used in Norwegian salmon farming. All of them source fish oil from FAO 34. In 2020, one-quarter (23%) of the total volume of fish oil sourced from FAO 34 by Norwegian companies was purchased by MOWI: it sourced 5,100 tonnes of fish oil from Mauritania in 2020, which we calculate was produced from 28,300 tonnes of fish. A further 17,000 tonnes of fish oil were sourced by Skretting, Cargill and BioMar from FAO 34 (also referred to as the Eastern Central Atlantic Area) – which comprises Mauritanian fisheries – but these companies do not report sourcing per individual fishery area.

- Despite public sustainability pledges, salmon and feed producers' take-up of alternative ingredients to replace wild-caught fish in feed remains minimal. Without significant changes in feed composition, Norway's ambition to more than triple salmon production to 5 million tonnes by 2050 would require over three times as much wild-caught fish as in 2020.

- The extraction of precious fish from West Africa by corporations headquartered in the Global North for the benefit of mainly high-income consumers in Europe, North America and Asia has far-reaching consequences in terms of further entrenching global inequity and food insecurity. The expansion of industrial aquaculture is fuelling a modern-day nutrient colonialism, or food imperialism, with little attention or care paid to the grave ramifications of the food-feed competition driven in part by salmon farming.

- New modelling by Feedback shows that it is possible to significantly reduce salmon production in Norway while increasing overall seafood production, improving food security and protecting fish stocks in Northwest Africa and other regions in the world where companies source feed. An alternative aquaculture-fisheries model combining the direct consumption of wild-caught fish alongside salmon fed on fish oil and fish meal exclusively made from trimmings (waste from processing) rather than whole fish delivers equal amounts of key micronutrients for the same number of people[c], while freeing up nearly 1 million tonnes of wild fish to feed additional people or to continue playing their critical role in the marine ecosystem.

a 4 million figure assumes fish is eaten whole, a practice promoted for the consumption of small fish in Asia and Africa. 2.5 million figure is a conservative estimate based on edible portion sizes estimated by the FAO. For instance, for Sardina Pilchardus and two different sardinella species, the edible flesh makes up 62% and 65% of the whole fish according to the FAO estimates. Based on daily consumption of 100g of fish per person. This is at the upper end of the range recommended by EAT-Lancet and the portion size considered by Hicks et al. in their 2019 paper on Harnessing global fisheries to tackle micronutrient deficiencies. References: Christina C. Hicks et al., 'Harnessing Global Fisheries to Tackle Micronutrient Deficiencies', Nature 574, no. 7776 (October 2019): 95–98, https://doi.org/10.1038/s41586-019-1592-6; FAO, Yield and nutritional value of the commercially more important fish species. FAO Fisheries Technical Paper. No. 309. (1989) Torry Research Station, Aberdeen (UK). Rome, FAO. https://www.fao.org/3/t0219e/T0219E01.htm#ch1; Walter Willett et al., 'Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems', The Lancet (January 2019) https://doi.org/10.1016/S0140-6736(18)31788-4.

b MOWI is a vertically integrated company which produces farmed salmon as well as feed.

c It is important to note that we are not suggesting here that these fish should necessarily be consumed by the high-income consumers currently buying salmon. Our calculations show that in an alternative aquaculture-fisheries model we do not need to rely on any fish oil from West Africa to deliver the nutrition currently delivered by the Norwegian farmed salmon industry. Further analysis would be needed to determine more broadly our moral obligation to avoid nutrient colonialism and nutrient extractivism.

SUMMARY OF RECOMMENDATIONS

We recommend the Norwegian government:

- Halt the growth of Norway's salmon farming sector.
- Require full and mandatory transparency on feed sourcing at each stage of the aquaculture supply chain.
- Ensure the domestic farmed salmon industry does not undermine its global development goals.

We demand that corporations, including feed manufacturers and salmon producers:

- Disclose transparently, consistently and in detail aquafeed sourcing volumes, locations and species used.
- Stop sourcing fish meal and fish oil (or products dependent on FMFO) from locations where its production is driving food-feed competition and exacerbating food insecurity, especially vulnerable West African countries.
- End the use of whole wild caught fish in feed.

Salmon on ice at a market. Credit: kipgodi (iStock).

INTRODUCTION: THE BLUE REVOLUTION HAS FAILED

Aquaculture is widely promoted as a way to reduce pressure on global fisheries and the environment whilst maintaining or improving food security in a process known as 'the blue revolution'. In reality, a significant part of the sector is highly industrialised and extractive. This is particularly true of the farming of carnivorous (or 'fed') fish species such as salmon and seabass, which are now ubiquitous in supermarkets and restaurants all over Europe. And nowhere is industrial aquaculture's potential for harm more evident than in the production of feed destined for salmon farming.

The farmed salmon industry warrants particular scrutiny given its reliance on fish meal and fish oil (FMFO) made from wild-caught fish such as sardines, anchovies and herring, which also provide nutritious food to millions of people around the world. Krill, a keystone species in the Southern Ocean ecosystem[12], which is facing threats ranging from climate change to concentrated fishing[13], is also used to produce meal for farmed salmon[14]. Each year, around one-fifth of the world's annual marine catch (over 16 million tonnes in 2020) is used to produce FMFO[15], the bulk of which goes to producing feed for the aquaculture industry[16]. Astonishingly, while salmonid production only accounts for 3.9% of farmed fish produced globally[17], it uses up 58% of fish oil and 14% of fish meal destined for aquaculture[18].

Most of the FMFO produced worldwide is sourced from countries in the Global South, where its production is driving the overexploitation of fish populations, harming the environment and damaging traditional livelihoods in small-scale fisheries and fish processing[19] [20]. Additionally, a sizeable share of FMFO is produced in Europe, putting pressure on key fisheries. For example, by May 2022, an estimated 65 percent of North Sea herring fished by the Norwegian fleet so far that year had been sold for fish meal and oil processing, despite being fit for human consumption[21]. In October 2023, it was reported that in the space of just two months, Iceland had caught 75% of its substantial mackerel quota "for fishmeal"[22].

Over the past decade, Northwest Africa has emerged as a key sourcing hub for FMFO, including for Norwegian salmon production. This growing industry is putting pressure on vital fish stocks at a time when hunger is on the rise in sub-Saharan Africa[23].

Despite this, farmed salmon producers and feed suppliers – many of which are multimillion or multibillion-euro companies – make great play of their sustainability credentials. They variously present salmon farming as "one of the most efficient ways to produce protein"[24](Norsk Industri[d]); leading the 'blue revolution' (MOWI)[25]; making a positive contribution to society by helping "feed the future" (Skretting)[26]; attaining the UN Sustainable Development Goals (Lerøy)[27]; and providing health benefits to consumers (Cargill)[28]).

This report exposes how the Norwegian salmon industry's promise to feed the world is both unfounded and unrealistic. Instead, it shows how the industry's voracious appetite for wild caught fish is threatening food security and livelihoods in West Africa, as well as decimating wild fish populations. It offers recommendations to the Norwegian government and calls on the industry to change its practices to end the salmon's industry's blue empire.

"The fishmeal and fish oil industry claims it only uses what is not fit for people to eat, but that has been proven untrue time and again. The industry also tries to deflect criticisms by claiming it drives economic growth and adds value through employment. But the FAO's research confirms that the net benefits of the industry are negative. The industry provides a limited number of quality jobs, most of which are taken up by foreign employees, while it directly undermines the jobs and livelihoods of thousands of people, including women working in processing and selling fish for human consumption."

Andre Standing, Coalition for Fair Fisheries Arrangements, 2022[11]

d Federation of Norwegian Industries

NORWAY'S VAST SALMON INDUSTRY REQUIRES VAST AMOUNTS OF WILD FISH

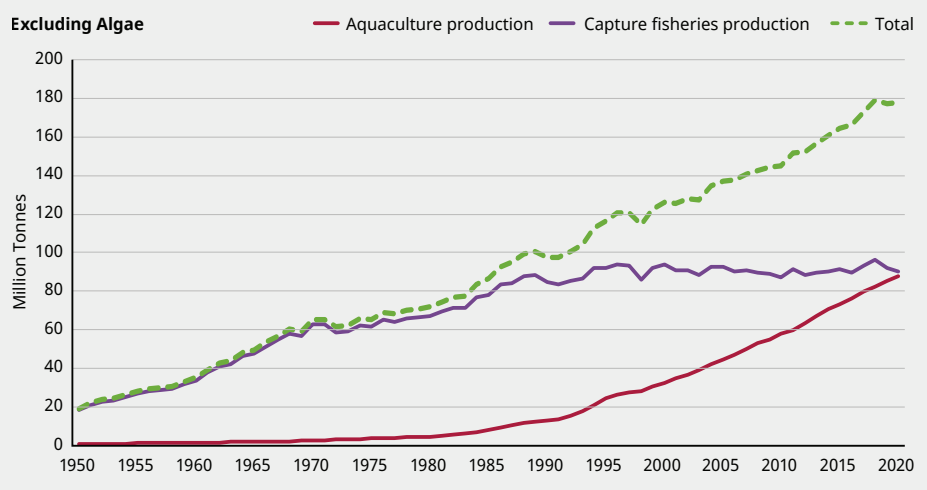
"The Government's ambition is for Norway to become the world's leading seafood nation through a five-fold increase in salmon production and a six-fold increase in value creation between 2010 and 2050... The total production costs of Norwegian aquaculture need to be reduced to ensure future competitiveness. Further industrialisation is therefore needed."

Norsk Industri (Federation of Norwegian Industries), 2017

NORWAY'S SALMON INDUSTRY HAS GROWN TO DOMINATE THE GLOBAL MARKET

Global aquaculture production has seen exponential growth since the industry took off in the 1970s.

Figure 1: World capture fisheries and aquaculture production (excluding algae)



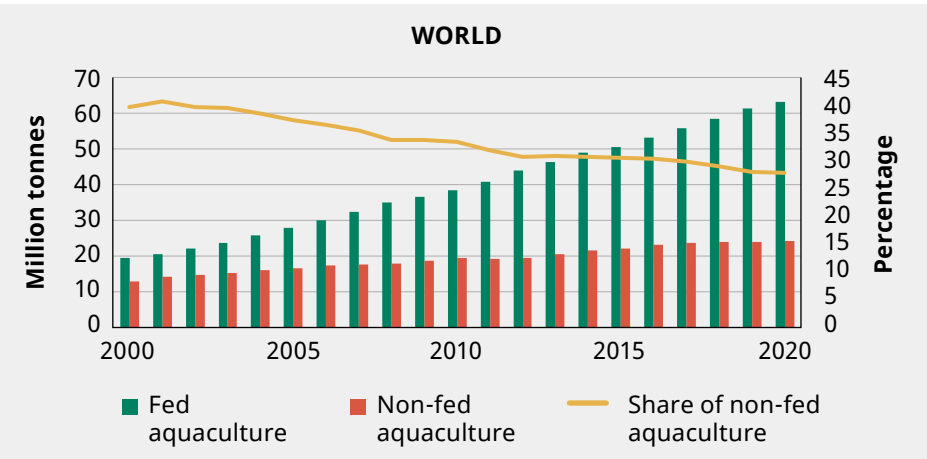
NOTES: Excluding aquatic mammals, crocodiles, alligators and caimans. Data expressed in live weight equivalent.

Source: FAO, 2022

The growth in fed aquaculture, which is the farming of species requiring feed inputs – such as Atlantic salmon – has consistently outpaced the growth in non-fed aquaculture in recent decades (see Figure 2).

Figure 2: World fed and non-fed aquaculture production of animal species, 2000–2020

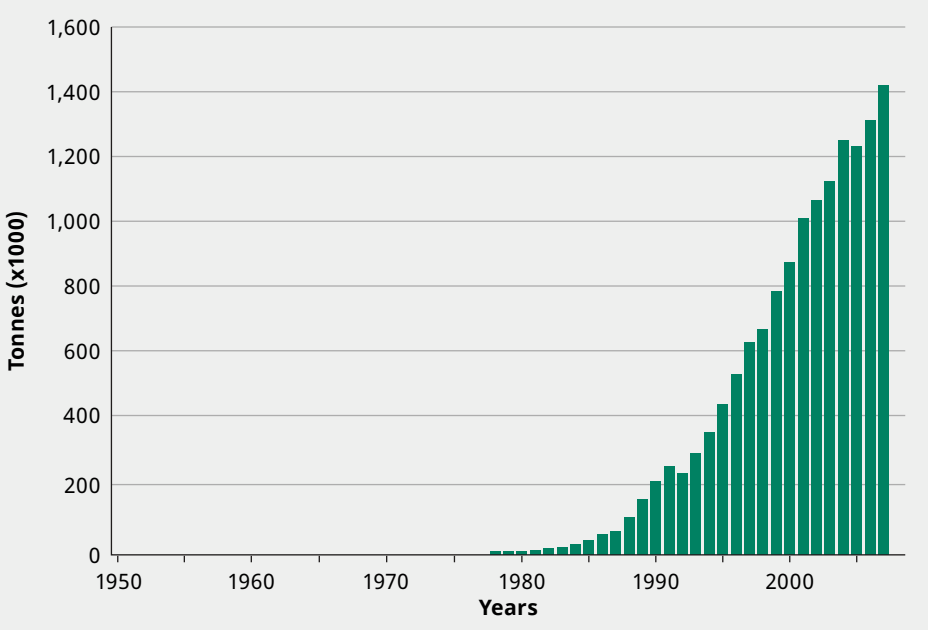
Data in million tonnes expressed in live weight equivalent.



Source: FAO, 2022

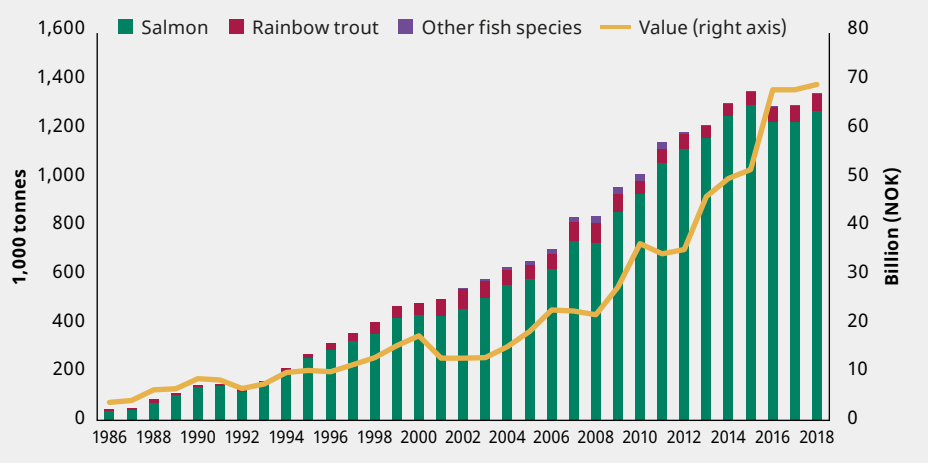
Norway has been a key driver of the global boom in salmon farming. Salmon represents by far the largest share of Norwegian aquaculture production (see Figure 4).

Figure 3: Global aquaculture production of Salmo salar (Atlantic salmon)



Source: FAO

Figure 4: Sales of harvested edible fish in Norway. 1986–2018.
Volume in 1,000 tonnes and value in billion NOK (2019)



Source: Norwegian Government

Today, Norway is the world's largest farmed salmon producer, supplying more than half of global production[29]. In 2020, it produced 1,467,655 tonnes of farmed salmon of which 78% was exported[30]. Norway has stated a national ambition to produce 5 million tonnes of salmon a year by 2050[31], which would represent more than a tripling of production on current levels.

Eleven of the world's 20 biggest producers of salmon are Norwegian companies[32], with MOWI, Salmar, Lerøy Seafood Group and Cermaq occupying the top four slots in Norway in 2021, accounting for around half of production[33].

Table 1: Norway's top 10 salmon producers in 2021

	Top 10 – Norway Company	H.Q. GWT*
1	Mowi	273,000
2	Salmar	170,00
3	Lerøy Seafood	161,500
4	Mitsubishi / Cermaq	92,000
5	NTS**	70,000
6	Grieg Seafood	61,000
7	Nova Sea	43,500
8	Nordlaks	35,000
9	Alsaker Fjordbruk	34,000
10	Sinkaberg-Hansen	33,000
	Top 10	973,500
	Others	405,400
	Total	1,378,900

*Gutted Weight Tonnes

**Including Norway Royal Salmon where NTS acquired a majority stake in 2021

Source: MOWI Salmon Farming Industry Handbook 2022

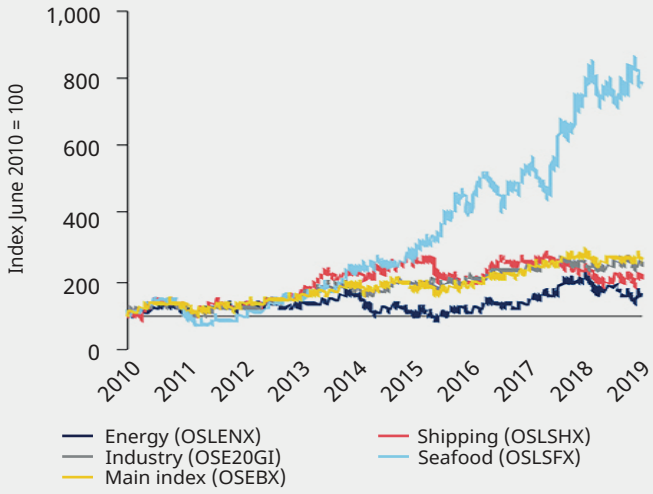
Since its relatively humble beginnings in the 1970s, the Norwegian farmed salmon industry has gone from being a fragmented market with many small players to one of Norway's most important export industries dominated by listed companies supplying products to the global market[34]. Consequently, Norwegian farmed salmon producers have attracted significant interest and investment from Norwegian and global investors including BNP Paribas[35], BlackRock. Danske Bank, Norway's Government Pension Fund (*Folketrygdfondet*), Vanguard Group, Schroders, UBS, Legal & General, Nordea[36] and Rabobank[37]. Table 2 provides an overview of the seven largest aquaculture companies listed on the Oslo Stock Exchange (*Oslo Børs*). Figure 5 shows that the Oslo Seafood Index outperformed other key indices between 2010-19.

Table 2: Seven largest aquaculture companies listed on the Oslo Stock Exchange (Oslo Børs). Market value as of 24 October 2019.

Ranking by market value for all companies on Oslo Børs	Company	Market value. billion NOK
1	Mowi (formerly Marine Harvest)	118
2	Salmar	49
3	Lerøy Seafood Group	37
4	Bakkafrost	31
5	Austevoll Seafood	19
6	Grieg Seafood	12
7	Norway Royal Salmon	10

Source: Norwegian Government, 2019

Figure 5: Evolution of share prices for selected indices on the Oslo Stock Exchange 2010–2019



Source: Norwegian Government (2019) based on data from Macrobond and Oslo Stock Exchange

HOW DID NORWAY'S SALMON FARMERS BECOME SO SUCCESSFUL?

Whilst wild salmon have always played a significant role for the Sámi people[38] (Indigenous people of the northern part of the Scandinavian Peninsula and parts of the Kola Peninsula[39]) Norway's modern-day salmon farming industry is still relatively young. The industry was born in the late 1960s, expanded to global distribution in the 1970s, and, over the last 50 years, has continued to grow rapidly[40].

Norwegian salmon is now available in most European markets and is sold as a premium product all around the world, including the United Kingdom, France, the Netherlands, and the United States. Despite its current global dominance, in the late 1980s, the Norwegian salmon industry ran into a significant problem: the industry was producing too much salmon and, in its struggle to find customers, was being forced to freeze salmon rather than export it for profit. At the same time, Japan – a country that accounts for one-tenth of global fish consumption – was only able to supply half of its domestic demand for fish. The Norwegian fisheries minister, believing this to be an opportunity to spur demand for salmon, launched a programme called "Project Japan" to promote raw salmon as a sushi staple. After first targeting Nichirei, a company known for selling frozen foods in Japan, and then chefs, who started to use raw salmon in national cooking shows, Project Japan succeeded and, since then, salmon has become a staple in sushi restaurants around the world[41].

NORWAY'S SALMON INDUSTRY HAS A VORACIOUS APPETITE FOR WILD FISH

In 2020, a total of 1,976,709 tonnes of feed ingredients were used to produce 1,467,655 tonnes of salmon in Norway[42]. The feed was produced from 22.4% marine ingredients, 73.1% vegetable ingredients and 4.1% micro ingredients such as vitamin and mineral premixes, astaxanthin (a pigment used to give salmon fillets their red-orange colour) and crystalline amino acids[43].

According to our analysis (see methodology in Annex), nearly 2 million tonnes (1,948,220 tonnes) of edible fish such as anchovy, sardine, sprat and herring, and a smaller share of fish critical to the marine ecosystem, such as sand eels, were required to produce the fish oil supplied to the Norwegian farmed salmon industry in 2020. This is equivalent to 2.5% of global marine catch, which was 78.8 million tonnes in 2020[44].

The industry's ambition to more than triple farmed salmon production to 5 million tonnes by 2050 would require 6.2 million tonnes of feed and[45] over three times as much wild-caught fish as was used in salmon feed in 2020.

The Norwegian salmon industry is highly dependent on the import of feed ingredients from overseas. More than 91% of feed ingredients used in Norwegian salmon farming were imported in 2020[46]. Four large aquafeed companies – BioMar, Cargill, MOWI and Skretting – produce close to 100% of the feed used in Norwegian salmon farming[47].

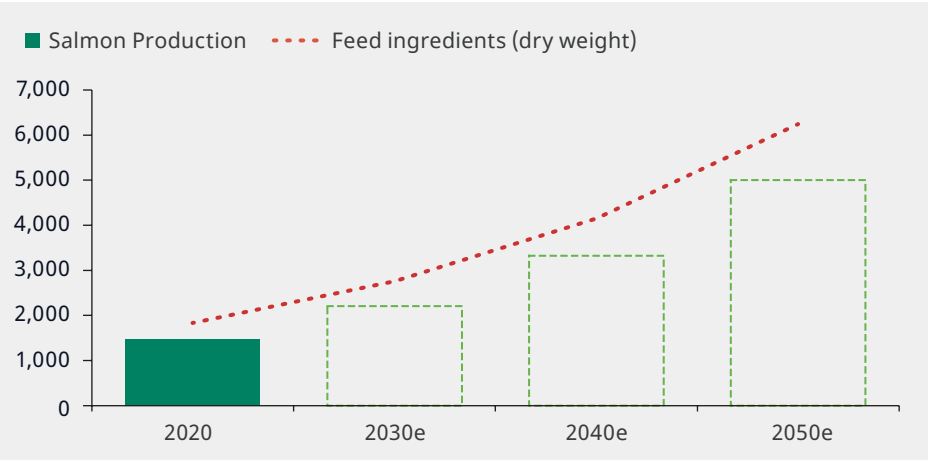
While most of the biggest feed producers present on the Norwegian market disclose some information on volumes and sourcing of feed ingredients used in compound feed, data is not presented consistently. When it comes to FMFO, there is no transparency regarding which fish oil producers they source from on the ground. However, analysis of corporate information, industry data and correspondence with companies did enable us to ascertain that MOWI[48], Skretting[e 49], Cargill[50] and BioMar[51] all source fish oil from Northwest Africa. The latter three companies are all involved in the Mauritania Small Pelagics Fisheries Improvement Programme (FIP), which has been criticised by NGOs including an organisation representing small-scale fishermen in West Africa (see section below on voluntary initiatives and certification schemes).

In 2020, one-quarter (23%) of the total volume of fish oil sourced from FAO 34 by Norwegian companies was purchased by MOWI: it sourced 5,100 tonnes of fish oil from Mauritania in 2020, which we calculate was produced from 28,300 tonnes of fish. A further 17,000 tonnes of fish oil were sourced by Skretting, Cargill and BioMar from FAO 34 (also referred to as the Eastern Central Atlantic Area) – which comprises Mauritanian fisheries – but these companies do not report sourcing per individual fishery area.

e In correspondence with Feedback in summer 2023, Skretting said that Skretting Norway only purchases fish oil and/or fish meal ("raw materials") from the MarinTrust Fishery Improvement Project (FIP) for Mauritania (see later in this report for more details on the FIP): "For 2020 and 2021, we did not source anything from Mauritania, but in 2022 we sourced a relatively small amount of fish oil from Sardine (Sardinella Sp) from the Mauritanian FIP."

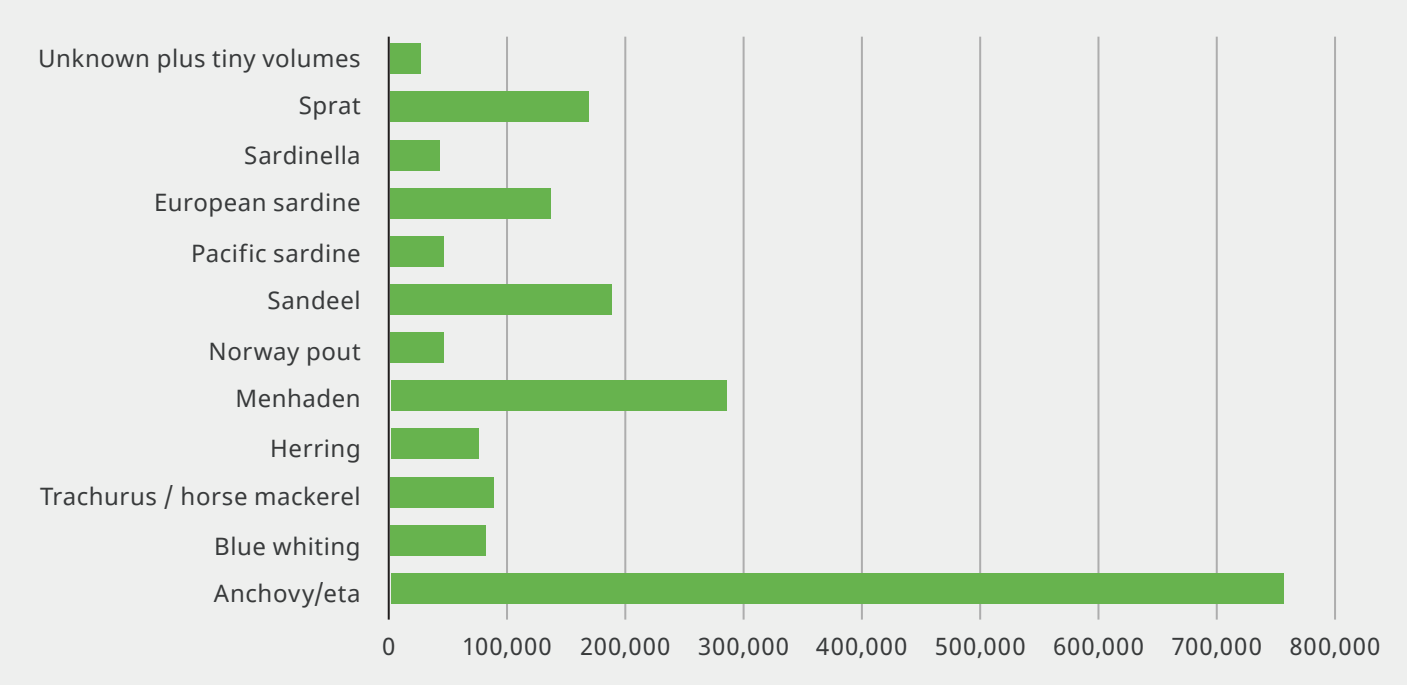
The lack of transparency in aquafeed sourcing has caught the attention of investors. In a January 2023 post, BNP Paribas's Head of Stewardship Europe remarked of Norwegian salmon producer Grieg Seafood that: "the lack of comprehensive, comparable data, and the ability to trace feed to its source, is hindering accurate corporate reporting and the ability of this and other companies to implement effective sustainability strategies"[52].

Figure 6: Norwegian salmon and feed ingredients production actual and projected 2020–2050 (tonnes)



Source: Ernst & Young, 2022

Figure 7: Wild-caught fish used in Norwegian salmon feed
(units = tonnes)



Source: Feedback calculations. See methodology annex and supplementary spreadsheet for full details and data sources.

"The last decade has seen a reckless boom in investments in the [FMFO] industry throughout West Africa that has been unplanned and lacking in transparency."

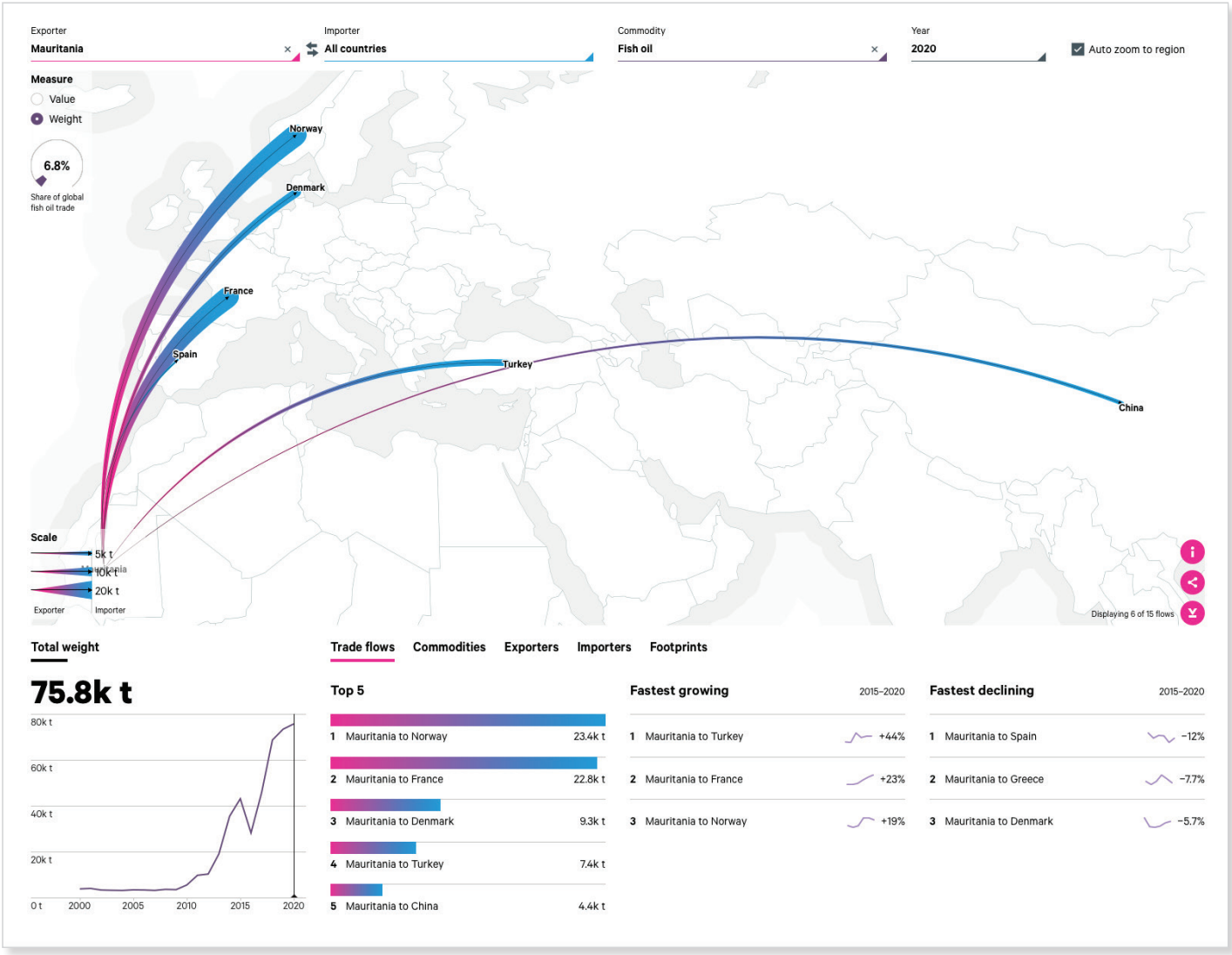
(Andre Standing, Coalition for Fair Fisheries Arrangements, 2022)[53]

THE NORWEGIAN SALMON INDUSTRY IS THREATENING FOOD SECURITY AND LIVELIHOODS IN WEST AFRICA

The geographic location aquafeed ingredients are sourced from is a key matter, as reduction fisheries for FMFO can compete with fishing for direct human consumption, with impacts on livelihoods and food security.

To satisfy aquaculture's appetite for fish, the FMFO industry has expanded into West Africa in recent years. In the past decade, the number of FMFO factories in West Africa has increased from 5 to 49[54 55 56]. This is fuelling the depletion of small, oily pelagic fish stocks, which were once abundant and are a key source of accessible, nutritious food for coastal and inland communities[57].

Figure 8: Mauritanian fish oil exports 2020



Source: https://resourcetrade.earth

Aerial view of pirogues (fishing boats) in Kayar, Senegal. Credit: Curioso Photography (Shutterstock).

Mauritania is the main supplier of small pelagics to ECOWAS countries such as Côte d'Ivoire, Mali and Nigeria[58] but in recent years it has also become the main hub of FMFO production in West Africa: in 2020, its fish oil exports surpassed 75,000 tonnes[59] and fish meal reached 121,000 tonnes[60], putting the country into the top 10 producers worldwide.

As some of the target fish are migratory and widely consumed in countries without an Atlantic coastline, the industrial scale of the fish meal industry in West Africa is driving up the price of fish sold across several West African markets, including inland. This price increase is impacting food security, dispossessing local populations of livelihoods and food and threatening the survival of one of the most productive segments of several West African economies. Particularly impacted are fishing communities – women processors, fishmongers, and people working in the artisanal fishing sector – who exclusively depend on marine resources for their livelihoods.

Increasingly, migration from West Africa and its attendant human catastrophes are being linked to the decline in fish populations in the region[61]. The depletion of marine resources in traditional fishing areas is also leading to migration of fishers between West African coastal states[62]. This has been identified as a factor in stoking conflict between Mauritania and Senegal[63].

"The situation of these stocks is very worrying for all the countries of the region"

Dr Baye Braham (FAO, 2021)[64]

The FAO's working group on West Africa's small-pelagic fish has repeatedly sounded the alarm about the likelihood of long-term risk to small-pelagic resources in West Africa as a result of overfishing[65]. The state of two stocks of sardinella (*Sardinella aurita* and *S. maderensis*) is especially dire: sardinella – in Ghana, known as one of the 'people's fish'[66] – is a major contributor to local communities' food and nutrition security and economy (including employment). It is simultaneously undergoing pressure from overfishing, in part by the FMFO industry, as well as environmental conditions, including the climate crisis[67]. These impacts are reflected in the scarcity and increased price of sardinella in local markets, and the loss of employment due to low catches by artisanal fishers[68].

The small fish targeted by the FMFO industry contain key nutrients including iron, zinc, and calcium that are those most needed for children's cognitive development and for women in West Africa, where more than half of the female population suffer from anaemia[69]. This is happening at a time when hunger is on the rise across sub-Saharan Africa (SSA)[70] and new research shows that of eight global regions, SSA is the one most severely impacted by lack of micronutrient availability[71]. In 2020, the number of undernourished people in the region rose to 274 million, with 84% of people unable to afford a healthy diet. Fish consumption in Senegal alone declined by 50% in the 10 years between 2009-2018, driven by a reduction in the availability of small pelagic fish[72].

WOMEN PROCESSORS MOBILISE TO PROTECT THEIR LIVELIHOODS

In West Africa, it is mainly women who process and sell fish they source from nearby fish landings. They dry, salt, ferment and smoke fish, then store and sell them for local consumption. This craft is a heritage handed down from mother to daughter each generation and is a source of pride[73].

In recent decades, however, increasing rarefication of fish stocks has driven more and more women out of business as they are unable compete with ever increasing prices per crate of fish. To survive, Senegalese women processors came together in so-called economic interest groups (*groupements d'intéret économique* or GIE) to ensure purchasing strength through numbers. But in recent years, more and more GIEs have lost a substantial amount of their members who, despite mobilising, could no longer make a living through fish processing and sales[74] [75].

The arrival of fish meal and fish oil factories has been a key driver of an increase of overfishing and large price hikes in what can only be described as unfair competition. *"Normally we as female fish processors would be able to buy our fish at 5000 CFA franc a case. Now we are competing with fish factories that have enough money to pay 8000 CFA franc a case. This means female fish processors have less access to the fish. This is a disaster for the population because we need fish, we need to work and so do all the others who are relying on the activities in the ports and processing sites. If the agreements on prices are not complied with, we may no longer have access to fish caught in our own seas",* says Fatou Samba, president of a processing site in Bargny, Senegal[76].

To counteract this problem, processors and fishmongers have been calling for a recognition of their profession which would grant them a better place in decision-making and policy-making processes to defend themselves against powerful fishing and FMFO industries. However, their call has yet to be acted upon despite the economic, social and cultural significance of their work[77].

We have found evidence of the deleterious impacts of FMFO production throughout West Africa. In Senegal, highly skilled women fish processors and fishmongers have been affected by the scarcity of pelagic fish and have been left to compete for what fish is available with fish meal and fish oil factories, which pay a higher price than they can afford[78]. This leaves them exposed to the dangers of extended unemployment and lack of income, very often leading to the health and education of their children being compromised.

In the Gambia, the cost of reduction fisheries and overfishing is clear. Artisanal fishing communities face increasing pressure from dwindling resources and unfair competition, which has led to violence: in March 2021, a protest that turned violent took place in the coastal town of Sanyang after a fisher who worked for a fish meal factory allegedly killed a local man. The local population directed its frustration towards the Senegalese fishers and the fish meal factory, burning fishing equipment and part of the factory building. At least 50 people were arrested, some of them arbitrarily, and detained

under poor conditions. The fish meal factory targets pelagic fish, which are usually preferred by the local population for their daily protein intake due to their affordable price. However, local fishers, fish traders and artisanal fish processors complain about the lack of fish and the increase in prices since the arrival of the factory. Since factories in Gambia began processing bonga – the species most used by fish smokers in the country – its wholesale price has quadrupled[79]. This not only has a negative impact on people's standard of living but also threatens their food security[80].

In Mauritania, a hotspot for the fish meal and fish oil industry, we see the problem replicated[81]. There, the right to food for many is flouted, and conflict stoked. Conflict occurs not only between industrial fishing fleets and artisanal fishers[82], but, due to an increasingly desperate situation, also between the fishing communities themselves[83].

THE NORWEGIAN SALMON INDUSTRY IS ENTRENCHING FOOD INSECURITY AND GLOBAL INEQUITY

The extraction of precious fish from West Africa by corporations headquartered in the Global North for the benefit of mainly high-income consumers has far-reaching consequences and further entrenches global inequity and food insecurity. The expansion of industrial aquaculture is fuelling a type of modern-day colonialism, or food imperialism, with little attention or care paid to the far-reaching consequences of the food-feed competition driven in part by salmon farming.

We are witnessing a transfer of food and wealth from the Global South to the Global North. In Senegal and The Gambia, pelagic fish provide people with 65% of their animal protein requirements[84]. But each year, over half a million tonnes of fish – which could feed over 33 million people in the region – are instead extracted from the ocean off the coast of West Africa and converted into FMFO to feed farmed fish and livestock. Virtually all FMFO produced in West Africa is exported for the benefit of industries in overseas markets. Norway and other European countries as well as Turkey and Chile are the major importers of the fish oil and Asia takes most of the fish meal[85]. And whilst FMFO can be made from fresh fish waste and trimmings (i.e., 'byproducts'), which are currently undesirable or not fit for human consumption, the vast majority is made from whole fish[86]. In Mauritania, 90% of the fish used are fresh, whole fish[87].

Regarding the end product, farmed salmon, it is salient to note here that Norway's salmon companies do not target low-income markets. According to the industry, *"Norwegian salmon is too expensive to feed the poorest populations, but make (sic) an important contribution to world food production."*[88]. In reality, the top 5 export destinations by volume in 2022 for Norwegian salmon were Poland, Denmark, France, the Netherlands and Spain, with the United States becoming the biggest consumer market for Norwegian salmon in value terms[89]. These are all countries where protein and micronutrient requirements are already met.

Tiep Bou Dien (thiéboudiène), is the national dish of Senegal and widely eaten throughout West Africa including in The Gambia and Mauritania. It contains rice, vegetables and fresh fish, providing excellent nutrition. FMFO production makes fish for direct human consumption less available to people in coastal and inland communities throughout the West Africa region. Credit: Frederique Wacquier (iStock).

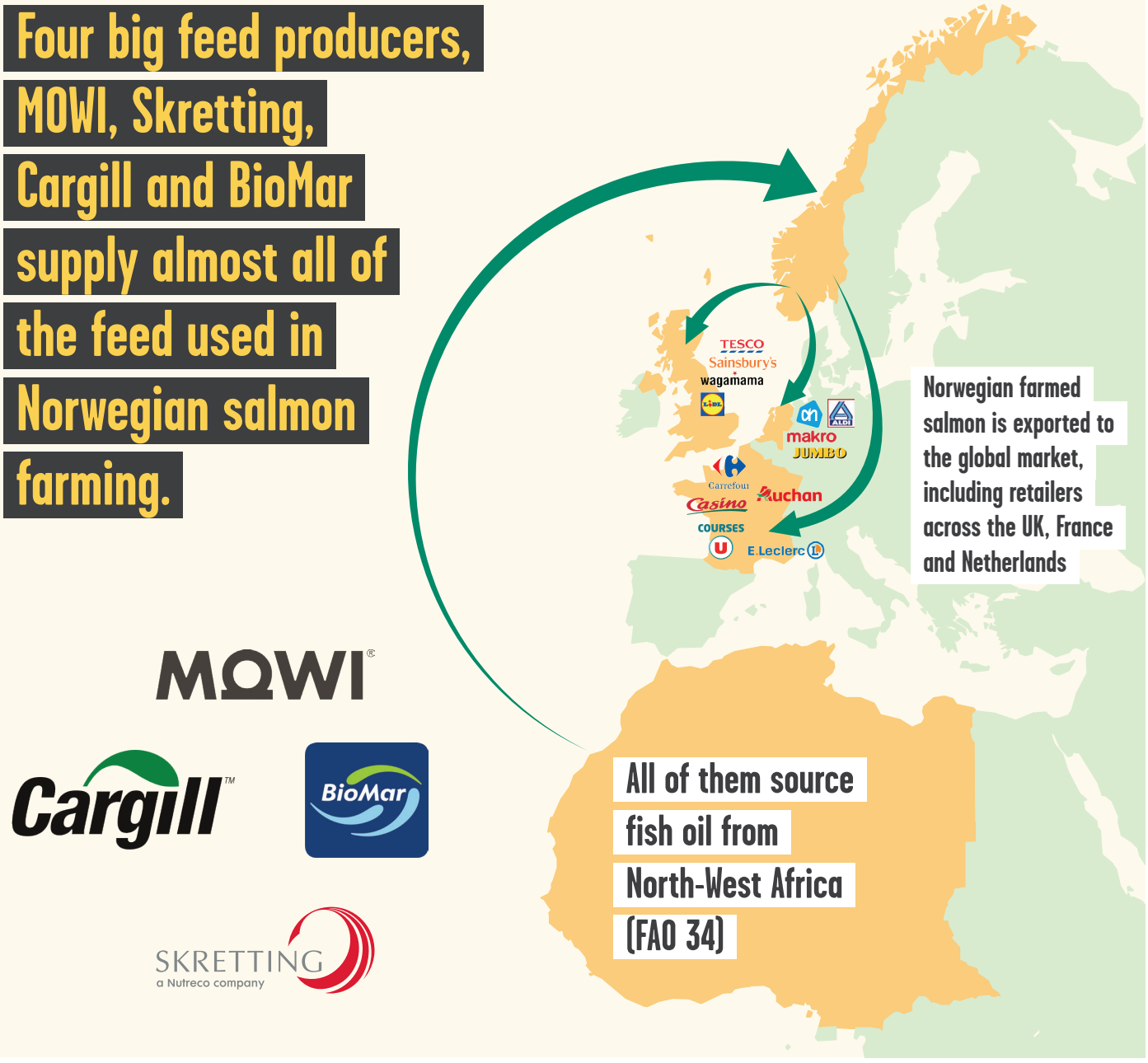
This transfer of food and nutrients from Global South countries to Global North countries, or from food insecure to food secure countries, chimes with a recent academic analysis showing that the prioritisation of fed aquaculture over fisheries management (for maximum sustainable yield aimed at direct human consumption) would result in significant food insecurity in coastal African and South American countries and small island developing states[90].

Figure 9: Extract and Export: The main consumer markets for Norwegian salmon are in the Global North

Norway salmon end markets

Norwegian salmon is now available in most European markets and is sold as a premium product all around the world, including the UK, Netherlands and France where it can be found in major supermarkets including Tesco, Sainsbury's, Albert Heijn, Jumbo, Carrefour, and Auchan as well as wholesalers such as Makro (NL) and Costco (UK) and hybrid retailer Chronodrive in France.

Increasingly, salmon farmed in Norway is exported to be processed in third countries. Poland is by far Europe's largest salmon processing country[91] and the largest processor of Norwegian farmed salmon, with MOWI-owned company Morpol and its competitors Suempol, Graal, Milarex and Limito dominating the processing market[92]. Norway's third-biggest producer of farmed salmon in 2021, Lerøy, outsources production of some of its farmed salmon products to the Netherlands – where smoked salmon and pre-packed fish are "flying off the shelves to grocery stores all over the world" including the United States – and Spain, where the company's factories make gyoza and sushi for the local market[93].

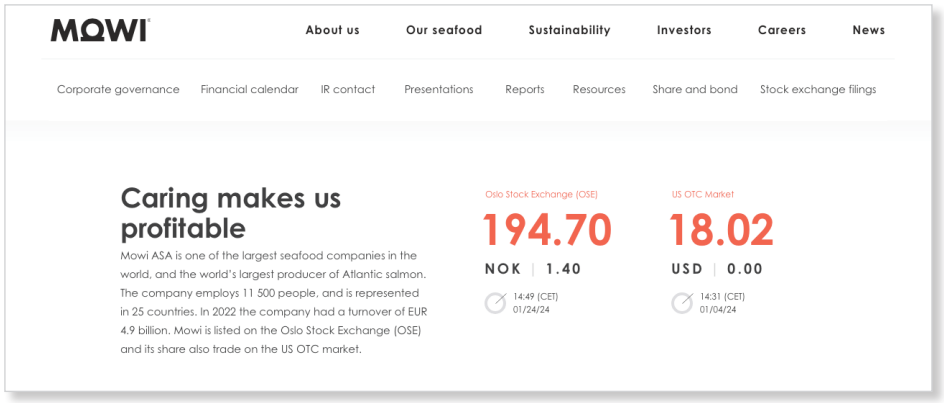


Source: Feedback analysis

The negative impacts of the FMFO industry in West Africa stand in stark contrast to the benefits reaped from salmon farming in Norway. The industry has become one of the country's most important export industries, second only to oil and gas production[94], with significant profit generated by Global North corporations, including salmon producers, retailers and investors. For example, in 2022, MOWI, the world's largest producer of Atlantic salmon and a flagship Norwegian company had a turnover of EUR 4.9 billion[95]. In short, the people benefiting from the Norwegian salmon industry's success, whether as consumers, company executives or investors, are unlikely to be found in West Africa.

"Caring makes us profitable"

MOWI, world's largest producer of Atlantic salmon.[96]



Source: MOWI's corporate website https://mowi.com/investors

THE NORWEGIAN SALMON INDUSTRY UNDERMINES THE NORWEGIAN GOVERNMENT'S DEVELOPMENT GOALS

"We have a long tradition in Norway in which value that is created from using our common natural resources shall benefit society as a whole."
Prime Minister Jonas Gahr Stoere

Africa can feed itself. Africa wants to feed itself. African leaders have been very clear: they want to develop their own primary industry and increase self-sufficiency.
Norway's strategy for promoting food security in development policy

In 2022, the Norwegian government published *Norway's strategy for promoting food security in development policy*, a wide-ranging document that was presented as forming part of its effort to follow up the ambitions set out in the Government's political platform. In the foreword to the strategy, Anne Beathe Kristiansen Tvinnereim, Minister of International Development, noted that "We are making food itself a priority" and that, "An overall objective of the Government's development policy is to fight hunger and increase global food security." The Minister also emphasised that while in sub-Saharan Africa, 70–80% of the population works in agriculture and fishing, "Paradoxically, these very farmers and fishers represent the majority of chronically hungry families."[97].

The strategy further identified malnutrition and undernutrition as critical global issues, noting that "In 2024 more than 1 billion people in Africa could not afford to buy healthy food." It urged greater recognition of the unique role of fish in food security and nutrition, noting that, "Seafood has major potential as a key source of micronutrients, the lack of which in many diets

leads to hidden hunger." It also underlined the key role women play in food production: "Of those employed globally in fishing and aquaculture, 21% are women, a proportion that rises to more than 50% when the rest of the value chain is included." In light of this, the government of Norway pledged to invest in targeted measures that strengthen women's position as food producers[98].

In addition, the Norwegian Agency for Development Cooperation (NORAD) is involved in funding projects focused on sustainable fisheries in West Africa. For example, NORAD is currently providing ongoing funding for the next iteration of the EAF-Nansen Programme, a collaboration between the FAO and the Norwegian Institute for Marine Research (a government body) and, previously, an FAO project on empowering women in small-scale fisheries for sustainable food systems[99] [100].

Nevertheless, while highlighting the macrotrends driving food insecurity in Africa, including climate change and population growth, the government's development strategy remains silent on the proximate factors which are creating hunger and unemployment on the continent. In doing so, it ignores Norway's role in creating the very conditions the Norwegian government says it wants to improve.

While it is clearly impossible to lay responsibility for food insecurity across sub-Saharan Africa at the door of the Norwegian aquaculture industry alone, it is certainly playing a major role in driving demand for pelagic fish for industrial uses, commoditising a staple food which plays a critical role in West African diets. The socio-economic costs of Norwegian salmon production are nowhere to be seen on company balance sheets while the negative externalities created by its sourcing of feed occur in countries which see minimal to no benefits.

It is ironic therefore that Norway presents increasing aquaculture production as a central solution to global hunger, noting that the High-level Panel for a Sustainable Ocean Economy (Ocean Panel), which was established at Norway's initiative and is chaired by the Prime Minister of Norway and the President of Palau, emphasises the important role of the oceans in providing enough food for a growing population, increasing resilience against crises and enhancing food security. The Ocean Panel has estimated that food production from the sea could be increased sixfold by 2050. Most of the increase would come from aquaculture and would require research and substantial investment.[101]. The increase projected by the Ocean Panel also depends on technological innovations allowing a 95% reduction in the use of FMFO in mariculture (aquaculture in marine environments). However, a reduction of this scale would imply a significant decrease in farmed salmon production (bearing in mind that salmonids use 58% of global fish oil production), climate change mitigation, a substantial increase in unfed bivalve aquaculture, and much better science-based fisheries management[102]. It is striking that Norway's policies in support of a sustainable ocean economy capable of feeding the world do not recognise fundamental tensions between preserving the resources and livelihoods of communities in FMFO producing countries and the demand generated by its aquaculture industry for the very same fish that sustain these communities.

THE NORWEGIAN SALMON INDUSTRY LACKS TRANSPARENCY, CONCEALS ITS IMPACTS AND OVERSTATES ITS BENEFITS

THE NORWEGIAN SALMON INDUSTRY IS NOT TRANSPARENT ABOUT ITS IMPACTS ON WILD FISH STOCKS

Farmed salmon is particularly reliant on wild-caught fish for the omega–3 fatty acids they contain. Norwegian farmed salmon are fed a diet containing on average 22.4% FMFO (12.1% marine protein and 10.3% marine oils)[103] alongside other ingredients such as vegetable oils and meals. In some cases, the use of FMFO in salmon feed can be much higher – France's prestigious *Label Rouge*, for example, which is viewed as a marker of quality and confers a price premium on the Norwegian and Scottish salmon products it certifies, specifies that its farmed salmon must contain a minimum of 51% of ingredients "of marine origin" (in other words, principally FMFO) increasing to a maximum of 30% fish oil plus 70% fish meal[104].

Despite a wealth of laboratory and small-scale experiments, it seems unlikely that novel ingredients will significantly change the reliance on fish oil[105] [106]. The FMFO industry views novel ingredients as complementary, but as yet unable to completely substitute marine ingredients[107].

Skretting's fish feed factory on Averøy, Norway. Credit: Line.miranda.and, 2013. https://commons.wikimedia.org/wiki/File:Skretting_Aver%C3%B8y.jpg

Table 3: Spotlight on feed ingredients: Key facts about MOWI, Skretting, BioMar and Cargill's use of FMFO and novel ingredients

Company	Average fish oil and fish meal content in aquafeed	Fish oil volume	Fish meal volume	Salmon	Sources from FAO 34?	Use of Novel ingredients	Novel ingredient targets
MOWI	'Fish and algal oils': 2022: 12.8% Fish meal: 2022: 16.9% MOWI Feed supplied salmon feed to all its seawater farms in Norway in 2022, with only limited amounts sourced from other suppliers.	2020 : 62,436 tonnes 2021 : 54,701 tonnes 2022 : 66,080 tonnes	2020: 78,333 tonnes 2021: 87,376 tonnes 2022: 86,802 tonnes	MOWI is Norway's biggest supplier of farmed salmon and one of its biggest feed producers. As a vertically integrated company, most of its feed is used for its own salmon production.	MOWI's recent annual reports show that it sourced fish oil from Mauritania in 2020 (5,100 tonnes), 2021 (2,802 tonnes) and 2022 (3,040 tonnes)	In 2022, MOWI Feed included 2.5% emerging feed raw materials in its feed composition (which includes algal oils and pea protein concentrate). This was a 1.5% decline on the previous year.	By 2030, MOWI aims to achieve an includion of 10-15% ingredients from emerging feed raw materials
Skretting	Total fish oil 2022: 11.9%* Total fish meal 2022: 16.5%**	Not provided	Not provided	Approx. one-quarter of total Norwegian feed production for salmon/trout farming	In 2022 Skretting sourced fish oil from Sardine (Sardinella Sp) from Mauritania. Skretting participates in the Mauritanian FIP.	Novel oils (micro algae): 2022: 0.53% 2021: 0.2% 2020: 0.2% Novel proteins (insects, krill, calanus, crab): 2022: 0.089% 2021: 0.044% 2020: not provided	Skretting states that "In 2022 we made important progress in novel ingredients, increasing our overall inclusion rate from 0.064% to 1% of total raw materials purchased." No information is given on a target.
BioMar	'Marine oils' 2022: 10% 'Marine dry matter' 2022: 17%	In 2022, BioMar used 129,303 tonnes of 'marine oil'	In 2022, BioMar used 241,049 tonnes of 'marine protein'	Atlantic salmon made up 62% of species fed by BioMar in 2022	In 2022 BioMar used 2,813 tonnes of oil produced from sardinella sourced from FAO 34 and FAO 37*** It states that of the total oil used (129,303 tonnes), 8,248 tonnes were sourced from fisheries improvement projects, which is likely to include the Mauritanian FIP It also used 449 tonnes of sardinella sourced from FAO 34 and FAO 37, with 16,738 tonnes coming from FIPs. BioMar participates in the Mauritanian FIP.	Not provided. BioMar states that it "can only introduce large volumes of novel raw materials into the market if the reward outweighs the added cost.... the value proposition must be clear and attractive.	Not provided.
Cargill	Fish oil 2022 (incl. trimmings): 10.6% Fish meal 2022 (incl. trimmings): 15.8% Both figures for coldwater (salmonid) feeds.	Not provided	Not provided	Cargill is a leading supplier of salmon feed, distributed under the EWOS brand. In 2023, it produced 967,000 tonnes of feed for coldwater (salmonid) fish species	2.26% of Cargill's marine materials originate from FAO 34. Cargill participates in the Mauritanian FIP.	2022: 4.61% Cargill states that "In early 2022, we committed to incorporating algal oil in all our Norwegian feeds effective almost immediately" but does not provide information on percentages or volumes.	Not provided.

** Note this amount comprises 6.7% FO from whole fish, 4.3% FO from trimmings and 0.9% FO from farmed fish*

*** Note this amount comprises 11.1% FM from whole fish and 5.4% FM from trimmings*

**** FAO 34 Northwest Africa / FAO 37 Mediterranean & Black Sea*

THE NORWEGIAN SALMON INDUSTRY CONCEALS ITS IMPACTS THROUGH VOLUNTARY INITIATIVES AND CERTIFICATION SCHEMES

As the world's appetite for West African fish (and FMFO) grows, so too do the number of initiatives providing international companies with access to this contested commodity while protecting their reputation. These initiatives are voluntary, lack credible independent oversight and are subject to conflicts of interest as a result of their membership or governance structures.

Fisheries Improvement Projects (FIPs) have existed since the early 2000s. They are multi-stakeholder initiatives (e.g. seafood and feed companies, government regulators, NGOs, scientists, fishery managers, and fishers) with the stated aim of creating more sustainable fisheries by improving fishing practices and management across the globe. There are now around 200 FIPs in existence, and evidence points to this increasing in the future[108]. Fisheries signed up as a FIP are also encouraged to obtain various eco-labels, such as the Marine Stewardship Council certification or the contested MarinTrust label. Achieving an eco-label isn't necessarily the primary aim of every FIP: those with this intention are called 'comprehensive FIPs' and those without are called 'basic FIPs'[109].

A company will often highlight its involvement in or association with a FIP to evidence its sustainability credentials, a theoretical precursor to full certification.

Fish feed. Credit: Wuttichai Jantarak, Shutterstock

FIPs, which, some argue, are often tick box exercises for corporations and governments, are merely *commitments* by certain actors involved in a fishery to become sustainable in the future: there is little evidence that a fishery under a FIP is currently or will likely become sustainable in the future[110].

In Mauritania, global feed and feed ingredients companies with a vested interest in maintaining access to high quality West African FMFO, are part of the Small Pelagics Fisheries Improvement Project. Alongside various Mauritanian institutional actors and industry bodies appear the names of European and North American companies including Olvea (a French importer and refiner of fish oil), Cargill, Skretting and pet food company Royal Canin. Mauritanian FMFO producers Omaurci SA, Atyfen SARL, Rim Fish Meal, Mah-El-Turk SARL and Alfa Service LTD are also listed as partners in the FIP[111]. BioMar also states on its website that it has chosen to participate in the FIP "due to its focus on artisan fishermen, stock management and ensuring a percentage of the catch goes to building resilient Mauritanian communities"[112].

According to correspondence with Feedback in summer 2023, all four of the big aquafeed corporations BioMar, Cargill, MOWI, and Skretting source marine ingredients from FIPs. In its 2022 ESG report, Cargill recognises Mauritania's ocean ecosystem "provides a source of food and livelihood for millions of people across the region", which is why the Mauritanian FIP "is also working to ensure that the impact of the fishery is positive socially as well as environmentally"[113].

Despite all the good words, there is scant evidence of improvements on the ground. Ongoing protests by local fishers and concerns about the sustainability of pelagic fisheries are swept under the carpet with claims that the production of fish meal and fish oil is a force for good. For example, in 2019, the Norwegian Director General of IFFO, the FMFO trade body, Petter Martin Johannessen stated at the organisation's annual meeting that reduction fisheries play a positive role in meeting the SDGs and suggested "the fish meal industry is positive for poverty reduction and food security in developing countries"[114]. However, a report by NGO Changing Markets in the same year found that IFFO was providing a "sustainability smokescreen" for FMFO producers and feed companies, "preventing further probing by downstream customers of FMFO producers regarding the true impacts of using wild fish to feed farmed seafood"[115].

In a similar vein, in April 2023, food industry giants Cargill, Skretting, Mars, Costco, Walmart and Sodexo joined a new programme launched by the World Wildlife Fund and Finance Earth called Fisheries Improvement Fund (FIF), which aims to provide sustainable financing to projects scaling fishery reform[116]. However, a recent assessment by Partner Africa, an NGO specialising in auditing and advisory services points to serious problems on the ground, which suggest that the multiplication of initiatives will be inadequate in the face of the widespread systemic harms created by international feed and farming companies' hunger for West African fish.

Partner Africa was commissioned by the Global Roundtable on Marine Ingredients to undertake a human rights impact assessment (HRIA) of the small pelagic fish value chain in Mauritania and Senegal[117]. Released in October 2023, the HRIA found that while there was much potential for the small pelagic fish industry to positively impact human rights of the local population (including the

right to an adequate standard of living, the right to work and the right to food), populations in both countries were instead subjected to multiple major adverse impacts across a broad range of themes, including: pollution; lack of availability, accessibility, acceptability, and quality of food; regular employment; Child labour; occupational health and safety and labour rights.

The tables below represent the findings for points 1-4. In its assessment, Partner Africa emphasised the duty of care of international businesses, buyers and investors towards all stakeholders in Mauritania and Senegal given the presence of artisanal and industrial pelagic fisheries from these countries in international supply chains.

The adverse impacts identified in this study have been assessed based on the severity of the impact (scale, scope and remediability) using the framework to the right – aligned with the UNGPs.

ACTUAL IMPACTS			
SCALE	MINOR	MODERATE	MAJOR
SCOPE	SMALL	MEDIUM	LARGE
REMEDIABILITY	EASY	MODERATE	DIFFICULT
OVERALL IMPACT	MINOR	MODERATE	MAJOR

POTENTIAL IMPACTS			
LIKELIHOOD	POSSIBLE	LIKELY	HIGHLY LIKELY
OVERALL IMPACT	POSSIBLE	LIKELY	HIGHLY LIKELY

MAURITANIA

= RIGHT TO A HEALTHY ENVIRONMENT
= RIGHT TO AN ADEQUATE STANDARD OF LIVING
= LABOUR RIGHTS

AFFECTED RIGHTS-HOLDERS

	ARTISANAL FISHERS	PURSE SEINE PIROGUE FISHERS	COMMERCIAL VESSEL FISHERS	TRANSPORTERS	FISHMONGERS	ARTISANAL PROCESSORS	FMFO FACTORY PERMANENT EMPLOYEES	FMFO FACTORY SEASONAL EMPLOYEES	COMMUNITY MEMBERS	CHILDREN (BOYS)	CHILDREN (GIRLS)
POLLUTION											
Despite the fact that some factories do have smoke filters on their chimneys, according to all stakeholders interviewed, smoke and odours from the factories have impacted their right to health. It may lead to respiratory and skin problems, which community members and children have reported and/or showed during the field research. This issue was also reported by the FAO.	ACTUAL	ACTUAL	–	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
Despite the fact that some factories do have stick-waters treatment plants, stakeholders interviewed complained about some factories still releasing untreated water into the ocean. This is likely to affect marine ecosystems, as reported by all community members and fishers who see fewer coastal lobsters and shrimps. In addition, this is likely to affect people's right to health as wastewaters have been linked to cases of diarrhoea, vomiting and nausea. This issue was also reported by the FAO.	ACTUAL	ACTUAL	–	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
General waste (plastics, bins etc) and production waste have been reported and observed (during the field research) to be dumped on the beach, landing site and artisanal processing site by stakeholders themselves. This is likely to affect marine ecosystems, as reported by all community members and fishers. In addition, this is likely to affect people's right to health as waste can lead to ill-health and affect fish quality.	ACTUAL	ACTUAL	–	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
AVAILABILITY, ACCESSIBILITY, ACCEPTABILITY AND QUALITY OF FOOD											
Limited availability (e.g. fish becoming a scarcer resource), accessibility (e.g. all stakeholders and desk-top research documented a price increase of especially sardinella), and quality of fish (e.g. due to a lack of freezing capacities and dirty landing/processing sites) for human consumption.	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
REGULAR EMPLOYMENT											
Loss of income and opportunities to work due to the competition with fishing vessels (for fishers) and FMFO factories (for artisanal processors), depleting fish stocks and increasing prices of fish operations, limited operations in FMFO factories (affecting factory employees)	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	–	–	–
CHILD LABOUR											
Children working on artisanal boats (both pirogues and purse seine pirogues) and landing sites engaged in child labour	–	–	–	–	–	–	–	–	–	ACTUAL	–
Possiblity of underaged workers hired as daily labourers in FMFO factories due to a lack of age verification systems	–	–	–	–	–	–	–	–	–	POTENTIAL	–

Extract from Track the Fish. A Human Rights Impact Assessment of the Small Pelagic Fish Value Chain in Mauritania, 2023. (Full source info – endnote reference no. 117) https://img1.wsimg.com/blobby/go/20e99f05-a548-4933-91bd-89ca35e3187d/downloads/Partner%20Africa%20report_HRIA%20of%20the%20small%20pelagi.pdf?ver=1696496840541

SENEGAL

= RIGHT TO A HEALTHY ENVIRONMENT
= RIGHT TO AN ADEQUATE STANDARD OF LIVING
= LABOUR RIGHTS

AFFECTED RIGHTS-HOLDERS

	ARTISANAL FISHERS	PURSE SEINE PIROGUE FISHERS	TRANSPORTERS	FISHMONGERS	ARTISANAL PROCESSORS	COMMUNITY MEMBERS	CHILDREN (BOYS)	CHILDREN (GIRLS)
POLLUTION								
All 48 community members that participated in the FGD reported that factories release untreated water into the sea. It was not the objective of this research to investigate factory by factory, however, the fact that this practice still happens does affect marine ecosystems, as reported by all community members and fishers. In addition, this is likely to affect people's right to health as wastewater from factories have been linked to cases of diarrhoea, vomiting and nausea.	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
General waste (plastics, bins etc) and production waste have been reported and observed (during the field research) to be dumped on the beach, landing site and artisanal processing site by stakeholders themselves. This is likely to affect marine ecosystems, as reported by all community members and fishers. In addition, this is likely to affect people's right to health as waste can lead to ill-health and affect fish quality.	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
Rising sea levels impacting the space available for artisanal fish processing in Senegal, as reported by all processors in Saint-Louis.	–	–	–	–	ACTUAL	–	–	–
AVAILABILITY, ACCESSIBILITY, ACCEPTABILITY AND QUALITY OF FOOD								
Limited availability (e.g. fish becoming a scarcer resource), accessibility (e.g. all stakeholders and desk-top research documented a price increase of especially sardinella), and quality of fish (e.g. due to a lack of freezing capacaties and dirty landing/processing sites) for human consumption.	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL
REGULAR EMPLOYMENT								
Loss of income and opportunities to work due to the competition with fishing vessels (for fishers) and FMFO factories (for artisanal processors), depleting fish stocks, oil exploration and increasing prices of fishing operations.	ACTUAL	ACTUAL	ACTUAL	ACTUAL	ACTUAL	–	–	–
CHILD LABOUR								
Children working on artisanal boats (both pirogues and purse seine pirogues) and landing sites engaged in child labour	–	–	–	–	–	–	ACTUAL	–
Children working as female artisanal processor assistants	–	–	–	–	–	–	–	ACTUAL

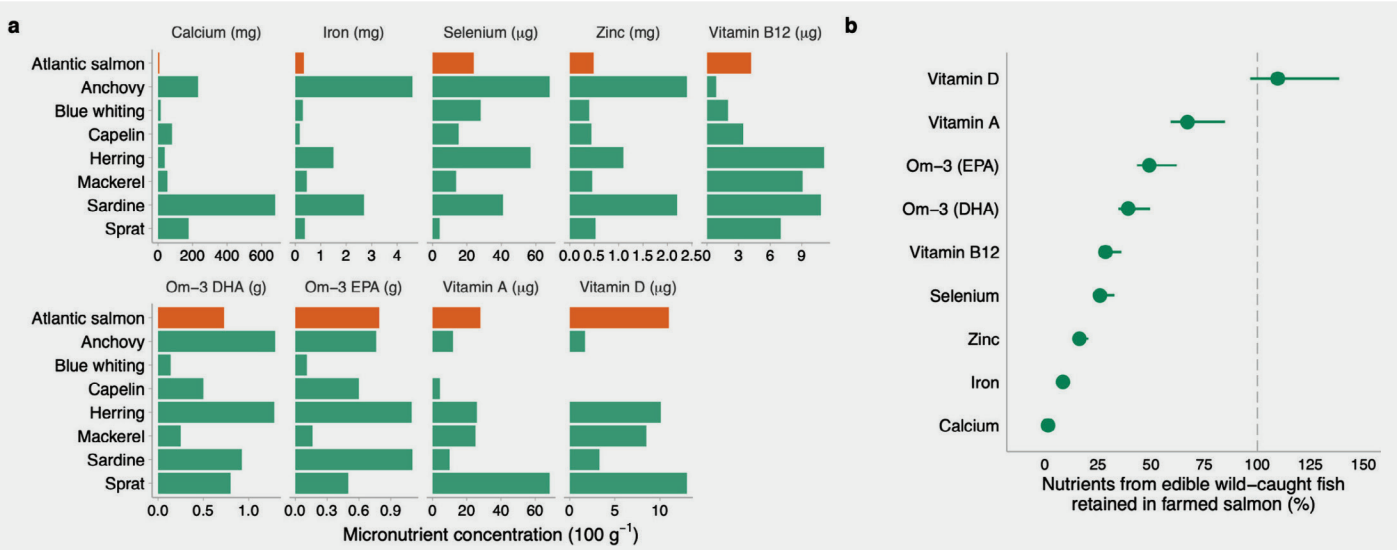
Extract from Track the Fish. A Human Rights Impact Assessment of the Small Pelagic Fish Value Chain in Senegal, 2023. (Full source info – endnote reference no. 117) https://img1.wsimg.com/blobby/go/20e99f05-a548-4933-91bd-89ca35e3187d/downloads/Partner%20Africa%20report_HRIA%20of%20the%20small%20pelagi.pdf?ver=1696496840541

Fishmonger on Yoff beach, Dakar. Credit: Hazel Healy, New Internationalist.

THE NORWEGIAN SALMON INDUSTRY OVERSTATES ITS CLAIMS ON GOOD NUTRITION

Salmon is often marketed as healthy food, rich in Omega-3 and other key micronutrients. In 2022, to examine industry claims more substantively, Feedback conducted research alongside the Universities of Cambridge, Lancaster and Liverpool to examine the role of salmon in providing the population with key micro-nutrients, especially those harder to source from plant-based foods such as DHA and EPA, vitamin B12 and vitamin D.[118] We found that most edible wild-caught fish species in FMFO have higher concentrations of key micronutrients than farmed salmon. For some of these micronutrients as little as 1% is retained in farmed salmon, indicating that salmon farming is a wasteful and inefficient means to produce nutritious food.

Figure 10: Retention of micronutrients from wild-caught fish in farmed salmon.



Panel (a) shows the micronutrient composition of wild-caught fish in salmon feed relative to the farmed salmon produced.

Panel (b) shows the proportion of these micronutrients from wild-caught fish included in feed that are retained in farmed salmon, based upon the mean volume of wild-caught fish in fish oil required to support Scottish salmon production in 2014. In (b) the error bars represent the uncertainty derived from the minimum and maximum contributions to fishmeal and oil among species.

Reference: David F. Willer et al., 'Maximising Sustainable Nutrient Production from Coupled Fisheries-Aquaculture Systems', PLOS Sustainability and Transformation 1, no. 3 (1 March 2022): e0000005, https://doi.org/10.1371/journal.pstr.0000005.

The recent publication of more precise data on fish oil yields from different species[119] and the volume of fish oil used in Norwegian salmon farming has allowed us to build on our analysis of micronutrient loss in the Scottish farmed salmon industry to calculate micronutrient retention in the Norwegian salmon farming industry, enabling us to ascertain whether Norwegian farmed salmon is an effective way to produce nutrition while safeguarding wild fish populations.

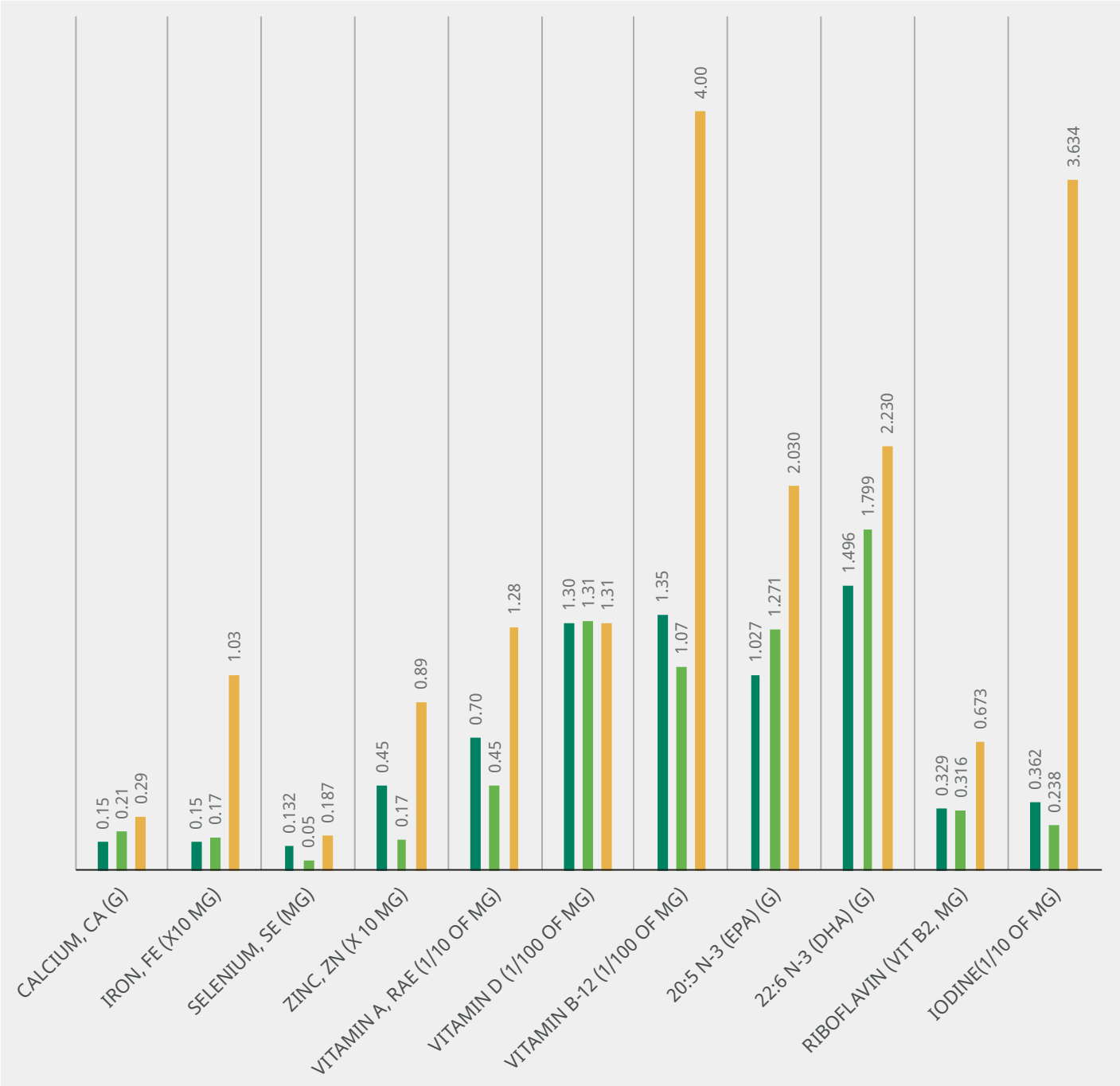
We constructed two alternative production scenarios to assess potential benefits in seafood production and nutritional quality from human consumption of fish used in salmon feeds, relative to a 'business-as-usual' scenario in which farmed salmon is fed on FMFO from both wild-caught fish and fish trimmings. A recommended seafood portion of 200g following the Nordic Nutrition Recommendations[120] was used to standardise comparison. Because salmon feed requires a lot more fish oil relative to fish meal, we also included farmed prawns in our calculations since farmed crustaceans use one third of fish meal for aquaculture globally[121] while requiring only minimal amounts of fish oil[122]

Our findings show that by directly consuming a wide variety of small, oily, wild-caught fish, together with around 20% of Norwegian salmon that can be fed with fish oil and fish meal made from trimmings alone, we could access the same level of micronutrients while consuming a smaller quantity of farmed salmon. This would have the benefit of avoiding the capture of around half of wild-caught fish currently used in Norwegian farmed salmon feed[f] – potentially increasing the local availability of wild fish in places like West Africa, while helping to maintain the health of fish populations.

By adopting this production model, Norway could halve the amount of wild-caught fish used to supply fish oil to its salmon industry based on 2020 levels, freeing up 985,000 tonnes (see methodology note 4) of wild fish for direct consumption by populations which rely on them to meet their nutritional needs, or to continue playing their critical role in the marine ecosystem.

f See notes 3 & 4 in methodology annex, Willer et al. 2022 and supplementary spreadsheet for full details regarding calculations

Figure 11: Nutritional profiles for different seafood production scenarios



- **Scenario A – 200g:** One weekly recommended portion of oily fish is 200g. Per 200g of salmon, we can also produce 219g of prawns if we are to use all available fishmeal and fish oil, so the nutrition from prawns is included.
- **Scenario B – 200g equivalent:** Salmon and prawn production is limited to the marine feed ingredients from trimmings only. Part of the "saving" in wild-caught fish is eaten directly in order to achieve similar or better Vit D, DHA and EPA.
- **Scenario C :** Salmon and prawn production limited to marine feed ingredients from trimmings only. Part of the "saving" in wild-caught fish is eaten directly, plus 200g of mussels to help keep all micronutrients at the same level or superior to Scenario A.

Source: Feedback calculations. See methodology annex and supplementary spreadsheet for full details and data sources.

CONCLUSION AND RECOMMENDATIONS: GLOBAL JUSTICE CALLS FOR A RETHINK OF THE NORWEGIAN SALMON INDUSTRY'S BLUE EMPIRE

The Norwegian salmon farming industry's huge and expanding appetite for wild-caught fish is accelerating the exploitation of marine resources beyond their limits to the detriment of biodiversity, the environment, and the good nutrition, food security and livelihoods of communities around the globe. This is especially true for fisheries already under pressure from overfishing and climate change, such as the sardinella species targeted by the aquafeed industry off the coast of West Africa.

In highlighting Norwegian salmon farming's voracious appetite, our analysis has also drawn attention to a shocking structural injustice which is being driven by the expansion of this industry. By this, we mean the scandal of removing food from people in the Global South, who are disproportionately impacted by food insecurity and malnutrition, to market a high value-added product to consumers in the Global North.

This deeply problematic practice gives the lie to aquaculture companies' claims to be on a mission to feed a growing global population; if this were the case, salmon farming, an inefficient way to produce both protein and micronutrient-rich food, would be an odd sector to prioritise. The Norwegian salmon industry's promise to feed the world is both unfounded and unrealistic and its actions are undermining Norway's development policy goals.

Given the nutrient loss inherent in all salmon farming and pressures on global fish stocks, it is impossible for Norwegian salmon farmers to source feed sustainably whilst maintaining or increasing production volumes. Hollow pledges from the likes of MOWI, Cargill, BioMar and Skretting to adopt more sustainable sourcing practices will not improve the situation for people on the ground and we are concerned that the much-touted Mauritanian Fisheries Improvement Project backed by these companies will result in nothing more than the greenwashing of their West African FMFO supply.

While some forms of aquaculture can improve food security, the farming of high-trophic species such as salmon is driving an unfair 'food-feed' competition. As the world's single largest producer of farmed salmon, Norway is one of the key players driving this dynamic.

OUR DEMANDS TO AQUACULTURE AND AQUAFEED CORPORATIONS

- Aquafeed companies must stop sourcing fish meal and fish oil (or products dependent on FMFO) from locations where its production is driving food-feed competition and exacerbating food insecurity.
- Salmon producers must have clear policies on responsible feed sourcing, which exclude the sourcing of feed produced with ingredients that are driving food-feed competition and exacerbating food insecurity.
- Producers must be fully transparent, consistent and granular on their aquafeed sourcing, including volumes, locations, species.

OUR RECOMMENDATIONS TO THE NORWEGIAN GOVERNMENT

Norwegian policymakers should:

- Halt the growth of Norway's salmon farming sector.
- Make full transparency on feed sourcing mandatory at each stage of the aquaculture supply chain.
- Ensure that the activities and sourcing practices of Norwegian companies in the Global South do not run counter to Norwegian development policy.

Inside the fish meal factory at Kartung, Gambia. Credit: Tim Webster, Reel Media for Changing Markets Foundation.

ANNEX – METHODOLOGY

1. TWO MILLION TONNES OF FISH FOR THE FISH OIL IN NORWEGIAN SALMON FEED

Of the 1,948,220 million tonnes of fish needed to produce the fish oil supplied to the Norwegian salmon industry in 2020, 1,470,000 million tonnes (three-quarters of total) are made up of food or prime food grade fish. The rest is made up of menhaden and sandeel which are considered "industrial grade" fish by the industry[123].

Sandeel is a generic term for a number of small species of highly nutritious fish which play a vital role in the marine ecosystem. They are preyed on by seabirds such as puffins and make up over half the diet of common minke whales[124]. The greater sandeel is the larger of the two main species of sandeel. While they are edible they are only caught for human consumption in tiny numbers, with the majority of greater sandeel which are caught by commercial vessels being used for non-human consumption (i.e. fish meal)[125].

Menhaden is closely related to sardine (both are in the *Alosidae* family, which forms part of the *Clupeiformes* [herring] order family). It is an important food source for predator fish and marine birds and mammals[126]. It is edible but bony and oily and so considered not very appetizing, although in the past would have been eaten commonly enough and a quick web search throws up an appealing recipe for freshly-caught menhaden[127]

Puffin with a beak full of sand eels. Credit: Anne Coatesy (iStock).

HOW DID WE ARRIVE AT THE 1,948,220 MILLION TONNES FIGURE?

Summary of calculation steps

Step 1. Total volume of fish oil from wild-caught fish used in 2020 Norwegian salmon feed reported by Aas, Åsgård, and Ytrestøyl, 2022 (hereafter 'Aas et al.')[128]: 164,611 tonnes.

Step 2. Estimate the species composition of the fish used to make this fish oil based on the breakdown per fishery area in Aas et al. and the species composition for three out of four main feed manufacturers in Johansen et al.[129], keeping the total the same as reported by Aas in step 1. We also compared these data against data in company reports.

Step 3. Apply species-specific yields reported in (Newton et al. 2023) to calculate the volume of whole wild-caught fish from each species used to make fish oil.

Step 4. Basic sensitivity analysis by rerunning step three but using the species composition as reported by Johansen at al., 2022 (hereafter 'Johansen et al.')[130] [The unknown species were assumed to be the same species in the same proportions as the known species].[g] Using only Johansen et al.'s species composition, the total volume of fish needed to make Norwegian salmon was 2.1 million tonnes. If we apply the standard average fish oil yield as reported by the FMFO trade association IFFO[131] to the fish oil volume reported by Aas et al. we end up with nearly 3.3 million tonnes of fish. This would be inaccurate though, because the species used for fish oil in Norwegian salmon feed are clearly higher yielding. However, we mention it here to show that we aimed to be as accurate and conservative as possible in our calculations.

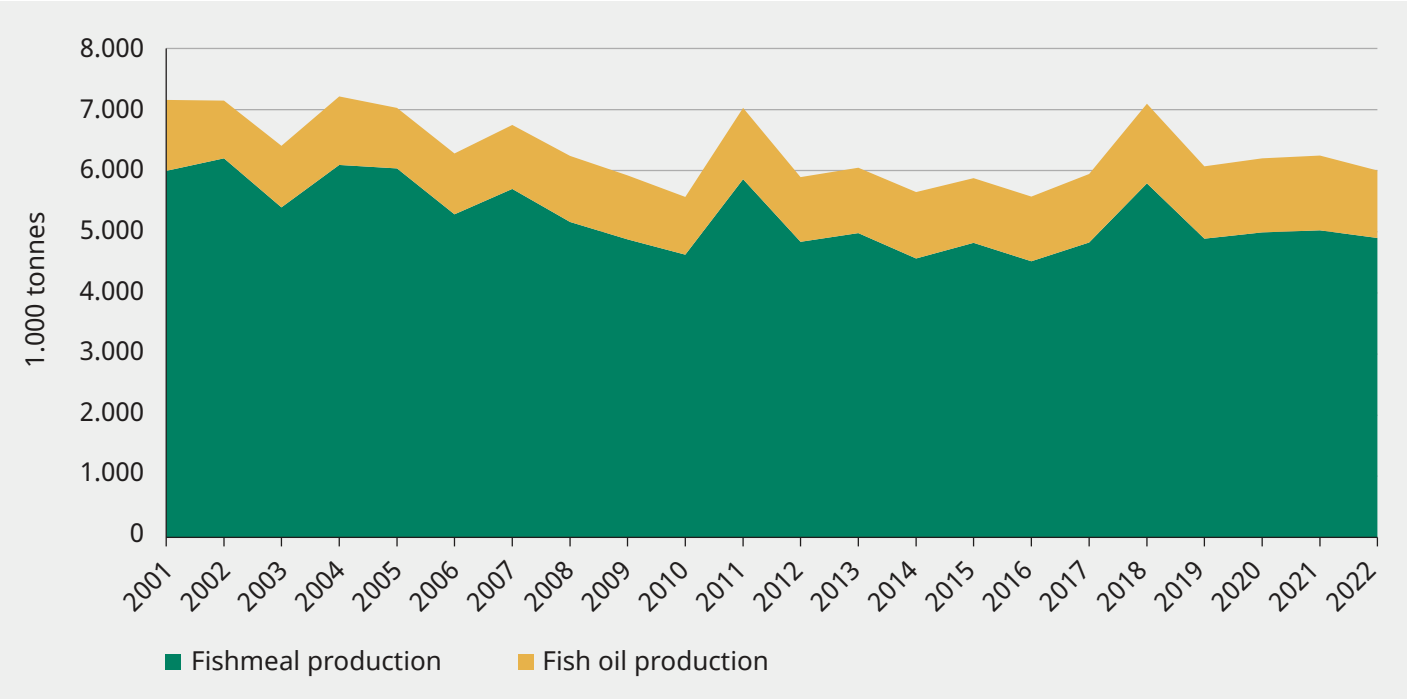
JUSTIFICATION AND MORE DETAILED EXPLANATIONS BEHIND THE CALCULATIONS

Why focus on fish oil when calculating how much wild caught fish is needed to farm salmon?

In recent years, Norwegian salmon feed producers have achieved further reductions in fish meal usage: 14.5% in 2016 down to 12.1% in 2020[132]. However, despite lots of R&D aimed at replacing fish oil with cheaper and more sustainable ingredients, in commercial settings it continues to be challenging to further reduce fish oil usage – with 10.4% of total Norwegian salmon feed ingredients consisting of fish oil in 2016 and 10.3% in 2020[133]. As can be seen in the figure below, despite yearly variations (mostly because of variations in the yearly catches of Peruvian anchoveta), global production of fish meal and fish oil is more or less static.

g For example, Johansen et al. found that of the known species, 7.5% was Peruvian anchoveta. Therefore, it was assumed that 7.5% of the unknown volume was also anchoveta. However, attributing the unknown species this way does not match FAO fishery areas, which is why we used the approach described in step 2 as the principal approach.

Figure A1: Global production of fishmeal and fish oil



European Commission, 2023, based on IFFO

In addition, in 2021, 58% of fish oil and 14% of fish meal in aquaculture was used to feed salmon and trout[134] but these two salmonid species only deliver 3.9% of global aquaculture production, not including algae[135]. A further factor is the fact that between 2002 and 2022 the yearly average price of fish oil increased by 173% to EUR 2,249 per tonne, compared to an increase of 72% in the cost of fish meal to EUR 1,422 per tonne[136]. This reflects the fact that there is more demand for FO relative to FM. Combined with salmon feed's disproportionate use of fish oil and the difficulty in reducing its usage in salmon feed, these facts mean that the use of fish oil is the primary driving factor of salmon aquaculture's dependence on reduction fisheries. Finally, fish oil carries most of the DHA and EPA, and Vitamin D, key nutrients hard to source from foods other than seafood.[137]

But what about the fish meal?

From the 1.94 million tonnes of fish used to make fish oil, we can also make 434,000 tonnes of fish meal. Of this fish meal, 174,000 tonnes is used in Norwegian salmon feed. The remaining 260,000 tonnes of fish meal is used in other aquaculture and livestock feeds. For instance, 23% of fish meal globally goes to feed pigs, which is an even more wasteful use since only 15% of protein fed to a pig ends up on our plates[138]. Since farmed crustaceans like prawns are the biggest consumers of fish meal (30% of fish meal used globally), in our nutrition retention calculations we included the prawn production that results from the 260,000 tonnes of fish meal not used for salmon.

Calculating the volume of fish used to make a certain volume of fish oil

When estimating the volume of fish needed to make a certain amount of fish oil, in Feedback's calculations for Scotland and in Willer et al. 2022[139], we used the average yield percentage of 5% as published by the industry

and used in other publications. However, we now have species-specific yield percentages[140]. This is important because species such as mackerel and sardine yield as much as 18% fish oil, whereas anchoveta only yields 4.5%. This means that in terms of total volumes of whole fish, a lot more anchoveta is used relative to high-oil-yielding species such as sardine.

Estimating the species composition used to make fish oil for Norwegian salmon feed

A complete and exact species composition for Norwegian salmon feed marine ingredients is not available. One study collected data on the species used for feed production in 2021 from three out of the four major salmon feed producers (Johansen et al.), but this left more than 20% of species unknown for the oil portion. Aas et al (2022) collected data from all four major salmon producers for feed produced in 2020, but do not report the species composition, instead they report a breakdown by FAO major fishing area. We also analysed the sustainability reports of the four feed companies and found that:

- MOWI does not provide a breakdown of the species in each area, just an aggregated figure lumping all species together (MOWI Integrated Annual Report 2021).
- BioMar aggregates data for all aquafeeds (tilapia, seabass, shrimp, etc). (Biomar Group Sustainability report 2022).
- EWOS Cargill aggregates the species composition for fish meal and fish oil. (Cargill Aqua Nutrition Sustainability Report 2021).
- Skretting provides a species composition for Norwegian salmon feed fish oil and fish meal separately. (Skretting environmental footprint of Skretting Norway salmon feed 2022).

In order to estimate the species composition as accurately as possible, we compared the volumes per FAO fishery area provided in Aas et al. against the partial species breakdown in Johansen et al. Further details on how the comparison was carried out are available in the supplementary spreadsheet provided alongside this report on Feedback's website.

2. 123,000 TONNES OF FISH FROM FAO 34 FOR FISH OIL IN NORWEGIAN SALMON DIETS

According to Aas et al. in 2020, Norwegian salmon used 22,198 tonnes of fish oil from whole fish caught in FAO 34 fishery area. Going by information provided in company reports, we deduced that this fish oil is most likely made from *Sardina Pilchardus*, which on average yields 18% of fish oil[141], thus 123,322 tonnes of sardine were needed to produce this fish oil. If instead, this fish oil was made from Sardinella, which is commonly fished for the FMFO industry in FAO 34 and yields less oil at 15.4%, then the volume of fish needed to produce this fish oil would be 144,142 tonnes. Not all companies use Latin names so we assume when they say sardine, they mean Sardina Pilchardus and not one or more of the sardinella species. However, MOWI's species breakdown mentions

both pilchard and sardine, so it is possible that this refers to *Sardina Pilchardus* and Sardinella species. This is an excellent illustration of the importance of using Latin names when reporting species used. Also note that only 43 tonnes of fish meal were sourced from Africa, so one could say that in 2020 the Norwegian salmon industry´s reliance on African fisheries is almost entirely driven by its need for fish oil.

3. FISH SAVINGS OF 50%.

Details of the calculations are available in the supplementary spreadsheet provided alongside this report on Feedback's website.

Step 1: Species distribution estimate as described in section 1 of this methodology annex

Step 2: Add in the prawns that can be produced with the fish meal not used for salmon

Step 3: An edible portion list was found in the FAO's Yearbook of Fishery Statistics[142]. To further finetune the nutrient flows we applied edible portion factors to reflect more realistically the nutrients ending up on our plates. The nutrient balance in favour of eating small fish versus farmed salmon could be further increased if we were to eat small fish whole as is the custom in Spain, for example.

Step 4: Nutritional data

We first looked at the Norwegian government food database. If data was not available we used UK government data, then USDA. We used data for the most common forms of cooking / preparation. For instance, for salmon we used the data for pan-fried salmon fillet, after finding that these were very similar to smoked salmon. Herring showed significant differences between summer and winter herring and smoked, simmered or pickled, so we calculated an average. For sardines, we used data for canned sardines. Details for other fish types in spreadsheet. No data were available for menhaden, but menhaden (*Brevoortia patronus*) is in the same subfamily as European sardine (*Sardina Pilchardus*). The subfamily is called Alosidae[h].

As a basic sensitivity check, we ran the model with the species distribution as reported by Johansen for 2021 and thus against 2021 production volumes. In this case, the fish savings are 52% in scenario B and 53% in Scenario C. However, we decided to keep the lower estimate as the headline result, using the redistributed species within total volumes reported by Aas et al.

h See : https://www.fishbase.se/home.php and https://www.marinespecies.org/index.php

4. FISH SAVINGS IN VOLUME

To find out how much fish can be left unfished (i.e. not used in the FMFO industry) we converted the species freed up from reduction fisheries from their edible volumes back to their live weight volumes using the same percentages from FAO as in section 3 of this methodology section. Percentages of fish freed up compared to the volumes currently used to make fish oil for Norwegian salmon feed: 38% of anchovy/eta, 20% of blue whiting (currently overfished in Europe), 100% of menhaden and sandeel, 90% of Norway pout, horse mackerel and herring 5% each, 10% of Pacific sardine, 65% of Sardina Pilchardus, and 100% of sardinella. These volumes of fish no longer caught for making fish oil add up to 985,000 tonnes of fish. Full list with Latin names in the supplementary spreadsheet.

Sardines. Credit M. Pessaris (iStock).

ANNEX – INFORMATION SOURCES

INFORMATION SOURCES USED TO COMPILE TABLE 3:

- **MOWI Biodiversity & Natural Capital Policy 2023**
  https://mowi.com/wp-content/uploads/2023/03/230310-Biodiversity-Policy.pdf

- **MOWI Integrated Annual Report 2022:**
  https://mowi.com/wp-content/uploads/2023/03/Mowi-Integrated-Annual-Report-2022.pdf

- **MOWI Integrated Annual Report 2021:**
  https://mowi.com/wp-content/uploads/2022/03/Mowi_Annual_Report_2021.pdf

- **MOWI Integrated Annual Report 2020:**
  https://mowi.com/wp-content/uploads/2021/03/Mowi_Integrated_Annual_Report_2020.pdf

- **Personal communication with Skretting in 2023**

- **Skretting Footprint Report 2022:**
  https://www.skretting.com/no/baerekraft/baerekraftsrapport/footprint-report-salmon-feed-2022/use-of-marine-raw-materials#origin

- **Skretting Sustainability Report 2022:**
  https://www.skretting.com/siteassets/global/sustainability/pdfs/skretting-sustainability-report-2022.pdf?v=4a9c6a

- **BioMar Global Sustainability Report 2022:**
  https://www.biomar.com/our-promise/sustainability-report

- **Cargill ESG Report 2023:**
  https://www.cargill.com/sustainability/doc/1432249640508/2023-esg-report-aqua-nutrition.pdf

REFERENCES

1 M. Jones, 'Salmo Salar (Linnaeus, 1758) [Salmonidae]', FAO, 2009, https://www.fao.org/fishery/docs/CDrom/aquaculture/I1129m/file/en/en_atlanticsalmon.htm.

2 Globefish (FAO), 'Salmon - Main Producers See Record-Breaking Exports', 31 May 2023, https://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1640993/.

3 M. Shahbandeh, 'Salmon Industry - Statistics & Facts', Statista, 10 January 2024, https://www.statista.com/topics/7411/salmon-industry/#topicOverview.

4 Ana Maria Caramelo and Merete Tandstad, 'FAO Fisheries Technical Paper 457' (FAO, n.d.), https://www.fao.org/3/y5852e/Y5852E04.pdf.

5 Anne Garland Mahler, 'What/Where Is the Global South?', University of Virginia, 2023, https://globalsouthstudies.as.virginia.edu/what-is-global-south.

6 Marine Stewardship Council, 'What Are Small Pelagic Fish and Why Are They Important?', 2023, https://www.msc.org/species/small-pelagic-fish/why-are-they-important.

7 FAO and EAF-Nansen Programme, 'Sardinella Fisheries: Quickly Disappearing Vital Source of Food and Nutrition Security in Northwest Africa', 15 October 2021, https://www.fao.org/in-action/eaf-nansen/news-events/detail-events/en/c/1444341/.

8 P. Albano, W. Lee, and NOAA, 'Small But Mighty: The Importance of Tiny Organisms in Marine Ecosystems', 31 August 2021, https://oceanexplorer.noaa.gov/technology/development-partnerships/21adcp-gliders/features/zooplankton/zooplankton.html.

9 Aslak Berge, 'Dette Er Verdens 20 Største Lakseoppdrettere', *iLaks.No*, 20 July 2020, https://ilaks.no/dette-er-verdens-20-storste-lakseoppdrettere-2/.

10 MOWI, 'Caring Makes Us Profitable', 2022, https://mowi.com/investors/.

11 Andre Standing, 'Certifying the Unsustainable: The Fisheries Improvement Project in Mauritania', Coalition for Fair Fisheries Arrangements, 14 June 2022, https://www.cffacape.org/publications-blog/certifying-unsustainable-fip-mauritania.

12 Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), 'Krill Fisheries and Sustainability', 16 February 2018, https://www.ccamlr.org/en/fisheries/krill-fisheries-and-sustainability.

13 N. Bransome and N. Kirkham, 'Scientists Studying Antarctic Krill Strive to Improve Management of Southern Ocean Fishery', Pew Charitable Trusts, 6 June 2023, https://www.pewtrusts.org/en/research-and-analysis/articles/2023/06/06/scientists-studying-antarctic-krill-strive-to-improve-management-of-southern-ocean-fishery.

14 QRILL Aqua, 'Salmon Prefer Krill and Thrive When It's in the Feed', n.d., https://www.qrillaqua.com/blog-and-news/salmon-prefer-krill-and-thrive-when-its-in-the-feed.

15 FAO, 'The State of World Fisheries and Aquaculture (SOFIA) 2022' (Rome: FAO, 2022), https://www.fao.org/3/cc0461en/cc0461en.pdf.

16 Rosamond L. Naylor et al., 'A 20-Year Retrospective Review of Global Aquaculture', *Nature* 591, no. 7851 (March 2021): 551–63, https://doi.org/10.1038/s41586-021-03308-6.

17 FAO, 'The State of World Fisheries and Aquaculture 2022. *Op. cit.*

18 European Commission, Directorate-General for Maritime Affairs and Fisheries, 'Fishmeal and Fish Oil – Production and Trade Flows in the EU' (Publications Office of the European Union, 2023), https://data.europa.eu/doi/10.2771/47090.

19 Changing Markets Foundation, 'Fishing for Catastrophe', October 2019, https://changingmarkets.org/wp-content/uploads/2019/10/CM-WEB-FINAL-FISHING-FOR-CATASTROPHE-2019.pdf.

20 Changing Markets Foundation and Greenpeace Africa, 'Feeding a Monster: How European Aquaculture and Animal feed Industries Are Stealing Food from West African Communities', June 2021, https://www.greenpeace.org/static/planet4-africa-stateless/2021/05/47227297-feeding-a-monster-en-final-small.pdf.

21 E. Lindbæk, '36.000 Tonn Nordsjøsild Har Gått Til Oppmaling', *Fiskeribladet*, 25 May 2022, https://www.fiskeribladet.no/fiskeri/36-000-tonn-nordsjosild-har-gatt-til-oppmaling/2-1-1225236.

22 Niall Duffy, 'Mackerel from Irish Waters Should Be For Human Consumption Not Animal Feed in Other Countries', *The Skipper*, 29 October 2023, https://theskipper.ie/mackerel-from-irish-waters-should-be-for-human-consumption-not-animal-feed-in-other-countries/.

23 FAO et al., 'The State of Food Security and Nutrition in the World 2023: Urbanization, Agrifood Systems Transformation and Healthy Diets across the Rural–Urban Continuum.' (Rome: FAO, 2023), https://doi.org/10.4060/cc3017en.

24 Norsk Industri, 'Summary Roadmap for the Aquaculture Industry: Sustainable Growth' (Oslo, Norway), 25 July 2017, https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/veikart-for-havbruksnaringen---kortversjon_eng.pdf.

25 MOWI, 'MOWI Integrated Annual Report 2020', 2021, https://mowi.com/wp-content/uploads/2021/03/Mowi_Integrated_Annual_Report_2020.pdf.

26 Skretting, 'Ingredient Innovation', 2023, https://www.skretting.com/en/Innovation/ingredient-innovation/.

27 Lerøy Seafood Group ASA, 'Sustainable Food Production for the Future', 2017, https://www.leroyseafood.com/en/about-us/news/sustainable-food-production-for-the-future/.

28 Cargill Aqua Nutrition, 'Sustainability Report 2019', n.d., https://www.cargill.com/doc/1432142322239/cargill-aqua-nutrition-sustainability-report.pdf.

29 PricewaterhouseCoopers, 'PwC Seafood Barometer 2023', 2023, https://www.pwc.no/no/publikasjoner/2023-rapport-sjoematbarometeret.pdf.

30 Turid Synnøve Aas, Torbjørn Åsgård, and Trine Ytrestøyl, 'Utilization of Feed Resources in the Production of Atlantic Salmon (Salmo Salar) in Norway: An Update for 2020', *Aquaculture Reports* 26 (October 2022): 101316, https://doi.org/10.1016/j.aqrep.2022.101316.

31 Ernst & Young (EY), 'The Norwegian Aquaculture Analysis 2022', 2022, https://assets.ey.com/content/dam/ey-sites/ey-com/en_no/topics/strategy-transactions/the-norwegian-aquaculture-analysis-2022.pdf

32 Aslak Berge, 'Dette Er Verdens 20 Største Lakseoppdrettere', *iLaks.No*, 20 July 2020, https://ilaks.no/dette-er-verdens-20-storste-lakseoppdrettere-2/.

33 Mowi, 'Salmon Farming Industry Handbook 2022', July 2022, https://mowi.com/wp-content/uploads/2022/07/2022-Salmon-Industry-Handbook-1.pdf.

34 Finansdepartementet, 'Skattlegging Av Havbruksvirksomhet', 2019, https://www.regjeringen.no/no/dokumenter/nou-2019-18/id2676239/?ch=4.

35 BNP Paribas (a), 'Does Farmed Fish Have a Place in Sustainable, Healthy Diets?', Research note, January 2023, https://docfinder.bnpparibas-am.com/api/files/55CEBA11-893D-4A6D-BA1E-B8CE83EF020A.

36 MOWI, 'Shareholder Analysis', 2023, https://mowi.com/investors/share-and-bond/shareholder-analysis/.

37 R. Fletcher, 'Rabobank Ramps up Concerns over Norway's Proposed Resource Rent Tax', *The Fish Site*, 26 January 2023, https://thefishsite.com/articles/rabobank-ramps-up-concerns-over-norways-proposed-resource-rent-tax.

38 Dorothee Schreiber and Camilla Brattland, 'Salmon Cultures: Indigenous Peoples and the Aquaculture Industry', RCC Perspectives (Rachel Carson Center, 2012), https://www.environmentandsociety.org/perspectives/2012/4/salmon-cultures-indigenous-peoples-and-aquaculture-industry.

39 International Work Group for Indigenous Affairs (IWGIA), 'Indigenous Peoples in Sápmi', n.d., https://www.iwgia.org/en/sapmi.html.

40 Bjørn Hersoug, 'Why and How to Regulate Norwegian Salmon Production? – The History of Maximum Allowable Biomass (MAB)', *Aquaculture* 545 (15 December 2021): 737144, https://doi.org/10.1016/j.aquaculture.2021.737144.

41 Daniel A, 'How Norway Convinced Japan That Sushi Was Made With Salmon', Medium, 1 May 2023, https://bettermarketing.pub/how-norway-convinced-japan-that-sushi-was-made-with-salmon-4776fd65b219.

42 Aas, Åsgård, and Ytrestøyl. *Op. cit*

43 *Ibid.*

44 FAO, 'The State of World Fisheries and Aquaculture 2022. *Op. cit.*

45 Ernst & Young (EY), 'The Norwegian Aquaculture Analysis 2022'. 2022 https://assets.ey.com/content/dam/ey-sites/ey-com/en_no/topics/strategy-transactions/the-norwegian-aquaculture-analysis-2022.pdf

46 Aas, Åsgård, and Ytrestøyl. *Op. cit*

47 *Ibid*.

48 MOWI, 'Integrated Annual Report 2022', 2022, https://mowi.com/wp-content/uploads/2023/03/Mowi-Integrated-Annual-Report-2022.pdf.

49 Skretting, 'Footprint Report 2022', 2023, https://www.skretting.com/no/baerekraft/baerekraftsrapport/footprint-report-salmon-feed-2022/use-of-marine-raw-materials#origin.

50 Cargill Aqua Nutrition, 'Cargill Aqua Nutrition Sustainability Report 2022', 2023, https://www.cargill.com/doc/1432219325606/cargill-aqua-nutrition-sustainability-report-2022.pdf.

51 BioMar Group, 2021, https://www.facebook.com/BioMarEMEADivision/posts/d41d8cd9/895496368053110/?locale=hi_IN.

52 BNP Paribas (b), 'Investing Responsibly in the Fast-Growing Farmed Fish Sector', View Point, January 2023, https://viewpoint.bnpparibas-am.com/investing-responsibly-in-the-fast-growing-farmed-fish-sector/.

53 Standing, 'Certifying the Unsustainable'.

54 Greenpeace, 'A Waste of Fish: Food Security under Threat from the Fishmeal and Fish Oil Industry in West Africa' (Amsterdam, the Netherlands: Greenpeace International, June 2019), https://www.greenpeace.org/static/planet4-international-stateless/2019/06/0bbe4b20-a-waste-of-fish-report-en-low-res.pdf.

55 Changing Markets Foundation and Greenpeace Africa, 'Feeding a Monster: How European Aquaculture and Animal feed Industries Are Stealing Food from West African Communities', June 2021, https://www.greenpeace.org/static/planet4-africa-stateless/2021/05/47227297-feeding-a-monster-en-final-small.pdf.

56 Djiga Thiao and Stuart W. Bunting, 'Socio-Economic and Biological Impacts of the Fish-Based Feed Industry for Sub-Saharan Africa' (Rome: FAO, 2022), https://www.fao.org/3/cb7990en/cb7990en.pdf.

57 Andre Standing, 'European Industries Must Disinvest in West Africa's Booming Fishmeal and Fish Oil Sector', Coalition for Fair Fisheries Arrangements, 10 December 2019, https://www.cffacape.org/publications-blog/european-industries-must-disinvest-in-west-africas-booming-fishmeal-and-fish-oil-sector.

58 El hadj Bara Deme, Moustapha Deme, and Pierre Failler, 'Small Pelagic Fish in Senegal: A Multi-Usage Resource', *Marine Policy* 141 (1 July 2022): 105083, https://doi.org/10.1016/j.marpol.2022.105083.

59 Chatham House, RESOURCETRADE.EARTH, Mauritania's fish oil exports 2020, https://resourcetrade.earth/?year=2020&exporter=478&category=60&units=weight&autozoom=1

60 Chatham House, RESOURCETRADE.EARTH, Mauritania's fish meal exports 2020, https://resourcetrade.earth/?year=2020&exporter=478&category=715&units=weight&autozoom=1

61 Annika Hammerschlag, 'Anger over Fish Stocks as Senegal Village Mourns Boat Disaster Dead', *The Guardian*, 25 August 2023, https://www.theguardian.com/global-development/2023/aug/25/fish-stocks-senegalese-village-boat-disaster-cape-verde.

62 Deme, Deme, and Failler, *Op. cit*.

63 A. Daniels, '"Fish Are Vanishing" - Senegal's Devastated Coastline', BBC News, 1 November 2018, https://www.bbc.co.uk/news/world-africa-46017359.

64 FAO and EAF-Nansen Programme, *Op. cit.*

65 *Ibid*.

66 EJF, 'The "People's" Fishery on the Brink of Collapse. Small Pelagics in Landings of Ghana's Industrial Trawl Fleet', 2020, https://ejfoundation.org/resources/downloads/EJF-report-small-pelagics-2020-final.pdf.

67 FAO and EAF-Nansen Programme, *Op. cit.*

68 CFFA, 'Mauritania: How the EU Agreement Can Be Used to Improve Fisheries Management', 26 February 2020, https://www.cffacape.org/publications-blog/how-the-eu-mauritania-fisheries-agreement-can-be-used-to-improve-fisheries-management?rq=Fishmeal.

69 'Closing Inequality Gaps: Prioritizing Nutrition among Women and Adolescents in West Africa' (African Population and Health Research Center (APHRC), November 2019), https://www.countdown2030.org/wp-content/uploads/2021/04/WA-Regional-policy-brief-final-18112019.pdf.

70 FAO et al., 'The State of Food Security and Nutrition in the World 2023'. *Op. cit.*

71 X. Wang et al., 'Global Food Nutrients Analysis Reveals Alarming Gaps and Daunting Challenges', *Nature Food* 4 (12 October 2023): 1007–17, https://www.nature.com/articles/s43016-023-00851-5 .

72 Deme, Deme, and Failler, *Op. cit*.

73 Awa Traore, 'Today, Let's Stand 4 Female Fish Processors of West Africa!', March 2020, https://www.greenpeace.org/africa/en/blog/9086/today-lets-stand-4-female-fish-processors-of-west-africa/.

74 Bocar Sakho, 'SENEGAL: Les Transformatrices Dans Le Creux de La Vague', *Le Quotidien*, 31 October 2018, https://earthjournalism.net/stories/senegal-les-transformatrices-dans-le-creux-de-la-vague.

75 Y. Reichling and Feedback EU, 'They Are Fighting for Their Rights and so Should We!', 31 July 2023, https://feedbackeurope.org/they-are-fighting-for-their-rights-and-so-should-we/.

76 Traore, 'Today, Let's Stand 4 Female Fish Processors of West Africa!''

77 Amagor Robert Niang, 'Greenpeace Afrique Se Joint Aux Milliers de Femmes Transformatrices Du Sénégal Pour Réclamer La Consécration de Leur Statut Juridique 10 Ans Après Que Les Autorités Aient Promis Cette Réforme.' (Greenpeace Africa, 8 March 2023), https://www.greenpeace.org/africa/fr/communiques-de-presse/53293/greenpeace-afrique-se-joint-aux-milliers-de-femmes-transformatrices-du-senegal-pour-reclamer-la-consecration-de-leur-statut-juridique-10-ans-apres-que-les-autorites-aient-promis-cette-reforme/.

78 Greenpeace and Runnymede Trust, 'Confronting Injustice: Racism and the Environmental Emergency', 2022, https://www.greenpeace.org.uk/wp-content/uploads/2022/09/Confronting-Injustice-2022-web.pdf.

79 Thiao and Bunting, 'Socio-Economic and Biological Impacts of the Fish-Based Feed Industry for Sub-Saharan Africa'. *Op. cit.*

80 Amnesty International, 'Gambia. The Human Cost of Overfishing: How the Overuse of Fisheries Resources in Sanyang Threatens Human Rights', 31 May 2023, https://www.amnesty.org/en/documents/afr27/6644/2023/en/.

81 Cheikh Bamba Ndao, 'Journée Mondiale des océans: L'ONG ZAKIA en partenariat avec Greenpeace Afrique, liste les maux de la pêche en République islamique de Mauritanie', Greenpeace Africa, 12 June 2022, https://www.greenpeace.org/africa/fr/les-blogs/51513/journee-mondiale-des-oceans-long-zakia-en-partenariat-avec-greenpeace-afrique-liste-les-maux-de-la-peche-en-republique-islamique-de-mauritanie/.

82 BBC News Afrique, 'Pêche artisanale contre pêche industrielle : pourquoi les conflits persistent sur les côtes ouest africaines ?', BBC News Afrique, 28 April 2023, https://www.bbc.com/afrique/articles/c0dxvme3kwgo.

83 Kassataya, 'Sénégal - Tensions entre communautés de pêcheurs : Relations en eaux troubles', *Kassataya* (blog), 7 April 2023, https://kassataya.com/2023/04/07/senegal-tensions-entre-communautes-de-pecheurs-relations-en-eaux-troubles/.

84 Deme, Deme, and Failler, *Op. cit*.

85 Changing Markets Foundation and Greenpeace Africa, 'Feeding a Monster'. *Op. cit.*

86 Djiga Thiao and Stuart W. Bunting. *Op. cit.*

87 *Ibid.*

88 Norsk Industri, 'Summary Roadmap for the Aquaculture Industry: Sustainable Growth' (Oslo, Norway), 25 July 2017, https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/veikart-for-havbruksnaringen---kortversjon_eng.pdf.

89 Bent-Are Jensen and Rachel Mutter, 'The United States just became Norway's largest salmon consumer market', *Intrafish*, 6 December 2022, https://www.intrafish.com/markets/the-united-states-just-became-norways-largest-salmon-consumer-market/2-1-1367120

90 U. Rashid Sumaila et al., 'Aquaculture Over-Optimism?', *Frontiers in Marine Science* Volume 9-2022 (14 November 2022), https://doi.org/10.3389/fmars.2022.984354.

91 Vince McDonagh, 'Sagging Krone Further Boosts Norway's Salmon Exports', *Fish Farmer*, 5 December 2023, https://www.fishfarmermagazine.com/2023/12/05/sagging-krone-further-boosts-norways-salmon-exports/.

92 Aslak Berge, 'Polish Processing Giants Increase Purchases of Norwegian Salmon by 52 Per-Cent', *Salmon Business*, 26 March 2021, https://www.salmonbusiness.com/polish-processing-giants-increase-purchases-of-norwegian-salmon-by-52-per-cent/.

93 Lerøy, 'Norwegian Salmon Makes a Splash in Spain and the Netherlands', 2017, https://www.leroyseafood.com/en/tasty-seafood/environment-and-society/norwegian-salmon-makes-a-splash-in-spain-and-the-netherlands/.

94 Hersoug, 'Why and How to Regulate Norwegian Salmon Production?' *Op. cit.*

95 MOWI, 'Caring Makes Us Profitable', 2022, https://mowi.com/investors/.

96 *Ibid.*

97 Norwegian Ministry of Foreign Affairs, 'Norway's Strategy for Promoting Food Security in Development Policy', 29 November 2022, https://www.regjeringen.no/en/dokumenter/Food-security-strategy/id2948780/.

98 *Ibid.*

99 FAO and EAF-Nansen Programme, *Op. cit.*

100 United Nations Department of Economic and Social Affairs, 'New Phase of the EAF-Nansen Programme', n.d., https://sdgs.un.org/partnerships/new-phase-eaf-nansen-programme.

101 , 29 November 2022, https://www.regjeringen.no/en/dokumenter/Food-security-strategy/id2948780/

102 C. Costello et al., 'The Future of Food from the Sea', *Nature* 588 (19 August 2020): 95–100, https://doi.org/10.1038/s41586-020-2616-y.

103 Aas, Åsgård, and Ytrestøyl. *Op. cit*

104 Ministère de l'agriculture et de l'alimentation, 'Cahier Des Charges Du Label Rouge N° LA 33/90 « SAUMON »' (Bulletin officiel du Ministère de l'agriculture et de l'alimentation n°2018-16, 12 April 2018), https://info.agriculture.gouv.fr/gedei/site/bo-agri/document_administratif-d63e60c5-429e-47e1-b574-e1ff1770b752/telechargement.

105 Aas, Åsgård, and Ytrestøyl. *Op. cit*

106 Rashid Sumaila et al., 'Aquaculture Over-Optimism?'. *Op. cit.*

107 N. Auchterlonie, 'The Continuing Importance of Fish meal and Fish Oil in Aquafeeds', https://www.aquafarm.show/wp-content/uploads/2018/06/AUCHTERLONIE-Neal.pdf.

108 Standing, 'Certifying the Unsustainable'. *Op. cit.*

109 *Ibid.*

110 *Ibid.*

111 FIP Petits Pélagiques en Mauritanie, 'FIP PP En Mauritanie Partenaires et Soutien', 2021, https://www.fip-petitspelagiques-mauritanie.org/partenaires.

112 Biomar, 'Mauritania Small Pelagics Fishery Improver Programme (FIP)', n.d., https://www.biomar.com/en/global/articles/news/mauritania-small-pelagics-fishery-improver-programme-fip/.

113 Cargill, '2022 ESG Report', 2023, https://www.cargill.com/sustainability/2022-esg-report#downloading-esg-report.

114 'Reduction Fisheries Play a "Positive" Role in Reaching SDGs', *The Fish Site*, 8 November 2019, https://thefishsite.com/articles/reduction-fisheries-play-a-positive-role-in-reaching-sdgs.

115 Changing Markets Foundation, 'Fishing for Catastrophe'. *Op. cit.*

116 Nicole Kerwin, 'Mars, Cargill, Skretting to Tackle Sustainability in Fisheries', Pet Food Processing, 28 April 2023, https://www.petfoodprocessing.net/articles/16922-mars-cargill-skretting-to-tackle-sustainability-in-fisheries.

117 Partner Africa, 'Track the Fish. A Human Rights Impact Assessment of the Small Pelagic Fish Value Chain in Senegal and Mauritania', 2023, https://img1.wsimg.com/blobby/go/20e99f05-a548-4933-91bd-89ca35e3187d/downloads/Partner%20Africa%20report_HRIA%20of%20the%20small%20pelagi.pdf?ver=1696496840541.

118 David F. Willer et al., 'Maximising Sustainable Nutrient Production from Coupled Fisheries-Aquaculture Systems', *PLOS Sustainability and Transformation* 1, no. 3 (1 March 2022): e0000005, https://doi.org/10.1371/journal.pstr.0000005.

119 Richard W. Newton et al., 'Life Cycle Inventories of Marine Ingredients', *Aquaculture* 565 (25 February 2023): 739096, https://doi.org/10.1016/j.aquaculture.2022.739096.

120 Rune Blomhoff et al., *Nordic Nutrition Recommendations 2023 : Integrating Environmental Aspects* (Nordisk Ministerråd, 2023), https://urn.kb.se/resolve?urn=urn:nbn:se:norden:org:diva-12891.

121 European Commission, Directorate-General for Maritime Affairs and Fisheries, 'Fishmeal and Fish Oil – Production and Trade Flows in the EU'.

122 Wesley Malcorps et al., 'The Sustainability Conundrum of Fishmeal Substitution by Plant Ingredients in Shrimp Feeds', *Sustainability* 11, no. 4 (2019): 1212, https://doi.org/10.3390/su11041212.

123 Auchterlonie, 'The Continuing Importance of Fishmeal and Fish Oil in Aquafeeds'.

124 Raquel Garcia-Vernet et al., 'Ecological Niche Partitioning between Baleen Whales Inhabiting Icelandic Waters', *Progress in Oceanography*, December 2021, https://doi.org/10.1016/j.pocean.2021.102690.

125 British Sea Fishing, 'Greater and Lesser Sandeel', n.d., https://britishseafishing.co.uk/greater-and-lesser-sandeel/.

126 Chesapeake Bay Foundation, 'Atlantic Menhaden', 2023, https://www.cbf.org/about-the-bay/chesapeake-wildlife/menhaden/index.html.

127 'Salt Crusted Menhaden (Bunker) with Lemon Ramp and Fennel Sauce', 25 April 2020, https://dearjuneberry.com/2020/04/25/salt-crusted-menhaden-bunker-with-lemon-ramp-and-fennel-sauce/.

128 Aas, Åsgård, and Ytrestøyl. *Op. cit*

129 Johansen et al., 'Greenhouse Gas Emissions of Norwegian Salmon Products', SINTEF, 2022, https://app.cristin.no/results/show.jsf?id=2106677.

130 Newton et al., 'Life Cycle Inventories of Marine Ingredients'. *Op. cit.*

131 IFFO, 'The Evolution of Sustainability Metrics for Marine Ingredients', January 2022, https://www.iffo.com/evolution-sustainability-metrics-marine-ingredients-0.

132 Aas, Åsgård, and Ytrestøyl. *Op. cit*

133 *Ibid.*

134 European Commission, Directorate-General for Maritime Affairs and Fisheries, 'Fishmeal and Fish Oil – Production and Trade Flows in the EU'. *Op. cit.*

135 FAO, 'The State of World Fisheries and Aquaculture 2022. *Op. cit*

136 European Commission, Directorate-General for Maritime Affairs and Fisheries, 'Fishmeal and Fish Oil – Production and Trade Flows in the EU'. *Op. cit.*

137 IFFO, 'The Benefits of Fish Oil', 2020, https://www.iffo.com/benefits-fish-oil-new.

138 Jillian P. Fry et al., 'Feed Conversion Efficiency in Aquaculture: Do We Measure It Correctly?', *Environmental Research Letters* 13, no. 2 (February 2018): 024017, https://doi.org/10.1088/1748-9326/aaa273.

139 Willer et al., 'Maximising Sustainable Nutrient Production from Coupled Fisheries-Aquaculture Systems'."plainCitation":"Willer et al., 'Maximising Sustainable Nutrient Production from Coupled Fisheries-Aquaculture Systems'. *Op. cit.*

140 Newton et al., 'Life Cycle Inventories of Marine Ingredients'. *Op. cit.*

141 *Ibid.*

142 FAO, 'FAO Yearbook of Fishery Statistics, Catches and Landings, Volume 64', n.d., https://www.fao.org/3/t0219e/t0219e01.htm.

Feedback regenerates nature by transforming the food system. To do this we challenge power, catalyse action and empower people to achieve positive change.

Disclaimer

All reasonable attempts have been made to verify the nature and status of the primary and secondary sources collected here in good faith and in the public interest. Any opinions expressed are honestly held and based on facts true at the time of publication.

Published January 2024

www.feedbackglobal.org
@feedbackorg

Global Feedback Ltd
Registered in England and Wales,
charity number: 1155064

www.feedbackeurope.org
@feedback_europe

Registered as charity with
ANBI status in the Netherlands
KvK number: 83634096