Until the Seas Run Dry

How industrial aquaculture is plundering the oceans

The purpose of this report is to shed light on industry-specific issues related to the environmental and food security impacts of the use of wild-caught fish as feed inputs in the aquaculture industry.

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Contents

Executive Summary 5

1. Introduction 15

2. The aquaculture industry's hunger for wild-caught fish 19

2.1. Overview 19
2.2. Feeding wild fish to farmed fish 21
Box 1: Fish welfare 24
Box 2: Why protect forage fish? 25
2.3. Future trends in aquaculture 27

3. Geography of destruction: Global hubs of FMFO production 29

3.1. Overview 29
3.2. Peru: The Saudi Arabia of FMFO production 30
3.3. West Africa: Fishmeal production undermining food security and local jobs 34
Box 3: Pollution scandals surrounding West African fishmeal factories 37
3.4. China: The aquaculture industry's 'black box' 38
Box 4: Norway: A multi-billion-euro aquaculture hub and the world's largest krill harvester 40
Box 5: IFFO: The certifier with a major conflict of interest 41

4. Feeding aquaculture: Big financial returns at the expense of the ocean 43

4.1. Overview 43
4.2. The growing use of aquafeed: What is driving demand? 46
4.3. The changing composition of feed 48
4.4. Profiles of main European aquafeed companies 49
4.4.1. Cargill Aqua Nutrition/EWOS 49
4.4.2. Skretting 51
4.4.3. Mowi 54
4.4.4. Biomar 55
Box 6: Why certification schemes should stop certifying FMFO 57

5. Conclusions and recommendations 59

5.1. Conclusions 59
5.2. Recommendations 60

6. Executive summary references 63

7. References 65

Executive Summary

Overview

As we gradually take stock of the full extent of the devastation humankind is wreaking on our planet's oceans and life therein, this report takes a critical look at one of the most wasteful industries currently plundering the seas: industrial aquaculture and its use of wild-caught fish for feed.

Through a comprehensive review of the latest scientific research on the impacts of reduction fisheries[a] on marine ecosystems, an examination of the geographies of destruction in which fishmeal and fish-oil (FMFO) production take place, and a brief analysis of some of the major corporate players behind the expansion of the aquafeed industry into a multi-billion-euro business, this report will show how current market dynamics are fundamentally broken. Grinding wild fish into FMFO to feed a growing aquaculture industry raises concerns of overfishing, poor animal welfare and disruption of aquatic food webs; it also undermines food security, as less fish is available for direct human consumption.[1] Given the rapid growth of the sector, it is clear that the aquaculture industry's business-as-usual approach is pushing marine resources beyond planetary boundaries and disregarding the welfare of hundreds of billions of sentient animals.

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a Reduction fisheries 'reduce', or turn fish catch into, fishmeal and fish oil.

Fish farm (© shutterstock)

Aquaculture: Is the cure worse than the disease?

Aquaculture is the fastest-growing segment of the food-production sector, accounting for roughly half of world fish consumption.[2] Proponents of the industry claim aquaculture has the potential to deliver affordable, healthy protein with a low carbon footprint, and could provide a way of diverting pressure from wild-capture stocks, which have been systematically overfished for decades.[3] However, the industry is failing to deliver on this promise due to its continued reliance on wild-caught fish;[4] almost a fifth of the world's total catch of wild fish is processed into FMFO,[5] of which 69% of fishmeal and 75% of fish-oil production are used to feed farmed fish.[6]

The Food and Agriculture Organization of the United Nations (FAO) projects that aquaculture will produce 109 million tonnes of fish, providing 60% of the world's fish consumption, by 2030.[2] The growing demand for carnivorous farmed fish, and the trend of feeding FMFO to non-carnivorous fish to speed up growth cycles, is reflected in FAO projections that fishmeal production will be 19% higher in 2030 than in 2016.[2] The business-as-usual scenario therefore places sustained pressure on wild fish populations to feed farmed fish.

At this critical juncture, this report takes stock of the impacts that intensive aquaculture is already having on the marine environment and food chains, as well as on the food security and wellbeing of vulnerable coastal communities, and proposes a more sustainable way forward by eliminating the industry's reliance on wild-caught fish.

Key findings

- **The aquaculture industry is targeting keystone species and causing environmental problems by fishing further down marine food webs**

Small forage fish (including sardines, anchovies, mackerel and herring) and crustaceans (mainly krill) constitute a critical link in marine food webs, transferring energy to predators (such as tuna, salmon, cod, sharks and whales) at higher trophic levels.[7] Highly nutritious, they are bursting with vitamins, minerals and omega-3 fatty acids. Paradoxically, it is these unique life-giving attributes that now threaten their existence, as they are highly sought-after as 'raw materials' for intensive aquaculture – one of the most voracious industries on the planet.

Despite increased focus on this issue in recent years, industrial aquaculture and the multinational aquafeed companies that supply it are putting increased pressure on forage fish, which, because they move around in dense schools, are highly susceptible to overfishing. Almost 70% of landed forage fish are processed into FMFO,[8] which based on industry data, represents nearly 20% of wild-caught fish landings.[9] The mass exploitation of these species poses the risk of localised population collapses with knock-on effects on other marine life, including marine mammals and seabirds, and could have other unknown consequences given the extreme complexity of marine ecosystems and the impacts of climate change.[10]

Because forage fisheries are subject to overfishing and frequent population declines, sometimes resulting in full-scale population collapse,[4] the industry is using a more diverse range of species for fishmeal production than in the past. Reduction fisheries (especially in Asia) are plundering the ocean for juvenile fish and exploring new species that were previously commercially uninteresting. Bycatch is now considered to be the origin of

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virtually all fish fed to fish and crustaceans in East Asia, and contains a very large share of juveniles, which undermines the recovery of fish stocks and ocean ecosystems. In addition, estimates suggest 3–6 million tonnes of low-value fish are captured and used as direct feed, which could amount to 20% of catches in South East Asian countries and up to 50% in Thailand and China.[11]

The use of wild-capture fish for fishmeal is therefore placing significant pressure on wild fish stocks rather than alleviating it. What is more, given widespread illegal, unreported and unregulated (IUU) fishing and a significant information gap on what is happening in Asia - the biggest aquaculture region globally - the problem is likely to be more significant than current knowledge suggests.[5]

- **Forage fisheries are impacting the food security and livelihoods of vulnerable coastal communities**

Apart from concerns over the impact of reduction fisheries on wild fish populations and ecosystems, there is growing evidence of the threat they can pose to food security in vulnerable countries, where fish protein is of great nutritional importance.[12] Of fish used in FMFO, 90%could be used directly for human consumption instead, as it comes from food-grade or prime-food-grade fish.[5] In West Africa and Southeast Asia, in particular, the ever-increasing use of wild fish for feeding farmed fish instead of human beings presents a significant challenge to food security, while also leading to pollution and corruption scandals.[13]

Despite limited publicly available information, this report shows that several major aquafeed producers that supply global markets, including Skretting, BioMar, MOWI and Cargill, source or have recently sourced raw materials and marine ingredients from West African and/or Latin American countries, where pollution scandals have prompted local protests and media reports, and NGO exposés have highlighted food security and corruption issues. For example, not only are reduction fisheries in Peru linked to the destruction of coastal ecosystems and local fish and bird die-offs but the region's fishmeal industry also causes serious air and water pollution, with knock-on health impacts such as skin diseases and respiratory illnesses.

In West Africa, fishmeal producers, often equipped with better fishing technologies or offering higher prices for forage-fish catches, enter into competition with local fishermen and markets; this directly impacts local communities, which rely on small pelagic fish for food security and their livelihoods. In Senegal and The Gambia, several instances of pollution from (often foreign-owned) fishmeal-production plants have threatened marine environments, contaminated waterways and damaged local fishing and tourism industries. As this report shows, in some cases this has led to highly publicised scandals, public protests and the closure of plants. Local people have accused fishmeal producers of failing to conduct environmental and social impact assessments, causing local fish die-off and building closer to residential areas than regulations allow.

As it is currently practiced, industrial aquaculture is therefore not the answer to, but rather part of the problem of, the global food security challenge.

- **Producing FMFO for farmed seafood is unsustainable, and claims of improving environmental credentials are not warranted**

Our research shows that, despite commitments to sustainability and transparency, fishmeal producers and major aquafeed companies disclose little information about the origin, quantity or sustainability of the wild-caught fish used in their feed. Before preparing this report, we contacted 15 aquafeed companies in a bid to understand more about their sourcing policies and practices, but received only three responses; this casts serious doubt over their commitment to transparency.

The limited information available shows that many companies source from fisheries that are not sustainably managed, or for which incomplete information exists to assess their stock status. Most FMFO comes from fisheries that '*take place in regions with low levels of governance, where fishing pressure can be very high and ecological impacts may be extreme*'.[11] Fishing fleets in Asia are notoriously unregulated, with vessels frequently changing names and identities. The current lack of registration systems makes evading scrutiny extremely easy. An intricate web of actors maintains this highly problematic lack of transparency and sustainability through complex supply chains and a lack of consumer awareness, which translates into aquafeed producers and retailers taking limited action to mitigate potential negative impacts from sourcing ingredients for feed.

The situation is further exacerbated by aquaculture certification schemes, which allow wild-caught fish to continue being used, as long as they are 'sustainably sourced'. The definition of 'sustainably sourced' is problematic; it mainly relies on existing initiatives and schemes, such as the Marine Stewardship Council (MSC) and the Marine Ingredients Organisation (IFFO). The latter is the trade body representing the FMFO industry; its 'responsible supply' standard (IFFO RS) currently certifies around half of global FMFO supply. The MSC has its own problems, and has been subject to criticism because it certifies fish that are not used for human consumption, which contradicts the FAO Code of Conduct for Responsible Fisheries.[8] But because the MSC is unable to certify sufficient quantities of fisheries to meet growing demand, companies mainly rely on IFFO, despite the apparent conflict of interest in its dual role as both a standard-setter and the body representing the interests of the global fishmeal industry. This becomes apparent in IFFO's controversial statements, such as its claim that 'almost all the remaining wild-caught fish used in fishmeal and oil would not typically be fished in significant quantities for human consumption', which contradicts independent research showing that 90% of fish used by the reduction industries is suitable for human consumption.

- **Catching vast quantities of wild fish for FMFO creates a hidden layer to the global animal welfare crisis**

Annually, 52 million tonnes of fish are produced worldwide in intensive aquaculture systems, which are essentially underwater factory farms.[14] As aquaculture intensifies and grows, the number of animals suffering in these systems multiplies. The widespread use of FMFO in aquaculture adds a hidden layer to this animal welfare crisis: the welfare of wild-caught fish destined for fish feed. The staggering 0.5–1 trillion forage fish (approximately) caught each year are reduced to ingredients to feed farmed animals – mainly fish. There is also the issue of bycatch of fish, mammals and birds who die slow deaths or are injured during capture and return to sea.

Although they may be small, forage and juvenile fish caught for use in FMFO are sentient beings, able to feel pain and fear, so there are ethical implications to harvesting them from the ocean in such huge numbers and using fishing methods that damage their welfare. These negative animal welfare implications are another strong incentive for reducing the aquaculture industry's reliance on wild-caught fish for feed.

Feeding fish on a farm (© istock)

Unloading fish from pirogues in St Louis, Senegal

The way forward and recommendations for action

The aquaculture industry has an opportunity to decouple its growth from that of the FMFO industry by phasing out the use of wild-caught marine ingredients altogether. It can do this by switching to farming herbivorous species, which do not require the use of wild-caught fish, and to aquaculture models that require fewer inputs, such as more extensive systems and integrated multi-trophic aquaculture. It should also seek more sustainable alternative sources of essential protein, such as insects and algae.

Our report shows that some aquafeed companies are already reducing their reliance on wild-caught fish for fish farming; some have even begun the commercial roll-out of fish-free aquafeed products. While we welcome these steps, this approach needs to be reinforced and rapidly scaled up across the entire sector if we are to sustain ocean resources, healthy ecosystems, food security and livelihoods in the Global South. The sustainability of alternative sources, such as soy, must also be carefully considered to avoid substituting unsustainable FMFO with equally unsustainable alternatives.

This report outlines specific steps the aquafeed industry, certification bodies, governments, retailers and consumers can take to rapidly scale up and accelerate the shift away from the wasteful, unsustainable practice of using wild-caught fish to feed farmed fish. This transformation will require the involvement of a range of actors including aquafeed producers, aquaculture companies, retailers, policymakers and consumers.

Recommendations

Aquafeed industry

- Stop using wild-caught fish and switch to more sustainable alternatives.
- Ensure alternative feed sources do not give rise to other ecological problems.

Aquaculture industry (fish farms)

- Focus on cultivating more species that do not require feed, require fewer inputs or can be fed an entirely vegetarian diet.

Certification schemes

- MSC and other wild catch schemes should stop certifying fish that is not used for direct human consumption.
- Aquaculture certification schemes should only certify farmed fish that is not reliant on the use of wild-caught fish.

Policymakers

- Strengthen governance frameworks to eliminate IUU and slave labour, prevent over-fishing, and enhance transparency and reporting in global fisheries' supply chains.
- Stop supporting aquaculture that relies on wild-caught fish, and support the phase-out of wild-caught fish for aquafeed and fish farming.

Retailers

- Commit to full supply-chain transparency.
- Commit to eliminating seafood cultivated using FMFO.

Consumers

- Reduce fish consumption, especially of carnivorous farmed species (such as salmon and shrimp).

The species that reduction fisheries target are already under immense pressure as a result of extreme weather events and climate change, which affect migration and reproduction patterns. The Lenfest Forage Fish Task Force, a panel of 13 fishery and marine scientists, has recommended that forage-fish management should be more precautionary, and catch target levels significantly reduced, to leave more of these fish populations (75% of the stock) in the ocean in order to safeguard the health of the ecosystem. It is high time that governments and regulators enforced this approach, and that the aquaculture industry aligned its objectives with the science and embraced more innovative production models – ones that genuinely make food security and healthy oceans a top priority.[15]

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1. Introduction

The ocean covers two-thirds of our planet and plays a crucial role in sustaining life on Earth. It regulates the global climate,[1] produces more than half of the oxygen we breathe,[2] provides us with food and other resources and, with its unique creatures and ecosystems, is a constant source of wonder and inspiration. Although the ocean is still largely unexplored,[3] we know enough about it to understand we cannot live without it - and that it is under extreme stress. Overfishing, pollution, growing demand for natural resources and climate change are wreaking havoc on ocean ecosystems.[4] The Food and Agriculture Organisation of the United Nations (FAO) estimates that over 90% of global fish stocks are either overfished (33.1%) or fished to maximum sustainable levels (59.9%).[5] Chronic over-harvesting of fish and other species poses a threat to biodiversity, to the long-term sustainability of fisheries and to the people who depend on them for their lives and livelihoods.[6]

Despite this alarming trend, demand for fish is growing more rapidly than the human population and is outpacing demand for meat.[a] Fish consumption has grown from 9.0kg per capita in 1961 to 20.2kg in 2015, at an average rate of about 1.5% per year. Estimates for 2016 and 2017 point to further growth to about 20.3kg and 20.5kg respectively.[5] This trend is influenced by health professionals' and nutritionists' recommendations to increase our fish consumption. In the UK, for example, the National Health Service recommends that most people should eat more fish – at least two portions a week.[7] However, dietary guidelines in most countries do not take environmental sustainability, or the pressure on the oceans associated with fishing and aquaculture, into account.

Wild catches of fish reached their limit in the late 1980s;[8] it is aquaculture that has allowed for the continuing increase in production of fish for human consumption. Fish farming is now the fastest-growing segment of the food-production sector,[9] accounting for roughly half of world fish consumption,[5] with projections for further rapid growth in the future; farmed species are expected to contribute to an increasing share of global fish consumption,[b] reaching about 60% of the total in 2030.[5]

Aquaculture is frequently presented as a solution to two problems: (1) the hugely wasteful industrial fishing industry's overfishing, and (2) hunger in the Global South.[10] Like other industrial food-production sectors, it is supported by substantial government subsidies.[11] However, this report shows the aquaculture sector is failing to deliver on its promises to improve global food security and relieve pressure on wild-fish stocks. There is also growing concern about the negative impact of the toxic chemicals and antibiotics[12] used on fish farms, combined with genetic contamination, on fish in the wild.[13]

a FAO estimates that since 1961, the 3.2% average annual increase in global fish consumption has outpaced population growth (1.6%) and exceeded increases in consumption of meat from all terrestrial animals, combined (2.8%) and individually except poultry (4.9%).[5]

b FAO projections show that combined world capture fisheries and aquaculture production will reach 200 million tonnes (Mt) (LWE) by 2030, up from just under 100Mt in 1990. Capture production will remain roughly stable (with a slight downward trend) up to 2030, with aquaculture production accounting for most of the growth.[5]

One of the many damaging aspects of industrial aquaculture is the reliance on wild-caught fish to make fishmeal and fish oil (FMFO).[14] Fishmeal (a very digestible fish protein) and fish oil are ingredients in feeds used mainly for aquaculture and agriculture.[15] Roughly one-third of FMFO goes to the agricultural sector (23% to chickens, 7% to pigs), but aquaculture became the dominant user of 'reduction fisheries' (which produce FMFO, rather than fish for direct human consumption[c]) in the early 2000s.[16] In 2016, 69% of fishmeal and 75% of fish-oil production went to fish farming.[17] Today, almost 70% of landed forage fish are processed into FMFO, representing roughly 20% of the world's total catch of wild fish.[16] The biggest reduction fishery, typically representing 30–35% of world production of FMFO,[18] is Peruvian anchoveta.[16]

The species destined for reduction fisheries are mainly low-trophic-level species that are often in high abundance and tend to form dense schools. They are generally plankton feeders and are preyed on by larger predators for food.[19] They include not only small pelagic[d] 'forage' fish (such as anchovy, sardine, herring and mackerel) but also invertebrate species (such as krill).[19] All of them play an important role in the marine environment because the entire marine food web depends on them. They are the principal means of transferring energy from plankton to fish, marine mammals and seabirds.[19] Therefore, overfishing down food webs is unsustainable, and can have large impacts on the ecosystem.[19]

In 2016, five of the seven largest global fisheries for reduction purposes were Peruvian anchoveta (3.19 million tonnes (Mt)), sardinella (2.28Mt), jack and horse mackerel (1.74Mt), Atlantic herring (1.63Mt) and Pacific chub mackerel (1.59Mt). Averaged out over a decade (2005–2014), Peruvian anchoveta was by far the world's biggest fishery, with 6.5Mt landed annually.[5] While Peru and Chile operate the world's largest single-species reduction fisheries catching Peruvian anchoveta, more than half (54%) of the fishmeal produced worldwide is derived from fish caught by South East Asian fisheries.[20] Krill, a type of zooplankton, is increasingly used as an ingredient in aquafeed (feed fed to aquatic animals);[21] also known as *euphausia superba,* it is a cornerstone of the Antarctic ecosystem,[16] and the vast majority (89.2%) of krill catch comes from the Antarctic part of the Atlantic Ocean.[16] In 2017, 236,938 tonnes of krill were caught in the Southern Ocean.[e]

Fisheries experts estimate that 90% of pelagic fish used to make FMFO could be used directly for human consumption instead.[16] The ever-increasing use of wild fish for feeding farmed fish instead of human beings presents a significant challenge to food security in West African countries, including Senegal, which has been impacted by the fishmeal industry's expansion;[22] even before this expansion, however, overexploitation of fishing resources affected the food security of millions of people who (directly or indirectly) depended on fishing for their survival.[23] In Asia, precarious working conditions – including forced labour and physical and psychological abuse – are prevalent in many fisheries supplying the global aquafeed industry.[24]

As this report will show, industrial aquaculture is not the answer to the problems of overfishing and food security; indeed, it is exacerbating these problems by removing species that are critical to the health of marine ecosystems from the oceans and feeding them to farmed fish. Moreover, there is evidence that it is affecting the livelihoods of coastal populations around the world, and that this is contributing to conflicts, hunger and migration.[f] Climate change and other environmental factors place further pressure on forage-fish stocks.[25]

Beginning with a review of the latest science on reduction fisheries' impacts on marine ecosystems, this report will go on to examine the 'geographies of destruction' in which FMFO production take place, before offering a brief analysis of some of the major corporate players behind the expansion of the aquafeed industry into a multibillion-euro business. It will show how current market dynamics are fundamentally broken and suggest a way forward to ensure the industry's future growth does not come at the expense of the oceans.

c A reduction fishery is one that uses ('reduces') its catch to produce fishmeal or fish oil, rather than for direct human consumption (see: http://blog.msc.org/blog/2017/03/22/reduction-fisheries-sustainable-fish-oil/).

d Pelagic fish are fish found near the ocean surface or in middle depths. They often move in large shoals, which greatly increases their detectability. (see: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/pelagic-fish)

e See: https://www.ccamlr.org/en/fisheries/krill. Krill, which are a keystone species in the Antarctic ecosystem, are extremely vulnerable to climate change. While the krill fishery has historically grown slowly, new technologies now allow catches to be processed more quickly, stimulating more interest in krill fishing from industry (https://www.asoc.org/advocacy/krill-conservation).

f A 2017 report by the Heinrich Boell Foundation notes that: *'Aquaculture destroys the livelihoods of local populations and leads to local conflicts because it massively reduces the catches of the traditional coastal fisheries. People are driven away or forced into new employment models. Today around 19 million people work in this sector. The working conditions are nevertheless extremely precarious. Contracts are often only verbally agreed upon, worker protection regulations are rare and their enforcement is even rarer. The result: exploitation and forced labor.'* (See: https://www.boell.de/en/2017/05/30/aquaculture-are-fish-farms-future); In their 2012 study of shrimp farming in Ecuador, Veuthey and Geber state: *'an increasing number of conflicts pitting coastal populations against shrimp farmers has been reported although very few conflicts have been studied in detail.'* (See: https://www.sciencedirect.com/science/article/abs/pii/S0959378011001634)

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2. The aquaculture industry's hunger for wild-caught fish

2.1. Overview

Farming of aquatic animals or plants has been practised for over 2,000 years.[10] Large-scale, intensive farming of fish is a relatively recent phenomenon, but it has grown significantly in recent decades; between 1980 and 2000, production increased sevenfold,[26] and doubled again between 2000 and 2012.[27] By 2016, aquaculture output had reached 80Mt of food fish and 30Mt of aquatic plants,[5] with carp as the dominant species followed by Nile tilapia, freshwater fish and Atlantic salmon.[5] Asia has accounted for almost 90% of world aquaculture production for over two decades.[g]

Historically, many herbivorous fish were raised in extensive fish-farming systems, which required no additional feed. However, aquaculture is intensifying, and even producers of herbivorous fish have begun using farm-made or commercial feed based on wild-caught fish in a bid to speed up the growth cycle and increase profits.[15] Fish and crustaceans raised on aquafeeds reach slaughter weight more quickly than animals raised without extra feed.[h] While in some cases the amount of wild fish used in aquaculture feeds for carnivorous species is being reduced and substituted, many aquaculture species that were formerly not artificially fed, or whose feed did not contain fish (such as tilapia and carp), are increasingly being supplemented with wild fish to speed up growth, either indirectly (through the inclusion of FMFO in feed) or directly.[i]

Other species, such as Atlantic salmon, rainbow trout and European sea bass, are carnivorous; they are either produced in or exported to developed countries, and in many cases still rely heavily on FMFO.[15] The global growth of aquaculture has dramatically expanded the use of commercial aquaculture feed. According to the FAO:

g The biggest producers of aquaculture animals are all from Asia: China (49.2Mt), India (5.7Mt), Indonesia (5Mt), Vietnam (3.6Mt) and Bangladesh (2.2Mt). (FAO (2018) *The State of World Fisheries and Aquaculture, 2018 - Meeting the sustainable development goals*. Rome. Licence: CC BY-NC-SA 3.0 IGO, p.26)

h Until recently, Asian carp farmers only fed on natural foods in ponds, whereas by 2000 they used almost 7Mt of feed. Tacon, A.G.J. (2002) *Thematic review of feeds and feed management practices in shrimp aquaculture*. Report prepared under the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment.

i Naylor et al. (2009) state: *'aquaculture's share of global fishmeal and fish oil consumption has risen substantially, as greater amounts of fishmeal are fed to omnivorous species, and high levels of fish oil are used to provide LC omega-3 oils in farmed fish. Our analysis shows that aquaculture's consumption of fish oil, in particular, is likely to determine the sector's absolute demand for marine resources, and hence, the sector's role in conserving or depleting wild fisheries in the future.'* Naylor, R.L. et al. (2009) Feeding aquaculture in an era of finite resources. *PNAS*, 106: 36, 15103–15110.

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During the period 1995–2015, production of farmed aquatic species reliant on feeds increased more than fourfold, from 12 to 51 million tonnes, largely through intensification of production methods for shrimp, tilapia, carp and salmonids. […] [B]etween 1995 and 2015, production of industrial aquaculture feeds increased six-fold from 8 to 48 million tonnes.[5]

In many ways, modern, intensive aquaculture farms mirror the intensification of terrestrial, industrial, high-input, highly polluting livestock-production systems. Intensification is reflected in higher stocking densities and greater reliance on commercial feeds.[15] Just like on industrial livestock farms, farmed fish and seafood are more susceptible to disease and injury, and in many countries are routinely administered with antibiotics and chemicals, such as disinfectants and parasiticides.[28] Water contaminated with fish excreta and uneaten feeds diminishes water quality; greater use of antibiotics, fungicides and anti-fouling agents may also pollute downstream ecosystems.[29] Precious and vulnerable ecosystems are cleared to provide space for coastal farms; for example, mangrove forests, one of the most biodiverse ecosystems in the world, are disappearing at an alarming rate as a result of shrimp farming[30] – experts calculate that half of all mangroves destroyed between 1980 and 2005 were victims of the growing aquaculture sector.[11]

2.2. Feeding wild fish to farmed fish

'Aquafeed' is a general term used to refer to all feed fed to aquatic animals. Broadly speaking, aquafeed falls into two categories: commercial (also known as compound feed) and non-commercial. Ingredients of commercial feeds vary, but are likely to include a combination of fishmeal, fish oil, vegetable proteins (e.g. soy, sunflower, wheat), vegetable oils (e.g. soy oil, palm oil) and animal byproducts (e.g. feather meal, bone meal), as well as vitamins and pigments. Non-commercial aquafeeds are farm-made; in some cases, wild-caught fish or trimmings are fed directly to the farmed fish, either whole or following simple processing in which they are mixed into a slurry or mash.[31] Frozen, whole pelagic fish are also used for fattening tuna and other large fish in cages.[31] Fish used directly for feed are mainly from the bycatch of non-selective fisheries, such as shrimp trawls.[16]

Global production of commercial aquafeeds was estimated to be 40Mt in 2012, whereas non-commercial feeds were estimated to be 18–36 Mt.[14,j] The largest consumers of commercial aquaculture feeds in 2012 were herbivorous and omnivorous carp species (11Mt), followed by tilapia (6.6Mt), shrimp (6.1Mt), catfish (4.2Mt) and salmon and marine fish (2.9Mt each).[14] While aquafeeds for salmonid species contain the highest share of FMFO, compound feeds for herbivorous and omnivorous fish can also contain low to moderate levels of protein obtained from fish and terrestrial animals.[15] The FAO reports that, between 1995 and 2015, production of feed-reliant farmed aquatic species increased more than fourfold (from 12Mt to 51Mt), largely through intensification of production methods for shrimp, tilapias, carps and salmonids. Today, 48% of total global aquaculture production (including aquatic plants; 66% excluding aquatic plants) is produced using exogenous feed.[5]

Increasingly, FMFO made from offcuts and trimmings generated in the processing of fish (wild-caught and farmed) are used as ingredients in compound feed.[32] It is possible that, in some cases, the fishmeal industry and aquafeed companies may classify edible fish as byproducts in a bid to appear less wasteful. In some countries, for example, landed bycatch may be used for fishmeal production, and Asian aquaculture is still largely reliant on so-called 'trash fish',[31] which, contrary to their ill-chosen label, perform an important role in marine ecosystems.[33]

The term 'trash fish' is also sometimes used to describe fish species that are generally small in size, have low consumer preference and were previously considered to have little commercial value.[k] Until recently, these fish were considered as unwanted bycatch and discarded at sea,[34] but bycatch is now the origin of virtually all fish given as feed to fish and crustaceans in East Asia.[35] Most bycatch contains a very large share of juveniles, which undermines the recovery of fish stocks and ocean ecosystems. Some estimates suggest 3–6Mt of low-value fish are captured and used as direct feed,[14] which could amount to 20% of catches in South East Asian countries, and up to 50% in Thailand and China.[20] This volume may be an underestimate; a recent Greenpeace report[36] found that one-third of China's total annual domestic fisheries catch is comprised of 'trash fish', equivalent to about 4Mt. Greenpeace states that China has been 'substantially' fishing down the food web, and estimates that about 80% of the catch in the country's exclusive economic zone is now pelagic fish, such as anchovies, mackerel and scads. Nearly half (44%) of 80 samples of 'trash fish' taken by Greenpeace at Chinese ports in 2016 were edible commercial species; three-quarters (75%) of these were in the juvenile size range.

j To put these numbers into broader context, aquafeeds still only represented 4% of the total global animal compound feed production in 2017 (Marine Harvest, 2018).

k The term is not really appropriate in many cases, as these fish form the basis of human nutrition in many coastal areas; fish can be trash for one community but preferred in another, making a precise definition difficult (Funge-Smith, S. and Lindebo, E. (2005) *Asian fisheries today: The production and use of low value/trash fish from marine fisheries in the Asia-Pacific region*. FAO, Bangkok. [ONLINE] Available at: http://www.fao.org/3/ae934e/ae934e00.htm#Contents).

FISH LAUNDERING

INDUSTRIAL AQUACULTURE'S HIDDEN PARADOX

THE OCEAN IS SICK – MARINE ECOSYSTEMS ARE SEVERELY DEPLETED

THE OCEAN COVERS

2/3

OUR PLANET AND **PLAYS A CRUCIAL ROLE** IN SUSTAINING LIFE ON EARTH

OVERFISHING

CLIMATE CHANGE

DEMAND FOR NATURAL RESOURCES

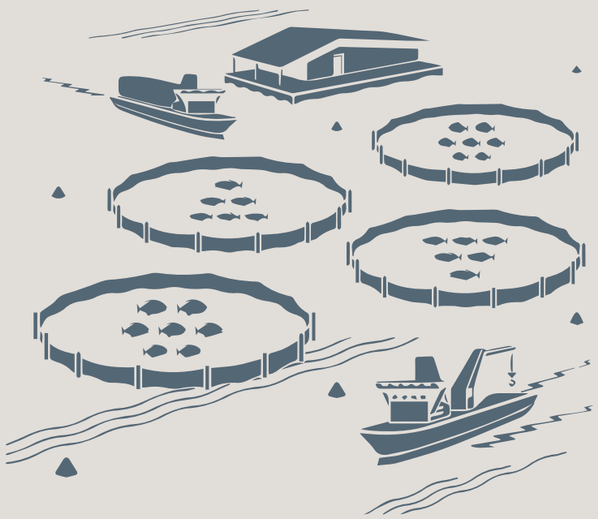
POLLUTION

ARE DESTROYING OCEAN ECOSYSTEMS

BILLIONS

OF WILD-CAUGHT FISH AND CRUSTACEANS ARE USED **TO FEED**

AQUACULTURE NOW SUPPLIES MORE THAN HALF OF THE FISH AND SEAFOOD WE EAT

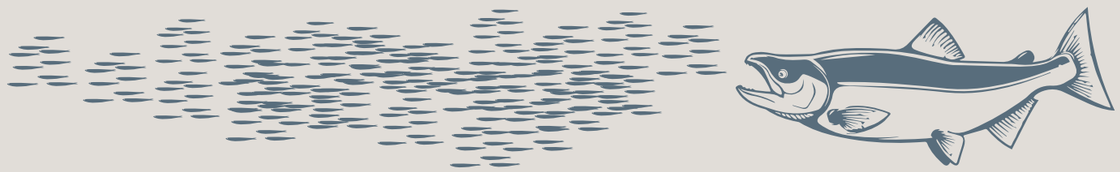


FISH AND SEAFOOD FARMING IS THE **FASTEST-GROWING** SEGMENT OF THE FOOD PRODUCTION SECTOR

SHARE OF FARMED FISH FOR FOR HUMAN CONSUMPTION

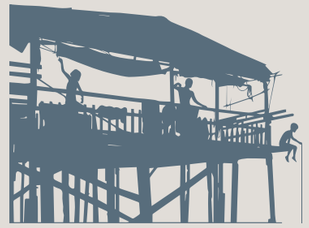
2019 **50%** | 2030 **60%**

THE DIETS OF MANY AQUACULTURE SPECIES ARE INCREASINGLY BEING **SUPPLEMENTED WITH WILD FISH**



FARMED FISH AND SEAFOOD ARE BEING FED WILD-CAUGHT FISH

IT IS PUTTING UNBEARABLE **PRESSURE ON OCEAN** ECOSYSTEMS



DEPRIVING PEOPLE IN **POOR** COUNTRIES OF VITAL NUTRITION

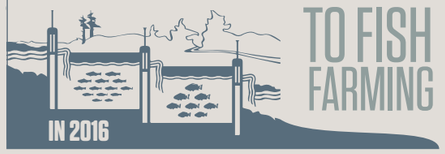
90%

OF THE WILD FISH USED TO PRODUCE **FISHMEAL AND FISH OIL** ARE PERFECTLY FIT FOR HUMAN CONSUMPTION

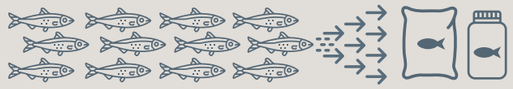
20% OF WILD-CAUGHT FISH **IS TURNED** INTO FISHMEAL AND FISH OIL

69% OF FISHMEAL | **75%** OF FISH OIL

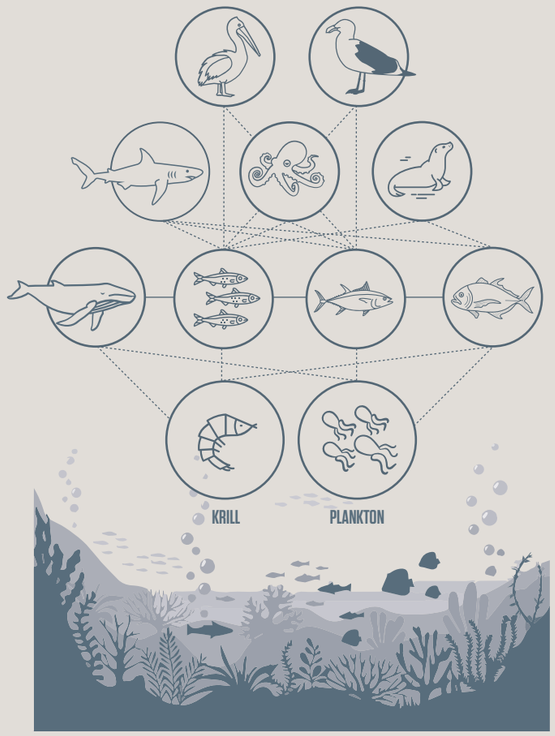
PRODUCTION **WENT** TO FISH FARMING IN 2016



THE SPECIES USED TO PRODUCE FISHMEAL AND FISH OIL



PLAY AN IMPORTANT ROLE IN THE MARINE ENVIRONMENT TRANSFERRING ENERGY FROM PLANKTON TO FISH, MARINE MAMMALS AND SEABIRDS



THEY INCLUDE SMALL PELAGIC "FORAGE" FISH SUCH AS ANCHOVY, SARDINE, HERRING, MACKEREL BUT ALSO INVERTEBRATE SPECIES AS KRILL

Round sardinella
9 to 11 inches
23 to 28 cm

Anchoveta
max 7,87 inches
max 20 cm

Krill
0,11811 inches
0,3 cm

Chub mackerel
9 to 11 inches
23 to 28 cm

Atlantic herring
8 to 14 inches
20 to 36 cm

Norway pout
8 to 14 inches
19 to 36 cm

Sandeels
About 8 inches
About 20 cm

(sources: Laffoley, 2013; Le Manach et al. 2017; FAO, n.d., FAO, 2018; Cashion et al., 2017; ActionAid, 2018; Smith et al. 2011; Bachis, 2017)

Box 1: Fish welfare

When considering the negative consequences of using wild-caught fish for FMFO, we must not overlook the huge impact these industries have on animal welfare. Animal welfare is an important issue because fish – even small forage fish – are sentient animals capable of feeling pain and emotions;[37] they are therefore capable of suffering.[38] The capacity of fish to feel pain is of particular relevance for farming and fishing, and there is scientific evidence for this based on physiological, behavioural and neuroanatomical studies.[39] International legislation acknowledges fish as sentient beings;[40] however, the protection offered by current legislation is weak and poorly enforced.

Fish are recorded by their tonnage only, which makes it difficult to picture the number of animals caught for FMFO. However, based on FAO fisheries capture tonnages, together with estimated mean weights for fish species, it is predicted that a staggering 0.5–1 trillion fish[41] caught each year are destined to be reduced to ingredients to feed farmed animals – mainly fish, but also pigs and chickens.[42]

Fish caught from the wild for direct or indirect (via FMFO fed to farmed animals) human consumption suffer immensely during the processes of catching, landing and killing.[43] Industrial fishing methods catch forage fish in huge numbers at a time. When hundreds of thousands of fish are caught – for example, in a purse seine net or trawling net – they are intensely crowded during capture, then packed tightly together as they are hauled to the surface of the water. Fish will be damaged (e.g. physical abrasions, compression, bursting of internal organs due to sudden pressure changes) and stressed during this process. A significant proportion will die, crushed under the weight of other fish in the nets. For fish that survive capture and landing (being brought aboard the vessel), there is usually no slaughter method; they are simply left to asphyxiate, or may die during processing.[44] There is also the issue of bycatch of fish: mammals and birds, which die slow deaths, or are injured during capture and release.

The use of FMFO is supporting the rise of intensive aquaculture, keeping fish in systems which are essentially underwater factory farms. Annually, 52Mt of fish (48–160 billion fish[41]) are produced in farms worldwide.[45]

In aquaculture, high stocking densities are the norm, and fish are kept in barren environments (uniform and simple cages, raceways, etc.) that offer very little environmental complexity.[46] Keeping fish in this way can lead to high stress, aggression and resultant injuries, and the risk of disease transmission increases.[46] Fish are often exposed to extremely stressful handling procedures (e.g. mechanical treatments to remove sea lice from salmon, which have led to poor welfare and mass deaths[47]), which involve taking fish out of water (e.g. when treating fish for parasites and stripping females of eggs[48]).

The vast majority of fish farmed around the globe are killed using inhumane slaughter practices.[49] Commonly, fish are killed by asphyxiation in air or ice slurry or exposure to carbon dioxide gas; alternatively, they may die during the process of gutting and processing.[49] Loss of consciousness and death by these methods is not quick, and suffering is unacceptably prolonged. Fish should be stunned before being killed to avoid pain and suffering.[50] Stunning methods (such as electrical or percussive stunning) are available, and can allow for a more humane death for some species, but there is a significant amount of work required to achieve widespread industry adoption.[51]

The increase in global aquaculture is compromising the future of forage-fish populations, which play a key role in the marine environment. Animal welfare in fish farms is a major problem and is starting to gain more attention in research, policy and the media. However, the hidden layer to this animal welfare crisis – the welfare of wild-caught fish destined for fish feed – is often overlooked. Together, these industries lead to immense suffering for a startling number of animals.

Box 2: Why protect forage fish?

Using wild fish to feed a growing aquaculture industry raises concerns of overfishing, poor animal welfare and disruption of aquatic food webs; it also undermines food security, as less fish is available for direct human consumption.[52] The mass exploitation of these forage fish poses the risk of localised population collapses, with knock-on effects on other marine life (including marine mammals and seabirds), and could have other, as-yet-unknown consequences, given the extreme complexity of marine ecosystems and the potential impacts of climate change.[9,19,42] The following points provide an overview of why we must protect forage fish from further exploitation.

- **Most forage fisheries are either fully exploited, overexploited or in the process of recovering from overexploitation**.[5,42] Forage fish are highly susceptible to overfishing because small pelagics usually form dense schools in the oceans, making them very accessible to fishing. Steep declines in forage-fish populations have frequently been observed, despite apparent stability of catches.[53] Beverton[54] examined forage fishery collapses from the 1960s to the 1980s and concluded that fishing caused or intensified collapse in many cases. The Lenfest Forage Fish Task Force found that fishing forage-fish species at a typical rate often led to population collapses, and therefore recommended reducing fishing pressure by half.[55]
- **The resilience of forage-fish populations has been overestimated and the effects of their depletion on other species ignored**. The Lenfest Forage Fish Task Force estimated that, globally, the economic value of forage fish as prey for other commercial fisheries ($11.3 billion) was twice the direct value of forage fish ($5.6 billion).[56] Fishmeal is mostly sourced from forage-fish species that play a vital role in ecosystems by transferring energy to the top predators. Sharp decreases in marine bird and mammal populations that depend on forage fish for food has been observed.[42] Most of these animals rely on abundant prey to gain weight before giving birth or after migration.[56] If there is not enough prey available when seabirds are expecting, both chicks and parents are at risk of starvation or death.[57] Endangered species are especially sensitive to food shortages and need abundant food to rebuild populations.
- **Prey species and the food web they support are highly sensitive to environmental changes.** Their stocks fluctuate because they are very sensitive to environmental conditions and therefore extremely variable in their abundance.[58] Further exploitation of forage fish, which play a key role in marine food webs, leads to local stress on higher trophic species, particularly during El Niño and La Niña events. There is new evidence that extreme El Niños could happen twice as frequently in the future as a result of climate change.[59] Peruvian anchoveta is particularly sensitive to environmental variables[60] when warm El Niño waters bring the fish towards the coast, where it can be more easily caught. Krill is at the base of the Southern Ocean food web and is critically important prey for a diverse population of seals, penguins, whales and other higher-level predators.[61] As sea ice declines due to climate change, krill's habitat is shrinking, which in turn affects predators that rely on abundance of krill.[62] Climate change, in combination with fishing, is in many cases forcing predator species to search for different prey, which could be less abundant, leaving them malnourished and less able to adapt to other environmental stresses.[63]
- **Reduction fisheries are largely unregulated and there is little data on origin and species of prey fish**. Most FMFO comes from fisheries which '*take place in regions with low levels of governance, where fishing pressure can be very high and ecological impacts may be extreme*'.[20] Fishing fleets in Asia are notoriously unregulated, with vessels frequently changing names and identities. The current lack of registration systems makes evading scrutiny extremely easy. There is scarce information on the amount and species caught, or on stock condition. China's non-specific and erroneous reporting of fish production and trade makes it especially difficult to quantify the impact of its aquaculture and aquafeed use on global wild fisheries.[64] In 2008, the FAO reported that 85% of fishmeal and 58% of fish-oil production was non-species-specific, with only a few countries reporting the species they caught (e.g. Chile, Peru, US, Canada).[5] Higher commodity prices only incentivise overfishing from poorly regulated fisheries. Lower traceability regarding the origin of feed means less accountability for feed producers.
- **The use of wild fish for aquaculture presents a challenge to food security.** Fish, such as those targeted by industrial fisheries or caught as bycatch by trawlers, are a particularly important food source for many people in South East Asia and Africa.[65] Coastal communities and fishermen are also dependent on these species for their livelihoods.[23] The FAO Code of Conduct on Sustainable Fisheries highlights that fish should be used for direct human consumption,[66] yet over 90% of fish landings for FMFO and other non-direct human consumption uses are food-grade or prime-food-grade fish perfectly fit for human consumption.[16] In a world of changing climate with unforeseen social and environmental consequences and a growing number of food-insecure populations, the use of 20Mt of fish to feed aquaculture and livestock animals is unjustifiable.

(©shutterstock)

2.3. Future trends in aquaculture

As demand for seafood is projected to continue growing, so too is the aquaculture industry, which is set to produce 109Mt of fish in 2030.[5] Freshwater species (such as carp, catfish and tilapia) are expected to represent about 62% of total world aquaculture production in 2030,[5] but higher-value, traditionally carnivorous species (such as salmon) are also on an upward trend, notably in emerging markets across East and Southeast Asia, where the potential for future growth is enormous.[5] There is also a growing trend to feed FMFO to non-carnivorous fish to speed up growth cycles.[67]

The FAO projects that, in 2030, fishmeal production will be 19% higher than in 2016 and fishmeal produced from fish byproducts will increase to 34% (compared to 30% in 2016).[5,l] However, fishmeal derived from by-products are of a lesser and more variable quality, so it is unlikely these will entirely replace whole fish in fishmeal.[68] As mentioned, it is also possible that in some cases the term 'byproduct' is used to refer to whole fish, which could otherwise be left in the ocean or used for direct human consumption.

Fishmeal production peaked in 1994 at 30Mt and has followed an overall declining trend since then.[5] The most important reason for the decrease in the share of global catch for FMFO production is the reduced landings of pelagics, mostly anchoveta, which declined from around 6.5Mt per year (averaged between 2005 and 2014) to 3.2Mt in 2016 before bouncing up to 4Mt in the first half of 2018.[69] Landings of Chilean mackerel, jack and horse mackerel and Atlantic herring have also fallen significantly. These declines can partly be attributed to a redirection to direct human consumption of former key reduction species (e.g. Atlantic herring and capelin),[16] the sensitivity of forage fish to environmental factors (such as El Niño) and the depletion of stocks through overfishing.[42]

(© iStock)

A growing diversity of species is used for fishmeal production: from 1950 to 2010, the top ten species used for reduction accounted for about 77% of fish landings destined for fishmeal, but this decreased to 53% by 2010.[16] In part, this is driven by the growth of non-selective fisheries, which is created and fuelled by the growth of fed aquaculture in Southeast Asia and China and its reliance on domestic and imported fish inputs; the overfishing of the former target species, such as shrimp; and the associated depletion of existing local ecosystems. While these fisheries may reduce the amount of fish discarded, they do so at the expense of the ecosystem health, as all taxa are taken indiscriminately, without regard for population status or ecosystem function.[16]

Some aquafeed producers have reduced the amount of fishmeal used in feed and, by doing so, claim to have achieved significant efficiencies. It is true that intensive aquaculture systems are now increasingly relying on crops, such as soy and grains, some of which pose serious sustainability challenges in their own right.[70] However, over time, this trend might be offset by further growth in volumes of farmed fish and the persistence of unsustainable fishing practices, leading to continued depletion of our oceans.

l These predictions are based on the assumptions of higher demand and technological improvements, but uncertainties like climate change, environmental degradation, overfishing and macroeconomic conditions are not accounted for.

Decline of anchovy biomass in Peru has been linked to decreases in populations of the Humboldt penguin (©Alamy)

3. Geography of destruction: Global hubs of FMFO production

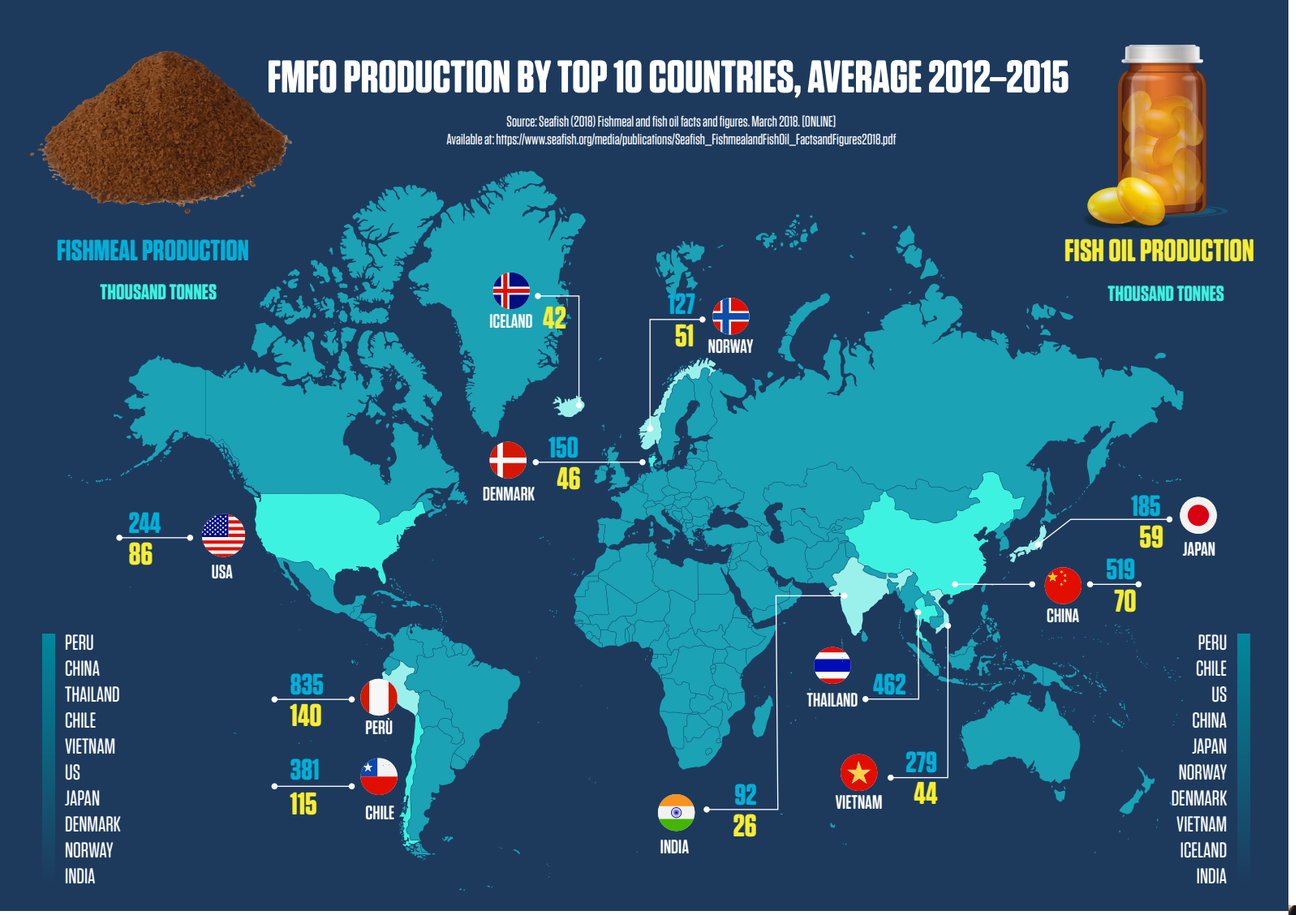
3.1. Overview

Taking fish out of the ocean for purposes other than feeding hungry humans is not a new practice; the Indigenous peoples of North America commonly used small fish (such as herring and menhaden) to fertilise agricultural land,[71] a practice that prevailed – by then, on an industrial scale – well into the 1940s.[72] However, what was once a relatively small-scale and localised activity has developed into a global industry.[73]

Globalisation and the complex dynamics of the international trade in seafood products make for complicated supply chains, in which fishing; the process of converting fish into FMFO; aquafeed production; fish farming, distribution and, finally, consumption of the end product often take place in different countries.

Reduction fisheries are implanted around the world, mostly in the Global South, with Peru, China, Thailand, Chile and Vietnam currently dominating fishmeal production.[74] In the Global North, the United States, Japan, Denmark, Norway and Iceland all have a sizeable share of the market.[75] In recent years, partly as a result of forage fish migrating northwards as the ocean warms under the effects of climate change,[75] Mauritania and Morocco have joined the list of more important FMFO producers;[76] this has been particularly visible in the case of Mauritania, in which multiple factories have been established along the coastline.[77] When it comes to fish-oil production, Denmark, Norway and Iceland are significant European players, on a par with Japan and trailing some way behind Peru, Chile and the United States.[75]

Fishing port in Nouadibhou, Mauritania



duction fishery.[82] This, combined with production in Argentina and Panama, makes Latin America the leading fishmeal-producing region,[16] supplying nearly 50% of the global market.[69,75] Peru plays such an important role in the global supply of fishmeal that some have compared its level of market influence to that of Saudi Arabia as a swing producer of crude oil.[76]

Over the last half-century, anywhere from 2–12Mt of anchoveta have been caught off Peru every year,[83] and the country has supplied roughly 20% of the world's fishmeal since the 1960s.[77] According to the Marine Ingredients Organisation (IFFO), from these landings, Peru produced on average 835,000 tonnes of fishmeal annually between 2012 and 2015.[75]

Most Peruvian fishmeal is exported to China, which accounted for more than 85% of Peruvian exports in 2018.[84] Other important markets are Vietnam, Taiwan,[82] Germany and Japan.[85]

Denmark is the main importer of Peruvian fish oil, followed by Chile and Canada. In the first half of 2018, Denmark increased its imports from Peru by almost a quarter (24%) (to 28,000 tonnes) compared with the same period in 2017.[82]

Peruvian anchoveta stocks have historically suffered from rampant overfishing and, since the early 1970s in particular, the vagaries of El Niño, a combination of which resulted in the industry's near-collapse in 1970.[84] This prompted the government to introduce a quota system to prevent further decline of anchovy stocks,[86] but there continue to be periodic collapses in Peru's anchovy catch. This has made the global market in FMFO extremely volatile over the past decade – especially between 2010 and 2014, when climate change appears to have increased the frequency of El Niño's effects, leading to long-term decline in fish stocks in the region.[76]


Shoal of anchovies (©iStock)

As the biggest global importer of fishmeal, and home to the world's largest aquaculture industry, China is a key player.[78] However, due to widespread illegal, unreported and unregulated (IUU) fishing, China – and Asia in general – remains something of a black box, making it difficult to assess its precise footprint and impacts.[79] After China, Norway is the biggest importer of fishmeal[80] and fish oil, which are mainly used to sustain its salmon-farming industry – the largest in the world.[81]

While fishmeal and fish-oil production, and their related environmental and social problems, are global in scope, we will focus here on a few key geographical areas: Peru, as the world's biggest producer and exporter; West Africa, as a region under several stresses linked to food security and climate change; China, as the world's biggest consumer and importer of fishmeal; and Norway, as a large importer of FMFO and an important hub for several large aquaculture and aquafeed companies.

This chapter presents information on how the industry in these regions is affecting local people and the environment surrounding production sites, and will identify global trade flows of FMFO. This information was gathered via an in-depth review of recent NGO and market reports, data compiled by government agencies and institutions, and an analysis of the substantial media coverage this topic continues to generate.

3.2. Peru: The Saudi Arabia of FMFO production

Peru is the world's leading producer and exporter of FMFO[5] manufactured from the Peruvian anchovy (anchoveta, or *Engraulis ringens*), which Chile also catches and which constitutes the world's largest single-species re-

FISHMEAL AND FISH OIL PRODUCTION: GEOGRAPHY OF DESTRUCTION

Reduction fisheries are implanted around the world, mostly in the Global South, with Peru, China, Thailand, Chile and Vietnam currently dominating fishmeal production. In the Global North, the United States, Denmark, Japan, Norway and Iceland all have a sizeable share of the market. In recent years, as a result of increasing demand in major markets, some West African countries have begun producing fishmeal and fish oil as well.

While Peru and Chile operate the world's largest single-species reduction fishery catching Peruvian anchoveta, almost half of the fishmeal produced worldwide is derived from fish caught by Southeast Asian fisheries. The fishmeal produced in Southeast Asia is used in the region's aquaculture industries, particularly for farmed shrimp. However, data is scarce and outdated for most countries.

China is home to the world's largest aquaculture industry and is the biggest consumer and importer of fishmeal.

150,000 t
45,000 t
Denmark mostly trades fishmeal and fish oil and absorbs half of all fish oil imported to the EU

Denmark imported 28,000 t from Peru in the first half of 2018

51,000 t
Norway is the main supplier of fish oil to the EU and, as the world's largest farmed salmon producer, a major consumer itself.

Germany acts as a trading hub for fishmeal and accounted from almost half (47%) of imports coming from outside the EU in in 2016 and a third (30%) in 2017;

Germany is traditionally supplied by Peru but in 2017 it imported most of its fishmeal from Morocco.

519,000 t
70,000 t

70,000 t in 2017

92,000 t
26,000 t
India is the world's biggest exporter of shrimp; its growing shrimp farming sector is a key consumer of fishmeal

462,000 t

279,000 t

835,000 t
140,000 t

Peru exported around 480,000 t of its FM to China in the first half of 2018

4/5 of Peru's fishmeal goes to China

FISHMEAL EXPORT | **FISH OIL EXPORT**

Reduction fisheries
Aquaculture industry
Pollution
Food insecurity
Ecosystem loss and damage

Unless specified otherwise, the values represent average production of fish meal/fish oil between 2012-2015.

(sources: Seafish, 2018; Sefish, 2016; FAO, 2018; FAO, 2019; Green, M., 2018; Veiga, P. et.al., 2018; European Commission, 2018; European Commission, 2017)

A blessing to some, a curse to others?

Reports by the media[87] and NGOs such as Oceana and Compassion in World Farming[87] have long shown how Peru's reduction fisheries are damaging the health of local communities and marine ecosystems in and around Chimbote, a six-hour drive north of the country's capital, Lima, and the heart of Peru's fishmeal industry. These reports have linked pollution and effluent disposal at production plants to severe health issues among the local population, including skin diseases, allergies and respiratory illnesses.[88] Exposure to these noxious fumes leads to dermatological problems, especially among children. Water pollution from processing plants also represents a threat to marine life. Despite these destructive impacts, local corruption makes it difficult to speak out.[87]

Peru has acknowledged that the increasing number of large boats fishing for anchovy is destroying the coastal ecosystem, as well as fish species that are important for human consumption and underpin many Peruvians' livelihoods and food security.[89] Loss of the species captured in small-scale fisheries is leading, in turn, to more consumption of imported frozen fish nationally.[90] Numerous studies have also reported on the linkages between the decline of anchovy biomass off Peru and local species, such as guano-producing seabirds[90] and Humboldt penguins,[91] as a result of competition for prey with large fishing fleets. Since the launch of the industrial anchovy fishery, driven by the fishmeal industry, there has been a 95% drop in bird numbers in a little over half a century.[87]

These impacts have been magnified by weak regulation and enforcement, which have led to the spread of IUU fishing and corruption in general.[92] For example, in early 2019, Oceana reported that every year around 150,000 tonnes of Peruvian anchovy intended for direct human consumption are instead used for the illegal production of fishmeal. The study identified over 60 Peruvian facilities involved in this crime.[93]

The waste and illegal exploitation of marine resources to feed fish instead of people constitutes a paradox in a country where severe malnutrition continues to affect a substantial share of the population. According to the World Bank, 38% of Indigenous children in Peru are malnourished, and anaemia – a growing concern – affects 59% of children aged 6–11 months.[94] As an abundant, highly nutritious and affordable species, anchovy could provide the nutrition Peru's children are lacking; however, as little as 1% of anchoveta is likely to end up on dinner plates in Peru.[87,95]

In 2018, Peru's anchovy biomass was reported to have reached its highest level in 25,000 years.[96] According to the FAO, in the first half of 2018, approximately 4Mt of 'raw material' were landed in Peru, which was processed to produce nearly 1Mt of fish meal and 170,000 tonnes of fish oil. This exceeded the previous year's tonnage for the same period by 40% for fishmeal and 77% for fish oil. The FAO stated: '*This biomass growth reflects the sustainable management of this species*'.[70] However, based on historical patterns, future El Niño events are bound to significantly disrupt anchoveta stocks in the future.[82] In light of this and several other important factors – including clear evidence of the damage wrought by past overfishing on local ecosystems, the as-yet poorly understood impacts of climate change and the shocking persistence of malnutrition in Peru – current fishing practices cannot be sustained.

3.3. West Africa: Fishmeal production undermining food security and local jobs

With increasing demand in major markets, notably China, West Africa is quickly growing in importance in the global fishmeal sector; according to the latest UN Comtrade figures, in 2016, it produced 7% of the world's fishmeal. The most abundant species of the region's small pelagics are round sardinella, which migrate across a 1,000-mile zone in the Atlantic Ocean.[76] These and other small, pelagic fish migrate along the Atlantic coast between The Gambia and Morocco and are shared among all those countries.[97]

The region is facing numerous challenges, including IUU fishing by large foreign vessels, overfishing by both local and foreign vessels, and pollution from fishmeal factories.[98] In 2015, Greenpeace exposed 74 Chinese distant-water fishing vessels in West Africa for fishing in prohibited waters and falsifying their vessel tonnage, reporting that decades of intense exploitation of marine resources in the region had resulted in over 50% of fishing resources being overfished.[99] It is against this backdrop that, for the past several years, the FAO has recommended the reduction of fishing efforts on round sardinella off the coast of West Africa.[98] Moreover, industrial trawlers turning fish into fishmeal for export to Europe and Asia[100] are in direct competition for fish used in local consumption. This can have a dire impact on people's livelihoods in a region where few economic opportunities exist.[101] It also poses an obvious threat to food security.

In Senegal, for example, the fisheries sector employs about 20% of the country's workforce, and the population relies heavily on pelagic fish not only for employment but also as a cheap staple food.[102] Fish caught here provide up to 75% of the protein consumed by millions of people in Senegal and across Africa.[22]

In recent years, roughly a dozen fishmeal factories have been built along the Senegalese coast, many of which are Chinese-owned, processing pelagic fish into fishmeal. Senegalese fishmeal plants supply aquaculture industries in Europe and Asia,[103] including China and Korea.[103] Several have been involved in social and environmental scandals, triggering local protests (see Box 3).

Chinese - owned fishmeal plant in outskirts of St Louis, Senegal

The presence of foreign trawlers and the area's expanding fishmeal industry have put pressure on sardinella stocks, pushing them to the point of collapse, as well as threatening the livelihoods and food security of Senegalese people.[103] About one-fifth of Senegalese fishers exclusively catch sardinella. Locals report that, with the factories now willing to buy every last fish, small-scale food producers of fish products (many of whom are women) have to compete with large international companies. Selling to the factories has become a much more attractive option for fishers than selling on the local market, as there is constant, ever-growing demand and they know they will always find a buyer.[104]

In the past decade, the size of Senegal's small-scale fishing fleet has doubled, and fishers are fishing further out to sea. However, increasing ocean temperatures caused by climate change have pushed sardinella north to neighbouring Mauritania – by roughly 200 miles since 1995, according to French development institution IRD-France.[76] This has further depleted resources available to sustain Senegal's national fishing industry and feed its population.

While Senegal is facing the negative consequences of stocks moving further north, Mauritania's fishmeal industry has expanded; in 2017, half of its 800,000-tonne fish catch ended up being used for fishmeal, to-

Unloading fish from a pirogue for fishmeal plant in Nouadibhou, Mauritania

talling 70,000 tonnes – almost double the quantity used for fishmeal in 2010 (36,900 tonnes).[m] Historically, Mauritanian small-scale fishers have not targeted small pelagic fishing on a significant scale. Mauritania also has a much smaller population that is less reliant on fish.[78] In the past 15 years, over 30 fishmeal factories have been built along its coast.[103]

For decades, Mauritania's fishing sector has been dominated by foreign industrial fishing vessels, including from China, Russia and the EU, which pay license fees to operate there but predominantly process and transship pelagic fish offshore.[78] The Mauritanian government's hope is that recent moves to boost domestic processing capacity will create jobs and increase the fishing industry's contribution to the national economy.[x] However, in reality, the mainly foreign-backed industry that has sprung up along the Mauritanian coastline appears to be contributing very little to the country's economy beyond menial jobs and environmental pollution.[104]

According to an analysis the European Parliament published in 2018, vessels from third-party countries fishing for small pelagic species in Mauritanian waters are significantly increasing their efforts.[105] While Asia[78] and Russia[106] are reported to be the largest markets for Mauritanian FMFO, in the following section we also explore evidence that major European aquafeed producers are sourcing fish for feed from Mauritania.

In 2017, 0–15% of pelagic fish in Mauritania was designated for human consumption. The government wants to increase this to 60% by 2020 by adopting measures to discourage industrial fishmeal production, such as increasing export taxes.[107]

Concerns over pollution from fishmeal factories, the impact on local forage-fish stocks and people's livelihoods and food security have also sparked off demonstrations in The Gambia; according to our research, there are currently three fishmeal plants in the country, all of which have been involved in social and environmental scandals. The plants are processing a Gambian food staple known locally as 'bonga fish' – a small pelagic fish that plays a key role in food security, 90% of which normally goes to local consumption, which is today jeopardised

m Fishmeal production data for 2017 was provided directly to one of the authors of this investigation by the Mauritanian government. Past data is from UN Comtrade.

Trawler in Nouadibhou industrial port, Mauritania

by the more profitable reduction industry processing bonga fish into animal feed for export to China and Europe.[108] Making matters worse, the fishmeal companies are reported to be processing most of the fish catch, particularly affecting the jobs of local female fish processors, who buy from the artisanal fishermen, smoke the fish and sell it in the market.[109]

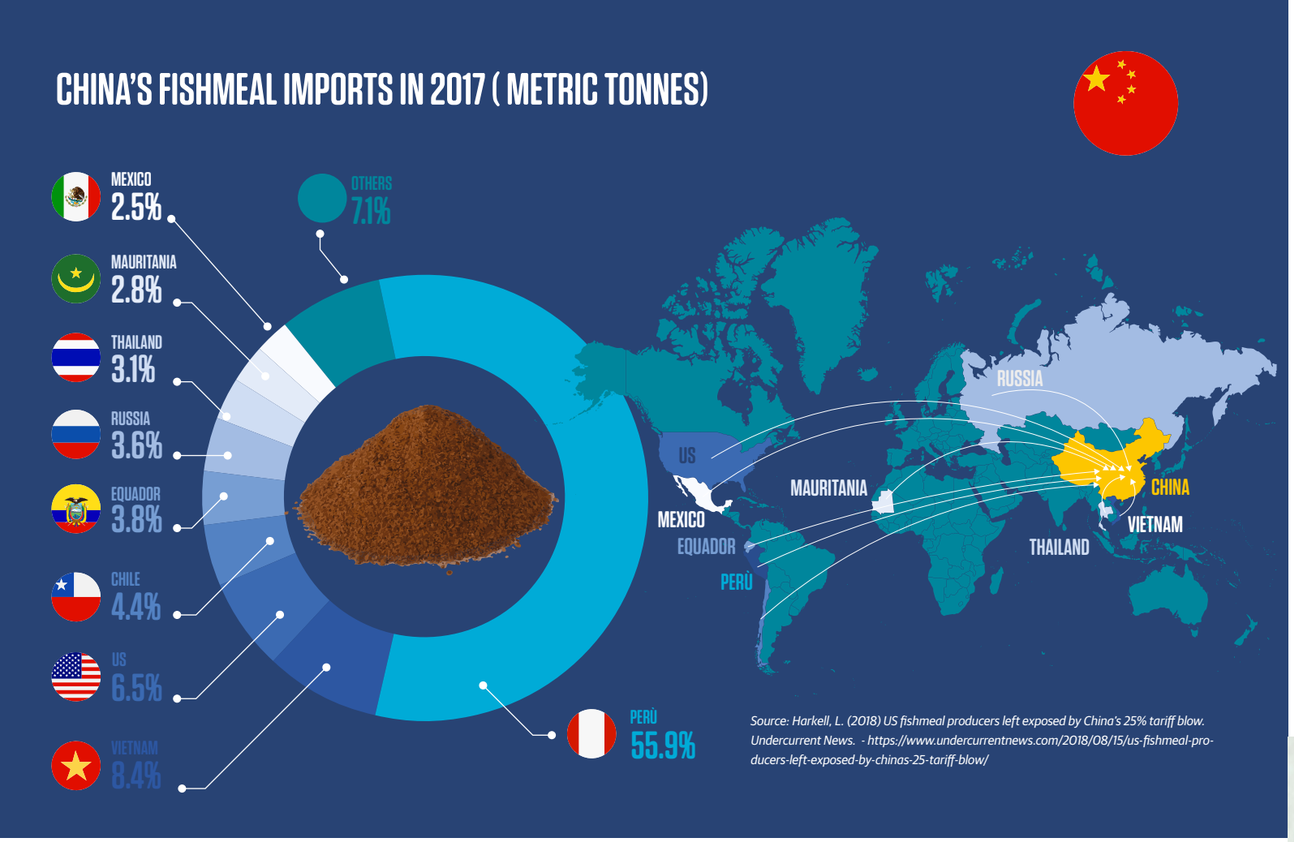
Box 3: Pollution scandals surrounding West African fishmeal factories

The tourist town of Abéné in Casamance, Senegal, located adjacent to a Marine Protected Area,[110] is at the centre of one of the biggest scandals related to fishmeal production in the country. According to local campaigners, the plant did not undergo an environmental and social impact assessment and was built closer to a residential area than regulation allows.[111] In 2018, the population of Abéné launched a number of protests – including an awareness-raising campaign: '*SOS to save the Yaboye*' ('*yaboye*' means 'sardinella' in Wolof) – related to the protection of fisheries resources.[112] Another controversial Chinese-owned plant in Senegal is located in Saint-Louis, Mbambara. In June 2018, there were protests after locals accused the company of polluting waterways and emitting noxious gases, causing respiratory illnesses.[113]

In The Gambia, pollution from three fishmeal plants poses a threat to the tourism industry and the wellbeing of local communities. The first plant, established in 2015, was Chinese-owned Golden Lead in Gunjur, which processed bonga fish into animal feed for export to China and fish oil to Europe.[76] In 2017, the factory was temporarily closed and fined following allegations of pollution.[114] However, in March 2018, the locals found pipes pouring factory effluent into the sea, which they believed to be linked to fish die-off, and an ugly red stain clouding the water.[115]

In June 2018, The Gambia's Parliamentary Select Committee on the Environment ordered the closure of another fishmeal plant, the Nessim Fish Meal Factory, for operating without a waste-treatment plant and discharging waste products directly into the sea.[99] Local protestors accused the plant of damaging the tourism industry; following the factory's reopening in late 2018, there were reports of tourists leaving beachside restaurants and cancelling bookings, suggesting that problems remain.[116]

The third fishmeal plant identified in The Gambia is Mauritanian-owned and Chinese-run JXYG. This plant was accused of failing to install a waste-water-treatment plant and of generating air and water pollution.[117]



Source: Harkell, L. (2018) US fishmeal producers left exposed by China's 25% tariff blow. Undercurrent News. - https://www.undercurrentnews.com/2018/08/15/us-fishmeal-producers-left-exposed-by-chinas-25-tariff-blow/

3.4. China: The aquaculture industry's 'black box'

China is a key country in global supply chains; it is not only home to the world's largest aquaculture industry but also a major producer of fishmeal.[5] The country's aquaculture industry grew tenfold in the three decades from 1986–2015.[33] In 2016, it accounted for around 62% of global aquaculture production; the FAO estimates this will remain fairly stable, and that it will account for 59% in 2030.[5]

China is also the largest exporter, and a major importer, of fish and fishery products; other countries routinely outsource processing to China, and there is growing domestic consumption of species not produced locally.[82] According to Sea Food Scotland, thousands of tonnes of British fish are shipped in refrigerated containers each year to China for processing, and re-exported back to the European market.[118]

China is the world's largest importer of fishmeal, the majority of which comes from Peru (estimated around 56% in 2017);[119] a much smaller percentage comes from Vietnam (8.4%) and the US (6.5%).[120,120] The fishmeal is used for the domestic farmed-fish industry and livestock rearing.

As well as being a major fishmeal importer, China is among the world's top three fishmeal producers; it produced on average 519,000 tonnes annually between 2012 and 2015 (in comparison to Peru's 835,000 tonnes).[75] In 2014, China's aquaculture industry consumed 7.2Mt of domestically caught wild fish as fish feed, and an additional 5.1Mt sourced from abroad.[33] A large share (roughly 4Mt) of domestic fisheries' catch relies on so-called 'trash fish' (see section 2.2); according to a 2017 Greenpeace report, this corresponds to almost one-third of China's annual fisheries' catch (and more than Japan's entire annual catch) for human consumption, and is placing additional pressure on the country's already overexploited fish resources and ecosystem. Moreover, half of the Chinese marine catch is carried out by trawling, in which fishermen drag nets along the ocean floor, killing coral reefs and other living organisms along the way.[36]

The overfishing of China's seas and resultant lack of fish is one of the factors pushing Chinese fishing companies to venture further away from Chinese shores and to fish in other waters[121] – including off the coast of West Africa. According to Greenpeace, China, which has over 500 industrial fishing fleets, is now the largest fishing power in West Africa.[121]

The growth of the aquaculture industry and China's role as the biggest player in global fish production is bound to increase fishing pressure on already overexploited fish stocks in the region. This threat is only amplified by large-scale IUU in China and deficient reporting on fisheries. The Sustainable Fisheries Partnership states that fisheries in Asia are characterised by data deficiency and low governance.[n] For most of these fisheries, information on the amount of catches, species captured and size composition is scarce and not systematically collected, while there is no information on stock conditions or exploitation status.[80] This makes it difficult, if not impossible, to assess the full scale of the problem in China.

n SFP (2018). SFP releases 2018 reduction fisheries report. Sustainable Fisheries Partnership. [ONLINE] Available at: https://www.sustainablefish.org/News/SFP-releases-2018-reduction-fisheries-report

(© iStock)

Box 4: Norway: A multi-billion-euro aquaculture hub and the world's largest krill harvester

European countries collectively constitute the world's third-largest production hub of FMFO, and generated about 14% of fishmeal production 2016. With Denmark, Norway and Iceland leading the industry, production in Europe equates to around 500,000 tonnes of fishmeal and 190,000 tonnes of fish oil every year, at a total value of approximately €1 billion.[75]

Norway is the second-biggest exporter of fish and fish products (after China) and has the world's largest salmon-farming industry.[5] Intensive farming of Atlantic salmon accounts for more than 80% of total Norwegian aquaculture production,[122] and is hugely resource-intensive when it comes to feed, especially FMFO. According to the Norwegian Seafood Council, in 2017 Norway exported 2.6Mt of seafood, worth 94.5 billion kr (€9.7 billion).[123]

Norway is not only one of the biggest producers of fish oil but also one of the world's main importers of FMFO,[75] importing substantial quantities from abroad, predominantly from Denmark. Fishmeal is mainly imported from Iceland, followed by Denmark and the Faroe Islands.[82]

Norway is also the world's largest producer of krill, and has controlled 70.3% of the global catch since 2000.[69] The largest krill harvester in the Southern Ocean is Aker BioMarine, a Norwegian company. The krill fishery operates from December,[o] mostly in the waters around the Antarctic Peninsula.[124] The most recent krill biomass surveys were completed in 2000, which means the data used to determine catch limits are nearly two decades old.[125]

In Antarctica's Southern Ocean, most marine animals are either direct predators of krill or just one step removed.[127] Many animals there (including whales, penguins, seals and squid) are directly dependent on krill; others (such as albatross and killer whales) are indirectly dependent on krill.[126] Scientists report troubling impacts on Antarctica's wildlife as a result of anthropogenic climate change and other human activities: for example, on the west coast of the Antarctic Peninsula, penguin populations have declined significantly due to changes in the abundance of krill.[127]

Despite concerns about Antarctica's fragile ecosystem and the extreme vulnerability of krill, there are clear signs that krill harvesters are planning to step up fishing efforts. For example, Aker BioMarine recently invested $120 million (€107 million) in a new state-of-the-art krill-fishing trawler. The company has not disclosed the production capacity of the new vessel, 'Antarctic Endurance', but has said it will not replace existing vessels – meaning any added capacity will be on top of existing catch, which is already substantial.[128] Interestingly, in 2018, Norway blocked a move to expand marine protected areas in the Antarctic, where krill fishing would be prohibited.[129]

Finally, Norway is also home to a number of large aquafeed companies, including Skretting, Cargill Aqua Nutrition/EWOS and Mowi. These companies and their sourcing policies are investigated in the next chapter.

o Fishing for krill follows a seasonal pattern over the course of the CCAMLR fishing season (December–November). The fishery usually begins during the Austral summer in December at the Antarctic Peninsula and progresses to the South Orkneys in the period April to July, usually as a result of Autumn seasonal sea ice formation. Subsequently, as the seasonal sea ice expands during late Autumn, the fishery moves from the South Orkneys to South Georgia, where it operates as a winter fishery. See: 'Krill fishing at the South Sandwich Islands (CCAMLR Subarea 48.4)', available on the government website of South Georgia & the South Sandwich Islands: http://www.gov.gs/docsarchive/Environment/Marine%20Protected%20Area/presentations/Cefas%208%20BAS%20Briefing%20on%20Krill%20Fishing%20at%20the%20South%20Sandwich%20Islands.pdf.

Box 5: IFFO: The certifier with a major conflict of interest

Fishmeal is big business – from approximately €5.3 billion ($6 billion) in 2017, it is forecast to reach €8.8 billion ($10 billion) by 2027.[74] The industry is represented internationally by the trade body IFFO, which was established in 2001 as the FMFO Organisation, and since 2012 has gone by the name 'IFFO: The Marine Ingredients Organisation'. IFFO's members reside in more than 50 countries and account for over 60% of world production and 80% of the FMFO traded worldwide. In 2017, over half of its new members were based in South America, closely followed by South East Asia.[130]

IFFO '*represents and promotes the marine ingredients industry, such as fishmeal, fish oil and other related industries*'. While set up to defend the interests of the industry, IFFO also claims to support '*the world's only certification programme for FMFO, the Global Standard for Responsible Supply (IFFO RS)*'.[131]

Out of 20Mt of '*raw materials*' (whole-fish crustaceans, capture-fishery byproduct, aquaculture byproduct), the reduction industries produce 5Mt of fishmeal and 1Mt of fish oil a year[p] – a figure that has been relatively stable for the past 20 years.[77] China has consistently been the main consumption market for fishmeal, and Norway for fish oil, primarily for their sizeable aquaculture industries.[5]

IFFO's certification programme,[132] launched in 2009, now certifies over 50% of the world's production of marine ingredients and is the leading business-to-business certification programme for such production. It consists of three interrelated standards:

1. **Global Standard for Responsible Supply (IFFO RS)**: to assess raw fisheries products used in fishmeal and oil production, as well as factory operations;
2. **Chain of Custody for Responsible Supply (IFFO RS CoC)**: to ensure traceability of raw fish into the factories; and
3. **Improver Programme (IFFO RS IP)**: to support factories to make improvements to reach the new standards.

IFFO owns the standard, while assessments are carried out by independent third-party certifiers. Neither retailers nor other actors further along the supply chain seem to question the fact that the industry association also acts as the main certification body for its own products.

While the companies involved in producing FMFO are not household names, and therefore escape the level of scrutiny common in other parts of the seafood industry, some are major corporate players with operations spanning the globe. They include:

- Austevoll Seafood (Norway)
- Pacific Andes International Holdings Ltd (Hong Kong)
- Tecnologia de Alimentos SA – TASA (Peru)
- Pesquera Diamante (Peru)
- Camanchaca (Chile)
- Exalmar (Peru)
- TripleNine Group (Denmark)
- Aker Biomarine (Norway)

Although the fishmeal industry presents the use of FMFO as '*strategic*' – that is, as just one of several ingredients in feed, and used only when necessary[133] – the projected growth of the industry and its lack of independent scrutiny should cause concern, particularly as some of IFFO's claims clearly do not stand up to scrutiny. For example, it claims that '*almost all the remaining wild-caught fish used in fishmeal and oil would not typically be fished in significant quantities for human consumption*',[q] which contradicts independent research showing that 90% of fish used by the reduction industries are suitable for human consumption.[16]

p The remaining 14Mt appear to be lost as steam during processing.[135]

q Communication from IFFO to Changing Markets, March 2019.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4. Feeding aquaculture: Big financial returns at the expense of the ocean

4.1. Overview

Industrial fish farming and the industries that support it generate substantial revenues, which are forecast to grow further still in the coming decades. While far less visible than the aquaculture industry it underpins, the business of 'feeding aquaculture' is booming, and is frequently presented as highly attractive to companies and investors seeking to make long-term returns in a resource-constrained world. However, as this chapter will show, when it comes to sourcing ingredients for feed, producers continue to employ highly unsustainable practices, and the industry requires significant reform to be fit for the future.

The aquafeed industry, which was worth €100bn ($114 bn) in 2017, is forecast to grow at a compound annual growth rate of 10.9% to reach €255.75bn ($289.94 bn) by 2026.[134] While Europe is home to several of the world's largest aquafeed producers, Asia looks set to be the sector's engine for growth over the coming decades. According to IntraFish, in terms of volumes, the top seven animal-feed-producing countries (China, the US, Brazil, Russia, Mexico, India and Spain) account for more than half of global aquaculture feed production, and the Asia-Pacific region alone accounts for 70%.[77]

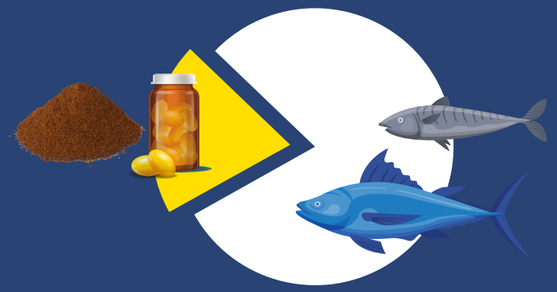
The prospect of making big profits has encouraged some companies not traditionally associated with fish to branch out into this flourishing sector. For example, in 2015, US agricultural giant Cargill bought Norwegian fish-feed supplier EWOS for €1.35bn.[135] Looking at the returns of one major integrated aquafeed and seafood producer, it is not hard to see why: In 2017, the *Financial Times* reported that Norway's Marine Harvest (recently rebranded as Mowi), the world's largest salmon producer, generated average annual total shareholder returns of 47% during the five years to 2016 (compared with 17% returns for the protein sector and 7% for the entire agricultural sector).[137]

The aquafeed sector is complex and its supply chains opaque. Some companies are highly integrated, with operations across several different activities: FMFO production, aquafeed manufacturing, fish farming and seafood distribution. Lines between the different activities are often blurred, making it difficult to build a detailed picture of sourcing patterns and trade flows. In light of this complexity, in February 2019, we wrote to 15 of the world's largest aquafeed companies with the objective of understanding more about their sourcing practices and policies on the fishmeal, fish oil and soy products used in their aquafeeds. At the time of writing, three companies had responded - Norway's Skretting and Cargill Aqua Nutrition, and Denmark's Aller Aqua. The latter two companies declined to respond directly to our questions, meaning that Skretting was the only company of the 15 to provide detailed information. Its input is provided on page 51.

FEEDING AQUACULTURE

Every year, millions of tonnes of forage fish and crustaceans are fished from the ocean and ground down into fishmeal and fish oil by the reduction industries

ROUGHLY $\frac{1}{5}$ OF WILD CAUGHT FISH IS USED TO MAKE FISHMEAL AND FISH OIL



01 RAW MATERIALS: WILD-CAUGHT FISH AND CRUSTACEANS

The raw materials are either processed at sea or in factories which are often located along the coast.

02 FISHMEAL AND FISH OIL FACTORIES

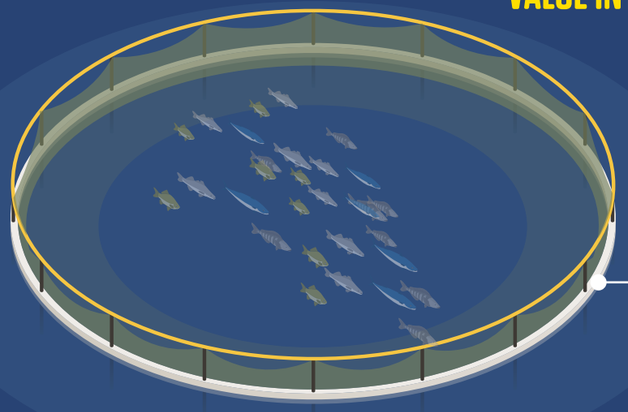
Some fishmeal and fish oil goes into animal feed. Most of it is used as an ingredient in aquafeed

ANIMALFEED **28%**

AQUAFEED **69%**

03 FEED INDUSTRY

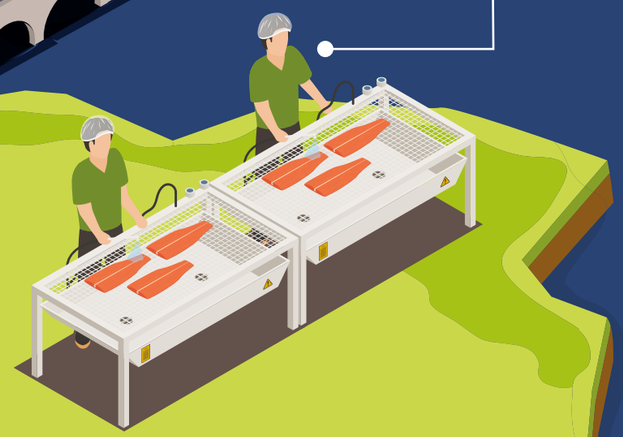
$114 BILLION MARKET VALUE IN 2017



04 FISH AND SEAFOOD FARMS

Aquafeed is the aquaculture industry's biggest cost

70% OF BUSINESS EXPENDITURE



05 PROCESSORS AND DISTRIBUTORS

Farmed fish and seafood is processed for human consumption and distributed to retailers and restaurants.

06 RETAILERS AND RESTAURANTS

Aquaculture is the fastest-growing sector of animal food production globally and now supplies more than half of the fish we consume

The following pages examine the growing use of aquafeed, providing a brief overview of the factors driving the industry's rapid expansion. Based on extensive desk research and the limited information companies shared with us, it will also review the main European aquafeed producers' practices and policies when it comes to sourcing marine ingredients (specifically, their use of wild-caught fish and crustaceans, such as krill, for use in feed) and scrutinise their sustainability claims. Through analysis of supply chains (based on information available in the public domain), it will show that key players in the aquafeed industry are either sourcing from West African countries (including Mauritania, Senegal and Morocco) or refusing to reveal their suppliers, which casts doubt over their claims to be producing sustainably sourced feed.

Finally, there are worrying indications from some companies that, far from planning a future without fishmeal or fish oil, they are actively pursuing new sources in the ocean, fishing further down the food chain as stocks of fish become depleted.[136]

4.2. The growing use of aquafeed: What is driving demand?

Feed is currently the aquaculture industry's biggest cost, accounting for roughly 70% of business expenditure.[77] With rising production of farmed fish, it is projected that requirements for feed will rise significantly in the coming decades. FAO estimates that global aquaculture production currently stands at 80Mt and will grow by another 30Mt by 2030.[5] According to Skretting, '*In order to produce 30 million tons of fish and shrimp we probably need 45 million tons of aqua feed*'.[77] The question is: '*Where are we going to get all this?*'[138]

It is clear that the global expansion of the aquaculture industry is resulting in boom times for the industry. However, in principle, it should be possible to decouple the growth of fish farming from that of the aquafeed industry by cultivating more species that do not require feed, such as shellfish (which are filter feeders) or species that require fewer inputs (such as tilapia, which can be fed an entirely vegetarian diet).[137] 'Innovative' approaches, such as integrated multi-trophic aquaculture (which was actually practised centuries ago), also present a less resource-intensive way of farming different species in the same farm system, with one species' waste serving as another species' feed.[138] Other innovations could also hold significant potential: yeast produced from algae, wood chips and insects reared on food waste could provide sustainable raw material for feed. Insect-based ingredients seem to be taking off the fastest, and, in 2018, the first companies to sell fishmeal-free, insect-raised farmed fish species appeared.[139] This was supported by new EU rules permitting the use of insect proteins in aquafeed in 2017.[140]

In reality, and with a few notable exceptions, the trend is moving in the opposite direction. According to the FAO, during the period 1995–2015, production of feed-reliant farmed aquatic species increased more than fourfold, from 12–51Mt (largely through intensification of production methods for shrimp, tilapias, carp and salmonids), and production of industrial aquaculture feeds sixfold, from 8–48Mt.[5] Table 2 shows how much the use of feeds has grown since 2000, and is expected to grow to 2025, for six major farmed species: Chinese fed carp, tilapia, catfish, marine fish, shrimp and salmon.

Table 2: Estimated global usage of commercial aquaculture feeds by major species groupings (values given in thousand tonnes)

Year	Total production	Growth (%/year)	% on feeds	Total feeds used	Major producer country (in 2012)
Chinese fed carp					
2000	7,184	3.9	37	5,316	
2012	12,473	6	52	11,026	China (90.8%)
2025	20,366	3	65	21,181	
Tilapia					
2000	1,190	14.7	75	1,696	
2012	4,507	13.3	87	6,666	China (34.4%) Egypt (17%) Indonesia (15.9%)
2025	12,950	8	100	20,720	
Catfish					
2000	529	-2.3	72	772	
2012	3,909	15.4	78	4,269	Vietnam (32.2%) China (23.4%) Indonesia (20.2%)
2025	8,817	6	85	9,743	
Marine fish					
2000	977	16.4	60	1,172	
2012	2,181	6.6	76	2,984	China (47.3%) Japan (11%) Egypt (7.7%)
2025	4,691	5	90	6,333	
Shrimp					
2000	1,137	8.6	77	1,751	
2012	4,327	3.4	84	6,179	China (39.2%) Thailand (13.8%) Vietnam (11.3%)
2025	6,354	3	90	8,578	
Salmon					
2000	1,025	12.3	100	1,332	
2012	2,294	18.3	100	2,982	Norway (53.7%) Chile (24.5%) UK (7.2%)
2025	5,725	5	100	7,442	

Source: Compiled after Table 1 in Tacon and Metian (2015).[14]

4.3. The changing composition of feed

The composition of aquafeed has evolved considerably over the years. One major producer notes: '*The main grower diet in 1990 was heavily based on marine ingredients held together by wheat*'.[141] Today, aquafeed comes in many different varieties depending on the species being farmed and other considerations, such as marketability. When it comes to the composition of aquafeed, two competing trends are currently playing out within the industry.

On the one hand, as seen previously in this report, many aquaculture species that were formerly not artificially fed, or had no fishmeal or fish oil in their feed, are increasingly being supplemented with wild-fish-based inputs, both to speed up growth and on the basis that this will boost omega-3 content, which makes the end product more attractive to consumers.[142]

On the other hand, several aquafeed companies have successfully produced and marketed fish-free feeds. For example, since 2015, the F3 Fish-Free Feed Challenge – a collaborative effort between NGOs, researchers and private partnerships to accelerate the commercialisation of innovative, alternative aquaculture feed ingredients to replace wild-caught fish – has challenged companies to produce seafood-free aquaculture feed using innovative formulations of proteins and lipids.[143] To date, however, these innovations are happening at the margin, and production volumes are too low to put the industry on a path to transformation.

While a handful of companies have shown it is technically possible to produce high-performance aquafeed without the addition of wild-caught fish and crustaceans, there is significant resistance to rolling out fish-free feed industry-wide. In part, this is because of the powerful voice of the fishmeal lobby itself, which has fought hard to protect its interests and make the case that the use of wild-caught 'marine ingredients' in feed is necessary to produce fish and seafood with optimal omega-3 levels and nutritional value for human consumers.

Indeed, new trends and innovations notwithstanding, feed for carnivorous fish and crustaceans (such as salmon and shrimp) still tends to contain a significant share of fishmeal. According to information supplied by the Norwegian Seafood Council, salmon feed is currently composed of 70% vegetable ingredients and 30% marine raw materials (FMFO).[144] Reflecting this general trend, Cargill Aqua Nutrition's salmon feed consists of around 30% marine ingredients (20% fishmeal and 10% fish oil), roughly the same amount of vegetable protein and the rest from vegetable oils, carbohydrates, etc.[77,143]

Against this backdrop, the following section provides an overview of the state of play at four major, European-headquartered aquafeed companies: Cargill Aqua Nutrition/EWOS, Skretting, Mowi and BioMar. These companies have been selected on the basis of their presence in Europe; however, as our analysis will highlight (and like all major aquafeed producers), their supply chains are global.

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4.4. Profiles of main European aquafeed companies

4.4.1. Cargill Aqua Nutrition/EWOS

HQ: Bergen, Norway

2017 sales: $2.19 billion (€1.8 billion) (estimated[r])[76]

2017 production (aquafeed): 1.49Mt[141]

Parent company: Cargill, America's largest privately held company, which had revenues of $114.7 billion in 2018[145]

Response to Changing Markets: Cargill responded to our letter requesting information about its sourcing practices and policies, but did not directly respond to our questions

In 2015, US agribusiness giant Cargill purchased Norwegian salmon-feed producer EWOS for €1.35 billion,[146] and combined it with its own warm-water aqua business to create a global leader in aquafeed and nutrition. According to IntraFish, Cargill Aqua Nutrition now represents about 2% of Cargill's total revenue, which was $107.2 billion (€95.4 billion) for fiscal year 2016[141] and $114.7 billion (€102 billion) for 2018.[145] The EWOS brand is still in use, and Cargill reports that an '*increasing proportion of our sales go to market under the EWOS brand*', which represents '*quality products and a strong focus on sustainability*'.[141]

The company has a significant share of the aquafeed market – in 2017, its 1.49Mt of aquafeed represented 3.7% of total global production and was used to feed over 30 species.[141]

Cargill Aqua Nutrition/EWOS supplies feeds for the full life cycle of farmed finfish, with a major focus on salmonids.[147] In total, the company has 40 production facilities worldwide, 20 of which are entirely dedicated to aquafeed production.[138] Among these, it has production facilities in the world's four key salmon-producing countries: three in Norway, one in Chile, one in Canada and one in Scotland.[148] Its other core species are tilapia (in China, Indonesia, Thailand and Vietnam) and shrimp (in China, Thailand, Vietnam, Indonesia, Ecuador, India and Mexico).[149] The company plans to expand its production of shrimp and tilapia feed in Asia.[138]

4.4.1.1. Share of marine ingredients (FMFO)

In 2017, Cargill Aqua Nutrition reported that the 'marine index' (i.e. the proportion of the diet sourced from marine ingredients) for salmon feed was 30.7% as a percentage of feed sold (up slightly from 30.1% in 2016 and relatively constant since 2011). The company noted: '*This is completely different to the warm water index of 11.2% in 2017 but is a long way below the 55% marine ingredient use in 2005*'.[141]

For salmon feed, Cargill reports that, in 2017, 33.6% of the FMFO used was made from trimmings, slightly down from 2016. In volume terms, over 100,000 tonnes of fishmeal and oil from trimmings was used in 2017 for salmon feed, but the company did not report on the figure for warm-water feeds, because insufficient data was available in 2017 to calculate the share of trimmings for warm-water feeds with reasonable accuracy.[141] Accurate data was only available for Vietnam, indicating that 1.3% of fish oil (of which 0.5% was from trimmings) and 8.7% fishmeal (of which 4.7% was from trimmings) were used. Local 'trash fish' and a small proportion of Peruvian anchovy provided the balance of marine ingredients for Vietnam.[141]

r Based on Cargill estimates of 2% of 2017 group sales, revenue of $109.7 billion, following IntraFish (2018).[76]

Under the umbrella of its '*COMPASS concept*', Cargill offers a range of different feed '*diets*', including '*[d]esign diets, to remove GMOs and fishmeal for certain markets*'.[141] We take this to mean that, in some countries, it sells feed that does not contain fishmeal, based on local market requirements and customer preferences rather than technical considerations.

4.4.1.2. Sustainability commitments

The information provided in Cargill Aqua Nutrition's 2017 sustainability report only pertains to 17 of its 40 facilities worldwide. These, in addition to three facilities it said would be coming on line in 2018, are the only facilities dedicated to aquafeed production.[141] According to the company, this covers about 80% of Cargill's aquafeed production footprint, with the remainder coming from multipurpose mills.[141]

When it comes to marine ingredients, Cargill Aqua Nutrition states: '*Our goal is to reduce dependency on forage fish through use of co-products from fisheries*'.[141] The company, however, does not seem to define what counts as a 'co-product'. A key plank of its commitment to sourcing sustainable marine ingredients is its focus on purchasing certified fishmeal and oil, specifically by IFFO RS and the Marine Stewardship Council (MSC). It also supports fisheries in the improvers' programme, or those transitioning to these certifications.[141]

Cargill states: '*When sourcing and selecting raw materials, we demand high quality, sustainably sourced ingredients. We focus on ensuring that our actions do not compromise the supply of marine resources for future generations*.'[149] Raw materials account for more than 85% of its environmental footprint.[141]

While noting that '*sustainability is too big a topic to handle alone*', the company acknowledges that raw material sources are a critical area, especially marine ingredients, and states it works with its suppliers to address the challenges relating to raw materials, focusing particularly on marine ingredients, soy and oil palm.[141] Its Code of Conduct sets out its expectations of suppliers with respect to managing environmental and social impacts, but does not appear to be publicly available.[s] On marine ingredients, it has the following commitments:[141]

- By 2020, source all marine ingredients from IFFO RS certified factories; and
- By 2025, only source MSC-certified marine ingredients.

Despite Cargill Aqua Nutrition's claim to have the health of the oceans and the interests of future generations at heart, in early 2019 its incoming president, Adriano Marcon, indicated that the company has its eyes on previously unexploited resources: '*there is a potential in large quantities of deep water fish that are not fished today, so-called meso-pelagic small fish. Here it is possible with a regulated and sustainable use*.'[136]

This is deeply concerning. In light of the destructive impact the industry has already made higher up the food chain, and the manifest failure of regulation to protect our oceans, it is difficult to understand how fishing further down the marine food chain can be contemplated as being a viable option for aquafeed producers.

Moreover, according to information the company supplied to the Ocean Disclosure Project (ODP), in 2017 and 2018 Cargill sourced anchoveta from Peru through a 'managed' fishery, which means it may have negatively impacted food availability to protected, endangered and threatened species.[150] Evidence shows that overfishing of anchoveta has resulted in social and environmental problems in Peru, including the collapse of coastal ecosystems, fish and bird species (see section 3.2). Other countries that supply its wild-caught fishmeal and oil include Chile, Denmark, the Faroe Islands, Iceland and Norway.[141]

Cargill is one of ten companies committed to the Seafood Business for Ocean Stewardship (SeaBOS) initiative, which aims to make the international fishing and aquaculture industry more sustainable. This includes a pledge to protect the world's oceans by working to eliminate illegal activities, including slave labour, and preventing overfishing.[151]

4.4.2. Skretting

HQ: Stavanger, Norway

2017 sales: 6.03 billion kr (€637 million/$742 million)[77]

2017 production (aquafeed): 2.5Mt annually[152]

Parent company: Nutreco, a Dutch feed company, which is owned by SHV, a '*family-owned multinational*'

Response to Changing Markets: Skretting responded to our letter requesting information about its sourcing practices and policies. The information it supplied is integrated below.

Skretting has production facilities in 19 countries on five continents and manufactures feeds, from hatching to harvest, for more than 60 species. The total annual production volume of feed is more than 2.5Mt.[153]

Skretting appears to have consolidated its market position with acquisitions of existing businesses (plants, brands and customers) in countries into which it has expanded, converting the old companies into divisions of Skretting or partnering with existing companies (e.g. through joint ventures). It sells products within the countries in which its operations are located, as well as exporting to other markets.

Skretting is owned by parent company Nutreco, a global leader in animal nutrition and aquaculture feed. Nutreco has two global company brands: Skretting (which distributes Nutreco's fish and shrimp feed) and Trouw Nutrition (which distributes its animal feed).[154]

Nutreco is a wholly owned subsidiary of SHV Holdings NV, which is presided over by the Dutch Fentener van Vlissingen family.[155] It employs over 12,000 people in 35 countries and had net sales of €5.6 billion in 2016.

On its website, Nutreco notes a transition '*from an integrated company active in feed, farming and meat processing to a focused animal nutrition and fish feed company*'. The company outlines a current strategy of growth in Latin America, Russia, Asia and Africa, and the development of new markets '*such as Brazil, China, Ecuador, Russia and Vietnam*'.[156]

4.4.2.1. Share of marine ingredients (FMFO)

In correspondence with Changing Markets in March 2019, Skretting said the percentage of FMFO in its aquafeeds varies, based on the species for which the feed is formulated and the availability of raw materials that can easily replace FMFO: '*This means that the range of fishmeal in diets for aquaculture species vary in the range from 0% up to between 10–20% in some cases. For fish oil the variability is lower and normally in the range from 0–10% of the diet.*'[t]

Skretting's 2017 sustainability report shows that Skretting feeds are made up of:

s We could only find parent company Cargill's supplier Code of Conduct online; however, this does not contain any references to fish or aquaculture: https://www.cargill.com/doc/1432101078794/supplier-code-of-conduct-pdf_en.pdf.

t Correspondence with Changing Markets, March 2019.

- 60% agricultural crops;
- **15% small wild-capture pelagic fish and krill;**
- 13% byproducts from land animals;
- **5% byproducts from a wide range of wild-capture fish and crustaceans** (must not originate from threatened species, according to the International Union for the Conservation of Nature (IUCN) redlist);
- **1% byproducts from farmed fish and crustaceans (salmon, tilapia and shrimp);** and
- 5% vitamins, minerals and pigments.[157]

In correspondence with Changing Markets, Skretting stated: '*where we have data, it supports that fishmeal from by-products [is] in the area of 30% and from whole fish 70%*'.[u]

4.4.2.2. Sustainability commitments

Skretting states that sustainability is a key element of its operations.[158] In 2005, Skretting launched Sustainable Economic Aquafeeds (SEA), its first programme for developing sustainable feed solutions for aquaculture. In 2016, SEA was rebranded to Nuterra, Nutreco's company-wide sustainability programme.

Since 2017, Skretting has implemented a system of systematic evaluation of the sustainability risks linked to primary sources of feed ingredients and their manufacture. Skretting only buys the feed ingredient once the manufacturer has been approved, based on the outcome of the risk assessment.

Its minimum criteria for suppliers, with regard to the sustainable sourcing of marine ingredients and the responsible management of the fisheries where these ingredients originate, cover the following aspects:

- Traceability systems to verify species and country of origin;
- Species must not be classified as Endangered or Critically Endangered on the IUCN Red List (species listed as vulnerable are not eligible for use as a trimmings product, unless from a sub-population assessed to be responsibly managed);
- Marine ingredients must not be from IUU fishing activity;
- Promoting compliance with the fishery management principles of the FAO Code of Conduct for Responsible Fisheries; and
- Encouraging suppliers to obtain recognised third-party certification, such as International FMFO code of Responsible Supply (IFFO RS) or MSC.[159]

In correspondence with Changing Markets, Skretting said it is addressing the finite supply of marine raw materials through its MicroBalance® technology. This aims to enable the growth of the aquaculture industry without putting additional pressure on wild fisheries, and has, according to the company, already significantly reduced the amount of fishmeal used in its aquafeeds: '*Today, for example, we are able to make salmon diets completely independent of fishmeal*'. Skretting also says it is exploring ways in which it can extend the technology to find alternatives to fish oil in our diets. The company believes this technology will allow a reduction in Skretting's dependency on critical raw materials without compromising fish performance.[xvii] It also states: '*Where possible Skretting purchases fish meal and fish oil that are certified by IFFO RS or MSC*'.[160]

u Correspondence with Changing Markets, March 2019.

The company notes that food security in Africa is a major concern. According to Rob Kiers, Managing Director of Skretting Asia and Africa: '*Skretting wants to help achieve food security in Africa, a goal that is in line with our mission of 'Feeding the Future"*'.[161]

Despite these noble intentions, according to information the company supplied to the ODP,[162] Skretting appears to source FMFO from Mauritania, Senegal and Morocco, despite the fact that growing fishmeal production is undermining food security and livelihoods in West Africa.[v]

Sardinella caught in Senegal for fishmeal

Additionally, Skretting appears to have sourced fishmeal from fisheries regarded as being unsustainable. Globally, Skretting used 17 fisheries in 2018, of which 9 were regarded as '*well managed*', 4 '*managed*', 3 '*needing improvement*' and 1 with incomplete information.[164]

In 2018, the company sourced European pilchard (*sardina pilchardus*) from the North West Africa southern fishery in Mauritania, which was regarded as '*managed*' and had a FishSource score of ≥6 (indicating the fishery has medium risk and requires improvements).[163] This is problematic, since fish caught in Mauritanian waters reportedly have broader implications for the food security of the region, including neighbouring Senegal, as well as allegations of corruption.[22]

There are no entries for 2017, but 2016 ODP data shows that Skretting sourced European pilchard from the North West Africa southern and central stocks (encompassing Mauritania, Senegal and Morocco) regarded as '*reasonably managed*'. It also sourced from the North West Africa southern and central stocks in 2015, which at the time were classified as '*poorly managed*'.

v The Ocean Disclosure Project (ODP) provides a reporting framework for seafood-buying companies (retailers, suppliers, fish feed manufacturers and more) to voluntarily disclose their wild-caught seafood sourcing, alongside information on the environmental performance of each fishery. The ODP was launched in 2015 by the Sustainable Fisheries Partnership (SFP), a US-registered non-profit that works directly with the seafood industry to deliver sustainable seafood. The project started with the support and participation of five companies: UK retailers Asda (the first company to report via the ODP), Morrisons, and The Co-operative Food, and aquaculture feed producers BioMar and Skretting.[164]

Skretting is one of ten companies committed to the SeaBOS initiative, which aims to make the international fishing and aquaculture industry more sustainable.[153]

4.4.3. Mowi

HQ: Bergen, Norway

Sales: €320 million ($371 million)[77]

Production volume (aquafeed, 2017): 2Mt.[164]

Response to Changing Markets: Mowi did not respond to our letter requesting information about its sourcing practices and policies

Norway's Mowi ASA ('Mowi'), better known as Marine Harvest (until 1 January 2019), was established in 1964; it has become one of the largest seafood companies in the world, and the world's largest salmon farmer. It also produces aquafeed; its first feed plant was opened in Bjugn, Norway, in 2014.[77] Marine Harvest's market share in salmonid feed more than doubled between the end of 2014 and 2017.[165]

The company employs 13,233 people and is represented in 25 countries. In 2017, it had a turnover of €3.6 billion. Mowi supplies farmed salmon and processed seafood to more than 70 markets worldwide.[166]

The company's current form is the result of significant expansion in 2006, when Pan Fish ASA conducted an effective three-way merger with Marine Harvest NV and Fjord Seafood. A significant chunk of the company is still owned by John Fredriksen, the billionaire associated with Seadrill and Frontline Ltd.[167]

4.4.3.1. Share of marine ingredients (FMFO)

In its 2017 sustainability report, Mowi discloses that its FMFO are produced using wild-caught fish (such as anchovies) and other ingredients (such as canola oil, soy-bean protein and wheat). Fishmeal accounts for 14.7% and fish oils for 10.3% of Mowi's salmon feed.[168] Mowi states that, in 2017, particular attention was given to expanding the raw materials basket for fish-feed production, which involved lowering reliance on wild-caught fish for salmon farming.[170]

4.4.3.2. Sustainability commitments

On its website, Mowi states: '*from producing fish feed to delivering premium portioned fish fillets, Mowi operates the entire value chain of all its products – ensuring every stage of farming and production adheres to their strict best practice and category-leading guidelines.*'[169]

Juan Manuel Nunez Mendez - Unsplash

Mowi regards third-party certification as key to its sustainability strategy. In 2017, the company accounted for 36% of all the Aquaculture Stewardship Council (ASC)-certified Atlantic salmon sites worldwide, becoming the leading producer of ASC-certified farmed salmon. Mowi certified a total of 13 new sites in 2017, bringing the company's accumulated total to 72 sites, representing 31% of all their farming facilities.[170]

Mowi also emphasises that sourcing sustainable feed ingredients is crucial to remaining a frontrunner on environmental responsibility. The company's policy for sustainable feed ingredients applies to both feed purchased externally and the feed it produces. It adds that all ingredients – marine as well as non-marine in origin – used in the production of its feeds are fully traceable. Its commitments include:

- Sourcing marine raw materials from suppliers that adhere to responsible fishery management practices, as defined by the ASC and/or the IFFO RS scheme; and
- None of its raw materials originate from IUU catches, or from fish species classified as endangered on the IUCN Red List.

In its 2017 annual report, Mowi said it sources fishmeal from Mauritania, Morocco and South Africa, in addition to Peru, Panama, the US, China, Turkey, Chile, Denmark and Norway. For example, Peruvian anchovy accounted for close to one-third (29.1%) of fish oil produced by Mowi in 2017.[171] This is highly concerning in light of evidence that Peru's fishmeal industry is polluting coastal cities and destroying ecosystems, and that fishing for fishmeal in North West Africa is threatening regional food security.

Mowi is one of ten companies committed to the SeaBOS initiative which aims to make the international fishing and aquaculture industry more sustainable.[153]

4.4.4. Biomar

HQ: Aarhus, Denmark

Sales (2017): 17 million kr (€2.3 million/ $2.6 million)[77]

Production volume (Aquafeed): 1.2Mt (2017)[170]

Response to Changing Markets: Biomar did not respond to our letter requesting information about its sourcing practices and policies

Founded in 1962 by a group of Danish fish farmers, BioMar sees its heritage as a long-term commitment to developing the aquaculture industry in a responsible and sustainable way.[171] BioMar is fully owned by Danish conglomerate Schouw & Co. and represents more than half of the group's turnover.[172]

According to the company's website, 1 out of 5 farmed fish produced in Europe and Chile is fed with BioMar feed,[172] and BioMar provides diets for more than 45 fish and shrimp species in more than 80 countries.[174]

4.4.4.1. Share of marine ingredients (FMFO)

Biomar states its aquafeed consists of 18% marine dry matter, 9% marine oils, 15% plant oils and 48% plant dry matter.[173] Sardine and anchoveta together account for at least one-quarter of its FMFO; fishmeal consists of 16.4% sardine and 19.7% anchoveta, while fish oil includes 17.7% anchoveta and 12.8% sardine. According to its sustainability report, BioMar uses exclusively deforestation-free soy-bean and palm products, and strives to utilise byproducts in its feed production.[175]

4.4.4.2. Sustainability commitments

BioMar highlights sustainability as a key element of its operations, citing its presence on the board of IFFO RS and the ASC's steering committee.

Operationally, BioMar's Supplier Approval, Audit and Traceability team is responsible for overall approval and auditing, as well as ensuring traceability of common raw materials and suppliers to BioMar divisions. All suppliers need to be approved based on minimum standards decided by the executive committee before raw materials are contracted and purchased for commercial use.[175]

BioMar says it seeks to purchase the most sustainable products on the market. It does this largely through certification; in 2017, 81% of all fish oil and 89% of all fishmeal sourced was certified by IFFO RS or equivalent (MSC, ASC). BioMar states it is capable of tracing 100% of the purchase and sourcing of its raw materials used to produce feed.[175]

According to the ODP, BioMar has sourced fishmeal from fisheries regarded as being unsustainable. Globally, BioMar used 34 fisheries in 2018, of which 16 were regarded as '*well managed*', 9 '*managed*', 5 '*needing improvement*' and 4 with incomplete information.[175]

In Africa in 2018, BioMar sourced round sardinella from The Gambia, Mauritania, Senegal, Russia and Ukraine. North West Africa round sardinella is a migratory species and is key to the food security of the most vulnerable populations across West Africa. There is also evidence on the ground of this fish stock collapsing recently.[22] FishSource warns the future health of this fish stock is at high risk (score of <6).[174]

In 2016 and 2017, BioMar sourced European pilchard from Morocco, Mauritania and Senegal. These were regarded in 2017 as being '*managed*' (FishSource score of ≥6).[165] In 2016, BioMar sourced these stocks using fisheries considered to be '*reasonably managed*' (Category B), and in 2015 using '*poorly managed*' fisheries (Category C).

Despite their claims to be sourcing responsibly and transparently, it is clear that the aquafeed companies described here are failing to put their policies into practice. Only two of the four companies surveyed responded to our questions. Furthermore, while Skretting is now able to make salmon diets entirely without fishmeal and the other producers appear to acknowledge the need to reduce the 'marine index' of their feeds, several were found to be sourcing fishmeal from West Africa and Latin America, where environmental pollution and food security pose serious problems. Finally, many of these fisheries are either classified as poorly managed or lack sufficient information to assess the status of stocks.

Aquafeed companies' reliance on certification – specifically, IFFO RS – is problematic, for the reasons outlined in Chapter 4 and Box 6. Although some of them claim to only source from factories certified by IFFO RS or equivalent, they have disclosed through the ODP that they are sourcing from fisheries in The Gambia, Senegal and Mauritania, where there are serious concerns about the impact of reduction fisheries on local small-scale fisheries and regional food security.

Finally, we are particularly worried about Cargill Aqua Nutrition's apparent interest in fishing further down the marine food chain for meso-pelagic species. This seems to demonstrate a shocking lack of concern or understanding regarding the potential ecosystem impacts of such a move.

Box 6: Why certification schemes should stop certifying FMFO

While aquaculture is the fastest-growing sector of global animal-food production, only 7% of the world's farmed-fish supply is certified.[175] Certification is also highly concentrated on a relatively small number of species that are mainly consumed in the EU, Japan and North America.[176] According to the International Institute for Sustainable Development, sustainable seafood is concentrated in a relatively small number of species groups. With the exception of certified Peruvian anchoveta (29% of total), the main species groups – cod (16%, including Alaska pollock), salmon (15%), tuna (8%) and mackerel (4%) – represent high-value species destined for Global North retail markets. These same species groups account for a mere 15% of total global seafood production.[178]

Despite the relatively small market share of certified farmed fish, certification schemes for aquaculture have proliferated in recent years, leading to confusion among producers, retailers and consumers.[177] The schemes' criteria, level of coverage, robustness and implementation are complex and show substantial variation.[178] This box therefore focuses on some of the biggest and best-known aquaculture certification schemes, focusing on their requirements regarding the use of FMFO for feed. Table 3 provides an overview of the main aquaculture certification schemes and their criteria for the use of wild-caught fish.

Most schemes prohibit the use of raw materials from:

- fisheries involved in IUU fishing;
- those that target fisheries, contain byproducts or have bycatch with significant impact on species categorised as vulnerable, endangered or critically endangered on the IUCN Red List; and/or
- those that come from fish species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendices.

However, they rarely go beyond existing sourcing initiatives when it comes to the origin of wild-caught fish. Moreover, the responsible sourcing of feed is addressed very differently by different schemes, and even by different species-specific standards within the same scheme. Although some schemes encourage the improvement of feed efficiencies (e.g. the quantity of wild-caught fish per output of farmed fish), these efficiency ratios only need to be calculated; most schemes do not have any actual restrictions on the share of FMFO in feed.

The certification schemes most frequently referred to are the MSC and IFFO RS. MSC reports that it certifies 7% of global reduction fisheries, including krill, blue whiting, mackerel and herring.[68] Scientists and NGOs have criticised MSC for a lack of robustness and its commitment to the growth of certified fisheries, which puts quantity before sustainability. But even with high projections for growth, MSC-certified fisheries do not appear sufficient to meet aquaculture certification schemes' growing demand for certified FMFO.[179] Most schemes do not require an ecosystem-based approach to be applied to reduction fisheries; they merely require some percentage of MSC-certified feed ingredients, with IFFO acting as a fallback standard. Given that IFFO was established to defend the interests of FMFO producers, it is highly questionable whether it can also act as an objective and independent certification standard body – and surprising that aquaculture certification schemes and retailers seem to accept it as such.

It is doubtful whether any of these schemes should be certifying the use of wild-caught fish and crustaceans to feed farmed fish at all. The troubling fact is that 90% of fish caught and processed by the reduction industries are food-grade fish fit for direct human consumption.[16] Certifying fisheries that reduce fish caught in the wild to produce farmed fish is in direct contradiction of the FAO Code of Conduct for Responsible Fisheries and elementary ethics, as it undermines food security for local populations in many developing countries.[69] In addition to this, most certification schemes that address the sourcing and use of FMFO fail to take important elements of sustainability into account, such as the ecosystem impacts of removing a keystone species from the food chain. For these reasons, we believe certification schemes should stop certifying fish that is not used for direct human consumption, and that aquaculture schemes should only certify fish farmed without the use of wild-caught fish for feed.

Table 3: Largest aquaculture certification schemes (in terms of volume certified)

Name	Certified aquaculture (Mt)	Short description	Criteria for the use of wild-caught fish	Environmental ranking* (%) on SSI index
GlobalG.A.P.	**2,100** (2015)	Private-sector body set up by a group of retailers. Covers 38 aquaculture species operating in 29 countries.	FMFO should adhere to the FAO Code of Conduct for Responsible Fisheries, and/or be certified by MSC, IFFO RS or equivalent. The share of certified FMFO in the feed should be recorded.	**87%**
Global Aquaculture Alliance – Best Aquaculture Practices (BAP)	**1,500** (2018)	International NGO. Certifies the entire supply chain. More than 150 retail and food-service companies are publicly committed to sourcing from BAP's (>2,155) facilities.	FMFO should be produced from certified sustainable fisheries or fishery improvement projects. Facilities should develop action plans to transition towards those sources and to avoid unsustainable sources. In BAP's feed standard, at least 50% of FMFO must come from sources certified by either MSC or IFFO RS.	**58%**
Aquaculture Stewardship Council (ASC)	**1,180** (2017)	Independent charity and multi-stakeholder. Standards comply with ISEAL guidelines. Has certified over 700 farms (and over 350 farms are currently in assessment) and over 10,000 products in 66 countries.	The use of wild-caught fish in feed should be minimised. If used, FMFO should be traceable back to a responsibly managed source, preferably certified by MSC or another ISEAL member scheme. The vision was that all FMFO should be MSC certified within 5 years, but even this is likely to be watered down in ASC's upcoming feed standard.	**63%**
Friend of the Sea (FOS)	**750** (2015)	Founded by the NGO Earth Island Institute. Certifies wild-caught fisheries, fish farms, processing facilities and final products. Had certified 122 aquaculture companies as of 2018.	Fish feed should come from FOS-certified fisheries, suppliers of raw material (i.e. byproducts) or IFFO RS.	**48%**
Naturland	**40** (2011)	Farmers' association promoting organic agriculture. Private standard that sets its requirements in line with EU organic regulation. Certified farms in over 20 countries.	Wild-caught fish feed should come from known and documented sources. The objective is to decrease the use of FMFO as much as possible and replace them with plant-based products. For some species, maximum limits of FMFO are already set.	**77%**

Source: Schemes' own websites; Jonell et al. (2013)[9]

** Ranking developed by Potts et al. in 2016 for the State of Sustainability Initiatives (SSI) review.* (Potts, J. *et al.* (2016) *The State of Sustainability Initiatives: Standards and the Blue Economy.* Winnipeg: IISD/IIED/FAST [ONLINE] Available at: https://www.iisd.org/ssi/standards-and-the-blue-economy/). *Percentage score reflects coverage of different aquaculture standards on a variety of indicators, such as water pollution, the list of prohibited antibiotics, escapees, responsible sourcing of aquatic animal feed, feed regulation, disease management, GHG emissions and habitat set-asides. In the case of the ASC, the authors assessed four species-specific standards (pangasius, salmon, tilapia and shrimp).*

5. Conclusions and recommendations

5.1. Conclusions

In a scenario of rapidly expanding aquafeed production, there is widespread scientific agreement that the production of FMFO for industrial aquaculture is placing significant pressure on wild-fish stocks and marine ecosystems, contributing to overfishing and disrupting aquatic food webs. Moreover, disruption of fish stocks driven by overfishing – and, increasingly, by climate change – has undermined food security and the livelihoods of some of the planet's most vulnerable people, such as inhabitants of the coastal regions of Senegal, who have relied on the small-scale sardine fishery for generations. These pressures will be further exacerbated by projected growth in aquaculture over the coming decades unless the industry urgently reconsiders its dependency on wild-caught fish for feed.

While IFFO claims industry supply chains are becoming more and more sustainable, fishmeal factories are actually bringing pollution and environmental degradation to producing regions, prompting outcry and protest from local communities. Even worse, with the depletion of traditional forage-fish stocks, reduction fisheries (especially in Asia) are plundering the ocean for juvenile fish and exploring new species that were previously not commercially interesting. Traditional forage-fish species are being fished down to the extent that fleets need to target other, previously unwanted species, such as boarfish, lanternfish and krill.[69] This is leading to a pattern of serial depletion. The Asian aquaculture industry is especially opaque, and there is a huge information gap regarding the quantities and species caught and the condition of the fisheries. Rapid future growth, along with the industry's apparent lack of commitment to anything that goes beyond 'business as usual', mean the implications for global ecosystems and food security might become irreversible.

The negative impacts of the fishmeal industry go unchallenged by their customers further along the supply chain, many of which are major multinational players with well-developed policies on sustainability and transparency. However, despite impressive-sounding claims, our research shows that aquafeed producers often do not reveal the factories and fisheries that supply ingredients for their feed. Before preparing this report, we contacted 15 aquafeed companies in a bid to understand more about their sourcing policies and practices but received only three responses, which casts serious doubt over their commitment to transparency. The limited information disclosed, either to us directly or via other public disclosure initiatives, shows that major players in the aquafeed business source from countries in West Africa and Latin America, where the reduction industries are placing significant pressure on ecosystems, the environment and food security. Furthermore, these companies also source from fisheries that are not sustainably managed or for which incomplete information exists. This problematic lack of transparency and sustainability is sustained by an intricate web of actors in complex supply chains.

It is also crucial to bear in mind that fish are sentient animals;[38] as such, for both fish farmed intensively and those caught in the wild, industrial aquaculture poses major animal welfare problems. This is highly concerning given the sheer quantity of individuals involved. It is estimated that up to 2.5 trillion fish are commercially killed every year for direct (farmed and wild-caught) and indirect (forage fish for FMFO fed to farmed animals) human consumption.[41]

Considering the problems outlined above, it is extremely worrying that these practices are endorsed by aquaculture certification schemes, which retailers and consumers rely on to make purchasing decisions. All of the aquaculture certification schemes examined for this report allow the use of wild-caught fish in feed. Many of them address the sourcing and use of FMFO by relying on other certification schemes, such as MSC and IFFO RS, which have significant problems themselves. IFFO's role is particularly controversial because it is questionable how a body representing the interests of the FMFO industry can simultaneously be an independent standard-setting body. IFFO certifies around half of global FMFO supply,[180] but our research indicates it is at best highly questionable whether it can guarantee high sustainability standards. Furthermore, no certification scheme considers elements that are critical to measuring the impact of the reduction fisheries, such as the ecosystem and food security effects of removing a key species from the food chain, or the fact that 90% of fish used for reduction fisheries could instead be directly used for human consumption. Certifying reduction fisheries as 'sustainable' is therefore unethical and should be stopped.

The evidence presented in this report shows that, if we are to optimise ocean resources and sustain healthy ecosystems – for both food security and livelihood viability – FMFO have no place in the aquafeed industry of the future. The finite nature of marine resources, combined with the fact that more people around the world are eating more seafood, calls for finding alternative, truly sustainable ingredients for feed. Great care should be taken here to avoid substituting unsustainable FMFO with equally unsustainable soy, palm oil or any other plants grown in monocultures in a manner that disrupts and destroys natural habitats and ecosystems. In addition, the current model of carnivorous fish-rearing needs to give way to more breeding of omnivorous and herbivorous fish, coupled with a substantial reduction in consumption of unsustainable farmed seafood in the Global North.

5.2. Recommendations

Eliminating the use of wild-caught fish to feed farmed fish, and the related social and environmental impacts of the reduction industries documented in this report, will require the involvement of a range of different actors, including aquafeed producers, aquaculture companies, retailers, policymakers and consumers.

Aquafeed industry

- **Stop using wild-caught fish and switch to more sustainable alternatives.** While some companies are taking action to reduce reliance on forage fish in their aquafeed, the use of FMFO needs to be phased out across the entire industry for transformational change to take place. Companies should also stop using FMFO to feed other animals, such as pigs, chickens and mink.

- **Ensure that alternative feed sources do not give rise to other ecological problems.** It is critical that the industry understands and minimises negative impacts linked to other sources of feed; for example, there are huge environmental and social problems linked with expansion of soy-bean and palm-oil production, which are currently not sufficiently addressed by any existing sustainability initiatives.[w]

Aquaculture industry (fish farms)

- **Cultivate more species that do not require feed, require fewer inputs or can be fed an entirely vegetarian diet.** The aquaculture industry should reduce its focus on carnivorous fish (e.g. salmon and shrimp) and instead opt for cultivating species that do not require feed (e.g. shellfish), that are filter feeders (e.g. shellfish), that require fewer inputs (e.g. tilapia) or that can be fed an entirely vegetarian diet (e.g. carp). The aquaculture industry should also take animal welfare into account by keeping fish in more extensive systems, which more closely resemble their natural habitat, and with low stocking densities.

Certification schemes

- **Reduction fisheries should not be certified.** Certifying reduction fisheries gives a false impression that exploiting wild-caught fish for use in FMFO can be sustainable. Wild-caught fisheries certification schemes, such as the MSC, should stop certifying fish that is not used for direct human consumption, while aquaculture certification schemes should only certify farmed fish not reliant on the use of wild-caught fish.

Policymakers

- **Implement stricter regulations on due diligence and transparency in aquafeed supply chains.** Governments and policymakers need to step up to the plate and strengthen governance frameworks to eliminate IUU and slave labour, prevent overfishing, and enhance transparency and reporting in global fisheries supply chains.

- **Stop supporting aquaculture that relies on wild-caught fish.** Governments should support the phase-out of wild-caught fish for aquafeed and fish farming. Furthermore, aquaculture that relies on wild-caught fish should not receive any subsidies or other public support measures. Policymakers should instead encourage plant-based alternatives to fish that do not result in the destruction of natural habitats and ecosystems, as well as other innovative and truly responsible approaches.

Retailers

- **Provide full transparency about the supply chain of farmed fish** – from companies supplying farmed fish, to aquafeed companies, FMFO producers and the location of reduction fisheries.

- **Commit to eliminating seafood cultivated using FMFO.** Retailers should put in place a roadmap for eliminating the use of FMFO in their products, and conduct regular audits to ensure this is being implemented.

w We have explored in detail the problems with numerous voluntary initiatives and certification schemes (including MSC and Roundtable for Sustainable Palm Oil) in our previous report, *The false promise of certification*, available here: http://changingmarkets.org/wp-content/uploads/2018/06/THE_FALSE_PROMISE_OF_CERTIFICATION_FINAL_WEB.pdf.

Consumers

- **Reduce consumption of seafood – especially carnivorous farmed species, such as salmon and shrimp.** Through their purchasing decisions, consumers have an opportunity to send a clear message to the industry that they care about the impacts reduction fisheries have on people and the environment. They can do so by opting for omnivorous/herbivorous fish and seafood species not cultivated using FMFO, or reducing their consumption of seafood products altogether.

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